catalog

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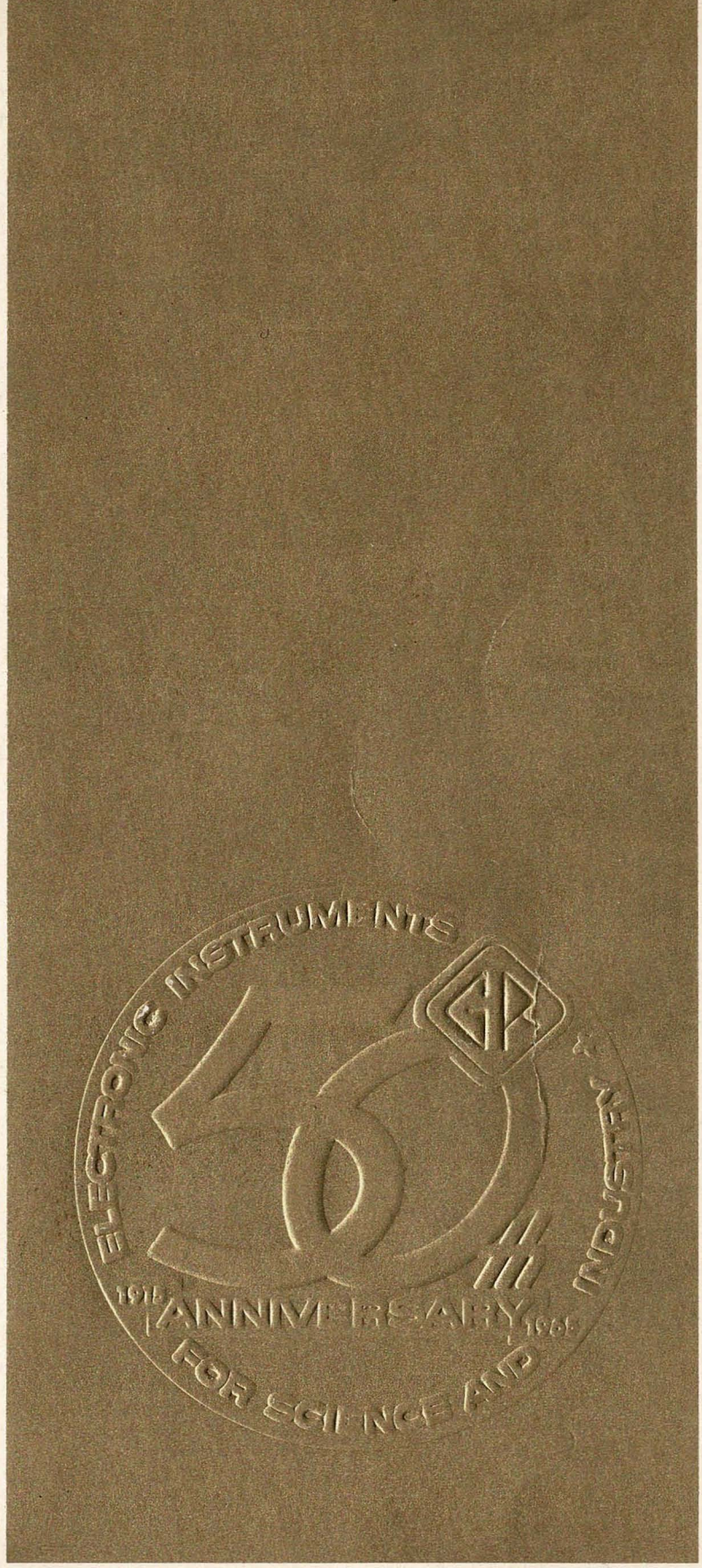

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS, USA

GENERAL RADIO COMPANY

MAIN OFFICE AND PLANT: WEST CONCORD, MASSACHUSETTS 01781

TELEPHONE: (CONCORD) 617 369-4400
(BOSTON AREA) 646-7400

TWX NO. 710 347-1051

CABLE ADDRESS: GENRADCO CONCORD (MASS.)

SALES ENGINEERING OFFICES

General Radio Sales Engineering Offices are maintained in the following areas in the United States and Canada. These offices are staffed by competent factory-trained engineers. We invite your inquiries for technical, commercial, and service information.

OFFICE	*SALES AREA*	*TELEPHONE AND TWX*	*STAFF*
*NEW ENGLAND 22 Baker Avenue West Concord, Massachusetts 01781	Conn., Maine, Mass., N.H., R.I., Vt.	617 646-0550 TWX: 710 347-1051	Kenneth J. Castle, Manager John F. Kemper, Engineer Ralph K. Peterson, Engineer Robert E. Wilson, Engineer
*METROPOLITAN NEW YORK Broad Avenue at Linden Ridgefield, New Jersey 07657	N.Y. City and vic., Long Island, Northern N.J.	(N.Y.) 212 964-2722 (N.J.) 201 943-3140 TWX: 201 943-8249	George G. Ross, Manager J. Peter Eadie, Engineer Richard K. Eskeland, Engineer Thomas H. Mujica, Engineer Raymond J. Jones, Service Supervisor
SYRACUSE Pickard Building East Molloy Road Syracuse, New York 13211	Upstate N.Y.	315 454-9323 TWX: 710 541-0464	Robert P. Delzell, Manager Crawford E. Law, Engineer
PHILADELPHIA Fort Washington Industrial Park Fort Washington, Pennsylvania 19034	Del., Eastern Penn., Southern N.J.	215 646-8030 TWX: 510 661-2920	John E. Snook, Manager Carl W. Alsen, Engineer
*WASHINGTON and BALTIMORE 11420 Rockville Pike Rockville, Maryland 20852	D.C., Md., Va., W. Va., N.C. S.C., Tenn.	301 946-1600 TWX: 710 828-9780	C. William Harrison, Manager James L. Lanphear, Engineer Gerald L. Lett, Engineer Donald W. Brown, Service Supervisor
ORLANDO 113 East Colonial Drive Orlando, Florida 32801	Ala., Fla., Ga.	305 425-4671 TWX: 810 850-0144	John C. Held, Manager Richard G. Rogers, Engineer
*CHICAGO 6605 West North Avenue Oak Park, Illinois 60302	Ill., Ind., Iowa, Kan., Mich., Minn., Mo., Wis.	312 848-9400 TWX: 910 228-3325	William M. Ihde, Manager Robert E. Anderson, Engineer Lane W. Gorton, Engineer R. William Raymond, Engineer Uwe F. (Fred) Wiechering, Service Supervisor
CLEVELAND 5579 Pearl Road Cleveland, Ohio 44129	Ky., Ohio, Western Penn.	216 886-0150 TWX: 810 421-8320	L. C. (Tom) Fricke, Manager Danny L. Woodward, Engineer
DALLAS 2501-A West Mockingbird Lane Dallas, Texas 75235	Ark., Colo., La., Miss., Okla., Texas	214 FLeetwood 7-4031 TWX: 910 861-4229	Edward F. Sutherland, Manager Eric L. Mudama, Engineer
*LOS ANGELES 1000 North Seward Street Los Angeles, California 90038	Ariz., So. Calif., N. Mex.	213 469-6201 TWX: 910 321-4153	Frank J. Thoma, Manager David P. Friedley, Engineer John R. Ross, Engineer Harold Stevens, Engineer Alfred J. Guay, Service Supervisor
SAN FRANCISCO 1186 Los Altos Avenue Los Altos, California 94022	No. Calif., Idaho, Nev., Ore., Utah, Wash.	415 948-8233 TWX: 910 370-7459	James G. Hussey, Manager Allan L. Abbott, Engineer David M. Lloyd, Engineer
*TORONTO 99 Floral Parkway Toronto 15, Ontario, Canada	Canada	416 247-2171 TELEX: 02-29294	Arthur Kingsnorth, Manager Ronald F. Mossman, Engineer Walter F. Oetlinger, Service Supervisor
MONTREAL 1255 Laird Boulevard Town of Mount Royal, Quebec, Canada	Maritime and Quebec Provinces, Ottawa	514 737-3673	Richard J. Provan, Engineer

*SERVICE, INCLUDING REPAIRS, CALIBRATION, AND SPARE PARTS STOCK, AVAILABLE AT THESE OFFICES.

OVERSEAS REPRESENTATIVES

For a list of representatives in other countries, see inside back cover.

THIS *50th Anniversary* CATALOG CONTAINS THE MOST IMPRESSIVE COLLECTION OF ELECTRONIC INSTRUMENTS, STANDARDS, AND COMPONENTS EVER CATALOGED BY GENERAL RADIO

catalog S

JULY 1965

You'll find these* NEW *products of particular interest:

There are many others. For your convenience all new items are clearly designated as such in the Table of Contents and on the individual pages.

For further information, quotations, demonstrations, please call our nearest office (see inside cover) or mail us one of the postcards at the rear.

50th 1915 · ANNIVERSARY · 1965

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS · USA

NEW ENGLAND · NEW YORK · PHILADELPHIA · SYRACUSE · WASHINGTON · CLEVELAND
ORLANDO · CHICAGO · DALLAS · LOS ANGELES · SAN FRANCISCO · TORONTO · MONTREAL

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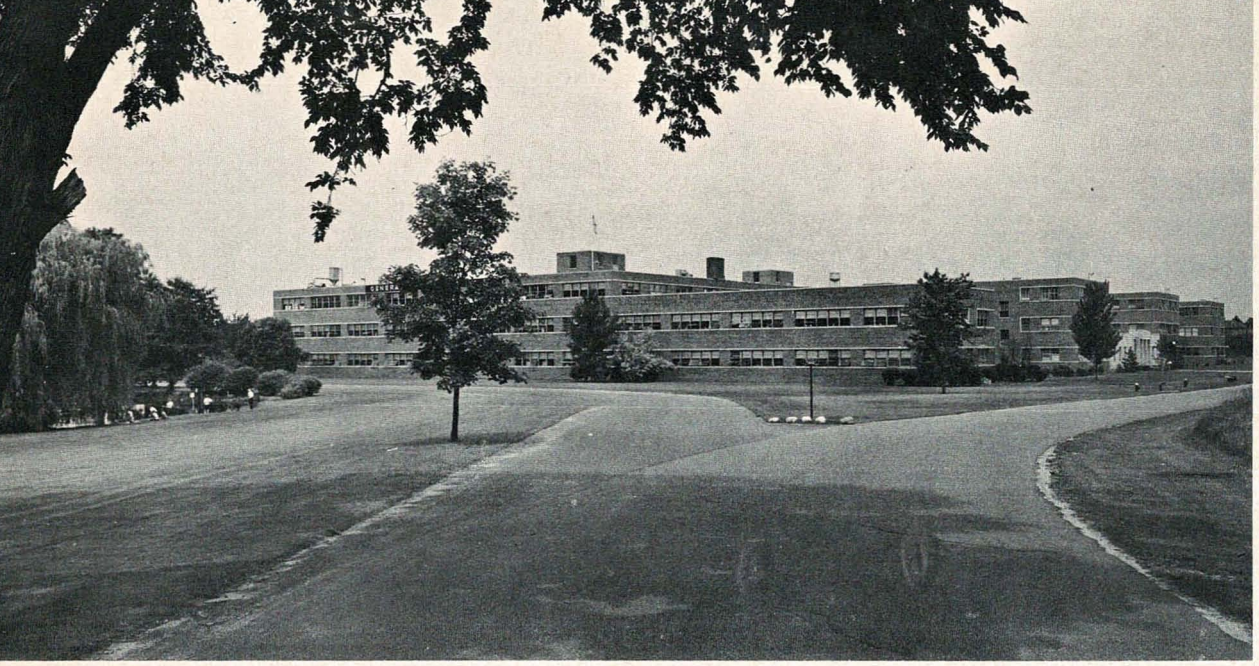
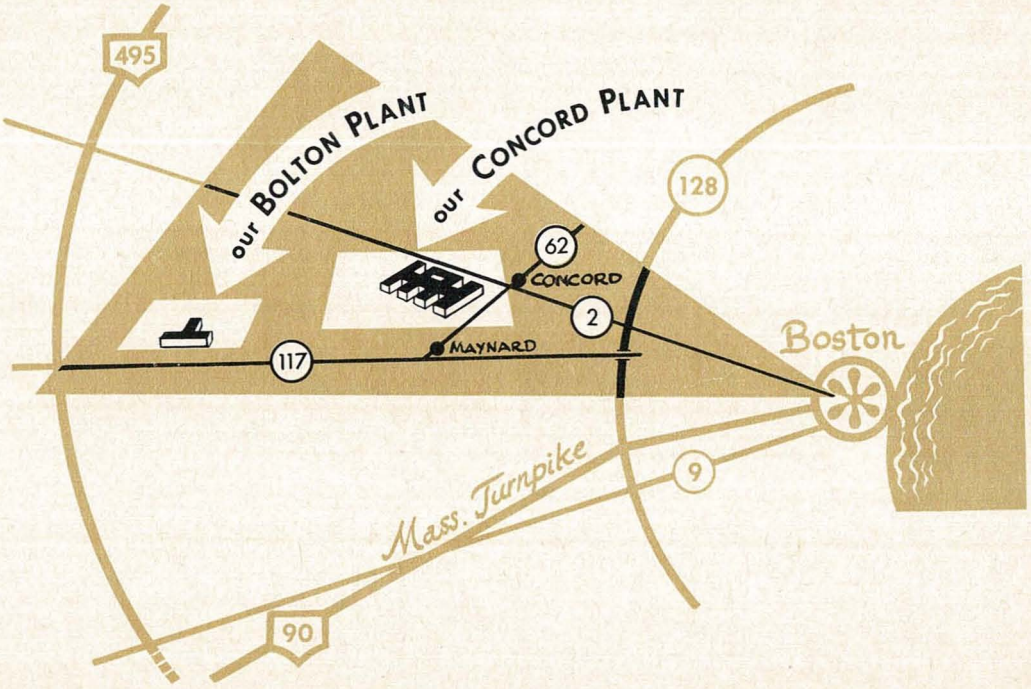
▶ *indicates items introduced since our last Catalog*



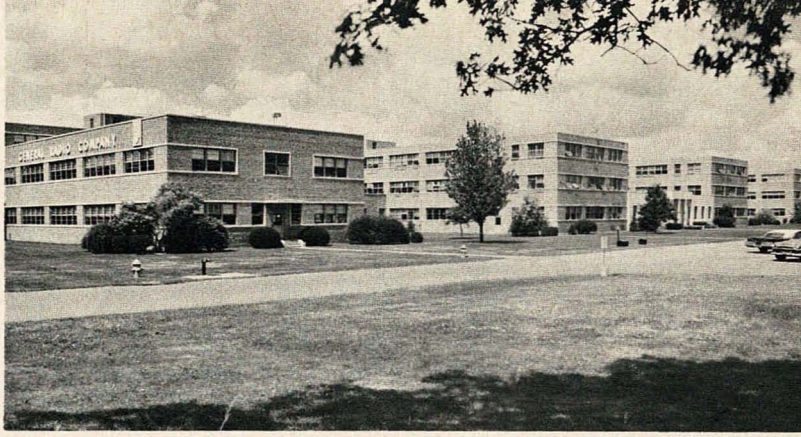
COME VISIT US

We are always glad to see our customers at our plants as well as at our Sales Engineering Offices. The best time to visit us is between 10 AM and 3 PM any day except Saturdays, Sundays, and legal holidays in Massachusetts.

Our West Concord plant is at 22 Baker Avenue, near the intersection of State Routes 2 and 62, about 25 miles northwest of Boston. Our Bolton plant is on State Route 117, about a mile east of its intersection with Interstate Route 495. The accompanying map shows key routes to the two plants. Excellent train service is available to West Concord from Boston's North Station.




General Radio's First Plant


General Radio's Concord Plant Today

OUR FIFTIETH ANNIVERSARY

The publication of this catalog comes at the time of our fiftieth anniversary. General Radio is thus the oldest company in the United States, probably in the world, continuously in the business of manufacturing electronic test equipment. Melville Eastham founded GR in 1915, specifically to manufacture measuring equipment for the electronics (then "radio") industry. The first General Radio plant was in Cambridge, Massachusetts, where the Company remained until its move, in 1958, to the present site in West Concord.

General Radio's "Catalogue A" included the following items: a universal wavemeter (150 to 9000 meters), four inductance standards (0.05 to 5.00 mH), an Ayrton-Perry variable inductance, a variable air condenser, an audibility meter for measuring telephone signal strength, a decade resistance box, and several standard resistors and condensers. As the technology of electrical measurement advanced (helped in no small way by General Radio innovations), instruments grew in sophistication and versatility, to the level represented in the pages of this catalog. Despite the changes, it is easy to see, behind the relatively primitive devices of Catalogue A and the modern instruments of Catalog S, a common genealogical link — the craftsmanship of a specialist in measurement.

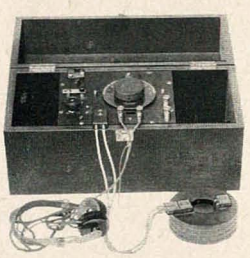
For General Radio, the half century from 1915 to 1965 has been a period of almost constant growth both in size and in capability as an instrument manufacturer. Our history is distinguished by many commercial "firsts": the heterodyne wave analyzer, the continuously adjustable autotransformer, the audio oscillator (including the beat-frequency and RC types), the electronic stroboscope, the transfer-function and immittance bridge, the hermaphrodite coaxial connector, the butterfly circuit, the standard-signal generator, the sound-level meter — these and many more instruments and devices were introduced in commercial form as GR products.

The fact of fifty years is of only passing interest. Far more important to our customers is the *experience* that fifty years in the instrument business implies. That experience is a bonus ingredient in every General Radio product.


Type 1680-A Automatic Capacitance Bridge Assembly


Type 216 Capacity Bridge 1920


Type 1150-BH Digital Frequency Meter

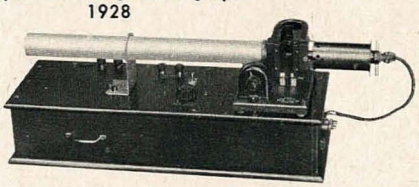

Type 105 Wavemeter 1916

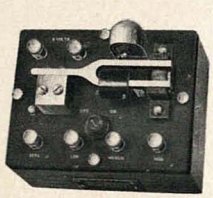

Type 1531-A Strobotac® electronic stroboscope

Type 631 Strobotac® 1935


Type 1521-B Graphic Level Recorder

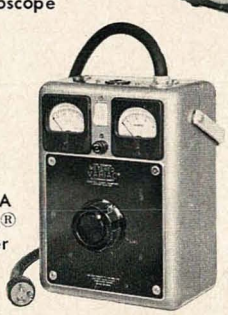
Type 338 String Oscillograph 1928




Type 213 Audio Oscillator 1923


Type 1311-A Audio Oscillator


Type 340 Rheostat 1930


Type W20MT3A Metered Variac® autotransformer

OUR COMPANY

General Radio is an employee-owned manufacturer of electrical and electronic measuring instruments for science and industry. Our administrative offices and main plant are at West Concord, Massachusetts. A new plant in nearby Bolton, Massachusetts specializes in the development and manufacture of signal generators and of microwave instruments and devices.

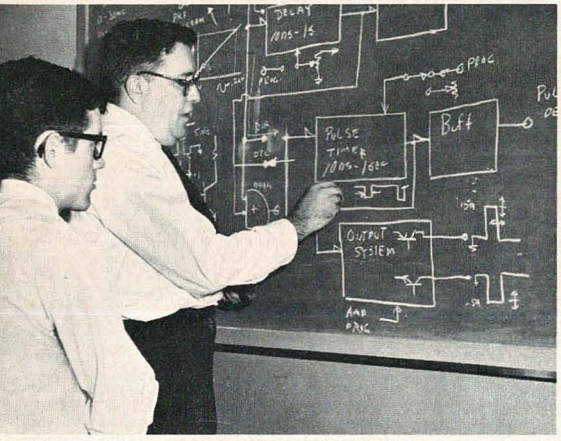
Our sales engineering and service network includes offices in 13 metropolitan areas in North America and subsidiaries in Zurich and London.

General Radio sells standard, proprietary, off-the-shelf products, listed in this catalog. In addition, systems are custom-assembled to serve special requirements, notably in the data-handling area. The Company has also developed a number of special-purpose instruments for various Government agencies and for industry. General Radio does not sell consulting services, patents, or proprietary rights or processes.

OUR PEOPLE

Because of the highly technical nature of our products, there is a high proportion of professional employees among the 1000-plus workers who make up General Radio. We have been called "an engineer's company," and it is true that the engineering personality and discipline are present in most of the Company's operations.

Every employee is, directly or indirectly, a part owner of the Company, shares in its fortunes, and is jealous of his Company's reputation for quality. The extra



reliability and years of life built into GR instruments are the result of both a deliberate corporate dedication to quality and an employee-by-employee commitment to the same principle.

ENGINEERING

The great majority of our development engineers have advanced degrees, and many are among the leaders in their fields. In every one of its product areas, GR has the advantage of many years of valuable development experience. Since the average annual engineering turnover is almost nil (well under 2%, excluding retirees), there is an impressive continuity of experience to serve as a base for the constant growth of our engineering staff.

MANUFACTURING

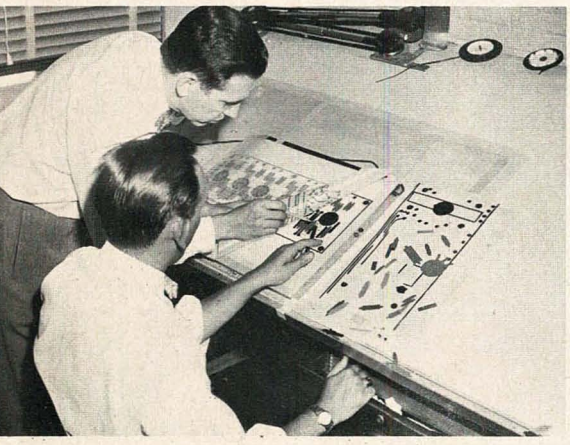
Our all-male manufacturing operations also benefit from very low turnover. The highly skilled men who assemble GR instruments average well over 10 years on the job. Each of these men assembles the complete instrument (there are no assembly lines at GR); their craftsmanship is one of the reasons why we can back up our products with a two-year warranty.

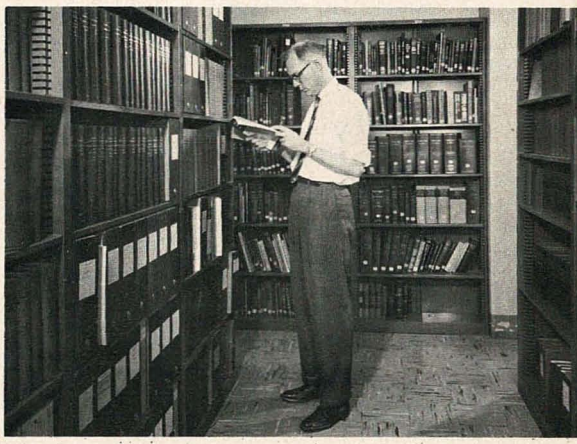
Quality, of course, begins long before instrument assembly. Components must meet rigid standards, and, for closest control of quality, we make many of them ourselves. We also do our own plating and painting, braid our own cables, wind our own potentiometers. For those components we buy, we still demand GR-grade quality.

From such preoccupation with quality come instruments that perform, and perform, and perform. Instruments built 25 or 30 years ago that are still going strong. Instruments in this catalog that will still be in use in the next century. Instruments that, for all their quality, are manufactured efficiently and are priced competitively.

SALES ENGINEERING

All GR sales engineers have technical degrees and intensive home-office training in both the technical and commercial aspects of sales engineering. The GR sales engineer sells our entire product line, from stroboscopes to sound-level meters, from capacitance bridges to coaxial connectors. He is thus a uniquely



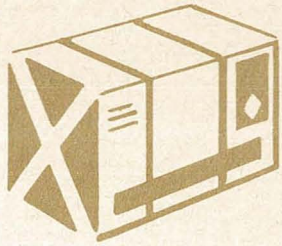


qualified consultant in the broad field of measurement instrumentation. He is, moreover, a salaried employee of General Radio, known and respected for his expert, honest advice, even when the application calls for a competitor's product.

Sales Engineering Offices are located in 13 metropolitan areas in the United States and Canada. Repair centers at six of these locations are staffed by factory-trained service technicians.

General Radio has long served its many customers overseas through a network of representatives, most of whom have been associated with GR for many years. To supplement this coverage, we have in the last few years added two overseas subsidiaries, General Radio (Overseas), based in Zurich, and General Radio (U.K.) Ltd., located near London.

SALES, SHIPPING AND SERVICE INFORMATION



NOTE: The following information applies only to transactions originating in the United States and Canada. Customers in other countries will find pertinent sales, shipping, and service information in the International Edition of this catalog.

WE SELL DIRECT

We believe that we serve our domestic customers best by serving them directly. The men who sell GR instruments are *engineers,* in the strictest sense. They are General Radio employees, qualified to act for the Company, and they are paid salaries, not commissions. Every GR sales engineer is an experienced, expert consultant on electrical measurement, and his advice is yours for the asking.

A GR sales policy of long standing is the single price to all, published as an essential part of a product's specifications. The prices given in this catalog are what we charge for our products, the only discounts being the quantity discounts noted below.

(Variac® autotransformers are sold in the U.S. both direct and through distributors, either way at the same advertised prices.)

HOW TO ORDER

Always order by both catalog number and complete description. For example:

Catalog No. 1900-9801, Type 1900-A Wave Analyzer, Bench Model.

Ac-operated instruments are supplied wired for operation on 115-volt power lines, unless otherwise specified. Most ac-operated instruments can also be supplied for nominal power-line voltages of 220, 230, and 240 volts, as indicated in the specifications under *Power Required.* Be sure to specify operating voltage and frequency if other than a nominal 115 volts, 50 to 60 cycles.

	2 POUNDS				5 POUNDS				25 POUNDS				40 POUNDS			
USA	*Air Freight*	*Air Express*	*Air Parcel Post*	*REA*	*Air Freight*	*Air Express*	*Air Parcel Post*	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*
ATLANTA	$12.60	$6.60	$1.34	$3.50	$12.60	$6.60	$3.02	$3.50	$12.60	$10.75	$6.46	$5.60	$12.60	$14.86	$6.46	$6.10
BUFFALO	11.20	6.60	1.23	3.60	11.20	6.60	2.73	3.60	11.20	6.75	5.67	4.87	11.20	8.46	5.67	4.87
CHICAGO	13.25	6.60	1.34	3.80	13.25	6.60	3.02	3.80	13.25	10.75	6.62	6.00	13.25	14.86	6.62	6.39
CLEVELAND	11.45	6.60	1.23	3.70	11.45	6.60	2.73	3.70	11.45	8.35	6.23	5.40	11.45	11.02	6.23	5.42
DALLAS	16.90	6.60	1.55	3.70	16.90	6.60	3.71	3.70	16.90	16.35	9.40	6.75	16.90	23.82	9.40	7.79
DETROIT	11.35	6.60	1.23	3.75	11.35	6.60	2.73	3.75	11.35	8.35	6.64	5.65	11.35	11.02	6.64	5.84
HOUSTON	15.90	6.60	1.55	3.75	15.90	6.60	3.71	3.75	15.90	16.35	9.72	6.80	15.90	23.82	9.72	7.83
LOS ANGELES	24.75	6.60	1.68	3.95	24.75	7.67	4.08	3.95	24.75	22.75	12.16	8.35	24.75	34.06	12.16	9.75
ST. LOUIS	12.75	6.60	1.47	3.85	12.75	6.60	3.39	3.85	12.75	11.55	7.51	6.30	12.75	16.14	7.51	6.93
SEATTLE	23.65	6.60	1.68	3.90	23.65	7.67	4.08	3.90	23.65	22.75	12.16	8.30	23.65	34.06	12.16	9.65
*CANADA***	*Air Freight*	*Air Express*	*Air Mail*	*REA*	*Air Freight*	*Air Express*	*Air Mail*	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*
CALGARY	$12.55	$6.60	$2.56	$4.75	$12.55	$8.20	$6.40	$4.75	$12.55	$25.40	$10.43	$8.74	$18.30	$38.30	$10.43	$11.74
MONTREAL	9.50	6.60	2.56	4.02	9.50	6.60	6.40	4.02	9.50	6.60	6.50	5.12	9.50	7.90	6.50	5.96
OTTAWA	9.50	6.60	2.56	4.03	9.50	6.60	6.40	4.03	9.50	6.60	6.08	5.28	9.50	7.90	6.08	6.22
QUEBEC	9.50	6.60	2.56	4.03	9.50	6.60	6.40	4.03	9.50	7.40	6.50	5.78	9.50	9.50	6.50	6.72
TORONTO	9.50	6.60	2.56	4.62	9.50	6.60	6.40	4.62	9.50	8.40	6.93	5.59	10.70	11.10	6.93	7.20
VANCOUVER	14.00	6.60	2.56	4.85	14.00	8.60	6.40	4.85	14.00	27.40	12.16	9.48	20.30	41.50	12.16	12.89
WINNIPEG	10.50	6.60	2.56	4.43	10.50	7.00	6.40	4.43	10.50	18.40	7.40	8.01	14.70	27.10	7.40	9.43

	75 POUNDS				100 POUNDS				200 POUNDS				400 POUNDS			
USA	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*
ATLANTA	$16.35	$24.45	$6.46	$6.10	$17.00	$31.30	$6.46	$6.13	$28.90	$61.90	$11.80	$10.40	$55.80	$123.80	$23.60	$20.80
BUFFALO	12.10	12.45	5.67	4.87	12.10	15.30	5.67	4.90	19.00	29.90	8.62	7.80	36.00	59.80	17.24	15.60
CHICAGO	17.00	24.45	6.62	6.39	17.00	31.30	6.62	6.42	28.25	61.90	11.04	10.80	55.60	123.80	22.08	21.60
CLEVELAND	12.95	17.25	6.23	5.42	12.95	21.70	6.23	5.45	20.45	42.70	8.88	8.80	39.60	85.40	17.76	17.60
DALLAS	22.00	41.25	9.40	7.79	22.00	53.70	9.40	7.82	39.10	106.70	16.10	13.90	76.80	213.40	32.20	27.80
DETROIT	13.50	17.25	6.64	5.84	13.50	21.70	6.64	5.87	21.65	42.70	10.12	9.70	41.80	85.20	20.24	19.40
HOUSTON	21.40	41.25	9.72	7.83	21.40	53.70	9.72	7.86	37.90	106.70	16.72	14.00	74.60	213.40	33.44	28.00
LOS ANGELES	31.70	60.45	12.16	9.75	31.70	79.30	12.16	12.00	58.20	157.90	24.32	25.00	115.60	315.80	48.64	50.00
ST. LOUIS	16.50	26.85	7.51	6.93	17.35	34.50	7.51	6.96	29.50	68.30	12.28	12.00	58.20	136.60	24.56	24.00
SEATTLE	31.10	60.45	12.16	9.65	31.10	79.30	12.16	11.90	57.05	157.90	24.32	25.00	112.40	315.80	48.64	50.00
*CANADA***	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*	*Air Freight*	*Air Express*	*Truck**	*REA*
CALGARY	$31.25	$68.40	$10.43	$18.77	$32.85	$89.90	$10.43	$23.94	$62.20	$179.10	$20.86	$48.38	$123.60	$358.20	$41.72	$ 96.26
MONTREAL	13.45	11.40	6.50	7.90	13.45	13.90	6.50	9.45	23.40	27.10	6.98	18.40	53.00	54.20	13.96	36.30
OTTAWA	14.35	11.40	6.08	8.38	14.35	13.90	6.08	10.08	25.20	27.10	8.10	19.66	49.60	54.20	16.20	38.82
QUEBEC	12.95	14.40	6.50	8.88	12.95	17.90	6.50	10.08	22.40	35.10	7.42	19.66	44.00	70.20	14.84	38.82
TORONTO	16.75	17.40	6.93	9.82	16.75	21.90	6.93	11.40	30.00	43.10	9.16	22.30	59.20	86.20	18.32	44.10
VANCOUVER	35.00	74.40	12.16	20.98	36.75	97.90	12.16	26.88	70.00	195.10	24.32	53.26	139.20	390.20	48.64	106.02
WINNIPEG	24.50	47.40	7.40	14.47	25.15	61.90	7.40	18.22	46.80	123.10	14.80	35.94	92.80	246.20	29.60	71.38

NOTES: Additional charges, based on value of goods shipped, apply on all shipments not forwarded by truck or rail freight forwarder. For all such shipments, full invoice value will be declared unless specific alternate instructions are received.

* Or rail freight forwarder.

** Canadian rates do not include handling or brokerage fees, duties, or any other taxes.

Special features and modifications not listed in the specifications (such as, for instance, extra calibrations) are available at extra cost. Please include in your order information on any nonstandard features desired.

SHIPPING INSTRUCTIONS

Unless specific instructions accompany the order, we shall use our judgment as to the best method of shipment. Repair parts and other items needed quickly will be shipped by air if requested. The table on the preceding page shows the cost of four different methods of shipment to major cities in the United States and Canada, door-to-door.

The price of the instrument includes packing but does not include the cost of shipping. Shipping containers are not returnable.

OUR ADDRESS

Communications may be addressed to General Radio Company, West Concord, Massachusetts, or to one of the Sales Engineering Offices listed on the inside front cover of this catalog.

Customers may call on whichever Sales Engineering Office is most convenient for them. Areas regularly served by the various offices are listed on the inside front cover. States not listed are covered by the Sales Engineering Department at West Concord.

We have direct teleprinter connections with both Western Union and Bell System TWX. Our cable address is GENRADCO CONCORD (MASS), and our TWX call numbers are 617-369-5708. Complete addresses and telephone numbers for our Sales Engineering Offices are listed on the inside front cover.

PRICES

All prices given in this catalog are established on a direct-to-customer basis, with no discounts other than the quantity discounts noted below. Prices are FOB our plant, West Concord, Massachusetts, and are exclusive of all taxes now in effect or that may be imposed hereafter by Federal, State, or local governments. Prices given are subject to change without notice. Formal price quotations remain in effect for 30 days.

Canadian customers may obtain prices FOB Toronto from our Sales Engineering Offices in Toronto or Montreal.

CONDITIONS OF SALE

Determination of prices, terms, and conditions of sale, and final acceptance of orders are made only at our plant in West Concord, Massachusetts.

Terms are net 30 days if credit has been arranged; otherwise, unless payment is received before shipment, shipment will be made COD.

QUANTITY DISCOUNTS

Quantity discounts apply only to Variac® autotransformers and to parts, not to instruments. When 10 or more identical parts or autotransformers are ordered at the same time for single shipment to the same place, with ultimate destination in the continental United States (not including the Canal Zone) or Canada, the following quantity discounts apply unless otherwise noted:

Quantity	Discount
10 through 19	5 percent
20 through 99	10 percent
100 or more	15 percent

MINIMUM BILLING

The minimum billing per order is $10.00. This applies to all purchases except repair parts and cash-with-order transactions.

SOURCE-INSPECTION SURCHARGE

A surcharge of 1 percent ($2.50 minimum) applies on all orders requiring inspection at our plant either by one of the Government services or by the customer's own inspection department or other private agency. The inspection surcharge applies on each shipment inspected and covers only our costs.

SPECIFICATION CHANGES

We reserve the right to discontinue any item without notice and to change specifications at any time without incurring any obligation to incorporate new features in instruments or parts previously sold.

WARRANTY

We warrant that each new instrument sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of *two years* after original shipment. Any instrument or component that is found within the two-year period not to meet these standards, after examination by our factory, district office, or authorized repair agency personnel, will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

SERVICE AND PARTS

Repair service is available from our plant at West Concord, Massachusetts, or from our field service facilities (see inside front cover).

Repair parts may be ordered from our home plant or our field service laboratories. When ordering repair parts, please specify the part number and description of the item and the type and serial numbers of the instrument in which it is used.

Before returning an instrument for repair, please write to us, requesting a Returned Material Tag, which includes packing and shipping instructions to ensure protection in transit. Also state the type and serial numbers of the instrument, date of purchase, and details concerning the difficulty.

EXPORT ORDERS

Customers outside the United States and Canada are served by General Radio, by its subsidiaries, General Radio (Overseas) and General Radio (U.K.) Ltd., and by the group of export representatives listed inside the rear cover of this catalog. All communications should be directed to the appropriate export representative. For countries not listed, inquiries should be addressed to General Radio Company, West Concord, Massachusetts, U.S.A., or, for customers in Europe, to General Radio Company (Overseas), Helenastrasse 3, Zurich 8008, Switzerland.

Full information on export transactions is given in the International Edition of this catalog, available on request from General Radio Company, West Concord, Massachusetts, USA.

ABBREVIATIONS, SYMBOLS, AND PREFIXES

In this catalog, as in other General Radio publications, our use of symbols, prefixes, and abbreviations follows the recommendations of the International Electrotechnical Commission, the American Standards Association, the Institute of Electrical and Electronics Engineers, and various other scientific and engineering organizations. Where there is not agreement among these groups, we generally choose the usage favored by the majority.

ABBREVIATIONS AND SYMBOLS

A	ampere
ac	alternating current
AFC	automatic frequency control
a-m	amplitude modulation
ASA	American Standards Association
ASTM	American Society for Testing Materials
AVC	automatic volume control
avg	average
B	susceptance
BCD	binary-coded decimal
C	capacitance
C	Celsius (Centigrade)
CIF	cost, insurance, freight
cm	centimeter
COD	cash on delivery
c/s	cycle per second
CW	continuous wave
D	dissipation factor
dB	decibel
dBm	decibel referred to one milliwatt
dc	direct current
dia	diameter
E	voltage
EIA	Electronics Industries Association
emf	electromotive force
F	farad, Fahrenheit
f	frequency
fm	frequency modulation
FOB	free on board
G	conductance
g	gram, gravitational constant
Gc/s	gigacycle per second
g_m	transconductance
H	henry
h_f	forward current-transfer ratio
h_i	short-circuit input impedance
h_o	open-circuit output admittance
h_r	reverse voltage-transfer ratio
Hz	Hertz
I	current
ID	inside diameter
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
i-f	intermediate frequency
in	inch
IRE	Institute of Radio Engineers
ISO	International Standards Organization
j	$\sqrt{-1}$
kc/s	kilocycle per second
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kΩ	kilohm
L	inductance
lb	pound
LC	inductance-capacitance
log	logarithm
m	mass
m	meter
mA	milliampere
max	maximum
mbar	millibar
Mc/s	megacycle per second
mH	millihenry
mil	0.001 inch
min	minimum, minute
mm	millimeter
mV	millivolt
mW	milliwatt
m℧	millimho
mΩ	milliohm
MΩ	megohm
ns	nanosecond
n℧	nanomho
oz	ounce
p	page, parallel (as L_p)
pf	power factor
pF	picofarad
ppm	parts per million
pps	pulses per second
p-to-p	peak-to-peak
prf	pulse repetition frequency
Q	quality factor (storage factor)
R	resistance
®	registered trademark
RC	resistance-capacitance
re	referred to
rf	radio frequency
RH	relative humidity
rms	root-mean-square
rpm	revolutions per minute
s	second, series (as L_s)
shf	super-high frequency
sq	square
sync	synchronous, synchronizing
T	period
t	time
uhf	ultra-high frequency
v	velocity
V	volt
VA	volt ampere
vhf	very-high frequency
vlf	very-low frequency
W	watt
wt	weight
X	reactance
Y	admittance
Z	impedance
α	short-circuit forward current-transfer ratio (common base)
β	short-circuit forward current-transfer ratio (common emitter)
Γ	reflection coefficient
Δ	increment
δ	loss angle
θ	phase angle
λ	wavelength
μA	microampere
μbar	microbar
μF	microfarad
μH	microhenry
μs	microsecond
μV	microvolt
Ω	ohm
℧	mho
ω	angular velocity ($2\pi f$)

PREFIXES

Orders of magnitude from 10^{-18} to 10^{12} are designated by the following prefixes:

Order	*Prefix*	*Symbol*
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

POWER-SUPPLY CONSIDERATIONS

General Radio ac-operated instruments will meet the published specifications when operated from power lines whose voltages and frequencies are within the limits stated in the specifications under the heading *Power Required.*

Most instruments have input voltage ranges of 105 to 125 and 210 to 250 volts and will therefore operate on nominal power-line voltages of 115, 220, 230, and 240 volts. In certain instruments an additional range of 195 to 235 volts is included. The voltage range for which an instrument is wired is marked at the power-input plug or cord. Proper fuses for this voltage range are fitted in the fuse holders.

When the power-line voltage on which the instrument is to be operated is specified on the order, the necessary changes in connections, fuses, and nameplate are made at the factory. This change can also be made easily by the user, in accordance with directions given in the instruction manual.

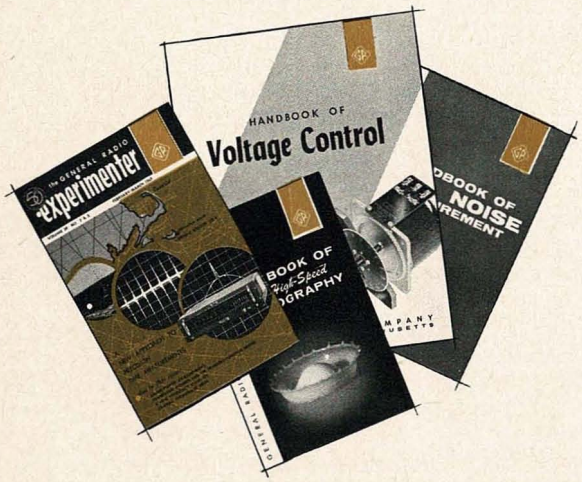
Certain instruments are available for use only on power lines of 220, 230, and 240 volts (nominal). Such instruments are identified by the suffix Q18 in the type designation.

For most instruments, the normal operating frequency range is 50 to 60 cycles per second. Instruments identified by the suffix Q1 in the type designation are for 50-cycle operation only.

All ac-operated instruments are supplied with three-wire power cords, designed for standard three-wire receptacles.

BATTERY OPERATION

Portable, battery-operated instruments are shipped with dry-cell batteries in place but disabled to prevent drain and leakage during shipment. To render the instrument operative, the user need only remove the yellow insulating disks from the battery terminals.



PUBLICATIONS

A monthly publication, the *General Radio Experimenter,* discusses new products and applications as well as general technical subjects. Sent free on request, this periodical is distributed to over 100,000 readers throughout the world.

Other General Radio publications include the *Handbook of Noise Measurement, Handbook of Voltage Control, Handbook of High-Speed Photography,* and instrument notes, booklets, and reprinted articles on a wide range of technical subjects.

PATENTS

Many of our products are manufactured and sold under United States Letters Patent owned by the General Radio Company or under license grants from other companies. To simplify the listing of these patents they are given here in a single list and referred to at each instrument only by appropriate reference number.

1. "Certain vacuum-tube amplifier devices, electric wave filters, vacuum-tube oscillators, and sound-level meters are licensed by Western Electric Company, Inc., under all United States Letters Patent owned or controlled by American Telephone and Telegraph Company, or Western Electric Company, Inc., and any or all other United States patents with respect to which Western Electric Company, Inc., has the right to grant a license, solely for utilization in research, investigation, measurement, testing, instruction and development work in pure and applied science, including engineering and industrial fields."
2. 2,578,429.
3. Patent 2,586,397.
4. Patent 2,548,457.
5. Patent 2,802,907.
6. Licensed under designs, patents and patent applications of Edgerton, Germeshausen and Grier.
7. Patent 3,067,388.
8. Patent Applied For.
9. Patent Re 24,204.
10. Patent 3,050,685.
11. Patent 3,022,944.
12. Patent 3,012,197.
13. Patent 2,977,540.
14. Patent 2,763,733.
15. Patent D 187,740.
16. Patent 2,970,258.
17. Patent 2,538,122.
18. Patent 2,581,133.
19. Patent 2,872,639.
20. Patent 2,943,277.
21. Patent 2,942,172.
22. Patent 2,966,257.
23. Patent 2,506,648.
24. Patent 2,702,736.
25. Patent 2,715,718.
26. Patent 2,786,140.
27. Patent 3,156,870.

ACOUSTICS

General Radio's comprehensive line of acoustical and audio-frequency instruments provides the essential elements for the efficient evaluation of noise and vibration and for the measurement of other acoustical phenomena. The basic instruments described in this section comprise a sound-level meter, a vibration meter, and a variety of transducers and calibrators, for the quantitative measurement of both air-borne and solid-borne vibrations.

These are supplemented by:

(1) A group of analyzers, which operate from the electrical output of the sound-level meter* to measure the amplitude and frequency of the components of the sound or vibration spectrum. These include narrow-band, 1/3-octave, and octave-band instruments, as well as a peak-reading device for evaluating impact-type sounds. (See pages 27–35.)

(2) A preamplifier that operates directly from a microphone or vibration pickup to increase the sensitivity of any of the analyzers or to allow the use of long cables between the transducer and an instrument without loss in sensitivity. (See page 17.)

(3) Audio-frequency oscillators, a random-noise generator, tone-burst generator, and pulse generators for exciting acoustical and electrical systems under test. (See pages 130, 160, 169.)

(4) Graphic recorders for automatic spectrum analysis, reverberation-time measurements, and permanent records of measurements. (See page 177.)

(5) Stroboscopes for visual analysis of vibration phenomena. (See page 210.)

(6) Impedance bridges for determining the characteristics of transducers and other acoustical devices. (See page 41.)

(7) Auxiliary equipment, such as frequency meters and amplifiers. (See pages 36 and 119.)

With GR instruments, one can make the measurements necessary for rating and evaluating practically any industrial noise problem. They can be used by nontechnical personnel and are designed for long life and trouble-free operation. The use of these and other noise-measuring instruments is discussed thoroughly in the *Handbook of Noise Measurement*, published by General Radio Company, and available at one dollar a copy, postpaid.

SOUND-LEVEL MEASUREMENTS

The standard sound-level meter is the basic sound-measuring instrument and has been improved in each successive model in performance, in convenience, and in versatility, culminating in the Type 1551-C Sound-Level Meter. The Type 1565-A Sound-Level Meter is a simplified version, particularly designed for convenience in use, small size, and low cost. Both instruments meet the requirements of the current American Standard Specification for General-Purpose Sound Level Meter and the IEC Recommendation.†

The excellent, general-purpose piezoelectric ceramic microphone supplied as standard equipment is stable and rugged, has a smooth frequency response, and is relatively unaffected by normal temperature changes. It can be mounted directly on the instrument or separately with connection by extension cable when it is necessary to avoid the effects of the observer on the acoustical measurement. For very wide band measurements the Type 1551-P1 Condenser Microphone System is available.

Either of these instruments can be used to measure over-all level, the first important measure of a noise. A frequency analysis is also often desirable to estimate the effects of the noise, to track down the source, and to determine efficient control measures.

OCTAVE-BAND AND NARROWER-BAND MEASUREMENTS — SPECTRUM ANALYSIS

The Type 1558 Octave-Band Noise Analyzers and Type 1564-A Sound and Vibration Analyzer can be used directly with a ceramic microphone to measure octave-, 1/3-octave-, and 1/10-octave-band sound-pressure levels in the range from 44 to 150 dB, which yields adequate data for comparison with most hearing-damage criteria, test codes, and noise ordinances. For even lower band levels, the Type 1560-P40 Preamplifier can be used, or the electrical output of the Type 1551-C Sound-Level Meter can be analyzed. This output is the amplified electrical replica of the acoustic signal at the microphone, and it has a wide dynamic range. Its frequency spectrum can be analyzed by the Octave-Band Noise Analyzers, the Sound and Vibration Analyzer, with both 1/10-octave and 1/3-octave bandwidths, and the Type 1900-A Wave Analyzer with 3-, 10-, and 50-cycle bandwidths.

IMPACT NOISE

The measurement of impact noise can be made simply with the sound-level meter and the Type 1556-B Impact-Noise Analyzer. This analyzer can also measure electrical noise peaks in communication circuits.

CALIBRATION

Although GR sound-measuring instruments are inherently reliable and stable, after long periods of use their performance may change. To ensure that important changes will be discovered and corrected, the Type 1552-B Sound-Level Calibrator has been developed. When driven by the Type 1307-A Transistor Oscillator at a 2-volt level, it supplies a known (400-cycle) acoustic signal to the microphone for over-all calibration of the system.

* The TYPE 1564-A Sound and Vibration Analyzer and the TYPE 1558 Octave-Band Analyzers can also be operated directly from a microphone or vibration pickup.

† ASA S1.4-1961; IEC Publication 123, 1961.

Greatest accuracy of calibration is achieved with the Type 1559-B Microphone Reciprocity Calibrator. This device, which uses the closed-coupler reciprocity method of calibration, will determine the sensitivity of GR microphones over a frequency range of 20 to 8000 c/s. It is also a precision acoustic source, as well as a sound-level calibrator.

VIBRATION MEASUREMENTS

GR vibration-measuring equipment includes the Type 1553 Vibration Meters to measure the acceleration, velocity, displacement, and jerk* of a vibrating element; the Type 1564-A Sound and Vibration Analyzer or the Type 1900-A Wave Analyzer to analyze the vibration; and the Type 1560 Vibration Pickup Systems to convert the sound-level meter to a vibration meter. The Octave-Band Noise Analyzers and the Sound and Vibration Analyzer can also be operated directly from the output of a vibration pickup. These instruments are easily calibrated with the Type 1557-A Vibration Calibrator, a self-contained electromagnetic shaker.

Stroboscopes comprise another important group of vibration measuring instruments. They permit vibrating objects to be viewed intermittently and produce the optical effect of slowing down or stopping a periodic vibration.

LEVEL RECORDERS

The Type 1521-B Graphic Level Recorder can record the level and spectral distribution of sound and vibration, operating from the output of the sound-level meter, the vibration meter, or one of the analyzers. The frequency dials of the Type 1564-A Sound and Vibration Analyzer and the Type 1900-A Wave Analyzer can be driven by the recorder for automatic plotting of the spectrum. Reverberation measurements can also be made with this recorder.

The Type 1520-A Sampling Recorder can record the instantaneous value of the wave from the output of a vibration meter or a sound-level meter. Its high speed makes it particularly useful for studying transient signals.

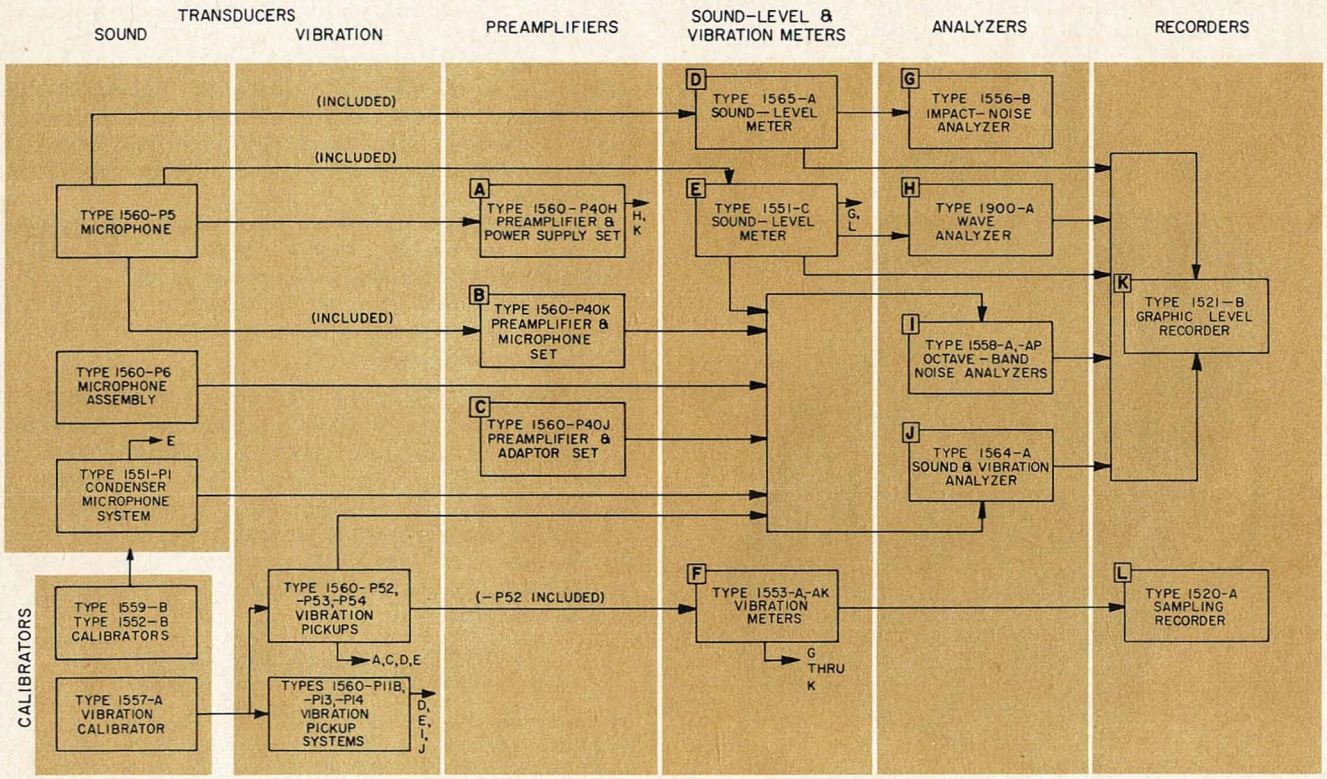
MEASUREMENT POWER SOURCES

The Type 1304-B Beat-Frequency Audio Generator can drive transducers with pure tones to excite vibratory and acoustical systems. If the response is recorded on the Type 1521-B Graphic Level Recorder, a plot of the transfer-response level in decibels versus frequency on a standard logarithmic scale is obtained. An output of the Type 1910-A Wave Analyzer can also be used to drive transducers or networks, and the response can be detected by the same analyzer and plotted automatically on the Type 1521-B Graphic Level Recorder. When higher power is needed, the Type 1308-A Audio Oscillator and Power Amplifier is recommended.

The Type 1390-B Random-Noise Generator can supply a useful broad-band noise. When its output is fed to one of the General Radio analyzers, the analyzer output is a narrower band of noise that is tunable over the range of the analyzer. Such a signal has many applications in acoustical testing, particularly in architectural acoustics and psychoacoustics. For transient-response measurements, square-wave and pulse generators can provide steep-wavefront signals, and the tone-burst generator provides a signal that is particularly useful in acoustical testing.

The accompanying diagram shows the functional relations among these various instruments, which collectively make up the General Radio Sound-Measuring System.

* Jerk = rate of change of acceleration.



SOUND-LEVEL METERS

The standard sound-level meter, whose essential characteristics are specified by the American Standards Association and the International Electrotechnical Commission, is the accepted instrument for the measurement of both product noise and environmental noise by industry, laboratories, and noise-abatement groups.

Typical users include:

Machine and Appliance Manufacturers, in industrial and development laboratories as well as on the production line. The sound-level meter provides a means of establishing noise standards and of accepting or rejecting products on the basis of noise tests.

Acoustical Engineers and Physicists, for the measurement of machinery and product noise and for determining the acoustical properties of buildings, vehicles, and materials.

Industrial Hygienists and Psychologists, in surveys of the psychological and physiological effects of noise and for the determination of satisfactory noise environments in factories and offices.

Public Authorities, for measuring noise levels in streets, highways, airports and other public places.

General Radio manufactures two sound-level meters. The Types 1565-A and 1551-C Sound-Level Meters are both designed to meet ASA and IEC specifications. The Type 1565-A Sound-Level Meter is a simplified version, particularly designed for convenience in use, small size, and low cost. As a result it does not have the ultimate sensitivity, the added frequency range, the internal calibration, and the low output distortion of the larger Type 1551-C Sound-Level Meter. The Type 1551-C Sound-Level Meter provides the greater versatility that is needed when a variety of measurements must be made. But, as is often the case, when no more than a single weighted sound-level measurement at levels above 44 dB is required, the Type 1565-A Sound-Level Meter is admirably suited to the job. If over-all sound levels need to be recorded, either instrument can be used with the graphic level recorder; and for impact noise, the impact-noise analyzer is essential.

Type 1551-C SOUND-LEVEL METER

FEATURES:

Compact, and portable — weighs less than 8 pounds with batteries.
Rugged ceramic microphone. ■ Low internal noise level. ■ Low distortion.
Simple to operate. ■ Uses standard batteries.
Meets requirements of ASA S1.4-1961 and IEC Publication 123, 1961.
Two-speed meter movement permits measurement of either steady or fluctuating sound.
Wide sound-level range — from 24 to 150 dB. ■ Wide dynamic range.
Wide frequency response of amplifiers and circuit from 20 c/s to 20 kc/s.
Internal calibration system for standardizing gain.
Rms response in accordance with ASA S1.4-1961.

USES: In addition to its primary use as a self-contained sound-level meter, the TYPE 1551-C Sound-Level Meter is the heart of an extensive sound-measuring system, which includes spectrum analyzers, special-purpose microphones, calibrators, and vibration pickups. Many other accessories, such as graphic level recorders and tape recorders, can also be operated from the sound-level-meter output.

This sound-level meter can also be used as a portable amplifier, attenuator, and voltmeter for laboratory measurements in the audio-frequency range.

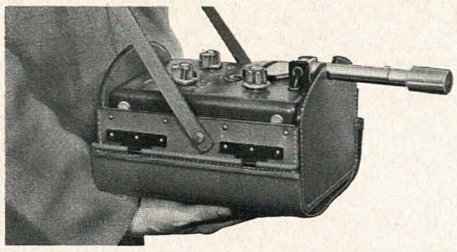
Its many applications are described in detail in the *Handbook of Noise Measurement*, a copy of which is available to each user.

DESCRIPTION: The TYPE 1551-C Sound-Level Meter consists of an omnidirectional microphone, a calibrated attenuator, an amplifier, standard weighting networks, and an indicating meter. The complete instrument, including batteries, is mounted in an aluminum case. The microphone can be used in several positions and, when not in use, folds down into a storage position, automatically disconnecting batteries. An ac power-supply unit is available.

SPECIFICATIONS

Sound-Level Range: From 24 to 150 dB (re 0.0002 μbar).

Frequency Characteristics: Four response characteristics, A, B, C, or 20-kc, as selected by a panel switch. The A-, B-, and C-weight-



(Left) Microphone in the storage position (batteries automatically disconnected). *(Center)* The sound-level meter operated in its leather carrying case, microphone in the horizontal operating position. *(Right)* The sound-level meter ac-operated with the Type 1262-B Power Supply, which plugs directly into the base of the sound-level meter.

ing positions are in accordance with ASA S1.4–1961 and IEC Publication 123, 1961. Frequency response for the 20-kc position is flat from 20 c/s to 20 kc/s, so that complete use can be made of very wide-band microphones such as the TYPE 1551-P1 Condenser Microphone Systems.

Microphone: Highly stable ceramic type. Accessory condenser microphone is available. (See page 19.)

Sound-Level Indication: Sound level is indicated by the sum of the meter and attenuator readings. The clearly marked, open-scale meter covers a span of 16 dB with calibration from −6 to +10 dB. The attenuator is calibrated in 10-dB steps from 30 to 140 dB above 0.0002 μbar.

Output: 1.4 V behind 7000 Ω (panel meter at full scale). The output can be used to drive analyzers, recorders, oscilloscopes, and headphones. Harmonic distortion (panel meter at full scale) less than 1%.

Input Impedance: 25 MΩ in parallel with 50 pF.

Meter: Rms response, and fast and slow meter speeds in accordance with ASA S1.4–1961 and IEC R123, 1961.

Calibration: Built-in calibration circuit standardizes the sensitivity of the electrical circuits within ±1 dB at 400 c/s, as specified in ASA standards. The TYPE 1552-B Sound-Level Calibrator (page 21) is available for making periodic acoustical checks on the over-all calibration, including microphone. Microphone can be accurately calibrated with the TYPE 1559-B Microphone Reciprocity Calibrator (page 22), which can also be used for over-all acoustical checks.

Environmental Effects:

Temperature and Humidity: Microphone is not damaged at temperatures from −30 to +95°C and relative humidities from 0 to 100% When standardized by its internal calibration system or a TYPE 1552-B Sound Level Calibrator, the instrument will operate within catalog specifications (for panel-meter indications above 0 dB) over the temperature range of 0 to 60°C and the relative humidity range of 0 to 90%.

Magnetic Fields: When exposed to a 60-cycle, 1-oersted (80 A/m) field, the sound-level meter will indicate 60 dB (C weighting) when oriented for maximum sensitivity to the magnetic field.

Electrostatic Fields: Aluminum case provides sufficient shielding, so that normally encountered electrostatic fields have no effect.

Vibration: Case is fitted with soft rubber feet and amplifier is resiliently mounted for vibration isolation. When the instrument is set on its feet on a shake table and vibrated at 10 mils p-to-p displacement over the frequency range of 10 c/s to 55 c/s, the unwanted signals generated do not exceed an equivalent C-weighted sound-pressure level of 45 dB when motion is vertical, 60 dB when motion is lengthwise, or 40 dB when motion is sidewise.

Power Supply: Two 1½-V size D flashlight cells and one 67½-V battery (Burgess XX45 or equivalent) are supplied. An ac power supply, the TYPE 1262-B, is available.

Accessories Supplied: Telephone plug.

Accessories Available: TYPE 1551-P2 Leather Case (permits operation of the instrument without removal from the case). TYPE 1560-P95 Adaptor Cable, for connecting output to TYPE 1521-B Graphic Level Recorder. For other accessories, including analyzers, see pages 17 to 34.

Mechanical Data: Aluminum cabinet, finished in gray crackle.

Width		*Height*		*Depth*		*Net Weight**		*Shipping Weight**	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
7¼	185	9¼	235	6⅛	160	7¾	3.6	16	7.5

* With batteries (add 2 pounds for leather case).

For a more detailed description, see *General Radio Experimenter*, August 1961.

Catalog Number	*Description*	*Price*
1551-9703	**Type 1551-C Sound-Level Meter**	**$450.00**
8410-9499	**Set of Replacement Batteries**	**4.25**
1551-9602	**Type 1551-P2 Leather Carrying Case**	**25.00**
1560-9695	**Type 1560-P95 Adaptor Cable**	**3.00**

PATENT NOTICE. See Note 12, page 11.

MILITARY SPECIFICATIONS: We can supply Type 1551-C Sound-Level Meters to meet the specifications of MIL-STD-740. Price and details on request.

Type 1262-B POWER SUPPLY

Attaches to the TYPE 1551-C Sound-Level Meter for AC-Line Operation

Catalog No.	*Volts*	*Input c/s*	*Watts*	*Dimensions*	*Weight Net*	*Weight Shipping*	*Price*
1262-9702	105-125 or 210-250	50-400	2	5, 7¼, 3⅛ in (130, 185, 80 mm)	2½ lb (1.2 kg)	8 lb (3.7 kg)	**$95.00**

Type 1565-A SOUND-LEVEL METER

FEATURES:

Meets requirements of ASA S1.4-1961, IEC Publication 123, 1961.
Pocket sized and light weight — 1¾ pounds. ■ Powered by single 1.5-volt C cell.
Uses rugged and stable lead-zirconate-titanate ceramic microphone.
Rms response in accordance with ASA S1.4-1961.
Use of only solid-state elements virtually eliminates microphonics.

USES: Although not so versatile in application as the TYPE 1551, this instrument is a standard sound-level meter capable of accurate noise measurements, in conformity with national and international standards. It is particularly useful for rapid surveys, for periodic checks on noisy environments, and for production testing of manufactured products.

DESCRIPTION: The TYPE 1565-A Sound-Level Meter is a pocket-sized, light-weight instrument that can be held and operated with one hand. It includes most of the features usually found only in larger, more expensive instruments. It consists of an omnidirectional microphone, which drives a cascade of amplifier stages and a panel-control attenuator. Standard frequency weighting is introduced along the amplifier chain, which ultimately drives a panel meter and output jack. The microphone can be replaced with an adaptor for connection to sources fitted with a 3-terminal male microphone connector.

SPECIFICATIONS

Sound-Level Range: 44 to 140 dB (re 0.0002 μbar).

Weighting: A, B, and C weighting in accordance with American Standard ASA S1.4-1961 and IEC Publication 123, 1961.

Microphone: Lead-zirconate-titanate ceramic unit.

Output: At least 1.5 V behind 20 kΩ when meter reads full scale. Output is intended primarily for driving a TYPE 1556-B Impact-Noise Analyzer, a graphic level recorder, or headphones. Harmonic distortion, 2% or less for frequencies above 200 c/s and 5% or less for frequencies below 200 c/s (panel meter at full scale).

Meter: Rms response, and fast and slow meter speeds, in accordance with ASA S1.4-1961 and IEC Publication 123, 1961.

Auxiliary Input Provision: A TYPE 1560-P96 Adaptor is available to allow connection to any source fitted with a male 3-terminal microphone connector. Input impedance is approximately 13 MΩ in parallel with 25 pF. For correct weighting, source impedance must be 380 pF ± 5%.

Calibration: Sound-level meter can be pressure calibrated at 400 c/s with a TYPE 1552-B Sound-Level Calibrator or at any frequency in the range from 20 to 2000 c/s with a TYPE 1559-B Microphone Reciprocity Calibrator.

Operating Temperature Range: 0 to 50°C.

Storage Temperature Range: −20° to +70°C (battery removed).

Operating Humidity Range: 0 to 90% R.H.

Temperature Coefficient of Sensitivity: Approximately +0.03 dB/°C.

Effect of Magnetic Field: Equivalent C-weighted sound level of a 1-oersted (80 A/m) 60-cycle field is about 47 dB when meter is oriented for maximum indication.

Power Supply: One 1½-V size C flashlight cell. Battery life approximately 35 hours for 2 h/day service.

Accessories Available: TYPE 1565-P1 Leather Carrying Case, TYPE 1560-P96 Adaptor to adapt input to mate with 3-terminal male microphone connector necessary for connection to vibration pickup, page 20. TYPE 1560-P95 Adaptor Cable to connect output to TYPE 1521-B Graphic Level Recorder or other devices fitted with jack-top binding posts on ¾-in centers.

Mechanical Data:

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
3 1/16	78	7 3/8	190	2 1/8	54	1 3/4	0.8	5	2.3

See also *General Radio Experimenter*, October-November 1964.

Catalog Number	*Description*	*Price*
1565-9701	**Type 1565-A Sound-Level Meter**	**$240.00**
1565-9601	**Type 1565-P1 Leather Carrying Case**	**15.00**
1560-9695	**Type 1560-P95 Adaptor Cable**	**3.00**
1560-9696	**Type 1560-P96 Adaptor** to 3-terminal male microphone connector	**11.00**
8410-9899	**Replacement Battery**	**.20**

NEW
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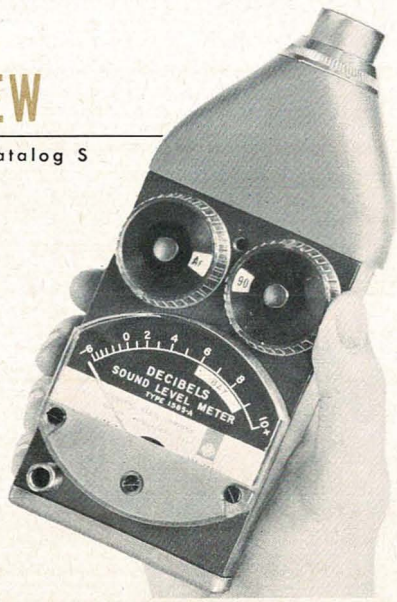
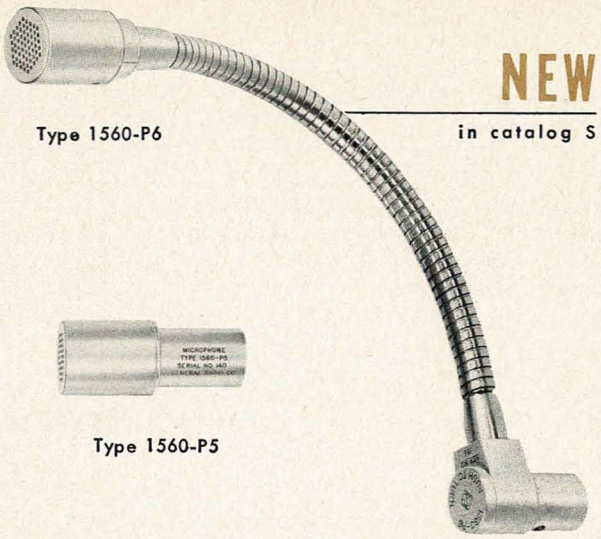


Sound-Level Meter in leather carrying case.

Type 1560-P5 and Type 1560-P6 MICROPHONES

These microphones, which are manufactured by General Radio, are piezoelectric ceramic units, whose characteristics closely approach those of condenser microphones used as laboratory standards. They require no polarizing voltage, however, and their impedance is lower by an order of magnitude. Thus, leakage due to high humidity is less of a problem than with the condenser type, and the microphone can be more readily used at the end of a cable. Its stable capacitance makes the cable correction relatively independent of temperature. The TYPE 1560-P5 and the TYPE 1560-P6 Microphones use the same cartridge. The TYPE 1560-P5 consists of the cartridge mounted directly on a 3-terminal microphone connector as used in the TYPE 1551-C Sound-Level Meter. In the TYPE 1560-P6 the cartridge is attached to a short length of flexible conduit, which in turn mounts on a swivel base, and is used with the TYPE 1558 and TYPE 1564 Analyzers. The microphone cartridge is the same diameter as the Western Electric 640AA laboratory standard microphone.



NEW in catalog S

Type 1560-P6

Type 1560-P5

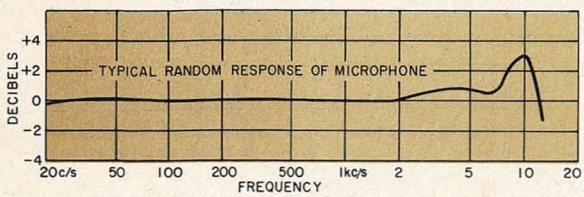
SPECIFICATIONS

Frequency Response: Typical response is shown in the accompanying plot. Deviations of individual units from the typical response are approximately ±0.3 dB from 20 to 1000 c/s and ±1 dB up to about 7000 c/s.

Sensitivity: −60 dB re 1 V/μbar nominal.

Temperature Coefficient of Sensitivity: Approximately −0.01 dB/°C.

Internal Impedance: Capacitive; TYPE 1560-P5, 390 pF at 25°C, nominal; TYPE 1560-P6, 425 pF at 25°C, nominal. Temperature coefficient of capacitance: 2.2 pF/°C over range of 0 to 50°C.



Environmental Effects: Microphone is not damaged by temperatures from −30 to +95°C and relative humidities of 0 to 100%.

Terminals: Microphones fit 3-terminal microphone cable connector. For hum reduction both microphone terminals may be floated with respect to ground.

Cartridge Dimensions: Diameter 0.936 ± 0.002 in (23.7 mm), length 1⅛ in (29 mm).

Net Weight: TYPE 1560-P5, 2 oz (60 g); TYPE 1560-P6, 8 oz (0.3 kg).

Shipping Weight: TYPE 1560-P5, 1 lb (0.5 kg); TYPE 1560-P6, 3 lb (1.4 kg).

Catalog No.	*Description*	*Price*
1560-9605	**Type 1560-P5 Microphone**	**$60.00**
1560-9606	**Type 1560-P6 Microphone Assembly**	**75.00**

Type 1560-P40 PREAMPLIFIER

FEATURES:

High input impedance; low output impedance.
Low electrical noise level. ■ Voltage gain of 1 or 10.
Compact. ■ Adaptable to many uses.
Microphone cartridge attaches directly.

USES: The TYPE 1560-P40 Preamplifier is a high-input impedance, low-noise preamplifier. It is particularly well suited for amplifying the output of piezoelectric transducers, such as microphones and vibration pickups, and for driving long connecting cables without loss in signal voltage. It is also a useful probe amplifier for other electrical signals where its high input impedance and low noise are necessary. For example, it can increase the sensitivity and input impedance of the TYPES 1900, 1564, and 1558 Analyzers, the TYPE 1521 Graphic Level Recorder, the TYPE 1142 Frequency Meter, the TYPES 1150 and 1151 Digital Frequency Meters, the TYPES 1232, 1206, and 1233 Amplifiers, the TYPE 1806 Electronic Voltmeter, and low-frequency oscilloscopes.

DESCRIPTION: The TYPE 1560-P40 is a three-stage negative-feedback amplifier that makes full use of the low-noise and high-input-impedance characteristics of a unipolar transistor (FET). The feedback can be switched by the user to obtain a voltage gain of either 1:1 or 10:1. The amplifier is housed in a small cylindrical case. The GR TYPE 1560-P5 Microphone cartridge plugs directly on to the input end of the case. Adaptors are available for connecting the preamplifier to the cartridge of the GR TYPE 1560-P3 Microphone, to GR874 Connectors,

and to 3-terminal microphone connectors. Output from the preamplifier is through a 3-terminal shielded connector. The required dc supply voltage is applied from one of these terminals to ground. This voltage can be obtained directly from the TYPES 1558 and 1564 Analyzers or the rechargeable-battery power supply listed under TYPE 1560-P40H, below.

The preamplifier and accessories are available in various combinations.

The TYPE 1560-P40H Preamplifier and Power Supply Set is self-powered and independent of any external supply so that it can be used with the TYPE 1900-A Wave Analyzer as well as with all the other instruments mentioned above (see USES).

The TYPE 1560-P40J Preamplifier and Adaptor Set is dependent for its power on the instrument to which it is connected, so that it should be used with the TYPES 1558 and 1564 Analyzers. If the connector from the source is not one of those for which an adaptor is supplied, the GR874 Adaptors listed on page 81 can be used with the TYPE 1560-P98 Adaptor to mate with almost all standard coaxial connectors.

The TYPE 1560-P40K Preamplifier and Microphone Set is for use with the TYPES 1558 and 1564 Analyzers when an acoustical measurement is needed at low levels and the microphone must be mounted at the end of a cable.

SPECIFICATIONS

Gain: 1:1 or 10:1 (20 dB) ± 0.3 dB.
Input Capacitance: 6 pF.
Input Resistance: >500 MΩ at low audio frequencies.
Output Resistance: 1:1 gain — approx 5 Ω.
10:1 gain — approx 100 Ω.
Noise: ≤2.5 μV equivalent input voltage (400-pF source impedance, C-weighted, 8-kc effective bandwidth).
Frequency Response: ±0.3 dB from 5 c/s to 500 kc/s.
Harmonic Distortion at Audio Frequencies:
Open circuit, at 1 V, peak-to-peak: <0.25%.
Capacitor load of 0.01 μF (equivalent to a cable over 200-ft long): Maximum output (peak-to-peak) at 1% distortion is 5 V for 1 kc/s, 2 V for 10 kc/s.
Accessories Available (in combinations listed below): Power supply, includes two 9.6-volt nickel-cadmium rechargeable batteries, a charging circuit, a battery-check light, and a power cord.

TYPES 1560-P96, 1560-P97, and 1560-P98 Adaptors for converting the input pin connections to 3-terminal shielded microphone connectors, to the pin sockets necessary for the cartridge of a TYPE 1560-P3 Microphone, and to a General Radio TYPE 874 Connector, respectively.

TYPES 1560-P72 (25-ft) and 1560-P72C (4-ft) cables for supplying power to and transferring the signal from the preamplifier.

TYPE 1560-P95 Adaptor Cable for connecting the signal from the power supply through a cable to a TYPE 274 Double Plug.

TYPE 1560-P99 Adaptor Cable for connection from phone plug to microphone plug.

Power Supply: 15 V to 25 V, 1 mA to 2 mA, dc.
Dimensions: length 6⅞, diameter 1.155 by 1 in (175, 30, 26 mm).
Net Weight: 9 oz (0.3 kg).
Shipping Weight: 3 lb (1.4 kg).

TYPE 1560-P40H
PREAMPLIFIER AND POWER SUPPLY SET
Consists of:
Type 1560-P40 Preamplifier
Type 1560-P96 Adaptor
Type 1560-P98 Adaptor
Type 1560-P95 Adaptor Cable
Type 1560-P99 Adaptor Cable
Type 1560-P72C Cable (4 ft)
Type 874-Q2 Adaptor
Power Supply
Shipping Weight: 10 lb (4.6 kg).

TYPE 1560-P40J
PREAMPLIFIER AND ADAPTOR SET
Consists of:
Type 1560-P40 Preamplifier
Type 1560-P96 Adaptor
Type 1560-P97 Adaptor
Type 1560-P98 Adaptor
Type 1560-P72C Cable (4 ft)
Shipping Weight: 4 lb (1.9 kg).

TYPE 1560-P40K
PREAMPLIFIER AND MICROPHONE SET
Consists of:
Type 1560-P40 Preamplifier
Type 1560-P72C Cable (4 ft)
Type 1560-P72 Cable (25 ft)
Type 1560-P32 Tripod
Microphone Cartridge
Shipping Weight: 14 lb (6.5 kg).

Catalog Number	*Description*	*Price*
1560-9640	**Type 1560-P40 Preamplifier**	**$140.00**
1560-9500	**Type 1560-P40H Preamplifier and Power Supply Set**	**310.00**
1560-9510	**Type 1560-P40J Preamplifier and Adaptor Set**	**184.00**
1560-9520	**Type 1560-P40K Preamplifier and Microphone Set**	**251.00**

NEW
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Type 1560-P40


Microphone Cartridge


Adaptor to 3-terminal Microphone Connector


Adaptor to GR874 Connector

Type 1551-P1 CONDENSER MICROPHONE SYSTEM

USES: The TYPES 1551-P1L (for normal-level measurement) and 1551-P1H (for high-level measurement) Condenser Microphone Systems are designed for use with the TYPE 1551-C Sound-Level Meter for measuring sound levels over wide frequency ranges. These microphones are not damaged by high sound levels or by high temperatures.

Applications include:

Measurement of high-frequency and high-level noises produced by such noise sources as air streams, woodworking and metalworking machinery, turbines, and jet engines.

General-purpose sound-level measurements where ambient temperature and sound level are high.

Measurements on high-fidelity sound systems over the full audio spectrum.

DESCRIPTION: The TYPE 1551-P1L Condenser Microphone System uses an Altec 21-BR-150 microphone and measures sound-pressure levels up to 155 dB; the TYPE 1551-P1H, which uses a 21-BR-180 microphone, measures levels up to 170 dB.

The microphone base houses a subminiature preamplifier tube. A battery-operated power supply provides power and polarizing voltage. An extension cable, a tripod, and a leather carrying case are supplied.

SPECIFICATIONS

Frequency Response: 20 c/s to 18 kc/s with either microphone. Typical response curves are shown at right.

Calibration: Output level vs frequency is measured in our laboratory by comparison with a standard microphone. The measured level at 400 c/s and a calibration curve are supplied.

Output Impedance: 6500 Ω (typical).

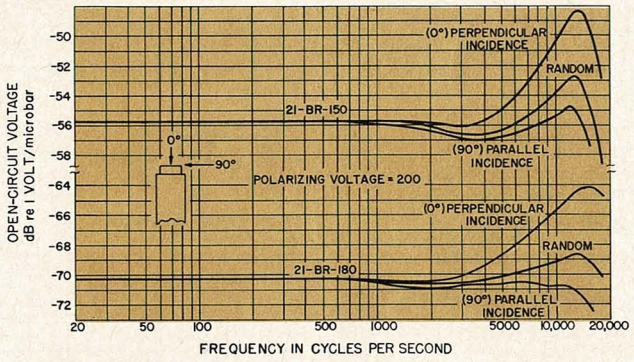
Direct Use with Analyzers: These assemblies can supply a signal directly to either the TYPE 1558 Octave-Band Noise Analyzer or the TYPE 1564-A Sound and Vibration Analyzer, provided that the levels of the measured components are above the following indicated values:

	1551-P1H	*1551-P1L*
TYPE 1558-A, -AK	65 dB	50 dB
TYPE 1564-A	65 dB	50 dB

A TYPE 1552-B Sound-Level Calibrator is necessary for absolute level calibration.

Maximum Sound-Pressure Level:

Frequency	Up to 1.5 kc/s		At 15 kc/s	
Distortion	<1%	<10%	<1%	<10%
Type 1551-P1L	135 dB	155 dB	125 dB	135 dB
Type 1551-P1H	150 dB	170 dB	140 dB	150 dB



Typical response vs frequency.

Minimum Measurable Sound-Pressure Level:
TYPE 1551-P1L—50 dB (re 0.0002 μbar)
TYPE 1551-P1H—65 dB (re 0.0002 μbar)
} with 10 dB signal-to-noise ratio

Temperature and Humidity: Maximum recommended operating temperature of the microphone in its probe is 100°C. Microphone is not damaged by exposure to high humidity, but prolonged exposure may render it temporarily inoperative.

Batteries: One 1½-V size D flashlight cell and one 300-V B battery (Eveready 493, Burgess V-200 or equivalent) are supplied. Batteries should last at least 150 hours under normal use.

Mounting: The microphone on its base plugs into one end of a 10-ft cable and will slip into a receptacle on the tripod. The other end of the cable is connected to the power-supply unit, which fastens to one end of the sound-level meter.

Components and Accessories Supplied: Microphone base assembly, cable assembly, power supply, microphone, microphone cap, carrying case, and tripod.

Dimensions: Leather carrying case is approximately 7 by 5½ by 8½ in (180, 140, 220 mm).

Net Weight: Complete in carrying case, 7¼ lb (3.3 kg).

Shipping Weight: 15 lb (7 kg).

Catalog No.	*Description*	*Price*
1551-9866	**Type 1551-P1L Condenser Microphone System (Normal Level)**	**$475.00**
1551-9865	**Type 1551-P1H Condenser Microphone System (High Level)**	**475.00**
8410-9599	**Set of Replacement Batteries**	**12.15**

STANDARD ACCESSORIES FOR THE SOUND-LEVEL METERS

TRIPOD AND EXTENSION CABLE

A 25-foot extension cable (TYPE 1560-P73) and tripod (TYPE 1560-P32) for mounting the microphone of the TYPE 1551-C Sound-Level Meter are available as the TYPE 1560-P34 Tripod and Extension Cable. A 100-foot cable is also available.

Net Weight: 5½ lb (2.5 kg).
Shipping Weight: 8 lb (3.7 kg).

Catalog Number	*Description*	*Price*
1560-9634	**Type 1560-P34 Tripod and Extension Cable**	**$45.00**
1560-9982	**Type 1560-P73B 100-ft Extension Cable, only**	**29.00**

VIBRATION PICKUP SYSTEMS

For the measurement of solid-borne vibrations with the sound-level meter a vibration pickup is used in place of the microphone.

Each of these Vibration Pickup Systems consists of a vibration pickup, a control box, and a connection cable. The vibration pickup is an inertia-operated, ceramic device, which generates a voltage proportional to the acceleration of the vibrating body. By means of integrating networks in the control box, voltages proportional to velocity and displacement can also be delivered to the sound-level meter. The desired response is selected by means of a three-position switch on the control box. Conversion data are supplied for translating the decibel indications of the sound-level meter into the vibration parameters of displacement, velocity, and acceleration.

Three models are offered, differing in frequency range, sensitivity, and price.

Type 1560-P11B

This system uses a lead-zirconate-titanate pickup, identical with that used on the TYPE 1553-A Vibration Meter (page 24). Probe and probe tips are provided. A permanent-magnet mount is also available (see page 24).

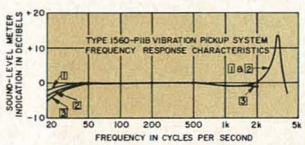
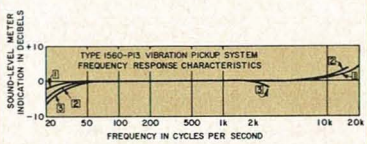
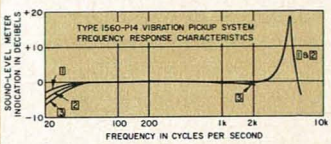
Type 1560-P13

For measurements at higher frequencies than the -P11B system affords, the -P13 combination is recommended, consisting of the TYPE 1560-P53 Vibration Pickup and the TYPE 1560-P23 Control Box. A small holding magnet is included.

This system with the TYPE 1551-C or -B Sound-Level Meter provides the flat frequency response and low-noise operation required by MIL-STD-740 (SHIPS) for vibration measurement. (The holding magnet is not used for measurements according to that standard.)

Type 1560-P14

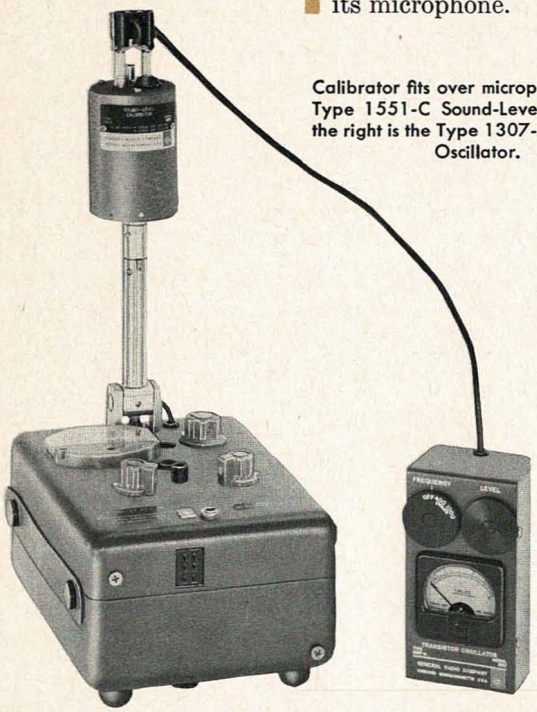
The vibration pickup used in this system has approximately 8 times the sensitivity and 10 times the impedance of the TYPE 1560-P52.

	Type 1560-P11B Vibration Pickup System	**Type 1560-P13 Vibration Pickup System**	**Type 1560-P14 Vibration Pickup System**
Ranges of Measurement			
Rms Acceleration (in/s²)	0.1 to 39,000 (100 g)†	0.3 to 390,000 (1000 g)†	0.01 to 3900 (10 g)†
Rms Velocity (in/s)	0.001 to *	0.001 to 1000	0.0001 to *
Rms Displacement (in)	0.00003 to *	0.00003 to 30	0.000003 to *
Frequency Range Response characteristics for constant applied (1) acceleration, (2) velocity, and (3) displacement.			
Net Weight of System (lb)	1¾ (0.8 kg)	1¾ (0.8 kg)	2 (1 kg)
Shipping Weight (lb)	5 (2.3 kg)	5 (2.3 kg)	5 (2.3 kg)
Catalog Number	1560-9922	1560-9613	1560-9614
Price: Vibration Pickup System	**$160.00**	**$290.00**	**$220.00**
	Pickup Characteristics		
Pickup Type Number	Type 1560-P52	Type 1560-P53	Type 1560-P54
Sensitivity (mV/g), nominal	75	72	580
Temp Coeff of Sens (dB/°C)	0.06	<0.02	0.01
Resonant Frequency (c/s)	3200	35,000	5000
Capacitance (pF)	10,000	350	700
Temperature Range (°C)	0 to 75	−18 to 120	−18 to 120
Relative Humidity Range (%)	0 to 100	0 to 100	0 to 100
Cable Length (ft)	5 (1.55 m)	8 (2.5 m)	8 (2.5 m)
Dimensions (in)	1⅝ by 1 7/16 by 9/16	⅝ hex by 0.7	1 3/16 dia by 1 1/16
(mm)	42 by 37 by 15	15.5 by 18	31 by 27
Net Weight (oz)	1.6 (45 grams)	1.1 (31 grams)	3.1 (90 grams)
Catalog Number	1560-9652	1560-9653	1560-9654
Price: Pickup Only	**$100.00**	**$220.00**	**$160.00**

* Upper limit of displacement and velocity measurements depends upon frequency and is determined by the maximum acceleration possible before nonlinearity occurs (100 g for Type 1560-P11B, 10 g for Type 1560-P14).
† g = acceleration of gravity.

Type 1552-B SOUND-LEVEL CALIBRATOR

USES: The TYPE 1552-B Sound-Level Calibrator supplies an acoustic signal of known sound-pressure level for checking the over-all performance of a sound-level meter, including its microphone.



Calibrator fits over microphone of the Type 1551-C Sound-Level Meter. At the right is the Type 1307-A Transistor Oscillator.

It can be used to calibrate not only the TYPES 1551-C and 1565-A Sound-Level Meters but also the TYPE 1558 Octave-Band Noise Analyzers and TYPE 1564-A Sound and Vibration Analyzer when they are used directly with the microphones listed in the specifications, below. The calibrator can also be used to supply an acoustic reference level for audio systems.

The TYPE 1307-A Transistor Oscillator serves as both power source and level indicator when used with the sound-level calibrator.

DESCRIPTION: A small, stable loudspeaker is mounted in one end of a cylindrical enclosure. The other end of the enclosure fits over the microphone. Acoustic coupling between the speaker and microphone is fixed by chamber and microphone dimensions. The calibrator provides acoustic shielding and a high test level to reduce effects of ambient noise during calibration. Calibration checks under these conditions are accurate and readily repeatable.

FEATURES:

- Accurate — ±1 dB at 400 c/s. Long-term stability and low temperature coefficient.
- Easily portable — calibrator and battery-powered TYPE 1307-A Oscillator together weigh under 3 pounds.

SPECIFICATIONS

Accuracy of Calibration: ±1 dB at 400 c/s.

Microphones: The calibrator can be used on the following microphones and instruments without the need of special adaptors:

Current Types	*Discontinued Types*
GR 1560-P5, -P6 Microphones	GR 1560-P3, -P4 Microphones
GR 1551-P1H, -P1L Condenser Microphone Systems	GR 1555-A Sound-Survey Meter
GR 1565-A Sound-Level Meter	Shure Brothers 98B99 (GR 1551-B Sound-Level Meter)
Western Electric 640AA	Shure Brothers 9898 (GR 759-B and 1551-A Sound-Level Meters)
Kellogg Microphone	

Terminals: Input terminals are TYPE 938 Binding Posts, spaced ¾ in to fit TYPE 274-MB Double Plug.

Accessory Required: A 400-cycle source, with output control and voltmeter. The TYPE 1307-A Transistor Oscillator is recommended (see below).

Accessory Available: TYPE 1560-P31 Leather Carrying Case, for both calibrator and TYPE 1307-A Oscillator.

Dimensions: Length 4½, dia 2½ in (115, 64 mm), over-all.

Net Weight: 14 oz (0.4 kg).

Shipping Weight: 3 lb (1.4 kg).

Type 1307-A TRANSISTOR OSCILLATOR

Recommended as a power source for the sound-level calibrator, this oscillator is a convenient 400- and 1000-cycle source for general testing at audio frequencies. Output voltage is indicated by a voltmeter, and a fingertip output control facilitates setting the output level.

SPECIFICATIONS

Frequency: 400 and 1000 c/s.

Frequency Accuracy: ±3% at 2 V output into 600-Ω resistive load.

Output: Adjustable to a maximum of at least 2 V into a 600-Ω load.

Distortion: Less than 5% at 400 c/s and less than 6% at 1000 c/s with 2 V across a resistive 600-Ω load.

Voltmeter: Calibrated in volts, with 3 V full scale.

Output Circuit: Output cable (20 in) terminated in TYPE 274-MB Double Plug.

Batteries: Three mercury A batteries (Mallory RM-1 or equivalent) are supplied. Battery life is about 100 h for 8 h use per day.

Carrying Case: Leather case with a strap is available for holding both oscillator and sound-level calibrator.

Mechanical Data: Aluminum panel and case

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
3⅛	80	6	155	2½	64	1¾	0.8	3	1.4

Catalog Number	*Description*	*Price*
1552-9702	**Type 1552-B Sound-Level Calibrator**	**$ 52.50**
1307-9701	**Type 1307-A* Transistor Oscillator**	**115.00**
1560-9631	**Type 1560-P31 Leather Carrying Case,** for both calibrator and oscillator	**15.00**

See also the Type 1559-B Microphone Reciprocity Calibrator, described on page 22.

* PATENT NOTICE. See Note 1, page 11.

Type 1559-B MICROPHONE RECIPROCITY CALIBRATOR

FEATURES:

Rapid and simple operation. ■ High accuracy.
Direct readout — answers available with no calculations.
Useful for daily verification of calibrations.
Portable or relay-rack mounting.
Traceable to NBS by direct calibration of WE 640AA-type microphones.

USES: This unique instrument is a primary calibrator for microphones*, a precision acoustical source, and a sound-level calibrator. It employs the closed-coupler (cylindrical cavity) reciprocity calibration procedure, the recognized method of performing the absolute calibration of laboratory standard microphones. Without calculations, one can rapidly determine the sensitivity of a microphone in dB re 1 volt/microbar.

As a sound-level calibrator of constant acoustic output, it covers a wide frequency range for rapid check on microphones and sound-level meters or for setting the reference levels in analyzing systems.

DESCRIPTION: This instrument provides the circuit and the structure required for closed-coupler reciprocity calibrations of microphones. An audio oscillator and a detector are also needed.

Basic Principles

In addition to the transducer to be calibrated, the reciprocity technique requires two other transducers, one of which is reciprocal, and an acoustic cavity. One transducer is used as a sound source, which excites the remaining two transducers (microphones) with a sound pressure. The ratio of the open-circuit voltages of the two microphones equals the ratio of the microphone sensitivities. If the two microphones are then coupled together by a known acoustic impedance (the cavity) and the reciprocal microphone is driven as a sound source, the ratio of the open-circuit voltage of the second microphone to the driving current of the first microphone can be related to the product of the microphone sensitivities. The two relationships, one for the *ratio* of microphone sensitivities and one for the *product* of microphone sensitivities, can then be solved for the sensitivity of either microphone. The acoustic impedance of the cavity is the independent calculable quantity in terms of which microphone sensitivity is established.

The uniqueness of the TYPE 1559-B Microphone Reciprocity Calibrator rests on the following design features:

(1) The transducer used to determine the ratio of sensitivities is a piezoelectric ring, which makes up the cavity wall, thereby eliminating the need for interchanging the location of microphones during the measurement.

(2) A switch is used to connect the circuits for the required operations without the need for physically interchanging the transducers.

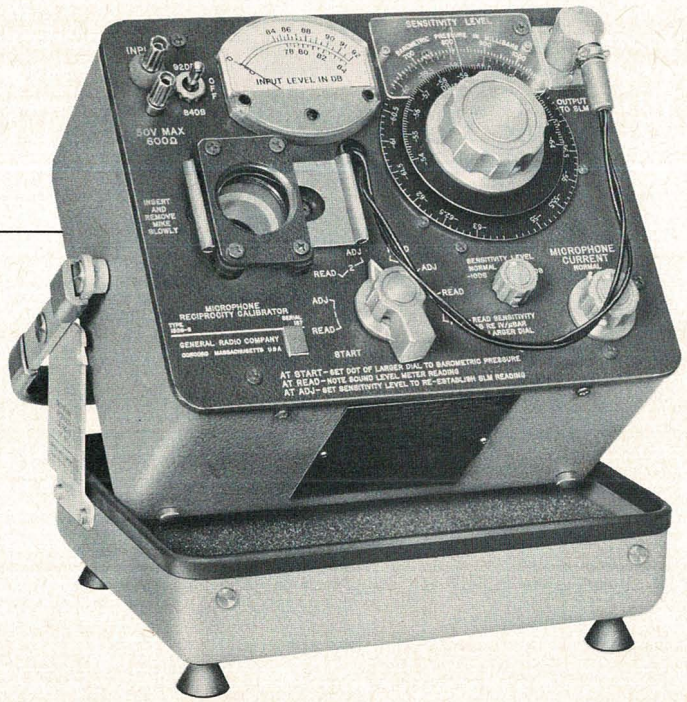
(3) A standard capacitor is used to measure the driving current of the reciprocal transducer.

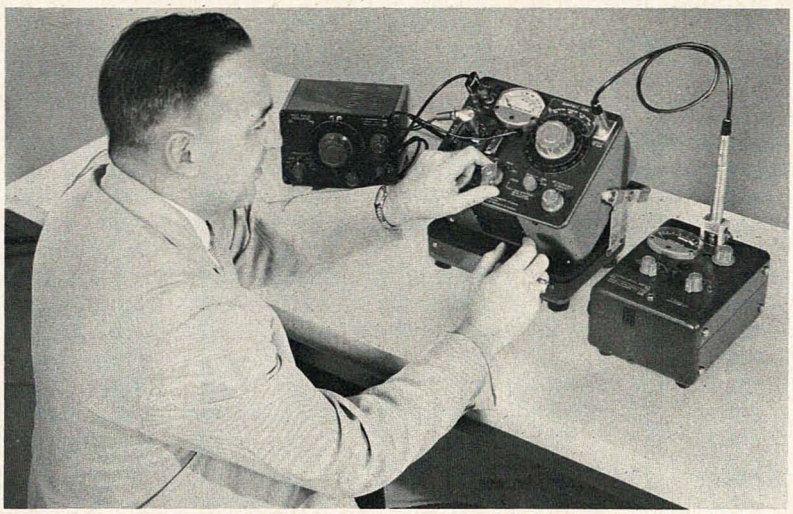
(4) The necessary calculations are performed by a simple dial-type analog computer coupled to the switch.

The piezoelectric cylinder used in the reciprocity calibration also serves as a stable acoustical source for the sound-level-calibrator applications of the instrument. The sound-pressure level produced is indicated on a meter, which is actuated by the signal applied to the piezoelectric cylinder.

* General Radio TYPES 1560-P3, 1560-P4, 1560-P5, 1560-P6, Western Electric 640AA or equivalent, and (with special adaptor) GR TYPE 1551-P1L.

NEW MODEL
in catalog S





The microphone reciprocity calibrator as set up for calibrating a GR Type 1560-P5 Microphone. The power source is a Type 1310-A Oscillator and the detector a Type 1551-C Sound-Level Meter.

SPECIFICATIONS

MICROPHONE CALIBRATOR

Range: Direct reading for microphone sensitivities between −35 dB and −75 dB re 1 V/μbar.

Accuracy:

Microphone Type	*Accuracy*	*Frequency Range*
GR 1560-P5, -P6 and WE 640AA	±0.2 dB ± 0.1 dBf_{kc}	20 c/s to 2.5 kc/s
	±0.7 dB	2.5 to 6 kc/s*
GR 1560-P3, -P4	±0.2 dB ± 0.1 dBf_{kc}	20 c/s to 2.5 kc/s
	±0.7 dB	2.5 to 7 kc/s*
GR 1551-P1L†	±0.2 dB ± 0.1 dBf_{kc}	20 c/s to 2.5 kc/s
	±0.7 dB	2.5 to 5 kc/s

* To 8 kc/s with corrections. † Requires special adaptor.

PRECISION ACOUSTICAL SOURCE

Frequency Range: 20 c/s to 7 kc/s.

Output: 92 dB re 0.0002 μbar for excitation of 50 V.

Accuracy: At 92 dB, ±0.1 dB + error in determining microphone sensitivity.

SOUND-LEVEL CALIBRATOR

Frequency Range: 20 c/s to 2.5 kc/s.

Output: 92 dB re 0.0002 μbar for excitation of 50 V.

Accuracy: ±0.7 dB at standard atmospheric pressure.

GENERAL

Maximum Safe Input Voltage: 50 V behind 600 Ω.

Accessories Required: Generator and detector. Generator to supply 5 V or more into a 2000-pF load, and 2.5 V or more into a 600-Ω load. Lower voltage can be used, with a resultant lowering of signal-to-ambient-noise ratio. The TYPE 1304-B Beat-Frequency Audio Generator, the TYPE 1210-C Unit R-C Oscillator, and the TYPE 1310-A Audio Oscillator are recommended. The TYPE 1551-B or -C Sound-Level Meter is recommended for the detector.

Accessories Supplied: TYPE 274-NP Patch Cord and an extension cable for connection to generator and detector; and adaptors for reciprocity and comparison calibration of the TYPE 1560-P5, TYPE 1560-P6, and Western Electric 640AA or equivalent microphones.

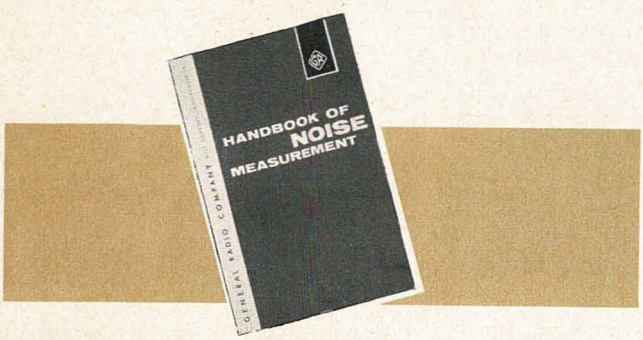
MECHANICAL DATA Flip-Tilt Case (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Portable	10	255	8	205	7½	190	13	6	16	7.5
Rack	19	485	10½	270	5*	130	14	6.5	25	11.5

* Behind panel.

Catalog Number	*Description*	*Price*
1559-9702	**Type 1559-B Microphone Reciprocity Calibrator,** Portable Model	**$525.00**
1559-9842	**Type 1559-B Microphone Reciprocity Calibrator,** Rack Model	**525.00**

PATENT NOTICE. See Notes 15 and 22, page 11.



HANDBOOK

The *Handbook of Noise Measurement*, published by General Radio Company, covers thoroughly the subject of noise and vibration measurement. Authors are Dr. A. P. G. Peterson and Ervin E. Gross, Jr., of the General Radio Engineering Staff. Copies of this handbook are available from General Radio at a price of $1.00 each, postpaid, in the United States and Canada.

Type 1553 VIBRATION METER

USES: Vibrations in machines and structures can be measured quickly and easily with this instrument. For the manufacturer of machinery and equipment, the TYPE 1553 Vibration Meter is extremely useful in research, design, and production testing.

Maintenance engineers will find it useful for checking the operating condition of bearings, gear trains, and other mechanisms. Excessive vibrations due to improper adjustment or to structural resonances can be located and measured.

Its excellent low-frequency response permits the study of the operation of belt drives and of the effectiveness of mountings designed to reduce vibrations in adjacent structures.

A frequency analysis of the measured vibration can be made with the TYPE 1564-A Sound and Vibration Analyzer or the TYPE 1900-A Wave Analyzer.

DESCRIPTION: The TYPE 1553 Vibration Meter consists of an inertia-operated, lead-zirconate-titanate ceramic pickup, which delivers a voltage proportional to the acceleration of the vibratory motion; an adjustable attenuator; an amplifier; and an indicating meter. Integrating networks can be switched to convert the output of the vibration pickup to a voltage proportional to either displacement or velocity.

A differentiating network can be switched in to convert the output of the vibration pickup to a voltage proportional to jerk (time rate of change of acceleration).

The TYPE 1553-A Vibration Meter indicates directly in peak-to-peak, peak, or average inches; in/sec; in/sec^2; or in/sec^3. The TYPE 1553-AK indication is in metric units: mm, m/sec, m/sec^2, and m/sec^3.

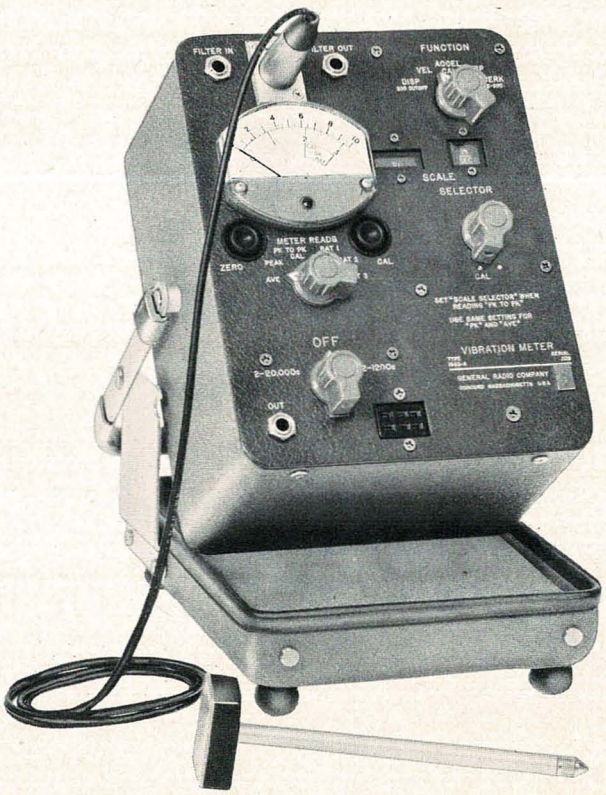
Filter jacks on the panel allow the use of external high-pass filters where it is desired to eliminate the frequency components below 30 or 70 c/s.

The vibration meter is portable and is mounted in a Flip-Tilt cabinet, which serves as protective cover and case in transit, and as a base on which the instrument can be operated in almost any position from vertical to horizontal.

Accessories include various tips and a metal probe for the pickup to facilitate measurements in normally inaccessible places. Available at additional cost is the TYPE 1560-P35 Permanent-Magnet Clamp, which replaces the probe or tip when measurements are made under conditions where hand-held operation would not be satisfactory.

FEATURES:

- Portable and self-contained. ■ Easy to operate.
- Direct read-out includes units being measured.
- Low-frequency response down to 2 cycles per second.
- Meter indication independent of load connected to output jack.
- Meter is true peak, peak-to-peak, or average indicator.
- 20-cycle cutoff position on function switch increases displacement sensitivity by a factor of 100 over that obtainable with a 2-cycle cutoff.
- Measures jerk as well as conventional vibration parameters.
- Can be used to measure acceleration with a suitable pickup over the full range (2-20,000 c/s) of the amplifier.
- Panel jacks provided for addition of external filters.

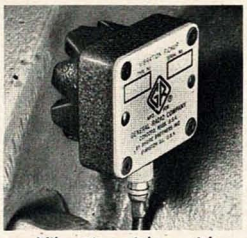


The Type 1553 Vibration Meter can be furnished with calibration in either English or metric units. The portable model in the convenient Flip-Tilt case is shown here. A rack-mount model is also available, as listed on the opposite page.

SPECIFICATIONS

Ranges of Measurement:

Type No	Quantity	Peak to Peak Min	Peak to Peak Max	Average Min	Average Max	Units	Frequency Range (c/s)
1553-A	Acceleration	0.3	300,000	0.1	100,000	in/sec²	2-2000
1553-AK	Acceleration	0.01	10,000	0.003	3,000	m/sec²	2-2000
1553-A	Velocity	0.03	30,000	0.01	10,000	in/sec	2-2000
1553-AK	Velocity	0.001	1,000	0.0003	300	m/sec	2-2000
1553-A	Displacement	3	300,000	1	300,000	mils	2-2000
1553-AK	Displacement	0.1	10,000	0.03	10,000	mm	2-2000
1553-A	Displacement	0.03	30,000	0.01	10,000	mils	20-2000
1553-AK	Displacement	0.001	1,000	0.0003	300	mm	20-2000
1553-A	Jerk	30	300,000	10	300,000	in/sec³	2-20
1553-AK	Jerk	1	10,000	0.3	10,000	m/sec³	2-20

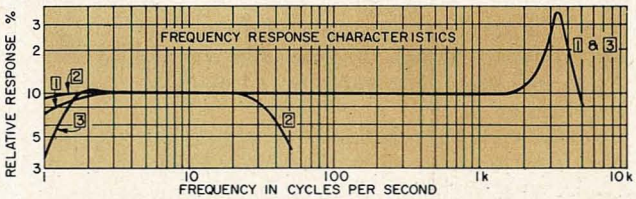


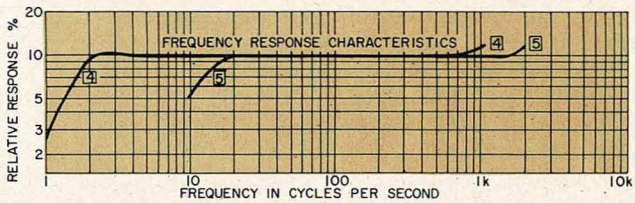
Vibration pickup with permanent-magnet clamp.

Response characteristics for constant applied (1) acceleration, (2) jerk, (3) velocity, (4) displacement, 2-cycle cutoff, and (5) displacement, 20-cycle cutoff.

Accuracy: ±10% of full scale.
Input Impedance: 25 MΩ.
Voltage at Output Jack: 5 V, rms, behind 75 kΩ for full-scale deflection.
Attenuators: A 10-step attenuator changes the meter-scale range by a factor of 100,000 to 1. Window readout indicates full-scale values and units.
Calibration: Internal.
Allowable Pickup Sensitivity for Direct Reading: 30 to 150 mV/g.
Terminals: A panel jack is provided for plugging in earphones, TYPE 1564-A Sound and Vibration Analyzer, TYPE 1556-B Impact-Noise Analyzer, TYPE 1531-A STROBOTAC® electronic stroboscope, TYPE 1900-A Wave Analyzer, or an oscilloscope.
Power Supply: Portable model, 3 size-D cells and one 67½-V battery (Burgess Type XX45 or equivalent) supplied. Typical battery life, 7 days at 8 h per day. For ac operation, use TYPE 1262-C Power Supply (listed below). Rack model, TYPE 1262-C Power Supply is included.
Accessory Supplied: TYPE 1560-P52 Vibration Pickup.
Accessories Available: TYPE 1560-P35 Permanent-Magnet Clamp; TYPE 1557-A Vibration Calibrator.

The Type 1553 Vibration Meters can be supplied on special order with either the wide-frequency range Type 1560-P53 Pickup or the high-sensitivity Type 1560-P54 (see page 20). Write for details.





Mechanical Data: Flip-Tilt Case (*see page 258*)

Model	Width in	Width mm	Height in	Height mm	Depth in	Depth mm	Net Wt lb	Net Wt kg	Ship Wt lb	Ship Wt kg
Portable	8	205	9¼	235	7½	190	10½	4.8	14	6.5
Rack	19	485	10½	270	5*	130	14	6.5	31	14.5

*Behind panel

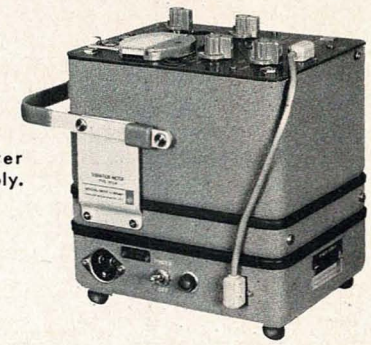
See also *General Radio Experimenter*, November 1961.

Catalog Number	Description	Price
1553-9701	**Type 1553-A Vibration Meter** (English Units), Portable Model	**$775.00**
1553-9550	**Type 1553-A Vibration Meter** (English Units), Rack Model	**920.00**
1553-9819	**Type 1553-AK Vibration Meter** (Metric Units), Portable Model	**775.00**
1553-9560	**Type 1553-AK Vibration Meter** (Metric Units), Rack Model	**920.00**
1560-9652	**Type 1560-P52 Replacement Vibration Pickup**	**100.00**
8410-9799	**Set of Replacement Batteries**	**4.45**
1560-9635	**Type 1560-P35 Permanent-Magnet Clamp**	**6.50**

PATENT NOTICE. See Note 12, page 11.

Type 1262-C POWER SUPPLY

Attaches to the TYPE 1553-A Vibration Meter for AC-Line Operation. Included with rack model.



Vibration meter with power supply.

SPECIFICATIONS

Catalog No.	Volts	Input c/s	Watts	Dimensions	Weight Net	Weight Shipping	Price
1262-9703	105-125 or 195-250	50-400 50	3 6	7¼, 9¼, 3¼ in (185, 235, 83 mm)	2¼ lb (1.1 kg)	8 lb (3.7 kg)	**$135.00**

Type 1557-A VIBRATION CALIBRATOR

USES: This vibration calibrator is a convenient device for calibrating vibration pickups, accelerometers, vibration meters, and other vibration-measuring systems that use small, piezoelectric accelerometers as sensing elements.

The calibrator provides a single-frequency (100 c/s), single-level (1 g*) check on the General Radio Vibration Pickups, the TYPE 1553 Vibration Meter, or any pickup whose total mass is 300 grams or less. It can provide on-the-spot calibration of vibration-measuring systems immediately before and after important measurements and can also be used to compare transducers or to calibrate working transducers against a standard transducer.

DESCRIPTION: The TYPE 1557-A Vibration Calibrator is a small, battery-operated unit consisting of a transistorized electromechanical oscillator and a cylindrical shaker. The acceleration output of the calibrator appears at two pillbox-shaped, 50-gram disks mounted on an internal cylinder that projects through the sides of the instrument.

Operation of the calibrator is simple. A pickup of known mass is attached to the shaker, either in place of one of the removable 50-gram disks or to one of the disks by double-faced, pressure-sensitive tape. The user adjusts the LEVEL control until the panel meter, calibrated in grams, indicates the mass of the pickup. The pickup will then be automatically subjected to an acceleration of 1 g at 100 c/s. The only other control on the instrument is a combination of on-off switch and battery checker.

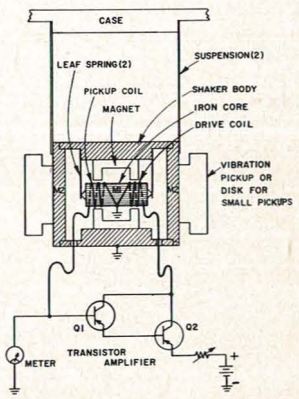
Life tests on the calibrator indicate that it will operate continuously for over 1000 hours. Since normal operation will usually be below the maximum and will not be continuous, the calibrator should give trouble-free service for many years.

*g = acceleration of gravity.

FEATURES:

- Completely portable, with long-life mercury batteries.
- Accommodates most of the accelerometers and vibration pickups in use today.
- Weighs less than four pounds, with leather carrying case.

View of the calibrator with Type 1560-P52 Vibration Pickup attached.



Functional diagram of the calibrator.

SPECIFICATIONS

OUTPUT

Acceleration: 1 g, rms, ±10%.

Velocity: 0.614 in/s (15.6 mm/s), rms.

Displacement: 0.000978 in (0.0248 mm), rms; 0.00277 in (0.0704 mm), peak-to-peak.

Frequency: 100 c/s ± 1% for 50-gram load; 100 c/s + 0, −2% for 300-gram load.

GENERAL

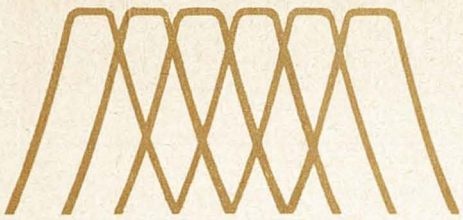
Batteries: Four RM-4 (or equivalent) mercury cells. Battery life is 100 hours of continuous operation. (Dry cells optional; please specify.)

Accessory Supplied: Leather carrying case.

MECHANICAL DATA Aluminum Case

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
4	105	8	205	4	105	3¼	1.5	5¼	2.4

Catalog No.	*Description*	*Price*
1557-9701	**Type 1557-A Vibration Calibrator**	**$225.00**



WAVE ANALYSIS

ANALYZERS

The instruments described in this section are used to determine the components and the wave shape of complex electrical signals, acoustic noise, or mechanical vibrations. The choice of an instrument for evaluating the individual components of such a signal depends upon the character of the signal, the information that is needed, and how the results are to be used.

HETERODYNE ANALYZER — FIXED BANDWIDTH

If, for example, the signal is a periodic one that is reasonably stable in frequency, each spectrum component is readily measured with the Type 1900-A Wave Analyzer. The very high selectivity of this analyzer, with its bandwidths of 3, 10, and 50 c/s, is independent of the frequency to which the analyzer is tuned. These selectivity characteristics, which are obtained through the use of quartz-crystal filters, are particularly useful in the measurement of intermodulation distortion of amplifiers and other audio equipment. When this analyzer is used as an electronic voltmeter in the measurement of the transmission characteristics of electrical wave filters or as a null detector for impedance bridges, the excellent selectivity is of particular value in avoiding the effects of interfering signals, hum, noise, and distortion products. When used as a bridge detector, the analyzer will also supply the generator signal for operating the bridge.

If the signal is a random noise, whether it is electrically generated noise or acoustic noise transformed by a microphone into an electrical signal, the 50-cycle bandwidth of this analyzer can be very useful in the frequency analysis of such a signal, particularly when the spectrum is automatically plotted.

CONSTANT-PERCENTAGE-BANDWIDTH ANALYZER

The Type 1564-A Sound and Vibration Analyzer finds its greatest use in the measurement of the components of noise, either electrical or acoustic, when the bandwidth of the Type 1900-A Wave Analyzer is too narrow for rapid analysis, and in the measurement of noises and complex waveforms whose frequency components fluctuate. It provides two bandwidths, which are constant percentages of the center frequency: 1/3 octave (23%) and 1/10 octave (7%).

Although its tuning is continuous, if one assumes that the analyzer divides its range from 2.5 to 25,000 c/s into contiguous bands according to its effective bandwidth, it will have about 135 bands without appreciable overlap for the 1/10-octave bandwidth and about 41 bands for the 1/3-octave bandwidth. This contrasts with approximately 18,000, 5400, and 1080 bands for the 3-, 10-, and 50-cycle bandwidths, respectively, of the wave analyzer, whose frequency coverage is 20 c/s to 54 kc/s.

RECORDING ANALYZERS

Either of the above-mentioned analyzers can be combined with the Type 1521-B Graphic Level Recorder to form a recording analyzer. The analyzer dial is driven automatically by the recorder, and chart paper is available to fit the scale of each type of analyzer. These combinations are listed and illustrated on pages 29 and 31. With such a combination, complex spectra can be plotted automatically over the complete frequency range of the analyzer.

TUNED AMPLIFIER

Approximate magnitudes of spectrum components can be determined by measurement with the Type 1232-A Tuned Amplifier and Null Detector (page 104). This highly sensitive instrument has a bandwidth of about 5% and is tunable from 20 c/s to 20 kc/s.

OCTAVE-BAND ANALYZER

For many noise measurements a simpler division of the spectrum is desired than that provided by either the Type 1564-A Sound and Vibration Analyzer or the Type 1900-A Wave Analyzer. Much time can be saved in the evaluation of the general spectral distribution of a noise through the use of a wide-band device such as the Type 1558 Octave-Band Analyzers. These divide the audio spectrum into ten bands. Like the more selective analyzers, the octave-band analyzer can also be used as a selective voltmeter when it is desired to exclude certain bands of frequencies or individual frequencies from a signal.

DISTORTION METER

The Type 1932-A Distortion and Noise Meter is a specialized yet versatile device for the measurement of distortion in audio-frequency systems. Here the complete signal is used as a reference value; the fundamental component is suppressed. The remainder, which includes distortion components, hum, and noise, is then measured to give a single-number distortion rating. When used with a cathode-ray oscilloscope, this instrument is a versatile testing tool, immediately indicating optimum conditions whenever adjustments are made that affect distortion and noise.

STEEP WAVEFRONTS

With impact-type acoustic noise and electrical noise, which have extremely steep wavefronts, a frequency analysis is usually of little value. The important characteristics of such signals are the peak amplitude and the duration or decay time. To evaluate these quantities, the Type 1556-B Impact-Noise Analyzer is used.

Type 1900-A WAVE ANALYZER

FEATURES:

Wide frequency range — 20 to 54,000 c/s. ■ Three bandwidths — 3, 10, and 50 c/s.
30 microvolts to 300 volts, full scale.
Outputs for dc recorder and graphic level recorder (80-dB dynamic range).
Tunable filter — output at selected frequency is provided.
Tracking generator — analyzer can be used as both source and detector.
Self-contained voltage-calibrating system.
Input impedance of one megohm on all voltage ranges.
Three meter speeds for easier noise analysis. ■ Mirror-backed meter.
Linear frequency scale for optimum tuning characteristics over full range.
AFC holds analyzer in tune despite small drifts in input frequency.
In-line frequency readout. ■ Incremental-frequency dial for high resolution.

USES: The wave analyzer is used for measuring the components of, or analyzing the spectra of, complex electrical signals, including those which are replicas of acoustic noise or mechanical vibrations.

Individual components of periodic complex waveforms such as harmonic or intermodulation distortion are readily separated and measured, owing to the excellent selectivity available.

This analyzer is particularly suited for analyzing noise, because its bandwidth in cycles per second is independent of the center frequency. The required averaging time is, therefore, constant, and the calculation of spectrum level is simple. Furthermore, when the 50-cycle bandwidth is used, the averaging time required is reasonably short.

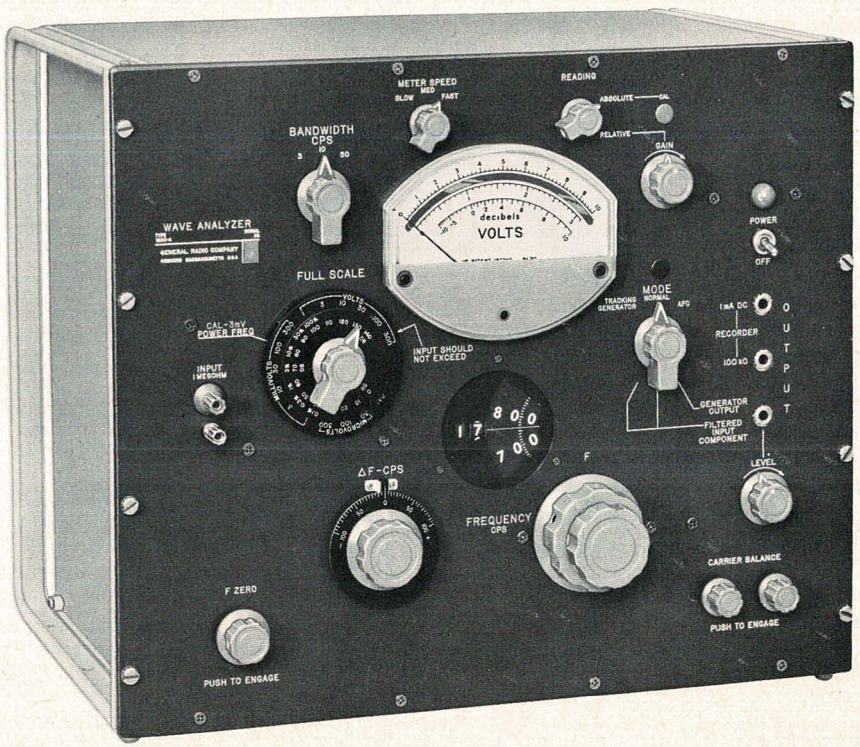
The analyzer can also be used as a tunable filter, so that the individual components of a complex input signal can be used to drive other instruments, such as frequency counters, when a highly accurate measure of the component frequencies is desired, or to drive earphones. When a wide-band noise generator drives the analyzer, the output is a tunable narrow band of noise. Such a signal is useful in a number of psychological and architectural-acoustics tests.

In the "tracking generator" mode of operation the output is a sine-wave signal tunable over the 54-kc range and always in tune with the analyzer. When this signal is used to drive a bridge or other network, the output can be measured by the analyzer, whose selectivity reduces the interference from extraneous noise, hum, and distortion.

For automatic waveform analysis, outputs are provided for driving the TYPE 1521 Graphic Level Recorder as well as dc recorders.

The TYPE 1560-P40H Preamplifier and Power Supply Set is available to extend the full-scale sensitivity to 3 microvolts and to increase the input impedance.

DESCRIPTION: The TYPE 1900-A Wave Analyzer is a heterodyne type of voltmeter. The intermediate-frequency amplifier at 100 kc/s includes a highly selective quartz-crystal filter whose bandwidth can be switched to 3, 10, and 50 c/s. The use of a heterodyne system makes it possible to vary the response frequency although the filter frequency is fixed. The 100-kc output of the filter is indicated on a meter and is also available at the panel. In one mode of operation the output is also heterodyned back to the original frequency. In another mode the local oscillator beats with a 100-kc quartz-crystal oscillator to function as a beat-frequency oscillator. These two outputs are also available at panel terminals as FILTERED INPUT COMPONENT and INDICATED FREQUENCY, respectively.



SPECIFICATIONS

FREQUENCY

Range: 20 to 54,000 c/s. The frequency is indicated on a counter and a dial with a linear graduation, 10 c/s per division.

Accuracy of Calibration: ±(½% + 5 c/s) up to 50 kc/s; ±1% beyond 50 kc/s.

Incremental-Frequency Dial (ΔF): ±100 c/s. Accuracy is ±2 c/s below 2 kc/s, ± 5 c/s up to 54 kc/s.

Automatic Frequency Control: At frequencies below 10 kc/s, total range of frequency lock is 400 c/s for the 50-cycle band and 150 c/s for the 10-cycle band, as defined by 3-dB drop in response from full-scale deflection. At 50 kc/s, the lock ranges decrease to one-half these values.

SELECTIVITY Three bandwidths (3, 10, and 50 c/s).

Effective bandwidth for noise equal to nominal bandwidth within ±10% for 10- and 50-cycle bands and ±20% for 3-cycle band.

3-Cycle Band: At least 30 dB down at ±6 c/s from center frequency, at least 60 dB down at ±15 c/s, at least 80 dB down at ±25 c/s and beyond.

10-Cycle Band: At least 30 dB down at ±20 c/s, at least 60 dB down at ±45 c/s, at least 80 dB down at ±80 c/s and beyond.

50-Cycle Band: At least 30 dB down at ±100 c/s, at least 60 dB down at ±250 c/s, at least 80 dB down at ±500 c/s and beyond.

INPUT

Impedance: 1 MΩ shunted by 30 pF on all ranges.

Voltage Range: 30 μV to 300 V, full scale, in 3, 10 series. A decibel scale is also provided.

Voltage Accuracy: After calibration by internal source, the accuracy up to 50 kc/s is ±(3% of indicated value + 2% of full scale) except for the effects of internal noise when the attenuator knob is in the maximum-sensitivity position. From 50 to 54 kc/s, the above 3% error becomes 6%.

Residual Modulation Products and Hum: At least 75 dB down.

OUTPUT

100-kc Output: Amplitude is proportional to amplitude of selected component in analyzer input signal. With the TYPE 1521-B Graphic Level Recorder connected, full-scale output is at least 3 V. Dynamic range from overload point to internal noise is >80 dB with attenuator knob fully clockwise.

Recording Analyzer: See the TYPE 1910-A Recording Analyzer. The recorder is described on page 178.

DC Output: 1 mA in 1500 Ω, full scale, one side grounded.

Filtered Input Component: Output at least 1 V across 600-Ω load for full-scale meter deflection with output control at maximum.

Tracking Analyzer (Indicated Frequency): 20 c/s to 54 kc/s; output is at least 2 V across 600-Ω load with output control at maximum.

GENERAL

Terminals: Input, binding posts; output, telephone jacks.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, approximately 40 W.

Accessories Supplied: TYPE 1560-P95 Adaptor Cable, phone plug, TYPE CAP-22 Power Cord, spare fuses.

Accessories Available: TYPE 1900-P1 Link Unit for coupling to TYPE 1521-B Graphic Level Recorder (page 178); TYPE 1560-P40H Preamplifier and Power Supply Set (page 18).

MECHANICAL DATA Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	16¼	415	15¼	390	56	26	140	64
Rack	19	485	15¾	400	13¼*	340	56	26	140	64

* Behind panel

For a more detailed description, see *General Radio Experimenter*, April 1964.

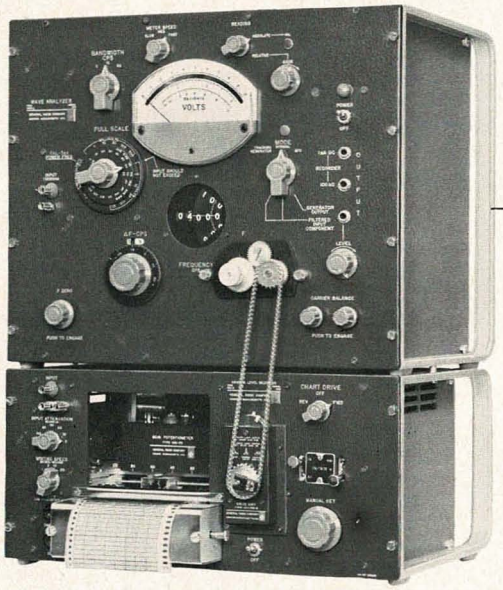
Type 1910-A RECORDING WAVE ANALYZER

The Recording Wave Analyzer consists of the following items:

TYPE 1900-A Wave Analyzer
TYPE 1521-B (or -BQ1) Graphic Level Recorder, with medium-speed motor (see page 178)
TYPE 1521-P10B Drive Unit
TYPE 1900-P1 Link Unit
1521-9464 Chart Paper, 10 rolls
1521-9465 Chart Paper, 10 rolls
TYPE 1521-P3 80-dB Potentiometer*

The recording analyzer is shipped completely assembled with end frames. Supports for installation in a standard 19-inch rack are supplied.

* In addition to the 40-dB potentiometer installed in the recorder.



NEW
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MECHANICAL DATA Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	25¼	645	15¼	390	116	53	227	104
Rack	19	485	24½	625	13¼*	340	116	53	227	104

* Behind panel

Catalog Number	*Description*	*Price*
1900-9801	**Type 1900-A Wave Analyzer,** Bench Model	**$2150.00**
1900-9811	**Type 1900-A Wave Analyzer,** Rack Model	**2150.00**
1910-9701	**Type 1910-A Recording Wave Analyzer** (for 60-cycle supply)	**3500.00**
1910-9494	**Type 1910-AQ1 Recording Wave Analyzer** (for 50-cycle supply)	**on request**

PATENT NOTICE. See Notes 1, 15, and 18, page 11.

Type 1564-A SOUND AND VIBRATION ANALYZER

FEATURES:

Wide frequency range — 2.5 c/s to 25 kc/s. ■ True logarithmic frequency scale.
High input impedance — 25 megohms in parallel with 80 pF.
Direct reading in either volts or, when used with microphone, in dB re 0.0002 μbar.
Operates from either power line or rechargeable battery.
Internal amplitude calibration system. ■ All-solid-state circuits.
Rms detector with three averaging times.
Detent at ASA preferred frequencies can be engaged with panel control.

USES: The TYPE 1564-A Sound and Vibration Analyzer is designed primarily for measuring the amplitude and frequency of the components of complex sound and vibration spectra. Its 1/3-octave (23%) and 1/10-octave (7%) noise bandwidths provide the flexibility needed for analysis of both line (single frequency) and continuous spectra. The high input impedance of the analyzer permits direct connection of piezoelectric transducers for measuring sound pressures from 44 to 150 dB re 0.0002 μbar and acceleration from 0.0007 g to 100 g.

The TYPE 1560-P40 Preamplifier is available to extend the full scale sensitivity of the analyzer to 30 μV (24 dB SPL or 70 μg minimum level) and to allow use of the transducer at the end of a long extension cable. See page 17. Alternatively, for high sensitivity, the analyzer can be driven from a sound-level meter or vibration meter.

Automatic range switching is provided so that the TYPE 1521-B Graphic Level Recorder can record automatically the spectrum of the signal under analysis. The combination of analyzer and recorder is available as the TYPE 1911-A Recording Sound and Vibration Analyzer.

The analyzer can be used in conjunction with the TYPE 1390-B Random-Noise Generator for transfer and reverberation measurements using 1/3- or 1/10-octave bands of random noise.

The analyzer is also a useful tuned voltmeter or general-purpose wave analyzer for work at audio and subaudio frequencies. The TYPE 1560-P41 Audio-Frequency Voltage Probe is available for convenient connection to high impedance electric circuits. See below.

DESCRIPTION: The TYPE 1564-A Sound and Vibration Analyzer consists of a high impedance amplifier, a continuously tunable filter having a noise bandwidth of either 1/3 or 1/10 octave, an output amplifier, and a meter. The center frequency of the filter is continuously adjustable. An all-pass, or flat, characteristic permits measurement of the over-all signal amplitude.

SPECIFICATIONS

FREQUENCY

Range: From 2.5 c/s to 25 kc/s in four decade ranges.

Dial Calibration: Logarithmic.

Accuracy of Calibration: ±2% of frequency-dial setting.

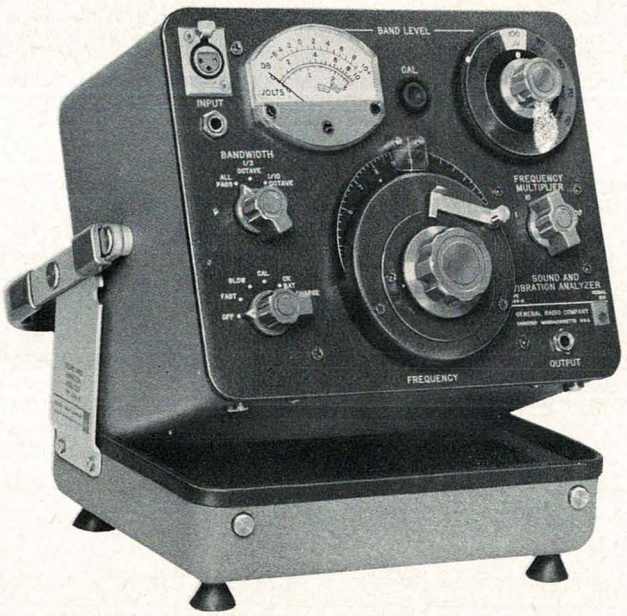
Filter Characteristics: Noise bandwidth is either 1/3 octave or 1/10 octave. One-third-octave characteristic has at least 30-dB attenuation at one-half and twice the selected frequency (see plot). One-tenth-octave characteristic has at least 40-dB attenuation at one-half and twice the selected frequency. Ultimate attenuation is 70 dB or greater for both characteristics. For both bandwidths peak response is uniform ±1 dB from 5 c/s to 10 kc/s and ±1.5 dB from 2.5 c/s to 25 kc/s.

INPUT

Impedance: 25 MΩ in parallel with 80 pF (independent of attenuator setting).

Voltage Range: 0.3 mV to 30 V full scale in 10-dB steps.

Microphone: TYPE 1560-P6 Microphone Assembly or the TYPE 1560-P40K Preamplifier and Microphone Set (page 17) is recommended.



OUTPUT

Voltage: At least 1.0 V open circuit when meter reads full scale.

Impedance: 6000 Ω. Any load can be connected.

Meter: Three scales, 0 — 3 V; 0 — 10 V; −6 to +10 dB.

Recording Analyzer: Automatic range switching at the end of each frequency decade allows convenient continuous recording of spectra with the Type 1521-B Graphic Level Recorder. See below for recording analyzer assembly.

GENERAL

Amplitude Calibration: Built-in, feedback-type calibration system permits amplitude calibration at any frequency.

Detector: Rms with three averaging times. Faster two speeds conform with ASA standard for sound-level meters.

Power Required: Operates from 105 to 125 or 210 to 230 V, 50–60 c/s, or from nickel-cadmium battery supplied. Battery provides 25 h of operation when fully charged and requires 14 h for charging.

Accessories Supplied: Type CAP-22 Power Cord, shielded cable, and detented knob and dial assembly.

Accessories Available: Type 1560-P6 Microphone Assembly for direct acoustic pickup; Types 1560-P52, -P53, -P54 Vibration Pickups for solid-borne vibrations; Type 1560-P41 Audio-Frequency Voltage Probe for voltage measurements; Type 1560-P40K Preamplifier and Microphone Set (power is available for the Type 1560-P40 Preamplifier at the input connector).

MECHANICAL DATA Flip-Tilt Case (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Portable	10¼	260	8⅛	210	8	205	14½	7	17	8
Rack	19	485	10½	270	6*	155	15½	7.5	28	13

* Behind panel

For a more detailed description, see *General Radio Experimenter*, September-October 1963.

Catalog No.	*Description*	*Price*
1564-9701	**Type 1564-A Sound and Vibration Analyzer, Portable Model**	**$1150.00**
1564-9820	**Type 1564-A Sound and Vibration Analyzer, Rack Model**	**1150.00**
1560-9520	**Type 1560-P40K Preamplifier and Microphone Set**	**251.00**

PATENT NOTICE. See Notes 12, 15, and 22, page 11.

TYPE 1911-A RECORDING SOUND AND VIBRATION ANALYZER

The recording analyzer consists of the following components:

Type 1564-A Sound and Vibration Analyzer (rack model)

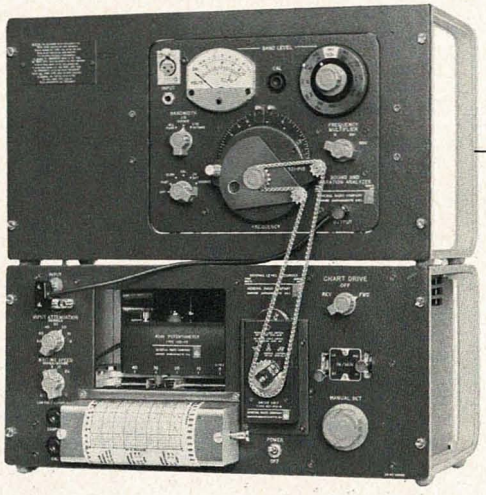
Type 1521-B (or -BQ1) Graphic Level Recorder, with medium-speed motor (see page 178)

Type 1521-P10B Drive Unit

Type 1521-P15 Link Unit, with interchangeable 16- and 24-tooth sprockets

1521-9469 Chart Paper, 10 rolls

The recording analyzer is shipped completely assembled with end frames. Hardware for installation in a standard 19-inch rack is supplied.



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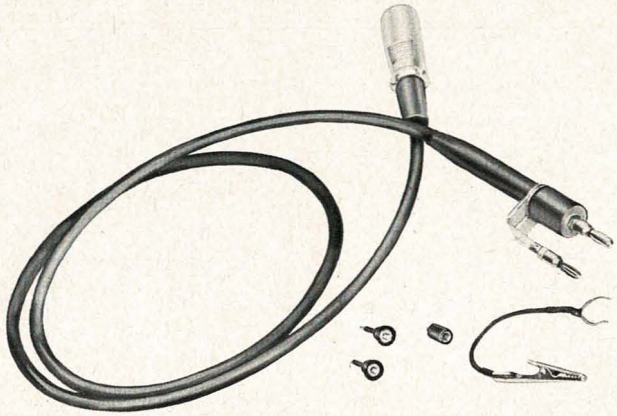
Catalog No.	*Description*	*Price*
1911-9701	**Type 1911-A Recording Sound and Vibration Analyzer (for 60-cycle supply)**	**$2315.00**
1911-9494	**Type 1911-AQ1 Recording Sound and Vibration Analyzer (for 50-cycle supply)**	**on request**

TEST PROBE FOR VOLTAGE MEASUREMENT WITH THE ANALYZER

The Type 1560-P41 Audio-Frequency Voltage Probe consists of a 10:1 RC divider. It presents a high impedance to the circuit under test and connects to the analyzer with a 4-foot cable. It is supplied with a variety of probe tips, including plugs, to fit jack-top binding posts on ¾-inch centers.



Input Impedance: 25 MΩ in parallel with 20 pF.
Net Weight: ¼ lb (115 gram).

Catalog No.	*Description*	*Price*
1560-9641	**Type 1560-P41 Audio-Frequency Voltage Probe**	**$45.00**

Type 1558 OCTAVE-BAND NOISE ANALYZER

USES: The TYPE 1558 Octave-Band Noise Analyzer is used for the rapid analysis of broadband noises, where a knowledge of individual frequency components is not required. For the measurement of octave-band sound-pressure levels above 44 dB re 0.0002 μbar, the analyzer can be used directly with a piezoelectric microphone. For lower levels, it can be operated from the output of the TYPE 1560-P40 Preamplifier or the TYPE 1551-C Sound-Level Meter.

It is particularly useful for:

Measurement of aircraft, vehicle, and machinery noise.

Measurement of environmental noise, as in offices and factories, where speech-interference level is important.

Studies of environmental noise as related to hearing damage.

Production testing and noise-level acceptance tests.

Loudness determinations.

Acoustical studies of rooms and materials.

DESCRIPTION: Two models of the octave-band noise analyzer are available. The TYPE 1558-A has bands as specified by the ASA Standard for Octave-Band Filters, Z 24.10-1953. In the TYPE 1558-AP, the bands are centered at the ASA Preferred Frequencies for Acoustical Measurements, ASA S 1.6-1960.* In addition, the -A model has bandpass filters that extend the range at both ends beyond the range specified in the standard.

Essentially, the analyzer consists of a high-impedance amplifier, a filter, an output amplifier, and a meter. The amplifier frequency response can be set to be either flat or C-weighted. A built-in reference allows calibration for microphones ranging in sensitivity from −52 to −62 dB re 1 volt/μbar. RC active filters are used, resulting in small size, light weight, and lack of interference from stray magnetic fields. The high input impedance and preamplification permit the use of piezoelectric microphones and vibration pickups. The analyzer is portable and powered by rechargeable nickel-cadmium batteries.

* Also specified by ISO Recommendation 402 and German Standard DIN45-401.

FEATURES:

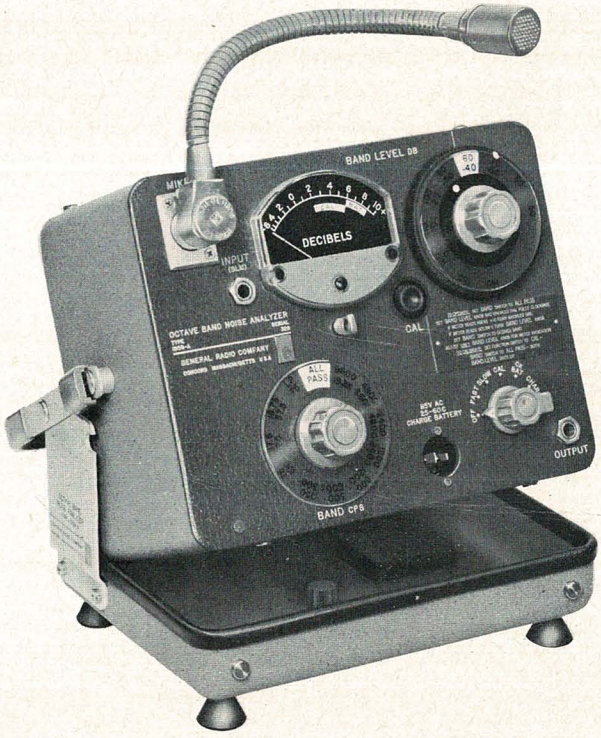
- Direct use with piezoelectric microphones for levels in the range from 44 to 150 dB (down to 24 dB with preamplifier).
- Small, compact, and portable — weighs less than 9 pounds.
- Measures level in 10 octave bands.
- Uses rechargeable nickel-cadmium battery.
- All-solid-state circuitry.
- Internal calibration system.
- Rms response in accordance with ASA S1.4-1961.

ACCESSORY MICROPHONE and PREAMPLIFIER

The TYPE 1560-P6 Microphone Assembly consists of a ceramic microphone unit attached to a short length of flexible conduit, which in turn mounts on a swivel base. The microphone assembly plugs into the MIKE input connector on the panel of the octave-band analyzer.

It has a flat response to sounds of random incidence from 20 c/s to 8 kc/s. It will withstand temperatures from −30 to 95°C and relative humidity from 0 to 100%. It shows little change in sensitivity and internal impedance with temperature.

The sensitivity of the analyzer can be extended to 24 dB by use of the TYPE 1560-P40K Preamplifier and Microphone Set. The preamplifier also allows the microphone to be used at the end of a long extension cable.



The Type 1558-A Octave-Band Noise Analyzer with the Type 1560-P6 Microphone Assembly.

SPECIFICATIONS

Filter Characteristics:† Level at center frequency in bands from 37.5 to 9600 c/s is uniform ±1 dB. Maximum deviation from ALL PASS level at center frequency in any band is 1 dB. For bands from 37.5 to 9600 response at nominal cutoff frequency is (3.5 ± 1) dB below response at center frequency. Attenuation is at least 30 dB at one-half the lower nominal cutoff frequency and twice the upper nominal cutoff frequency for all octave bands. Attenuation is at least 50 dB at one-fourth the lower nominal cutoff frequency and four times the upper nominal cutoff frequency for all octave bands. The 75-cycle low-pass filter has at least 35-dB attenuation at 200 c/s and at least 50-dB attenuation at 400 c/s.

† Measured with signal applied at INPUT (SLM) terminals.

Bands: **Type 1558-A**

Lower Cutoff Frequency-c/s	*Upper Cutoff Frequency-c/s*	*Center Frequency* c/s*
18.75	37.5	26.5†
37.5	75.0	53.0†
75.0	150	106
150	300	212
300	600	424
600	1200	849
1200	2400	1700
2400	4800	3390
4800	9600	6790
9600	19,200	13,590†
LP	75	
ALL PASS		

* Geometric mean. † These bands are not required by Z24.10.

For TYPE 1558-AP, center frequencies are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, 16,000 c/s.

Sound-Pressure-Level Range: 44 to 150 dB above 0.0002 μbar in any band when TYPE 1560-P6 Microphone Assembly is used.

Input: Impedance at MIKE terminals is approximately 50 pF in parallel with 50 MΩ. It is intended for use with high-impedance transducers such as the TYPE 1560-P6 Microphone Assembly.

Impedance at INPUT (SLM) terminals is approximately 100 kΩ. Maximum input is 3 V. Low-input terminal, connected to case, is intended for connection to output of a sound-level meter.

Amplifier Frequency Characteristic: Can be set to be either C weighting, which is specified by the American Standards Association (ASA S1.4-1961 SLM), or 20 kc/s, an essentially flat response.

Output: Output is at least 1 V behind 6000 Ω (panel meter at full scale). Any load can be connected across the output terminals.

Relay-rack model is adapted from portable model; see page 258.

Meter: Rms response and FAST and SLOW meter speeds in accordance with ASA S1.4-1961.

Internal Calibration: A built-in reference allows the gain of the analyzer to be calibrated for use with piezoelectric microphones having sensitivities from −52 to −62 dB re 1 V/μbar. The absolute accuracy for ALL PASS is then within 1 dB over a wide range of atmospheric conditions.

Batteries: Two 9.6-V rechargeable nickel-cadmium batteries give 30-h operation. They are recharged from a 25- to 60-cycle power line. Full charge takes about 14 h.

Accessories Supplied: Carrying strap, power cord for charging battery, shielded cable for connection to sound-level meter.

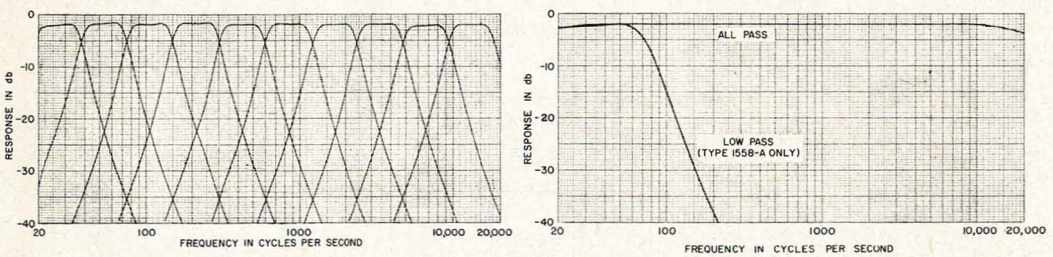
Accessories Available: TYPE 1560-P6 Microphone Assembly. TYPE 1560-P40K Preamplifier and Microphone Set. Power is available for the TYPE 1560-P40 Preamplifier at the MIKE connector.

Mechanical Data: Flip-Tilt Case (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Portable	1¼	260	9¼	235	7¼	185	8¾	4	12	5.5
Rack	19	485	8¾	225	5*	130	9	4.1	22	10

* Behind panel

For a more detailed description, see *General Radio Experimenter*, October 1962.



(Left) Filter characteristics of the Type 1558-A. The Type 1558-AP characteristics are similar, except that the center frequencies are changed, as specified in the data above. *(Right)* Lowpass and allpass characteristics of the Type 1558.

Catalog Number	*Description*	*Price*
1558-9701	**Type 1558-A Octave-Band Noise Analyzer** (ASA Standard), Portable Model	**$815.00**
1558-9820	**Type 1558-A Octave-Band Noise Analyzer** (ASA Standard), Rack Model	**815.00**
1558-9829	**Type 1558-AP Octave-Band Noise Analyzer** (ASA Preferred Frequencies), Portable Model	**795.00**
1558-9822	**Type 1558-AP Octave-Band Noise Analyzer** (ASA Preferred Frequencies), Rack Model	**795.00**
1560-9606	**Type 1560-P6 Microphone Assembly**	**75.00**
1560-9520	**Type 1560-P40K Preamplifier and Microphone Set**	**251.00**

PATENT NOTICE. See Notes 15 and 22, page 11.

Type 1556-B IMPACT-NOISE ANALYZER

This device evaluates the characteristics of impact-type sounds and electrical noise impulses, which cannot be satisfactorily measured with conventional noise-meters.

IMPACT NOISES

include those produced by punch presses, forging hammers, fire alarms, pile drivers, office machinery, and similar equipment. From the standpoint of hearing damage, some of these sounds constitute a serious problem for industry. They have hitherto been measurable only by complicated methods employing oscilloscopes.

The two characteristics of impact sounds that seem most significant are the peak amplitude and the duration, or decay time. This analyzer measures both of these quantities and also a quasi-peak value that is useful in determining the variation among repetitive peak values.

Peak value is the maximum sound-pressure level reached by the noise; quasi-peak is a continuously indicating measure of the high sound-pressure levels reached just before the time of indication; time-average is a measure of the average level over a predetermined period of time, which, when subtracted from peak level, is a measure of the time duration of the sound.

For these applications, the TYPE 1556-B Impact-Noise Analyzer operates from the output of a TYPE 1551 or TYPE 1565-A Sound-Level Meter and, when a vibration pickup is used in place of the microphone on the sound-level meter, will measure vibration impacts. It will also operate from octave-band analyzers, tape recorders, and vibration meters.

ELECTRICAL NOISE PEAKS

in a wire communication circuit can be measured with this instrument as one of the tests to determine the adequacy of the circuit for transmitting data pulses to and from computers and other business machines. In such measurements, many peaks may be measured in a short time, and, after each peak, the stored signal must be erased before the next pulse occurs. To facilitate this, to reduce operator fatigue, and to minimize acoustic noise from the switching process, a RESET pushbutton is provided, which can also be operated by an ordinary camera cable release.

CIRCUIT

A battery-operated, degenerative, transistor amplifier simultaneously drives three ac voltmeter circuits, which comprise rectifiers, storage capacitors, and a dc electronic voltmeter. The electrical storage system (a capacitor charged by a rectifier) makes it possible to measure three characteristics of an impulse — peak, quasi-peak, and time-average — with a single meter.

SPECIFICATIONS

Input: Any voltage from 1 to 10 V for normal range. Inputs below 1 V reduce the range of reading.

Input Impedance: Between 25,000 and 100,000 Ω, depending on the setting of the LEVEL control.

Frequency Range: 5 c/s to 20 kc/s.

Level Indication: Meter calibrated in dB from −10 to +10. Attenuator switch increases range by 10 dB.

Peak Reading: Rise time is less than 50 μs for a value within 1 dB of peak value (for rectangular pulses). Storage time at normal room temperature is greater than 10 s for a 1-dB change in value.

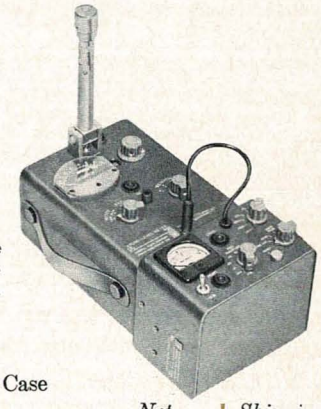
Quasi-Peak Reading: Rise time of less than ¼ ms and decay time of 600 ± 120 ms for rectifier circuit.

Time-Average Reading: Charge time of rectifier circuit selected by seven-position switch, having times of 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, and 0.2 s for the resistance-capacitance time constant. Storage time at normal room temperature is greater than 1 min for a 1-dB change in value.

Input Terminals: Cord with phone plug at one end.

Batteries: One 1½-V size-D flashlight cell and one 45-V battery are supplied. Typical battery life is 100 hours.

Cabinet: Aluminum; carrying case supplied. Cabinet can be fastened directly to one end of a TYPE 1551 Sound-Level Meter.

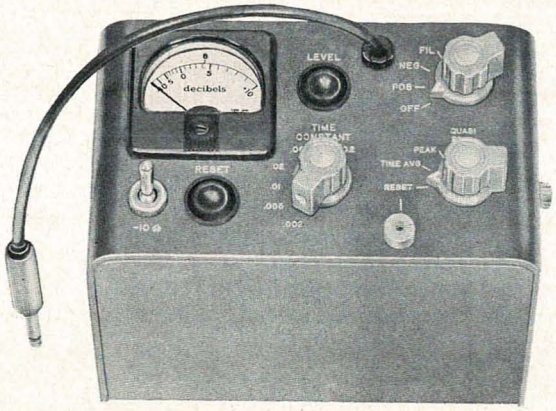


The Type 1556-B Impact-Noise Analyzer attaches to the Type 1551-C Sound-Level Meter as shown here.

Mechanical Data: Aluminum Case

Width		Height		Depth		Net Weight		Shipping Weight	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
7½	190	6½	170	4½	110	4½	2.1	12	5.5

Catalog No.	*Description*	*Price*
1556-9702	**Type 1556-B Impact-Noise Analyzer**	**$240.00**



MEASURES BOTH ELECTRICAL AND ACOUSTICAL NOISE PEAKS

Type 1932-A DISTORTION AND NOISE METER

USES: The TYPE 1932-A Distortion and Noise Meter measures distortion, noise, and hum level in audio-frequency circuits.

It finds many uses in the electronics laboratory and in the production testing of radio receivers as a wide-range, highly sensitive voltmeter for such measurements as signal-to-noise ratio, AVC characteristics, and hum level. With the aid of an oscilloscope, individual hum and distortion components can be identified.

DESCRIPTION: The principal elements of the unit are a high-gain amplifier with an RC interstage coupling unit that balances to a sharp null, a calibrated attenuator for adjusting the sensitivity, and a vacuum-tube voltmeter. Degeneration maintains stability in amplifier gain and a flat transmission characteristic, except within an octave of the null frequency. The null frequency is continuously variable. The null network eliminates the fundamental of the audio-frequency signal, leaving only the distortion products, which are indicated directly on the meter.

The null network is switched out of the circuit for noise and hum measurements, and the instrument then operates as a highly sensitive voltmeter. Two input circuits are provided: (1) a transformer for bridging a 600-ohm line; and (2) a direct connection to the 100,000-ohm gain control.

FEATURES:

- Continuous frequency adjustment over audio range.
- Quick frequency selection.
- Frequencies up to 55,000 c/s are passed by the amplifier circuits, so that distortion measurements can be made on fundamental frequencies up to 18,000 c/s.
- Distortion as low as 0.1% can be measured.

SPECIFICATIONS

RANGES OF MEASUREMENT

Distortion: 0.3%, 1%, 3%, 10%, or 30%, full-scale.

Frequency: 50 to 18,000 c/s fundamental; with bridging-transformer input, harmonics up to 30 kc/s; with 100,000-Ω input, harmonics up to 55 kc/s.

Noise: 80 dB below reference calibration level, or 80 dB below an audio-frequency signal of zero dbm level, at maximum sensitivity.

ACCURACY

Distortion: ±5% of full scale ± residual distortion, where distortion is the ratio of harmonics + noise to total input signal.

Noise, dBm: ±5% of full scale for specified bandwidths.

Residual Distortion and Hum Level: 50 to 150 c/s, 0.07%; 150 to 5000 c/s, 0.02%; 5000 to 18,000 c/s, 0.10%.*

Residual Noise Level: At least 80 dB down.

INPUT

Impedance: 100,000 Ω, unbalanced, and 600-Ω bridging input (10,000 Ω), balanced or unbalanced.

GENERAL

Meter: Scale is calibrated in percentage and dB. The ballistic characteristic is similar to that of a VU meter.

Terminals: Terminals are provided at the rear for permanent wiring connections. A Western Electric jack is provided at the panel also, as an auxiliary input circuit. Plugging into this jack automatically disconnects the rear connectors.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s. The line input power is 65 W.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Accessories Required: For measuring the distortion in oscillators and other audio-frequency sources, no additional equipment is required. For measurements on amplifiers, lines, and other communications networks, a low-distortion oscillator is required. When the modulated output of a radio transmitter is to be measured, a linear demodulator having minimum undistorted output of 1.5 V, rms, can be used.

Mounting: Relay-rack panel. End frames are available for bench use. (See price list below.)

MECHANICAL DATA

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
19	485	7	180	12†	305	35½	16.5	41	19

† Behind panel

* Can be reduced to 0.02% by use of low-level calibration techniques.

Catalog No.	*Description*	*Price*
1932-9701	**Type 1932-A Distortion and Noise Meter**	**$850.00**
5310-9478	**Type FRI-412-2 Aluminum End Frames**	**15.00 Pair**

FOR DISTORTION AND NOISE-LEVEL MEASUREMENTS ON AUDIO EQUIPMENT AND CIRCUITS

AMPLIFIERS

The two amplifiers listed in this section are broadband instruments, adaptable to a variety of applications encountered in the electronics laboratory. The Type 1206-B Unit Amplifier, with a 3-watt output, covers subaudio, audio, and ultrasonic frequencies. The Type 1233-A Power Amplifier, a 15-watt instrument, operates well up into the rf range.

Other amplifiers, with many applications in addition to those for which they are primarily designed, are listed in other sections of the catalog. Among them are:

TUNED AMPLIFIER: Type 1232-A Tuned Amplifier and Null Detector, page 104, is a selective amplifier, tunable continuously from 20 c/s to 20 kc/s, and at 50 kc/s and 100 kc/s; it also has a broadband characteristic, 20 c/s to 100 kc/s.

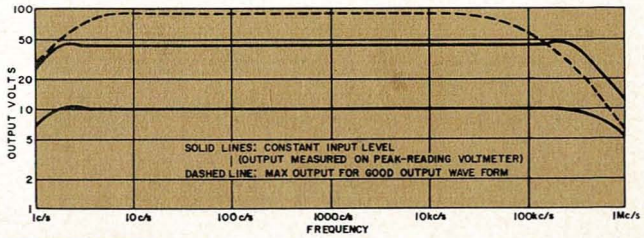
DC AMPLIFIER: Type 1230-A Electrometer, page 174, amplifies weak voltages and currents to operate a recorder.

HIGH-GAIN AMPLIFIER: Type 1551-C Sound-Level Meter, page 14, has a full-scale sensitivity of 20 microvolts and a range of 126 dB.

HIGH-POWER AUDIO AMPLIFIER: The amplifier portion of the Type 1308-A Audio Oscillator and Power Amplifier will produce from 20 to 200 watts from a 2-volt input. See page 137.

Type 1206-B UNIT AMPLIFIER

This well-designed, high-quality, compact amplifier delivers 3 watts at audio and ultrasonic frequencies. It has many uses in the laboratory — as a bridge amplifier, as a driver for low-power electronic and electro-acoustical devices, and as an amplifier for use with the TYPE 1210-C Unit R-C Oscillator. Single-ended, push-pull circuit produces excellent low-frequency response.



SPECIFICATIONS

INPUT

Voltage: Less than 1 V for full power output.

Impedance: 100,000 Ω in parallel with 35 pF.

OUTPUT

Power: With TYPE 1203 Unit Power Supply, 600-Ω load: 3 W from 10 c/s to 50 kc/s; 1.5 W from 5 c/s to 100 kc/s; 0.5 W at 250 kc/s.

Load Impedance: 600 Ω optimum. Blocking capacitor is 100 μF. (Internal impedance about 100 Ω.)

Distortion: Less than 1% harmonic distortion with 2-W output (2% with 3 W) into 600 Ω from 20 c/s to 40 kc/s.

Ac Hum in Output: Less than 15 mV, rms, with TYPE 1203 Unit Power Supply; less than 3 mV, rms, with TYPE 1201 Unit Regulated Power Supply.

Voltage Gain: Continuously adjustable. Max gain is 50 to 1 (34 dB), with no load; 42.5 to 1 (32.6 dB) into 600 Ω.

Frequency Response: (See curve above.) Down less than 3 dB at 2 c/s and 500 kc/s at 10-V (or less) output, with gain control set at maximum. See also power output specification.

Pulse Response:	*No Load*	*600 Ω*
Droop in 30-cycle square wave	15%	20%
Approx rise time: 50 V, p-to-p	1 μs	2 μs
100 V, p-to-p	2 μs	4 μs
Max output, p-to-p magnitude	260 V	120 V

GENERAL

Power Required: TYPE 1203 Unit Power Supply or TYPE 1201 Unit Regulated Power Supply (page 215). Will operate satisfactorily from a 400-cycle supply.

Accessories Supplied: Two multipoint connectors.

Accessories Available: Relay-rack adaptor panel (7 in high).

MECHANICAL DATA Unit-Instrument Cabinet (*see page 258*)

	Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
With Power Supply	15	380	5¾	145	6¼	160	9	4.1	11	5

See also *General Radio Experimenter*, November 1953.

Catalog Number	*Description*	*Price*
1206-9702	**Type 1206-B Unit Amplifier**	**$95.00**
1203-9702	**Type 1203-B Unit Power Supply** (for 105-125 V line)	**55.00**
1203-9818	**Type 1203-BQ18 Unit Power Supply** (for 195-250 V line)	**on request**
0480-9986	**Type 480-P4U3 Relay-Rack Adaptor Panel** (for Amplifier and Power Supply)	**12.00**

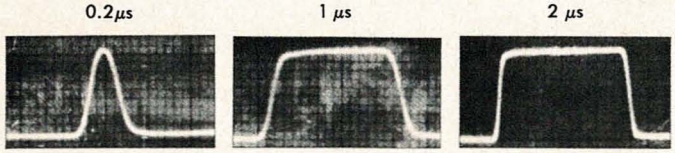
PATENT NOTICE. See Notes 5, 9, and 14, page 11.

Amplifier plugs into the Unit Power Supply. Units lock together to form a rigid assembly.

Type 1233-A POWER AMPLIFIER

USES: The wide frequency range and high power output of this amplifier make it adaptable to many uses in electronic and electro-acoustical laboratories. Typical uses are:

- Exciting antennas for radiation-pattern and impedance measurements.
- Driving acoustic generators.
- Amplifying received signals for operating remote modulation and frequency monitors.
- Amplifying weak signals for oscilloscope deflection.



Output pulse waveforms 20-cycle to 3-Mc range; input-pulse rise time, 0.03 μs; three pulse lengths shown.

DESCRIPTION: The excellent frequency response of this amplifier is obtained in three push-pull, broadband circuits with series-peaked interstage couplings. The two power ranges use toroidal output transformers; the voltage-amplification range uses a series-peaked video-output network with gradual roll-off above 3 Mc/s. Ranges are selected by panel switch. Meter reads output volts and can be switched to read plate current of output tubes.

SPECIFICATIONS

Input Voltage: Less than 0.2 V for full output.

Input Impedance: 100,000 Ω in parallel with 37 pF (grounded).

Power Required: 105 to 125 or 210 to 250 V, 40 to 60 c/s; 120 W at zero output; 140 W max. On 400-cycle supply, max output is 10 W.

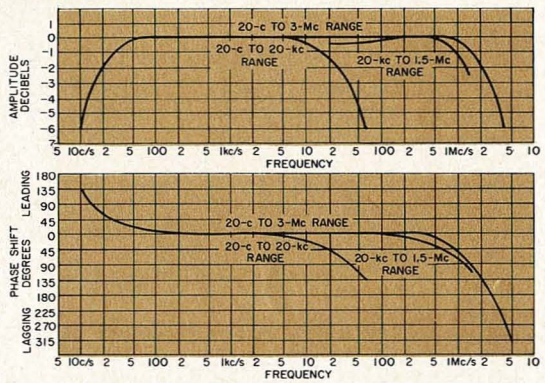
Voltmeter: Full-wave-average type; 150, 50, and 15 V, full scale; accuracy ±10%, compensated to 3 Mc/s.

Terminals: Input and output, TYPE 874 Coaxial Connectors with ground post for double-plug connection; TYPE 938 Binding Posts for balanced output. For adaptors to other coaxial types, see page 81.

Accessories Supplied: Two TYPE 274-MB Double Plugs, TYPE CAP-22 Power Cord, spare fuses.

Mechanical Data: Relay-Rack Panel with end frames for bench use.

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
19½	495	7½	190	15½	395	46½	21.5	56	26



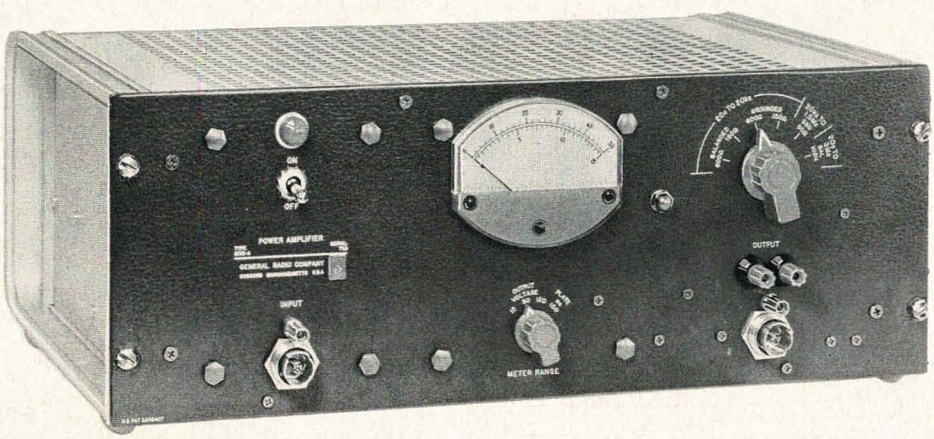
(Above) Typical response curves. The smooth roll-off at the high end ensures good transient response. (*Below*) Phase shift versus frequency for Type 1233-A Power Amplifier.

Range Switch Position	*Operating Freq Range*	*Output Power**	*Output Voltage*	*Optimum Load Impedance*	*Rise Time*	*Distortion at Rated Output*	*Noise Level*
20 c/s to 20 kc/s	20 c/s — 20 kc/s 50 c/s — 15 kc/s	8 W 15 W		600 or 150 Ω		4%	60 dB below 15 W or equivalent to 200 μV input.
20 kc/s to 1.5 Mc/s	20 kc/s — 1.5 Mc/s 20 kc/s — 0.5 Mc/s	8 W 15 W		50 Ω grounded		4%	70 dB below 15 W or equivalent to 63 μV input.
20 c/s to 3 Mc/s	20 c/s — 3 Mc/s		150 V, p-to-p, bal; 50 V grounded	CRO deflection plates; 1 MΩ, 36-in leads	0.1 μs	4%	Less than 0.6 V, p-to-p, bal, or equivalent to 600 μV p-to-p input.
Disconnected	Any single frequency, 20 c/s to 5 Mc/s; 15 W, with external tuned output transformer						

* Rated output is obtainable at 105-V line; output is greater for higher line voltages.

Catalog Number	*Description*	*Price*
1233-9701	**Type 1233-A Power Amplifier**	**$690.00**

PATENT NOTICE. See Notes 4 and 15, page 11.



20 c/s TO 3 Mc/s

ATTENUATORS

Calibrated attenuators are basic instruments for measurement of voltage ratios, linearity, circuit gain or loss, transmission efficiency, and for the calibration of meters and other measuring devices. Described in this section are resistive decade attenuators, precise voltage dividers, and an audio-frequency Microvolter* for use with an audio oscillator to standardize low output voltages.

* Trademark registered in U.S.A.

Type 546-C AUDIO-FREQUENCY MICROVOLTER*

FEATURES:

Converts an audio oscillator to an audio signal generator.
An excellent frequency characteristic — up to 100 kc/s.
Excellent accuracy for absolute voltage levels as well as for voltage ratios.
Decibel and voltage scales.

DESCRIPTION: This instrument consists, essentially, of a constant-impedance attenuator and a voltmeter that standardizes the input to the attenuator. A switch controls the output voltage in decade steps, while an individually calibrated dial provides continuous control over each decade.

USE: The TYPE 546-C Audio-Frequency Microvolter used in conjunction with an oscillator is a useful source of small, known, audio-frequency voltages for response measurements of amplifiers, transformers, and other audio equipment. The Microvolter can also be used to measure small voltages by substitution methods.

SPECIFICATIONS

Output-Voltage Range: From 0.5 μV to 1.0 V open circuit, when the input voltage is set to the reference value (2.2 V).

Accuracy: Open-circuit output voltage, $\pm(3\% + 0.5\ \mu V)$ for output settings above 1 μV and for frequencies between 20 and 20,000 c/s. For frequencies up to 100 kc/s, $\pm 5\%$ for output settings above 100 μV. These specifications apply only where waveform and temperature errors are negligible.

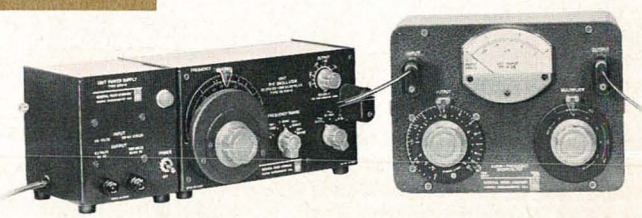
Ratios of output voltage at a given frequency, $\pm(2\% + 0.5\ \mu V)$ up to 100 kc/s. Above 20 kc/s this accuracy applies only at levels above 100 μV.

The Microvolter can be used on dc with an external dc meter. Internal meter can be calibrated for dc.

Output Impedance: Approximately 600 Ω, constant with setting within $\pm 5\%$. No correction of the output voltage is necessary for load impedances of the order of 100,000 Ω and greater.

Input Impedance: Approximately 600 Ω, substantially independent of output setting on all but the highest multiplier position.

Waveform Error: When this instrument is used as a calibrated attenuator or voltage divider, accuracy is independent of waveform. Absolute accuracy of output-voltage calibration depends on the characteristics of the input copper-oxide rectifier voltmeter, which has a small waveform error that can usually be neglected when the Microvolter is used with ordinary laboratory oscillators. The rectifier-type voltmeter introduces some distortion unless source impedance is very low. With a 600-Ω source, distortion introduced is about 0.2%.



The Microvolter with the Type 1210-C Unit R-C Oscillator.

Temperature Error: Ratios are independent of temperature. Absolute accuracy is affected slightly by temperature because of change in the voltmeter characteristics. Correction for temperatures from 65 to 95°F is furnished. The effects of humidity are negligible.

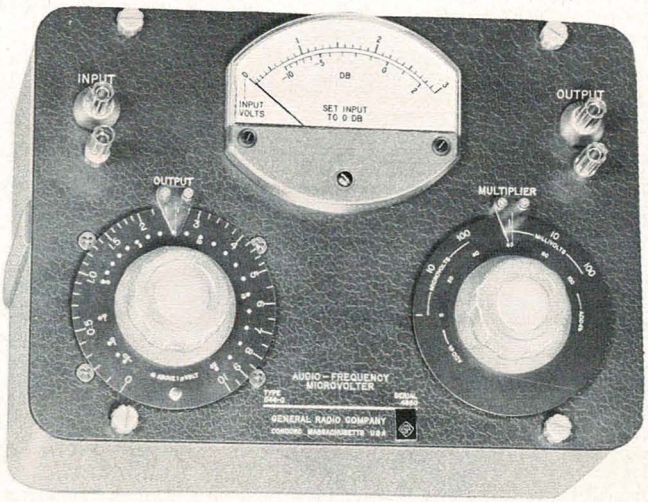
Input Requirements: 2.2 V across 600 Ω, or 8 mW.

Mechanical Data: Lab-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
10	255	7¼	185	6¼	160	6½	3	13	6

Catalog Number	*Description*	*Price*
0546-9703	**Type 546-C Audio-Frequency Microvolter***	**$195.00**

PATENT NOTICE. See Note 15, page 11.



Type 1450 DECADE ATTENUATOR — 0-110 dB

FEATURES:

Wide range of attenuation values in small steps.
Accuracy is maintained even at low radio frequencies.
Convenient, decade-type switches are arranged for break-before-make operation to prevent "blasting" and meter damage. They can be adjusted for make-before-break operation if requested at time of ordering.

USES: The TYPE 1450 Decade Attenuator provides accurate steps of attenuation for power-level measurements, transmission-efficiency tests, and gain or loss measurements on transistors, filters, amplifiers, and similar equipment. It can also be used as a power-level control in circuits not equipped with other volume controls.

DESCRIPTION: The resistors used in each decade are mounted in compartments in an aluminum housing, which is completely shielded by the addition of aluminum covers. Each decade consists of four T-pads series-connected by cam-operated switches, arranged with positive detents. All cams are mounted on a control shaft, which is provided with ball bearings. Each pad is completely shielded, and a shield is interposed between the input and output series elements of each pad. Each decade has eleven positions, 0 to 10 inclusive, so the decades overlap. There are no stops on the 0.1- and 1-dB-per-step decades, so that quick return from full to zero attenuation is facilitated.

SPECIFICATIONS

Attenuation Range: 110 or 111 dB in steps of 1 or 0.1 dB, respectively.

Terminal Impedance: 600 Ω in either direction. An etched plate indicates the mismatch loss for other than 600-Ω circuits.

Accuracy: Each individual resistor is adjusted within ±0.25% of its correct value. The low-frequency error in attenuation is less than ±0.02 dB ± 0.25% of indicated dB setting plus a switch-resistance error of 0.003 dB (for -TA) or 0.005 dB (for -TB), when attenuator is terminated at both ends in a pure resistance of 600 Ω. For differences in attenuation between any two settings, switch-resistance error virtually disappears. To maintain accuracy at high attenuations, special wiring methods are employed to the "low" INPUT post.

Frequency Discrimination (with low terminal at panel potential): Less than 0.1 dB ± 1% of the indicated value at frequencies below 200 kc/s. For increments in attenuation, the 1% tolerance extends to approximately 1 Mc/s.

Maximum Input Power: 1 W.

Switches: Cam-type switches are used with twelve positions covering 360°. Dials are numbered from 0 to 10 inclusive, and the twelfth point is also connected to 0. Stops are provided in the switch mechanism for the 100-dB decade. No stops are provided to prevent complete rotation of the 10- and 1-dB decades, but spacers, which are provided, can be used under the mounting screws to act as stops for the knob, if desired.

Characteristic Impedance: 600 Ω both directions. One end must be terminated in 600 Ω.

Terminals: Low-thermal-emf jack-top binding posts with ¾-inch spacing; common terminal insulated from chassis; ground terminal provided.

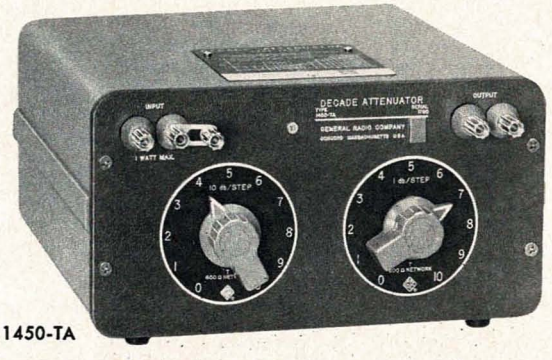
Shielding: Each decade is individually shielded, and all shields are connected to the panel, to which the "G" post is also connected. Terminals are insulated from panel, the "low" ones being connected together. The user is thus given free choice of grounding point for the "low" side, including connection to the panel post by the link provided.

Mechanical Data: Lab-Bench Cabinet (*see page 258*)

	Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
-TA	10	255	5¾	145	12¼	315	10¾	4.9	17	8
-TB	12	305	5¾	145	12¼	315	14½	7	20	9.5
-TAR	19	495	5¾	145	12¼	315	12	5.5	22½	10.5
-TBR	19	495	5¾	145	12¼	315	15½	7.5	26	12

Catalog Number	*Description*	*dB Attenuation Max*	*dB Attenuation Per Step*	*Price*
1450-9891	**Type 1450-TA Decade Attenuator,** Bench Model	110	1	**$285.00**
1450-9894	**Type 1450-TAR Decade Attenuator,** Rack Model	110	1	**295.00**
1450-9893	**Type 1450-TB Decade Attenuator,** Bench Model	111	0.1	**390.00**
1450-9895	**Type 1450-TBR Decade Attenuator,** Rack Model	111	0.1	**400.00**

Type 1450-TB



Type 1450-TA

Type 1454 DECADE VOLTAGE DIVIDER

FEATURES:

Two models, 10,000 ohms and 100,000 ohms. ■ Constant input resistance.
Linearity, 0.005% of full scale.
High accuracy, 0.04% of indicated ratio.
Low-thermal-emf binding posts. ■ Complete shielding.

USES: The TYPE 1454 Decade Voltage Divider provides accurately known voltage ratios from 0.0001 to 1.0000 for use in determining voltage transmission ratios by direct comparison or by null methods, in linearity measurements and in meter calibration.

Its high input impedance, high resolution, and high accuracy make it a widely used laboratory accessory for dc and audio-frequency measurements.

DESCRIPTION: Four decade resistors of the 510-type are connected in a Kelvin-Varley circuit. The voltage drop in switches and wiring is compensated by a resistor so that accuracy is maintained down to the lowest settings. The case provides an electrostatic shield, to which the separate ground terminal is connected. The divider circuit can be used either grounded or floating, as desired.

SPECIFICATIONS

Voltage Ratio: 0.0001 to 1.0000 in steps of 0.0001.

Linearity: ±0.005% of full scale at dc and low-audio frequencies for input voltages below one-half of maximum rating (see below).

Accuracy: ±0.04% of indicated ratio $\pm 4 \times 10^{-8}$ of full scale for input voltage below one-half of maximum rating (see below). With low terminals common, there is an additional $\pm 2 \times 10^{-7}$ of full scale error.

Frequency Characteristics: If the external capacitance across the output terminals of the TYPE 1454-A is less than 50 pF, the frequency error is less than 0.1% to 20 kc/s for any setting. For the TYPE 1454-AH, the limit is 2 kc/s for the same capacitance.

Input Resistance: TYPE 1454-A, 10,000 Ω. TYPE 1454-AH, 100,000 Ω.

Maximum Input Voltage: For TYPE 1454-A, 230 V, rms (or dc), for 40°C rise of resistors of the input decade. Input voltage should be limited to 120 for maximum accuracy. At maximum rated voltage the total error can approach ±0.1%. For TYPE 1454-AH, 700 V, rms, limited to 350 V for maximum accuracy.

Resistance Units: TYPE 510 Decade Resistors.

Temperature Coefficient: Of each resistor, less than ±0.002% per degree C. Since the voltage ratios are determined by resistors of similar construction, ambient temperature effects are very small.

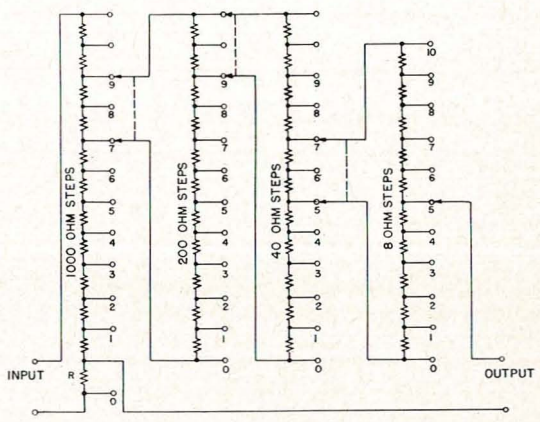


TABLE I

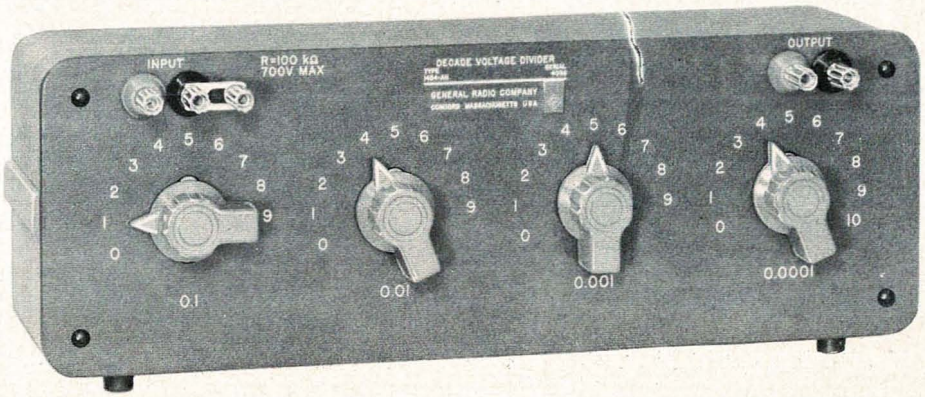
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0	189	356	501	624	725	804	861	896	909
0.1	900	1069	1216	1341	1444	1525	1584	1621	1636	1629
0.2	1600	1749	1876	1981	2064	2125	2164	2181	2176	2149
0.3	2100	2229	2336	2421	2484	2525	2544	2541	2516	2469
0.4	2400	2509	2596	2661	2704	2725	2724	2701	2656	2589
0.5	2500	2589	2656	2701	2724	2725	2704	2661	2596	2509
0.6	2400	2469	2516	2541	2544	2525	2484	2421	2336	2229
0.7	2100	2149	2176	2181	2164	2125	2064	1981	1876	1749
0.8	1600	1629	1636	1621	1584	1525	1444	1341	1216	1069
0.9	900	909	896	861	804	725	624	501	356	189

Output Resistance: Varies with output setting, from zero to approximately 2700 Ω for the TYPE 1454-A, from zero to approximately 27,000 Ω for the TYPE 1454-AH, depending primarily on the setting of the highest decade in use. Directions for accurate calculation of the output resistance are given in the instruction manual. Approximate values can be determined by interpolation from the figures in the table at the left, which apply to the 10,000-Ω model; for the 100,000-Ω model, multiply the values by 10.

Mechanical Data: Lab-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
15¾	400	5	130	5½	135	7¼	3.3	9	4.1

Catalog Number	*Description*	*Price*
1454-9701	**Type 1454-A Decade Voltage Divider** (10,000 ohms)	**$160.00**
1454-9817	**Type 1454-AH Decade Voltage Divider** (100,000 ohms)	**160.00**



IMPEDANCE MEASUREMENT

Null methods have long been recognized as the most precise and convenient way to measure all types of impedance — resistive and reactive, inductive and capacitive, from low frequencies to uhf. Most null-type instruments evolved from the century-old Wheatstone Bridge, still the fundamental circuit for measuring dc resistance. Other null circuits, such as the admittance meter and transfer-function bridge, have been developed by General Radio to meet the diverse requirements of modern measurement. In all, GR produces 19 bridges, covering virtually the entire field of impedance measurement. Some of these bridges include built-in generator and detector and are thus complete, self-contained measurement systems. Others are available in combination with various General Radio oscillators and detectors, as complete assemblies.

DC BRIDGES

The Wheatstone bridge measures an unknown resistance, R_X, in terms of calibrated standards of resistance connected as shown in Figure 1. The relation is:

$$R_X = \frac{R_N R_B}{R_A} \qquad (1)$$

which is satisfied when the voltage across the detector terminals is zero.

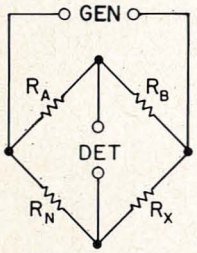
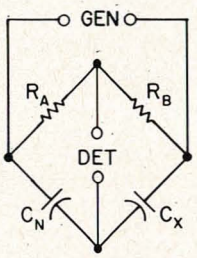
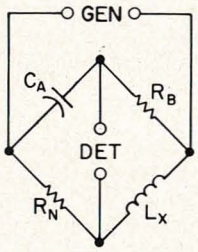


Figure 1. The general Wheatstone bridge circuit.





Figures 2 and 3. Circuits for capacitance bridges in which like reactances (*left*) or unlike reactances (*right*) are compared.

AC BRIDGES

The Wheatstone bridge circuit is easily adapted to ac measurement. With complex impedances, two balance conditions must be satisfied, one for the resistive component and one for the reactive component. At balance:

$$Z_X = R_X + jX_X = Z_N Y_A Z_B \qquad (2)$$

or

$$Y_X = G_X + jB_X = Y_N Z_A Y_B \qquad (3)$$

Equation (2) expresses the unknown in terms of impedance components; equation (3) expresses the unknown as an admittance. To satisfy these equations, at least one of the three arms *A*, *B*, or *N* must be complex.

The reactance X_X can be measured in terms of a similar reactance in an adjacent arm (Figure 2) or an unlike reactance in the opposite arm (Figure 3).

The complex arm required to satisfy the balance conditions of equation (2) or (3) is a combination of a resistance and a reactance, in series or in parallel. With a *series* combination in an arm *adjacent* to the unknown or a *parallel* combination in the arm *opposite* the unknown, the bridge measures the equivalent series components of the unknown. Conversely, an adjacent parallel or an opposite series combination will yield a measurement of equivalent parallel components. (Every impedance can be expressed in terms of either series or parallel equivalents, as discussed below.) Examples of various combinations as used in the Type 1608-A Impedance Bridge are shown on page 49.

If both components of this complex arm are adjustable, the balances for the real and imaginary parts of the unknown will be independent of each other and orthogonal. If only one component of the combination is adjustable, this component will be proportional to either the *D* or the Q of the unknown impedance. If the adjustable component is the more prominent of the two, as it is when very low-Q inductors are measured, the balance convergence is slow, if not impossible. The general-purpose Type 1650-A Impedance Bridge uses a mechanical ganging of the bridge controls (called ORTHO-NULL®) to facilitate convergence.

D AND Q

An important characteristic of an inductor or a capacitor, and often of a resistor, is the ratio of resistance to reactance or of conductance to susceptance. The ratio is called dissipation factor, *D*, and its reciprocal is storage factor, Q. These terms are defined in Figure 4 in terms of phase angle θ and loss angle δ. Dissipation factor is directly proportional to energy dissipated, and storage factor to energy stored, per cycle. Power factor ($\cos\theta$ or $\sin\delta$) differs from dissipation factor by less than 1% when their magnitudes are less than 0.1.

In Figure 4, *R* and *X* are series resistance and reactance, and *G* and *B* are parallel conductance and susceptance, of the impedance or admittance involved.

Dissipation factor, *D*, which varies directly with power loss, is commonly used for capacitors. Storage factor, Q, is more often used for inductors because it is a measure of the voltage

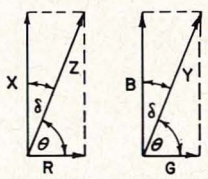


Figure 4. Vector diagram showing the relations between factors *D* and Q, and angles θ and δ.

$$D = \cot\theta = \frac{R}{X} = \frac{G}{B} = \frac{1}{Q} = \tan\delta$$

$$\text{Power Factor} = \cos\theta = \frac{R}{Z}$$

$$Q = \tan\theta = \frac{X}{R} = \frac{B}{G} = \frac{1}{D} = \cot\delta$$

step-up in a tuned circuit. Q is also used for resistors, in which case it is usually very small.

Most General Radio capacitance and inductance bridges also measure *D* or Q.

Series and Parallel Components

Many GR impedance bridges give the user the option of measuring the unknown in terms of either its series or parallel equivalents. The choice is a matter of convenience for the problem at hand. Since the distinction between series and parallel equivalents is sometimes overlooked in texts, we will briefly summarize the relationships here.

Regardless of physical configuration, every impedance can be expressed, for any given frequency, as either a series or a parallel combination of resistance and reactance, as shown in Figure 5. The relations between the elements of Figure 5 are:

$$R_P = \frac{1}{G_P} = \frac{R_S^2 + X_S^2}{R_S} = R_S(1 + Q^2)$$

$$X_P = \frac{1}{B_P} = \frac{R_S^2 + X_S^2}{X_S} = X_S(1 + D^2)$$

In terms of series and parallel capacitive and inductive reactances, these relations become:

$$C_P = C_S\left(\frac{1}{1 + D^2}\right)$$

$$C_S = C_P\,(1 + D^2)$$

$$L_P = L_S\left(1 + \frac{1}{Q^2}\right)$$

$$L_S = L_P\left(\frac{Q^2}{1 + Q^2}\right)$$

Where:

$$Q = \frac{X_S}{R_S} = \frac{R_P}{X_P} = \frac{B_P}{G_P} = \frac{\omega L_S}{R_S} = \frac{R_P}{\omega L_P} = \frac{1}{D}$$

and

$$D = \frac{1}{Q} = \frac{R_S}{X_S} = \frac{X_P}{R_P} = \frac{G_P}{B_P} = \omega R_S C_S = \frac{1}{\omega R_P C_P} = \frac{1}{Q}$$

If Q is 10 or more (or if *D* is 0.1 or less), the difference between series and parallel reactance is no more than 1%. For very low Q's or high *D*'s, however, the difference is substantial: when Q = 1, X_P is twice X_S. If there were no losses in the reactive elements (i.e., *D* = 0), X_S and X_P would be equal.

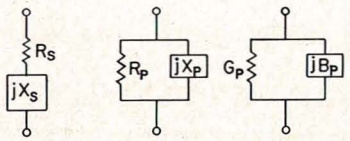
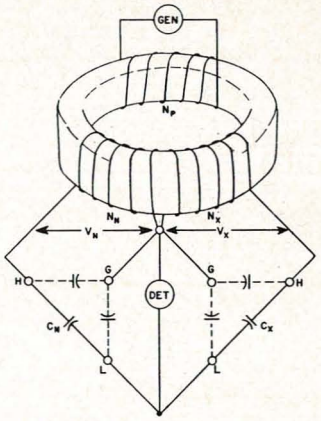


Figure 5. Series and parallel components of impedance.

Substitution Methods

In many ac bridges, the unknown is connected in series or in parallel with the main adjustable component, and balances are made before and after the unknown is connected. The magnitude of the unknown then equals the change made in the adjustable component, since the total impedance of the unknown arm remains constant. The chief advantage of this substitution technique is that its accuracy depends only on the calibration of the adjustable arm and not on the other bridge arms (as long as they are constant). The substitution principle can also be used to advantage with any bridge if the balances are made with an external, calibrated, adjustable component.

Figure 6. A capacitance bridge with transformer ratio arms.



BRIDGES WITH ACTIVE ELEMENTS

If a potentiometer-amplifier combination is connected as a bridge element, fixed capacitance and conductance standards can be used, with current adjusted by variation of voltage rather than of impedance magnitude. The principle is used in the Type 1633-A Incremental-Inductance Bridge, which can accurately measure nonlinear elements.

THE TRANSFORMER RATIO-ARM BRIDGE

Transformer ratio arms, introduced almost a century ago, have recently come into considerable favor because of certain outstanding advantages. Ratio accuracies of a few parts per million are possible, even for transformer ratios of up to 1000 to 1, and the ratio is virtually unaffected by age, temperature, and voltage.

Figure 6 shows a transformer bridge in elementary form. The balance condition for capacitance is

$$\frac{C_X}{C_N} = \frac{N_N}{N_X}$$

Figure 6 also explains the exceptional ability of the transformer bridge to make three-terminal measurements without the use of a guard circuit or auxiliary balance. Capacitances from the H terminals appear across the low-impedance transformer winding, while those from the L terminals are across the detector, where they do not enter the balance expression. These capacitances are thus excluded from the measurement of direct capacitance, C_X, between H and L terminals. Because this type of bridge can tolerate relatively large capacitances from both sides of the unknown to the guard point, long cables with guard shields can be used for remote measurement, and circuit capacitances can often be measured *in situ*.

Conventional bridges can also be adapted for three-terminal measurements (although they generally cannot tolerate as low an impedance to guard). On the Types 1650-A and 1608-A Impedance Bridges, any stray capacitance is in parallel with a standard capacitor of at least 0.1 μF and usually has negligible effect. A Wagner-type guard circuit (Type 716-P4) is available for use with the Type 716-C Capacitance Bridge. On the Type 1650-A Impedance Comparator an electronic amplifier provides a guard point.

LIMIT BRIDGES AND COMPARATORS

In limit bridges, the unbalance voltage of the bridge actuates a meter, which indicates the degree of deviation of one impedance from another. The Type 1652-A Resistance Limit Bridge, which includes an adjustable standard resistor, can limit-test resistors over a wide range. The Type 1605-A Impedance Comparator indicates the magnitude and phase differences between the unknown and an external standard. On this instrument, the availability of several sensitive ranges enables the user to measure small differences very accurately. For instance, the nominal ±3% accuracy of the comparator is translated into an actual measurement accuracy of ±0.009% on the ±0.3% full-scale range if suitable standards are used.

THE AUTOMATIC BRIDGE

The ultimate in convenience is a bridge that balances itself. The Type 1680-A Automatic Capacitance Bridge, introduced in this catalog, fully automates the balance procedure — selecting range, balancing, and indicating both capacitance and loss in digital in-line form.

The implications of such automatic measurement are far-reaching. The conversion of bridge-measured data into digital and binary-coded form (the Type 1680-A has a binary-coded decimal output) gives the bridge access to the whole modern arsenal of data-processing equipment — printers, tape-punchers, sorters, etc. Speed is one obvious byproduct of automatic equipment: GR's new automatic bridge takes about one-half second to achieve balance.

COAXIAL-LINE INSTRUMENTS

The Slotted Line

The upper-frequency limit of conventional bridge circuits using lumped-parameter elements depends on the magnitude of the residual impedances of the elements and leads. The corrections for these usually become unmanageable at frequencies above a few hundred megacycles, and circuits based on coaxial-line techniques are more satisfactory.

One of the basic methods of measuring the impedance of a coaxial device is the measurement of the standing-wave ratio it introduces in a uniform line. The measurement is best made by a slotted line, an instrument consisting of a length of coaxial air line with a longitudinal slot in its outer conductor and an electrostatic probe, which enters the line through the slot. The probe is moved along the length of the line, sampling the field inside. Thus are the magnitudes and positions of voltage maxima and minima determined and, from this information, the impedance of an unknown connected to the line. In this instrument the impedance standard is the line itself, and its accuracy depends primarily on its physical dimensions.

General Radio offers two slotted lines: the Type 874-LBA, for general impedance measurements, and the highly accurate Type 900-LB, the most advanced slotted line available commercially.

The Admittance Meter

The Type 1602-B UHF Admittance Meter uses adjustable loops to sample the currents flowing in three coaxial lines fed from a common source and terminated, respectively, in the unknown, a standard conductance, and a standard susceptance. The loops are adjusted so that the combined output from them is zero (a null balance). Scales associated with the three loops give the value of the unknown directly, in terms of admittance.

The Transfer-Function and Immittance Bridge

The Type 1607-A Transfer-Function and Immittance Bridge is similar to the Admittance Meter described above but also permits four-terminal measurements, such as those of forward and reverse transconductance and transsusceptance, transimpedance, and input-output voltage and current ratios. This bridge is widely used to evaluate the transfer characteristics of transistors and tubes in the vhf and uhf ranges.

GENERATORS AND DETECTORS

Several GR bridges include both generator and detector. Some others — the Types 1615-A, 716-C, and 716-CS1 Capacitance Bridges and the Types 1632 and 1633 Inductance Bridges — are available as complete measuring assemblies, with generator, detector, interconnecting cables, relay rack, and other accessories. Unless one obtains such a complete system, he must carefully choose generator and detector to ensure satisfactory measurement results. (Even with a complete system, the user may at times wish to connect a different generator or detector to the bridge, and almost all GR bridges include panel connectors for such use.)

The chief generator requirements are good frequency stability, adequate power output, and low harmonic content. A wide choice of GR oscillators is available (see pages 128 to 159), covering the frequency range from audio to microwave.

Desirable detector characteristics are

(1) High sensitivity, preferably the ability to detect a few microvolts.

(2) High selectivity, to reject harmonics, noise, and other interfering signals. This is particularly important in measurements on iron-core coils and other nonlinear elements.

(3) Logarithmic or nearly logarithmic response, to minimize gain adjustment during the balancing procedure.

(4) Good shielding, to prevent errors from extraneous pickup.

At audio frequencies, GR's Type 1232-A Tuned Amplifier and Null Detector is recommended for its high sensitivity and for its general versatility in the lab. The Type 1212-A Unit Null Detector is useful up to several megacycles. Crystal mixers are available for both the detectors, extending their frequency ranges to about 60 Mc/s. At these and higher frequencies, the heterodyne type of detector is preferred, because of its wide frequency range and excellent shielding. Type DNT detectors (see pages 108 and 109) operate from 70 kc/s to 2000 Mc/s.

One of the most popular generator-detector combinations, the Type 1311-A Audio Oscillator (50 c/s to 10 kc/s) with the Type 1232-A Tuned Amplifier and Null Detector, is now available in a single assembly as the Type 1240-A Generator-Detector Assembly (see page 106).

CONNECTIONS — SHIELDING

Adequate ground connection and shielded generator and detector leads are always important, but they are particularly so at high frequencies. At audio and low radio frequencies, electrostatic shielding of leads is usually enough; above a few megacycles, coaxial leads, securely grounded to the detector, generator, and bridge shields, are necessary. GR's patch cords and cables (see pages 85 and 257) are recommended for bridge connections.

Type	*Description*	*Ranges*	*Nominal Accuracy*	*Frequency*
CRL BRIDGES (for measurement of electrical components)				
1650-A *(page 50)*	Battery operated, portable, with built-in generator and detector.	C 1 pF-1000μF R 1mΩ-1MΩ L 1μH-1000H also D & Q	±1% ±1% ±1% ±5%	dc, 1kc/s (20c/s — 20kc/s with external generator)
1608-A *(page 48)*	For precise, accurate component selection, lab measurements; built-in generator and detector.	C 0.05pF-1100μF R 0.05mΩ-1.1MΩ L 0.05μH-1100H G 0.05n℧-1.1℧ also D & Q	±0.1% ±0.1% ±0.1% ±0.1% ±5%, ±2%	dc, 1kc/s (20c/s — 20kc/s with external generator)
IMPEDANCE BRIDGES				
1603-A *(page 45)*	Audio frequency. Balances for any Z, from 0 to ∞.	R, X 0-1000Ω G, B 0-1000μΩ	±1% ±1%	20c/s — 20kc/s
916-AL *(page 53)*	Measure antennas, lines, components at radio frequencies.	X ±11kΩ at 100kc/s R 0-1000Ω	±2% ±1%	50kc/s — 5Mc/s
1606-A *(page 52)*		X ±5000Ω at 1 Mc/s R 0-1000Ω	±2% ±1%	0.4 — 60Mc/s
1605-A *(page 46)*	For rapid sorting and matching. Meter indicates deviation. Operates from power line.	ΔZ ±0.01% to ±10% ΔΘ ±0.001 to ±0.1 radian	±3% of reading (±0.01% on most sensitive ranges)	0.1, 1, 10, 100kc/s
CAPACITANCE BRIDGES				
716-C *(page 60)*	Wide frequency range.	C 100pF-1μF, Direct C 100-1000pF, Direct C 0.1-1000pF, Subst D 0.00002-0.56	±0.1% ±0.1% ±0.05% ±2%	1kc/s 30c/s-300kc/s 30c/s-300kc/s 30c/s-300kc/s
716-CS1 *(page 61)*	1-Mc version of Type 716-C	C 0.1-1100pF D 0.00002-0.56	±0.1% ±2%	0.5 — 3Mc/s
1615-A *(page 58)*	High accuracy. Intercomparison accuracy, 1 ppm.	C 10^{-17} — 10^{-6}F D 10^{-6} — 1 G 10^{-6} — 100μ℧	±0.01% ±0.1% ±1%	50c/s-10kc/s
1611-B (1611-BQ1) *(page 67)*	Power-line frequency, for testing insulators, bushings, cables, polarized electrolytic capacitors.	C 0-11,000μF D 0-60% (50%)	±1% ±2%	60 (or 50), 120c/s with external generator
1680-A *(page 63)*	Automatic balancing: with generator, digital readout, and BCD data output. Ac-line operated.	C 0.01pF-100μF C 100pF-1000μF D 0.0001-1.0 G 0.1n℧-1.0℧	±0.1% ±0.1% ±1% ±0.1%	400, 1000c/s 120c/s
INDUCTANCE BRIDGES				
1632-A *(page 68)*	High precision. 6-figure resolution for intercomparison of standard inductors.	L 0.001μH-1111H G 0.01μ℧-1111℧	±0.1% ±1%	20c/s-1kc/s (to 10kc/s with reduced accuracy)
1633-A *(page 70)*	Incremental inductance. For measurement of iron-core coils at high excitation levels. Includes detector.	L 0.2μH-1000H R 10mΩ-1MΩ Q 1-∞	±1% ±2% ±2%	direct-reading at 9 frequencies, 50c/s-15.75kc/s
DC RESISTANCE BRIDGES *(see also* TYPES 1650-A and 1608-A *above and* TYPE 1230-A Electrometer, *page 174.)*				
1652-A *(page 73)*	Limit bridge for production-line or laboratory; operates from ac line.	R 1Ω-1MΩ	±0.5% as limit bridge, ±0.25% by null method	dc
1644-A *(page 74)*	High resistance. Internal test voltages 10-1000 V in 1-2-5 steps. Ac-line operated.	R 10^3 — 10^{15}Ω	±1%	dc
1862-C *(page 75)*	Megohmmeter (Not a bridge)	0.5 × 10^6 — 2 × 10^{12}Ω	±3% to ±12%	dc
VHF, UHF BRIDGES AND SLOTTED LINES				
1602-B *(page 54)*	For X, Y, and VSWR measurements on coaxial lines, antennas, networks, components.	B, G 0.01m℧-0.01℧ X, R 0.1Ω-0.1MΩ	±3%	20-1500Mc/s
1607-A *(page 56)*	Transfer-function bridge for 4-terminal measurements on transistors, tubes, and networks. Also 2-terminal measurements.	B, G 0-400m℧ X, R 0-1000Ω Also Z_{21}, Y_{21}, V_2/V_1, and I_2/I_1	±5%	25-1500Mc/s
900-LB *(page 101)*	High-precision slotted line.	VSWR	±0.13% at 300Mc/s, ±1% at 9Gc/s	300Mc/s-9Gc/s
874-LBA *(page 83)*	General-purpose slotted line.	VSWR	±2.5% at 300Mc/s, ±10.0% at 5Gc/s	300Mc/s-5Gc/s
SPECIAL-PURPOSE BRIDGE				
1661-B *(page 69)*	Measures vacuum-tube characteristics; α, β, and h factors of transistors with calculation.	μ 0.001-10,000 g_m 0.02-50,000μ℧ r_p 50Ω-20MΩ	±2%	270-400c/s, 1kc/s

Type 1603-A Z-Y BRIDGE

FEATURES: Balances for any unknown impedance 0 to ∞. ■ Covers entire audio-frequency range. 1% accuracy to 7 kc/s (to 20 kc/s for resistance and conductance). Fast, convenient operation. ■ Can measure grounded, direct, or balanced impedances.

USES: This remarkable bridge can easily be balanced for any impedance connected to its terminals. For example, it can be used to measure:

R, *L*, and *C* components, or any combination of them.

Impedances of active networks.

Complex impedance characteristics of transformers, transducers, transmission networks, and transistors.

Frequency characteristics of components, such as electrolytic capacitors and sonar elements.

DESCRIPTION: The basic circuit is a resistance-capacitance bridge, and a substitution method of measurement is used. Low impedances are measured directly in terms of *R* and *X*, and high impedances (low admittances) are measured directly in terms of *G* and *B*. *R* and *G* readings are independent of frequency. *X* and *B* are direct reading at 100 c/s, 1 kc/s, and 10 kc/s.

By selection of detector connections, one can measure (1) the grounded impedance, (2) the direct impedance, or (3) the impedance of the equivalent delta circuit, balanced or unbalanced, of the unknown element.

SPECIFICATIONS

RANGES OF MEASUREMENT

Frequency: 20 c/s to 20 kc/s.

Impedance and Admittance: $-\infty$ to $+\infty$.

Unknown is measured as an impedance if the resistance is less than 1000 Ω and the reactance is less than 1000 $(f_o/f)\Omega$.

Unknown is measured as an admittance if the absolute conductance is less than 1000 μ℧ and the absolute susceptance is less than 1000 $(f/f_o)\mu\mho$.

ACCURACY (with unknown grounded)

R: $\pm 1\% \pm (2\ \Omega$ on main R dial *or* $0.2\ \Omega$ on ΔR dial$) \pm 0.0002 f_{kc} X$

G: $\pm 1\% \pm (2\ \mu\mho$ on main G dial *or* $0.2\ \mu\mho$ on ΔG dial$) \pm 0.0002 f_{kc} B$

X: $\pm 1\% \pm (2 f_o/f\ \Omega$ on main X dial *or* $0.2\ f_o/f\ \Omega$ on ΔX dial$) \pm 0.0002 f_{kc} R$

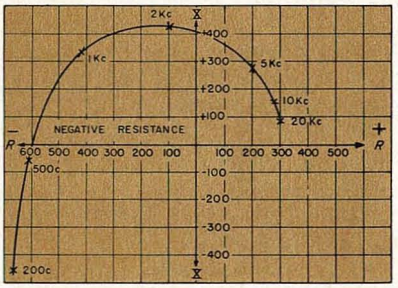
B: $\pm 1\% \pm (2 f/f_o\ \mu\mho$ on main B dial *or* $0.2 f/f_o\ \mu\mho$ on ΔB dial$) \pm 0.0002 f_{kc} G$

These expressions are valid for *R* and *G* up to 20 kc/s; for *X* and *B* the 1% term is valid up to 7 kc/s; above 7 kc/s it becomes 2%, above 15 kc/s, 3%. Slightly larger errors occur at high frequencies for direct or delta measurements.

GENERAL

Generator: External only (not supplied); 20 c/s to 20 kc/s; TYPE 1210-C, 1310-A, or 1311-A Oscillator recommended. Max safe voltage on bridge is 130 V, rms, giving less than 32 V on unknown.

Detector: External only (not supplied); TYPE 1232-A Tuned Amplifier and Null Detector recommended.



Input impedance of a feedback circuit; data taken with Type 1603-A Z-Y Bridge.

Accessories Supplied: TYPE 274-NP Patch Cord, TYPE 874-R34 Patch Cord.

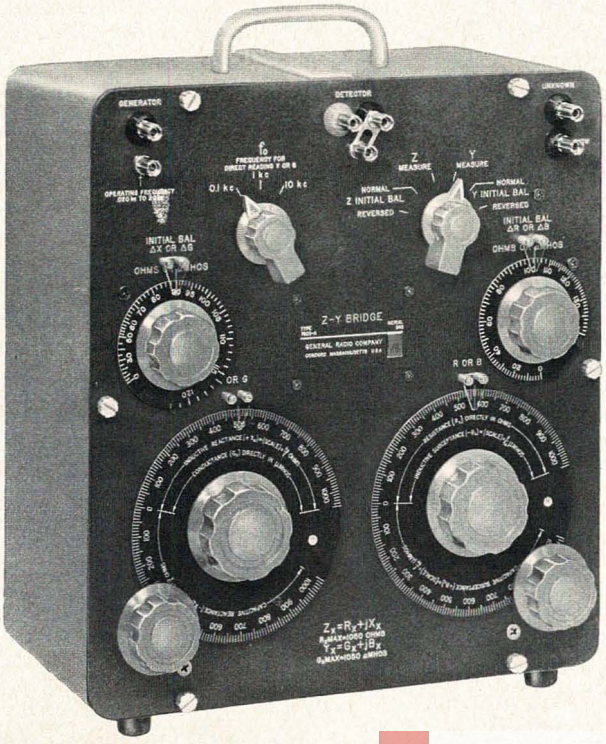
Accessories Required: Generator and detector.

MECHANICAL DATA Lab-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
12½	320	13½	345	8½	220	21½	10	31	14.5

For a more detailed description, ask for General Radio Reprint E-102.

Catalog Number	*Description*	*Price*
1603-9701	**Type 1603-A Z-Y Bridge**	**$515.00**



A UNIVERSAL AUDIO-FREQUENCY IMPEDANCE-MEASURING INSTRUMENT

Type 1605-A IMPEDANCE COMPARATOR

FEATURES:

- High-speed meter indication — no balancing operation required.
- High accuracy.
- Four internal frequencies — 100 c/s, 1 kc/s, 10 kc/s, and 100 kc/s.
- Versatile — compares impedances of any phase angle.
- Wide impedance range — 2 ohms to 20 megohms.
- 0.01%, full-scale (-AH models).
- Compares both impedance magnitude and phase angle simultaneously and indicates direction of unbalance.
- Guard point for reducing effect of stray impedance.
- Completely self-contained.
- Terminals at rear for operation of automatic selection devices, oscilloscope, or recorder.
- Meters are protected from off-scale damage.

USES: Typical uses for this highly precise instrument include:

Rapid testing, sorting, and matching of precision components, etched boards, subassemblies and complex networks, either manually or in combination with automatic sorting equipment.

Measuring the effects of time, temperature, humidity, and pressure on components, with high precision and continuous indication.

Rapid test for tracking of ganged potentiometers and variable capacitors.

Frequency characteristics of components.

Easy comparison of quantities usually requiring laboratory techniques, such as:

Small impedance differences.

D of low-loss dielectric materials.

$D\left(=\frac{1}{Q}\right)$ of inductors.

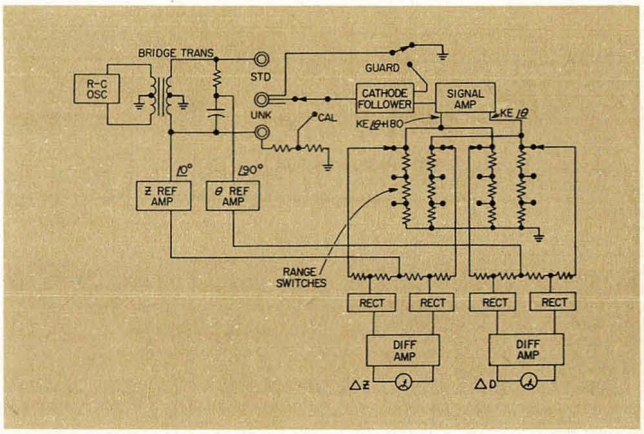
Q or phase angle of wire-wound resistors or potentiometers.

Balance of transformer windings.

Semiconductor capacitances.

Capacitance drift with temperature.

Can also be used as a null bridge with the addition of an adjustable standard, such as the TYPE 1422 Precision Capacitor or the TYPE 1412-BC Decade Capacitor.



Block schematic of the Type 1605-A Impedance Comparator.

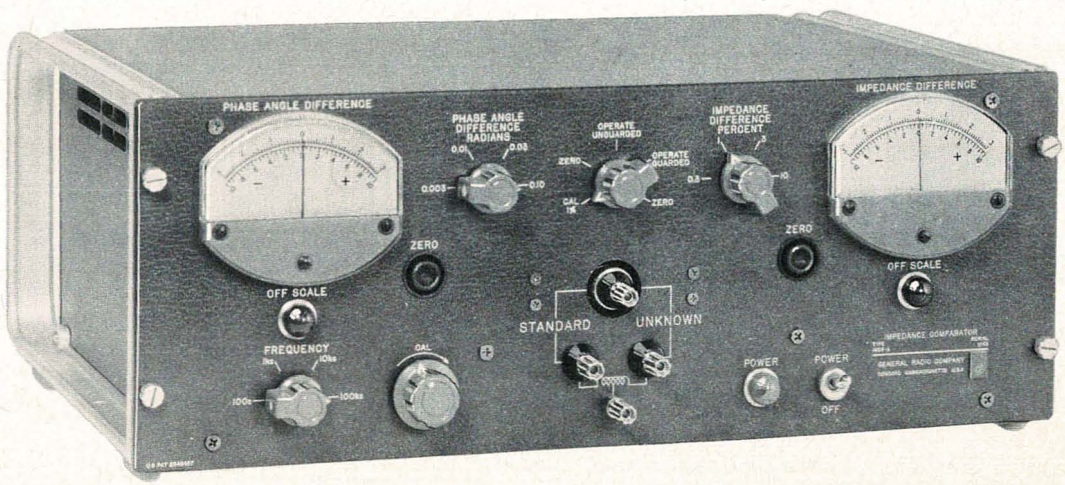
DESCRIPTION: This completely self-contained impedance comparator indicates directly on two panel meters the difference in impedance and phase angle between two elements connected to its terminals. Three highly desirable characteristics not usually obtained together are combined in this unique instrument:

- — high accuracy
- — high speed
- — wide ranges of impedance and frequency.

As a result, not only does it bring laboratory accuracy to production-line inspection, but, conversely, it brings the speed of the production test to measurements in the laboratory.

The basic circuit of the comparator is a bridge, with the unknown and standard impedances serving as two

RAPID, ACCURATE R-L-C LIMIT BRIDGE



of the bridge arms and the halves of a center-tapped transformer secondary winding serving as the other two arms. An internal RC oscillator driving the transformer primary winding produces test voltage frequencies of 100 c/s, 1 kc/s, 10 kc/s, and 100 kc/s. The bridge unbalance voltage, resulting from inequality of standard and unknown impedances, is separated into in-phase and out-of-phase components, which are amplified and indicated directly by two meters reading, respectively, impedance-magnitude difference in percent and phase-angle difference in radians.

The transformer is designed to have as high a degree of coupling as possible between the two halves of its secondary winding. The coefficient of coupling achieved is greater than 0.9997, and the open-circuit voltages of the two halves are balanced within 1 part in 10^6. This makes possible measurement of differences as low as 0.01% on the TYPE 1605-A and 0.003% on the TYPE 1605-AH and minimizes the loading effect of external impedances on the bridge transformer.

An unusual type of cathode-follower circuit provides a very high input impedance for the bridge detector and also a guard terminal, which makes possible the measurement of high impedances at a distance from the instrument, as in an environmental test chamber.

The GR Impedance Comparator in use for production testing of capacitors at Centralab's Milwaukee plant.

For operating external selector circuits, meter voltages are available at the rear of the instrument; a plug connector is supplied.

Calibration can quickly be checked at any time by means of a simple built-in network.

SPECIFICATIONS

RANGES AND ACCURACY

Type 1605-A: *Measurement*	*Impedance Range*	*Impedance-Magnitude Difference*	*Phase-Angle Difference***	*Accuracy*
Resistance or Impedance Magnitude	2Ω to 20 MΩ	±0.3%, ±1%, ±3%, ±10%, full scale. Can be adjusted for maximum of 50%.	±0.03, ±0.01, ±0.03, ±0.1, radian, full scale.	Difference readings accurate to within ±3% of full scale; i.e., for the ±0.3% impedance difference scale, accuracy is 0.009% of the impedance being measured.
Capacitance	40 pF* to 800 μF			
Inductance	20 μH to 10,000 H			
Type 1605-AH:				
Resistance or Impedance Magnitude	20Ω to 20 MΩ	±0.1%, ±0.3%, ±1%, ±3%, full scale. Can be adjusted for maximum of 15%.	±0.001, ±0.003, ±0.01, ±0.03 radian, full scale.	
Capacitance	40 pF to 80 μF			
Inductance	200 μH to 10,000 H			

* To 0.1 pF with reduced accuracy.

** Phase-angle difference is very nearly equal to *D* difference for capacitors and inductors, or to *Q* difference for resistors, as long as *D* or *Q* is less than 0.1.

GENERAL

Test Frequency and Voltage: Internal only, 100 c/s, 1 kc/s, 10 kc/s, 100 kc/s, all ±3%. Voltage across standard and unknown is approximately 0.3 V for TYPE 1605-A and 1 V for TYPE 1605-AH.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, approximately 100 W. Operates satisfactorily on 400 c/s if line voltage is at least 115 V.

Accessories Supplied: TYPE CAP-22 Power Cord, telephone plug, external-meter plug, coaxial adaptor-plate assembly (fits panel terminals), spare fuses.

Models with other meter ranges and other frequencies are available on special order.

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7¼	185	13½	345	29½	13.5	37	17
Rack	19	485	7	180	12*	305	29½	13.5	37	17

* Behind panel.

For a more detailed description, ask for General Radio Reprint E-103.

Catalog Number	*Description*	*Price*
1605-9801	**Type 1605-A Impedance Comparator,** Bench Model	**$925.00**
1605-9811	**Type 1605-A Impedance Comparator,** Rack Model	**925.00**
1605-9951	**Type 1605-AH Impedance Comparator,** Bench Model	**925.00**
1605-9961	**Type 1605-AH Impedance Comparator,** Rack Model	**925.00**

PATENT NOTICE. See Notes 4 and 15, page 11.

Type 1608-A IMPEDANCE BRIDGE

FEATURES:

- 0.1% basic accuracy for C, R, L, and G. Excellent phase-angle accuracy.
- Digital readout for C, R, L, and G; decimal point and unit indicated automatically.
- Appropriate D and Q scales illuminated automatically.
- Measures impedances of any phase angle.
- Rapid balancing with concentric coarse and fine controls for main balance.
- Self-contained generator and detector.

USES: This precise bridge will measure modern precision components requiring an accuracy of 0.1% — capacitance, inductance, and ac resistance and conductance, as well as dc resistance. An almost error-free readout and rapid-balance adjustments allow accurate and fast laboratory or production tests. Six internal ac bridges cover all possible phase angles so that any network can be measured, even such "black boxes" as filters, transducers, and equalizers.

Ac resistance and conductance measurements are made at a frequency of 1 kc/s. A Q adjustment for precise balancing gives phase information useful in predicting their high-frequency performance. This bridge is also useful for measuring high-loss reactances, such as rf chokes, without a sliding null. The high-phase precision of ± 0.0005 radian makes D or Q measurements meaningful on low-loss reactances, which must often have tight D or Q tolerances, for use in precision networks.

A wide range of resistors at EIA-specified dc voltages, three-terminal capacitors and small capacitors remotely located, voltage-biased capacitors or current-biased inductors and resistors can be measured. Almost any impedance is measurable over the audio-frequency range.

The ability to measure small capacitances by a three-terminal connection makes possible the measurement of the capacitance between components, wires, or mounting structures. Long, shielded cables can be used without significantly affecting the accuracy of the measurement.

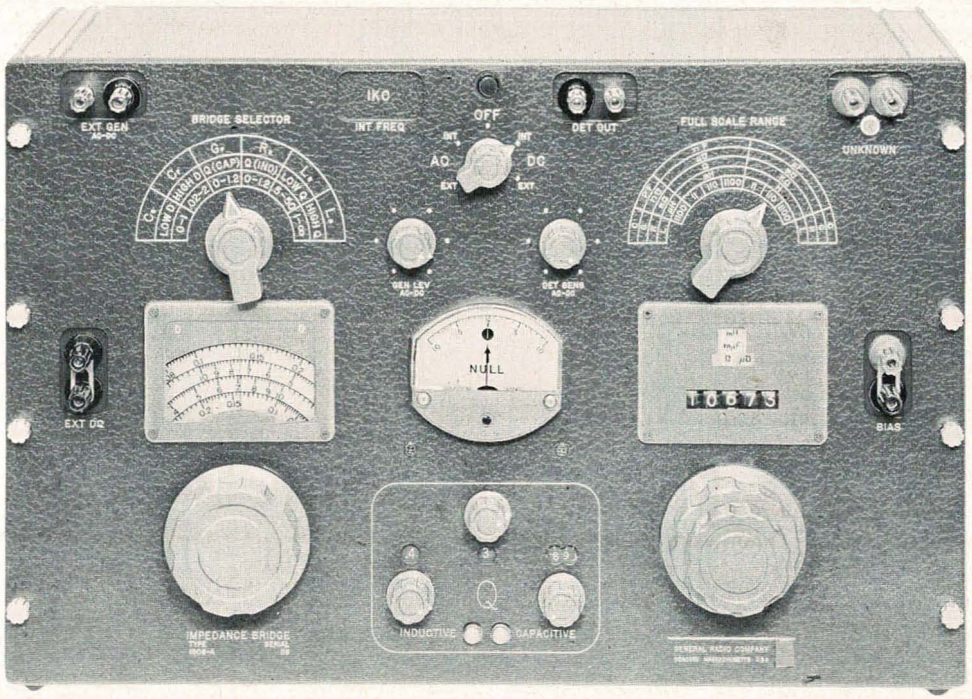
For production testing of components a test jig, TYPE 1650-P1, is available.

DESCRIPTION: This self-contained bridge system includes six bridges, along with suitable ac and dc sources and detectors. The bridge elements are precision units. The wire-wound resistors are similar to those used in General Radio decade resistance boxes; the standard capacitor is a combination silver-mica and stabilized-polystyrene unit, with a low temperature coefficient.

The readout system is digital for C, R, L, and G, as well as for the Q of resistors. D and Q for capacitors and inductors are read from a dial with the correct scale illuminated. Decimal points and units are indicated automatically, and there are no multiplying factors for any quantity at 1 kc/s or dc.

The C-R-L-G readout has both coarse and fine adjustments controlled by concentric knobs.

The 1-kc frequency-selective networks for the internal oscillator and tuned detector are on a plug-in module, which can be easily replaced with modules available for other internal test frequencies. Provision is made for use with an external oscillator and detector. Three dc supplies are included to obtain maximum sensitivity over a wide range of resistance.



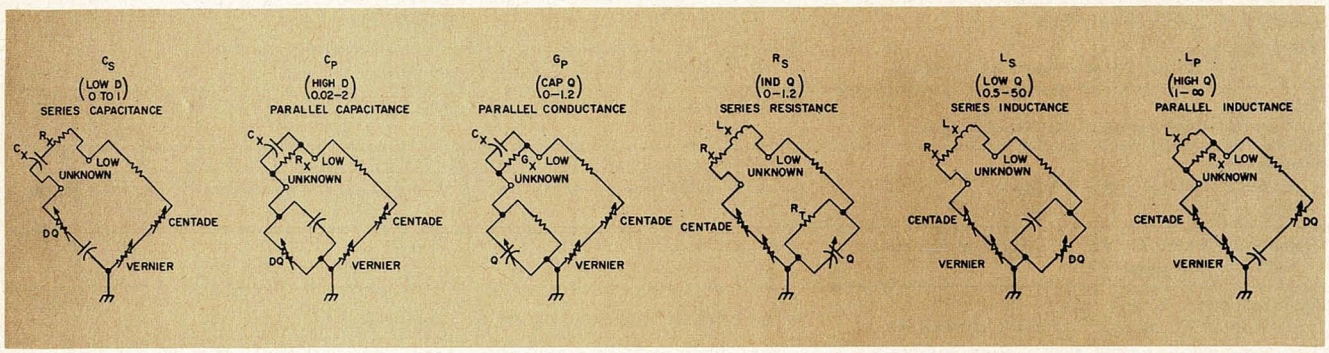
SPECIFICATIONS

RANGES AND ACCURACY

Measurement	*Range*	**1-kc Accuracy*		*Additional Error (for higher frequency and large phase angle)†*
		±0.1% ± 0.005% of full scale	*±0.2% ± 0.005% of full scale*	
Capacitance, series or parallel	0.05 pF to 1100 μF, in 7 ranges	lowest 6 ranges	highest range	$(\pm 0.001\ f_{kc}^2 \pm 0.1D\ f_{kc} \pm 0.5D^2)\%$ of measured value
Inductance, series or parallel	0.05 μH to 1100 H, in 7 ranges	highest 6 ranges	lowest range	
Resistance (series)	0.05 mΩ to 1.1 MΩ, ac or dc	highest 6 ranges	lowest range	$(\pm 0.002\ f_{kc}^2 \pm 0.000001\ f_{kc}^4 \pm 0.1\ Q)\%$ of measured value
Conductance (parallel)	0.05 n℧ to 1.1 m℧, ac or dc (20,000 MΩ to 0.9Ω)	lowest 6 ranges	highest range	
D (at 1 kc/s)	0.0005 to 1 of series capacitance, 0.02 to 2 of parallel capacitance	*D* or 1/*Q* $\pm 0.0005 \pm 5\%$ at 1 kc/s or lower, $\pm 0.0005\ f_{kc} \pm 5\%$ above 1 kc/s		
Q (at 1 kc/s)	0.5 to 50 of series inductance, 1 to 2000 of parallel inductance	$\pm 0.0005\ f_{kc} \pm 2\%$		
	0.0005 to 1.2 (inductive) of series resistance, 0.0005 to 1.2 (capacitive) of parallel conductance			

* Residual terminal impedance: $R \simeq 0.001\ \Omega$, $L \simeq 0.15\ \mu H$, $C \simeq 0.25$ pF.

† Bridge is usable up to 20 kc/s. Dc resistance and conductance accuracy is same as for 1 kc/s, except accuracy is limited by sensitivity at range extremes. Balances to 0.1% are possible from 1 Ω to 1 MΩ with internal supply and detector.



Elementary schematics of the capacitance, conductance, resistance, and reactance bridges.

GENERAL

Generator: Internal, 1 kc/s ± 1% module normally supplied; plug-in modules for other frequencies available on special order. Level control provided. With external generator, frequency range of bridge is 20 c/s to 20 kc/s. TYPE 1310-A or the TYPE 1210-C Oscillator recommended if external generator required. Internal dc supply 3.5, 35, and 350 V, adjustable; power limited to ⅓W or less.

Detector: Internal or external; ac; can be used either flat or selective at frequency of plug-in module (normally 1 kc/s); other frequencies available; second-harmonic rejection about 25 dB. Sensitivity control provided. TYPE 1232-A Tuned Amplifier and Null Detector recommended when external generator is used.

Dc Bias: Capacitors can be biased to 500 V from external source; bias current can be applied to inductors up to 40 mA.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s; 10 W.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses, spare indicator lamps.

Accessories Available: TYPE 1650-P1 Test Jig (page 51).

MECHANICAL DATA Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	12½	320	11½	295	36¾	17	54	24.5
Rack	19	485	12¼	315	10*	285	34¾	16.8	54	24.5

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, March 1962.

Catalog Number	*Description*	*Price*
1608-9801	**Type 1608-A Impedance Bridge,** Bench Model	**$1300.00**
1608-9811	**Type 1608-A Impedance Bridge,** Rack Model	**1300.00**

Type 1650-A IMPEDANCE BRIDGE

FEATURES:

- Completely self-contained and portable.
- Wide impedance range, covering all commonly used components.
- ORTHONULL® balance finder to facilitate low-Q balances.
- Visual null meter — taut-band suspension.
- Transistor oscillator and detector powered by commonly available D cells.
- Dc bias can be applied. ■ Easy-to-read dials.

USES: The TYPE 1650-A Impedance Bridge will measure the inductance and storage factor, Q, of inductors,* the capacitance and dissipation factor, D, of capacitors, and the ac and dc resistance of all types of resistors.

In the laboratory it is extremely useful for measuring the circuit constants in experimental equipment, testing preliminary samples, and identifying unlabeled parts. In the shop and on the test bench it has many applications for testing and component sorting.

Three-terminal measurements can be made in the presence of considerable stray capacitance to ground.

DESCRIPTION: This bridge is completely self-contained and portable. Battery-powered, low-drain transistor oscillator and detector are included. The panel meter indicates both dc and ac bridge unbalances.

The measured quantities, R, L, C, D, and Q, are indicated directly on dials with constant-percentage-accuracy logarithmic scales. Multiplier and the units of measurement are indicated by the range setting.

The bridge circuit elements are high-quality, stable components that ensure long-term accuracy. The ORTHONULL® balance finder, a patented mechanical-ganging device, is used to make a low-Q (high-D) balance possible without a sliding null. This mechanism, which may be switched in or out as desired, adds accuracy as well as convenience to low-Q measurements that are practically impossible on other impedance bridges.

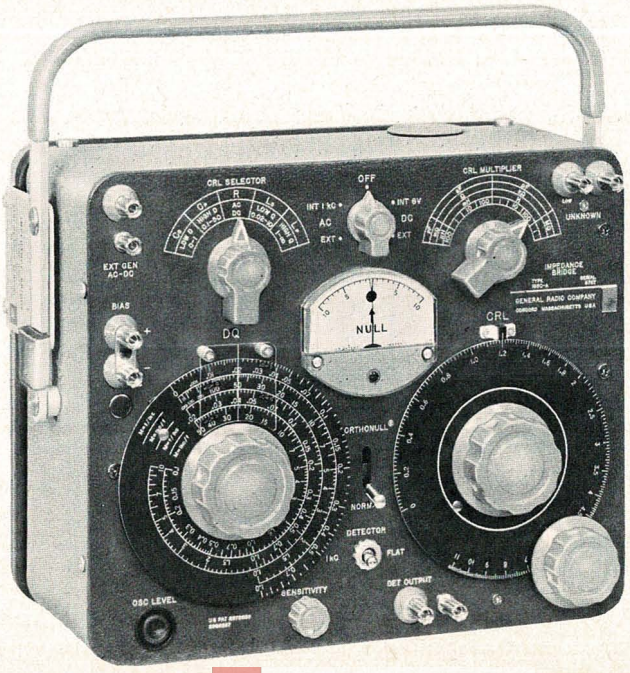
The Flip-Tilt case provides a handle and a captive, protective cover that allows the bridge panel to be tilted and held firmly at any angle. The portable model uses dry cells; the rack model has a built-in, rechargeable battery and charger. Battery and charger are also available, as listed below, for use with portable model.

* Including such low-Q inductors as rf coils measured at 1 kc/s.

SPECIFICATIONS

RANGES OF MEASUREMENT	ACCURACY
Capacitance 1 pF to 1100 μF, series or parallel, 7 ranges.	At internal 1-kc frequency or at 20 c/s to 20 kc/s, externally supplied.† ±1% of measured value or ±1 pF (residual C ≈ 0.5 pF).
Inductance 1 μH to 1100 H, series or parallel, 7 ranges.	At 1 kc/s or 20 c/s to 20 kc/s,† ±1% of measured value or ±1 μH (residual $L \approx 0.2$ μH).
Resistance ac or dc, 1 mΩ to 11 MΩ, 8 ranges.	At 1 kc/s or 20 c/s to 5 kc/s, ±1% or ±1 mΩ (residual $R \approx 1$ mΩ). At dc, ±1% of measured value from 1Ω to 100 kΩ. External dc supply required for 1% accuracy above 100 kΩ.
Dissipation Factor, D, at 1 kc/s. 0.001 to 1 of series C. 0.1 to 50 of parallel C.	±5% of indication ±0.001 at 1 kc/s or lower.
Storage Factor, Q, at 1 kc/s 0.02 to 10 of series L. 1 to 1000 of parallel L.	$\frac{1}{Q}$ = ±5% of indication ± 0.001 at 1 kc/s or lower.

† Bridge operates up to 100 kc/s with reduced accuracy.



COMPLETELY SELF-CONTAINED UNIVERSAL BRIDGE

GENERAL

Generator: Internal; 1 kc/s ± 2%. TYPE 1310-A or TYPE 1311-A Oscillator recommended if external generator is required. Internal dc supply, 6 V, 60 mA, maximum.

Detector: Internal or external; internal detector response flat or selective at 1 kc/s; sensitivity control provided. TYPE 1232-A Tuned Amplifier and Null Detector is recommended if external detector is required.

DC Polarization: Capacitors can be biased to 600 V from external dc power supply for series capacitance measurements.

Power Required: Portable model, 4 D cells, supplied; rack model, rechargeable, 6-volt, nickel-cadmium battery, supplied. Battery capacity is adequate for 40 hours of use in ac measurements, 8 hours minimum in dc measurements. Charging time, 10 hours.

Accessories Required: None. Earphones can be used for high precision at extremes of bridge ranges.

Accessories Available: TYPE 1650-P1 Test Jig.

MECHANICAL DATA Flip-Tilt Case or Rack Mount (*see page 258*)

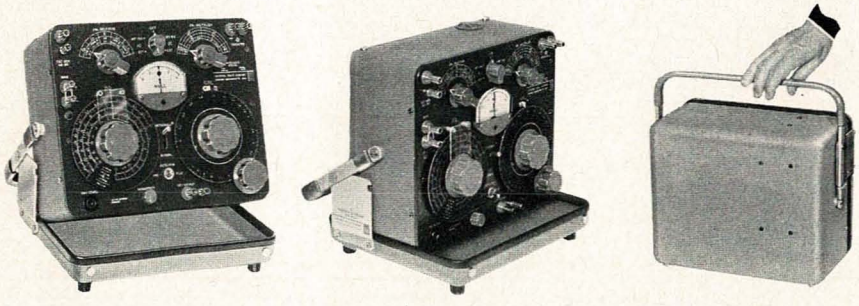
Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
*Portable**	12¾	325	12½	320	7¾	200	17	8	21	10
Rack	19	485	12½	320	5†	130	18	8.5	30	13.5

* Case closed. † Behind panel.

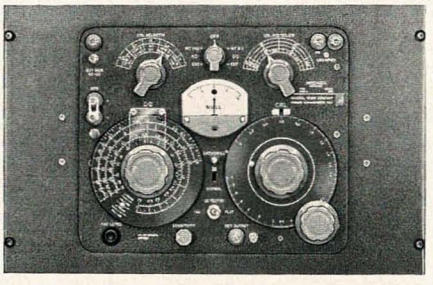
For a more detailed description, ask for General Radio Reprint E-108.

Catalog Number	*Description*	*Price*
1650-9701	**Type 1650-A Impedance Bridge,** Portable Model (with dry cells)	**$475.00**
1650-9540	**Type 1650-A Impedance Bridge,** Rack Model (with rechargeable battery and charger, for 115-volt supply)	**540.00**
1650-9570	**Type 1650-A Impedance Bridge,** Rack Model (with rechargeable battery and charger, for 230-volt supply)	**on request**
1650-9602	**Type 1650-P2 Battery and Charger,** for 115-volt supply	**55.00**
1650-9568	**Type 1650-P2Q18 Battery and Charger,** for 230-volt supply	**on request**

PATENT NOTICE, See Notes 15, 19, and 22, page 11.



Flip-Tilt case holds bridge firmly tilted at almost any angle and provides protection when bridge is not in use.



Type 1650-A Impedance Bridge, for relay-rack mounting.

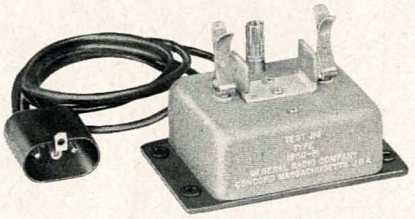
Type 1650-P1 TEST JIG

This test-jig adaptor is used to connect components quickly to a pair of terminals and can be placed on the bench directly in front of the operator. Thus, the test jig and TYPE 1650-A Impedance Bridge make a rapid and efficient component sorting device when the panel meter of the bridge is used as a limit indicator.

The test jig makes a three-terminal connection to the bridge, so that the residual zero capacitance is negligible. The lead resistance (0.08 ohm total) has effect only when very low impedances are measured, and the lead capacitance affects only the measurement of the Q of inductors, introducing a small error in $D\left(\text{or } \frac{1}{Q}\right)$ of less than 0.007.

Net Weight: 10 oz (285 grams).
Shipping Weight: 4 lb (1.9 kg).

Catalog No.	*Description*	*Price*
1650-9601	**Type 1650-P1 Test Jig**	**$20.00**



MINIMIZES EFFECTS OF LEAD CAPACITANCE

Type 1606-A RADIO-FREQUENCY BRIDGE

FEATURES: Wide, frequency range — 400 kc/s to 60 Mc/s. ■ Direct reading in ohms. Fast, simple operation. ■ Accurate, reliable measurements. Small, light, and rugged — suitable for field or laboratory.

USES: The TYPE 1606-A Radio-Frequency Bridge measures impedances simply and accurately at frequencies from 400 kc/s to 60 Mc/s. It measures directly the resistance and reactance of antennas, transmission lines, networks, and components. It is particularly well suited for measuring low values of impedance of rf devices. Its range can be extended by means of an external parallel capacitor to measure high impedances.

DESCRIPTION: Measurements are made by a series-substitution method in which the bridge is first balanced by means of capacitors C_P and C_A with a short circuit across the unknown terminals. The short is then removed, the unknown impedance connected, and the bridge rebalanced.

The unknown reactance at 1 Mc/s is read directly in ohms from the dial of C_P, and the unknown resistance in ohms from the dial of C_A.

The resistive component is measured in terms of a fixed resistor (R_B), a fixed capacitor (C_N), and a variable capacitor (C_A). This feature is an important factor in the high-frequency performance of the bridge, because residual parameters can be made much smaller in a fixed resistor and a variable capacitor than in a variable resistor.

The TYPE 1606-A Bridge incorporates several important features. A single, internal transformer, used to couple an external generator to the bridge circuit, covers the entire 150:1 frequency range, and its triple shielding keeps undesired couplings to an insignificant level.

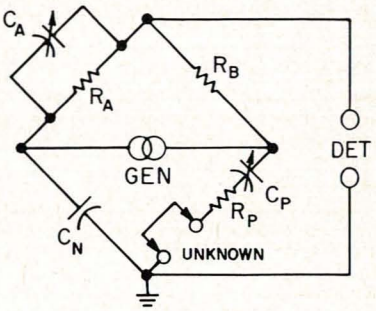
The resistance is given by

$$R_X = R_B \frac{(C_{A_2} - C_{A_1})}{C_N}$$

and the reactance by

$$X_X = \frac{1}{\omega}\left(\frac{1}{C_{P_2}} - \frac{1}{C_{P_1}}\right)$$

where the subscripts 1 and 2 denote the dial readings for the initial and final balances respectively.



The variable air capacitors in this bridge are designed for low inductance and low losses. The complete rotor and stator sections are milled out of solid blocks of aluminum, a construction that avoids losses at the joints between plates and spacers and provides the utmost stability.

The entire mechanical design is such that the instrument can operate under difficult environmental conditions similar to those specified for testing military electronics equipment, which makes the TYPE 1606-A bridge an excellent instrument for field use.

SPECIFICATIONS

RANGES OF MEASUREMENT

Frequency: 400 kc/s to 60 Mc/s.
Satisfactory but somewhat less accurate operation can be obtained at frequencies as low as 100 kc/s and somewhat above 60 Mc/s.

Reactance: ±5000 Ω at 1 Mc/s. This range varies inversely as the frequency; at other frequencies the dial reading must be divided by the frequency in Mc/s.

Resistance: 0 to 1000 Ω.

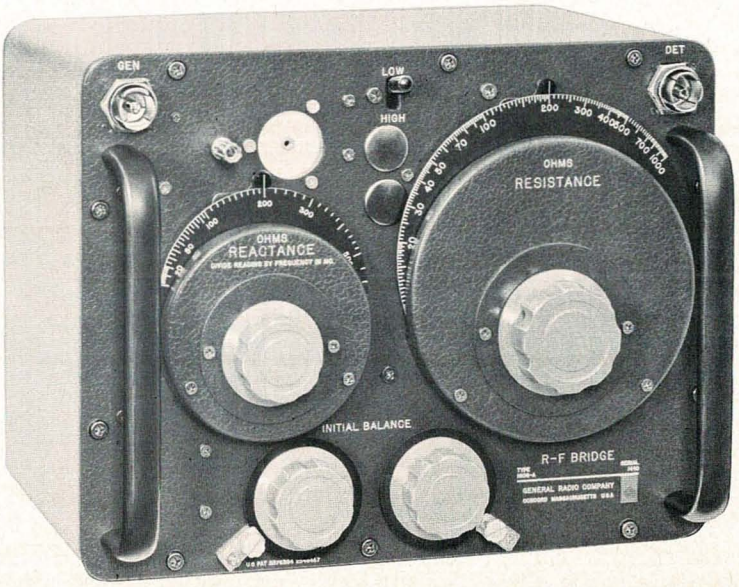
ACCURACY

Reactance: At frequencies up to 50 Mc/s, $\pm(2\% + 1\ \Omega + 0.0008\,Rf)$ where R is the measured resistance in ohms and f is the frequency in Mc/s.

Resistance: At frequencies up to 50 Mc/s,

$$\pm\left[1\% + 0.0024f^2\left(1 + \frac{R}{1000}\right)\% \pm \frac{10^{-4}\,X}{f}\,\Omega + 0.1\Omega\right]$$

(where X is the measured reactance in ohms). Subject to correction for residual parameters.



FOR THE MEASUREMENT OF ANTENNAS, LINES, NETWORKS, AND COMPONENTS FROM 400 kc/s TO 60 Mc/s

GENERAL

Generator: External only (not supplied), to cover desired frequency range. Recommended, TYPE 1211-C and TYPE 1215-C Unit Oscillators, TYPE 1330-A Bridge Oscillator, TYPE 1310-A Oscillator, TYPE 1001-A and TYPE 1021-AV Standard-Signal Generators.

Detector: External only (not supplied). A heterodyne detector, TYPE DNT-6 (page 109), is recommended for use above 3 Mc/s. A well shielded radio receiver is also satisfactory.

Accessories Supplied: 2 leads of different lengths to connect unknown impedance to bridge terminals; ½-in spacer and ¾-in spacer to mount component to be measured directly on bridge terminals; 2 TYPE 874-R22LA Patch Cords to connect generator and detector.

Accessories Available: Luggage-type carrying case. See price table below.

MECHANICAL DATA Welded Aluminum Cabinet

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
12½	320	9½	245	10¼	260	23	10.5	30	14
					With carrying case	29	13.5	31	14.5

For a more detailed description, see *General Radio Experimenter*, June 1955.

Catalog Number	*Description*	*Price*
1606-9701	**Type 1606-A Radio-Frequency Bridge**	**$825.00**
1606-9601	**Type 1606-P1 Luggage-Type Carrying Case**	**25.00**

PATENT NOTICE. See Note 4, page 11.

Type 916-AL RADIO FREQUENCY BRIDGE

The TYPE 916-AL Radio-Frequency Bridge uses the same series-substitution circuit as the TYPE 1606-A to cover the low and medium frequencies between 50 kc/s and 5 Mc/s.

An important feature is the ΔX dial, which greatly facilitates the measurement of large capacitances and small inductances.

SPECIFICATIONS

RANGES OF MEASUREMENT

Frequency: 50 kc/s to 5 Mc/s. Satisfactory operation for many measurements can be obtained at frequencies as low as 15 kc/s.

Reactance: ±11,000 Ω at 100 kc/s. This range varies inversely as the frequency; at other frequencies the dial readings must be divided by the frequency in hundreds of kc/s.

ΔX Dial: 100 Ω at 100 kc/s.

Resistance: 0 to 1000 Ω.

ACCURACY

Reactance: Below 3 Mc/s, $\pm(2\% + 0.2 \times \frac{100}{f_{kc}}\ \Omega + 3.5 f_{kc}^2 R \times 10^{-10}\Omega)$, where R is the measured resistance in ohms and f_{kc} is the frequency in kc/s. The errors increase at frequencies above 3 Mc/s; at 5 Mc/s, the accuracy is $\pm(2\% + 0.01\Omega + 2.3R^{1.4} \times 10^{-3}\Omega)$.

Resistance: Below 5 Mc/s, ±(1% + 0.1Ω), subject to correction for residual parameters at low frequencies. The correction depends upon the frequency and upon the magnitude of the unknown reactance component.

GENERAL

Generator: External only (not supplied). TYPE 1330-A Bridge Oscillator, TYPE 1211-C Unit Oscillator, TYPE 1001-A Standard-Signal Generator recommended.

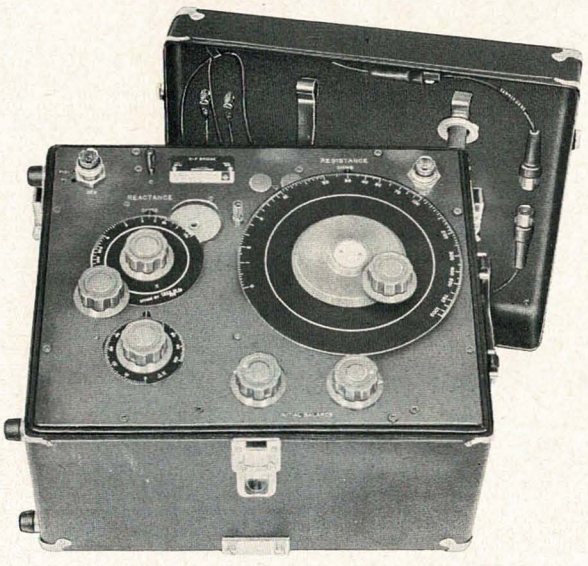
Detector: External only (not supplied). A heterodyne detector, the TYPE DNT-5 (page 109), is recommended. A well shielded radio receiver is also a satisfactory detector.

Accessories Supplied: 2 leads of different lengths to connect unknown impedance to bridge terminals; 2 input transformers, one to cover lower portion of frequency range, the other the higher portion; 2 TYPE 874-R22LA Patch Cords to connect generator and detector.

MECHANICAL DATA Luggage-Type Cabinet, Shielded.

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
13½	345	17	435	11¼	290	34½	16	45	20.5

For a more detailed description, see *General Radio Experimenter*, March 1949.



50 kc/s to 5 Mc/s

Catalog Number	*Description*	*Price*
0916-9831	**Type 916-AL Radio-Frequency Bridge**	**$925.00**

PATENT NOTICE. See Note 4, page 11.

Type 1602-B UHF ADMITTANCE METER

AND VSWR BRIDGE

FEATURES:

Direct reading in conductance and susceptance, independent of frequency.
With line stretcher, can indicate impedance (resistance and reactance).
Can measure VSWR directly, with TYPE DNT Detector or any other linear detector
No sliding balance — resistive and reactive adjustments are independent.
Wide frequency range — direct reading from 40 to 1500 Mc/s.
Accurate, rapid, easy to use.

USES: This null-type instrument measures impedance and admittance in coaxial systems such as antennas, lines, and networks.

It can be used for adjusting a network to a predetermined admittance, for matching one network to another, and for matching antennas and other networks to 50-ohm circuits.

As a comparator, the Admittance Meter is used to determine impedance magnitude, reflection-coefficient magnitude, and voltage standing-wave ratio.

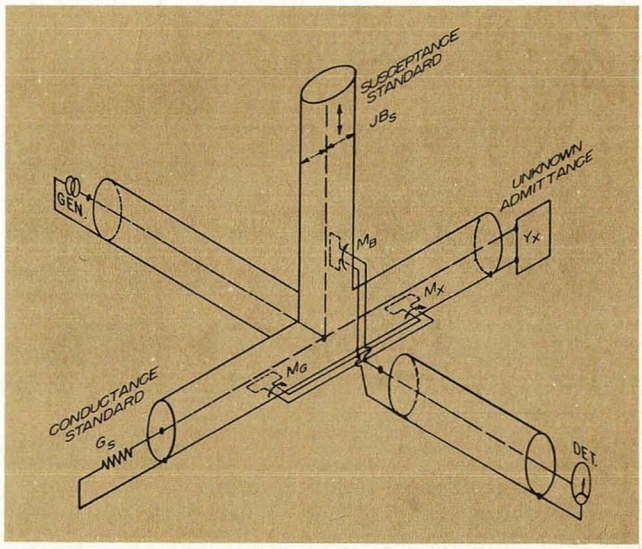
A full line of accessories is available to adapt the Admittance Meter to specific types of measurements:

The TYPE 874-LK20L Constant-Impedance Adjustable Line, which can be set to one-half wavelength to eliminate corrections for the length of transmission line between the unknown and the measuring point. When the line is set to one-quarter wavelength, the Admittance Meter dials read in impedance parameters, i.e., the series resistance and reactance of the unknown.

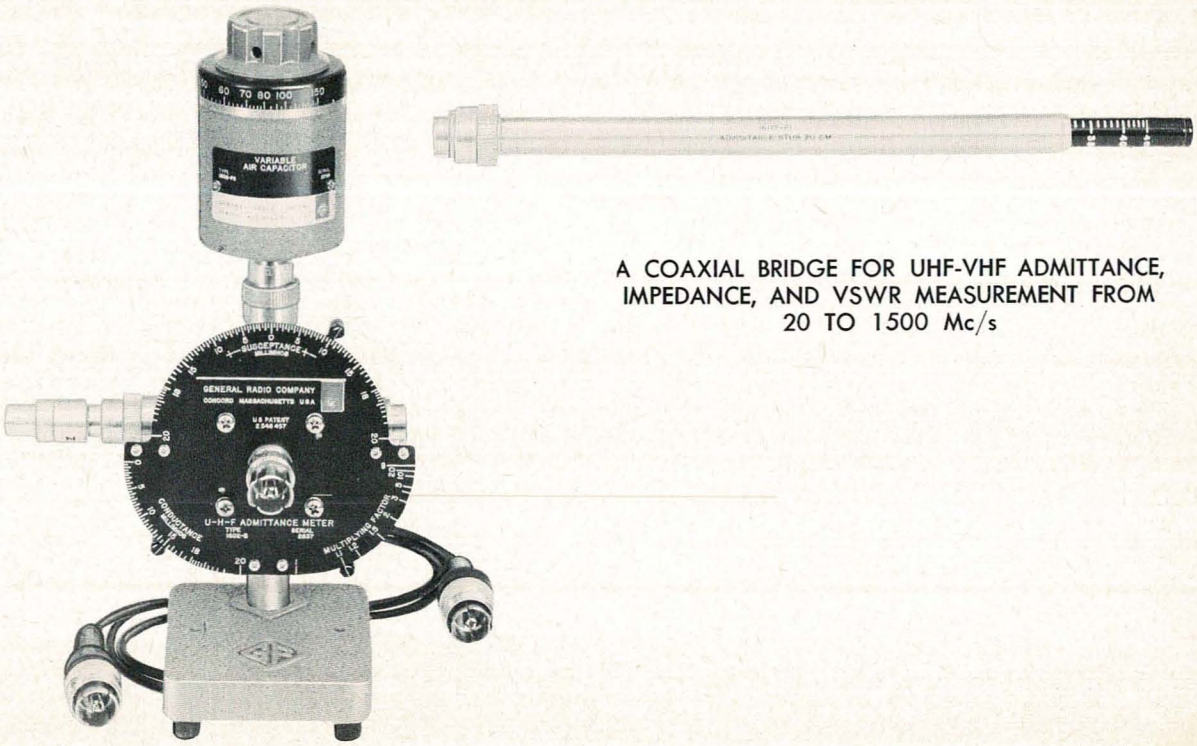
The TYPE 874-UBL Balun, for use with balanced impedances.

The TYPE 874-ML Component Mount, for the connection of lumped elements (resistors, capacitors, or inductors).

Low-VSWR adaptors (which can be locked in place) for most types of military connectors and (nonlocking) for rigid vhf and uhf transmission lines used with TV transmitting antennas. With these adaptors and the adjustable line mentioned above, the over-all accuracy



Schematic diagram of admittance-meter circuit, with standards, generator, and null detector connected for admittance measurements.



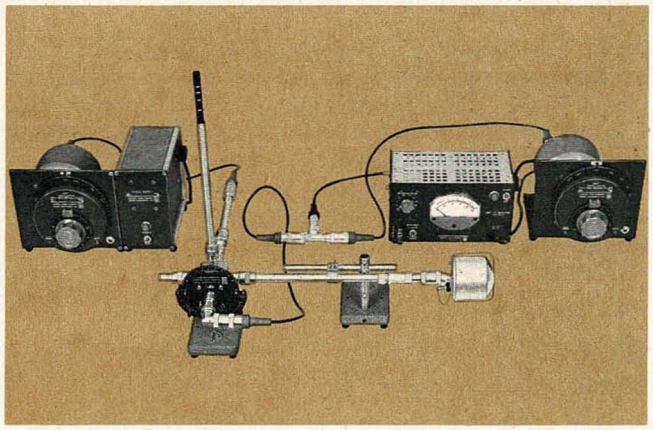
A COAXIAL BRIDGE FOR UHF-VHF ADMITTANCE, IMPEDANCE, AND VSWR MEASUREMENT FROM 20 TO 1500 Mc/s

of measurement is more than adequate for measurements in the design, test, and installation of antennas.

DESCRIPTION: The TYPE 1602-B UHF Admittance Meter comprises a coaxial line to which the unknown is connected, a shielded pickup loop to sample the current, a second line and loop terminated in a pure resistance, and a third line and loop terminated in a pure reactance. All are fed from the same voltage source, so that their input voltages are in phase, and the current in each line is proportional to the admittance. The voltage induced in each loop is proportional to the current in the corresponding line and is dependent upon the orientation of the loop, which is adjustable. Variation of this orientation is equivalent to variation of the magnitude of the impedances (including the standards).

The three loops are connected in parallel, and the voltage from the loop in the unknown line is canceled by adjustment of the loops coupled to the standard lines until a null is reached. The conductance and susceptance of the unknown are read directly from the scales of the standard loops, while the scale of the loop in the unknown line indicates the multiplying factor.

This arrangement produces the effect of continuously variable elements by using known fractions of the currents in fixed elements.



The Admittance Meter assembled for component measurements, with Unit Oscillator and DNT Detector. A line stretcher (Type 874-LKL) connects the component mount to the unknown terminal of the Admittance Meter.

SPECIFICATIONS

RANGES OF MEASUREMENT

Frequency: 40 to 1500 Mc/s (direct reading). Range can be extended downward to 20 Mc/s, if a frequency correction is applied to the susceptance reading.

	ACCURACY
Conductance: 0.01 to 4000 m℧. **Susceptance:** −4000 to +4000 m℧.	Up to 1000 Mc/s, from 0 to 20 m℧, $\pm(3\% + 0.2$ m℧$)$ from 20 to ∞ m℧, $\pm(3\sqrt{M}\% + 0.2$ m℧$)$ where M is the scale-multiplying factor. Above 1000 Mc/s, errors increase slightly, and, at 1500 Mc/s, the basic figure of 3% in the expression above becomes 5%. For matching impedances to 50 Ω, the accuracy is 3% up to 1500 Mc/s. The 0.2-m℧ fixed error can be reduced significantly with the multiplier plates.

GENERAL

Terminals: All terminals are GR874 Coaxial Connectors and are locking-type, except for the detector terminal. Adaptors to other types of coaxial connectors (page 81) can be used on the generator and detector terminals.

Generator: External only (not supplied). Unit Oscillators (pages 139 to 144) are recommended. Generator must supply 1 to 10 V.

Detector: External only (not supplied). Sensitivity must be 10 μV or better. TYPE DNT Detectors recommended.

Accessories Supplied: 2 TYPE 1602-P4 50-Ω Terminations for conductance standards, TYPE 1602-P1 Adjustable Stub and TYPE 1602-P3 Variable Air Capacitor for susceptance standards, 2 TYPE 874-R22LA Patch Cords for connections to generator and detector. TYPE 1602-P10 and P-11 Multiplier Plates, wooden storage case.

Accessories Available: TYPE 874-FBL Bias Insertion Unit, coaxial adaptors, line-stretcher, balun, component mount, Smith charts (see pages 76 to 94.)

MECHANICAL DATA

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
5½	140	7½	190	5½	140	8¼	3.8	18	8.5

For a more detailed description, see *General Radio Experimenter*, May 1950, August 1953, May 1960.

Catalog Number	*Description*	*Price*
1602-9702	**Type 1602-B UHF Admittance Meter**	**$365.00**
0874-9631	**Type 874-LK20L Constant-Impedance Adjustable Line**	**42.00**
0874-9663	**Type 874-ML Component Mount**	**35.00**

PATENT NOTICE. See Note 4, page 11.

OTHER COAXIAL IMPEDANCE-MEASURING DEVICES: *Type 1607-A Transfer-Function and Immittance Bridge (page 56), Types 874-LBA and 900-LB Slotted Lines (pages 82 and 100).*

Type 1607-A TRANSFER-FUNCTION AND IMMITTANCE BRIDGE

FEATURES:

- Measures effective network parameters of transistors, diodes, tubes, and two-terminal and four-terminal networks, active and passive.
- Simple to operate. Suitable for both laboratory and routine production measurements.
- Wide frequency range — 25 to 1500 Mc/s. ■ Direct reading.
- Component mounts available for transistors and tubes. ■ Bias terminals provided.

USES: The Transfer-Function and Immittance* Bridge is a null-type instrument for vhf and uhf measurements of the forward and reverse complex transfer functions and the input and output impedances and admittances of four-terminal electrical networks, either active or passive. The complex impedance or admittance of two-terminal circuits or components can also be measured easily.

Among these measurements are:

Transistors — $h_f(\alpha$ or $\beta)$, and $|\beta|$, h_r, h_i, h_o, Y_c, Y_o, Y_f, Y_r.

Tunnel Diodes — Equivalent circuit parameters.

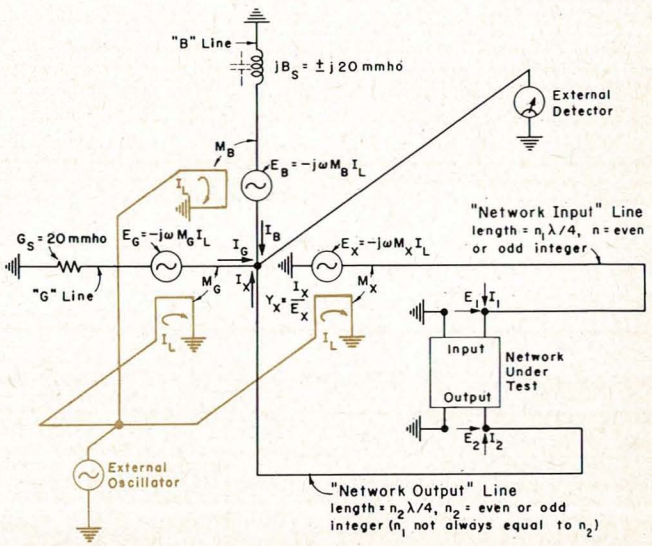
Vacuum Tubes — μ, Y_{21} and Y_{12}, Y_{11} and Y_{22}.

General two-terminal or four-terminal networks — Z_{11}, Z_{22}, Z_{21}, Z_{12} and Y_{11}, Y_{22}, Y_{21}, Y_{12}. I_2/I_1, I_1/I_2 and E_2/E_1, E_1/E_2.

Ungrounded components —
Inductors — inductance and self-resonance.
Capacitors — capacitance and resonances.
Resistors — resistance and shunt capacitance.

Components, Coaxial Lines, and Other Grounded Elements — Z, Y, $|T|$, *VSWR*.

DESCRIPTION: The TYPE 1607-A Transfer-Function and Immittance Bridge comprises three identical loops, fed from a common source and magnetically coupled to three coaxial lines. One of these lines is terminated with a resistance standard, one with a reactance standard, and one with the network to be tested. The coupling of each loop is adjusted until a null is obtained on an external detector in which the three lines are terminated. Each loop has a calibrated scale and the settings at null condition indicate the value of the unknown.



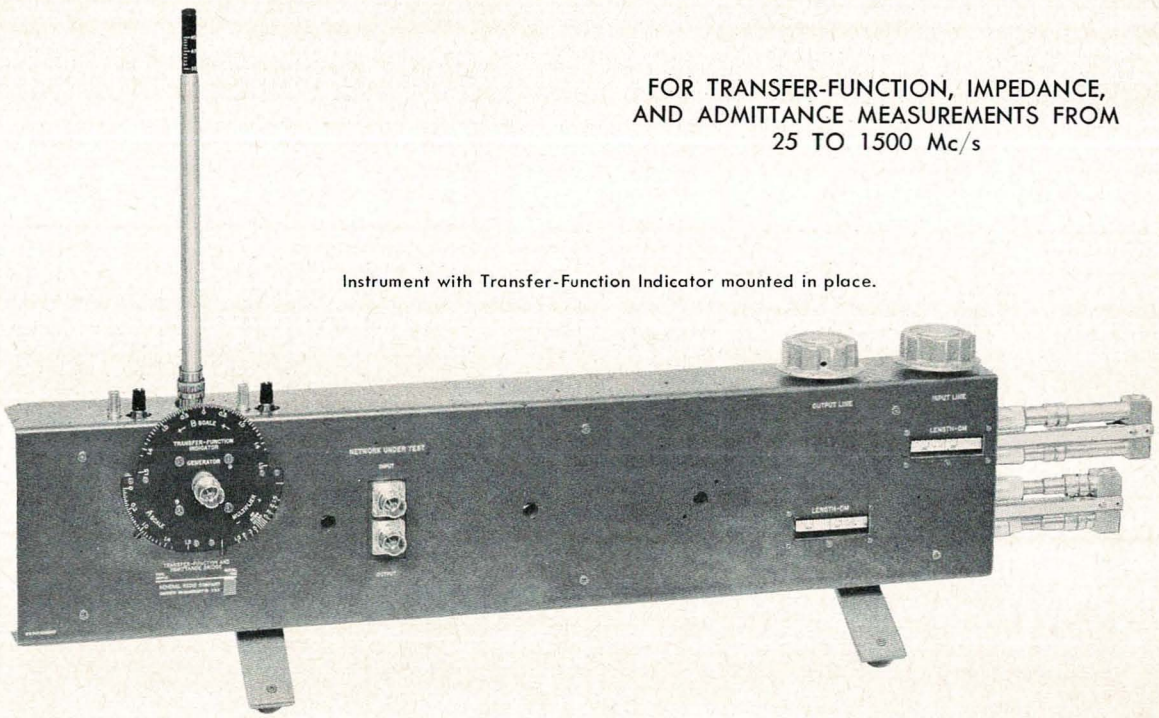
Schematic diagram of rf circuits of the Transfer-Function and Immittance Bridge.

Two interchangeable loop-and-scale assemblies (Transfer-Function Indicator and Immittance Indicator, respectively) allow either four-terminal or two-terminal networks to be measured with equal ease.

Two built-in constant-impedance, adjustable-length lines eliminate lead corrections.

* Immittance = impedance and/or admittance.

FOR TRANSFER-FUNCTION, IMPEDANCE, AND ADMITTANCE MEASUREMENTS FROM 25 TO 1500 Mc/s



Instrument with Transfer-Function Indicator mounted in place.

SPECIFICATIONS

Frequency Range: 25 to 1500 Mc/s, with reduced accuracy above 1000 Mc/s, or when flexible cable is used in the lines. The use of cable is generally required below 150 Mc/s and is optional at other frequencies.

Measurement Range:	**Accuracy:** (up to 1000 Mc/s)
Voltage and Current Ratios (R) 0–30, 0–300†	$2.5(1 + \sqrt{R})\% + 0.025$*
Transimpedance (Z_{21}) 0–1500 Ω, 0–15,000 Ω†	$2.5\left(1 + \sqrt{\frac{Z_{21}}{50}}\right)\% + 1.25\ \Omega$*
Transadmittance (Y_{21}) 0–600 m℧, 0–6000 m℧†	$2.5\left(1 + \sqrt{\frac{Y_{21}}{20}}\right)\% + 0.5$ m℧*
Impedance (Z_{11}) 0–1000 Ω, 0–10,000 Ω†	$2.0\left(1 + \sqrt{\frac{Z_{11}}{50}}\right)\% + 1.0\ \Omega$*
Admittance (Y_{11}) 0–400 m℧, 0–4000 m℧†	$2.0\left(1 + \sqrt{\frac{Y_{11}}{20}}\right)\% + 0.4$ m℧*

* When the 0.1 multiplier plate is used, these errors are significantly reduced.
† With multiplier plate.

Dc Bias: Bias terminals are provided. Maximum current, 2.5 A, continuous; higher currents are permissible for short periods; maximum voltage, 400 V.

Generator and Detector: External only, not included; GR Unit Oscillators and DNT Detectors are recommended. See pages 139 and 108.

Accessories Supplied: Range-Extension Unit; Transfer-Function Indicator; Immittance Indicator; 6 terminations (open, short, matched, etc.); standards; 10-dB attenuator; 8 air lines (21.5 and 43 cm); 3 U-line sections; constant-impedance adjustable line; a special tee; two 0.1 multiplier plates; 10 patch cords; storage for instrument and accessories.

Accessories Required: Mount for unknown device. For coaxial adaptors, see page 81. See below for mounts available. Note that termination kit is required for some transistor mounts.

Accessories Available: Transistor, component, and tube mounts as listed below.

Mechanical Data: (Complete, in storage case)

Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
40	1020	11½	295	14½	370	63	29	132	61

For a more detailed description, ask for General Radio Reprint E109.

Catalog Number	*Description*	*Price*
1607-9701	**Type 1607-A Transfer-Function and Immittance Bridge**	**$1925.00**

PATENT NOTICE. See Note 4, page 11.

ACCESSORY MOUNTS

Mount Type	*Transistor and diode packages accepted*
1607-P101 and -P102	TO-5, -9, -11, -39, and similar packages
1607-P111	TO-1, -18, -23, -24, and similar packages
1607-P201	Type 6AN4 and similarly based tubes
1607-P401	TO-12 and similar packages

Catalog No.	*Description*	*Price*
1607-9992	**Type 1607-P101 Transistor Mount,*** JEDEC-30, grounded base, 0.2-in-dia pin circle	**$60.00**
1607-9993	**Type 1607-P102 Transistor Mount,*** JEDEC-30, grounded emitter, 0.2-in-dia pin circle	**60.00**
1607-9994	**Type 1607-P111 Transistor Mount,*** 0.1-in-dia pin circle, grounded base.	**70.00**
1607-9995	**Type 1607-P201 Tube Mount,** grounded cathode, 7-pin miniature.	**85.00**
1607-9996	**Type 1607-P401 Tetrode Transistor Mount,*** grounded base, 0.2-in-dia pin circle.	**75.00**
1607-9997	**Type 1607-P601 Ungrounded Component Mount**	**25.00**

* For transistors whose maximum lead length is 5/16 inch.

Mounts For Long-Lead Transistors

These mounts or test jigs are used when transistor leads up to two inches in length must be retained. The leads plug into hollow contact tubes in the mount; as a result, the leads from about 1/32 inch from the header out to the lead tips are completely shielded. Bends or irregularities in the leads, therefore, do not affect the measurement. The coaxial line that connects to the transistor is small in size, thus minimizing the discontinuity at the transistor-to-mount connection and improving the measurement accuracy. Additional advantages are: Complete accessibility to the socket, provision for bolting a heat-sink to the mount body, and provision of a fourth lead in the mount, which is dc ground.

The electrical length of the mounts to the reference plane, which is 0.025 inch below the top of the socket, is 9.5 cm approximately. Appropriate open-circuit, short-circuit, and U-section units are required. These are available as the TYPE 1607-P40 Termination Kit.

Three-terminal measurements can be performed with both the previous series (listed above) and this new series of mounts.

SPECIFICATIONS

Mount Type	*Transistor and diode packages accepted*
1607-P41 and -P42	TO-5, 9, 11, 12, 16, 26, 31, 33, 37, 38, 39, 43; MD-14; MM-4, 8; MT-13, 20, 28, 37; RO-2, 3, 4, 5, 10, 24, 30, 32, 34, 46, 49, 50, 61, 62, 79, etc.
1607-P43 and -P44	TO-18, 28, 52, 54; MT-30, -38; RO-44, 48, 51, 64, 65, 66, 70, 73, 78; U-3; X-8; etc.

Accessory Supplied: One TYPE 1607-P30 Damper (to prevent oscillation).

Accessories Required: TYPE 1607-P40 Termination Kit.

Net Weight: Mount, approximately 12 oz (0.4 kg); Termination Kit, approximately 1 lb (0.5 kg).

Shipping Weight: One mount, 2 lb (1 kg); Termination Kit, 2½ lb (1.2 kg).

Catalog No.	*Description*	*Price*
1607-9641	**Type 1607-P41 Transistor Mount,** long-lead, 4-lead grounded-base; 0.2-in-dia pin circle.	**$115.00**
1607-9642	**Type 1607-P42 Transistor Mount,** long-lead, 4-lead grounded-emitter or grounded collector; 0.2-in-dia pin circle.	**115.00**
1607-9643	**Type 1607-P43 Transistor Mount,** long-lead, 4-lead grounded-base; 0.1-in-dia pin circle.	**115.00**
1607-9644	**Type 1607-P44 Transistor Mount,** long-lead, 4-lead grounded-emitter or grounded-collector; 0.1-in-dia pin circle.	**115.00**
1607-9640	**Type 1607-P40 Termination Kit** (Consists of Type 874-U10 U-line Section, Type 874-WN10 Short-Circuit Termination, Type 874-WO10 Open-Circuit Termination.)	**42.50**

Type 1615-A CAPACITANCE BRIDGE

FEATURES:

- 0.01% direct-reading accuracy; comparison accuracy, one ppm.
- 6-figure resolution for capacitance; one ppm for dissipation factor.
- Wide capacitance range — 10^{-5} pF to 11 μF.
- Loss can be measured as either dissipation factor or conductance.
- Lever-type balance controls.
- In-line readout in C, D, and G with automatically positioned decimal point.
- Makes both 2- and 3-terminal measurements.
- Low terminal at ground for 2-terminal measurements.

USES: Accurate and precise measurements of capacitance and dissipation factor.

Measurement of circuit capacitances.

Dielectric measurements.

Intercomparison of capacitance standards differing in magnitude by as much as 1000:1.

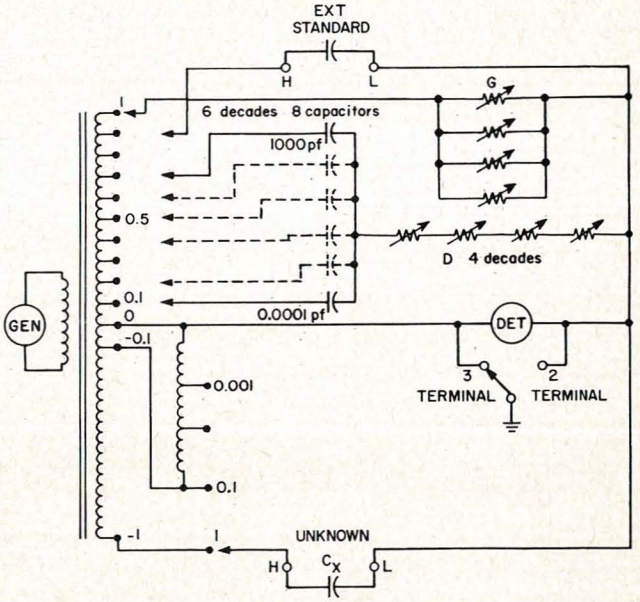
DESCRIPTION: High accuracy is achieved through the use of precisely wound transformer ratio arms and highly stable standards. The standards are fabricated from Invar and are hermetically sealed in nitrogen. Eight standard capacitors are used, in decade values from 1000 pF to 0.00001 pF. The internal standards can be easily compared with one another.

The circuit, shown here in elementary form, is also clearly delineated on the panel. Changes in connections and grounds are automatically indicated as the bridge terminals are switched for different measurement conditions.

The loss balance can be made in terms of either dissipation factor or conductance.

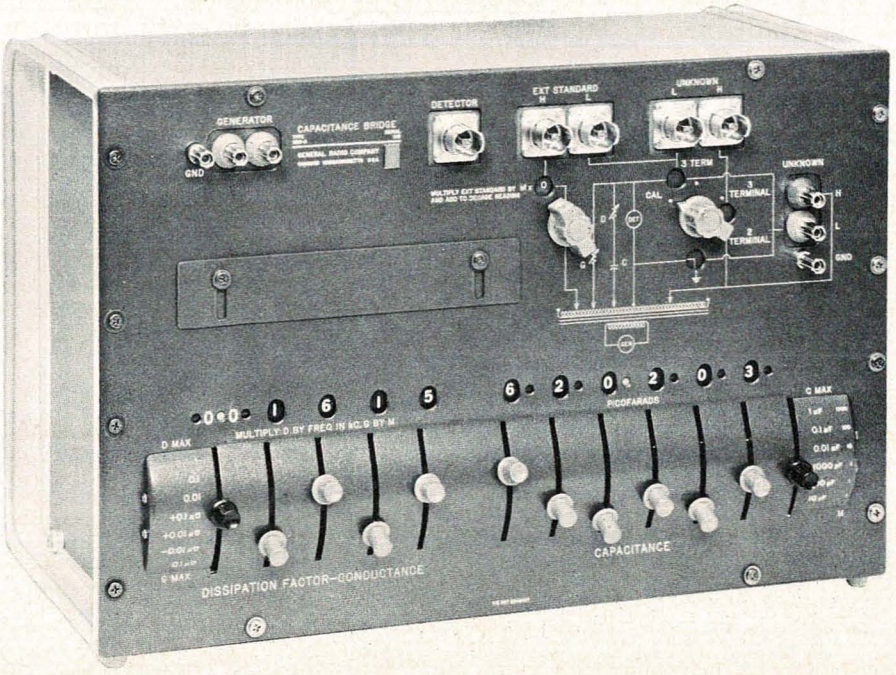
The impedance of the transformer ratio arms has been kept very low, so that accurate three-terminal measurements can be made even in the presence of capacitances to ground as large as 1 μF. Accurate measurements can be made with the unknown connected by means of long cables. The bridge has the necessary internal shielding to permit one terminal of the unknown to be directly grounded, so that both true two-terminal and three-terminal measurements can be made over the whole capacitance range.

For both capacitance and dissipation factor, the balance controls are smoothly operating, lever-type switches. The readout is digital, and the decimal point is automatically positioned. Each capacitance decade has a −1 position to facilitate rapid balancing.



Elementary schematic diagram of the capacitance bridge.

The TYPE 1615-A Capacitance Bridge brings to the measurement of capacitance, to the intercomparison of standards, and to the measurement of dielectric properties an unusual degree of accuracy, precision, range, and convenience.



TYPE 1615-P1 RANGE-EXTENSION CAPACITOR

This plug-in 0.01-μF unit extends the capacitance range of the TYPE 1615-A Capacitance Bridge by a factor of 10 to a maximum of 11.11110 μF. It plugs into the EXT STD terminals of the bridge and its trimmer is then adjusted to agreement with the bridge internal standards.

Dimensions: Diameter 3 1/16, length 4 7/8 in (78, 125 mm).
Net Weight: 1 lb (0.5 kg); **Shipping Weight:** 3 lb (1.4 kg).

SPECIFICATIONS

RANGES OF MEASUREMENT	ACCURACY
Capacitance, 10 aF to 1.11110 μF (10^{-17} to 10^{-6} farad) in 6 ranges, direct-reading, 6-figure resolution; least count 10^{-17} F (10 aF). With Range-Extension Capacitor, upper limit is 11.11110 μF.	*At 1 kc/s,* $\pm(0.01\% + 0.00003$ pF). *At higher frequencies and with high capacitance,* additional error is $[\pm 2 \times 10^{-5}\% + 2 \times 10^{-3}\% (C_{\mu F}) \pm 3 \times 10^{-7}$ pF$] \times f^2_{kc}$. *At lower frequencies and with low capacitance,* accuracy may be limited by bridge sensitivity. *Comparison, accuracy,* unknown to external standard, 1 ppm.
Dissipation Factor, D, At 1 kc/s, 0.000001 to 1, 4-figure resolution; least count, 0.000001; range varies directly with frequency.	$\pm[0.1\%$ of measured value $+ 1 \times 10^{-5}(1 + f_{kc})]$
Conductance, G, 10^{-6} $\mu\mho$ to 100 $\mu\mho$, 2 ranges +, 2 ranges −, 4-figure resolution, least count 10^{-6} $\mu\mho$ independent of frequency; range varies with C range.	$\pm[1\%$ of measured value $+ (1 \times 10^{-5} + 6 \times 10^{-2} f^2_{kc} C_{\mu F})$ $\mu\mho]$

FREQUENCY: Approx 50 c/s to 10 kc/s. Useful with reduced accuracy to 100 kc/s. Below 100 c/s, resolution beyond 0.01% or 0.01 pF may require special detectors.

GENERAL

Standards: Hermetically sealed in nitrogen; 1000, 100, 10, 1, 0.1, 0.01, 0.001, 0.0001 pF. Temperature coefficient of capacitance is less than 5 ppm/°C for the 1000-, 100-, and 10-pF standards, slightly greater for the smaller units.

Generator: External only (not supplied). TYPE 1310-A or TYPE 1311-A Audio Oscillator recommended. Max safe generator voltage 30 $\times f_{kc}$ V, 300 V max. If generator and detector connections are interchanged, 150 to 500 V can be applied, depending on switch settings.

Detector: External only (not supplied). TYPE 1232-A Tuned Amplifier and Null Detector recommended.

Accessories Supplied: TYPE 874-WO Open-Circuit Termination, TYPE 874-R22A Patch Cord, TYPE 274-NL Patch Cord.

MECHANICAL DATA Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	12¾	325	10½	270	38½	17.5	58	27
Rack	19	485	12¼	315	8½*	220	38½	17.5	58	27

* Behind panel.

For a more detailed description, see *General Radio Experimenter,* September 1962.

Catalog Number	*Description*	*Price*
1615-9801	**Type 1615-A Capacitance Bridge,** Bench Model	**$1475.00**
1615-9811	**Type 1615-A Capacitance Bridge,** Rack Model	**1475.00**
1615-9601	**Type 1615-P1 Range-Extension Capacitor**	**35.00**

PATENT NOTICE. See Note 4, page 11.

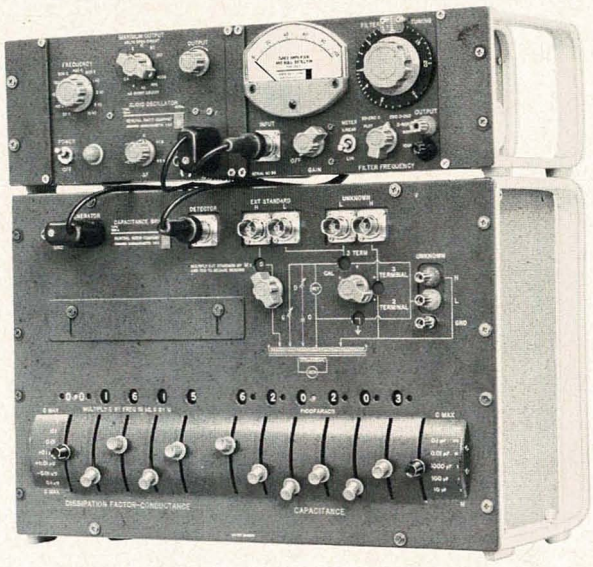
Type 1620-A CAPACITANCE-MEASURING ASSEMBLY

The TYPE 1620-A Capacitance-Measuring Assembly consists of the TYPE 1615-AM Capacitance Bridge with the TYPE 1311-A Audio Oscillator and the TYPE 1232-A Tuned Amplifier and Null Detector, thus providing a complete system for the precise measurement of capacitance over the range of 10 aF to 1 μF (10^{-17} to 10^{-6} farad). Frequency range is approximately 50 c/s to 10 kc/s. The sensitivity of the system provides resolution beyond 0.01% except for measurements of capacitors above 0.1 μF and below 100 pF at frequencies below 100 c/s.

Oscillator and detector are mounted side by side as shown in the photograph. The end frames are bolted together to make a rigid assembly without the use of a relay rack. Connection cables are supplied.

The oscillator operates from the power line, the detector from internal batteries.

Catalog No.	*Description*	*Price*
1620-9701	**Type 1620-A Capacitance-Measuring Assembly**	**$2090.00**



Type 716-C CAPACITANCE BRIDGE

FEATURES: Wide frequency range, 30 c/s to 300 kc/s. Direct-reading dials. ■ Convenient to operate. ■ Flexible in application.

USES: This direct-reading bridge measures capacitance and dissipation factor by either direct or substitution method. It can measure 3-terminal capacitance by addition of the TYPE 716-P4 Guard Circuit.

It is well suited to the measurement of the dielectric properties of insulating materials — dielectric constant, dissipation factor, loss factor, phase angle — and their change with frequency, temperature, and humidity.

By substitution methods it can measure capacitance beyond the range of the internal standards, the inductance and Q of large inductors, the inductance and resistance of cables, the resistance and parallel capacitance of high-valued resistors, and the conductance and parallel resistance of electrolytes.

DESCRIPTION: The TYPE 716-C Capacitance Bridge is a modified Schering bridge. To obtain a wide and direct-reading capacitance range at 1 kc/s, the ratio arms are switched to give decade multipliers of 1 to 1000. At other frequencies, the maximum direct-reading capacitance is that of the internal standard, which is a worm-driven, precision, variable capacitor. Careful shielding to eliminate the effects of stray capacitance permits a direct-reading accuracy of 0.1%.

SPECIFICATIONS

RANGES OF MEASUREMENT	ACCURACY
Capacitance (direct-reading) 100 pF to 1.1 μF at 1 kc/s; 100 pF to 1150 pF at 100 c/s, 10 kc/s, and 100 kc/s.	At 30 c/s to 300 kc/s ±0.1% ±(0.6 pF × capacitance multiplier setting) when $D < 0.01$. Residual C is approx 1 pF.
Capacitance (substitution) 0.1 pF to 1050 pF with internal standard. 0.1 pF up to value of available standard with external standard.	±1.2 pF. Correction chart for the precision capacitor is supplied, which allows a substitution measurement accuracy of ±0.05% or ±0.6 pF. With additional precision calibration of standard capacitor, ±0.05% or ±0.2 pF.
***D* (direct reading)** 0.00002 to 0.56	±0.0005 or ±2% of dial reading, whichever is larger.
***D* (substitution)** 0.00002 to 0.56 × $\frac{C_{STD}}{C_{UNK}}$	±0.00005 or ±2% for the change in D when the change is less than 0.06. Corrections are supplied for greater D's.

GENERAL

Temperature and Humidity Effects: Bridge accuracy not significantly affected by variations of temperature from 65 to 95°F. Precise measurements of dissipation factor should not be attempted when the bridge has been exposed to abnormally high relative humidity, unless it is first dried by heat or a desiccant.

Generator: External only (not supplied); 30 c/s to 300 kc/s; 1 W max, which allows 200 V at 1 kc/s or 50 V at 60 c/s. If generator and detector connections are interchanged, 700 V can be applied at 1 kc/s and lower. TYPE 1311-A or 1310-A Oscillator recommended.

Detector: External only (not supplied). TYPE 1232-A Tuned Amplifier and Null Detector recommended for audio range; for higher frequencies, add TYPE 1232-P1 Mixer and local oscillator.

Accessories Supplied: TYPE 274-NL Shielded Patch Cord, TYPE 874-R34 Patch Cord.

Accessories Available: TYPE 1422 Precision Capacitor and TYPES 505, 1409, and 1401 Fixed Capacitors as balancing capacitors for substitution measurements. TYPE 1690-A Dielectric Sample Holder for dielectric measurements. TYPE 716-P4 Guard Circuit for 3-terminal measurements.

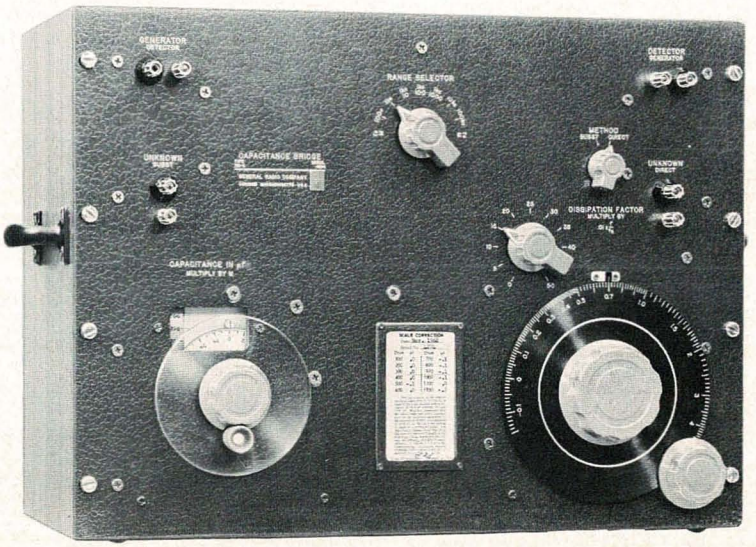
MECHANICAL DATA Wood Cabinet or Relay Rack (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Wt*		*ShipWt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Cabinet	21¾	555	14¼	365	11¼	290	40½	18.5	55	25
Rack	19	485	14	360	9*	230	30½	14	45	20.3

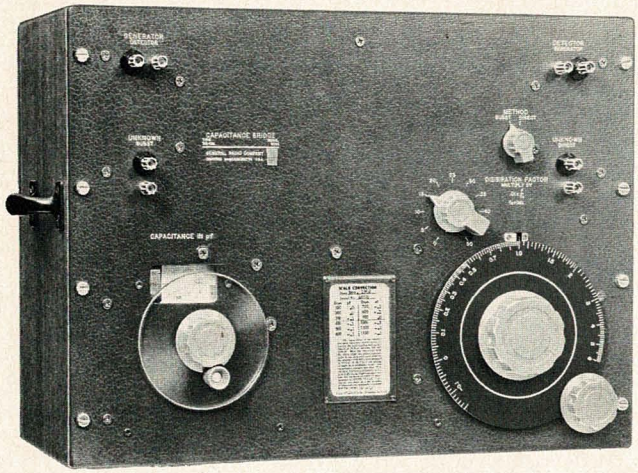
* Behind panel.

See also *General Radio Experimenter*, April 1947.

Catalog Number	*Description*	*Price*
0716-9803	**Type 716-C Capacitance Bridge,** Cabinet Model	**$875.00**
0716-9483	**Type 716-CP Capacitance Bridge,** with Precision Calibration, Cabinet Model	**925.00**
0716-9813	**Type 716-C Capacitance Bridge,** Rack Model	**835.00**
0716-9484	**Type 716-CP Capacitance Bridge,** with Precision Calibration, Rack Model	**885.00**



Type 716-CS1 CAPACITANCE BRIDGE



FOR CAPACITANCE MEASUREMENTS
UP TO 1150 pF AT 1 Mc/s

Both commercial and military specifications for capacitors of 1000 pF and less call for measurements of capacitance and dissipation factor at a frequency of 1 Mc/s. The TYPE 716-CS1 Capacitance Bridge has been designed specifically for these measurements. It is also satisfactory for measuring dielectrics with the TYPE 1690-A Dielectric Sample Holder at the ASTM test frequency of 1 Mc/s.

This bridge, a modification of the standard TYPE 716-C model, has a single capacitance range and a more limited frequency range.

SPECIFICATIONS

Ranges of Measurement:

Capacitance — Direct-reading, 100 to 1150 pF; substitution, 0.1 to 1050 pF.

Dissipation Factor — Same as TYPE 716-C.

Accuracy: At 1 Mc/s, same as stated for TYPE 716-C at 1 kc/s. Same accuracy can be obtained from 0.1 to 3 Mc/s if corrections are made for effects of residual impedances and if adequate selectivity is provided by null detector. Correction charts are supplied. Useful to 5 Mc/s with reduced accuracy.

Generator: External only (not supplied); TYPE 1214-M Unit Oscillator recommended for measurements at 1 Mc/s only. TYPE 1211-C Unit Oscillator recommended for measurements over range of 0.5 to 3 Mc/s.

Detector: External only (not supplied); TYPE 1212-A Unit Null Detector with TYPE 1212-P2 1-Mc Filter recommended for measurements at 1 Mc/s only. TYPE 1232-A Tuned Amplifier and Null Detector with TYPE 1232-P1 Mixer and a local oscillator recommended for measurements at frequencies other than 1 Mc/s.

Accessories Supplied: 2 TYPE 874-R34 Patch Cords, to fit the above generators and detectors.

Accessories Available: TYPE 1422 Precision Capacitor and TYPES 505, 1409, and 1401 Capacitors as balancing capacitors for substitution measurements. TYPE 1690-A Dielectric Sample Holder for dielectric measurements.

Other specifications same as those for standard TYPE 716-C.

See also *General Radio Experimenter*, February 1952.

Catalog No.	*Description*	*Price*
0716-9843	**Type 716-CS1 Capacitance Bridge,** Cabinet Model	**$800.00**
0716-9485	**Type 716-CS1P Capacitance Bridge,** with Precision Calibration, Cabinet Model	**850.00**
0716-9846	**Type 716-CS1 Capacitance Bridge,** Rack Model	**760.00**
0716-9486	**Type 716-CS1P Capacitance Bridge,** with Precision Calibration, Rack Model	**810.00**

PATENT NOTICE. See Note 4, page 11.

See page 58 for complete assemblies of bridge, generator, detector, and guard circuit.

Type 716-P4 GUARD CIRCUIT

The guard circuit facilitates three-terminal measurements of capacitors, such as guarded dielectric samples at frequencies up to 300 kc/s. It is particularly useful in the measurement of components and materials over wide ranges of frequency, temperature, and humidity, because it eliminates from the measurement the effects of the leads from the bridge to the sample.

SPECIFICATIONS

Capacitance Range: Designed for use with the 1-multiplier range, 100–1150 pF, of the TYPE 716-C Capacitance Bridge. The range can be extended by the addition of external capacitance to the standard arm of the bridge.

Frequency Range: 30 c/s to 300 kc/s.

Guard Balance Capacitor: Any value of capacitance up to 1000 pF between the guard point and the high measuring terminal can be balanced out.

Accessories Supplied: One TYPE 874-Q2 Coaxial Adaptor and one TYPE 838-B Alligator Clip.

Mechanical Data: Wood Cabinet or Relay Rack (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Cabinet	19	485	9⅛	235	8¾	225	23	10.5	37	17
Rack	19	485	8¾	225	7½*	190	17	8	29	13.5

* Behind panel.

Catalog No.	*Description*	*Price*
0716-9943	**Type 716-P4 Guard Circuit,** Cabinet Model	**$350.00**
0716-9945	**Type 716-P4 Guard Circuit,** Rack Model	**330.00**

PATENT NOTICE. See Note 4, page 11.

Type 1610 CAPACITANCE-MEASURING ASSEMBLIES

USES: Each TYPE 1610 Capacitance-Measuring Assembly is a complete system for the measurement of capacitance and dissipation factor by either direct or substitution methods.

DESCRIPTION: The TYPE 1610-B Capacitance-Measuring Assembly, which includes a guard circuit, makes both 2-terminal and 3-terminal measurements over the frequency range of 20 c/s to 100 kc/s. Thus it is well suited for studies of the frequency characteristics of dielectric samples and components in conditioning chambers.

When only 2-terminal measurements are to be made, the guard circuit is unnecessary, and the TYPE 1610-B2 Capacitance-Measuring Assembly, which covers the same frequency range, is used.

The TYPE 1610-AH Capacitance-Measuring Assembly is used for 2-terminal measurements at 1 Mc/s. The Dielectric Sample Holder, TYPE 1690-A (page 66), is recommended for use with any of these assemblies in the measurement of solid-dielectric specimens. All assemblies include cabinet rack, rack adaptor panels, connecting cables, spare fuses, and power cord.

SPECIFICATIONS

RANGES OF MEASUREMENT		Type 1610-B	Type 1610-B2	Type 1610-AH
	Frequency	20 c/s to 20 kc/s, 50 kc/s, 100 kc/s		1 Mc/s
C	Direct, 2-terminal	100 pF to 1.1 μf at 1 kc/s; 100 pF to 1150 pF at other frequencies		100 pF to 1150 pF
	Substitution, 2-terminal	0.1 pF to 1050 pF		
	Direct, 3-terminal	100 pF to 1150 pF		
	Substitution, 3-terminal	0.1 pF to 1050 pF		
D	Direct	0.0002 to 0.56		
	Substitution	0.0002 to 0.56 multiplied by C_{STD}/C_{UNK}		

ACCURACY, NOMINAL

Capacitance: ±0.1%. **Dissipation Factor:** ±2% of dial. For complete statement, see bridge specifications.

GENERAL

Power Supply	105 to 125 volts,† 50 to 60 c/s*		
	50 watts	50 watts	100 watts
Dimensions	Width 22½, height 43, depth 20 inches (570, 1090, 510 mm), over-all		
Net Weight	203 pounds (93 kg)	180 pounds (83 kg)	150 pounds (69 kg)
Shipping Weight	280 pounds (128 kg)	260 pounds (119 kg)	241 pounds (111 kg)
Catalog Number	1610-9702	1610-9422	1610-9817
Price	**$1970.00**	**$1620.00**	**$1350.00**

* Assembly will operate satisfactorily at power-supply frequencies up to 400 c/s, provided that supply voltage is at least 115 V.

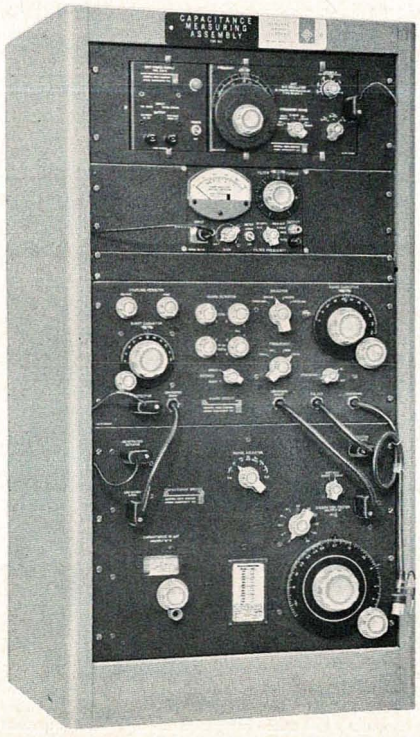
† TYPE 1610-BQ18 for 210- to 250-V, 50- to 60-cycle supply. Catalog Number: 1610-9818. Price: $1975.00.
TYPE 1610-B2Q18 for 210- to 250-V, 50- to 60-cycle supply. Catalog Number: 1610-9482. Price: $1625.00.

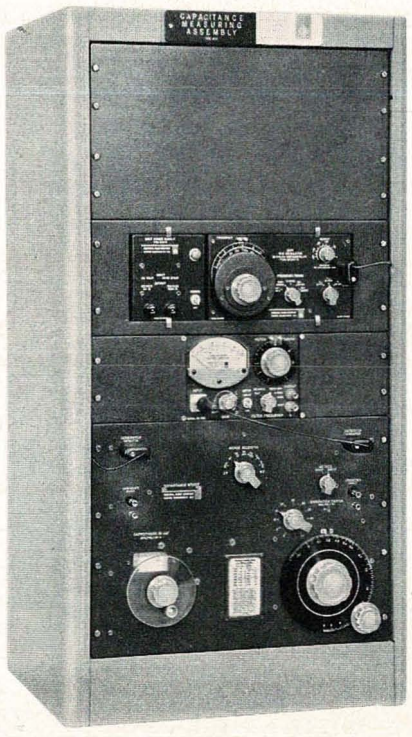
PATENT NOTICE. See Notes 4 and 15, page 11.

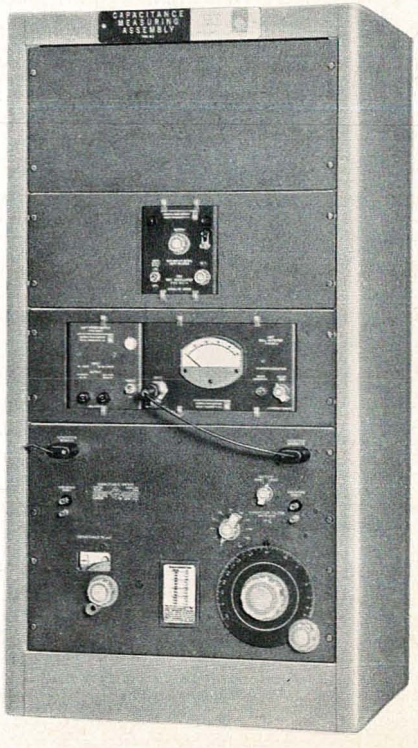
Type 1610-B
Type 1210-C Unit R-C Oscillator
Type 1203-B Unit Power Supply
Type 1232-A Null Detector
Type 716-P4 Guard Circuit
Type 716-C Capacitance Bridge

Type 1610-B2
Type 1210-C Unit R-C Oscillator
Type 1203-B Unit Power Supply
Type 1232-A Null Detector
Type 716-C Capacitance Bridge

Type 1610-AH
Type 1214-M Unit Oscillator
Type 1212-A Unit Null Detector
Type 1212-P2 1-Mc Filter
Type 1203-B Unit Power Supply
Type 716-CS1 Capacitance Bridge







Type 1680-A AUTOMATIC CAPACITANCE BRIDGE ASSEMBLY

FEATURES:

Completely automatic — selects range, makes balance, presents digital output data, displays values of both capacitance and dissipation factor (or conductance) with proper decimal point and units on illuminated indicators.
Accurate — ±0.1% of reading.
A true bridge circuit; both capacitance and loss are balanced simultaneously. Accuracy ensured by stable, passive standards.
Fast — completes balance in 0.5 second at 1 kc/s under worst conditions — can continuously track small changes.
Wide range — 0.01 pF to 1000 μF.
Three-terminal, guarded bridge circuit eliminates errors from lead capacitance.
Modular, plug-in construction; built-in test programs, operated from front panel for rapid checkout and convenient servicing.
BCD output data, 1-2-4-2 code.

USES: This automatic bridge assembly is an accurate, fast, and economical test device for production and laboratory applications where a great many capacitance measurements are needed. Its range and accuracy cover most capacitor-measurement requirements.

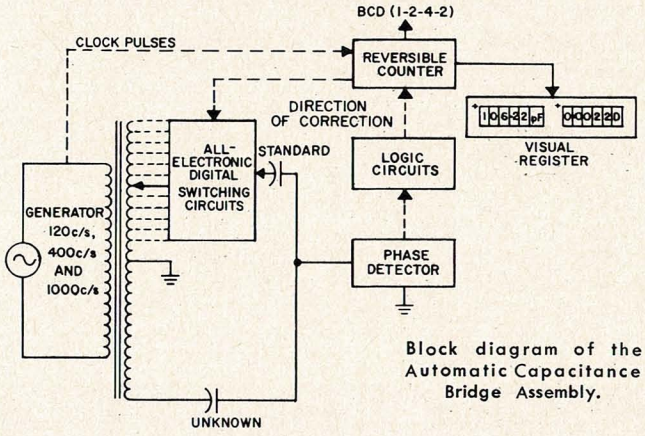
In component-inspection applications, measurement rate is up to ten times faster than is possible with manually balanced bridges. A simple test fixture, the TYPE 1680-P1, is available for rapid manual connection of capacitors. With a suitable limit comparator, automatic testing and sorting are possible.

In capacitor production applications, this bridge can be used as an integral part of automatic manufacturing processes to monitor production automatically.

In qualification testing, quality control, and reliability studies, freedom from stray-capacitance effects permits accurate measurements at the end of long cables, such as those necessary to connect to capacitors in environmental chambers. Lead resistance is negligible in the measurement of all but very large capacitors (see accuracy curves). Control and output signals are provided for use in data-acquisition systems that include scanners and automatic data-logging equipment such as card punches, tape punches, and electric typewriters.

There are four operating modes, selected by a front-panel switch:

AUTOMATIC RANGE — Provides fully automatic range switching as well as automatic balancing.



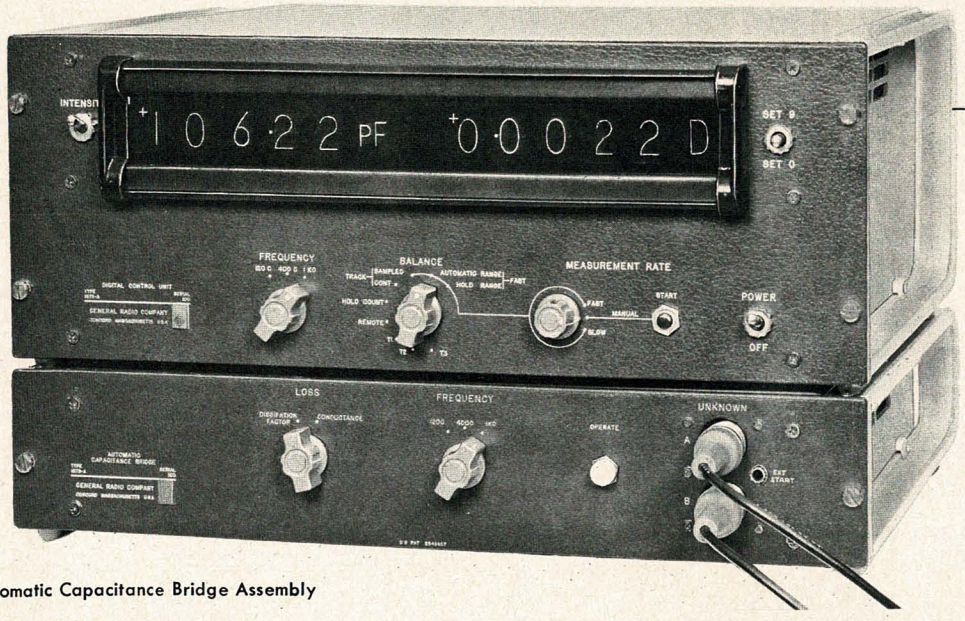
Block diagram of the Automatic Capacitance Bridge Assembly.

For fastest measurements of capacitors that differ widely in value from unit to unit.

HOLD RANGE — Prevents bridge from dropping to lower ranges. Retains a common decimal-point location for ease in comparison of a series of recorded values.

TRACK CONTINUOUS — Tracks changing capacitance and loss, supplying a continuous indication of the values of the unknown — useful for temperature-coefficient determination and similar measurements.

TRACK SAMPLED — Like the TRACKING-CONTINUOUS mode, tracks changing C and D but balances



NEW in catalog S

Type 1680-A Automatic Capacitance Bridge Assembly

and supplies indication only on command, as set either by a front-panel control or remotely. For fastest measurement of components near a fixed value, as in sorting.

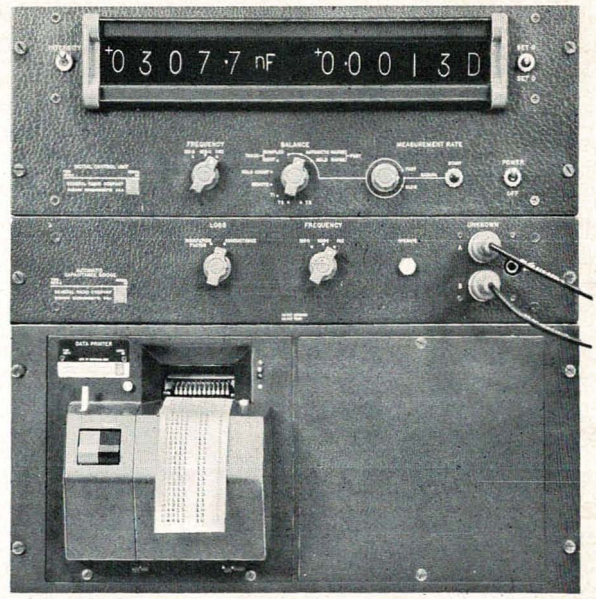
Additional switch positions (T1, T2, and T3) are provided for use in checking internal operations.

ACCESSORY EQUIPMENT

Output and control signals are provided for use with data-logging systems. A suitable data printer is listed on the next page and completely described on page 183. For analog plotting, a digital-to-analog converter and a graphic level recorder are described on page 182. Systems for limit comparison, punched cards, and punched-tape output are available. Inquiries are invited for systems incorporating such auxiliary devices.

DESCRIPTION: The Automatic Capacitance Bridge Assembly is a fully automatic, all-solid-state, three-terminal, capacitance bridge. It is a true bridge, relying on stable, passive standards for its accuracy. The bridge not only provides four different operating modes to fit a variety of measurement requirements but also includes built-in test programs for rapid, convenient checkout of all internal circuit modules.

The circuit is a transformer-ratio-arm bridge (see diagram). It is in balance when the currents through the standard capacitor and the unknown capacitor are equal so that the current in the phase detector is zero. The range is chosen automatically by dry-reed and mercury-wetted relays, which select decade taps on a ratio transformer. The phase detector determines whether the current passing through the unknown arm of the bridge is higher or lower than that through the standard arm and produces an error signal, which indicates whether more or less voltage is required on the standard capacitor to reach a balance. This information is used by a reversible counter, which controls, through electronic switching circuits, the voltage on the standard capacitor. The counter counts in a direction to minimize the error signal until balance is reached. At balance, the value of the unknown is displayed on an in-line digital readout, which indicates capacitance, dissipation factor or conductance, decimal points, and units. This information is also presented in binary-coded-decimal form for use with printers and other data-handling equipment.



The Type 1680-A Automatic Capacitance Bridge Assembly with the Type 1137-A Data Printer.

Components in the automatic capacitance bridge are arranged in modules consisting of plug-in, fiber-glass-epoxy, etched-circuit boards. A malfunction can be readily traced to an individual module by means of the internal test programs. The defective module can then be removed and serviced, or replaced, with minimum down time.

The TYPE 1680-A Automatic Capacitance Bridge Assembly is the first in a series of GR automatic bridges. It is constructed in two parts, the TYPE 1672-A Digital Control Unit, which has most of the logic and digital circuitry, and the TYPE 1673-A Automatic Capacitance Bridge, which contains the bridge circuits. This system permits other bridges to be added to or substituted for the capacitance bridge as they become available. Thus, the utility of the Digital Control Unit can be extended to cover a wide range of measurement applications.

SPECIFICATIONS

		At 120 c/s	*At 400 c/s*	*At 1000 c/s*
RANGES	**Capacitance (parallel)*:**	100 pF-1000 μF	0.01 pF-100 μF	0.01 pF-100 μF
	Conductance (parallel):	0.1 μmho-1.0 mho	100 pmho-1.0 mho	100 pmho-1.0 mho
	Dissipation Factor (direct reading)	0.0001-1.00 (100%)	0.0001-1.00 (100%)	0.0001-1.00 (100%)
	(Measured as conductance):	0 to ∞	0 to ∞	0 to ∞
BASIC ACCURACY (see curves)	**Capacitance:**	0.1% of reading	0.1% of reading	0.1% of reading
	Conductance:	0.1% of reading	0.1% of reading	0.1% of reading
	Dissipation Factor:	1% of reading	1% of reading	1% of reading
SPEED OF BALANCE (approx) (Speed may be somewhat slower than that listed when dissipation factor is measured near the low end of each range.)	**Fast Modes:**			
	No range changes	2.5 seconds	0.35 second	0.25 second
	With range changes	5.0 seconds	0.6 second	0.5 second
	Tracking Modes:			
	10-count change	1.0 second	0.1 second	0.1 second
	100-count change	2.0 seconds	0.35 second	0.2 second
	1000-count change	11.0 seconds	2.6 seconds	1.1 seconds

* For series capacitance measurements a correction (chart supplied) can be used: If $D_x = 0.1$ (10%), correction = 1%.
If $D_x = 0.03$ (3%), correction = 0.1%.

EFFECTS OF LEADS: There is no error introduced by stray capacitance if shielded cables are used. Series resistance of leads can cause errors on the highest range. Accuracy curves include the effects of up to 50 mΩ of external cable.

VOLTAGE ACROSS UNKNOWN: 1 V on lower capacitance ranges, decreasing to 1 mV on highest range. Can be set (internally) as low as 1/10 of these values with a proportionate loss in resolution.

DISPLAY: Two 5-digit banks of bright-light, numerical indicators, with decimal points and units of measurement. Lamp burnout does not affect instrument operation or coded output. Lamps can be replaced from front panel.

DC BIAS: Can be introduced from external source.

REMOTE CONTROL: Start and balance controls can be activated remotely by contact closures.

OUTPUT SIGNALS

Numerical Data: 10 digits BCD 1-2-4-2 code.

Range Code (1 to 7): 1 digit BCD 1-2-4-2 code.

Print Command at Completion of Balance: Change from "1" level to "0" level — returns to "1" level at end of display interval.

Signal Levels: "1" level, 0 V; "0" level, −12 V; both with respect to reference line, which is at +6 V above chassis ground. Impedance of lines = 12 kΩ.

MEASUREMENT RATE: Panel control allows adjustment of measurement rate so that display time between measurements is between approximately 0.1 and 5 s. The rate can be set manually (or remotely) at any rate compatible with balance time.

OPERATION AT OTHER MEASUREMENT FREQUENCIES: With internal modification, the measurement frequencies can be changed to any frequency between 100 c/s and 2 kc/s.

DIFFERENCE MEASUREMENTS: By the addition of a suitable standard to terminals provided, the bridge can be made to indicate the deviation, either positive or negative, from a nominal value.

Accessory Type 1680-P1 Test Fixture facilitates connection of capacitors to the bridge. Capacitor leads are inserted in the clips and the bridge balances when bar marked PRESS is pressed.

GENERAL

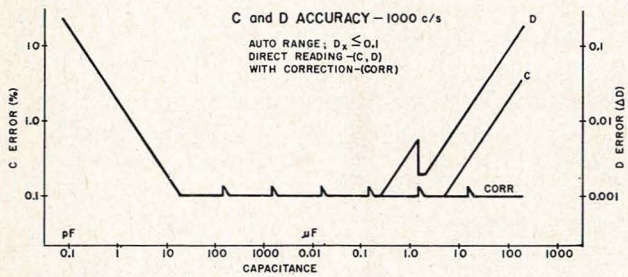
Power Required: 105 to 125 V, 195 to 235, or 210 to 250 V, 50 to 60 c/s, 100 W. Internal 120-cycle oscillator is locked to power line for 60-cycle operation.

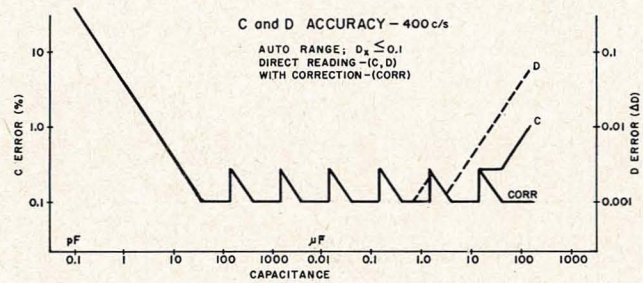
Auxiliary Controls: A rear-panel sensitivity control can be used to minimize balance time by a decrease in resolution.

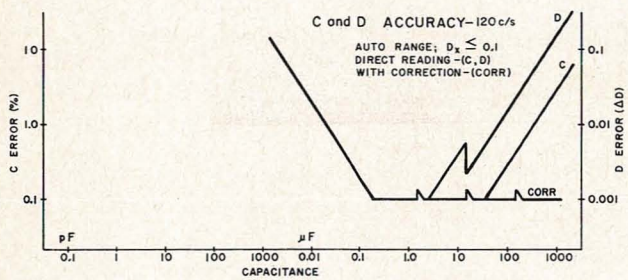
Mechanical Data: The Automatic Capacitance Bridge Assembly consists of two components, TYPE 1672-A Digital Control Unit and TYPE 1673-A Automatic Capacitance Bridge. End frames for bench mount (see photo) and hardware for rack mount are both supplied.

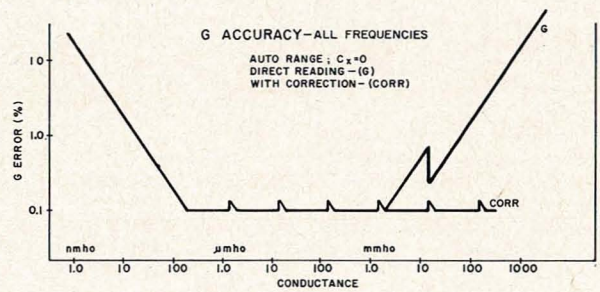
Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
19	485	10½	270	18*	460	71	33	145	67

* Behind panel.









Catalog Number	*Description*	*Price*
1680-9701	**Type 1680-A Automatic Capacitance Bridge Assembly**	**$4850.00**
1137-9744	**Type 1137-A Data Printer,**** 6-column BCD, Rack Model	**1565.00**
1136-9502	**Type 1136-A Digital-to-Analog Converter,**† Rack Model	**680.00**
1680-9601	**Type 1680-P1 Test Fixture**	**75.00**

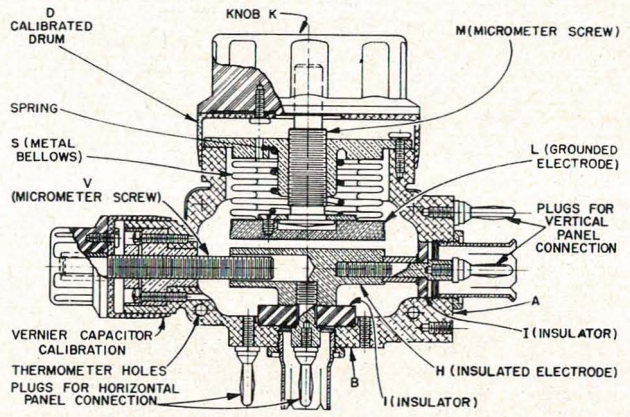
** See page 183. †See page 182.

PATENT NOTICE. See Notes 4 and 8, page 11.

Type 1690-A DIELECTRIC SAMPLE HOLDER

FEATURES:

Specimens can be measured over a wide range of frequencies with the same holder in different measuring circuits.
Precision calibration provided for each unit.
Calibration takes account of corrections for edge fringing and stray capacitance.
Rigid casting supports entire structure. ■ Complete shielding.
Large, easily read dials.



USES: The TYPE 1690-A Dielectric Sample Holder is a micrometer-driven sample holder of the Hartshorn type,* used for the measurement of dielectric constant and dissipation factor of specimens of dielectric materials in the form of standard ASTM 2-inch diameter disks. It is suitable for any flat sample whose largest dimension is not over 2 inches and whose thickness is not over 0.3 inch.

It can be used with resonant circuits for susceptance-variation or frequency-variation measurements, with the TYPES 1615-A, 716-C and 716-CS1 Capacitance Bridges, the TYPES 874-LBA and 900-LB Slotted Lines, and the TYPE 1602-B UHF Admittance Meter.

A precision micrometer screw, M, with large instrument knob, K, drives the movable grounded electrode, L, with respect to a fixed, insulated electrode, H. An accurately divided drum, D, indicates the electrode spacing. The micrometer screw is electrically shunted by a metal bellows, S, to assure a positive, low-resistance connection. A release mechanism automatically disengages the drive to prevent damage when the electrodes are in contact. The movable electrode adjusts itself to the plane of the specimen surface.

The vernier capacitor with micrometer screw, V, is for use in the susceptance-variation method of measurement.

The assembly is mounted in a rugged aluminum casting, B, which it shields on four sides. Two removable cover plates, which permit access to the electrodes, complete the shielding. The holder can be mounted on either horizontal or vertical panels.

*L. Hartshorn and W. H. Ward, *Proceedings of the Institution of Electrical Engineers*, Vol. 79, pp. 597-609 (1936).

SPECIFICATIONS

Electrodes: Diameter, 2.000 in ± 0.0025 in. Surfaces ground optically flat within a few wavelengths.

Electrode Spacing: Adjustable from zero to 0.3 in, indicated by micrometer reading in mils.

Vernier: Incremental capacitance is 5 pF, nominal.

Calibration: For main capacitor, a chart gives calculated air capacitance as a function of spacing. Correction curve gives the measured deviations from calculated values over range from 300 mils to 10 mils spacing. In accordance with recommended ASTM practice, calibration is referred to the calculated geometric value at a spacing of 100 mils. Accuracy is ±0.2% ± 0.1 mil.

For vernier capacitor, correction chart is provided, from which capacitance differences can be determined to an accuracy of ±0.004 pF.

Zero Capacitance: Approximately 11 pF.

Operating Temperature: Up to 100°C.

Frequency: No significant error occurs at frequencies below 100 Mc/s.

Accessories Supplied: TYPE 1690-P1 Adaptor Assembly for mounting to TYPES 1615-A, 716-C and -CS1 Capacitance Bridges; hardware for mounting sample holder on TYPES 1611-B and 1644-A Bridges and TYPE 1862-C Megohmmeter.

Accessories Available: TYPE 1690-P2 Adaptor Assembly to TYPE 874-LBA Slotted Line or TYPE 1602-B UHF Admittance Meter.

Mechanical Data: Carrying and storage case supplied.

Dimensions: 6¼ by 5¾ by 4½ in (160, 150, 115 mm) over-all.

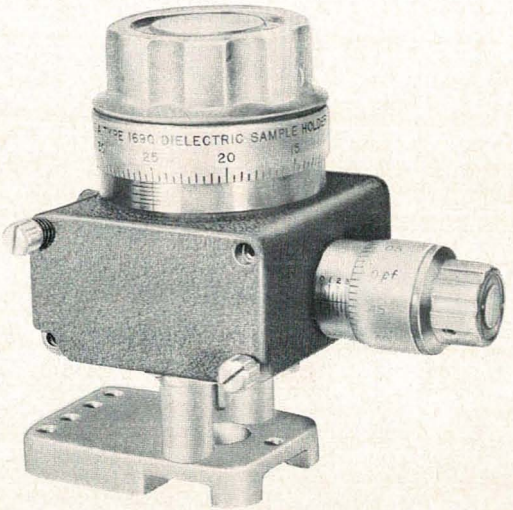
Net Weight: 3¾ lb (1.8 kg), including case.

Shipping Weight: 13 lb (6 kg).

For a more detailed description, see the *General Radio Experimenter*, August 1951.

Catalog No.	*Description*	*Price*
1690-9701	**Type 1690-A Dielectric Sample Holder**	**$435.00**
1690-9602	**Type 1690-P2 Adaptor Assembly** (for connection to coaxial equipment)	**20.00**

PATENT NOTICE. See Note 4, page 11.



Type 1611-B CAPACITANCE TEST BRIDGE

FEATURES:

Wide range — 0 to 11,000 μF. ■ Measures both 2- and 3-terminal capacitors.
Visual null indicator.
External polarizing voltage can be applied.
Measures polarized electrolytics under conditions of actual use — with 120-cycle ripple.
Measurements are unaffected by moderate electrostatic fields.

USES: Capacitance and dissipation-factor measurements can be made quickly and conveniently with this bridge. Among its uses in shop and laboratory are the measurement and test of:

Paper and mica capacitors.
Polarized electrolytic capacitors (also tantalytics) at 60 c/s without external generator (50 c/s for TYPE 1611-BQ1).
Dielectric properties of solid insulation and transformer oil.
Cables — testing and fault location.
Insulators and insulation — bushings, transformers, rotating machines.
Capacitance components for electric equipment.
Transformer interwinding and intershield capacitance.

DESCRIPTION: The series-resistance capacitance bridge circuit is used. A shield terminal is provided for 3-terminal measurements. The null detector consists of a tuned amplifier and electron-ray tube. Measurements are made at the power-line frequency. External generator can be connected for 120 c/s and other frequencies.

SPECIFICATIONS

Ranges of Measurement	Accuracy
Capacitance	
0 to 11,000 μF	±(1% + 1 pF)
Dissipation Factor	
Type 1611-B, 0 to 60% at 60 c/s, 0 to f% at other frequencies.	±(2% of dial reading +0.05% × f/60)
Type 1611-BQ1, 0 to 50% at 50 c/s, 0 to f% at other frequencies.	±(2% of dial reading +0.05% × f/50)

Generator: Internal, 60 c/s for TYPE 1611-B, 50 c/s for TYPE 1611-BQ1. Ac voltage on capacitor under test varies from about 125 V at 100 pF to less than 1 V at 10,000 μF. A maximum of 1 VA reactive power delivered to sample. Voltage can be reduced by external rheostat on 4 highest ranges for tantalum capacitor measurements. External, required for other than power-line frequency. TYPE 1214-D Unit Oscillator is recommended for 120-cycle measurements.

Detector: Internal detector tunes to power-line frequency and to 120 c/s; external filter can be plugged in for other frequencies. Capacitances from 100 pF to 10,000 μF can be balanced to precision of at least 0.1%.

Dc Bias: Capacitors can be externally biased to 500 V for measurements on capacitors of 1 to 11,000 μF.

Power Required: 105 to 125 or 210 to 250 V, 15 W, 60 c/s or 50 c/s.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

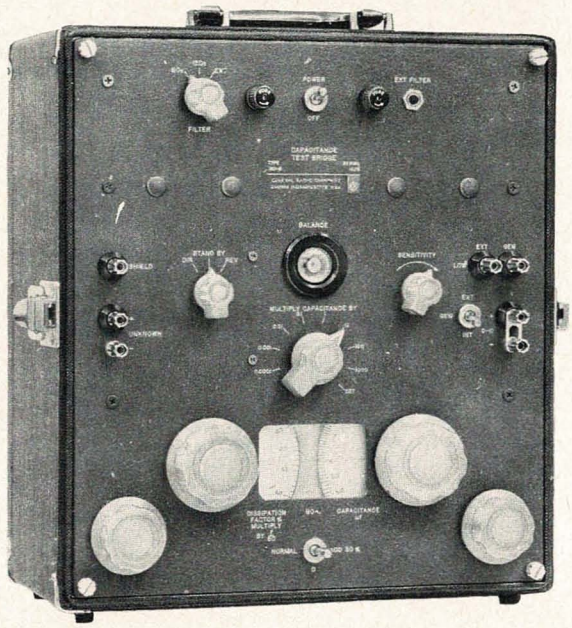
Accessories Required: External generator for 120-cycle measurements.

Mechanical Data: Shielded, luggage-type cabinet.

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
14¼	370	16	410	10	255	30½	14	37	17

For a more detailed description, see *General Radio Experimenter*, February 1958.

Catalog Number	*Description*	*Price*
1611-9702	**Type 1611-B Capacitance Test Bridge,** 60 c/s	**$665.00**
1611-9914	**Type 1611-BQ1 Capacitance Test Bridge,** 50 c/s	**on request**
1214-9704	**Type 1214-D 120-cycle Unit Oscillator**	**115.00**



WIDE-RANGE
POWER-FREQUENCY TEST BRIDGE
FOR SHOP, FIELD, OR LABORATORY

Type 1632-A INDUCTANCE BRIDGE

FEATURES:

Wide range, 0.0001 μH to 1111 H. ■ ±0.1% direct-reading accuracy.
Six-figure resolution. ■ Will detect 0.1 nanohenry.
Easy, fool-proof readout with in-line decade readings and indicated decimal points.
No sliding balance. ■ Measures series or parallel inductance.
Circuits and simplified instructions engraved on the panel.

USES: This bridge measures the series or the parallel components of two-terminal grounded inductors, at audio frequencies. Its high accuracy makes it suitable for standardization measurements, while its convenient inline readout feature and the absence of a sliding balance make possible rapid, highly precise measurements.

DESCRIPTION: The bridge circuit is shown schematically on the panel. The standard reactance is a capacitor, which, owing to its very low residual impedances, exhibits a negligible change in its effective capacitance over the audio range. The Owen circuit also makes possible the use of the high accuracy of decade resistors for the inductance balance. The bridge reads directly in either series or parallel components of the unknown inductor.

Inductance is indicated by the setting of a six-decade control; conductance by the setting of four decades and a continuously variable control. The dials, which show only the pertinent digit of each decade, indicate inductance directly. Resistance, either series or parallel, is the reciprocal of the conductance setting. An eight-position multiplier automatically indicates both the decimal point and the units of measurement.

For maximum accuracy in the measurement of both large and small values of inductance, the residual impedances associated with the unknown terminals have been minimized.

SPECIFICATIONS

RANGE AND ACCURACY

Inductance: Range, 0.1 nH to 1111 H. Accuracy, ±0.1%, direct reading, except at extremes of inductance, frequency, and Q ranges; ±1% on lowest range (0.1 nH to 111 μH). If Q is less than 1, accuracy is reduced to $(+0.05 \pm Q_B)\%/Q_X$. Values of Q_B at 1 kc/s are:

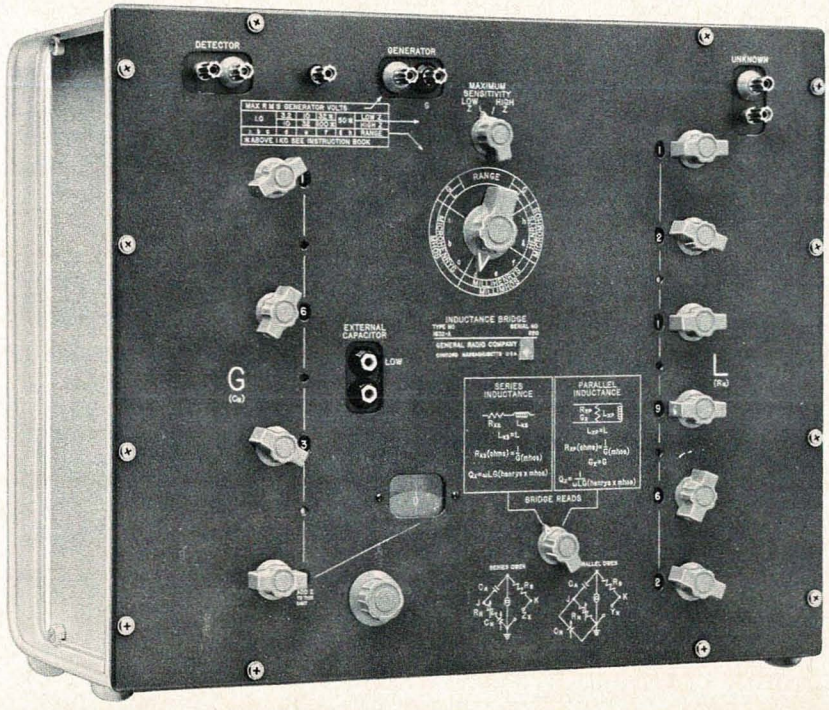
Range	*a, b, c*	*d- Low Z*	*d- High Z* *e- Low Z*	*e- High Z* *f- Low Z*	*f- High Z* *g*	*h*
R_B	1 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ
Q_B at 1 kc/s	±0.03%	±0.005%	±0.002%	±0.002%	±0.02%	±0.1%

Above 1 kc/s, multiply Q_B values by f_{kc}. Additional error of $0.1 \times 10^{-8} f^2_{kc}\%$ on lowest L range and of $4 \times 10^{-8} f^2_{kc}\%$ on highest range. Two nearly equal inductors can be intercompared to a precision of 10 ppm or better. Bridge adds about 1 pF to capacitance across inductor.

Conductance: Range, 0.1 nʊ to 1111 ʊ. Accuracy, ±1%, direct reading, reduced at extremes of inductance, conductance, frequency, and Q ranges. C_N capacitor decades are adjusted within ±1% + 2 pF.

If Q is greater than 10, the error in either series resistance or parallel conductance is increased to Q_X $(+0.05 \pm Q_B)\%$. (See above table for values of Q_B at 1 kc/s, and, above 1 kc/s, multiply Q_B values by f_{kc}.) When bridge reads series conductance, there is an additional error in series resistance of $0.15\,Q_X\%$ at 1 kc/s, when the L decades are set at 1/10 full scale (R_N = 10 kΩ); this error is proportional to frequency (with constant Q_X) and approximately proportional to resistance (R_N) of L decades.

Maximum Measurable Q: Series connection, proportional to frequency, 60 at 100 c/s; parallel connection, 80 at 100 c/s and R_N of 100 kΩ, inversely proportional to frequency and to R_N.



GENERAL

Generator: External only (not supplied). Bridge is designed primarily for measurements at 1 kc/s and lower, but is usable to 10 kc/s with some decrease in accuracy. Maximum safe bridge input voltage is 1 V on low-L ranges to 100 V on high ranges; values engraved on panel. TYPE 1311-A, TYPE 1310-A, or TYPE 1210-C Oscillator recommended.

Detector: External only (not supplied). TYPE 1232-A Tuned Amplifier and Null Detector recommended.

Accessories Supplied: TYPE 274-NL Shielded Patch Cord and TYPE 874-R34 Patch Cord for generator and detector connection; TYPE 1632-P1 Transformer to match low bridge input impedances to 600-Ω generator.

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

Model	Width		Height		Depth		Net Weight		Shipping Weight	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	16	410	10½	270	40	18.5	53	24.5
Rack	19	485	15¾	400	8½*	230	40	18.5	53	24.5

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, November 1959.

Catalog Number	*Description*	*Price*
1632-9801	**Type 1632-A Inductance Bridge,** Bench Mount	**$1050.00**
1632-9811	**Type 1632-A Inductance Bridge,** Rack Mount	**1050.00**

Type 1660-A INDUCTANCE-MEASURING ASSEMBLY

The TYPE 1660-A Inductance-Measuring Assembly consists of the TYPE 1632-A Inductance Bridge, the TYPE 1311-A Audio Oscillator, the TYPE 1232-A Tuned Amplifier and Null Detector, and the necessary patch cords for interconnection of the units.

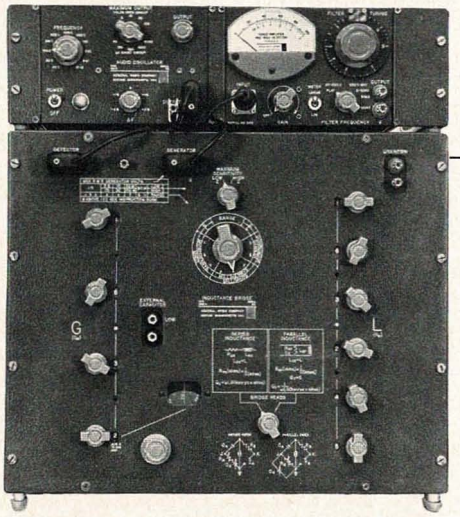
End frames of the generator-detector unit are bolted to those of the bridge to make a rigid assembly without the use of a relay rack. The oscillator operates from the power line, the detector from internal batteries.

This assembly is a complete system for the precise measurement of inductance from 0.1 nanohenry to 1.1 kilohenrys, at 11 fixed frequencies from 50 c/s to 10 kc/s.

Dimensions: Width 19, height 23, depth 10½ (485, 590, 270 mm), over-all.

Weight: Net, 62 lb (29 kg); shipping, 92 lb (42 kg).

Catalog No.	*Description*	*Price*
1660-9701	**Type 1660-A Inductance-Measuring Assembly**	**$1680.00**



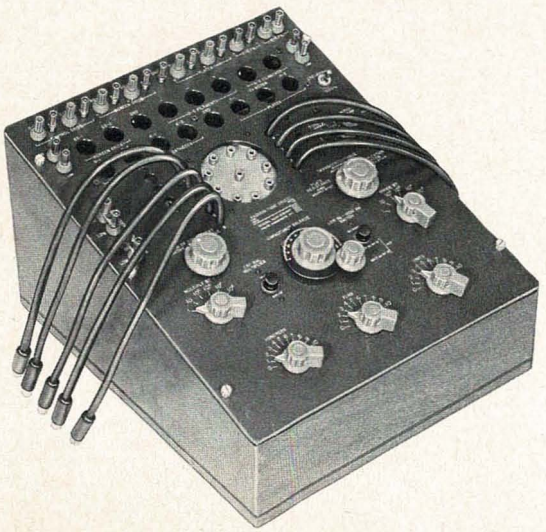
NEW

in catalog S

Type 1661-B VACUUM-TUBE BRIDGE

The TYPE 1661-B Vacuum-Tube Bridge measures the low-frequency dynamic coefficients of electron tubes and transistors over wide ranges and under a wide variety of conditions. It is suitable for research, development, and production measurements.

For electron tubes, independent, direct-reading measurements of voltage-amplification factor, resistance, and transconductance can be made quickly and easily. Voltage and current ratings permit many transmitting tubes to be tested. The bridge meets the requirements of IEC Document 39 (Central Office 141).



For transistors, the short-circuit conductance parameters g_i, g_o, g_r, and the h_r and h_i parameters can be determined directly. With external shielding, some open-circuit parameters can be measured. The $h_{fb}(\alpha)$ and h_{fe} (β) parameters and open-circuit impedance parameters can be calculated from short-circuit conductance measurements.

In this ac null method of measurement, each of the three coefficients is obtained in terms of the ratio of two alternating test voltages. Resistance, voltage ratio, and transconductance parameters can be measured with reference to any pair of electrodes. Connections are made with coaxial patch cords. Each section of two-section tubes can be tested independently.

Complete Description and Specifications on Request

Catalog No.	*Description*	*Price*
1661-9702	**Type 1661-B Vacuum-Tube Bridge**	**$1450.00**

Type 1633-A INCREMENTAL-INDUCTANCE BRIDGE

FEATURES:

Measures L and R or Q directly at nine frequencies. ■ Wide ranges of measurement.
High ac and dc power-handling capacity — up to 1250 volts and 50 amperes.
Dc and ac can be impressed simultaneously on the coil being measured.
Known induction levels can be set and maintained through a test procedure.
No sliding balance. ■ Both generator and detector can be grounded.
Extensive safety precautions have been taken to avoid shock hazard to the operator and damage to the equipment.

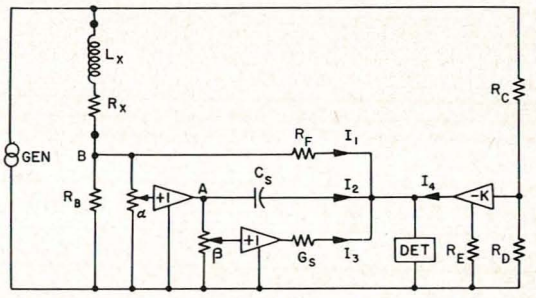
USES: The measurement of incremental inductance, or the inductance of a coil over very wide ranges of dc and ac excitation, is important to both manufacturers and users of silicon steel and other magnetic alloys, ferrites, chokes, transformers, and filters. Such measurements can be made accurately and conveniently with the TYPE 1633-A Incremental-Inductance Bridge. It can also be used to measure nonlinear resistors and the ac impedance, with dc superposed, of rectifiers, Zener diodes, thermistors, and other semiconductor devices. Complete assemblies of bridge and power supplies are listed on page 72.

DESCRIPTION: This bridge uses a new circuit, which includes active elements,* in order to obtain wide operating ranges of inductance and current without the use of excessive numbers of resistance and capacitance decades. For each range a single fixed capacitor and a single resistor are used, and the effect of changing magnitudes is simulated by changes in the applied voltage.

The active elements are three multistage, transistor, feedback amplifiers, designed to have parameters at least an order of magnitude more stable than is required for the desired bridge accuracy. Two are used for isolation, and, with their associated potentiometers, they form variable-voltage sources, with low output impedance, to simulate changes in magnitude of the fixed standards, C_s and G_s. The third amplifier is a phase inverter.

At balance, $I_1 + I_2 + I_3 + I_4 = 0$, and

$$L_x \sim \alpha R_B C_s, \qquad R_x \sim \beta R_B G_s, \qquad Q \sim \frac{\omega C_s}{\beta G_s}.$$

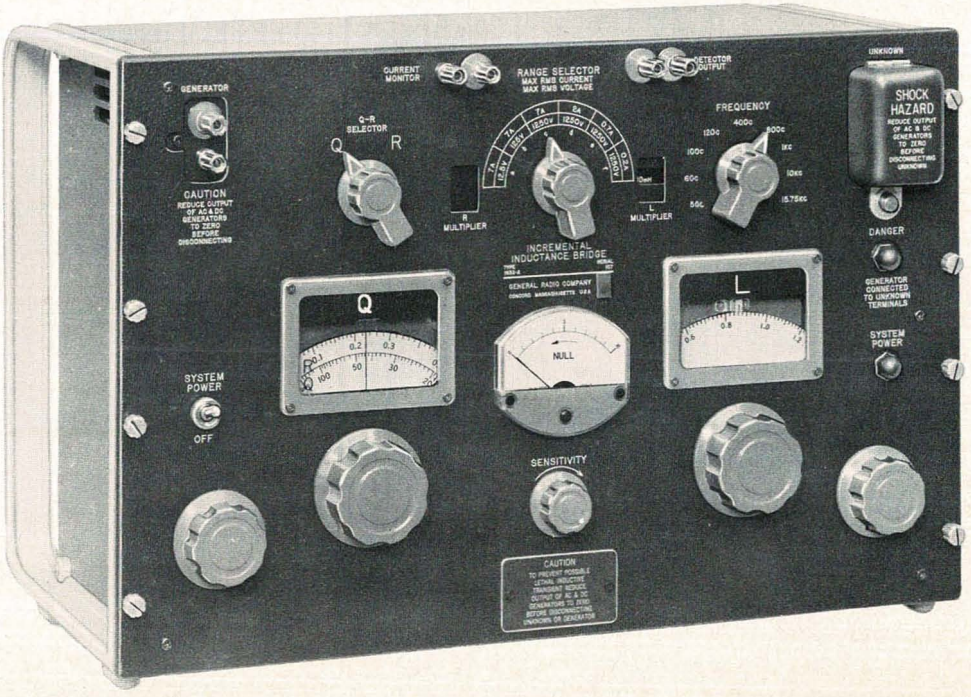


Where α and β = fractions of potentiometer voltage applied to the isolation amplifiers,
R_B = ratio-arm resistance,
C_s and G_s = capacitance and conductance standards.

Up to 7 amperes, rms (combined ac and dc), at up to 1250 volts, can be impressed on the sample, and, with a TYPE 1633-P1 Range-Extension Unit, up to 50 amperes. Three power supplies are available, a dc supply, a line-frequency supply, and a variable-frequency oscillator, which are designed specifically for use with the bridge. Most conventional power supplies are not suitable. See Specifications.

The internal detector is highly selective at nine frequencies between 50 c/s and 15.75 kc/s. Owing to high detector sensitivity and low noise, measurements can be made at excitation levels below one volt on the highest inductance ranges and 10 millivolts in the lowest range.

* H. P. Hall, R. G. Fulks, "The Use of Active Devices in Precision Bridges," *Electrical Engineering*, May 1962.



SPECIFICATIONS

RANGES OF MEASUREMENT

Measurement	*Frequency*	*Full-Scale Ranges* a	b	c	d	e	f	*Lowest Scale Division*	**ACCURACY**
Inductance	50, 60, 100, 120 c/s	10 mH	100 mH	1 H	10 H	100 H	1000 H	20 μH	±(1% of reading or 0.1% of full scale) ±(2π/100 × f_{kc}/Q_x)%
	400, 800, 1000 c/s	1 mH	10 mH	100 mH	1 H	10 H	100 H	2 μH	
	10, 15.75 kc/s	100 μH	1 mH	10 mH	100 mH	1 H	10 H	0.2 μH	
Resistance	All	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ	1 MΩ	10 mΩ	±(2% of reading or 0.1% of full scale) ± $\frac{Q_x f_{kc}}{2\pi}$ %
Q		∞ to 1, direct reading at above frequencies						1000	1/Q accuracy = ±2% ±0.001 ± 0.0005f_{kc}
Max rms volts		12.5	125	1250	1250	1250	1250		
Max rms amperes*		7	7	7	2	0.7	0.2	Max rms current = $\sqrt{I_{dc}^2 + I_{ac}^2}$	

* If application requires more than 7 A, TYPE 1633-P1 Range-Extension Unit, which contains a 0.1-Ω resistor, can be externally connected to shunt R_B on the 3 lowest bridge ranges; inductance and resistance values are then reduced by a factor of 10. With this resistor, measurements up to 50 A, ac or dc, are possible.

GENERAL

Generator: External only (not supplied). For optimum performance when dc bias is used, ac supply must be able to withstand large dc currents in output circuit, and dc supply large ac currents. For dc bias, TYPE 1265-A Adjustable DC Power Supply, 200 W; for line-frequency measurements, TYPE 1266-A Adjustable AC Power Source, 200 VA; over the audio-frequency range, use TYPE 1308-A Audio Oscillator and Power Amplifier, 200 VA.

Detector: Internal or external. Internal, selective at any one of above 9 frequencies ±1%; second-harmonic response about 60 dB below fundamental. External, for continuous coverage from 20 c/s to 20 kc/s, use TYPE 1232-A Tuned Amplifier and Null Detector.

Power Required: 105 to 125 or 210 to 250 V, about 60 W, 50 to 60 c/s.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Accessories Available: TYPE 1633-P1 Range-Extension Unit.

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

Model	*Width* in	mm	*Height* in	mm	*Depth* in	mm	*Net Weight* lb	kg	*Shipping Weight* lb	kg
Bench	19	485	12¾	325	10¼	260	31	14.5	48	21.8
Rack	19	485	12¼	315	8¾*	225	29	13.2	48	21.8

* Behind panel

For a more detailed description, see *General Radio Experimenter*, May 1962.

FOR COMPLETE MEASUREMENT ASSEMBLIES, SEE NEXT PAGE.

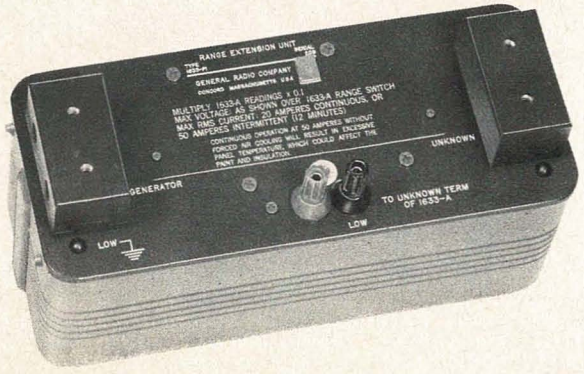
Catalog Number	*Description*	*Price*
1633-9801	**Type 1633-A Incremental-Inductance Bridge,** Bench Model	**$1050.00**
1633-9811	**Type 1633-A Incremental-Inductance Bridge,** Rack Model	**1050.00**

PATENT NOTICE. See Notes 1 and 15, page 11.

Type 1633-P1 RANGE-EXTENSION UNIT

The TYPE 1633-P1 Range-Extension Unit can be used with the TYPE 1633-A Incremental-Inductance Bridge to extend the current ratings to 50 amperes. It connects a 250-watt, 0.1-ohm resistor in parallel with one of the bridge arms.

High-current terminals capable of accommodating leads up to ¼ inch in diameter are provided on the range-extension unit for the generator and unknown. A cable is furnished for connection to the bridge.



When the range-extension unit is connected, the operation of the bridge is unchanged, but only the a, b, and c ranges can be used. Bridge readings must be multiplied by 0.1. The upper limit of measurement is 100 mH up to 120 c/s and 10 mH up to 1 kc/s.

The use of the TYPE 1633-P1 Range-Extension Unit at frequencies up to 400 c/s can cause up to 1% additional error in the bridge readings. Correction can be made for the larger error occurring at higher frequencies. The temperature coefficient of the resistor is less than 20 ppm per degree Centigrade.

Any current up to 30 amperes continuous, or 50 amperes intermittent, ac or dc, can be used. Continuous operation at 50 amperes without forced-air cooling is not recommended.

Dimensions: Width 10½, height 4¼, depth 5 inches (270, 110, 130 mm).

Net Weight: 5¼ lb (2.4 kg). **Shipping Weight:** 7 lb (3.2 kg).

Catalog No.	*Description*	*Price*
1633-9601	**Type 1633-P1 Range-Extension Unit**	**$125.00**

Type 1630 INDUCTANCE-MEASURING ASSEMBLIES

These assemblies are complete systems for the measurement of the inductance and loss of coils with ferromagnetic cores. They are particularly well suited for coil measurements at high levels of dc and ac excitation. Each assembly consists of the Incremental-Inductance Bridge, two power supplies (one dc and one ac), a cabinet-type rack, and the necessary cables for interconnections.

The power supplies can produce 200-voltampere outputs into a wide range of load impedances and are designed to pass the large dc and ac currents required.

Space is provided at the top of the rack for the addition of an oscilloscope, which permits the current waveform or the hysteresis loop to be viewed during the measurements.

TYPE 1630-AL INDUCTANCE-MEASURING ASSEMBLY

For measurements at power-line frequency (50–60 c/s).

Component Units:	*See page*
TYPE 1633-A Incremental-Inductance Bridge	70
TYPE 1265-A Adjustable Dc Power Supply	222
TYPE 1266-A Adjustable Ac Power Supply	222

TYPE 1630-AV INDUCTANCE-MEASURING ASSEMBLY

For measurements at 50, 60, 100, 120, 400, and 800 c/s, and 1, 10, and 15.75 kc/s.

Component Units:	*See page*
TYPE 1633-A Incremental-Inductance Bridge	70
TYPE 1265-A Dc Power Supply	222
TYPE 1308-A Audio Oscillator and Power Amplifier	137

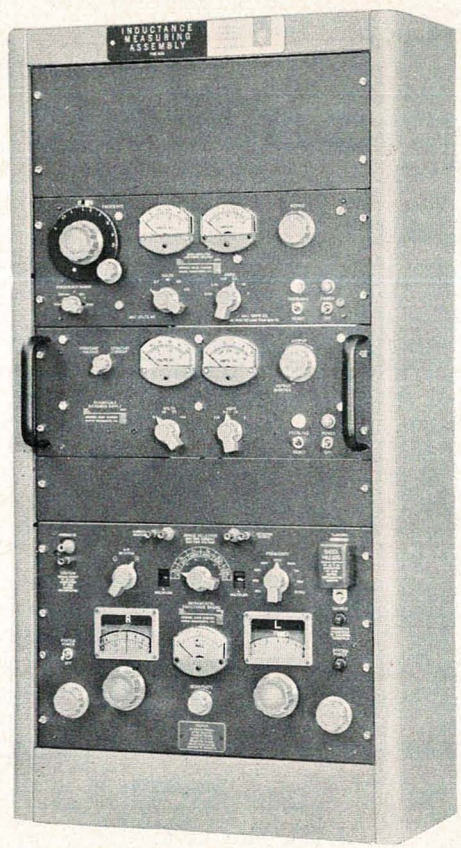
The TYPE 1308-A Audio Oscillator and Power Amplifier provides continuous coverage from 20 c/s to 20 kc/s. When measurements are required at frequencies other than the nine internal-bridge-detector frequencies, the TYPE 1232-A Tuned Amplifier and Null Detector should be used. Order also TYPE 480-P308 Rack Adaptor Set, so that the detector can be installed in the rack.

Mechanical Data:

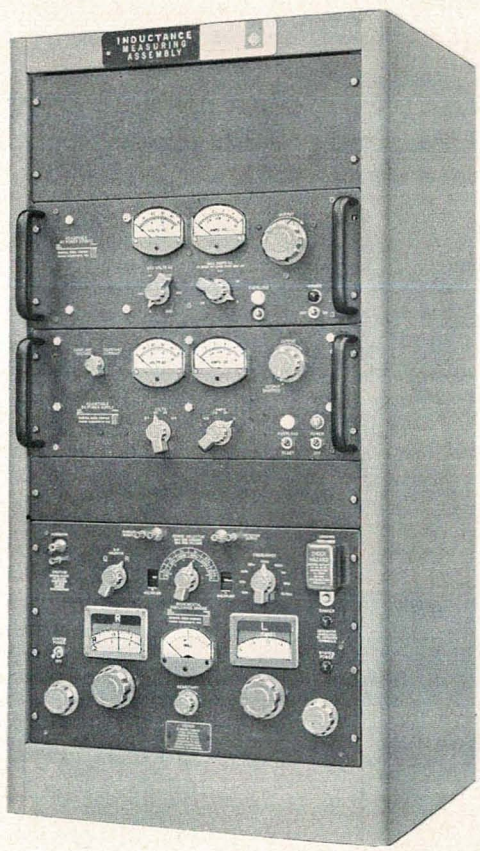
	Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
Type	*in*	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
1630-AL	22½	580	43	1100	20	510	250	115	400	185
1630-AV	22½	580	43	1100	20	510	310	145	460	215

Catalog Number	*Description*	*Price*
1630-9831	**Type 1630-AL Inductance-Measuring Assembly**	**$2685.00**
1630-9827	**Type 1630-AV Inductance-Measuring Assembly**	**3470.00**

PATENT NOTICE. See Notes 1 and 15, page 11.



Type 1630-AL



Type 1630-AV

Type 1652-A RESISTANCE LIMIT BRIDGE

FEATURES: Rapid, accurate for limit tests. ■ Equally useful for null measurements. Large, open-scale meter, color coded. ■ Wide range — one ohm to one megohm. Ac-operated — no batteries needed.

USES: This resistance limit bridge is intended for the production testing of resistors at dc. It can be used:

To indicate deviation from nominal value.

To match pairs of resistors.

To compare resistors to a standard sample.

To measure resistance by the null method.

For manufacturers and users of resistors, this bridge is a rapid and accurate means for sorting into tolerance classifications, for selection to close tolerances, and for matching pairs of resistors for balanced circuits.

In the laboratory, its accuracy is adequate for all but the most exacting requirements, and it will measure resistors up to one megohm.

For automatic sorting, a relay and amplifier can be connected to actuate a selector mechanism.

DESCRIPTION: The circuit is a conventional equal-arm Wheatstone bridge, supplied from a constant-voltage dc source. The meter indicates percent deviation directly. The internal standard consists of seven TYPE 510 Decade-Resistance Units and is adjustable in 0.1-ohm steps from one ohm to 1,111,111 ohms.

For limit testing, the standard is set to the desired nominal value, and the percentage deviation is read from the meter. Terminals are provided for connection of a test jig such as the TYPE 1650-P1 (page 51).

For matching pairs, the resistor to be matched is substituted for the internal standard.

For null measurements, the internal standard is adjusted to equality with the unknown resistor.

SPECIFICATIONS

RESISTANCE RANGES	ACCURACY
As Limit Bridge	
With internal standard, 1 to 1,111,111 Ω	±0.5% of measured value
With external standard, 1 to 2,000,000 Ω	±0.2% + tolerance of standard
Meter reads from −20 to +20%; standard EIA (RETMA) ± 5% and ±10% tolerances indicated by gold and silver lettering, respectively.	
As Null Bridge	
With internal standard, 1 to 1,111,111 Ω	±0.25% of measured value above 100 Ω; ±0.4% between 10 Ω and 1 Ω.
With external standard, 1 to 2,000,000 Ω	±0.2% + tolerance of standard
For matching, 1 to 2,000,000 Ω	±0.2%.

Test Voltage:	0.9 V	1 V	1.1 V
Meter Indication	−20%	0	+20%

Power Required: 105 to 125 or 210 to 250 V, 60 c/s (50-c model available), about 30 W.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

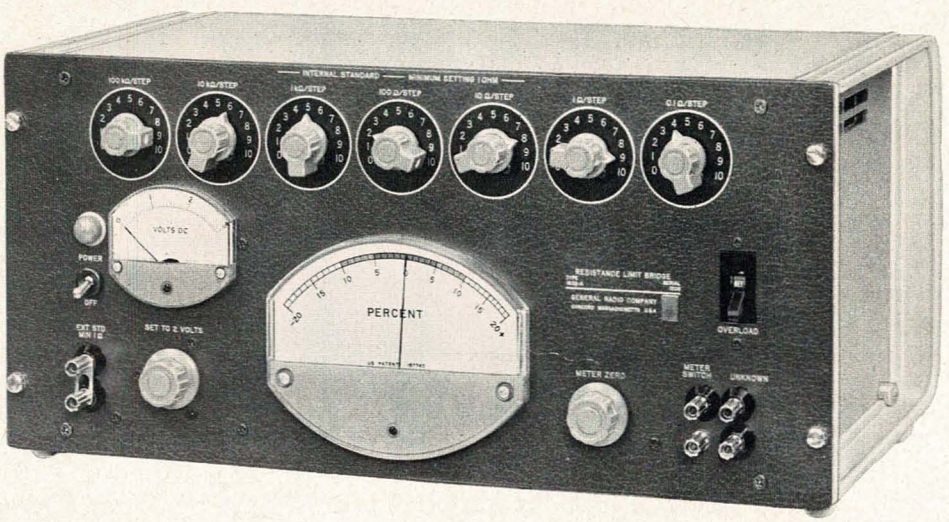
Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	9	230	12¼	315	29	13.5	43	19.6
Rack	19	485	8¾	225	11*	280	29	13.5	43	19.6

* Behind panel.

See also *General Radio Experimenter*, January 1952.

Catalog Number	*Description*	*Price*
1652-9801	**Type 1652-A Resistance Limit Bridge** (for 60-cycle supply), Bench Model	**$660.00**
1652-9811	**Type 1652-A Resistance Limit Bridge** (for 60-cycle supply), Rack Model	**660.00**
1652-9495	**Type 1652-AQ1 Resistance Limit Bridge** (for 50-cycle supply), Bench Model	**on request**
1652-9496	**Type 1652-AQ1 Resistance Limit Bridge** (for 50-cycle supply), Rack Model	**on request**

PATENT NOTICE. See Note 15, page 11.



Type 1644-A MEGOHM BRIDGE

FEATURES:

10^3 to 10^{15} ohms. ■ 1% accuracy to 10^{12} ohms.
$\Delta R\%$ dial for matching resistors and measuring small differences, and for voltage- and temperature-coefficient measurements.
Self-checking against internal wire-wound standards.
High-sensitivity, electrometer-tube detector. ■ Guard terminals provided.
Seven fixed test voltages from 10 to 1000 volts. Other voltages below 1000 are easily set.
Quick charge and discharge for capacitor measurements.

USES: To measure

INSULATION RESISTANCE of cables, transformers, chokes, components, connectors, wiring, terminals, resistors, capacitors, relays, printed circuits, rotating machines, switches, circuit breakers, meters, strain gages, thermocouples, delay lines, slip rings, commutators, heaters, filters, lightning arresters, and other devices.

RESISTANCE of high-valued resistors, resistance films, diodes, transistors, and piezoelectric elements.

VOLTAGE AND TEMPERATURE COEFFICIENTS of resistance.

VOLUME AND SURFACE RESISTIVITY of solids, such as printed-board material, resins, plastics, potting and casting compounds, rubber, refractories, and semiconductors; of liquids, such as oils, plasticizers, and solvents; and of sheet materials, including plastics, recording tape, and varnished fabrics.

DESCRIPTION: The circuit is a dc Wheatstone bridge with a high-impedance, high-sensitivity detector. Precision, wire-wound resistors are used for the fixed bridge arm and the lower-valued decade-step arms. Metal-film and carbon-film resistors are used for the higher decade steps, with trimmers for precise adjustment in terms of the wire-wound standards. The balancing arm is a wire-wound variable resistor.

The guard terminal eliminates the effects of stray resistances to ground. For capacitor leakage resistance measurement, charging time is a fraction of a second.

SPECIFICATIONS

Resistance Range: 1 kΩ to 1000 TΩ (10^3 to 10^{15} Ω) in ten ranges.
Accuracy: 10^3 Ω to 10^{10} Ω, ±1%. After self-calibration: 10^{10} to 10^{12} Ω, ±1%*; 10^{13} Ω, ±2%; 10^{14} Ω, ±10%; 10^{15} Ω, ± one scale division.
ΔR% Dial: ±5% range; accurate to ±0.2% or, for small changes, to ±0.1%.
Test Voltage: Voltage accuracy is ±3% ± 0.5 V.

Fixed Voltages	10	20	50	100	200	500	1000	V
Minimum Unknown R	1	3	7	20	50	150	500	kΩ

Minimum Test Voltage for 1% Resolution: for approx 1-mm meter deflection

Multiplier Setting	*Max R_x*	*Volts*
100 G or less	10^{11}	10
100 G	10^{12}	100
1 T	10^{13}	200

* At high voltages; 1% accuracy is obtainable at 10 V up to 10^{11} Ω; see above.

Short-Circuit Current: <15 mA, 10–50 V; <10 mA, 100–1000 V.
Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 13 W.
Mechanical Data: Flip-Tilt Case (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
*Portable**	12¾	325	12½	320	7¾	200	18	8.5	29	13.5
Rack	19	485	12¼	315	5†	130	19	9.0	31	14.5

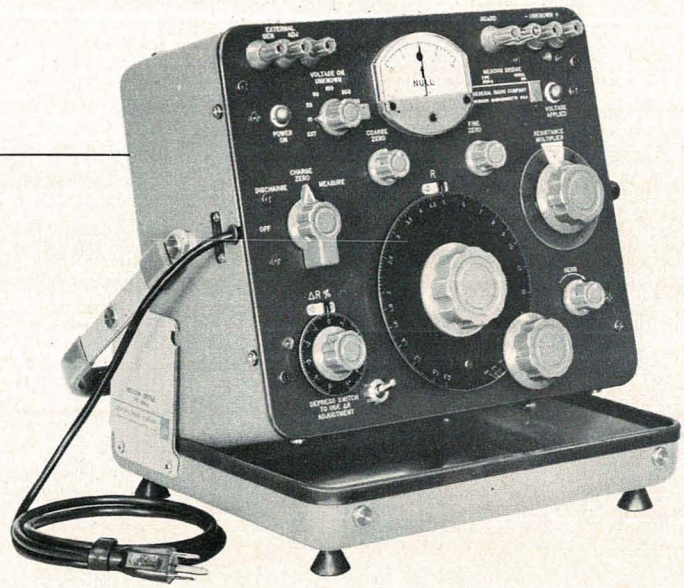
* Dimensions with case closed and including handle. † Behind panel.

See also *General Radio Experimenter*, July 1964.

Catalog No.	*Description*	*Price*
1644-9701	**Type 1644-A Megohm Bridge,** Portable Model	**$625.00**
1644-9820	**Type 1644-A Megohm Bridge,** Rack Model	**625.00**

PATENT NOTICE. See Notes 1, 15, and 22, page 11.

NEW
in catalog S



Type 1862-C MEGOHMMETER

FEATURES:

Direct reading and simple to operate.
Test potentials of 100 volts and 500 volts permit approximate measurement of voltage coefficient.
Voltage can be removed from *unknown* terminals by setting of either switch to DISCHARGE position, thus permitting connections to be made without danger of shock.
Panel light indicates when voltage is applied to the terminals.
Guard and ground terminals provided.

USES: Rugged, versatile, and safe, this megohmmeter rapidly measures wide ranges of resistance at either of two test voltages. The 100-volt level is the EIA standard for measurement of composition, film, and wire-wound resistors above 100 kilohms. The 500-volt level is a standard value in the measurement of the insulation resistance of rotating machinery, transformers, cables, capacitors, appliances, and other electrical equipment.

Regulated power supply and charging circuit permit rapid and accurate measurement of the leakage resistance of capacitors.

Guard and ground terminals permit measurement of grounded or ungrounded two- or three-terminal resistors.

DESCRIPTION: The megohmmeter consists of a regulated power supply, a complement of resistance standards, and a balanced, dc, vacuum-tube voltmeter with very high input resistance.

SPECIFICATIONS

Resistance Range: 0.5 MΩ to 2 TΩ (5×10^5 to 2×10^{12} Ω) at 500 V; 0.5 MΩ to 0.2 TΩ at 100 V; 6 decade ranges; 90% of meter scale utilized for resistance scales up to 500,000 MΩ; center-scale values are 1, 10, 100, 1000, 10,000 and 100,000 MΩ for 500-V operation.

Accuracy: ±3% of indication at low-resistance end of each decade to ±12% (accuracy to which scale can be read) at high-resistance end up to 50,000 MΩ; possible additional ±2% error at top decade. Switch position provided for standardizing calibration at 500 V.

Test Voltage:	*Min R*	*Max R*	*Max I*
100 V ± 4 V	0.5 MΩ	200 GΩ = 2×10^{11} Ω	≈2 mA
500 V ± 10 V	0.5 MΩ	2 TΩ = 2×10^{12} Ω	≈10 mA

Power Required: 105 to 125 or 210 to 250 V, 40 to 60 c/s (operates satisfactorily up to 400 c/s), 25 W.

Accessories Supplied: Spare fuses, 2 color-coded test leads.

Mechanical Data: Flip-Tilt Case (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Portable	8½	210	11½	295	7½	190	9	4.1	12	5.5
Rack	19	485	12¼	315	5*	130	10	4.6	23	10.5

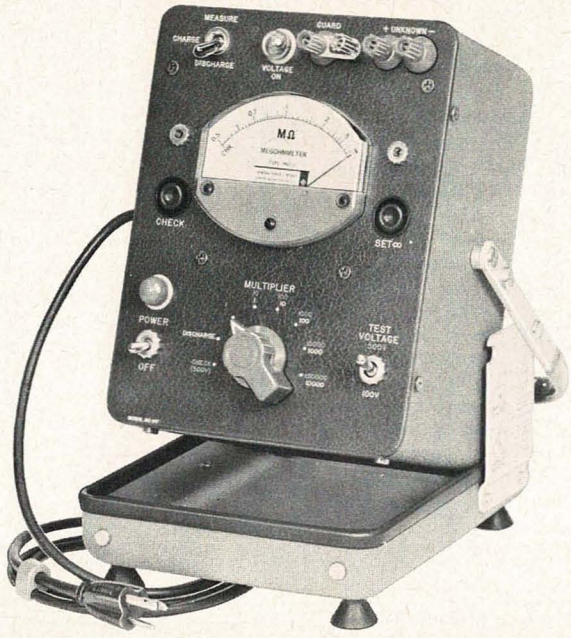
*Behind panel.

For a more detailed description, see *General Radio Experimenter*, July 1963.

Catalog Number	*Description*	*Price*
1862-9703	**Type 1862-C Megohmmeter,** Portable Model	**$310.00**
1862-9844	**Type 1862-C Megohmmeter,** Rack Model	**310.00**

PATENT NOTICE. See Notes 15 and 22, page 11.

ELECTROMETER: *The Type 1230-A Electrometer and DC Amplifier, described on page 174, measures resistances as high as 5×10^{14} ohms as well as very low voltages and currents.*



COAXIAL ELEMENTS

GR874

GR900

DC TO MICROWAVE

Described on the following 26 pages is one of the most comprehensive lines of coaxial equipment available anywhere. There are two basic classifications: the GR874 series, whose common element is the general-purpose GR874 Coaxial Connector, and the GR900 series, based on the GR900 Precision Coaxial Connector. Each series includes connectors, adaptors, and circuit elements, as well as a slotted line, so that measurement setups can be conveniently assembled.

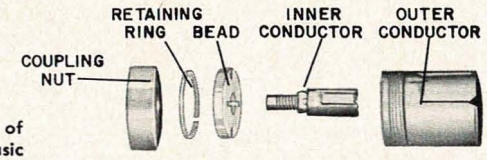
Both the GR874 and the GR900 Connectors have gained wide popularity, not only as circuit elements but also among instrument manufacturers, who have put the electrical and physical advantages of these connectors to good use on their products.

General Radio entered the coaxial instrument field more than 16 years ago, with the introduction of the GR874 Connector, which offered not only excellent electrical performance but a major convenience feature: any two, although identical, could be mated. The hermaphrodite, quick-connect GR874 was soon joined by a family of circuit elements and adaptors using the new connector. GR874-equipped instruments — notably the slotted line and the admittance meter — were added to solve the special measurement problems of vhf and uhf. The availability of precise measuring instruments in turn made possible a continuous refinement of the basic connector. A particularly important chapter in the GR874 development was written a few years ago, when a locking version, fully compatible with the nonlocking GR874 and retaining the hermaphrodite feature, was announced.

True precision came to coaxial measurements in 1963, in the form of the GR900 Precision Coaxial Connector and associated equipment. Until that breakthrough, the development of precise instruments for coaxial measurements had been retarded for want of a precise connector. The GR900 Connector opened the door to the development of a new, ultraprecise slotted line, new measuring techniques, and new applications for coaxial lines where only waveguide had gone before. Today, the GR900 line includes adaptors, terminations, air-line sections, and other components. Another significant figure has been added to coaxial measurement: Where one formerly spoke of a VSWR of 1.03, one now speaks of a VSWR of, say, 1.034, with confidence in the last figure. In terms of accuracy and resolution gained, the GR900 development must rank as one of the most significant of the past decade.

INDEX

The GR874 Connector is the keystone of the GR874 line of coaxial equipment, which includes adaptors, stubs, attenuators, filters, patch cords, and many other devices. The GR874 connector also appears on the TYPE 874-LBA Slotted Line, the TYPE 1602-B Admittance Meter, and the TYPE 1607-A Transfer-Function and Immittance Bridge, and throughout the entire GR instrument line wherever a good general-purpose coaxial connector is called for.

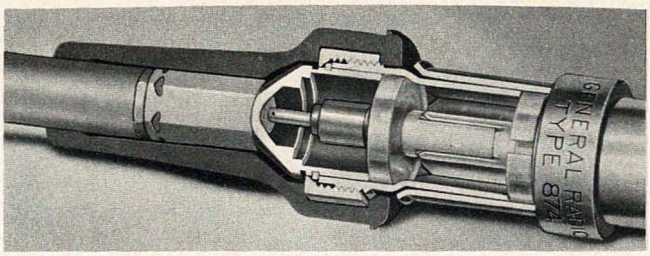


Exploded view of Type 874-B Basic Connector.

The elements of a GR874 Connector, as shown in the exploded view, are an inner conductor, an outer conductor, a supporting polystyrene bead, a phosphor-bronze retaining ring, and a threaded coupling nut. All metal parts are machined and formed to very close tolerances, and all are made of hard-drawn brass, except for the center conductor, which is heat-treated beryllium copper to ensure good gripping capability and long wear. A bright-alloy finish on all surfaces produces high conductivity for low loss and gives long-lasting protection against tarnish.

Inner and outer conductors are similar in principle; each is a tube with four longitudinal slots in one end, with two opposite quadrants displaced inward. When two connectors are joined, the undisplaced quadrants of one overlap the displaced quadrants of the other (see cutaway view).

The locking version of the GR874 is fully compatible with the nonlocking type. Locking connectors, besides furnishing a strong mechanical connection, minimize leakage. Most GR874-equipped instruments use the locking connector. With this panel connector, and particularly with the recessed version, an instrument can, by means of appropriate GR874 Adaptors, be quickly equipped with coaxial connectors of any popular type.

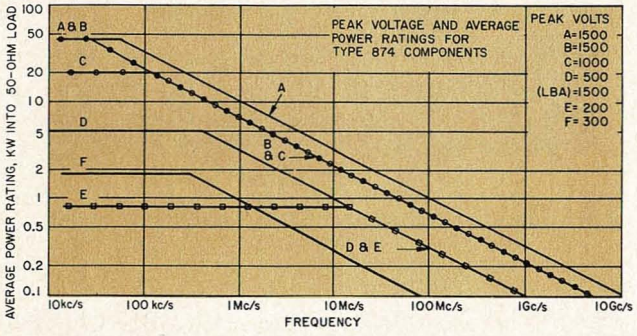


Cutaway view of GR874 basic connector mated with GR874 cable connector.

The GR874 Connector is backed up by one of the most complete lines of coaxial components and devices available anywhere. The user of a GR874-equipped laboratory need seldom, if ever, turn to other connector types for a needed element. If he does, he will almost certainly be able to select a GR874 Adaptor for the conversion.

Many GR874 components are now available equipped with locking as well as nonlocking connectors. The locking version in each case is identified by an L in the type designation.

New members of the GR874 line are constantly being developed, so that equipping a laboratory with the GR874 line today will seem an even wiser choice tomorrow.



ELECTRICAL CHARACTERISTICS

The GR874 Connector has the lowest reflection characteristics of any standard, general-purpose, 50-ohm coaxial connector in the dc-to-7-Gc frequency range. Its VSWR performance is typically superior to that of the most highly regarded military-type connector in common laboratory use. GR874 cable connectors, in fact, offer VSWR performance superior to that of any cable with which they can be used, and therefore add no significant reflections when used in measurement setups.

Power-handling, peak-voltage, leakage, and VSWR data are given on the charts on this and the following pages.

PATENT NOTICE. See Note 4, page 11.

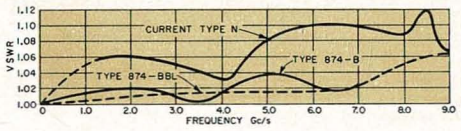
Category	*Page*	*Applicable Type 874 Items*	*See Curve*	*Peak Volts*
Adaptors	81	-QHJA, -QHPA, -QLJA, -QLPA, -QLTJ, -QLTP, -QU1A, -QU2, -QU3A	A	1500
		-QCP, -QCJA, -QCJL, -QNP, -QNPL; -QNJA, -QNJL, -QSCP, -QSCJ, -QSCJL	C	1000
		-QBJA, -QBJL, -QBPA, -QTNJ, -QTNJL, -QTNP, -QUJ, -QUJL, -QUP	D	500
		-QMDJ, -QMDJL, -QMDP	F	300
Air Lines	90			
Adjustable		-LAL, -LK10L, -LK20L	B	1500
Fixed		-L10, -L10L, -L20, -L20L, -L30, -L30L	A	1500
Connectors	79	-B, -BBL, -PLT, -PRLT, -PFL	A	1500
		-CA, -CLA, -C8A, -CL8A, -PBA, -PB8A, -PLA, -PL8A, -PRLA, -PRL8A	C	1000
		-C58A, -CL58A, -C62A, -CL62A, -PB58A, -PB62A, -PL58A, -PL62A, -PRL58A, -PRL62A	D	500
		-C174A, -CL174A, -PB174A, -PL174A, -PRL174A	F	300
Elements	92	-EL, -EL-L, -T, -TL	A	1500
		-K, -KL	D	500
Filters	87	-F185L, -F500L, -F1000L, -F2000L, -F4000L	E	200
Patch Cords	85	-R20A, -R20LA	C	1000
		-R22A, -R22LA	D	500
Slotted Line	82	-LBA	D	1500

GR874 CONNECTORS

The GR874 line of coaxial connectors includes 30 different types, as listed in the chart on page 79.

AIR-LINE CONNECTORS

The TYPES 874-B and 874-BBL Basic Connectors are for use on rigid, 50-ohm air lines made from 9/16-inch-ID, 5/8-inch-OD tubing and 0.244-inch-diameter rod. The TYPE 874-BBL is a locking connector specially designed for excellent performance up to 9 Gc/s.



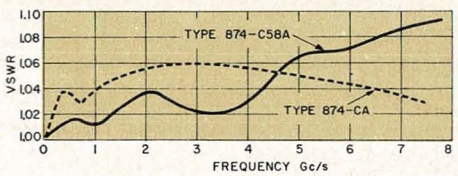
Typical VSWR of pairs of Type 874-B and -BBL Connectors compared with a pair of the latest standard type-N connectors.

CABLE CONNECTORS

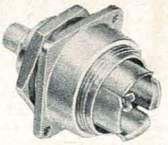
The GR874 cable connector is available in 10 types to accommodate five basic cable sizes in both locking and nonlocking versions. These connectors fit more than 40 different RG types of coaxial cable, as well as General Radio TYPES 874-A2 and -A3 cable. Each cable connector consists of a basic connector plus inner and outer transition pieces, a soft-copper ferrule, a heat disk, and a flexible cable guard. The cylindrical transition pieces maintain the 50-ohm characteristic impedance of the connector throughout the reduction to the cable diameter. The cable inner conductor is soldered to the inner transition piece, and the cable braid and jacket are crimped to the outer transition by the ferrule. Braid and jacket are thus kept from working loose and causing reflections and leakage.

A Neoprene cable guard serves as a protective handle. Sized to grip the cable securely without compressing it, the cable guard adds to the quick-connect-disconnect convenience of the connector.

Average VSWR of single connector on infinite length of 50-ohm cable.



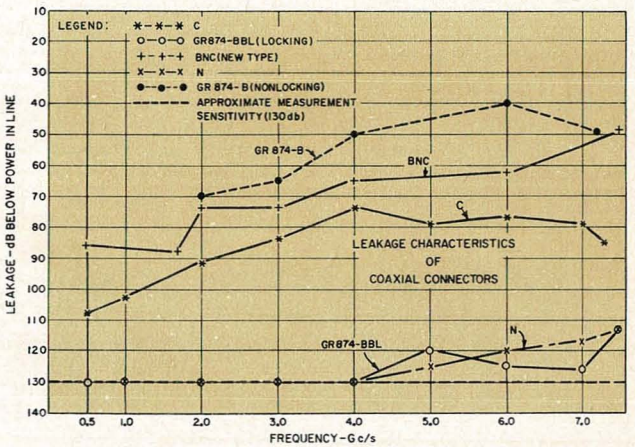
PANEL CONNECTORS



Panel connectors are available for five basic cable sizes (as for cable connectors) and in three configurations: flanged, locking, and locking recessed. The flanged (nonlocking) connector can be mounted on either the front or the back of the panel and is attached by means of four screws. The locking panel connector is also flanged and attached by four screws. The recessed locking connector reduces the protrusion in front of the panel to 1/8 inch to save space and to present a neat appearance.

Locking panel connectors are also available with a solder terminal to accommodate single-wire leads.

The TYPE 874-PFL Panel-Feedthrough Locking Connector is a short section of air line with a locking GR874 connector at each end. It is useful for joining GR874 cable connectors directly through a panel, avoiding awkward patch-cord runs on instrument racks.



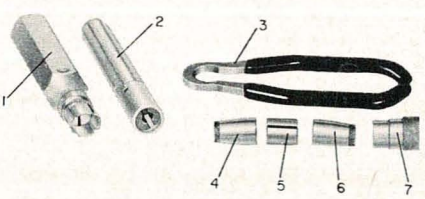
Typical leakage characteristics of GR874 Connectors compared with other types.

TOOLS

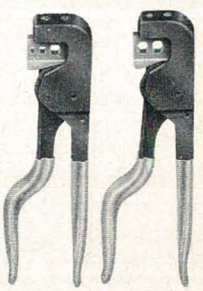
Several special tools are available to facilitate assembly of GR874 Connectors — these tools ensure quick assembly, neat, uniform appearance, and best electrical and mechanical performance.

The TYPE 874-TOK Tool Kit consists of an inner-conductor wrench to install both the insulating bead and the inner conductor and an outer-conductor wrench to install the outer conductor and to tighten the coupling nut. The other pieces aid in installation of the retaining ring.

When a GR874 Connector is installed on cable, the ferrule must be crimped to secure the cable to the connector. Pliers can be used to crimp the ferrule, but, for the neatest crimp in the shortest time, use of a TYPE 874-TO58 or -TO8 Crimping Tool is recommended. Die dimensions for these hexagonal crimping tools are as follows: TYPE 874-TO58: 0.215, 0.250, 0.375 inch; TYPE 874-TO8: 0.389, 0.411 inch.



1. Outer-conductor wrench
2. Inner-conductor wrench
3. Coupling-nut wrench
4. Front-ring expander (red)
5. Keeper for ring expanders
6. Back-ring expander (green)
7. Ring pusher



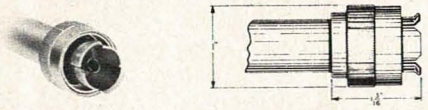
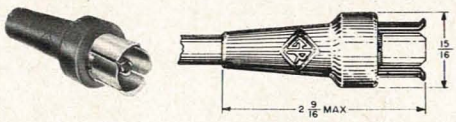
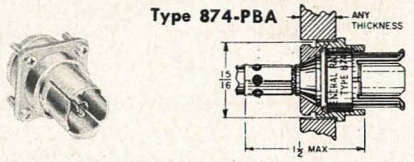
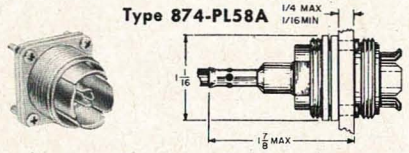
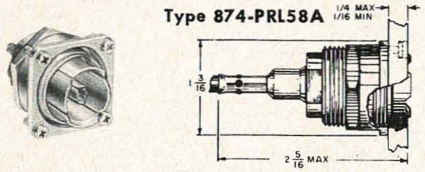
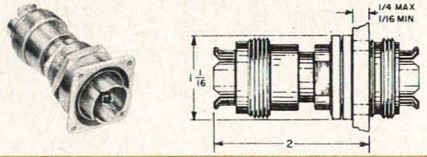
874-TO58 874-TO8

Catalog No.	*Description*	*Net Weight*	*Price*
0874-9902	**Type 874-TOK Tool Kit**	1 lb (0.5 kg)	**$25.00**
0874-9901	**Type 874-TO58 Crimping Tool**	1 3/4 lb (0.8 kg)	**85.00**
0874-9900	**Type 874-TO8 Crimping Tool**	1 3/4 lb (0.8 kg)	**75.00**

Use on Cable Connector	*Crimping Tool Type*
874-CA, CLA, C58A, CL58A, C62A, CL62A, C174A, CL174A, PBA, PLA, PRLA, PB58A, PL58A, PRL58A, PB62A, PL62A, PRL62A, PB174A, PL174A, PRL174A	874-TO58
874-C8A, CL8A, PB8A, PRL8A	874-TO8

GR874 CONNECTOR SERIES

See page 77 for power and voltage ratings

Type	Fits	Catalog Number	Price*
BASIC CONNECTOR — NONLOCKING			
			
874-B	50-ohm Rigid Air Line	0874-9400	**$2.25**
BASIC CONNECTOR — LOCKING			
			
874-BBL	50-ohm Rigid Air Line	0874-9403	**3.25**
CABLE CONNECTORS — NONLOCKING			
874-CA	(50-ohm) 874-A2 Cable	0874-9410	**3.00**
874-C8A	(50-ohm) RG-8A/U, -9B/U, -10A/U, -87A/U, -116/U, -156/U, -165/U, -166/U, -213/U, -214/U, -215/U, -225/U, -227/U, (non-50-ohm) RG-11A/U, -12A/U, -13A/U, -63B/U, -79B/U, -89/U, -144/U, -146/U, -149/U, -216/U Cables	0874-9412	**3.00**
 Type 874-CA			
874-C58A	(50-ohm) 874-A3, RG-29/U -55/U (series), -58/U (series), -141A/U, -142A/U, -159/U, -223/U Cables	0874-9414	**3.00**
874-C62A	(non-50-ohm) RG-59/U, -62/U (series), -71B/U, -140/U, -210/U Cables	0774-9416	**3.00**
874-C174A	(50-ohm) RG-174/U, -188/U, -316/U; (non-50-ohm) RG-161/U, -179/U Cables	0874-9418	**4.50**
CABLE CONNECTORS — LOCKING			
 Type 874-CL174A			
874-CLA	Same as Type 874-CA.	0874-9411	**4.00**
874-CL8A	Same as Type 874-C8A.	0874-9413	**4.00**
874-CL58A	Same as Type 874-C58A.	0874-9415	**4.00**
874-CL62A	Same as Type 874-C62A.	0874-9417	**4.00**
874-CL174A	Same as Type 874-C174A.	0874-9419	**5.50**
PANEL CONNECTORS — FLANGED			
 Type 874-PBA			
874-PBA	Same as Type 874-CA.	0874-9440	**4.00**
874-PB8A	Same as Type 874-C8A.	0874-9442	**4.00**
874-PB58A	Same as Type 874-C58A.	0874-9444	**4.00**
874-PB62A	Same as Type 984-C62A.	0874-9446	**4.00**
874-PB174A	Same as Type 874-C174A.	0874-9448	**5.00**
PANEL CONNECTORS — LOCKING			
 Type 874-PL58A			
874-PLA	Same as Type 874-CA.	0874-9441	**4.00**
874-PL8A	Same as Type 874-C8A.	0874-9443	**4.00**
874-PL58A	Same as Type 874-C58A.	0874-9445	**4.00**
874-PL62A	Same as Type 874-C62A.	0874-9447	**4.00**
874-PLT	Wire Lead.	0974-9459	**4.00**
874-PL174A	Same as Type 874-C174A.	0874-9449	**5.00**
PANEL CONNECTORS — LOCKING RECESSED			
 Type 874-PRL58A			
874-PRLA	Same as Type 874-CA.	0874-9461	**4.00**
874-PRL8A	Same as Type 874-C8A.	0874-9463	**4.00**
874-PRL58A	Same as Type 874-C58A.	0874-9465	**4.00**
874-PRL62A	Same as Type 874-C62A.	0874-9467	**4.00**
874-PRLT	Wire Lead.	0874-9479	**4.00**
874-PRL174A	Same as Type 874-C174A.	0874-9469	**5.00**
PANEL CONNECTOR — LOCKING FEEDTHROUGH			
			
874-PFL	Mates any pair of GR874 Connectors directly through a panel or wall. Can be mounted as recessed or non-recessed panel locking connector.	0874-9451	**9.50**

Net weight 1 to 4 ounces, depending upon item.

* For quantities of 1 to 99; prices for larger quantities on request.

GR874 ADAPTORS

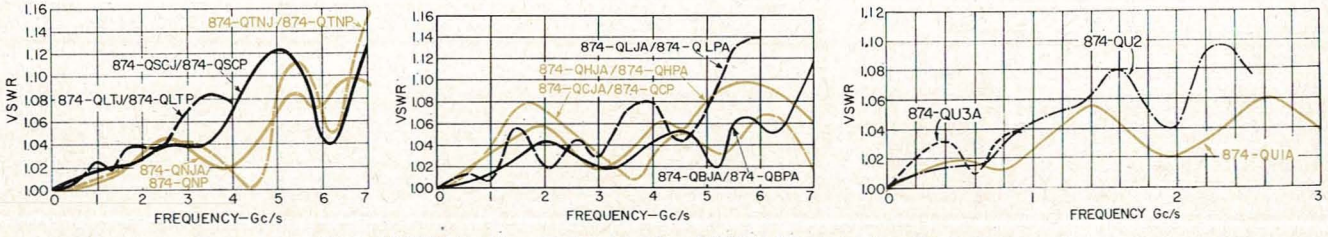
Thirty-five different adaptors provide easy conversion from the GR874 Connector to most popular military and commercial coaxial connectors, including high-power TV broadcast types. Many of these adaptors are available in locking as well as nonlocking versions.

GR874 Adaptors extend the usefulness of GR874 Connectors without sacrificing electrical performance. The VSWR of the combination of GR874 Connector and GR874 Adaptor is actually comparable to that of the "other series" connector alone.

Original-equipment manufacturers will recognize the possibilities of these adaptors in combination with the GR874 locking recessed panel connector. An instrument originally equipped with these connectors can, by means of appropriate GR874 Adaptors, be quickly converted to almost any coaxial connector series, with the resulting panel connector rigidly attached and protruding less than an inch beyond the panel surface.

Because any two GR874 Adaptors mate, a few of them can perform a cross-connection task that would otherwise involve a costly collection of direct adaptors. For instance, interconnection of all possible combinations of types N, C, BNC, TNC, UHF, and Microdot plugs and jacks would require 72 direct adaptors, whereas only 12 GR874 Adaptors are needed to do the same job.

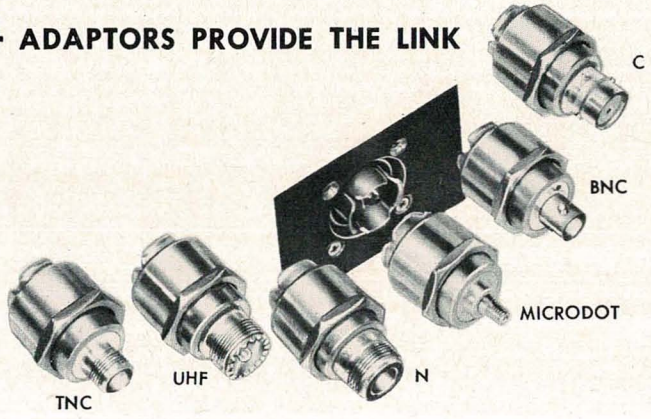
In ordering adaptors by type number, note that the P or J suffix letter identifies the connector on *the adaptor*, not the connector that the adaptor fits. (For instance, the TYPE 874-QNJ Adaptor *contains* a type N *jack*, and therefore fits a type N plug.) An L in the type designation indicates a locking adaptor.

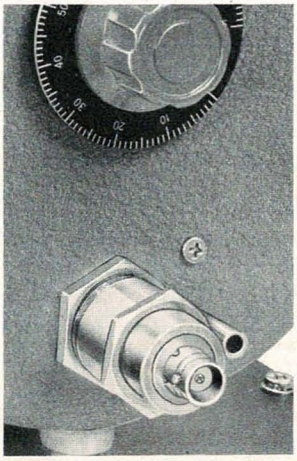


Typical VSWR introduced in line by pairs of GR874 Adaptors plugged together.

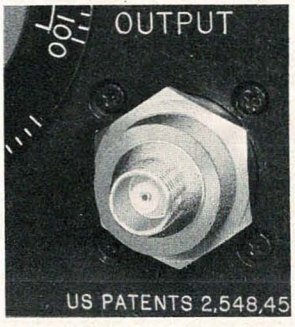
Now —
YOU CAN CONNECT GR874-EQUIPPED INSTRUMENTS TO MOST OTHER COAXIAL CONNECTORS

GR874 ADAPTORS PROVIDE THE LINK





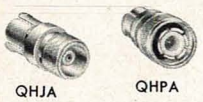
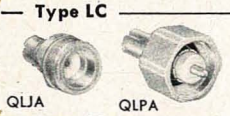
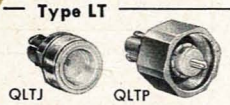
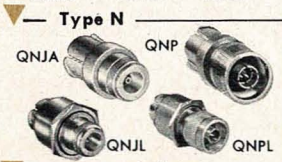
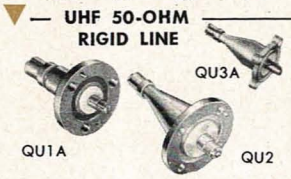
recessed GR874 panel connector adapted to type TNC with Type 874-QTNJL Adaptor



unit-oscillator output connector adapted to type BNC with Type 874-QBJL Adaptor

locking GR874 panel connector converted to type N with Type 874-QNJL Adaptor

GR874 ADAPTORS

ADAPTORS TO:	Type Nonlocking	Type Locking	Contains GR874 and . . .	Connects GR874 to . . .	Net Wt	Catalog Number	Price
Type BNC							
 QBJA QBJL QBPA	874-QBJA	874-QBJL	BNC Jack	BNC Plug	1 oz (30 g)	0874-9700	$ 4.75
			BNC Jack	BNC Plug	1½ oz (45 g)	0874-9701	5.75
	874-QBPA		BNC Plug	BNC Jack	1½ oz (45 g)	0874-9800	6.50
Type C							
 QCJA QCJL QCP	874-QCJA	874-QCJL	C Jack	C Plug	1 oz (30 g)	0874-9702	7.50
			C Jack	C Plug	2 oz (60 g)	0874-9703	8.50
	874-QCP		C Plug	C Jack	2 oz (60 g)	0874-9802	7.00
Type HN							
 QHJA QHPA	874-QHJA		HN Jack	HN Plug	1½ oz (45 g)	0874-9704	6.00
	874-QHPA		HN Plug	HN Jack	2½ oz (75 g)	0874-9804	7.50
Type LC							
 QLJA QLPA	874-QLJA		LC Jack	LC Plug	5 oz (145 g)	0874-9706	8.00
	874-QLPA		LC Plug	LC Jack	7½ oz (215 g)	0874-9806	33.00
Type LT							
 QLTJ QLTP	874-QLTJ		LT Jack	LT Plug	4¾ oz (135 g)	0874-9708	26.00
	874-QLTP		LT Plug	LT Jack	7 oz (200 g)	0874-9808	31.00
Type MICRODOT							
 QMDJ QMDJL QMDP	874-QMDJ	874-QMDJL	Microdot Jack	Microdot Plug	1 oz (30 g)	0874-9720	10.00
			Microdot Jack	Microdot Plug	1½ oz (45 g)	0874-9721	11.00
	874-QMDP		Microdot Plug	Microdot Jack	1 oz (30 g)	0874-9820	10.50
Type N							
 QNJA QNP QNJL QNPL	874-QNJA	874-QNJL	N Jack	N Plug	1½ oz (45 g)	0874-9710	5.00
			N Jack	N Plug	2 oz (60 g)	0874-9711	6.00
	874-QNP	874-QNPL	N Plug	N Jack	1¾ oz (50 g)	0874-9810	5.50
			N Plug	N Jack	2¼ oz (70 g)	0874-9811	6.50
Type OSM/BRM							
 QMMJ QMMP	874-QMMJ	874-QMMJL	OSM/BRM* Jack	OSM/BRM* Plug	1 oz (30 g)	0874-9722	11.00
			OSM/BRM Jack	OSM/BRM Plug	1½ oz (45 g)	0874-9723	12.00
	874-QMMP	874-QMMPL	OSM/BRM Plug	OSM/BRM Jack	1 oz (30 g)	0874-9822	11.00
			OSM/BRM Plug	OSM/BRM Jack	1½ oz (45 g)	0874-9823	12.00
Type SC							
 QSCJ QSCJL QSCP	874-QSCJ	874-QSCJL	SC Jack	SC Plug (Sandia)	1⅜ oz (40 g)	0874-9712	10.00
			SC Jack	SC Plug (Sandia)	2 oz (60 g)	0874-9713	11.00
	874-QSCP		SC Plug	SC Jack (Sandia)	1⅝ oz (50 g)	0874-9812	13.00
Type TNC							
 QTNJ QTNJL QTNP	874-QTNJ	874-QTNJL	TNC Jack	TNC Plug	1 oz (30 g)	0874-9716	8.50
			TNC Jack	TNC Plug	1½ oz (45 g)	0874-9717	9.50
	874-QTNP		TNC Plug	TNC Jack	1¼ oz (35 g)	0874-9816	6.50
Type UHF							
 QUJ QUJL QUP	874-QUJ	874-QUJL	UHF Jack	UHF Plug	1 oz (30 g)	0874-9718	5.50
			UHF Jack	UHF Plug	2 oz (60 g)	0874-9719	6.50
	874-QUP		UHF Plug	UHF Jack	1½ oz (45 g)	0874-9818	5.00
Type 274							
 Q2 Q9	874-Q2		274 Plug/Jack	274 Plug or Jack	2 oz (60 g)	0874-9870	5.50
	874-Q9		938 Jack	938 Binding Posts	3 oz (85 g)	0874-9874	6.00
UHF 50-OHM RIGID LINE							
 QU3A QU1A QU2	874-QU1A			⅞-in, RG-155/U (EIA TR-134)	7 oz (200 g)	0874-9770	35.00
	874-QU2			1⅝-in, RG-153/U (EIA TR-134)	1¼ lb (0.6 kg)	0874-9772	80.00
	874-QU3A			3⅛-in, RG-154/U (EIA TR-134)	5¼ lb (2.4 kg)	0874-9774	240.00

* Also mates with NPM and STM.

See page 77 for power and voltage ratings

Type 874-LBA SLOTTED LINE

FEATURES:

High accuracy at a reasonable price.
Rugged construction for production use.
Integral probe and crystal.
Wide frequency range, 300 Mc/s to 5 Gc/s.
Wide variety of available accessories, including adaptors to other connector series.

One of the most important basic measuring instruments used at uhf and higher frequencies is the slotted line. General Radio offers two models: the general-purpose TYPE 874-LBA and, for measurements requiring accuracies of a few tenths of one percent, the TYPE 900-LB Precision Slotted Line.

The slotted line is used to determine the standing-wave pattern of the electric field in a coaxial transmission line. From a knowledge of the standing-wave pattern, one can determine several characteristics of the circuit connected to the load end of the slotted line. For instance, the degree of mismatch between the load and the transmission line can be calculated from the ratio of the maximum amplitude of the wave to the minimum. This ratio is called the voltage standing-wave ratio, or VSWR. The load impedance can be calculated from the standing-wave ratio and the position of a minimum point on the line with respect to the load. The wavelength of the exciting signal can be measured as the distance between minima, as successive minima or maxima are spaced a half wavelength apart. These capabilities make the slotted line a valuable instrument for measurements on antennas, components, coaxial elements, and networks.

The TYPE 874-LBA Slotted Line is a 50-ohm, air-dielectric, coaxial line whose electric field is sampled by a probe, which projects through a longitudinal slot in the outer conductor. The probe rides on a carriage, which is driven by a pulley-and-cord linkage conveniently operated from one end of the line. Both the position of the probe and the degree of coupling can be precisely set. A crystal rectifier, built into the carriage, can be tuned to the operating frequency by means of an adjustable stub.

A source of about one milliwatt rf power is adequate for most measurements. Suitable generators and detectors are listed on the following page.

SPECIFICATIONS

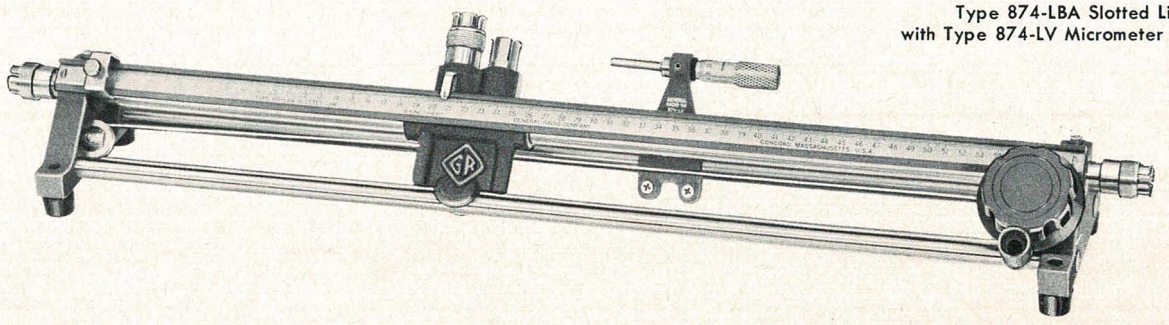
Characteristic Impedance: 50Ω ± 0.5%.
Probe Travel: 50 cm. Scale in centimeters; each division is 1 mm.
Scale Accuracy: ±(0.1 mm + 0.05%).
Frequency Range: 300 Mc/s to 5 Gc/s. At 300 Mc/s, the slotted line covers a half wavelength. Operation below 300 Mc/s is possible with slightly reduced accuracy by use of lengths of TYPE 874 Air Lines (page 90).
Constancy of Probe Pickup: ±1.5%.
Residual VSWR: Less than 1.025 at 1 Gc/s, 1.04 at 2 Gc/s, 1.055 at 3 Gc/s, 1.07 at 4 Gc/s, 1.1 at 5 Gc/s.
Accessories Supplied: Storage box and spare drive cable.
Accessories Required: Adjustable Stub (TYPE 874-D20L) for tuning the crystal rectifier when audio-frequency detector or microammeter is used; suitable detector and generator; one each, TYPE 874-R22LA and TYPE 874-R22A Patch Cords, for generator and detector connections.
Accessories Available: A complete slotted-line kit is described on page 83. For measurement of VSWR greater than 10, a TYPE 874-LV Micrometer Vernier is recommended. Smith Charts are listed on page 84. Adaptors are listed on page 81. TYPE 900-DP Probe Tuner is described on page 83.
Dimensions: 26 by 4½ by 3½ in (660, 115, 89 mm).
Net Weight: 8½ lb (3.9 kg).
Shipping Weight: 23 lb (10.5 kg).

Type 874-LV MICROMETER VERNIER

For precise measurements of large VSWR by the width-of-minimum method, and for precise phase measurements. Consists of a micrometer head calibrated in centimeters (calibrated to 0.001 cm), mounted on an arm that can be attached to the rear base rod of the slotted line. One turn of the micrometer barrel advances the head by 0.5 mm. Maximum range is 2.5 cm. Can be read to ±0.002 mm.

Net Weight: 8 oz (230 g).

Catalog Number	*Description*	*Price*
0874-9650	**Type 874-LBA Slotted Line**	**$315.00**
0874-9652	**Type 874-LV Micrometer Vernier**	**37.50**



Type 874-LBA Slotted Line with Type 874-LV Micrometer Vernier.

SLOTTED-LINE ACCESSORIES

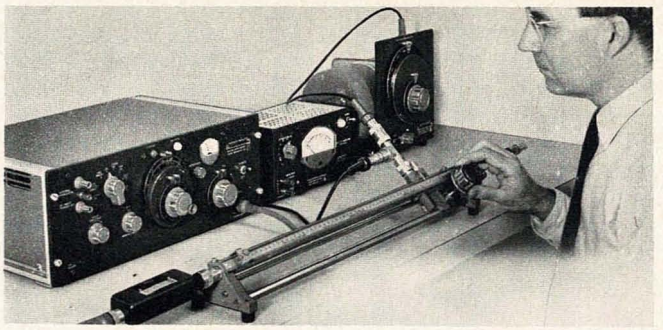
Type 900-DP PROBE TUNER

NEW 

The precise probe and tuner assembly is available as an optional accessory for the TYPE 874-LBA. It comprises a screw-driven adjustable stub and an adjustable probe, whose depth of penetration is indicated on the control knob. It will tune the probe-crystal diode assembly to resonance at any frequency from 300 Mc/s to 9 Gc/s.

Frequency Range: 0.3 to 9 Gc/s. **Tuning:** Shunt.
Probe Depth Scale: Calibrated in inches (0.001/div).
Stub Tuner: Calibrated in cm.
Dimensions: Length 11 in (280 mm), dia ⅞ in (23 mm), over-all, closed.
Net Weight: 8½ oz (245 g).

Catalog No.	*Description*	*Price*
0900-9654	**Type 900-DP Probe Tuner**	**$75.00**



GENERATORS

Oscillators covering the frequency range of the slotted line are described on pages 139 to 144. They can be square-wave modulated at 1 kc/s with the TYPE 1264-A Modulating Power Supply. For use at higher frequencies, both the TYPE 1220-A Unit Klystron Oscillator and the TYPE 1360-B Microwave Oscillator have internal 1-kc square-wave modulation.

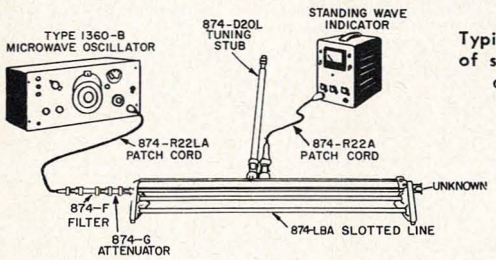
DETECTORS

The simplest suitable detector consists of a microammeter and the slotted line's built-in crystal. Its sensitivity is low. For measurement of VSWR between 1 and 5, satisfactory results can be obtained with a 50-microampere meter and oscillator power levels between 100 milliwatts and 20 watts. A TYPE 874-D20L 20-cm Adjustable Stub is required. A meter-sensitivity control, consisting of a 10-kilohm variable shunt resistor, is recommended.

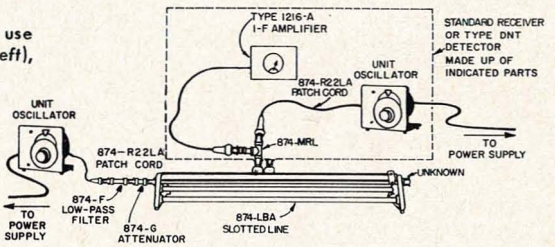
Most popular VSWR indicators are satisfactory detectors. The generator must be modulated at 1 kc/s. A TYPE 874-D20L 20-cm Adjustable Stub or a TYPE 900-DP Probe Tuner is required for tuning.

The heterodyne detector is a general-purpose laboratory detector. It is excellent for measurements of nonlinear circuits and of high values of VSWR, where a high degree of harmonic rejection is necessary. It is not recommended for VSWR's below 1.05. The General Radio TYPE DNT Detectors cover the frequency range from 40 to 2030 Mc/s (up to 5 Gc/s by the use of harmonics). See page 109.

A low-pass coaxial filter should be used to eliminate harmonics of the signal source, and a TYPE 874-G10L Fixed Attenuator to isolate the oscillator from the effects of load changes. See pages 87 and 88.



Typical measurement setups showing use of slotted line, VSWR indicator (*left*), and heterodyne detector (*right*).



COAXIAL KITS

Type 874-EKA BASIC SLOTTED-LINE KIT

For impedance and VSWR measurements with the slotted line, the coaxial elements listed below are available as the TYPE 874-EKA Basic Slotted-Line Kit. The TYPE 874-LBA Slotted Line is included in the kit, but the generator and detector are not.

Shipping Weight: 38 lb (17.5 kg).

Catalog No.	*Description*	*Price*
0874-9521	**Type 874-EKA Basic Slotted-Line Kit**	**$592.50**

KITS FOR CABLE MEASUREMENTS

Various combinations of GR874 coaxial elements can be used very effectively with Unit Instruments and associated equipment to measure attenuation, characteristic impedance, velocity of propagation, and capacitance of both coaxial and twin-conductor cables.

For convenience in ordering, the necessary equipment is offered in assemblies for specific types of measurement. These kits and their use are described in General Radio Reprint E-104, "The Measurement of Cable Characteristics," available on request.

Type	*Description*	*Type*	*Description*	*Type*	*Description*
874-A2	**Coaxial Cable** (25 ft)	**874-D50L**	**Adjustable Stub**	**874-QNPL**	**Adaptor,** Connects to type N Jack
874-A3	**Coaxial Cable** (25 ft)	**874-LAL**	**Adjustable Line**	**874-R22A**	**Patch Cord**
874-BBL	**Basic Connector,** Locking (2)	**874-LBA**	**Slotted Line**	**874-R22LA**	**Patch Cord,** Locking
874-B	**Basic Connector** (2)	**874-PL58A**	**Panel Connector,** Locking	**874-R34**	**Patch Cord**
874-CA	**Cable Connector** (2)	**874-PRL58A**	**Panel Connector,** Locking, Recessed	**874-TL**	**Tee,** Locking
874-C8A	**Cable Connector** (2)			**874-W50BL**	**50-ohm Termination**
874-CLA	**Cable Connector,** Locking (2)	**874-QBJL**	**Adaptor,** Locking, Connects to type BNC Plug	**874-WN**	**Short-Circuit Termination**
874-C58A	**Cable Connector** (2)			**874-WO**	**Open-Circuit Termination**
874-CL58A	**Cable Connector,** Locking (2)	**874-QNJL**	**Adaptor,** Locking, Connects to type N Plug	**874-TOK**	**Tool Kit**
874-D20L	**Adjustable Stub**			**874-Z**	**Stand**

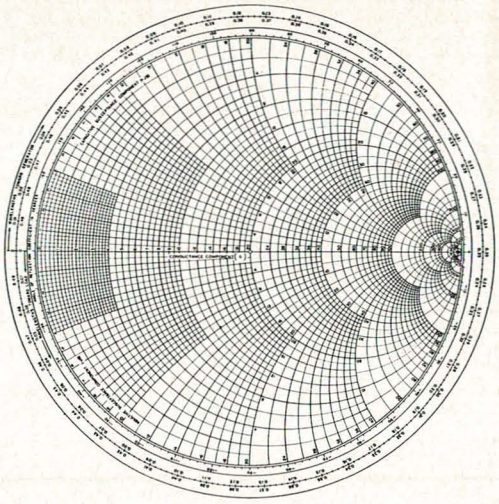
SMITH CHARTS

The Smith Chart facilitates measurements made with slotted lines. It can be used to determine the impedance corresponding to any VSWR and to convert from impedance to admittance, and vice versa. Five forms of Smith Chart are available. Those with normalized coordinates are for use with lines of any impedance. The 50-ohm characteristic impedance (20-millimho characteristic admittance) is common to all General Radio coaxial equipment. Charts are 8½ by 11 inches.

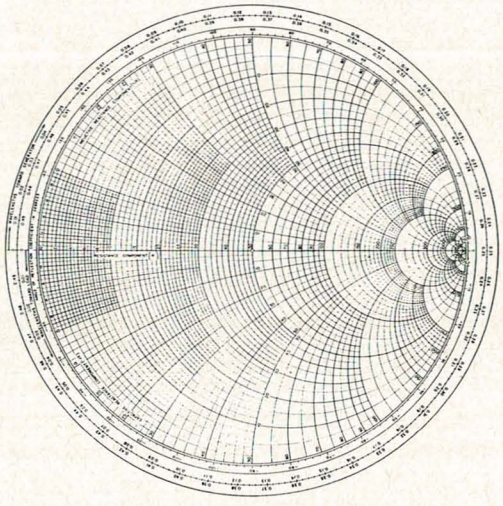
Catalog Number	*Description*	
5301-7568	**Type Y Smith Chart**	(20-mmho admittance coordinates)
5301-7569	**Type Z Smith Chart**	(50-ohm impedance coordinates)
5301-7560	**Type N Smith Chart**	(normalized coordinates)
5301-7561	**Type NE Smith Chart**	(normalized expanded coordinates)
5301-7562	**Type HE Smith Chart**	(normalized highly expanded coordinates)

Price per unit of 50 (minimum quantity sold)

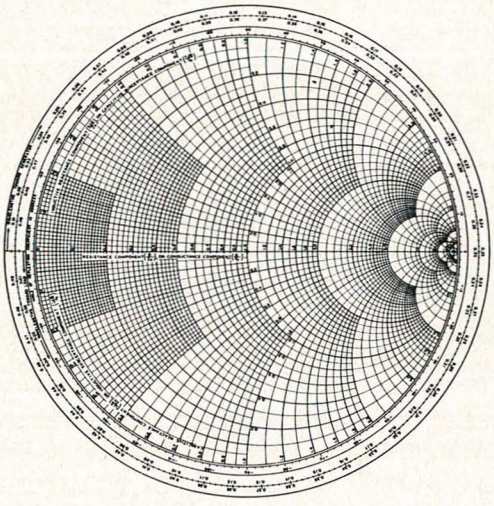
No. of units	1	2–3	4–9	10–19	20 and over
Price	**$2.00**	**$1.90**	**$1.75**	**$1.40**	**$1.25**



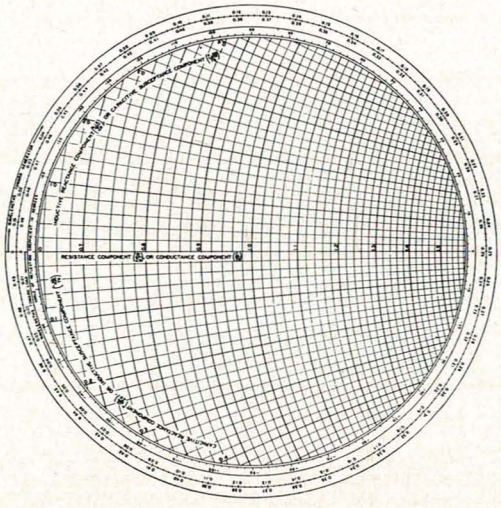
Catalog Number 5301-7568, admittance coordinates.



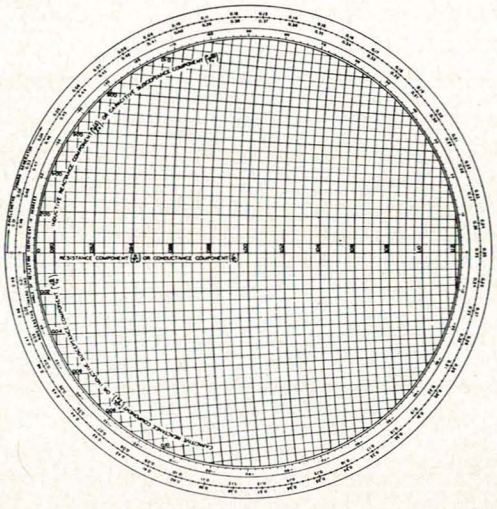
Catalog Number 5301-7569, impedance coordinates.



Catalog Number 5301-7560, normalized coordinates.



Catalog Number 5301-7561, normalized expanded coordinates.



Catalog Number 5301-7562, normalized highly expanded coordinates.

GR874 COAXIAL CABLE AND PATCH CORDS

TYPE 874-A2 COAXIAL CABLE

This is a flexible, double-shielded, low-loss coaxial cable, consisting of No. 14 stranded inner conductor separated from the two tinned-copper braids by 0.244-inch-OD polyethylene dielectric and a 0.375-inch-OD, gray, noncontaminating polyvinyl-chloride jacket.

SPECIFICATIONS

Characteristic Impedance: 50Ω ± 5%.
Nominal Capacitance: 30.8 pF/ft.
Attenuation 2.6 dB/100 ft at 100 Mc/s; 10.5 dB/100 ft at 1 Gc/s.
Propagation Velocity Factor: 66%.
Net Weight: 2¾ lb (1.3 kg) per 25 ft.

Catalog Number	*Description*	*Price*
0874-9500	**Type 874-A2 Coaxial Cable**	**$0.60**/ft **(0.40**/ft in lengths of 25 ft or more)

TYPE 874-A3 COAXIAL CABLE

This cable is more flexible than the TYPE 874-A2, but the losses are somewhat higher. The inner conductor is 19 strands of 0.0071-inch tinned soft-copper wire, separated from the double braid by 0.116-inch-OD polyethylene dielectric. The jacket is 0.206-inch-OD, black, noncontaminating polyvinyl chloride. This cable is recommended for most general-purpose applications.

SPECIFICATIONS

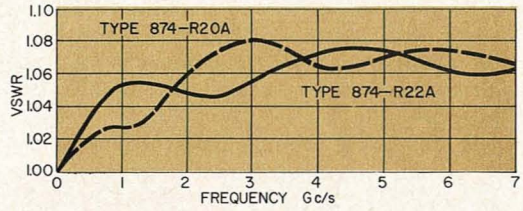
Characteristic Impedance: 50Ω ± 5%.
Nominal Capacitance: 29 pF/ft.
Attenuation: 5.3 dB/100 ft at 100 Mc/s; 22 dB/100 ft at 1 Gc/s; 45 dB/100 ft at 3 Gc/s.
Propagation Velocity Factor: 66%.
Net Weight: 1 lb (0.5 kg) per 25 ft.

Catalog Number	*Description*	*Price*
0874-9501	**Type 874-A3 Coaxial Cable**	**$0.35**/ft **(0.20**/ft in lengths of 25 ft or more)

PATCH CORDS

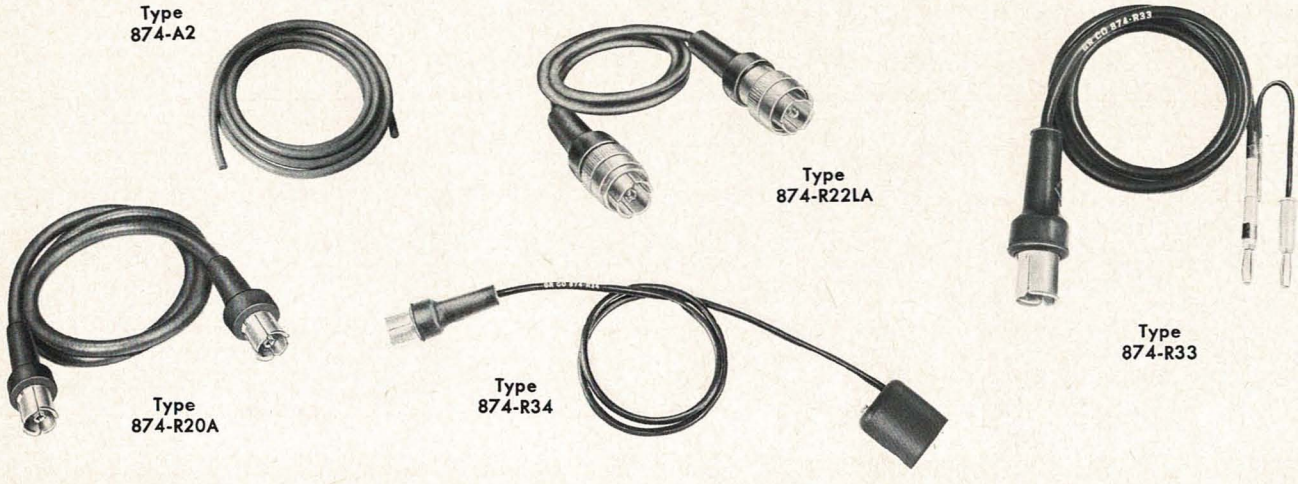
The following three-foot coaxial patch cords meet the need for flexible connections in the measurements laboratory. The TYPES 874-R20A and -R22A Patch Cords have very low VSWR characteristics (see curves) and are available with either locking or nonlocking GR874 Connectors.

The TYPE 874-R33 Patch Cord terminates in a pair of banana plugs, one connected to the center conductor and the other to the braid through a 5-inch pigtail. These plugs mate directly with TYPE 274 and 938 Jacks, TYPE 938 Binding Posts, and TYPE 838 Alligator Clips (see pages 252, 253, and 256). The TYPE 874-R34 Patch Cord terminates in a TYPE 274-NK Shielded Double Plug (see page 256).



Other patch cords, equipped with General Radio TYPE 274 double plugs, are described on page 257.

Catalog No.	*Patch Cord Type*	*Cable Type*	*Connectors (see p 79 & 256)*	*Braid*	*Length (ft)*	*Freq Range*	*Net Weight*	*Price*
0874-9680	**874-R20A**	**874-A2**	**874-CA**	Double	3	1–9 Gc/s	7 oz (200 g)	**$12.50**
0874-9681	**874-R20LA**	**874-A2**	**874-CLA**	Double	3	1–9 Gc/s	9 oz (255 g)	**14.50**
0874-9682	**874-R22A**	**874-A3**	**874-C58A**	Double	3	1–9 Gc/s	4 oz (115 g)	**11.50**
0874-9683	**874-R22LA**	**874-A3**	**874-CL58A**	Double	3	1–9 Gc/s	6 oz (170 g)	**13.50**
0874-9690	**874-R33**	**low C, 72Ω coaxial**	**874-C58A & 274-NO**	Single	3	—	2½ oz (75 g)	**7.00**
0874-9692	**874-R34**	**RG-58C/U**	**874-C58A & 274-NK**	Single	3	—	3½ oz (100 g)	**7.00**



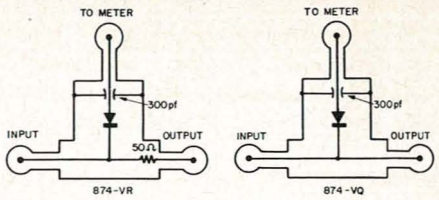
Type 874-VQ VOLTMETER DETECTOR

Used with the TYPE 874-VI Voltmeter Indicator (see below) for voltage measurement, with the TYPE 1232-A Tuned Amplifier and Null Detector (see page 104) as a sensitive (approximately 100 μV full-scale) detector of modulated signals, or with a microammeter as an rf detector. It introduces no appreciable discontinuity when inserted in a 50-ohm coaxial line. It can be used with the TYPE 874-W50B 50-ohm Termination as a matched detector to terminate a line.

SPECIFICATIONS

Frequency Range (as Matched Detector): 0.5 Mc/s to 2 Gc/s. Usable from 60 c/s to 7 Gc/s.
Maximum Voltage: 2 V.
VSWR: Less than 1.1 at 1 Gc/s, 1.2 at 2 Gc/s.

Schematic diagram of Types 874-VQ and 874-VR.



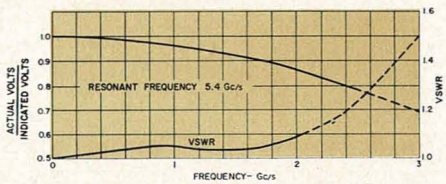
Bypass Capacitance: Approximately 300 pF.
Crystal: 1N23B.
Dimensions: Length 3¾, height 2½ in (96, 64 mm).
Net Weight: TYPE 874-VQ, 5 oz (145 g); TYPE 874-VQL, 6 oz (170 g).

Catalog No.	*Description*	*Price*
0874-9940	**Type 874-VQ Voltmeter Detector**	**$30.00**
0874-9941	**Type 874-VQL Voltmeter Detector (locking connectors)**	**32.00**

Type 874-VR VOLTMETER RECTIFIER

Used with the TYPE 874-VI Voltmeter Indicator (see below) to measure or to monitor the voltage in coaxial systems. It contains a 50-ohm resistor in series with the output line and thus can be used to measure the voltage behind a 50-ohm impedance. In combination with a signal source and TYPE 874-VI Voltmeter Indicator, this device simulates a 50-ohm generator with a known equivalent open-circuit voltage. It is also a good general-purpose detector for use with a microammeter or, for high sensitivity (100 μV full scale) for modulated signals, with the TYPE 1232-A Tuned Amplifier and Null Detector. It is used with the TYPE 1263-A Amplitude-Regulating Power Supply, in an oscillator amplitude-leveling system.

Typical VSWR for Type 874-VQ and correction factor for Types 874-VQ and 874-VR.



SPECIFICATIONS

Frequency Range (as Calibrated Voltmeter): 15 Mc/s to 2.5 Gc/s.
Maximum Voltage: 2 V.
Bypass Capacitance: Approximately 300 pF.
Crystal: 1N23B.
Dimensions: Length 3¾, height 2½ in (96, 64 mm).
Net Weight: TYPE 874-VR, 5 oz (145 g); TYPE 874-VRL, 6 oz (170 g).

Catalog No.	*Description*	*Price*
0874-9942	**Type 874-VR Voltmeter Rectifier**	**$30.00**
0874-9943	**Type 874-VRL Voltmeter Rectifier (locking connectors)**	**32.00**

Type 874-VI VOLTMETER INDICATOR

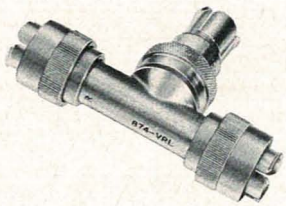
Measures dc output of either TYPE 874-VQ or TYPE 874-VR at any level between 0.1 and 2 volts. A built-in 60-cycle calibration system eliminates errors arising from differences in crystal rectification efficiencies.

SPECIFICATIONS

Range and Accuracy of Calibrating Voltage: 0.1 to 2 V, ±0.05 V.
Crystal Current for Full-Scale Indication: 200 μA.
Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s.
Input Resistance: 600 Ω min, 10,000 Ω max.
Accessory Supplied: TYPE CAP-22 Power Cord.
Accessory Required: One TYPE 874-R34 Patch Cord (page 85).
Dimensions: 5½ by 5½ by 4½ in (140, 140, 115 mm), over-all.
Net Weight: 3 lb (1.4 kg).
Shipping Weight: 5 lb (2.3 kg).

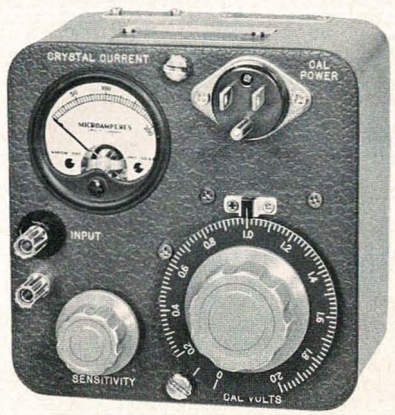
Catalog No.	*Description*	*Price*
0874-9936	**Type 874-VI Voltmeter Indicator**	**$110.00**

Type 874-VQL



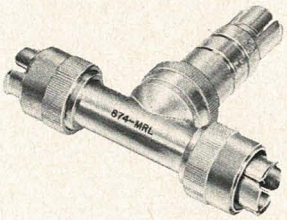
Type 874-VRL

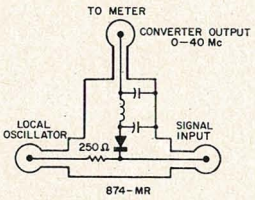
Type 874-VI



Type 874-MR MIXER RECTIFIER

A broadband rf mixer. Used with a TYPE 1216-A Unit I-F Amplifier, it acts as a heterodyne detector with a 30-Mc difference frequency. The output circuit contains a low-pass filter with a cutoff frequency of 40 Mc/s. A 250-ohm series resistor isolates the circuit from the local oscillator.





Schematic diagram of Type 874-MR.

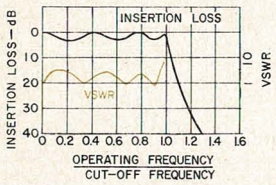
SPECIFICATIONS

Frequency Range: 40 Mc/s to 5 Gc/s; at lower and higher frequencies with less sensitivity.
Cutoff Frequency of Output Filter: 40 Mc/s.
Maximum Input from Local Oscillator: 2 V.
Typical Sensitivity: 5 μV for discernible deflection on meter of TYPE 1216-A Unit I-F Amplifier or communications receiver S meter.
Crystal Current: 5 mA max, 0.2 mA min.
Output Impedance: Approximately 400 Ω.
Crystal: 1N21B.
Accessories Required: For complete detector assembly, see page 109.

Dimensions: Length 3¾, height 3½ in (96 by 89 mm).
Net Weight: TYPE 874-MR, 7 oz (200 g); TYPE 874-MRL, 8 oz (230 g).

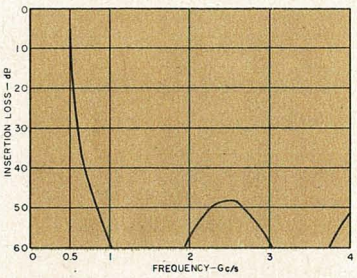
Catalog No.	*Description*	*Price*
0874-9944	**Type 874-MR Mixer Rectifier**	**$32.50**
0874-9945	**Type 874-MRL Mixer Rectifier (locking connectors)**	**34.50**

Type 874-F LOW-PASS FILTERS



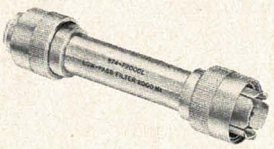
Typical insertion loss and VSWR, Type 874-F Filters.

Recommended for use in immittance- or voltage-measuring systems to reduce harmonics, and especially in systems containing nonlinear elements or sections that might resonate at a harmonic. Also useful in slotted-line measurements. Filters are Tschebyscheff type, which produce a very steep cutoff characteristic at the expense of passband flatness. Spurious responses in the stopband are very small. All filters are equipped with locking GR874 Connectors.



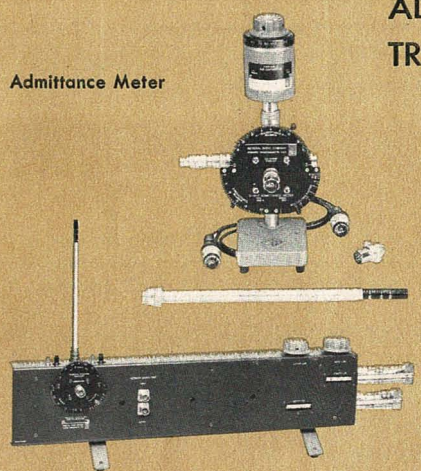
Typical stop-band response of Type 874-F500L Low-Pass Filter.

Catalog No.	*Description*	*Physical Length*	*Net Weight*	*Price*
0874-9533	**Type 874-F185L 185-Mc Low-Pass Filter**	17⅝ in	12 oz (340 g)	**$32.00**
0874-9537	**Type 874-F500L 500-Mc Low-Pass Filter**	10⅜ in	8½ oz (245 g)	**26.00**
0874-9541	**Type 874-F1000L 1-Gc Low-Pass Filter**	7⅛ in	8 oz (230 g)	**24.00**
0874-9545	**Type 874-F2000L 2-Gc Low-Pass Filter**	4⅜ in	4½ oz (130 g)	**24.00**
0874-9549	**Type 874-F4000L 4-Gc Low-Pass Filter**	2⅞ in	3 oz (85 g)	**24.00**



ADMITTANCE METER
TRANSFER-FUNCTION AND IMMITTANCE BRIDGE

Admittance Meter



Transfer-Function and Immittance Bridge

Two important VHF-UHF instruments are the Type 1602-B UHF Admittance Meter (page 54) and the Type 1607-A Transfer-Function and Immittance Bridge (page 56). Both are GR874-equipped, null-type instruments useful up to 1500 megacycles.

The admittance meter is widely used in VSWR and impedance measurements on antennas, transmission lines, and coaxial systems and components. It can be used to adjust a network to a given admittance, to match one network to another, and to match an antenna to a 50-ohm circuit.

The transfer-function and immittance bridge performs all the measurements of the admittance meter and also measures the forward and reverse complex transfer functions of four-terminal networks, both active and passive. This instrument has become a fundamental tool in transistor work, where it is used to measure α, β, and h parameters, and is also used to measure characteristics of tunnel diodes, tubes, and many other networks and components.

GR874 ATTENUATORS

Type 874-G FIXED ATTENUATORS

Single-section, T-type resistance pads, for insertion of fixed attenuation in 50-ohm systems and for isolation and matching to 50 ohms over a broad frequency range. Each attenuator consists of one disk and two cylindrical resistors, as shunt and series elements, respectively.

SPECIFICATIONS

Dc Resistance: 50 Ω ± 1% when terminated in 50 Ω.

VSWR: Less than 1.1 to 1 Gc/s, 1.2 to 3 Gc/s for all units; to 4 Gc/s, less than 1.3 for −G20, 1.35 for −G10, and 1.4 for −G3 and −G6.

Accuracy in 50-Ω System: ±1.5% of nominal at dc; ±0.2 dB from value indicated on curve to 1 Gc/s; ±0.4 dB to 2 Gc/s; ±0.6 dB to 4 Gc/s.

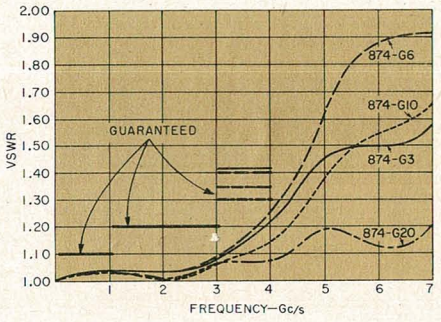
Temperature Coefficient: Less than 0.0003 dB/°C/dB.

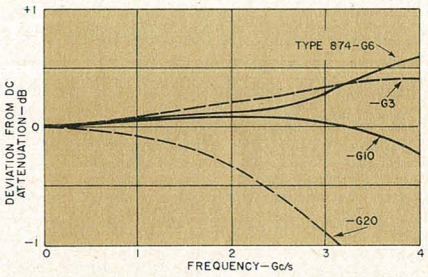
Maximum Power: CW — 1 W; pulse — 2000 W peak, 1 W average.

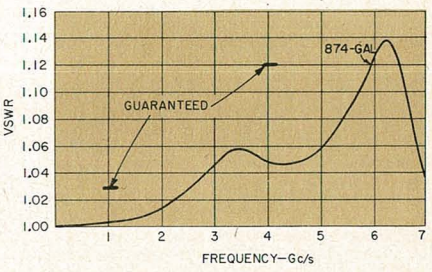
Physical Length: 3½ in (89 mm), over-all.

Catalog Number	*Description*	*Net Weight*	*Price*
0874-9564	**Type 874-G3 Fixed Attenuator** (3 dB)	3 oz (85 g)	**$36.00**
0874-9565	**Type 874-G3L*** **Fixed Attenuator** (3 dB)	4 oz (115 g)	**38.00**
0874-9568	**Type 874-G6 Fixed Attenuator** (6 dB)	3 oz (85 g)	**30.00**
0874-9569	**Type 874-G6L*** **Fixed Attenuator** (6 dB)	4 oz (115 g)	**32.00**
0874-9570	**Type 874-G10 Fixed Attenuator** (10 dB)	3 oz (85 g)	**30.00**
0874-9571	**Type 874-G10L*** **Fixed Attenuator** (10 dB)	4 oz (115 g)	**32.00**
0874-9572	**Type 874-G20 Fixed Attenuator** (20 dB)	3 oz (85 g)	**30.00**
0874-9573	**Type 874-G20L*** **Fixed Attenuator** (20 dB)	4 oz (115 g)	**32.00**

* Locking connectors.

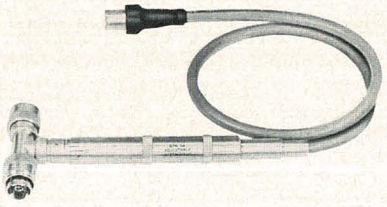






(*Left*) Guaranteed and typical VSWR and (*center*) correction factor for fixed attenuators. (*Right*) Guaranteed and typical VSWR introduced in line by Type 874-GAL.

Type 874-GAL ADJUSTABLE ATTENUATOR



A waveguide-below-cutoff type, useful as a calibrated attenuator or as a sampling device. Calibrated in decibels, on a micrometer-type scale. Absolute attenuation is the sum of insertion loss and scale reading. The main line is a short coaxial section with locking GR874 Connectors, one end for source and the other for load. It introduces minimum discontinuity when inserted in a 50-ohm line. The loop output is brought out through three feet of 50-ohm cable.

Can be used with Type 874-VR Voltmeter Rectifier and Type 874-VI Voltmeter Indicator (page 86) to convert a Unit Oscillator (pages 139 to 144) into a signal generator.

SPECIFICATIONS

Calibrated Range: 120 dB (relative attenuation) with input line terminated in 50 Ω; 129 dB with input line terminated in adjustable stub to minimize the electric field at the coupling point (scale reads −9 to 120 dB).

Insertion Loss (from input connector to end of output cable at 1 Gc/s, when signal source impedance is 50 Ω):

With input line terminated in 50 Ω, and scale set at 0 dB, 32 ± 2 dB; **set at −9 dB,** 17 ± 2 dB (settings below 0 are not accurate).

With input line terminated in adjustable stub (which extends the range over which the calibration is accurate to the −9 dB scale setting), 19 ± 2 dB minimum.

(Insertion loss is approximately inversely proportional to frequency up to 1 Gc/s.)

Insertion Loss Directly Through Tee: Negligible.

Accuracy of Attenuation:

Stub-terminated input, ±(0.01 times difference in attenuation reading +0.2) dB, direct-reading.

50-Ω terminated input, ±(0.015 times difference in attenuation reading + 0.2) dB, when corrected. Correction chart supplied.

VSWR Introduced into Line: Less than 1.03 at 1 Gc/s; less than 1.12 from 1 to 4 Gc/s.

VSWR of Output: Less than 4 at 1 Gc/s; less than 5 from 1 to 4 Gc/s.

Maximum Power: Input power limit inversely proportional to square root of frequency. Power should not exceed 300 W at 1 Gc/s. Output power should not exceed ½ W.

Frequency Range: 100 Mc/s to 4 Gc/s.

Net Weight: 1¼ lb (0.6 kg).

Catalog No.	*Description*	*Price*
0874-9577	**Type 874-GAL Adjustable Attenuator**	**$82.00**

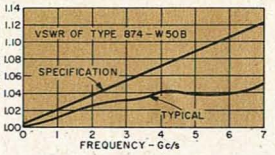
50-OHM TERMINATIONS

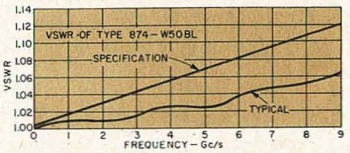
Type 874-W50B, -W50BL 50-OHM TERMINATIONS

Each unit comprises a 50-ohm cylindrical resistor mounted in a tapered coaxial holder and is useful for impedance matching, establishment of reference conditions, and as a termination. The TYPE 874-W50BL is equipped with a TYPE 874-BBL Basic Connector and thus offers greater stability and repeatability as well as extended frequency range (to 9 Gc/s) and locking capability.

	Type 874-W50B	*Type 874-W50BL*
Frequency Range:	dc to 7 Gc/s	dc to 9 Gc/s
VSWR:	$<1.005 + 0.017 f_{Gc}$	$<1.005 + 0.013 f_{Gc}$
Dc Resistance:	50 Ω ± 0.5%	50 Ω ± 0.5%
Maximum Power:	2 W continuous	2 W continuous

Type W50B





Type W50BL

Catalog No.	*Description*	*Net Weight*	*Price*
0874-9954	**Type 874-W50B 50-ohm Termination**	2½ oz (70 g)	**$23.00**
0874-9955	**Type 874-W50BL 50-ohm Termination, locking**	3 oz (85 g)	**24.00**

COAXIAL STANDARDS — 100 AND 200 OHMS

Type 874-W100 100-OHM COAXIAL STANDARD

Produces known resistive termination at specific locations on coaxial lines. Useful for checking accuracy of directional couplers, bridges, and admittance meters. The known location of the purely resistive termination permits the production of many known complex impedances through the addition of sections of TYPE 874-L Air Line (page 90).

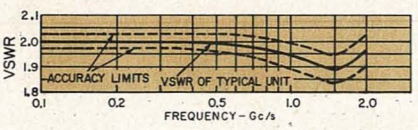
Dc Resistance: 100 Ω ± 1%.
Maximum Power: ⅛ W continuous, 150 W peak.

Type 874-W200 200-OHM COAXIAL STANDARD

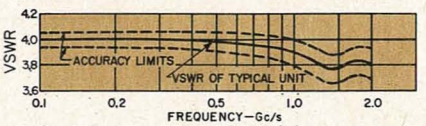
Same as TYPE 874-W100 except standard resistance is 200 ohms.

Dc Resistance: 200 Ω ± 1%.
Maximum Power: ¼ W continuous, 50 W peak.

Catalog No.	*Description*	*Net Weight*	*Price*
0874-9956	**Type 874-W100 100-ohm Coaxial Standard**	3 oz (85 g)	**$35.00**
0874-9958	**Type 874-W200 200-ohm Coaxial Standard**	3 oz (85 g)	**35.00**



Typical VSWR of (*left*) Type 874-W100 and (*right*) Type 874-W200.



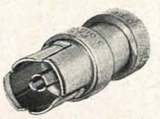
SHORT-CIRCUIT TERMINATIONS

Type 874-WN SHORT-CIRCUIT TERMINATION

A fixed short circuit mounted in a connector, for establishing reference conditions on coaxial lines and for use in substitution measurements.

Catalog No.	*Description*	*Net Weight*	*Price*
0874-9970	**Type 874-WN Short-Circuit Termination**	1 oz (30 g)	**$4.50**

Type 874-WN3 SHORT-CIRCUIT TERMINATION



Same as TYPE 874-WN, except that the short circuit is at a point 3 cm (3.2-cm electrical distance) beyond the face of the bead in the GR874 Connector.

Catalog No.	*Description*	*Net Weight*	*Price*
0874-9972	**Type 874-WN3 Short-Circuit Termination**	1½ oz (45 g)	**$6.50**

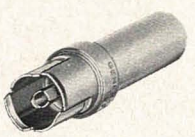
OPEN-CIRCUIT TERMINATIONS

Type 874-WO OPEN-CIRCUIT TERMINATION

A shielding cap for open-circuited lines, for establishing reference conditions on coaxial lines, and for use in substitution measurements. Produces an open circuit at same point in line that TYPE 874-WN produces a short circuit.

Catalog No.	*Description*	*Net Weight*	*Price*
0874-9980	**Type 874-WO Open-Circuit Termination**	1 oz (30 g)	**$2.75**

Type 874-WO3 OPEN-CIRCUIT TERMINATION



Same as TYPE 874-WO, except that the open circuit is at a point corresponding to that of the short circuit in the TYPE 874-WN3 Short-Circuit Termination.

Catalog No.	*Description*	*Net Weight*	*Price*
0874-9982	**Type 874-WO3 Open-Circuit Termination**	1½ oz (45 g)	**$5.00**

GR874 Air Lines

Type 874-L RIGID AIR LINES

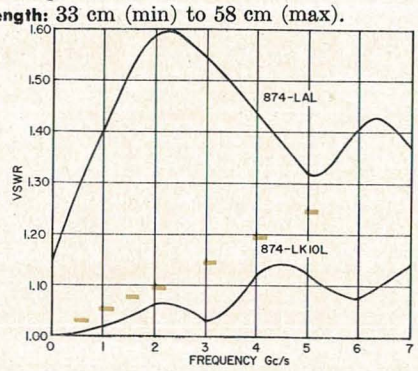
For spacing stubs or other elements of a coaxial system; also useful as time-delay elements and as absolute impedance in time-delay reflectometers. Each air line consists of a length (10, 20, or 30 cm) of 50-ohm, air-dielectric coaxial line with a GR874 Coaxial Connector, either regular or locking, at each end. Locking versions use TYPE 874-BBL Basic Connectors and are thus usable up to 9 Gc/s.

Time Delay: 10 cm, 0.334 ns ±0.7%; 20 cm, 0.667 ns ±0.4%; 30 cm, 1.001 ns ±0.3%.
Characteristic Impedance: 50 Ω ±0.4%.

Type 874-LAL ADJUSTABLE LINE

An air-dielectric coaxial line that can be telescoped to change its length. Used in matching networks, as a phase shifter, and as a variable time-delay element. Contacts are made by multiple-spring fingers. Connectors are locking GR874.

Characteristic Impedance: Not constant — approximately 50 Ω when fully collapsed, approximately 57 Ω when fully extended.
Adjustment Range: 25 cm.
Physical Length: 33 cm (min) to 58 cm (max).



Curves shown are typical VSWR; dashed points are specifications.

Type 874-LK CONSTANT-IMPEDANCE ADJUSTABLE LINES

A line stretcher with a very low VSWR and a uniform characteristic impedance of 50 ohms. Especially useful for eliminating the usual Smith-chart corrections for length of line between unknown and impedance-measuring device. These lines are useful as impedance-matching transformers and phase-adjustment elements in coaxial systems. Locking GR874 Connectors.

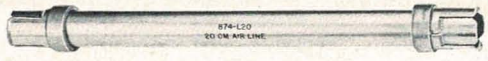
Characteristic Impedance: 50 Ω.
Adjustment Range: TYPE 874-LK10L, 10 cm (half wavelength at 1.5 Gc/s); TYPE 874-LK20L, 22 cm (half wavelength at 680 Mc/s).
Physical Length: TYPE 874-LK10L, 35 cm (min) to 45 cm (max); TYPE 874-LK20L, 58 cm (min) to 80 cm (max).
VSWR: TYPE 874-LK20L, less than 1.03 at 500 Mc/s, less than 1.06 at 1 Gc/s, less than 1.08 at 1.5 Gc/s, less than 1.10 at 2 Gc/s. TYPE 874-LK10L, same as TYPE 874-LK20L to 2 Gc/s, less than 1.15 at 3 Gc/s, less than 1.2 at 4 Gc/s, less than 1.25 at 5 Gc/s.

Type 874-LTL TROMBONE CONSTANT-IMPEDANCE ADJUSTABLE LINE

With this line stretcher, built like a trombone slide, the user can vary the length of a 50-ohm transmission line between two fixed terminals without moving the terminals or using flexible cable. Consists of two TYPE 874-LK20L Adjustable Lines mounted in parallel and joined at one end by a U-shaped section to form a rigid assembly. Can be plugged into two adjacent GR874 Coaxial Connectors or inserted in a line by means of two ells (not included) when installed vertically to save bench space. Low VSWR. An excellent phase shifter.

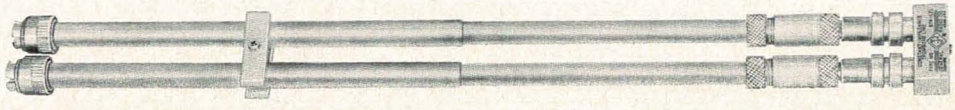
Characteristic Impedance: 50 Ω.
Frequency Range: Dc to 2 Gc/s (TYPE 874-LK10L is recommended above 2 Gc/s).
Adjustment Range: 44 cm (half wave at 340 Mc/s).
Physical Length: 61 cm (min) to 83 cm (max).
Spacing: 1 3/16 inch between centers.
VSWR: Less than 1.10 to 1 Gc/s, and 1.25 to 2 Gc/s.

Catalog Number	*Description*	*Net Weight*	*Price*
0874-9604	**Type 874-L10 10-cm Air Line**	2½ oz (70 g)	**$ 9.50**
0874-9605	**Type 874-L10L 10-cm Air Line,** locking connectors	3½ oz (98 g)	**11.50**
0874-9608	**Type 874-L20 20-cm Air Line**	4½ oz (126 g)	**10.50**
0874-9609	**Type 874-L20L 20-cm Air Line,** locking connectors	5½ oz (154 g)	**12.50**
0874-9612	**Type 874-L30 30-cm Air Line**	6½ oz (182 g)	**11.50**
0874-9613	**Type 874-L30L 30-cm Air Line,** locking connectors	7½ oz (210 g)	**13.50**
0874-9621	**Type 874-LAL Adjustable Line**	10 oz (280 g)	**27.00**
0874-9627	**Type 874-LK10L 10-cm Constant-Impedance Adjustable Line**	9 oz (255 g)	**42.00**
0874-9631	**Type 874-LK20L 22-cm Constant-Impedance Adjustable Line**	15 oz (425 g)	**42.00**
0874-9645	**Type 874-LTL Trombone Constant-Impedance Adjustable Line**	2¼ lb (1.02 kg)	**97.00**


Type 874-L20


Type 874-LAL


Type 874-LK10L


Type 874-LTL

Type 874-D20L and -D50L ADJUSTABLE STUBS

For matching or tuning, for use as adjustable short-circuit terminations, and as reactive elements. With an external indicator, the stub can function as a reaction-type wavemeter. Consists of a coaxial line with a sliding short circuit of the multiple-spring-finger type. The 20-centimeter stub is calibrated in electrical length. The 50-centimeter stub is not calibrated but has an adjustable reference marker. Each is equipped with a locking connector.

SPECIFICATIONS

Characteristic Impedance: 50 Ω.
Maximum Travel: TYPE 874-D20L, 20 cm; TYPE 874-D50L, 50 cm.
Physical Length: TYPE 874-D20L, 28 cm (min) to 48 cm (max); TYPE 874-D50L, 58 cm (min) to 109 cm (max).
Net Weight: TYPE 874-D20L, 7 oz (196 g); TYPE 874-D50L, 13 oz (364 g).

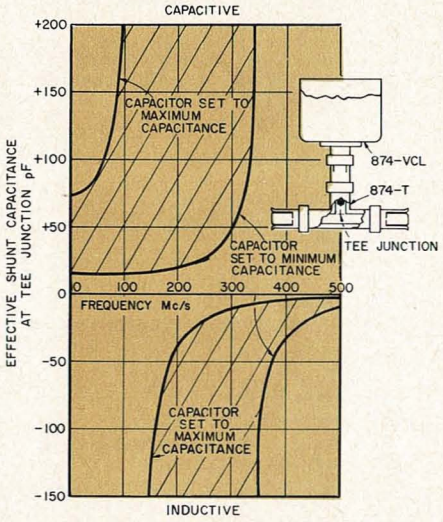
Catalog No.	*Description*	*Price*
0874-9511	**Type 874-D20L 20-cm Adjustable Stub**	**$17.50**
0874-9513	**Type 874-D50L 50-cm Adjustable Stub**	**21.00**

Type 874-VCL VARIABLE CAPACITOR

Tuning element for resonant-line circuits, matching transformers, and baluns at low frequencies where line-type elements are awkward to use. Well shielded, high-temperature polystyrene insulation, precision ball bearings, locking connector.

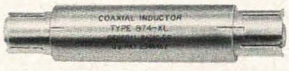
SPECIFICATIONS

Scale: 0 to 100.
Capacitance Range: Low frequencies, 14 to 70 pF at connector, 16.5 to 72.5 pF at T-junction. Linear capacitance variation.
Dimensions: Diameter 2½, height 5¼ in (64, 135 mm).
Net Weight: 12½ oz (350 g).



Catalog No.	*Description*	*Price*
0874-9931	**Type 874-VCL Variable Capacitor**	**$70.00**

Type 874-XL SERIES INDUCTOR



Used as a general-purpose tuning element in resonant-line circuits, matching transformers, and baluns at low frequencies.

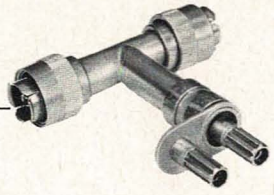
SPECIFICATIONS

Series Inductance: 0.226 μH ± 5% at 1 kc/s.
Net Weight: 3½ oz (98 g).

Catalog No.	*Description*	*Price*
0874-9998	**Type 874-XL Series Inductor**	**$19.00**

Type 874-FBL BIAS INSERTION UNIT

NEW
in catalog S



Used in immittance and similar measurements where bias is to be applied to diodes, transistors, and other solid-state devices. It comprises a blocking capacitor in series with the line, an isolating choke, and a low-pass filter.

In slotted-line measurements, it is inserted at the source end of the line and therefore introduces no reflections at the measurement terminals.

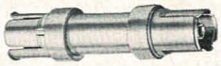
SPECIFICATIONS

Current Rating: 2.5 A.
Voltage Rating: 400 V.
VSWR: Typically, less than 1.25 from 300 Mc/s to 5 Gc/s.
Insertion Loss: Typically, less than 0.4 dB from 300 Mc/s to 3 Gc/s, less than 0.8 dB from 3 Gc/s to 5 Gc/s.
Dimensions: 4⅜ by 3⅞ in (115, 99 mm). **Weight:** 6½ oz (185 g).

Catalog No.	*Description*	*Price*
0874-9759	**Type 874-FBL Bias Insertion Unit**	**$45.00**

GR874 COUPLING ELEMENTS

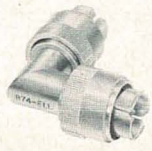
Type 874-K COUPLING CAPACITOR (Dc block)



A short length of coaxial line having a disk capacitor in series with the inner conductor. High frequencies are transmitted with small reflections, but dc and low audio frequencies are blocked. Available with regular or locking connectors.

Coupling Capacitance: 4700 pF −20% +50%.
VSWR: Less than 1.06 at 1 Gc/s; 1.15 at 2 Gc/s; 1.3 from 2 to 4 Gc/s.
Voltage Rating: 500 V.
Length: 3 in (77 mm).
Net Weight: TYPE 874-K, 2 oz (60 g); -KL, 3 oz (85 g).

Catalog No.	*Description*	*Price*
0874-9596	**Type 874-K Coupling Capacitor**	**$10.50**
0874-9597	**Type 874-KL Coupling Capacitor, locking connectors**	**12.50**

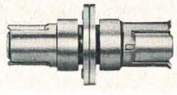


Type 874-EL 90° ELL

Convenient right-angle line section with GR874 Coaxial Connector at each end. Available with regular or locking connectors.

Characteristic Impedance: 50 Ω.
Electrical Length: Approximately 7 cm.
VSWR: Less than 1.06 at 2 Gc/s; less than 1.15 at 4 Gc/s.
Dimensions: 2¼ in (57 mm) on a side.
Net Weight: TYPE 874-EL, 2½ oz (70 g); -EL-L, 3 oz (85 g).

Catalog No.	*Description*	*Price*
0874-9526	**Type 874-EL 90° Ell**	**$11.00**
0874-9527	**Type 874-EL-L 90° Ell, locking connectors**	**13.00**

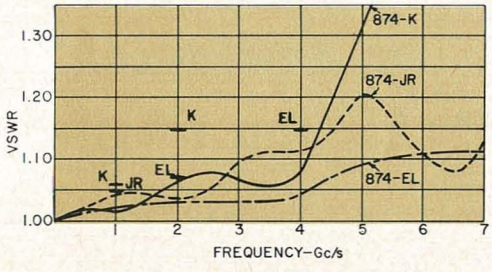


Type 874-JR ROTARY JOINT

Used when one part of a coaxial system must be rotated with respect to another part. Not for motor-driven applications.

VSWR: Less than 1.06 at 1 Gc/s; less than 1.3 at 4 Gc/s.
Length: 2½ in (64 mm). **Net Weight:** 3 oz (85 g).

Catalog No.	*Description*	*Price*
0874-9590	**Type 874-JR Rotary Joint**	**$16.00**



Curves are typical; dashed points are specifications.

Type 874-LR RADIATING LINE

Leakage coupler for fields within a coaxial system. Short coaxial line with opening in outer conductor that can be partly or completely covered by a rotatable sleeve.

VSWR: Closed, less than 1.10 at 1 Gc/s, less than 1.4 at 3 Gc/s, and less than 1.35 at 4 Gc/s.
Length: 4⅜ in (112 mm).
Net Weight: 4 oz (115 g).

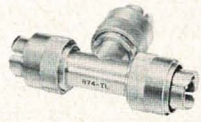
Catalog No.	*Description*	*Price*
0874-9660	**Type 874-LR Radiating Line**	**$12.00**

Type 874-MB COUPLING PROBE

Electrostatic probe consisting of a binding post mounted on a GR874 Coaxial Connector.

Length: 3 in (77 mm), over-all.
Net Weight: 1 oz (30 g).

Catalog No.	*Description*	*Price*
0874-9666	**Type 874-MB Coupling Probe**	**$5.50**

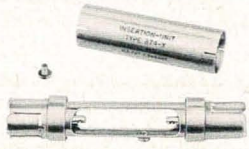


Type 874-T TEE

For connecting stubs and other elements in shunt with a coaxial line. Available with regular or locking connectors.

Dimensions: 3⅜ by 2¼ in (86, 58 mm).
Net Weight: TYPE 874-T — 4 oz (115 g), TYPE 874-TL — 5 oz (145 g).

Catalog No.	*Description*	*Price*
0874-9910	**Type 874-T Tee**	**$15.00**
0874-9911	**Type 874-TL Tee, locking connectors**	**18.00**

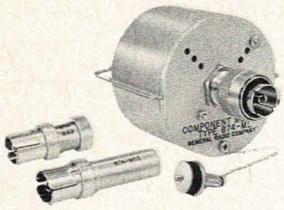


Type 874-X INSERTION UNIT

A hollow cylinder fitted with a GR874 Connector at each end and with a sleeve that slides back to provide access to a space about 2 inches long and 9/16 inch in diameter. In this space can be mounted arrangements of small components such as resistors, capacitors, or inductors. The insertion unit can be used as a shielded housing for impedance-matching networks, attenuator pads, vhf transformers, filters, and many other networks. It offers excellent shielding, minimal discontinuity in the line, and convenience.

Length: 4⅜ in (115 mm).
Net Weight: 3 oz (85 g).

Catalog No.	*Description*	*Price*
0874-9990	**Type 874-X Insertion Unit**	**$14.00**



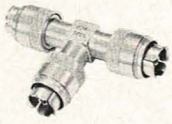
Type 874-ML COMPONENT MOUNT

A shielded enclosure for convenient mounting of small components being measured. Use of mount minimizes stray capacitance in impedance measurements of circuit elements and networks from dc to 5 Gc/s. Locking GR874 Coaxial Connector.

Accessories Supplied: One TYPE 874-WN3 Short-Circuit Termination, one TYPE 874-WO3 Open-Circuit Termination.
Accessory Recommended: One TYPE 874-LK20L Constant-Impedance Adjustable Line (page 90) for use with TYPE 1602-B UHF Admittance Meter.
Dimensions: Diameter 3 in (77 mm); height of shield can 2⅝ in (67 mm).
Net Weight: 10½ oz (295 g).

Catalog No.	*Description*	*Price*
0874-9663	**Type 874-ML Component Mount**	**$35.00**

NEW



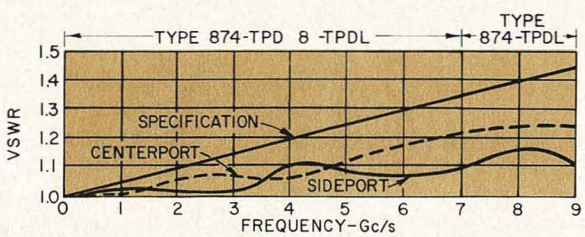
Type 874-TPD POWER DIVIDER

A coaxial tee with a 16.67-ohm resistor in each leg, connected so that the tee is matched at any port when the other two ports are terminated in 50-ohm loads. The match holds throughout the wide frequency range. The use of stable deposited-carbon-film resistors and the linear VSWR-frequency relationship makes the power divider particularly valuable for pulse work. The VSWR at 1 Gc/s is less than 1.05, at 3 Gc/s less than 1.15.

When a signal is applied at the center port of the tee, the amplitudes of the signals at the output ports are equal within 0.3 dB, and the phase relationship is nominally 0 degrees. The output signals are 6 dB (+2 dB − 0.5 dB) below the input signal in level.

Frequency Range: TYPE 874-TPD, dc to 7 Gc/s; TYPE 874-TPDL, dc to 9 Gc/s.
VSWR: Less than $1.0 + 0.05\,f_{Gc}$ (see curve).
Insertion Loss: Input to each output, 6 dB (+2, −0.5 dB).
Equality of Power Division: 0.3 dB (symmetrically fed).
Phase Difference Between Outputs: 0°.
Maximum Input Power: 2 W continuous.
Dimensions: 4 by 2⅜ in (105, 61 mm).
Net Weight: 6 oz (170 g).

Catalog No.	*Description*	*Price*
0874-9912	**Type 874-TPD Power Divider**	**$70.00**
0874-9913	**Type 874-TPDL Power Divider, locking connectors**	**73.00**



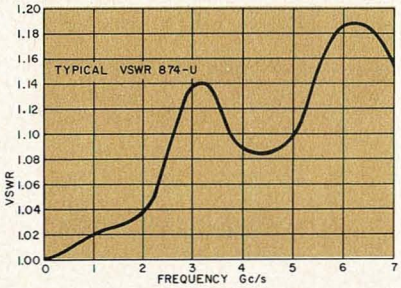
NEW

Type 874-U U-LINE SECTION

A coaxial line section in the shape of a U, with GR874 connectors. Supplied as an accessory with the TYPE 1607-A Transfer-Function and Immittance Bridge, but useful in many other coaxial setups as well.

Dimensions: 2¼ by 2 by ⅞ in (58, 51, 23 mm), over-all.
Weight: 7½ oz (215 g).

Catalog No.	*Description*	*Price*
0874-9528	**Type 874-U U-Line Section**	**$25.00**



Type 874-Y CLIPLOCK

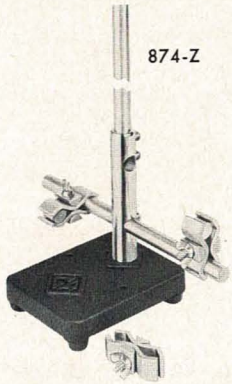
A cylindrical spring that can be slipped over non-locking GR874 connectors to provide a sure lock, preventing accidental disconnection.

Net Weight (of 10): 1 oz (28 g).

Catalog No.	*Description*	*Price*
0874-9992	**Type 874-Y Cliplock**	**10 for $2.50**

Type 874-Z STAND

A solid, stable support for components of coaxial systems. Consists of a heavy cast-iron base with rubber feet, 22-inch and 8-inch stainless-steel rods, and three universal clamps. The vertical rod can be used to hold long tuning stubs. The horizontal rod can be moved longitudinally or can be interchanged with the vertical rod. One 22-inch rod can be clamped to two bases to support a long horizontal run of coaxial parts. Clamps fit a range of diameters. Base can be bolted to bench top.



Dimensions: Base, 3½ by 4 7/16 in (89, 115 mm); rod lengths, 22 and 8 in (560 and 205 mm).
Net Weight: 5½ lb (2.5 kg).

Catalog No.	*Description*	*Price*
0874-9996	**Type 874-Z Stand**	**$19.50**
0874-9997	**Type 874-ZC Extra Clamp**	**2.25**

Type 874-UBL BALUN

The TYPE 874-UBL Balun is a tuned coaxial 4:1 transformer that matches 50-ohm coaxial line to 200-ohm balanced line and thus extends the usefulness of generally available coaxial instruments to balanced devices. Used with the slotted line, admittance meter, or transfer-function and immittance bridge, the balun permits measurements on balanced components over a frequency range from 54 Mc/s to 1 Gc/s without appreciable insertion loss or transformation error.

Tuning elements required for various frequency ranges are listed below. These elements, described on pages 90 and 91, are not supplied with the balun but must be purchased separately.

SPECIFICATIONS

Frequency Range: 54 Mc/s to 1 Gc/s with accessory tuning elements as listed above.
Accessories Supplied: One TYPE 874-UB-P1 300-ohm Terminal (below), one TYPE 874-WN3 Short-Circuit Termination (page 89), one TYPE 874-WO3 Open-Circuit Termination (page 89).
Accessories Recommended: One TYPE 874-LK20L Adjustable Line (for use with TYPE 1602-B UHF Admittance Meter; page 90), one TYPE 874-Z Stand (page 93), and tuning elements listed above.
Dimensions: 3⅛ by 3⅜ by 2⅜ in (79, 81, 60 mm), over-all.
Net Weight: 1¼ lb (0.6 kg).

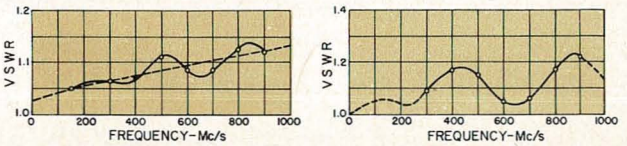
Frequency Range Mc/s	*Tuning Elements Required*	*Page Ref*
54–88	2 Type 874-VCL and 2 Type 874-XL	91
88–140	2 Type 874-VCL and 2 Type 874-L30L	90, 91
140–174	2 Type 874-VCL and 2 Type 874-L20L	90, 91
174–216	2 Type 874-VCL and 2 Type 874-L10L	90, 91
170–280	2 Type 874-D50L and 2 Type 874-L30L	90, 91
225–280	2 Type 874-D20L and 2 Type 874-L30L	90, 91
275–380	2 Type 874-D20L and 2 Type 874-L20L	90, 91
350–525	2 Type 874-D20L and 2 Type 874-L10L	90, 91
470–1000	2 Type 874-D20L	91

BALUN ACCESSORIES

Type 874-UB-P2 200-OHM TERMINAL UNIT

Connects the balun directly to 200-ohm transmission line or to balanced components via screw terminals.

Characteristic Impedance: 200 Ω.
Frequency Range: Dc to 1 Gc/s.
Recommended Transmission Line: RG-86/U.
VSWR: 1.2 to 300 Mc/s, 1.3 to 1 Gc/s.
Dimensions: 1 by 1¾ by 1⅞ in (25, 44, 48 mm), over-all.
Net Weight: 1 oz (28 g).



Typical VSWR of Type 874-BM (*left*) and Type 874-UB-P2 (*right*).

Type 874-UB-P3 300-OHM TERMINAL PAD

Converts the 200-ohm balanced output impedance produced by the balun to 300 ohms. Facilitates power and voltage measurements on balanced 300-ohm systems with signal generators and detectors designed for use with 50-ohm coaxial circuits.

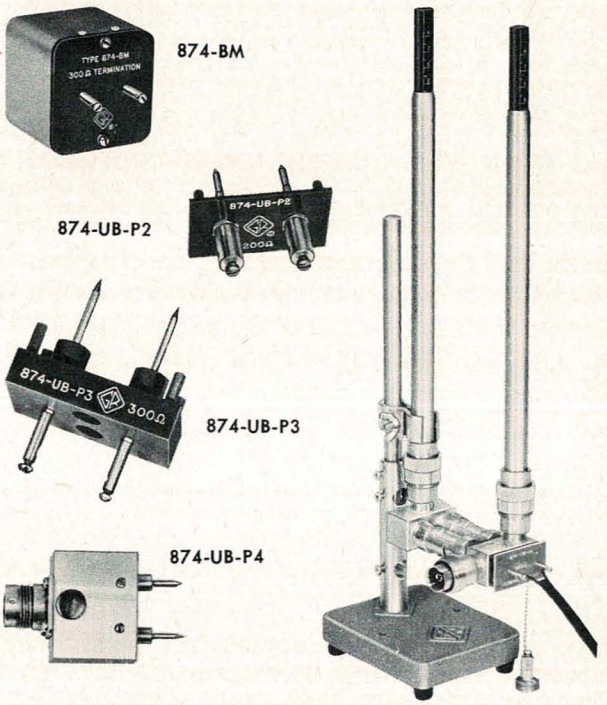
Type 874-BM 300-OHM BALANCED TERMINATION

Termination for 300-ohm lines under test.

Dc Resistance: 300 Ω ± 5%.
Frequency Range: Dc to 1 Gc/s.
VSWR: 1.2 to 900 Mc/s.
Dimensions: 2 by 2 by 2½ in (51, 51, 64 mm), over-all.
Net Weight: 1½ oz (42 g).

Type 874-UB-P4 ADAPTOR

Provides a reliable shielded connection between the balun and TYPE RG-22/U (small-size Twinax) cable. Adaptor includes UG-422/U Twinax connector, which connects to UG-421/U cable connector.



Type 874-UBL Balun with two Stubs and one Type 874-Z Stand.

Catalog Number	*Description*	*Net Weight*	*Price*
0874-9921	**Type 874-UBL Balun**	1 ¼ lb (0.6 kg)	**$95.00**
0874-9928	**Type 874-BM 300-ohm Balanced Termination**	1 ½ oz (45 g)	**15.00**
0874-9923	**Type 874-UB-P2 200-ohm Terminal Unit**	1 oz (30 g)	**9.00**
0874-9924	**Type 874-UB-P3 300-ohm Terminal Pad**	1 oz (30 g)	**22.00**
0874-9925	**Type 874-UB-P4 Adaptor** (Balun to Twinax)	4½ oz (130 g)	**60.00**

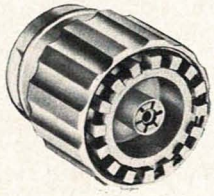
See page 76 for Index

For many years the coaxial connector had been the limiting factor in the design of highly accurate measuring equipment. Not only was it impossible to design such equipment without a precision connector, it was not even worth trying, since any improvements would be obscured by the connector deficiencies. It was obvious that the first step in the development of a line of ultra-precise coaxial instruments had to be the development of a precision connector. General Radio, using its long experience in coaxial-connector development, thus designed the first commercial coaxial connector that could honestly be called "precision" — the GR900.

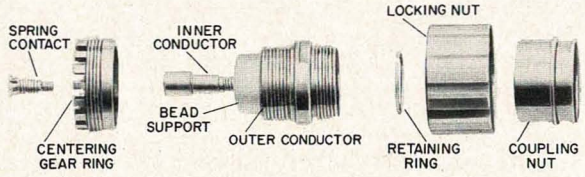
The design objective for the GR900 was a connector far better electrically than any existing type and one that could be sold at a reasonable price. The design tolerance on characteristic impedance was set at $\pm 0.1\%$. Extensive production engineering was required to find economical methods of manufacturing to such a close tolerance.

The successful completion of the GR900 Connector development signaled the initiation of an entire line of precision coaxial components and instruments. The GR900 line, which now includes a precision slotted line and recording system, air-line sections, adaptors, terminations, and a tuner, is well on its way to becoming a precision counterpart of the popular GR874 line.

GR900 CONNECTOR



The GR900 Precision Coaxial Connector is available in two models: the TYPE 900-BT for use with 9/16-inch rigid air line and the TYPE 900-C9 for use with coaxial cable. In addition, four connector kits permit custom fabrication of GR900 air lines, terminations, and panel connectors. All GR900 Connectors have the same basic mechanical features and mate with one another.



Exploded view of Type 900-BT Precision Coaxial Connector.

MECHANICAL FEATURES

The basic GR900 Connector (TYPE 900-BT) is designed for use on rigid, air-dielectric, 50-ohm, 14-mm (9/16-inch) coaxial transmission line (principal dimensions: 0.5625 inch and 0.24425 inch). The eight parts of the connector are shown in the accompanying exploded view. The spring contact and inner conductor are of gold-plated solid silver alloy, the bead support Teflon,* the centering gear ring stainless steel, the outer conductor gold-plated coin silver, the retaining ring phosphor-bronze, and the coupling and locking nuts chrome-plated brass.

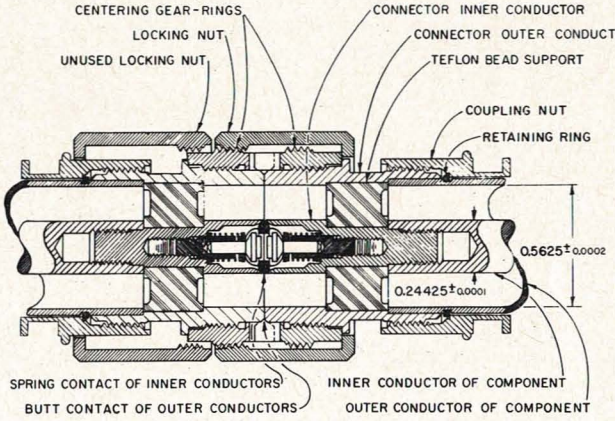
When the parts are assembled onto an air line, the coupling nut and retaining ring attach the outer conductor of the connector to the outer conductor of the line (see cross-section drawing). The inner conductor is threaded into the center conductor of the air line and is supported by the Teflon bead.

When two GR900 Connectors are mated, the centering gear rings interlock and overlap to center the connectors with respect to each other and also to provide indexing in one of 16 possible positions. The front surfaces of the outer conductors butt firmly together under the pressure of the locking nut. Only one of the locking nuts is used in a connection; the other is backed off to a storage position.

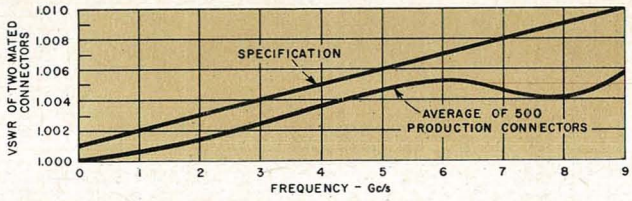
* Registered trademark of the E.I. du Pont de Nemours and Company.

The front surfaces of the inner conductors are recessed 0.001 inch with respect to the surfaces of the outer conductors to ensure outer-conductor contact. Inner-conductor contact is made by a spring-contact assembly, which projects slightly beyond the surface of the outer conductors until the connector is mated. The spring-contact assembly consists of six independently sprung segments, which are forced back and spread upon mating, thereby making a wiping contact both with the other spring contact and with the inside of the inner conductor. This method avoids the reflections caused by slots in the inner and outer conductors and eliminates changes in the electrical diameter due to wear. Only one spring contact is necessary for a good electrical connection; the spring contact will mate with any flat surface.

When two connectors are mated, the conductors meet in the midpoint of the connection, and this point becomes the electrical reference plane. The over-all diameter of the mated pair is 1-1/16 inches.



Cross-section view of mated Type 900-BT Precision Coaxial Connectors.

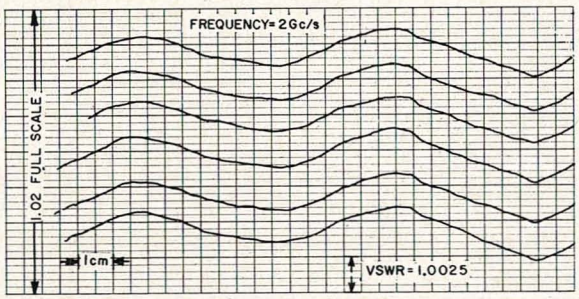


Typical and specified VSWR of mated pairs of Type 900-BT Precision Coaxial Connectors. Specified VSWR is identical to that given as IEEE Recommended Practice, except that latter extends only to 8 Gc/s.

ELECTRICAL CHARACTERISTICS

Probably the most important single characteristic of a precision connector is its VSWR, that is, the extent to which it introduces reflections into an otherwise matched transmission line. The accompanying graph shows the VSWR test specifications for a pair of TYPE 900-BT connectors ($1.001 + 0.001\,f_{Gc}$), as well as the average VSWR of a production lot. Since it is impossible to say how much each connector contributes to the VSWR of the pair, the test limits for the pair are used as the guaranteed VSWR of a single connector. Statistically, of course, the performance of an individual connector usually exceeds specifications by a comfortable margin.

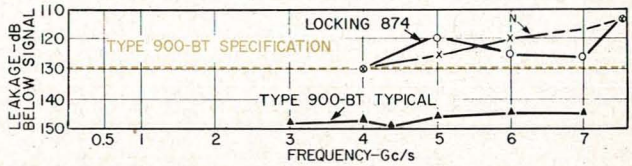
Another important characteristic of a precision connector is repeatability — the consistency of measured value as the connection is broken and remade in different orientations. Repeatability of a pair of GR900 Connectors is typically within 0.03% up to 9 Gc/s.



Repeatability run, showing typical consistency of performance as Type 900-BT Precision Coaxial Connector is rotated to six different orientations. Multiple plot was produced at 2 Gc/s by Type 1640-A Slotted Line Recorder System (page 101).

Leakage of the GR900 Connector (see graph) is better than 130 dB below signal level — lower than that of any other commonly used coaxial connector. This is due to the triple shielding action of the butt contact of the outer conductors, the interlocking and overlapping of the centering gear rings, and the outer locking nut.

The insertion loss, or attenuation, of the GR900 Connector is extremely small. It has been minimized by the use of Teflon for the bead, by the use of solid silver alloys for both inner and outer conductors, and by the design of the contact.



Typical leakage curve of mated pair of Type 900-BT Precision Coaxial Connectors compared with other popular types.

The electrical length of a pair of TYPE 900-BT Connectors is 3.50 cm and is virtually independent of frequency. The dc resistance of a mated pair is typically 0.4 milliohm for the inner conductors, 0.04 milliohm for the outer conductors.

The standard GR900 Connector (TYPE 900-BT) meets all the specifications contained in Part III, Section 1 of the IEEE Recommended Practice for Precision Coaxial Connectors. The TYPE 900-BT Connector is also available in pairs with calibration certificate, which verifies that combined VSWR of the *two* connectors is within the limits specified in the IEEE document.

OTHER MEMBERS OF THE GR900 FAMILY

One of the most important advantages of the GR900 Connector over other precision types is the broad and rapidly expanding line of instruments and components equipped with the GR900. Moreover, the availability of a GR900 cable connector and of kits for fabricating GR900 panel and component connectors and air-line sections brings GR900 precision to every corner of the laboratory.

Type 900-BT PRECISION COAXIAL CONNECTOR

This is the basic GR900 connector, for use on rigid air-dielectric 50-ohm coaxial lines (principal dimensions: 0.5625 inch and 0.24425 inch). The TYPE 900-TOK Tool Kit is recommended for proper assembly.

The stated VSWR specification (less than $1.001 + 0.001\,f_{Gc}$) is conservative, since this is actually the specification for a pair of connectors as they are tested at General Radio. TYPE 900-BT Connectors are available in pairs (Catalog Number 0900-9407), with a calibration certificate to verify that the total VSWR of the pair is within the same limits as those given for a single connector. These limits are those approved in the IEEE Recommended Practice for Precision Coaxial Connectors in the 14-mm general precision connector class. Measured VSWR is specified at 6 frequencies.

SPECIFICATIONS

Frequency Range: Dc to 9 Gc/s.

Characteristic Impedance: 50 Ω ± 0.1% at frequencies where skin effect is negligible.

VSWR: Less than $1.001 + 0.001\,f_{Gc}$ per connector. (Connectors are tested by pairs, with the above limit used for a *pair* of connectors.)

Repeatability of VSWR: Within 0.0005.

Repeatability of Phase: Within 0.008° at 1 Gc/s, 0.015° at 2 Gc/s, 0.05° at 6 Gc/s.

Leakage: Better than 130 dB below signal.

Insertion Loss: Less than $0.003\sqrt{f_{Gc}}$ dB per pair.

Maximum Voltage: 3000 V peak.

Maximum Power: 20 kW up to 1 Mc/s; $20\text{ kW}/\sqrt{f_{Mc}}$ above 1 Mc/s.

Electrical Length: 3.500 ± 0.005 cm per pair.

Dc Contact Resistance: Inner conductor, less than 0.5 milliohm; outer conductor, less than 0.07 milliohm.

Dimensions: Length of one connector, 1 3/16 inches (31 mm); maximum diameter, 1 1/16 inches (27 mm).

Net Weight: 2 oz (60 g).

Catalog No.	*Description*	*Price*
0900-9405	**Type 900-BT Precision Coaxial Connector**	**$35.00**
0900-9407	**Type 900-BT Precision Coaxial Connectors,** with Calibration Certificate	**72.00 per pair**

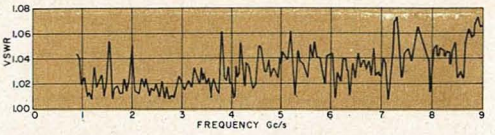
NEW Type 900-C9 PRECISION COAXIAL CABLE CONNECTOR

Cable-connector counterpart of the TYPE 900-BT. The VSWR of this connector is much lower than that of even the best-made cables.

The braid-retention system does not compress the cable, yet has good torque resistance. The usual distortion and flow of cable dielectric during inner-conductor soldering have been virtually eliminated by means of a Teflon spacer and a special, low-temperature solder supplied with every connector. All inner-conductor parts are firmly captured in place.

Although designed for RG-9B/U and RG-214/U cable, the Precision Cable Connector can be used with the following other cables with some sacrifice in performance or mechanical reliability: RG-8/U, RG-8A/U, RG-10A/U, RG-87A/U, RG-116/U, RG-156/U, RG-165/U, RG-166/U, RG-213/U, RG-215/U, RG-225/U, and RG-227/U.

The TYPE 900-TOK Tool Kit is recommended for assembling this connector.



Frequency Range: Dc to 9 Gc/s. **Characteristic Impedance:** 50 Ω. **Leakage:** Better than 130 dB below signal.

Insertion Loss: $<0.006\sqrt{f_{Gc}}$ dB per pair. **Max Voltage:** 1500 V peak. **Dimensions:** Length of one connector, 2⅛ in (54 mm); maximum diameter, 1⅛ in (27 mm). **Net Weight:** 2½ oz (75 g).

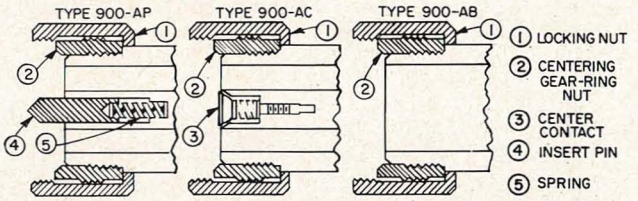
Catalog No.	*Description*	*Price*
0900-9421	**Type 900-C9 Precision Coaxial Cable Connector**	**$50.00**

NEW GR900 LABORATORY PRECISION CONNECTOR KITS

Three kits are available for custom fabrication of air lines and terminations compatible with the GR900 Connector.

TYPE 900-AP LABORATORY PRECISION CONNECTOR KIT is for use on elements having unsupported inner conductors. A reference air line can be assembled from a pair of these kits and appropriate lengths of precision rod and tube. The kit consists of GR900 coupling nut, centering gear ring, and a spring-loaded centering pin, which allows the inner conductor of a beadless air line to derive its support from the mating TYPE 900-BT Connector. Air lines from 5 to 30 cm long can be machined from the GR precision rod and tube described below.

TYPE 900-AC LABORATORY PRECISION CONNECTOR KIT contains the locking nut, centering gear ring, and center contact of a standard GR900 Connector. It can be used in place of the TYPE 900-BT on any component whose inner conductor is supported within the component itself. Since it includes only those parts necessary in such applications, this kit offers the user superior electrical performance at a considerable saving in cost.



TYPE 900-AB LABORATORY PRECISION CONNECTOR KIT is like the TYPE 900-AC Kit in appearance and function, except that it does not contain the GR900 center contact. Thus it can be used to fabricate an air line to be mated with a TYPE 900-BT Connector, but it cannot mate with a TYPE 900-LZ Reference Air Line or with another TYPE 900-AB Connector.

TYPE 900-PKM PANEL MOUNTING KIT is used to equip standard TYPES 900-BT and 900-C9 Connectors for panel mounting. The kit includes a threaded flange, which accepts the outer conductor and mounting hardware.

Type 900-PKM

Catalog Number	*Description*	*Net Weight (oz - g)*	*Length (in - mm)*	*Price*
0900-9402	**Type 900-AB Laboratory Precision Connector Kit**	1 - 30	1⅜ - 31	**$4.80**
0900-9404	**Type 900-AC Laboratory Precision Connector Kit**	1 - 30	1⅜ - 31	**7.10**
0900-9406	**Type 900-AP Laboratory Precision Connector Kit**	1¼ - 35	1¼ - 32	**5.40**
0900-9498	**Type 900-PKM Panel Mounting Kit**	1 - 30	1⅜ - 31	**7.00**

PRECISION ROD AND TUBE

Used in fabrication of custom-length air lines and components, in conjunction with GR900 Connectors and Connector Kits. Diameters are specified at 23°C. Both rod and tube have been stress-relieved to minimize dimensional changes during machining.

PRECISION INNER-CONDUCTOR ROD Centerless-ground, silver-layered brass rod stock with a nominal 0.24425-in diameter.
Length: 26 in (660 mm). **Straightness:** 0.002 in/foot.
Diameter Accuracy: ±65 microinches. **Uniformity:** ±25 microinches.
Surface Finish: 20 microinches, maximum.

PRECISION OUTER-CONDUCTOR TUBE Precision-forged, silver-lined brass tubing with a nominal OD of 0.830 in and a nominal ID of 0.5625 (9/16) in. Nominal wall thickness is 0.134 in.
Length: 26 in (660 mm). **Straightness of ID:** 0.005 in/foot.
Inner-Diameter Accuracy: ±140 microinches.
Inner-Surface Finish: 30 microinches, maximum.

Catalog No.	*Description*	*Net Weight*	*Price*
0900-9508	**Precision Inner-Conductor Rod**	7 oz (200 g)	**$17.00**
0900-9509	**Precision Outer-Conductor Tube**	2½ lb (1.2 kg)	**39.00**

Type 900-TOK TOOL KIT

Nine-piece tool kit in fitted case for convenient installation of TYPES 900-BT and 900-C9 Precision Coaxial Connectors on suitable air line or component. Complete instructions for use of tools are supplied with each connector to simplify assembly and to ensure precision results.

Catalog No.	*Description*	*Net Weight*	*Price*
0900-9902	**Type 900-TOK Tool Kit**	2 lb (1 kg)	**$95.00**

GR900 ADAPTORS

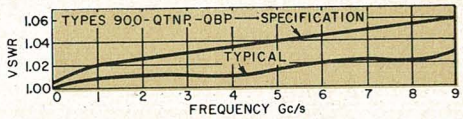
The availability of precision adaptors from the GR900 series to other popular coaxial connectors means that the user of GR900-equipped instruments can convert to other series and still retain precision performance. For example, a TYPE 900-LB Precision Slotted Line equipped with a TYPE 900-QBJ or -QBP Adaptor becomes a type BNC slotted line with an over-all residual VSWR (line plus adaptor) of only 1.022 at 1 Gc/s. Conversely, users of instruments equipped with BNC, TNC, N, C, and GR874 Connectors can, by means of adaptors, take advantage of the precision offered by GR900 tuners, air-line standards, terminations, and other elements.

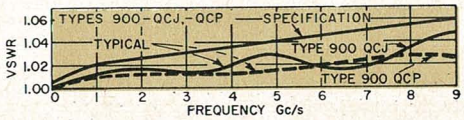
Each GR900 Adaptor includes a TYPE 900-BT Precision Coaxial Connector and an optimally designed connector of the other series. When ordering, note that the suffix letter "J" or "P" denotes the type of other-series connector (jack or plug) *included* in the adaptor. To obtain an adaptor to mate with a BNC plug, therefore, one would order a TYPE 900-QBJ Adaptor.

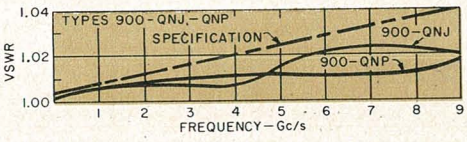
The Adaptor Flange (Catalog No. 0900-9782) listed in the table below threads onto a TYPE 900-BT Connector in place of the gear ring and locking nut to connect GR900 components to bridges and other instruments that terminate in a flat-plane surface or to other flange-type connectors.

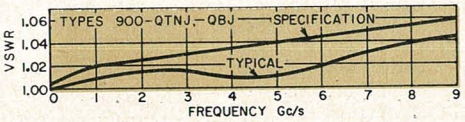
SPECIFICATIONS

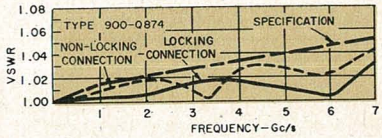
Frequency Range: Dc to 9 Gc/s.
Characteristic Impedance: 50 Ω.
VSWR: See curves.
Maximum Voltage: TYPES 900-QBJ, -QBP, -QTNJ, -QTNP, 500 V; TYPES 900-QCJ, -QCP, -QNJ, -QNP, 1000 V; TYPE 900-Q874, 1500 V.
Maximum Power: TYPES 900-QBJ, -QBP, -QTNJ, -QTNP, 3 kW; TYPES 900-QCJ, -QCP, -QNJ, -QNP, 7 kW; TYPE 900-Q874, 10 kW. These values apply at 1 Mc/s; at higher frequencies maximum power varies inversely with the square root of frequency.

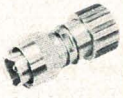






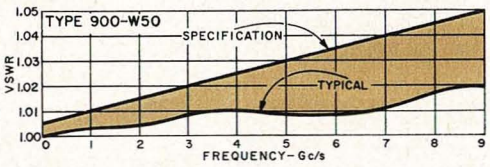




	Adaptor to	*Type*		*Contains GR900 and*	*Connects GR900 to*	*Net Weight*	*Length*	*Catalog Number*	*Price*
NEW	Type BNC	**900-QBJ**		BNC Jack	**BNC Plug**	3½ oz (100 g)	2 1/16 in (53 mm)	0900-9701	**$55.00**
		900-QBP		BNC Plug	**BNC Jack**	4 oz (115 g)	2⅛ in (54 mm)	0900-9801	**55.00**
NEW	Type C	**900-QCJ**		C Jack	**C Plug**	3½ oz (100 g)	1⅞ in (48 mm)	0900-9703	**55.00**
		900-QCP		C Plug	**C Jack**	4 oz (115 g)	2 1/16 in (53 mm)	0900-9803	**55.00**
	Type N	**900-QNJ**		N Jack	**N Plug**	3½ oz (100 g)	2¼ in (58 mm)	0900-9711	**55.00**
		900-QNP		N Plug	**N Jack**	4 oz (115 g)	2 5/16 in (59 mm)	0900-9811	**55.00**
NEW	Type TNC	**900-QTNJ**		TNC Jack	**TNC Plug**	3½ oz (100 g)	2 1/16 in (53 mm)	0900-9717	**55.00**
		900-QTNP		TNC Plug	**TNC Jack**	4 oz (115 g)	2 1/16 in (53 mm)	0900-9817	**55.00**
	GR874	**900-Q874**		GR874	**GR874**	3½ oz (100 g)	2 9/16 in (65 mm)	0900-9883	**50.00**
	Flat Surface			Flange adaptor; converts any GR900 connector to a flange connector.		3 oz (85 g)		0900-9782	**3.50**

TYPE 900-W50 50-OHM STANDARD TERMINATION

A precision, low-VSWR, 50-ohm standard for calibration of bridges, slotted lines, admittance meters, and reflectometers. Can also be used as a precision dummy load or as a termination in measurements of networks with more than one port. With appropriate GR900 precision adaptor, can be used as a low-VSWR, precision type N, BNC, C, etc, termination. A VSWR calibration chart is supplied with each unit.

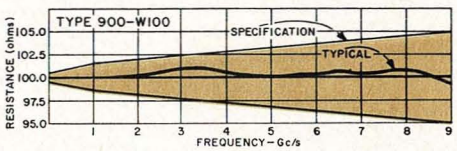


VSWR: Less than $1.005 + 0.005 f_{Gc}$ up to 9 Gc/s.
Dc Resistance: 50 Ω ± 0.3%.
Maximum Power: 1 W with negligible change; 5 W without damage.
Temperature Coefficient: Less than 150 ppm/°C.
Over-all Length: 2 in (51 mm). **Net Weight:** 3½ oz (100 g).

NEW TYPE 900-W100 100-OHM AND TYPE 900-W200 200-OHM STANDARD TERMINATIONS

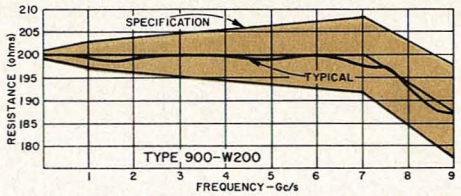
These known resistive terminations are especially useful in the calibration of bridges, admittance meters, reflectometers, etc. Position of pure resistance nominally 4 cm from the TYPE 900-BT reference plane. Short- and open-circuit terminations with a corresponding 4-cm offset are available (TYPES 900-WN4 and -WO4; see below). A calibration chart is supplied with each unit.

Resistance vs frequency, Type 900-W100 100-Ohm Standard Termination.



Magnitude of Mismatch: See curves.
Dc Resistance: TYPE 900-W100, 100Ω ± 0.3%
TYPE 900-W200, 200Ω ± 0.3%.
Maximum Power: 1 W with negligible change; 5 W without damage.
Temperature Coefficient: Less than 150 ppm/°C.
Over-all Length: 2 in (51 mm). **Net Weight:** 3½ oz (100 g).

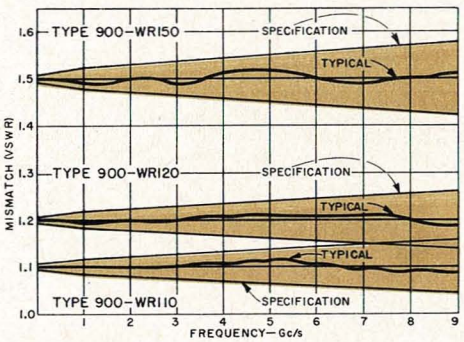
Resistance vs frequency, Type 900-W200 200-Ohm Standard Termination.



TYPES 900-WR110, -WR120, -WR150 STANDARD MISMATCHES NEW

Introduce reflections of known VSWR value (1.1, 1.2, and 1.5) into a 50-ohm transmission line. Useful in calibration of reflectometers and other VSWR-measuring instruments. Mismatch calibration data (in VSWR) are provided with each unit.

Magnitude of Mismatch: See curves.
Dc Resistance: TYPE 900-WR110, 45.45Ω ± 0.3%
TYPE 900-WR120, 41.67Ω ± 0.3%
TYPE 900-WR150, 33.33Ω ± 0.3%.
Maximum Power: 1 W with negligible change; 5 W without damage.
Over-all Length: 2 in (51 mm). **Net Weight:** 3½ oz (100 g).



Mismatch in VSWR, Types 900-WR110, -WR120, -WR150 Standard Mismatches.

Catalog No.	*Description*	*Price*
0900-9953	**Type 900-W50 50-Ohm Standard Termination**	**$60.00**
0900-9957	**Type 900-W100 100-Ohm Standard Termination**	**60.00**
0900-9959	**Type 900-W200 200-Ohm Standard Termination**	**60.00**
0900-9961	**Type 900-WR110 Standard Mismatch**	**60.00**
0900-9963	**Type 900-WR120 Standard Mismatch**	**60.00**
0900-9965	**Type 900-WR150 Standard Mismatch**	**60.00**

SHORT- AND OPEN-CIRCUIT TERMINATIONS

TYPE 900-WN PRECISION SHORT-CIRCUIT TERMINATION

The standard 50-ohm precision termination, with the position of short circuit right at the mating plane of the GR900 Connector. Reflection coefficient is greater than 0.999 at 9 Gc/s.

TYPE 900-WO PRECISION OPEN-CIRCUIT TERMINATION

Presents an open circuit 0.26 cm (±0.02 cm) from the mating plane of the GR900 Connector. (For short-circuit termination with corresponding 0.26-cm offset, see TYPE 900-WNE below.) Useful in establishing reference plane and in loss measurements. Reflection coefficient is greater than 0.999 at 9 Gc/s.

NEW TYPE 900-WNE PRECISION SHORT-CIRCUIT TERMINATION

Similar to TYPE 900-WN Termination, except that reference plane is displaced 0.26 cm to correspond to position of open circuit in TYPE 900-WO Precision Open-Circuit Termination. Reflection coefficient is greater than 0.998 at 9 Gc/s.

Type 900-WNE

TYPE 900-WNC REFERENCE-LINE SHORT-CIRCUIT TERMINATION NEW

Similar to TYPE 900-WN Termination, except that it includes a GR900 center contact to support the inner conductor of a beadless TYPE 900-LZ Reference Air Line (page 102). The reference plane of the termination is exactly at the reference plane of the GR900 Connector. Reflection coefficient is greater than 0.999 at 9 Gc/s.

NEW TYPE 900-WN4 AND TYPE 900-WO4 PRECISION SHORT- AND OPEN-CIRCUIT TERMINATIONS

These terminations are similar to the TYPES 900-WN and -WO, except that the reference plane is displaced 4 cm (±0.01 cm) to correspond to the 4-cm offset of the TYPES 900-W100 and -W200 Standard Terminations.

Catalog No.	*Description*	*Length*	*Net Weight*	*Price*
0900-9971	**Type 900-WN Precision Short-Circuit Termination**	1 1/16 in (27 mm)	2½ oz (75 g)	**$11.00**
0900-9981	**Type 900-WO Precision Open-Circuit Termination**	1 1/16 in (27 mm)	2 oz (60 g)	**11.00**
0900-9979	**Type 900-WNE Precision Short-Circuit Termination**	1 1/16 in (27 mm)	2½ oz (75 g)	**17.00**
0900-9977	**Type 900-WNC Reference-Line Short-Circuit Termination**	1 1/16 in (27 mm)	2½ oz (75 g)	**16.00**
0900-9975	**Type 900-WN4 Precision Short-Circuit Termination**	2 in (51 mm)	4 oz (115 g)	**40.00**
0900-9985	**Type 900-WO4 Precision Open-Circuit Termination**	2 5/16 in (59 mm)	4 oz (115 g)	**40.00**

Type 900-LB PRECISION SLOTTED LINE

FEATURES:

VSWR under 1.002 at 1 Gc/s, under 1.01 at 9 Gc/s.
Characteristic impedance 50 ohms ± 0.1%.
Converts quickly to type N, BNC, TNC, C, or GR874 slotted line by means of low-VSWR adaptors.
50-cm travel permits measurements down to 300 Mc/s.
Probe-pickup flatness ± 0.5% over full 50-cm travel.
Probe-position accuracy ± (0.1 mm + 0.05%) with vernier scale.
Probe-position resolution 0.002 mm with micrometer drive.
Low line loss — pure silver overlay on both inner and outer conductors.

USES: In the field of microwave impedance measurement, the slotted line is *the* fundamental instrument, because of its inherent accuracy, broadband characteristics, and phase-measuring capability. Of the several types of instruments commonly used to measure VSWR, only the slotted line gives the design engineer all the information he needs to evaluate the over-all performance of devices and networks over a wide band. Among the many parameters that can be determined by use of the slotted line are VSWR, reflection-coefficient magnitude and phase, impedance or admittance, insertion loss, and wavelength.

The most precise coaxial connector, the GR900, and a nearly perfect section of coaxial transmission line combine to give the TYPE 900-LB Precision Slotted Line unparalleled performance specifications. The residual VSWR of the instrument is that of its GR900 connector: $1.001 + 0.001\ f_{Gc}$. Equipped with the appropriate GR900 low-VSWR adaptor (see page 98), the TYPE 900-LB becomes a type N, BNC, C, etc, slotted line whose specifications still exceed those of slotted lines originally equipped with the other series (see curve below).

DESCRIPTION: The TYPE 900-LB is a slotted section of 14-mm (0.5625-in) coaxial transmission line whose characteristic impedance is very accurately known (50.0 ohms ± 0.1%). The outer conductor is precision-forged brass tubing lined with pure silver for low loss. The inner conductor is a precision-machined steel tube with a layer of silver. The true coaxial cross-section of the TYPE 900-LB allows reflectionless extension of the slotted section into the connector without gross diameter change or transition pieces.

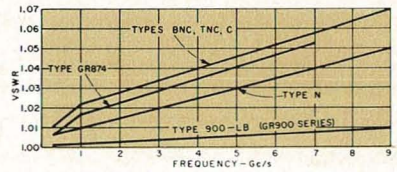
The removable, barrel-type probe tuner, which includes precisely calibrated adjustments for probe penetration (in increments of 0.001 inch) and for detector resonance (300 Mc/s to 9 Gc/s), mounts on the movable carriage. Probe position with reference to the GR900 contact surfaces is indicated by a vernier scale with an accuracy of 0.1 mm ± 0.05%. A micrometer carriage drive, also supplied, extends resolution to 0.002 mm.

Accessories supplied with the slotted line include, in addition to the probe tuner already mentioned, short- and open-circuit terminations, patch cord, micrometer carriage drive, and a separate probe accessory for applications requiring a direct rf output.

The outstandingly low VSWR of the TYPE 900-LB should save users the many hours required to calibrate less accurate instruments. For those whose applications demand the ultimate in accuracy, the TYPE 900-LB can be calibrated against a TYPE 900-LZ Reference Air Line (see page 102), an impedance standard with a VSWR under 1.0025 at 9 Gc/s. A TYPE 900-TUA or -TUB Tuner (page 102) can be used to tune out small residual reflections.

SPECIFICATIONS

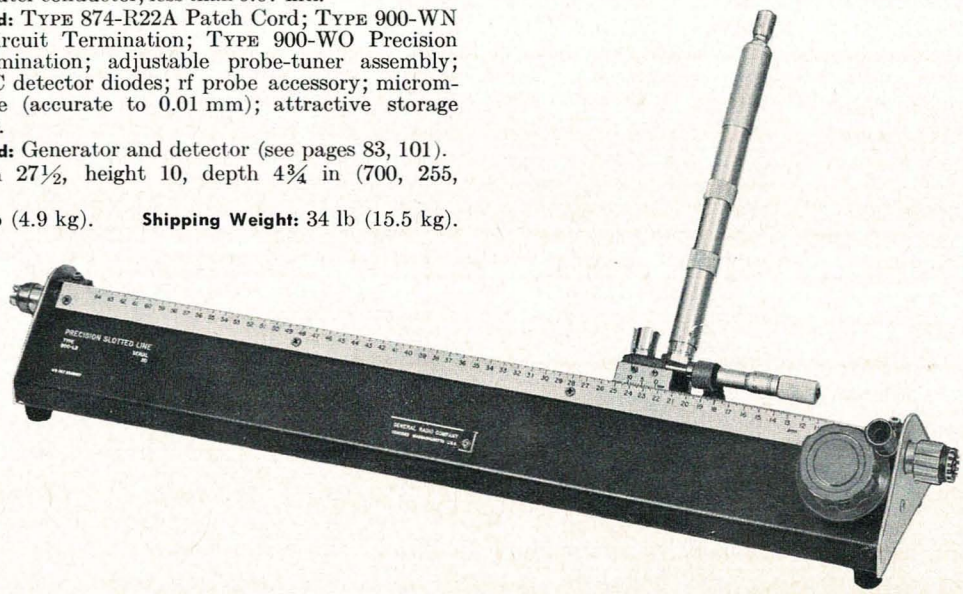
Characteristic Impedance: 50.0 Ω ± 0.1%.
Probe Travel: 50 cm. Scale calibrated in centimeters from reference plane. Attached vernier can be read to 0.1 mm, micrometer carriage drive (supplied) to 0.002 mm.
Scale Accuracy: ± (0.1 mm + 0.05%).
Frequency Range: 0.3 to 9 Gc/s. At 300 Mc/s, covers a half wavelength. Operates below 300 Mc/s with TYPE 900-L or -LZ Precision Air Line (page 102).
Constancy of Probe Pickup (Flatness): ±0.5%.
Residual VSWR: Less than $1.001 + 0.001\ f_{Gc}$ (e.g., 1.002 at 1 Gc/s). VSWR calibration data is supplied.
Repeatability: Within 0.05% (0.0005 in VSWR).
Dc Contact Resistance of Type 900-BT Connector: Inner conductor, less than 0.5 mΩ; outer conductor, less than 0.07 mΩ.
Accessories Supplied: TYPE 874-R22A Patch Cord; TYPE 900-WN Precision Short-Circuit Termination; TYPE 900-WO Precision Open-Circuit Termination; adjustable probe-tuner assembly; 1N21C and 1N23C detector diodes; rf probe accessory; micrometer carriage drive (accurate to 0.01 mm); attractive storage case; Smith charts.
Accessories Required: Generator and detector (see pages 83, 101).
Dimensions: Width 27½, height 10, depth 4¾ in (700, 255, 125 mm).
Net Weight: 10¾ lb (4.9 kg). **Shipping Weight:** 34 lb (15.5 kg).



Combined VSWR specification of Type 900-LB Precision Slotted Line and type N, BNC, TNC, C, and GR874 adaptors. Bottom curve is VSWR specification of slotted line without adaptor.

Catalog No.	*Description*	*Price*
0900-9651	**Type 900-LB Precision Slotted Line**	**$675.00**

PATENT NOTICE. See Note 4, page 11.



Type 1640-A SLOTTED LINE RECORDER SYSTEM

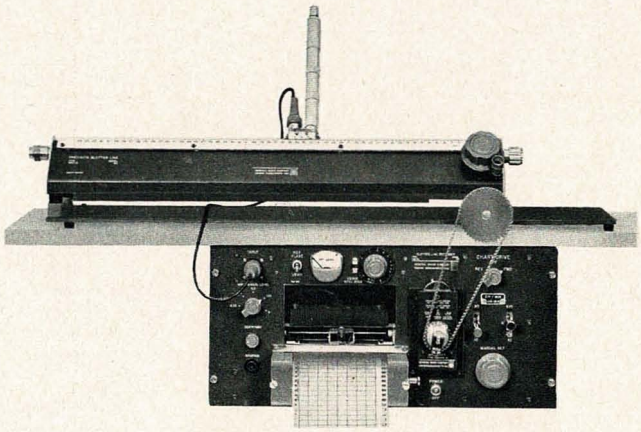
FEATURES:

Measures VSWR with full-scale resolution as low as 1.008 on a 4-inch chart; VSWR full-scale range continuously adjustable from 1.008 to 1.20.
True precision slotted line, with residual VSWR of 1.001 + 0.001 f_{Gc}.
Furnished complete with all accessories. Stable 1-kc-modulated rf source only additional requirement.

USES: The TYPE 1640-A Slotted Line Recorder System automatically produces a strip-chart record of standing-wave patterns and other slotted-line measurement phenomena. Such a recording far exceeds, in resolution and in usefulness, the conventional meter readout. The chart record can be stored, reproduced, or analyzed graphically.

A direct measurement of VSWR or phase with the slotted line recorder system is quick and easy. At any frequency from 0.6 to 9 Gc/s, two full cycles of the standing-wave pattern can be scanned in 10 seconds, without perceptible distortion of the pattern. Multiple recordings can be run to measure repeatability and insertion VSWR, and to make measurements by the substitution-air-line method,[1] by which accuracy can be increased by a factor of from 2 to 5, depending on frequency.

DESCRIPTION: The TYPE 1640-A comprises a TYPE 900-LB Precision Slotted Line (page 100), a TYPE 1521-SL Slotted Line Recorder, and the necessary connecting linkage. The recorder is a transistorized, servo-type instrument, whose accuracy depends only on three stable, custom-calibrated, wire-wound potentiometers in the servo loop. The chart drive has four speeds, which, combined with the two sprockets



supplied, permit a total of eight possible slotted-line carriage-drive speeds, from 5 to 0.08 centimeters per second.

The recordings shown on this page are all actual chart records made with a TYPE 1640-A Slotted Line Recorder System. They represent some, but by no means all, of the measurements possible with this new concept in instrumentation.

[1] A. E. Sanderson, "A New High-Precision Method for the Measurement of the VSWR of Coaxial Connectors," *IRE Transactions on Microwave Theory and Techniques*, Vol MTT-9, No 6, November 1961, p 524–528. (Reprint A-92.)

SPECIFICATIONS

SLOTTED LINE: (See TYPE 900-LB Specifications, page 100.)

RECORDER (TYPE 1521-SL)

Sensitivity: Continuously adjustable from 0.05 to 2.0 mV full-scale.

Frequency: 990 c/s ± 2%.

Bandwidth: 35 c/s ± 7 c/s (at 3 dB).

VSWR Range: Continuously adjustable from 1.008 (0.8%) to 1.20 (20%) full-scale; accurate to within one minor division. Can be adapted to higher values.

Noise Level (referred to input): Short-circuit, less than 0.1 μV; open-circuit, less than 3.0 pA. Noise figure less than 5 dB at optimum source resistance (about 30 kΩ).

Power Required: 105 to 125 or 210 to 250 V, 60 c/s, 35 W. TYPE 1521-SLQ1 Recorder, supplied with TYPE 1640-AQ1 System, 50 c/s.

Chart paper: 4-inch recording on 5-inch paper; 50 minor and 10 major vertical divisions. Horizontal scale ruling, ¼ inch.

Paper Speeds: Adjustable, 2.5 to 75 inches per minute; plots correspond to 5- to 300-cm/min carriage travel on slotted line. Two interchangeable sprockets advance paper 1 or 2 horizontal divisions per cm probe travel.

Servo Bandwidth of Pen Drive: More than 4 c/s.

Input Connector: GR874 Coaxial Connector, locking, recessed.

Accessories Supplied: Two pens, 2 oz red ink, 2 oz green ink, potentiometer cleaner, 10 100-ft rolls of chart paper, eyedroppers for filling pen, power cord, spare fuses.

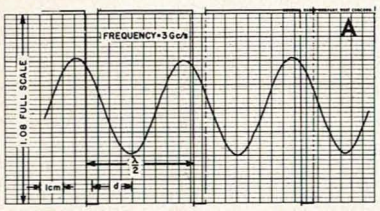
SYSTEM

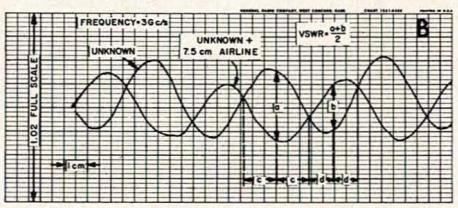
Bench Space Required: Width 48, depth 14 in (1220, 355 mm); height above bench 12 in, depth below bench 9 in (315, 230 mm).

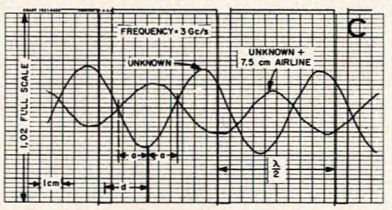
Net Weight: 67 lb (31 kg). **Shipping Weight:** 120 lb (55 kg).

Catalog No.	*Description*	*Price*
1640-9701	**Type 1640-A Slotted Line Recorder System** (60-cycle)	**$1975.00**
1640-9494	**Type 1640-AQ1 Slotted Line Recorder System** (50-cycle)	**on request**
1521-9310	**Chart Paper**, 100-foot roll	**2.75**

PATENT NOTICE. See Notes 1, 4, and 18, page 11.

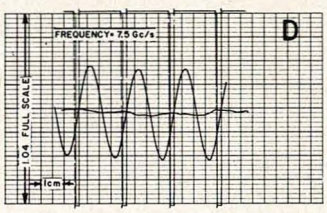


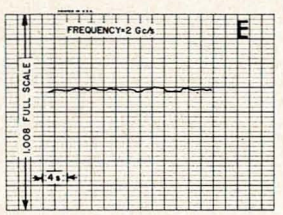




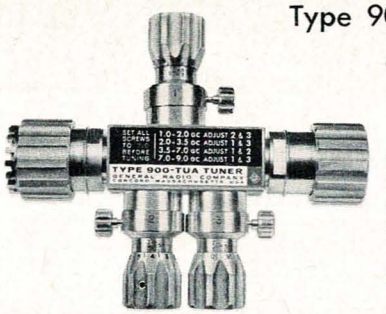
Actual recordings illustrating some of the measurements possible with the Slotted Line Recorder System.

A. VSWR and phase (direct method).
B. VSWR (substitution method).
C. VSWR and phase (substitution method).
D. Insertion VSWR of a mated pair of GR900 Adaptors.
E. System noise, with Type 1360-B Microwave Oscillator as signal source.





GR900 TUNERS AND AIR LINES



Type 900-TUA and Type 900-TUB TUNERS

USES: The TYPES 900-TUA and -TUB Tuners are compact, broadband, screw-type tuners useful in matching out small residual reflections in low-VSWR measuring instruments and devices.

DESCRIPTION: Each tuner has three smoothly adjustable tuning screws, used in pairs to tune out reflections of any phase throughout the tuner's frequency range. Each screw has a "neutral" setting, independent of frequency, at which it is effectively out of circuit. Screws can be locked at any setting, permitting excellent VSWR resettability, protection against accidental disturbance, and friction driving (with screws partially locked) if desired.

SPECIFICATIONS

	900-TUA	900-TUB
Frequency Range	1 to 9 Gc/s	0.25 to 2.5 Gc/s
Characteristic Impedance	50 Ω	50 Ω
VSWR Matching Range (worst-case minimum)	$1.00 + 0.012\,f_{Gc}$	$1.00 + 0.05\,f_{Gc}$ to 1 Gc/s 1.05 from 1 to 2.5 Gc/s
VSWR Resettability	$< 1.0005 \pm 0.0003\,f_{Gc}$	$< 1.0005 + 0.0003\,f_{Gc}$
Residual VSWR (all controls at neutral)	<1.03 to 5 Gc/s, <1.05 from 5 to 7 Gc/s	<1.03 to 1.5 Gc/s
Insertion Loss	<0.1 dB to 4 Gc/s <0.3 dB to 9 Gc/s	<0.1 dB
Repeatability of Connection	0.05%	0.05%
Electrical Length	12.0 cm	18.5 cm
Dimensions	4½ × 3½ × 1 in (115, 88, 25 mm)	6½ × 4¾ × 1 in (165, 120, 25 mm)
Net Weight	1 lb (0.5 kg)	1¼ lb (0.6 kg)
Shipping Weight	3 lb (1.4 kg)	4 lb (1.9 kg)

Catalog Number	*Description*	*Price*
0900-9635	**Type 900-TUA Tuner** (1.0 to 9.0 Gc/s)	**$165.00**
0900-9637	**Type 900-TUB Tuner** (0.25 to 2.5 Gc/s)	**195.00**

PRECISION AIR LINES

TYPE 900-L10, -L15, -L30 PRECISION AIR LINES

Short sections (10, 15, and 30 cm) of precision 50-ohm air line with a TYPE 900-BT Connector on each end. Useful as low-VSWR line extenders, as aids in checking the VSWR of precision connectors, and as 50-ohm impedance standards at frequencies at which the electrical length is an odd multiple of a quarter wavelength. Also useful as absolute impedance references in time-domain-reflectometer systems and as time-delay standards.

VSWR: Less than $1.0013 + 0.0013\,f_{Gc}$ up to 9 Gc/s.
Characteristic Impedance: 50Ω ± 0.065%.
Accuracy of Electrical Length: Within ±0.02 cm of nominal.

Catalog No.	*Type*	*Electrical Length*	*Time Delay — ps (±1 ps)*	*Physical Length in — mm*	*Net Weight oz — g*	*Price*
0900-9605	**900-L10**	10 cm	333	4–102	6.5–180	**$105.00**
0900-9607	**900-L15**	15 cm	500	6–155	10–285	**110.00**
0900-9613	**900-L30**	30 cm	1000	12–305	15–425	**125.00**

TYPE 900-LZ REFERENCE AIR LINES

Beadless, virtually reflectionless coaxial air lines, with spring-loaded tips on the ends of the inner conductor to mate with GR900 Connectors; microfinished outer-conductor ends butt-contact the mating connectors. VSWR is held to $1.0005 + 0.0002\,f_{Gc}$. Such near-perfect specifications make these air lines most useful in calibration applications, and especially in substitution measurements. The lines can also be used as precision capacitance or time-delay standards, as well defined reactance standards, and as dielectric sample holders for dielectric-constant and loss measurements with the slotted line.

SPECIFICATIONS

Frequency Range: Dc to 9 Gc/s.
Characteristic Impedance: 50 Ω ± 0.050%. Additional skin-effect error is calculable.

VSWR: Less than $1.0005 + 0.0002\,f_{Gc}$; calibration data supplied.
Repeatability: Within $(0.010 + 0.003\,f_{Gc})$%.
Leakage: Better than 130 dB below signal.
Insertion Loss: Less than $0.0008\sqrt{f_{Gc}}$ dB/cm.
Maximum Voltage: 3000 V peak.
Maximum Power: $20\ \text{kW}/\sqrt{f_{Mc}}$.
Dc Contact Resistance (each end, mated with GR900); Inner conductor, less than 0.5 mΩ; outer conductor, less than 0.07 mΩ.

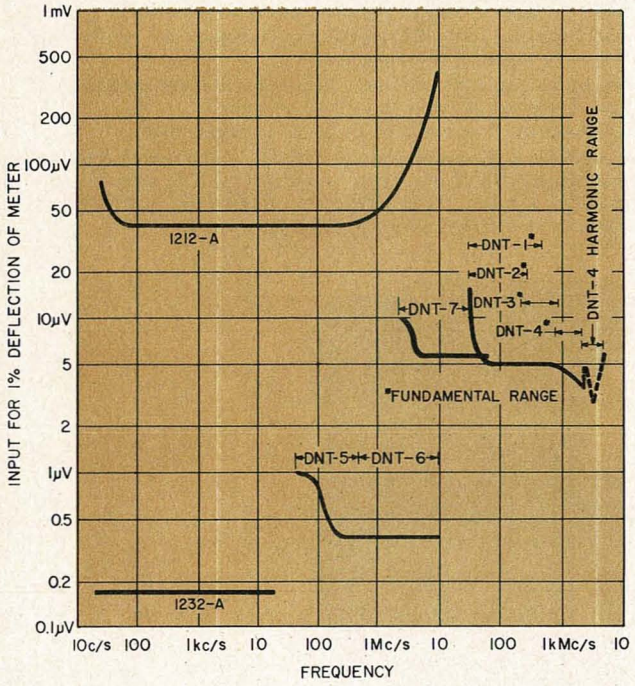
Catalog Number	*Type*	*Electrical Length — cm (±0.002 cm)*	*Capacitance — pF (±0.07%)*	*Time Delay — ps (±0.1 ps)*	*Odd λ/4 Frequencies* —Gc/s*	*Physical Length in — mm*	*Net Weight oz — g*	*Price*
0900-9600	**900-LZ5**	4.997	3.3333	166.7	(2n + 1)1.50	2⅛– 55	4.0–115	**$ 80.00**
0900-9601	**900-LZ6**	5.996	4.0000	200.0	(2n + 1)1.25	2½– 65	5.0–145	**82.00**
0900-9602	**900-LZ7H**	7.495	5.0000	250.0	(2n + 1)1.00	3 1/16– 80	5.5–160	**85.00**
0900-9604	**900-LZ10**	9.993	6.6667	333.3	(2n + 1)0.75	4 1/16–105	7.0–200	**90.00**
0900-9606	**900-LZ15**	14.990	10.000	500.0	(2n + 1)0.50	6 –155	10.5–300	**100.00**
0900-9612	**900-LZ30**	29.979	20.000	1000.0	(2n + 1)0.25	12 –305	20 –570	**130.00**

* Frequencies at which air-line section is an odd multiple of a quarter wavelength, where n is zero or any integer.

DETECTORS

In most types of electrical measurements, a detector is used for aural or visual indication of the desired measurement condition. Such devices as null indicators, demodulators, and voltmeters are usually combined with filters and amplifiers to constitute detectors for specific purposes. Different types of measurement impose different requirements on the detector. Thus, bridge measurements require both selectivity and shielding to reduce extraneous signals and high sensitivity for maximum precision of measurement. For measurement of relative signal levels (gain or loss), a wide linear range is desirable, as well as an accurately calibrated level indication. In demodulators, distortion must be minimized to ensure faithful reproduction of the modulation envelope.

A simple rectifier followed by a meter or earphones can be used to convert an ac signal to dc or to demodulate an rf signal, but such a system has inherently low sensitivity. For higher sensitivity, some form of amplifier is necessary. At audio frequencies, the signal is usually amplified directly and then rectified to operate a meter, although with null detectors, earphones can be used at the user's option. At radio frequencies, a radio receiver, if well shielded, is a satisfactory detector, but a broadband heterodyne detector employing a wide-range local oscillator is usually more flexible in application. Here, the incoming signal is heterodyned with that of a local oscillator to produce the difference frequency, which is amplified in an intermediate-frequency amplifier.



Sensitivity and frequency ranges of various detectors.

General Radio offers detectors using all three types of amplifiers — untuned, tunable, and fixed-tuned intermediate frequency.

The Type 1212-A Unit Null Detector is an untuned detector, which covers a wide frequency range and uses limiting amplifiers to produce a nonlinear compression of the meter scale so as to cover a range of at least 100 dB, thus eliminating the need for amplifier gain adjustments during bridge-balancing operations.

For maximum effective sensitivity, one of the accessory filters should be used at the input: the Type 1212-P1, for eliminating pickup at the power-line frequency in measurements above 10 kc/s; or the Type 1212-P2, for maximum sensitivity and selectivity at 1 Mc/s. The Type 1212-P3 RF Mixer is also available for this instrument, extending its frequency coverage to 60 Mc/s or more in conjunction with appropriate local oscillators (see DNT assemblies, page 109).

The Type 1232-A Tuned Amplifier and Null Detector is tunable over the audio-frequency range, with two additional fixed frequencies of 50 and 100 kc/s. Its unusually high sensitivity, low noise level, excellent selectivity, and high gain make it suitable for the most exacting bridge-measurement requirements. With the Type 1232-P1 RF Mixer, it can be used as the i-f amplifier in a heterodyne-detector system at frequencies up to 10 Mc/s (see page 109).

For audio-frequency bridge measurements, the Type 1240-A Bridge Oscillator-Detector provides both the bridge power source and the detector in a simple, compact structure.

Complete heterodyne-detector systems, the Types DNT-5, DNT-6, and DNT-7, are available, which use the above amplifiers and mixers.

For very-high and ultra-high frequencies, the Types DNT-1, DNT-2, DNT-3, and DNT-4 Detectors are used. The mixer is the Type 874-MR, and the i-f signal is amplified in the Type 1216-A Unit I-F Amplifier.

Simple rectifiers are often used at the high frequencies. The Type 874-VQ Voltmeter Detector and Type 874-VR Voltmeter Rectifier cover a very wide frequency range, as indicated on the chart. Used with an audio amplifier, such as the Type 1232-A, they are sensitive detectors of modulated signals.

OTHER INSTRUMENTS SUITABLE AS DETECTORS

The following general-purpose and special-purpose instruments can also be used in detection systems over their respective frequency ranges.

Type	*Name*	*See Page*
1206-B	Unit Amplifier	36
1551-C	Sound-Level Meter	14
1900-A	Wave Analyzer	28

Sensitivity and frequency ranges of various detectors.

Type 1232-A TUNED AMPLIFIER AND NULL DETECTOR

20 c/s TO 20 kc/s; 50 AND 100 kc/s

FEATURES:

High sensitivity — typically, better than 0.1 microvolt at 1 kc/s. ■ 120-dB gain.
High selectivity — approximately 5% bandwidth.
Very low noise level — generally below 0.1 microvolt.
Continuous (plus range switch) tuning — 20 c/s to 20 kc/s in 3 ranges.
Spot frequencies at 50 and 100 kc/s.

USES: Bridge detector for audio frequencies.

Extremely sensitive, heterodyne, rf null detector for frequencies up to 10 Mc/s, when used as a 20-kc and 100-kc i-f amplifier with the TYPE 1232-P1 RF Mixer and appropriate local oscillator. See listing of TYPES DNT-5 and DNT-6 Heterodyne Detectors on page 109.

Audio-frequency preamplifier for oscilloscopes, microphones, vibration pickups, and other transducers.

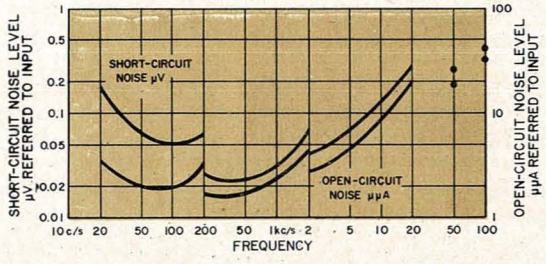
General-purpose, tunable, or broadband audio amplifier (±3 dB from 20 c/s to 20 kc/s plus spot frequencies at 50 kc/s and 100 kc/s).

Audio wave analyzer (for approximate measurements) with a sensitivity of a fraction of a microvolt.

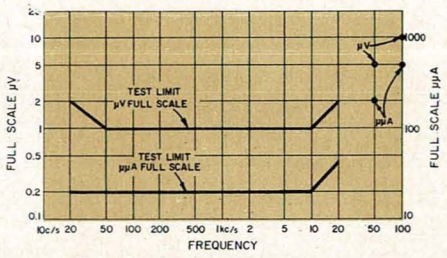
Detector for modulated frequencies from 500 kc/s to 5000 Mc/s, with the TYPE 874-VQ Voltmeter Detector.

DESCRIPTION: This battery-operated, solid-state amplifier consists of a low-noise preamplifier, followed by a frequency selective stage, and an amplifier-compressor stage. Tuning is accomplished by a GR-designed, single-control, RC, bridged-T network in a negative-feedback loop. The compact convertible-bench cabinet has extendible legs to tilt the panel at a convenient viewing angle. Panel extensions are available to adapt the assembly for rack mounting.

SPECIFICATIONS



Typical noise levels as a function of frequency. Minimum input for full-scale meter deflection as a function of frequency, when amplifier is tuned to peak response.



Frequency Response:

Tunable Filters — 20 c/s to 20 kc/s in 3 ranges; between 2% and 6% bandwidth to 15 kc/s; 2nd harmonic at least 34 dB down from peak, 3rd at least 40 dB down; rejection filter on two highest ranges reduces 60-cycle level to at least 60 dB below peak (50 dB at 50 c/s). Dial accuracy is ±3%.

50- and 100-kc Filters — 2nd harmonic 44 and 53 dB down, respectively.

Flat Response — ±3 dB 20 c/s to 100 kc/s.

Sensitivity: See plot. Typically better than 0.1 μV over most of the frequency range.

Noise Level Referred to Input: See plot. Noise figure at 1 kc/s is less than 2 dB at an optimum source impedance of 27 kΩ.

Noise Level Referred to Output: Less than 5 mV on FLAT filter-frequency position, minimum gain setting, and −20 dB switch position; less than 50 mV in MAX SENS position.

Input Impedance: Approximately 50 kΩ at maximum gain; varies inversely with gain to 1 MΩ at minimum gain.

Maximum Safe Input Voltage: 200 V ac or 400 V dc.

Voltage Gain: 120 dB on the tunable ranges; 100 dB, flat range; 106 dB at 50 kc/s; 100 dB at 100-kc position.

Output: 1 V into 10,000 Ω. Internal impedance is 3000 Ω.

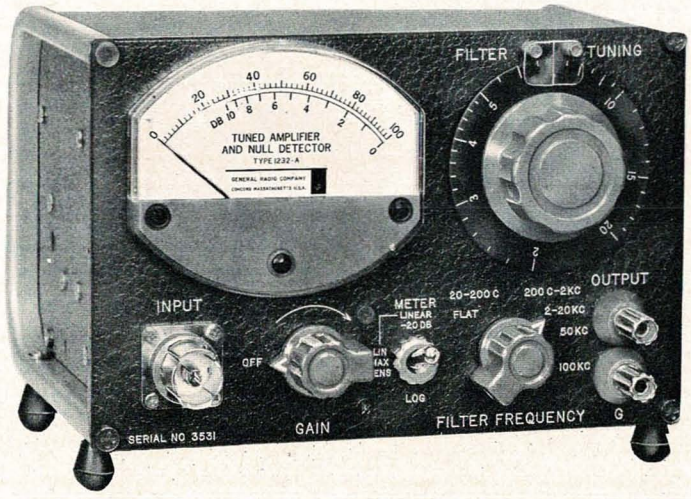
Meter Linearity: DB differences are accurate to ±5% ± 0.1 division for input of less than 0.3 V.

Compression (on LOG position): Reduces full-scale sensitivity by 40 dB. Does not affect bottom 20% of scale.

20-dB Position: Reduces gain by 20 dB in linear mode.

Distortion (in FLAT position): Less than 5% (from meter rectifiers).

Power Supply: 12 V dc, from 9 mercury (M72) cells in series. Estimated battery life is 1500 hours. Optionally, a rechargeable battery (non-mercury) can be supplied on special order.



Terminals: Input, GR874 Coaxial Connector (see pages 78 to 85 for mating connectors, patch cords and adaptors); output, binding posts.

Mechanical Data: Convertible-Bench Cabinet *(see page 258)*

Width		Height		Depth		Net Weight		Shipping Weight	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
8	205	6	155	7½	190	5¾	2.7	8	3.7

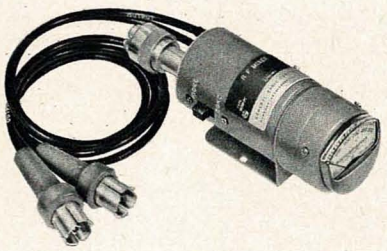
For a more detailed description, see *General Radio Experimenter*, July 1961.

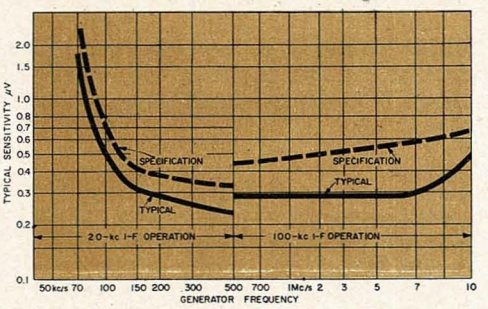
Catalog No.	*Description*	*Price*
1232-9701	**Type 1232-A Tuned Amplifier and Null Detector**	**$360.00**
0480-9638	**Type 480-P308 Relay-Rack Adaptor Set**	**7.00**

PATENT NOTICE. See Notes 4 and 15, page 11.

Type 1232-P1 RF MIXER

70 kc/s TO 10 Mc/s





Sensitivity (open-circuit voltage from 50-ohm source, equivalent to noise level).

This well-shielded rf mixer, with the TYPE 1232-A Null Detector and a local oscillator, becomes a sensitive heterodyne detector with a high degree of harmonic rejection. When the frequency of the local oscillator is swept, the combination can be used for approximate spectrum analysis with an oscilloscope. It can also be used as a sensitive level indicator in attenuation measurements. The circuit comprises a semiconductor diode, tuned i-f output transformer, crystal-current meter, and associated components. For complete detector assemblies, including local oscillator, see page 108.

SPECIFICATIONS

Frequency Range: 70 kc/s to 10 Mc/s. (Can be used up to 60 Mc/s, with care in the selection and identification of local-oscillator frequencies.) Recommended local oscillators for the 70-kc to 0.5-Mc and the 0.5- to 10-Mc ranges are TYPE 1210-C and TYPE 1211-C, respectively.

I-F Output Frequencies: Switch-selected, 20 kc/s or 100 kc/s.

Bandwidth: 0.8 kc/s in 20-kc position, 10 kc/s in 100-kc position with a 20-kΩ output load (TYPE 1232-P1 RF Mixer alone).

Sensitivity: See plot.

Input Impedance: Approximately 200 Ω.

Output Impedance: Approximately 20,000 Ω.

Dimensions: Diameter 2¼, length 6¾ in (58, 175 mm).

Net Weight: 1 lb (0.5 kg).

Shipping Weight: 3 lb (1.4 kg).

For a more detailed description, see *General Radio Experimenter*, December 1963.

Catalog No.	*Description*	*Price*
1232-9601	**Type 1232-P1 RF Mixer**	**$105.00**

Type 1240-A BRIDGE OSCILLATOR-DETECTOR

The TYPE 1232-A Tuned Amplifier and Null Detector and the TYPE 1311-A Audio Oscillator have been combined in a single, convenient unit for use with audio-frequency bridges and other null-balance devices. This assembly, the TYPE 1240-A Bridge Oscillator-Detector, occupies a minimum of bench space and is provided with removable panel extensions, which adapt it for rack mounting. The combination can also be easily disassembled so that component instruments can be used separately.

The oscillator supplies 11 fixed frequencies from 50 c/s to 10 kc/s. The detector is tunable continuously from 20 c/s to 20 kc/s, with additional spot frequencies of 50 kc/s and 100 kc/s.

SPECIFICATIONS

Power Required: Null detector, internal battery; oscillator, 105 to 125 or 210 to 250 V, 50 to 400 c/s, 22 W max.

Dimensions: Width 19, height 6, depth 7¾ in (485, 155, 200 mm), over-all, with panel extensions.

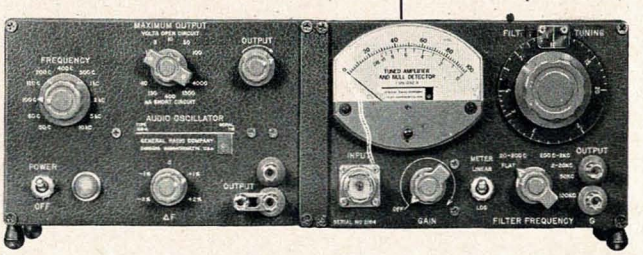
Net Weight: 13½ lb (6.5 kg).

Shipping Weight: 28 lb (13 kg).

Catalog No.	*Description*	*Price*
1240-9701	**Type 1240-A Bridge Oscillator-Detector**	**$590.00**

NEW

in catalog S



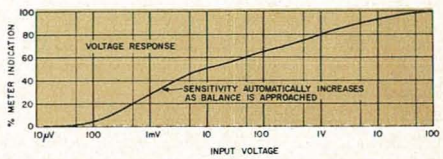
Type 1212-A UNIT NULL DETECTOR

FEATURES:

50 c/s to 5 Mc/s. ■ Quasi-logarithmic response.
On-scale range of approximately 120 dB.
Meter sensitivity control for setting of voltage range desired.
Sensitivity increases as balance is approached, thus increasing speed and precision.
Regulated tube voltages and balanced meter circuit maintain stability.

USES: This unit null detector is an inexpensive, broad-band balance indicator for ac bridge measurements from 50 c/s to 5 Mc/s. With the TYPE 1212-P3 RF Mixer and a local oscillator, its range can be extended to 60 Mc/s as a heterodyne detector. See TYPE DNT-7 Heterodyne Detector, page 109.

Meter indication vs input voltage.

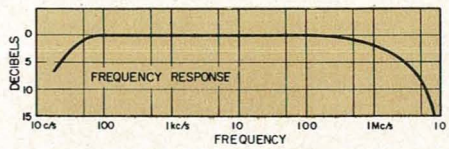


DESCRIPTION: The instrument consists of a three-stage, broadband amplifier with series-peaking compensation. Germanium-diode clippers are used between stages to obtain the quasi-logarithmic response. The output meter has a linear scale. Earphone terminals are provided.

SPECIFICATIONS

Frequency Response: See plot.
Sensitivity: Less than 40 μV at 1 kc/s for 1% of full scale.
Power Required: TYPE 1203-B (or 1203-BQ18) Unit Power Supply (see page 219).
Hum and Noise Level: Hum, 20 μV; broadband noise, 30 μV.

Frequency response characteristic.



Input Terminal: Locking GR874 Coaxial Connector.
Accessories Supplied: Power-supply plug.
Accessories Available: TYPES 1212-P1 and -P2 Filters, TYPE 1212-P3 RF Mixer (see below); TYPE 874 patch cords for input connection (page 85).

Mechanical Data: Unit-Instrument Cabinet *(see page 258)*

	Width		Height		Depth		Net Weight		Shipping Weight	
With Power Supply	in	mm	in	mm	in	mm	lb	kg	lb	kg
	15	385	5¾	150	6¼	160	9¾	4.5	13	6

Type 1212-P2 1-Mc FILTER

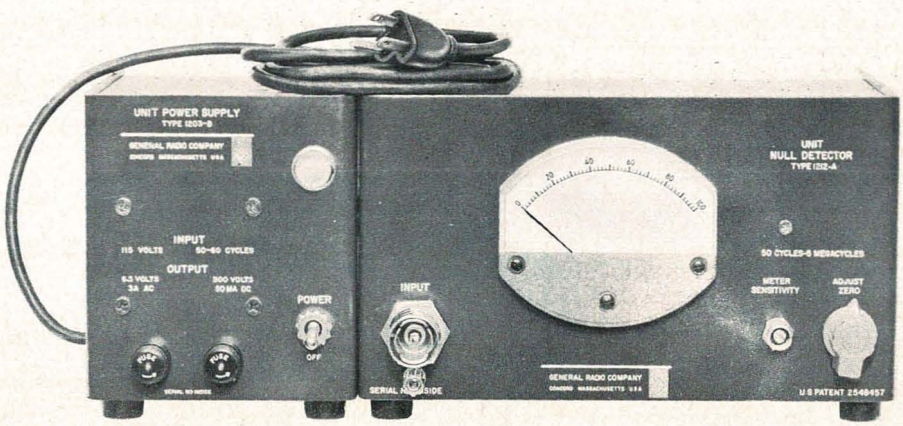
This shielded, tuned LC filter provides insertion gain at 1 Mc/s and attenuates higher and lower frequencies. Plugs into detector connector.
Insertion Gain: Between 22 dB and 32 dB at 1 Mc/s.
Second-Harmonic Rejection: At least 39 dB.
Maximum Input Voltage: 200 V.
Terminals: GR874 Coaxial Connector at each end.
Dimensions: Diameter 2, length 5 in (50, 130 mm).
Net Weight: 9 oz (0.3 kg). **Shipping Weight:** 1 lb (0.5 kg).

TYPE 1212-P1 HIGH-PASS FILTER

This shielded RC filter provides about 50-dB attenuation at 60 c/s. Plugs into detector input connector.
Nominal Load Impedance: 1 MΩ.
Input Voltage Limit: 150 V max.
Terminals: GR874 Coaxial Connector at each end.
Dimensions: Diameter ⅞, length 4¾ in (25, 110 mm).
Net Weight: 3 oz (0.1 kg).
Shipping Weight: 1 lb (0.5 kg).

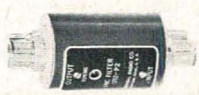
Catalog No.	*Description*	*Price*
1212-9701	**Type 1212-A Unit Null Detector**	**$195.00**
1203-9702	**Type 1203-B Unit Power Supply** (for 105- to 125-V supply)	**55.00**
1203-9818	**Type 1203-BQ18 Unit Power Supply** (for 210- to 250-V supply)	**on request**
1212-9601	**Type 1212-P1 High-Pass Filter**	**15.00**
1212-9602	**Type 1212-P2 1-Mc Filter**	**35.00**
0480-9986	**Type 480-P4U3 Relay-Rack Adaptor Set**	**12.00**

PATENT NOTICE. See Notes 4 and 15, page 11.



Type 1212-A Unit Null Detector with Type 1203-B Unit Power Supply

Type 1212-P1



Type 1212-P2

Type 1212-P3 RF MIXER

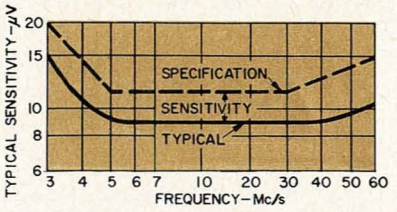
The TYPE 1212-P3 RF Mixer, which is similar to the TYPE 1232-P1, combines with the TYPE 1212-A Unit Null Detector to form a sensitive heterodyne null detector from 3 Mc/s to 60 Mc/s. For a complete detector assembly including local oscillator, see page 109.

This combination may also be used as a receiver or as an approximate spectrum analyzer and sensitive level indicator throughout its frequency range.

SPECIFICATIONS

Frequency Range: 3 Mc/s to 60 Mc/s. (Can be used up to 150 Mc/s if care is taken in the selection and identification of local-oscillator frequency.)

Sensitivity as a function of frequency.



Sensitivity: See plot.
I-F Output Frequency: 1 Mc/s.
Bandwidth: 25 kc/s with TYPE 1212-A Unit Null Detector.
Input Impedance: 200 Ω (approximately).
Output Impedance: 50 kΩ (approximately).
Terminals: GR874 Coaxial Connectors.
Dimensions: Diameter 2¼, length 6¾ in (58, 175 mm).
Net Weight: 1 lb (0.5 kg).
Shipping Weight: 2 lb (1 kg).

Catalog No.	*Description*	*Price*
1212-9603	**Type 1212-P3 RF Mixer**	**$105.00**

PATENT NOTICE. See Note 4, page 11.

Type 1216-A UNIT I-F AMPLIFIER

The basic element of the TYPES DNT-1, -2, -3, and -4 Detectors is the TYPE 1216-A Unit I-F Amplifier. It consists of four tuned i-f amplifier stages, a detector, a video amplifier stage, an accurate rf attenuator, and two power supplies. It is designed to operate from the output of the TYPE 874-MRL Mixer Rectifier.

The automatic volume control, which facilitates bridge balancing and other null-type measurements, can be switched out for voltage-level measurements.

A built-in, precision, step attenuator makes possible accurate measurements of relative signal levels. The meter is calibrated in dB, as well as in linear units, for convenient interpolation between the 10-dB attenuator steps.

Provision is made for measuring crystal-mixer current. One of the internal power supplies furnishes power for a heterodyning oscillator. See page 108 for complete detector assemblies.

Modulation on the input signal is available at the output terminals.

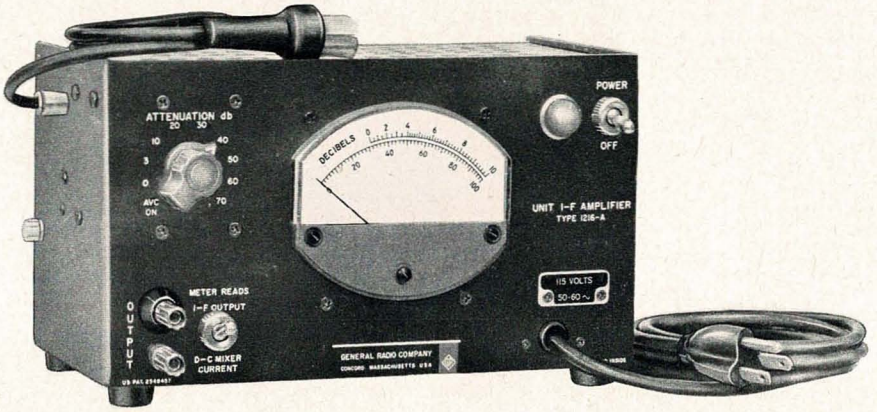
SPECIFICATIONS

Center Frequency: 30 Mc/s.
Bandwidth: >0.5 Mc/s at 3 dB down; 9.5 Mc/s at 60 dB down.
Sensitivity: From a 400-Ω source, 2-μV input for 1% deflection (above noise); 50-μV input for full-scale deflection. These are open-circuit source voltages.
Noise Figure: Approximately 5 dB.
Attenuator: 0 to 70 dB in 10-dB steps. **Accuracy:** ± (0.3 dB + 1%).
30-Mc Output-Circuit Bandwidth (Modulation): 0.4 Mc/s.
Output Impedance: 600 Ω.
Maximum Output Voltage: 2 V, open circuit.
Terminals: Input, GR874 Connector on 2-ft cable; output, ¾-in-spaced TYPE 938 Binding Posts.
Power Supply Output: 300 V, dc, at 30 mA; 6.3 V, ac, at 1 A.
Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s. Power input, 45 W at full load. Can also be operated at 400 c/s where line voltage does not drop below 110 (or 220) V.
Accessories Supplied: Spare fuses.
Mechanical Data: Unit-Instrument Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
10¼	260	5¾	150	6¼	160	8¼	3.8	10	4.6

Catalog No.	*Description*	*Price*
1216-9701	**Type 1216-A Unit I-F Amplifier**	**$375.00**
0480-9985	**Type 480-P4U2 Relay-Rack Adaptor Panel** (panel, 19 by 7 inches)	**11.00**

PATENT NOTICE. See Notes 4 and 15, page 11.



Type DNT HETERODYNE DETECTORS

Types DNT-1, -2, -3, AND -4 — 40 Mc/s TO 5 Gc/s

FEATURES: Wide frequency ranges. ■ High sensitivity. Excellent shielding. ■ AVC for null-detector use. Broad bandwidth with good selectivity. ■ Wide-range calibrated attenuator.

USES: This general-purpose, heterodyne detector is a high-sensitivity, high-frequency voltmeter for relative signal levels, a standing-wave indicator, and a null detector.

Its excellent shielding makes it suitable for low-level measurements in the presence of high-level external fields.

GAIN, LOSS, SIGNAL LEVEL

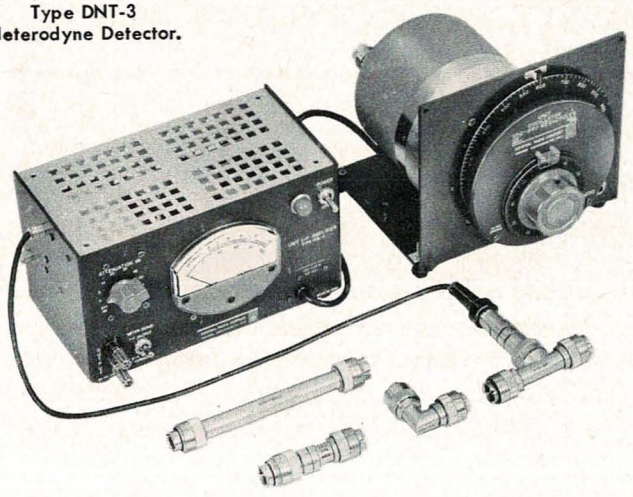
It can be used: to measure insertion loss and attenuation, crosstalk in multiterminal devices such as switches, and antenna gain and radiation patterns; as a field-strength indicator; and as a laboratory high-frequency receiver.

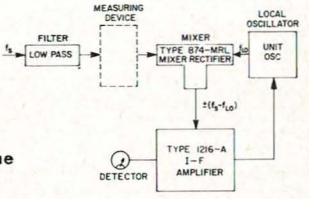
Signal levels can be measured over an 80-dB range, and, with the use of external TYPE 874-G20L Attenuators, 110 dB.

RF VOLTMETER

When standardized at one signal level in terms of a standard-signal generator, the TYPE DNT Detector can be used to measure rf voltage as low as 10 μV.

Type DNT-3 Heterodyne Detector.





Block diagram of the heterodyne detector.

DETECTOR

It is the recommended null detector for the TYPE 1602-B UHF Admittance Meter and the TYPE 1607-A Transfer-Function and Immittance Bridge.

As a standing-wave indicator with the TYPE 874-LBA and TYPE 900-LB Slotted Lines (VSWR > 1.05), it is particularly useful for measurements on nonlinear elements, where a high degree of harmonic rejection and small applied signal level are required.

DESCRIPTION: Each assembly comprises one TYPE 874-MRL Mixer Rectifier, one TYPE 1216-A Unit I-F Amplifier, one TYPE 874-G10L 10-dB Pad, one TYPE 874-EL-L 90° Ell, plus one unit oscillator and one filter, both depending on the frequency range desired (see price table). For maximum shielding, components are equipped with locking GR874 Coaxial Connectors, which can be used interchangeably with the non-locking type.

The frequency range can be extended through the use of oscillator harmonics, but sensitivity is decreased, and care must be taken to avoid ambiguous beats.

To cover wide frequency ranges, however, it is recommended that one complete DNT detector be ordered, plus the necessary oscillators and filters for the additional frequency ranges desired. For instance, for the range from 40 to 950 Mc/s, one would order a TYPE DNT-2 Detector, plus one TYPE 1209-C Unit Oscillator and one TYPE 874-F1000L Filter.

SPECIFICATIONS

Frequency Range: See sensitivity curves on page 103; also price table.

Sensitivity: Typically 5 μV; see curves on page 103.

Mixer: TYPE 874-MRL Mixer Rectifier (page 87).

Local Oscillator: See page 140 for specifications.

Input Terminal: Mixer input terminal is a locking GR874 Coaxial Connector. For connection to other coaxial types, see GR874 Coaxial Adaptors, page 81, and the TYPE 874-R22LA Patch Cord (page 85).

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 45 W.

Rack-Mount: Relay-rack adaptor panels are available for both oscillator and i-f amplifier. (See pages 107 and 143.)

Weights:	DNT-1, DNT-3	DNT-2	DNT-4
Net	16 lb (7.5 kg)	17 lb (8 kg)	24½ lb (11.5 kg)
Shipping	22 lb (10 kg)	23 lb (10.5 kg)	30 lb (14 kg)

Catalog Number		*Frequency Range — Mc/s*				*Local Oscillator Supplied*	*Filter Supplied*	*Price*
		Fundamental	*2nd Harmonic**	*3rd Harmonic**	*4th Harmonic**			
1235-9601	**Type DNT-1**	40†–530	100–1030	165–1530	230–2030	Type 1208-C	874-F500L	**$745.50**
1235-9602	**Type DNT-2**	40†–280	70–530	120–780	170–1030	Type 1215-C	874-F500L	**705.50**
1235-9603	**Type DNT-3**	220–950	470–1870	720–2790	970–3710	Type 1209-C	874-F1000L	**778.50**
1235-9604	**Type DNT-4**	870–2030	1770–4030	2670–6030	Not recommended	Type 1218-B	874-F2000L	**943.50**

* For harmonic operation, the appropriate low-pass filter must be used.

† 40 Mc/s is the practical low-frequency limit.

PATENT NOTICE. See Note 4, page 11.

Types DNT-5, -6, AND -7 — 70 kc/s TO 50 Mc/s

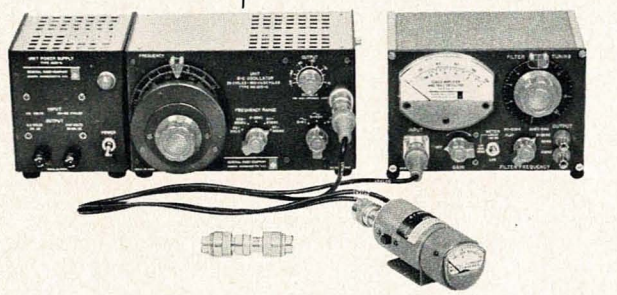
The TYPES DNT-5 and -6 Heterodyne Detectors use the TYPE 1232-A Tuned Amplifier and Null Detector as the i-f amplifier — TYPE DNT-5 at 20 kc/s and TYPE DNT-6 at 100 kc/s. TYPE DNT-7 uses the TYPE 1212-A Unit Null Detector. All three are well shielded from external fields and are suitable for low-level measurements.

They are excellent detectors for the TYPE 1606-A and TYPE 916-AL RF Bridges. With the addition of an external calibrated attenuator, such as the TYPE 874-GA (page 88), a substitution method can be used in the several voltage-level measurements listed under DNT-1 to DNT-4 on the preceding page. Sensitivity curves appear on page 103. For detailed specifications, see the listing of the various components, as indicated.

Type DNT-5 HETERODYNE DETECTOR

70 TO 500 kc/s

NEW in catalog S



Complete heterodyne detector consists of:	Page
1 TYPE 1232-A Tuned Amplifier and Null Detector	104
1 TYPE 1210-C Unit R-C Oscillator	134
1 TYPE 1203 Unit Power Supply	219
1 TYPE 1232-P1 RF Mixer	105
1 TYPE 874-G10L Fixed Attenuator	88

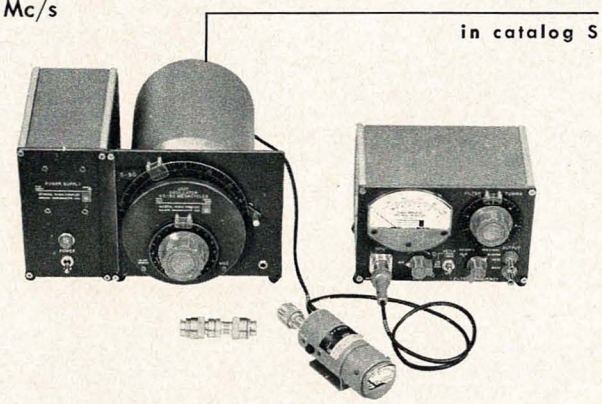
Net Weight: 17½ lb (8 kg). **Shipping Weight:** 24 lb (11 kg).

Catalog No.	*Description*	*Price*
1235-9605	**Type DNT-5 Heterodyne Detector,** for 105-to-125-volt supply	**$737.00**
1235-9795	**Type DNT-5Q18 Heterodyne Detector,** for 195-to-250-volt supply	**on request**

Type DNT-6 HETERODYNE DETECTOR

500 kc/s TO 10 Mc/s

NEW in catalog S



Complete heterodyne detector consists of:	Page
1 TYPE 1232-A Tuned Amplifier and Null Detector	104
1 TYPE 1211-C Unit Oscillator	140
1 TYPE 1269-A Unit Power Supply	219
1 TYPE 1232-P1 RF Mixer	105
1 TYPE 874-G10L Fixed Attenuator	88

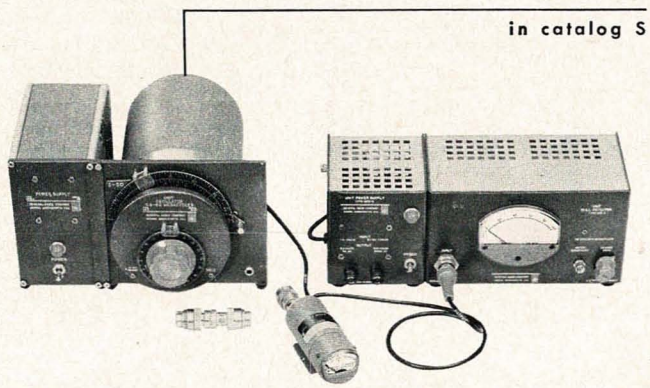
Net Weight: 24½ lb (11.5 kg). **Shipping Weight:** 33 lb (15 kg).

Catalog No.	*Description*	*Price*
1235-9606	**Type DNT-6 Heterodyne Detector,** for 105-to-125-, 195-to-235-, or 210-to-250-volt supply	**$912.00**

Type DNT-7 HETERODYNE DETECTOR

3 TO 50 Mc/s

NEW in catalog S



Complete heterodyne detector consists of:	Page
1 TYPE 1212-A Unit Null Detector	106
1 TYPE 1212-P3 RF Mixer	107
1 TYPE 1211-C Unit Oscillator	140
1 TYPE 1269-A Unit Power Supply	219
1 TYPE 1203 Unit Power Supply	219
1 TYPE 874-G10L Fixed Attenuator	88

Net Weight: 28½ lb (13 kg). **Shipping Weight:** 39 lb (18 kg).

Catalog No.	*Description*	*Price*
1235-9607	**Type DNT-7 Heterodyne Detector,** for 105-to-125-volt line	**$802.00**
1235-9797	**Type DNT-7Q18 Heterodyne Detector,** for 195-to-250-volt supply	**on request**

PATENT NOTICE. See Notes 4 and 15, page 11.

FREQUENCY STANDARDS

Time is one of the three fundamental physical dimensions. Since frequency is specified in terms of events per unit time (cycles per second, or Hertz), the production of an accurate frequency is directly related to the establishment of an exact time interval.[1] Although formerly determined by astronomical observations, exact time intervals are now derived from the atomic frequency standard. International agreement has defined the second as 9,192,631,770 cycles of the resonance-frequency transition of the cesium atom under zero-field conditions. This uniform time scale is called Atomic Time (A-1). By definition, this is the fraction 1/31,556,925,975 of the tropical year 1900. This definition relates time in the atomic scale to the previous most nearly constant time scale, Ephemeris Time, which is based on the orbital period of the earth about the sun (the time between vernal equinoxes). For everyday living, Solar Time, also known as Universal Time (UT-2) or Greenwich Mean Time, which is based on the mean rotational period of the earth, must be used. For example, for navigation and the tracking of artificial satellites with the earth used as a platform, a precise knowledge of the earth's average rotational period is required. Solar time is now defined in terms of atomic time, the rate being for the years 1965–1966 150×10^{-10} lower than A-1 time.

Standard frequencies and time intervals for measurement purposes are usually derived from a secondary frequency standard, such as the quartz-crystal oscillator, which is periodically calibrated in terms of a primary standard by means of standard-frequency or standard-time radio transmissions. Depending upon the accuracy required, local frequency can be established by either frequency or time measurement. All standard frequency and time transmissions in the United States are on the UT-2 time scale except for WWVB on 60 kc/s, which is on the A-1 scale.

Atomic clocks establish a perfectly uniform time. By international agreement, the time intervals broadcast are related to this uniform atomic time with step corrections not exceeding 100 milliseconds to agree with astronomical observations of the earth's rotation. Astronomical time observations are carried out by national observatories throughout the world. Their measurements are made available to users by radio time-signal transmissions and by telegraph in their respective countries. In the United States, the U. S. Naval Radio Observatory transmits radio time signals through the facilities of the U. S. Naval Radio Service. Standard time signals monitored by the Naval Observatory are also broadcast continuously by the standard-frequency transmitters of WWV, operated by the National Bureau of Standards. In Canada, a similar service, broadcast by CHU, is provided by the Dominion Observatory.

The user of a frequency standard equipped with means for measurement of the time of arrival of a radio time signal can then calibrate the standard directly in terms of time. For a precise calibration, the errors of the transmitted time signal must be taken into account. Correction data for this purpose may be obtained from the Superintendent, U. S. Naval Observatory, Washington 25, D. C.

Calibration accuracy using a standard-time transmission depends upon the characteristics of the transmitted signal and of the propagation path. The variations in the time of reception of a high-frequency sky-wave signal from such stations as WWV or CHU are seldom less than 100 microseconds, due to propagation path variations. A low-frequency signal, known to be propagated via a ground-wave, will have variations of less than 2 microseconds over a 1500-mile path.[2]

CALIBRATION METHODS

The basic methods of intercomparing the frequencies of two sources are the same whether the primary standard is local or remote. The techniques employed will differ because of the propagation characteristics of radio transmissions and noise on the radio signal, which do not exist with local calibration. The principal techniques are: zero-beat — direct phase comparison; direct time comparison; frequency difference measurement — usually digital.

A. ZERO-BEAT TECHNIQUES

The basic method for frequency intercomparison is a direct comparison of the phase difference of two signals nearly equal in frequency. If not nearly equal, they must be nearly harmonically related. A change in relative phase between two signals may be determined by measurement of their beat frequency, by observation of a Lissajous figure on an oscilloscope, or by measurement with a voltmeter of their common amplitude.

The precision of the zero-beat method is limited by the ability to detect the zero-beat condition. Suppose, for example, one has a "zero-beat" detector capable of 1-cycle resolution and it is desired to set two standard frequencies equal to one another as closely as possible. If the two frequencies are 1 Mc/s, then the error will be 1 ppm. Greater resolution can only be attained by multiplication of the two frequencies or by increased resolution of the zero-beat detector. As a practical example of the zero-beat technique, consider the comparison of the 5-Mc carrier of WWV against a local 5-Mc signal. By use of either the receiver S meter or the beat-frequency oscillator, about 1-cycle resolution is available, and the local standard can be set to about 1 part in 10^7.

VLF phase-tracking receivers take advantage of the more stable propagation characteristics of VLF transmissions.[3] Because the frequency is low, a very high degree of phase resolution is required. VLF trackers are capable of resolving 1 beat in about 5 days; this would be about 1×10^{-10} per day on 20 kc/s. If a very narrow bandwidth is used, a phase tracker can extract the desired data under very adverse signal-to-noise ratio conditions.

B. DIRECT TIME INTERCOMPARISON.

Frequency may be established to a high degree of precision by direct comparison of time intervals derived from the frequency to be calibrated and from the standard. The time interval compared is usually one second, derived from the standard to be calibrated by a precision electronic clock such as the GR Type 1123-A Digital Syncronometer. An example of this method is the comparison of locally produced one-second pulses with the one-second timing pulses transmitted by Radio Station WWV. There are two distinct advantages of this method of comparison over others: (1) Individual measurements do not have to have great accuracy since the accuracy

[1] F. D. Lewis, "Frequency and Time Standards," *Proceedings of the IRE*, September 1955, pp 1046–1069.
[2] Doherty, R. N. et al, "Timing Potentials of Loran-C," *Proceedings of the IRE*, November 1961, p 1659.
[3] Pierce, J. A. "The Diurnal Carrier Phase Variation of a 16-kilocycle Transatlantic Signal," *Proceedings of the IRE*, May 1955, p 584.

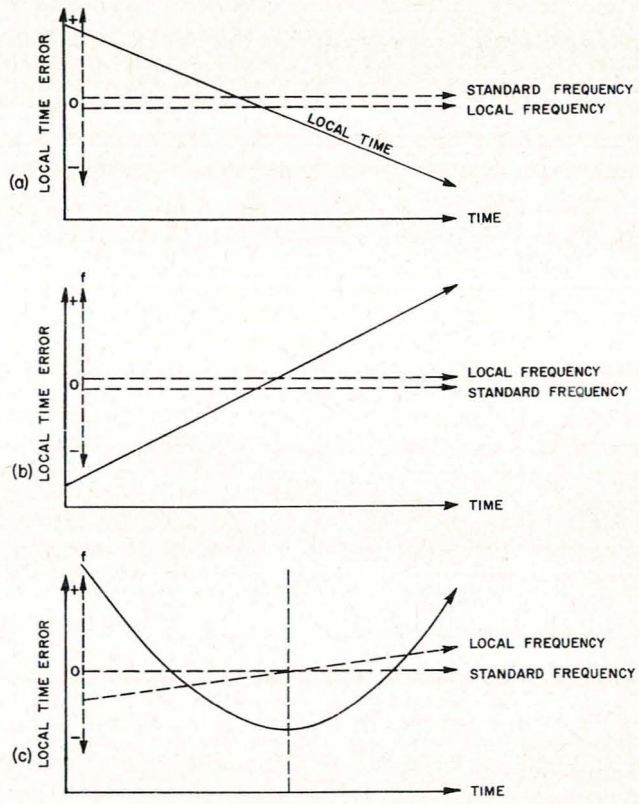


Figure 1.

is increased by taking longer and longer time intervals between measurements. (2) The measurement results in an accurately set local clock. Local time is known to the extent that the propagation time of the radio signal is known.

The basic principle of the measurement lies in the integrating character of the clock. If the frequency driving the clock is low, the time between successive zero crossings of the driving frequency is a little longer than standard, and at each cycle the clock will lose a fixed increment of time. Obviously, the longer the measurement interval, the larger the time error (Figure 1a). The case of a clock driven by too high a frequency is shown in Figure 1b; the clock steadily gains time with respect to standard time.

The assumption of an absolutely constant frequency with a fixed error with respect to the primary standard leading to a linear change in local time is not the situation usually encountered in practice. The local standard will generally have some drift, which will cause the time error to depart from linear as shown in Figure 1. If the drift in frequency is constant with time, for example $f = (f_o + kt)$, and the initial frequency setting, f_o, is low, it is obvious that at some future instant of time f will become equal to the standard frequency, and the time intervals will be precisely correct. The curves of time error are now parabolic. Figure 1c shows the shape of time error when the local frequency has a positive drift.

As an example of the use of this method of frequency calibration, assume that in your locality WWV can be received with a reproducibility of one millisecond. (This figure must be established by experiment.) Then, in a one day interval, a change in the local frequency of $10^{-3}/86{,}400$ or approximately $1{:}10^8$ can be established.

This method of calibration is limited in accuracy only by one's ability to establish time simultaneity in the measurement. If the local time is, for example, marked by a brief pulse like that produced by a Type 1123-A Digital Syncronometer and a cycle of a burst from a Loran C transmitter can be observed, then time can be compared to a fraction of a microsecond,[4] and the local frequency can be established to within a few parts in 10^{10} in a time interval of only a few minutes (Figure 2).

C. DIGITAL FREQUENCY MEASUREMENT

The introduction to the section on frequency meters describes the application of digital frequency meters to frequency measurement problems in general. Counters can obviously be used for precision frequency intercomparison. The accuracy is limited only by the maximum counting time from one source and the maximum counting rate of the counter. Thus, a 10-Mc counter such as the General Radio Type 1153-A with its ten-second time base controlled by the standard can be used to calibrate another frequency source at 10 Mc/s to an accuracy of $1{:}10^8$. The counter is particularly convenient when the oscillator to be calibrated is not harmonically related to the standard frequency.

THE STANDARD-FREQUENCY LABORATORY

Figure 3 shows equipment that might be encountered in a typical Frequency Standard Laboratory. The requirements of any specific application will dictate how elaborate the system must be. If time information is not required, a master oscillator combined with a VLF Phase Tracker to monitor its performance may suffice as reference frequency source. Alternatively, one can use time signals to monitor the oscillator performance. A cesium beam (primary) standard can be used to check the frequency of a master oscillator but does not provide time calibration, and reference to time signals is still required. In the system shown in Figure 3, the master oscillator is monitored against WWVB by a phase tracker and provides exact reference frequencies while the two other (working standard) oscillators are offset by -150×10^{-10} to provide time signals on the UT-2 scale. A

[4] D. O. Fisher and R. W. Frank, "A New Approach to Precision Time Measurements," *General Radio Experimenter*, February-March 1965.

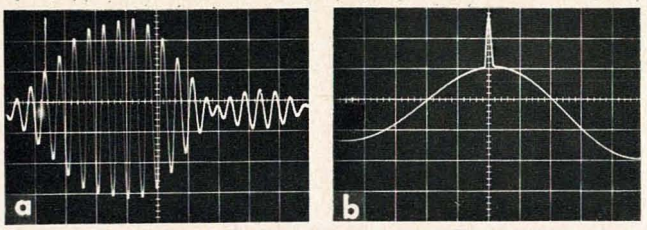


Figure 2. Time comparison of marker pulse and Loran-C 100-kc pulses. a. Sweep rate 20 μs/cm. (Note marker pulse on third cycle.) b. Sweep rate 1 μs/cm, pulse centered.

frequency-intercomparison system permits the working standards to be compared with the reference and plots continuous records of their stability.

Multipliers, dividers, and synthesizers make other frequencies available for distribution for calibration and test purposes. These frequencies can be derived either from the master oscillator on the exact frequencies or from the working standards with -150×10^{-10} offset. Distribution amplifiers provide isolation between the various users.

The frequency comparison system can consist of a 10-Mc counter using the master oscillator as time base. If the other oscillators are measured at 5 Mc/s, a 1000-second gate time in the counter will provide $\pm 2 \times 10^{-10}$ resolution. Higher resolution requires the use of multipliers or error-multipliers. Multiplication to 100 Mc/s and the use of a 100-Mc counter provides a resolution of $\pm 1 \times 10^{-11}$ for a 1000-second count. Error-multipliers can increase the basic resolution up to 1000 times and do not require a 100-Mc counter. In either case, the digital data from the counter can be printed in numerical form or a digital-analog converter can be used for continuous strip-chart recording. The same frequency intercomparison system can also be used to measure the frequencies of oscillators in other locations if the signals are fed through the distribution lines to the frequency standard equipment.

Listed in this section of the catalog are complete frequency and time standards, as well as their component instruments. They include a standard-frequency oscillator of high spectral purity, a frequency divider, and a digital time comparator of high precision with all-solid state circuitry, plus two frequency multipliers, which operate on the locked-oscillator principle.

FREQUENCY SYNTHESIZERS

A new class of instrument, the frequency synthesizer, is both a frequency standard and a variable-frequency signal source. All output frequencies are synthesized coherently from a single-frequency source, usually a quartz crystal oscillator. In General Radio synthesizers, the output frequency is adjustable in decade steps, plus a continuous control. Modular construction permits synthesizers to be assembled with any desired resolution from 3 to 9 significant figures.

GR synthesizers use a room-temperature quartz-crystal oscillator as the standard source, which can be locked to an external standard, such as the Type 1115-B Standard-Frequency Oscillator, when extreme stability is required. See page 155. FREQUENCY METERS, both digital and analog, are listed on pages 119 to 127.

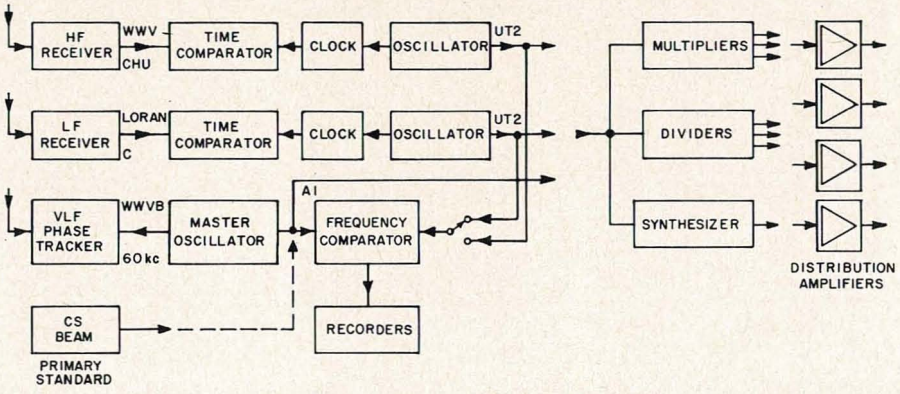


Figure 3.

Type 1121 FREQUENCY AND TIME STANDARDS

FEATURES:

- Excellent long-term and instantaneous stabilities.
- High spectral purity.
- Reliability — 24-hour emergency batteries in crystal oscillator and SYNCRONOMETER® time comparator.
- Wide range of output frequencies — up to 1000 Mc/s.

These frequency standards will supply standard frequencies for both laboratory measurements and production testing; for standardizing digital counters (either as a source for routine accuracy checks or directly as a counter time base); for measuring received signals in conjunction with frequency meters and other comparison equipment; and for the measurement and standardization of time.

The TYPE 1121 Frequency and Time Standards are combinations of the TYPE 1115-B Standard-Frequency Oscillator, the TYPE 1123-A Digital SYNCRONOMETER® time comparator and auxiliary equipment, completely assembled in floor-type relay racks with all interconnecting cables. Blank panels are included to fill unused space in the rack. The component instruments are described on pages 114-118.

Each standard is thoroughly tested as an operating system before shipment.

The TYPE 1115-B Standard-Frequency Oscillator operates at 5 Mc/s, uses a fifth-overtone-mode quartz crystal, and furnishes output frequencies of 5 Mc/s, 1 Mc/s, and 100 kc/s.

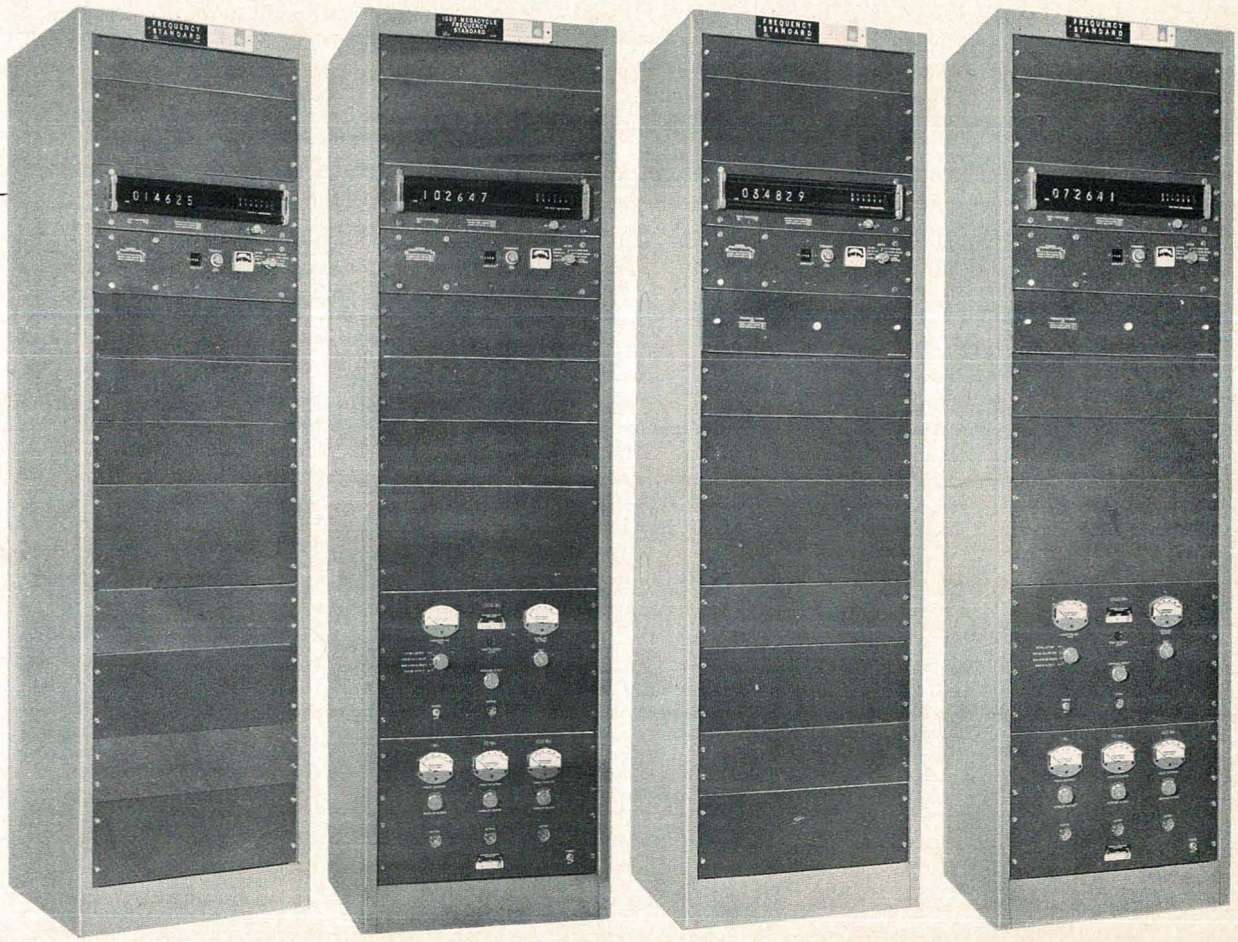
The TYPE 1123-A Digital SYNCRONOMETER time comparator integrates the oscillator frequency to produce precise time-of-day information, permits accurate comparison between the frequency standard and standard-time radio transmissions, and generates timing pulses at 100, 10, and 1 kc/s, 100, 10, 1, and 0.1 c/s.

In the TYPE 1121-AH model, frequencies of 10, 100, and 1000 Mc/s are produced in low-noise phase-locked-oscillator frequency-multiplier units for uhf and microwave applications. The vhf and uhf signals are essentially free from submultiple output frequencies. The spectral purity of the multiplier output frequencies is determined by the fm noise generated in the multipliers (see specification for TYPE 1112 Standard-Frequency Multiplier, page 118). The spectrum of the 5-Mc output of the crystal oscillator is unaffected by the presence of the multipliers.

The TYPE 1121-AL produces low-frequency sine waves of 10 and 1 kc/s, 400, 100, and 60 c/s, and 10-kc square waves from the TYPE 1114-A Frequency Divider.

The TYPE 1121-AHL includes all the items of the -AH and -AL models, and its output frequencies extend from 60 c/s to 1000 Mc/s.

TYPE 1121-A | TYPE 1121-AH | TYPE 1121-AL | TYPE 1121-AHL



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Type 1121-A FREQUENCY AND TIME STANDARD

Components:
- TYPE 1115-B Standard-Frequency Oscillator
- TYPE 1123-A Digital SYNCRONOMETER® time comparator
- Floor-type relay rack
- Blank panels to fill rack
- Connection cables

Output Frequencies: Sine waves, 5, 1 Mc/s, 100 kc/s, plus timing pulses of 100, 10, 1 kc/s, 100, 10, 1, and 0.1 c/s.

Power Required: 40 W at 90 to 130 or 180 to 260 V, 40 to 2000 c/s, or 24 to 32 V dc. Internal nickel-cadmium batteries provide at least 24-hour emergency operation.

Net Weight: 170 lb (78 kg).

Shipping Weight: 350 lb (161 kg).

Type 1121-AH 1000-Mc FREQUENCY AND TIME STANDARD

Components:
- TYPE 1115-B Standard-Frequency Oscillator
- TYPE 1123-A Digital SYNCRONOMETER® time comparator
- TYPE 1112-A Standard-Frequency Multiplier
- TYPE 1112-B Standard-Frequency Multiplier
- Floor-type relay rack
- Blank panels to fill rack
- Connection cables

Output Frequencies: Sine waves, 1000, 100, 10, 5, 1 Mc/s, 100 kc/s, plus timing pulse of 100, 10, 1 kc/s, 100, 10, 1, and 0.1 c/s.

Power Required: Frequency multipliers 235 W, max, at 105 to 125 or 210 to 250 V, 50 to 60 c/s. Standard-frequency oscillator and SYNCRONOMETER 40 W at 90 to 130 or 180 to 260 V, 40 to 2000 c/s, or 24 to 32 V dc. Internal nickel-cadmium batteries provide at least 24-hour emergency operation for standard-frequency oscillator and time comparator.

Net Weight: 220 lb (102 kg).

Shipping Weight: 400 lb (184 kg).

Type 1121-AL FREQUENCY AND TIME STANDARD

Components:
- TYPE 1115-B Standard-Frequency Oscillator
- TYPE 1123-A Digital SYNCRONOMETER® time comparator
- TYPE 1114-A Frequency Divider*
- TYPE 1114-P6, -P7 Plug-In Units
- Floor-type relay rack
- Blank panels to fill rack
- Connection cables

* The TYPE 1114-P1 and TYPE 1114-P2 Plug-In Units are not included.

Output Frequencies: Sine waves, 5, 1 Mc/s, 100, 10, 1 kc/s, 100, 400, 60 c/s. Timing pulses of 100, 10, 1 kc/s, 100, 10, 1, and 0.1 c/s.

Power Required: Standard-frequency oscillator and SYNCRONOMETER, 40 W at 90 to 130 or 180 to 260 V, 40 to 2000 c/s, or 24 to 32 V dc; frequency divider, 7 W, max, at 105 to 125 or 210 to 250 V, 50 to 400 c/s. Internal nickel-cadmium batteries provide at least 24-hour emergency operation for standard-frequency oscillator and time comparator.

Net Weight: 190 lb (87 kg).

Shipping Weight: 360 lb (166 kg).

Type 1121-AHL 1000-Mc FREQUENCY AND TIME STANDARD

Components:
- TYPE 1115-B Standard-Frequency Oscillator
- TYPE 1123-A Digital SYNCRONOMETER® time comparator
- TYPE 1112-A Standard-Frequency Multiplier
- TYPE 1112-B Standard-Frequency Multiplier
- TYPE 1114-A Frequency Divider*
- TYPE 1114-P6, -P7 Plug-In Units
- Floor-type relay rack
- Blank panels to fill rack
- Connection cables

* The TYPE 1114-P1 and TYPE 1114-P2 Plug-In Units are not included.

Output Frequencies: Sine waves, 1000, 100, 10, 1 Mc/s, 100, 10, 1 kc/s, 100, 400, 60 c/s, and 10-kc square waves. Timing pulses of 100, 10, 1 kc/s, 100, 10, 1, and 0.1 c/s.

Power Required: Standard-frequency oscillator and SYNCRONOMETER 40 W at 90 to 130 or 180 to 260 V, 40 to 2000 c/s, or 24 to 32 V dc, frequency multipliers, 235 W, max, at 105 to 125 or 210 to 250 V, 50 to 60 c/s; frequency divider, 7 W, max, at 105 to 125 or 210 to 250 V, 50 to 400 c/s. Internal nickel-cadmium batteries provide at least 24-hour emergency operation for standard-frequency oscillator and time comparator.

Net Weight: 230 lb (106 kg).

Shipping Weight: 410 lb (189 kg).

OTHER COMBINATIONS CAN BE SUPPLIED. SEND US YOUR REQUIREMENTS.

Catalog Number	*Description*	*Price*
1121-9701	**Type 1121-A Frequency and Time Standard**	**$5295.00**
1121-9817	**Type 1121-AH 1000-Mc Frequency and Time Standard**	**8110.00**
1121-9831	**Type 1121-AL Frequency and Time Standard**	**6300.00**
1121-9553	**Type 1121-AHL 1000-Mc Frequency and Time Standard**	**9115.00**

PATENT NOTICE. See Note 4, page 11.

Type 1115-B STANDARD-FREQUENCY OSCILLATOR

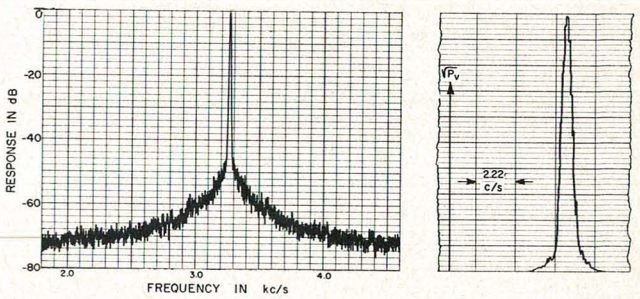
FEATURES:

Exceptional short-term stability, approaching the theoretical maximum.
Very high spectral purity.
35-hour emergency power supply — internal nickel-cadmium battery.
External supply can be either ac or dc.
Proportional-control oven. ■ All-solid-state circuitry.
Output frequencies of 5 Mc/s, 1 Mc/s, and 100 kc/s.
Meets MIL E16400D specification for vibration and MIL-I-26600 for RFI.
Voltage control of frequency permits use in phase-locked systems.

USES: This highly stable piezoelectric oscillator is suitable for exacting scientific and military uses — in both laboratories and manufacturing plants and on shipboard — wherever a rugged, high stability standard of frequency is required.

Exceptional spectral purity of the 5-Mc output permits multiplication to microwave frequencies for such applications as microwave spectroscopy and coherent-phase radar. Typical noise pedestal at X band is -80 dB per $\sqrt{c/s}$.

When combined with the TYPE 1123-A Digital SYNCRONOMETER (as in the TYPE 1121 Frequency Standards), this oscillator becomes a highly accurate time standard, which can be precisely compared with, and transferred to, other clocks, either remote or local.



(Left) X-band power spectrum of two Type 1115-B Standard-Frequency Oscillators. Analyzer bandwidth is 10 c/s. *(Right)* Center portion of spectrum measured with 0.54-cycle bandwidth. Vertical scale is linear ($\sqrt{\text{power}}$).

DESCRIPTION: The quartz crystal is a 5-Mc, 5th-overtone gettered unit. It is mounted in a single stage, proportional-control oven, which also contains the oscillator and AGC circuits. Power consumption of the oven is about 0.6 watt at 25°C ambient. This low power consumption is an important advantage when operation from the internal battery is necessary.

The frequency of the oscillator is adjusted by a panel control, direct reading in parts in 10^{10}, to allow correction of crystal aging.

Plug-in circuit boards provide easy access to the components.

A nickel-cadmium, 4-ampere-hour battery is floated across the dc supply. The cells are of the pressure-relief type and cannot explode. In the event of power-line failure, operation for at least 35 hours is ensured at room temperature and over 24 hours at 0°C. An external dc supply of 22 to 35 volts can also be used. If ac power, external dc, and internal battery are connected, the power will be drawn from the source that provides the highest voltage to the regulator circuit. The change-over is made by diodes and is completely continuous.

The battery is recharged by a current-limited voltage source, which maintains the battery at optimum charge conditions. The float, or trickle-charge, voltage is temperature compensated to correct for changes in the emf of the battery over the full temperature range.

SPECIFICATIONS

Output: 5 and 1 Mc/s, 100 kc/s; 1 V, rms, +50 −10% into 50 Ω at each frequency.

Frequency Adjustment: 2700×10^{-10} (1×10^{-10} per dial division).

External Frequency Control: Dc voltage from +0.5 to +12 V can be applied. Range is at least 5×10^{-7}, total.

Frequency Stability:

Temperature Effects: $< \pm 1 \times 10^{-11}$ per degree C between 0°C and 50°C.

Loading of Output: $< \pm 2 \times 10^{-11}$ open circuit to short circuit.

Supply Voltage: $< \pm 1 \times 10^{-11}$ for ±10% ac line-voltage changes.
$< \pm 2 \times 10^{-11}$ for 22 to 35 V, external dc.

Aging: $< 5 \times 10^{-10}$ per day after 30 days of operation;
$< 1 \times 10^{-10}$ per day is typical after 1 year.

Short-Term Stability (5 Mc/s): Standard Deviation (sigma) is less than stated below (95% confidence):

Averaging Time	*Frequency Deviation (Sigma)*	*Phase Deviation (Radians)*
300 μs	100×10^{-11}	1×10^{-5}
1 ms	50×10^{-11}	1.5×10^{-5}
10 ms	10×10^{-11}	3×10^{-5}
100 ms	1.5×10^{-11}	4.5×10^{-5}
1 s	1×10^{-11}	3×10^{-4}
10 s	1×10^{-11}	3×10^{-3}

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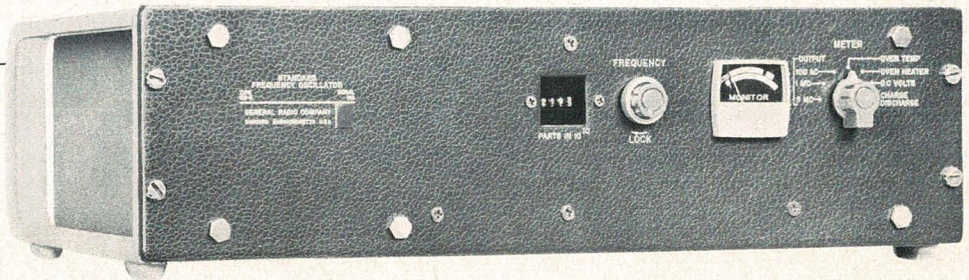


Spectral Purity: Line width of 5-Mc output multiplied by 2000 times (10 Gc/s or X band) is less than 0.25 c/s.

Noise Pedestal: Less than -145 dB per $\sqrt{c/s}$ at 5 Mc/s.

Power Required (ac or dc):

Ac: 90 to 130 or 180 to 260 V, 40 to 2000 c/s, 8 W at 115 V.

Dc: 22 to 35 V, 4 W at 24 V.

Emergency Power: Internal battery provides 24- to 35-hour operation depending on ambient temperature.

Terminals: Locking GR874, 5 Mc/s, 1 Mc/s, 100 kc/s; type BNC, 1 Mc/s and 100 kc/s for connection to TYPE 1123-A Digital SYNCRONOMETER.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	6	155	14½	370	35	16	52	24
Rack	19	485	5¼	135	14½*	370	35	16	52	24

* Behind panel.

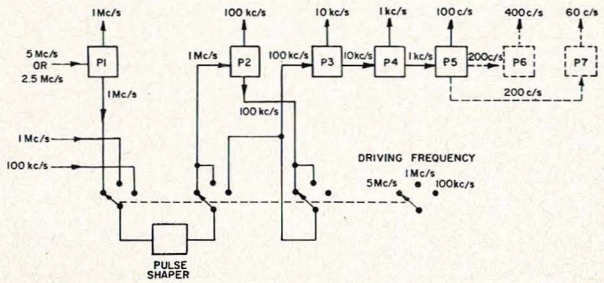
See also *General Radio Experimenter*, June 1964.

Catalog Number	*Description*	*Price*
1115-9802	**Type 1115-B Standard-Frequency Oscillator,** Bench Mount	**$2050.00**
1115-9812	**Type 1115-B Standard-Frequency Oscillator,** Rack Mount	**2050.00**

Type 1114-A FREQUENCY DIVIDER

FEATURES: Wide range of output frequencies. Fail-safe operation. ■ Very low jitter.

The frequency divider operates from the 5-Mc output of the standard-frequency oscillator to produce output frequencies of 1 Mc/s, 100 kc/s, 10 kc/s, 1 kc/s and 100 c/s; optionally, outputs of 400 c/s and 60 c/s are available. The 5-Mc to 1-Mc divider is a regenerative type; all others are switching types. *All circuits are fail-safe. There is no output when the input signal is absent.* Output is sine wave, with additional square waves at 10 kc/s and 100 kc/s. All divider units are plug-in modules.



SPECIFICATIONS

Input: 5 Mc/s, 1 Mc/s, 100 kc/s, 50 Ω, 1 V ± 50%.

Output (with 5-Mc input):

Sine Waves — 1 Mc/s, 100 kc/s: 1 V $\begin{Bmatrix}+50\%\\-10\%\end{Bmatrix}$ into 50 Ω

10 kc/s, 1 kc/s, 100 c/s: 1 V $\begin{Bmatrix}+50\%\\-10\%\end{Bmatrix}$ into 600 Ω

*400 c/s, *60 c/s: 1 V $\begin{Bmatrix}+50\%\\-10\%\end{Bmatrix}$ into 600 Ω

* Optional accessories.

Square Waves — 100 kc/s, 10 kc/s: Approximately 7 V, p-to-p, open circuit

Spurious Signals: Better than 34 dB down.

Jitter: <0.5 ns for 100-cycle output with respect to 5-Mc input.

Optional Frequencies: 400 c/s; 60 c/s. See below.

Power Required: 105 to 130 or 210 to 260 V, 50 to 400 c/s; approximately 7 W.

Mechanical Data: Rack-bench Cabinet (*see page 258*)

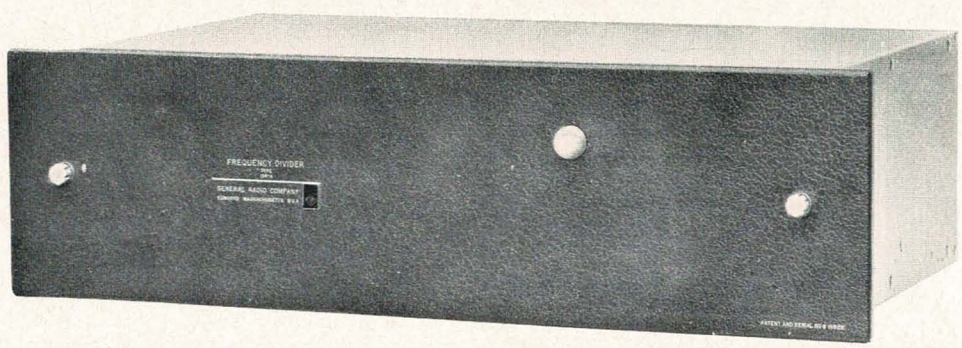
Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	5¼	135	11½	295	15	7	22	10
Rack	19	485	5¼	135	11*	280	15	7	22	10

* Behind panel.

See also *General Radio Experimenter*, April 1961.

Catalog Number	*Description*	*Price*
1114-9801	**Type 1114-A Frequency Divider,** Bench Model	**$950.00**
1114-9811	**Type 1114-A Frequency Divider,** Rack Model	**950.00**
1114-9606	**Type 1114-P6 400-cycle Plug-in Unit**	**115.00**
1114-9607	**Type 1114-P7 60-cycle Plug-in Unit**	**130.00**

PATENT NOTICE. See Notes 1 and 4, page 11.



Type 1123-A DIGITAL SYNCRONOMETER

PRECISION, SOLID-STATE, DIGITAL CLOCK

FEATURES:

All-solid-state logic circuitry — no moving parts.
Internal nickel-cadmium battery for approximately 24-hour emergency operation.
Bright, 6-digit indication of hours/minutes/seconds.
Any digit can be changed manually without disturbance to timing.
Time comparisons to 20 ns.
Manual start, fail-safe, regenerative circuits stop clock if input fails for even one cycle.
BCD 1-2-4-2 (1-2-4-8 optional at extra cost) output data — 10-μs resolution.
Low-jitter, standard, timing pulses at 100, 10, and 1 kc/s, 100, 10, 1, and 0.1 c/s.

USES: The TYPE 1123-A Digital SYNCRONOMETER® time comparator is a solid-state digital clock for the calibration of frequency and time standards. It provides precise time-of-day information, both visually and in BCD (1-2-4-2) form, and permits accurate comparisons between local standards and the transmission of standard time (WWV, Loran C, etc.). The clock can compare its own time with standard time without disturbance of its internal time. Clock's internal time can be automatically synchronized (within 10 μs) to standard time.

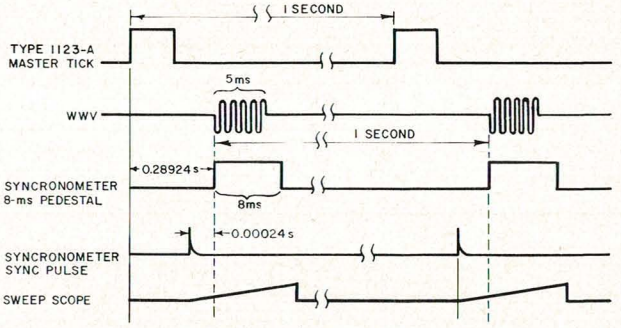
Any number of clocks can be started simultaneously from one location — remote clocks can be started from and synchronized to a local clock (without interruption of local clock). Time can be transferred from one location to another. One sets the clock at the master station and actually carries the standard time to remote locations.

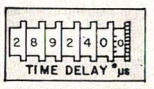
DESCRIPTION: (see diagram on page 117)

Circuit functions in the SYNCRONOMETER may be divided into four general parts: starting, timekeeping, synchronizing, and readout.

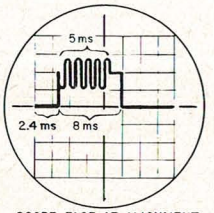
Starting is accomplished either by a front-panel push-button or by a pulse (from an external source or another SYNCRONOMETER). With either method any number of clocks can be started simultaneously, and remote units can be started in synchronism with an operating master clock, without disturbance of the master time indication.

Timekeeping A pulse train derived from the 100-kc input is fed through fail-safe, regenerative-gate circuits. The pulses in the train, 10 microseconds apart, are then divided in five anti-time-delay decade dividers to produce a 1-pps master tick. All timekeeping circuits use silicon transistors operated at low-power levels. In the event of power failure, the built-in battery will automatically sustain the timekeeping operation for approximately 24 hours.





TIME DELAY SETTING AT ALIGNMENT



SCOPE FACE AT ALIGNMENT

To determine the precise time relationship of the Digital Syncronometer's master tick to WWV standard timing bursts, both the time transmission and the clock's 8-millisecond pedestal are displayed on a CRO screen. By means of front-panel thumbwheels, successive amounts of delay are introduced until the pedestal is exactly aligned with the WWV bursts. When the delay is determined, the Type 1123-A need only be switched to self-sync operation, and the master tick will be shifted to synchronism with the transmission. The sync pulse retains oscilloscope synchronism and keeps the pedestal in view throughout the operation.

Where the characteristics of the standard-time transmission permit greater resolution than that provided by the 8-ms pedestal, the 0.2-μs marker can be used. With this marker, time comparisons with a precision of better than $\pm$20 ns are possible.

Time Comparison and Synchronization The decade dividers of the timekeeping circuits provide, at output jacks, low-jitter, timing pulses at 100 kc/s, 10 kc/s, 1 kc/s, 100 c/s, 10 c/s, 1 c/s, and 0.1 c/s. These signals also operate a five-digit recognition circuit to produce

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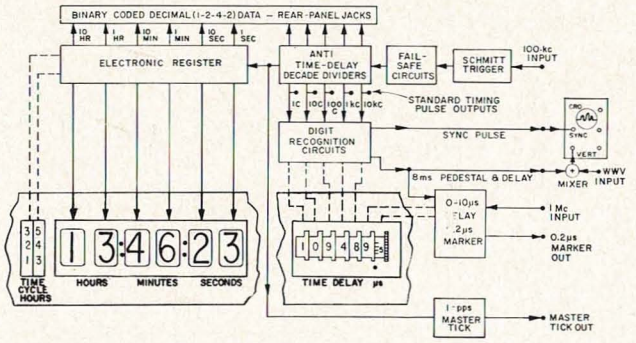
an 8-millisecond pedestal, occurring at 1 pps. This pedestal can be delayed a precise amount of time with respect to the master tick (delay time of 0.00000 through 0.99999 second is selected by front-panel thumbwheels). Pedestal and a sync pulse are provided for comparisons of the master tick with WWV-type transmissions on a CRO screen.

For intercomparisons where greater time resolution is possible (e.g., Loran C), a 1-Mc input is used to drive a delay circuit (0 to 9 microseconds in 1-microsecond steps, 0 to 1 microsecond continuously), which produces a 0.2-microsecond marker controlled by the last two front-panel thumbwheels.

The thumbwheels used in measuring the time interval between the master tick of the SYNCRONOMETER and the standard transmissions serve in *synchronizing* the master tick as well.

Readout is both visual and electrical. The clock's 1-pps master ticks are accumulated and displayed in a six-digit bank of illuminated indicators, which can be preset to re-cycle at any number of hours from 1 to 99. The indication of each digit may be changed without carrying to the next digit or interrupting the master tick. An output plug provides BCD data from each digit of the visual bank and from each of the five decade dividers (0.1 second through 10 microseconds). This data is in parallel (1-2-4-2) form, an invaluable aid in providing real-time information for time-dependent measurements.



Timekeeping, readout, and comparison circuits of the Type 1123-A Digital Syncronometer.

SPECIFICATIONS

Input: BNC connectors.
0.5 V at 100 kc/s (sinusoid or square wave).
0.5 V at 1 Mc/s (sinusoid or square wave).
Normally provided from TYPE 1115-B Standard-Frequency Oscillator (1 V into 50 Ω).

Outputs:

Time of Day: From all decades, parallel 1-2-4-2 BCD. 1-2-4-8 BCD available at extra cost; write for price and delivery.
Logical 0: Approx 0.5 V.
Logical 1: Approx +15 V (open circuit).
Logical Line Source Impedance: 100 kΩ.

Timing Pulses: 10 kc/s, 100, 10, 1, and 0.1 c/s are available at output fittings on rear. These outputs are +15-V pulses with approx 100-Ω source impedance and a duty ratio of 0.2. In addition, a 100-kc pulse signal is available.

Oscilloscope Sync Pulse: Settable in 1-ms steps 0.000 to 0.999 s.
Positive pulse, 13 V, $Z_o \equiv 2.2$ kΩ.
Duration, ≈7.5 μs.

Time Comparison Pedestal: Follows oscilloscope sync by 000 to 990 μs (100- and 10-μs steps).
Positive pulse, 10 V from emitter follower.
Duration, ≈8 ms.
$T_r = 0.5$ μs, $T_f = 0.5$ μs.

0.2-μs Marker: 10-V positive pulse, 0.2-μs duration, with approximately 20-ns rise and fall times, and 100-Ω source impedance. This marker is variable in 1-μs steps and a continuous 0- to 1-μs range from 0 to 10 μs after the 8-ms pedestal.

1-s Master Tick Output: Positive pulse from emitter follower.
Amplitude: 10 V. Duration, ≈7.5 ms. $T_r = 2$ μs, $T_f = 2$ μs.

Input Start Pulse: Logical 0 (0 V) to 1 (+15 V) holding for > 10 μs. May come from second clock or external system.

Output Start Pulse: 11 μs, 0 to +15 V, from emitter follower.

Inhibit Pulse Output: Logical 1 (+15 V) to 0 (0 V); lasting approx 9 to 11 time units at lower frequencies, established by setting internal links for desired inhibit rate (no print on carry).

Visual Indication: 6 dimmable digital indicators for h, m, s.

Delay Setting for Time Measurement: 6 digital thumbwheel switches and 1 continuous (0-1 μs) control calibrated in 20-ns increments.

Visual Register Setting: Direct access to all six visual decades, carries inhibited.

Clock Functions: All control and setting functions are operated by a single pushbutton and are normally locked out and covered.

1. Operate: All program controls locked out.

2. Start: Clock will be started by 11-μs start pulse from pushbutton or from external source (BNC connector on rear). Start pulse produced and fed from instrument.

3. Stop: Clock will be stopped and all counting decades from 100 kc/s to 1 c/s will be set to zero by pushbutton. Zero will hold until start command is received.

4. Set: Permits setting visual register. All-visual register carries interrupted; 100-kc to 1-cycle dividers not affected. Selected decade is advanced by 1 count for each push of the initiate pushbutton.

5. Self Sync: Permits synchronizing master tick to within 10 μs of a measured time in another time system, as WWV on UT-2.

6. Start-Slave: Permits setting a second clock from the first. After the initiate button is pushed, a start pulse will be produced when the count reaches the setting of the time-delay switches of the first clock.

Measurement Rate: Switch permits oscilloscope sync at 10-cycle rate rather than the standard one-cycle rate.

Power Required: 90 to 130 or 180 to 260 V, 50 to 60 c/s, 32 W approx. Self-contained, pressure-relief, nickel-cadmium battery for approx 24-hour off-line operation is supplied.

Accessories Supplied: Digital-output plug assembly, TYPE CAP-22 Power Cord, spare fuses.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	6	155	14½	370	30	14	40	18.5
Rack	19	485	5¼	135	12*	305	30	14	40	18.5

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, February 1965.

Catalog Number	*Description*	*Price*
1123-9801	**Type 1123-A Digital Syncronometer,** Bench Model	**$2950.00**
1123-9811	**Type 1123-A Digital Syncronometer,** Rack Model	**2950.00**

Type 1112 STANDARD-FREQUENCY MULTIPLIERS

FEATURES: Provides microwave-range standard frequencies — 250-milliwatt output at 1000 Mc/s. Excellent phase stability. ■ Extremely low noise.

USES: The TYPE 1112 Standard-Frequency Multipliers generate sine-wave signals of 1, 10, 100, and 1000 Mc/s when driven from a 100-kc or 1-Mc source or, when driven from a 1-, 2.5-, or 5-Mc source, outputs of 10, 100, and 1000 Mc/s.

The output provides standard frequencies in the microwave region for precise frequency measurements. The unusually low noise and excellent phase stability of output signals permit intercomparison of lower-frequency, standard-frequency oscillators and comparison of crystal with atomic standards.

DESCRIPTION: The phase stability and low noise of the multiplier outputs result from the use of a narrow-band filter, which selects only the desired harmonic at each output frequency.

In the TYPE 1112-A Multiplier, the 100-kc input signal is multiplied to 1, 10, and 100 Mc/s. Quartz-crystal filters are used, each in an oscillator circuit whose frequency is phase-locked to the desired harmonic frequency.

In the TYPE 1112-B Multiplier, which operates from a separate 100-Mc output of the TYPE 1112-A, a phase-locked klystron oscillator is used as a selective filter. Phase-modulation noise inherent in klystrons is minimized by negative feedback. The reference standard is the multiplied harmonic of the crystal-controlled 100-Mc driving signal.

SPECIFICATIONS

	Input		*Output*					
Type	*Freq in Mc/s*	*Volts*	*Residual FM Noise*	*Locking Range*	*Bandwidth† Decade*	*c/s*	*Power*	*Open-Circuit Volts*
1112-A	0.1 1 2.5 5	1 1.5 0.4 0.4	$< \pm 1 \times 10^{-9}$	± 15 in 10^6	0.1–1 Mc/s 1–10 Mc/s 10–100 Mc/s	50 500 5000	20 mW into 50Ω 4 channels: 1 at 1 Mc/s 1 at 10 Mc/s 2 at 100 Mc/s	2
1112-B	100	20 mW* (50Ω)	$< \pm 1 \times 10^{-9}$	± 100 kc‡	100 kc/s‡		1000 Mc/s, 250 mW, 50Ω sine wave	>3

* From TYPE 1112-A. † Expressed as allowable frequency deviation rate. ‡ At input frequency.

Spurious Signals: At least 100 dB below output level.

Terminals: Locking GR874 Coaxial Connectors; adaptors (page 81) are available to all commonly used types.

Accessories Supplied: TYPE 1112-A — TYPE CAP-22 Power Cord, TYPE 874-R22LA Patch Cord, spare fuses; TYPE 1112-B — TYPE CAP-22 Power Cord, two TYPE 874-R22LA Patch Cords, spare fuses.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s. TYPE 1112-A, 110 W; TYPE 1112-B, 125 W.

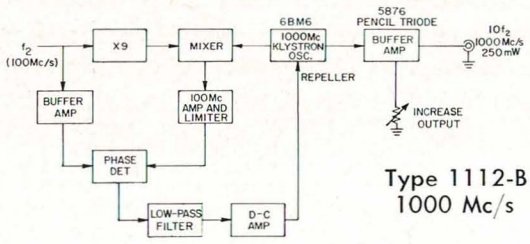
Dimensions: Relay-rack panel, 19 by 12¼ in (485 by 330 mm); depth behind panel, 11 in (280 mm).

Net Weight: TYPE 1112-A, 25 lb (11.5 kg); TYPE 1112-B, 35 lb (16 kg).

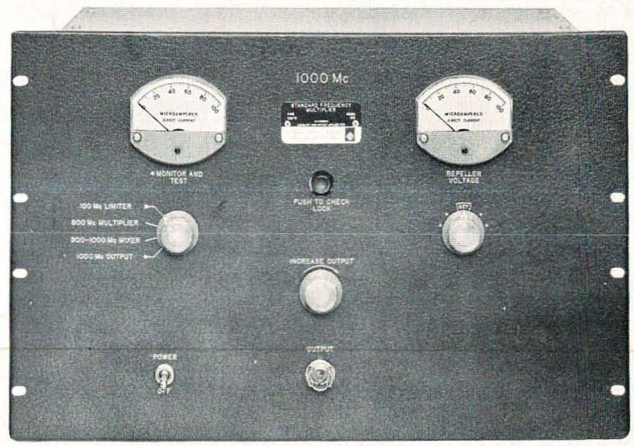
Shipping Weight: TYPE 1112-A, 40 lb (18.5 kg); TYPE 1112-B, 50 lb (23 kg).

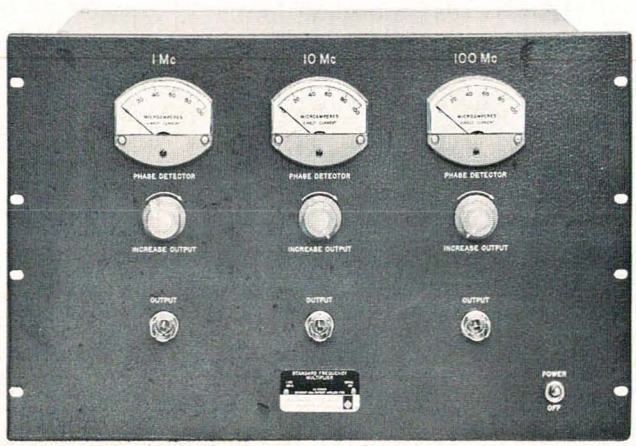
Catalog No.	*Description*	*Price*
1112-9701	**Type 1112-A Standard-Frequency Multiplier**	**$1450.00**
1112-9702	**Type 1112-B Standard-Frequency Multiplier**	**1360.00**

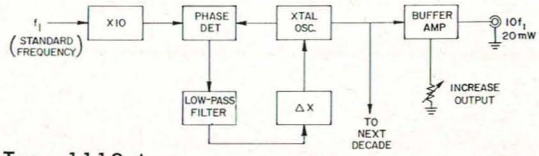
PATENT NOTICE. See Notes 4 and 15, page 11.



Type 1112-B
1000 Mc/s







Type 1112-A
1, 10, 100 Mc/s

47532 FREQUENCY METERS

An unknown frequency is measured by comparison with a standard frequency. The comparison may be direct, as with a digital frequency meter that includes a quartz-crystal-oscillator time base, or indirect, as with a calibrated, analog-type frequency meter.

The digital frequency meter, or counter, measures frequencies up to about 10 Mc/s directly and economically. The decade scaler is an economical means of extending the range, by direct-counting techniques, upward by a factor of 10. For higher frequencies, say, up to 500 Mc/s, heterodyne converters offer a convenient and accurate means of range extension.

For the measurement of intermittent signals and weak microwave signals, the harmonics of stable, tunable oscillators can be used to transfer the unknown signal to a high-level signal within the range of the measurement system.

Low frequencies, below a few kilocycles per second, can be measured in terms of their periods. The block diagram of Figure 1 illustrates these various techniques.

There are many measurements where the high resolution of the counter is not required, and, for these, the direct-reading analog frequency meter is satisfactory and is less expensive than the digital type.

DIGITAL FREQUENCY METERS

The elements of a digital frequency meter (commonly called a counter) are shown in Figure 2. The reference standard, usually called the time base, is a quartz-crystal oscillator. For period measurement (low frequencies), the counter totals the number of standard pulses from the time base for one or more periods of the unknown frequency. For direct frequency measurement, it counts the number of cycles of the unknown in a standard time interval, usually one second. In either type of measurement, the result is displayed as a series of illuminated digits.

In addition to its basic function of measuring frequency (or period), the counter can also count events (pulses), whether uniform in rate or random, and display the total. It can also be made to measure the ratio between two input frequencies.

General Radio counters use simple, reliable, all-solid-state circuits and are designed for maximum performance at low cost. All models include a precise quartz oscillator as the

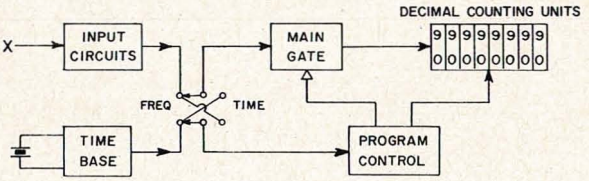


Figure 2. Elementary block diagram of a digital counter.

measurement reference. Input controls are provided to permit reliable counting, regardless of input waveform. The 5-digit readout indicators are bright, incandescent-lamp units designed for maximum legibility and simple bulb replacement. Counting-time controls vary the resolution of the readout over a 1000-to-1 range so that any five digits of interest are displayed — coarse digits for coarse measurements, fine digits for fine measurements.

Four counters are offered by General Radio, differing in frequency range and in the number of measurement capabilities.

TABLE 1 — Basic Frequency Meters

Type	*Frequency Range*	*Use*	*Page*	*Price*
1150-B	10 c/s to 400 kc/s	Freq, Total	121	$ 995
1150-BH	10 c/s to 1 Mc/s	Freq, Total	121	1095
1151-A	dc to 400 kc/s	Freq, Period, Ratio, Total	122	1195
1153-A	dc to 10 Mc/s	Freq, Total	123	1495

All models are available with data output (P suffix) for printer or D/A converter at an additional charge of $55.

RANGE EXTENSION — to 100 Mc/s or 500 Mc/s

Higher frequencies are measured by a combination of the Type 1153-A Digital Frequency Meter and the Type 1156-A Decade Scaler (up to 100 Mc/s) or the Type 1133-A Frequency Converter (up to 500 Mc/s). These extension units have been designed as independent, self-contained instruments based on the "add-a-unit" philosophy pioneered by General Radio. They may be used with other counters or other types of instruments for a variety of measurements.

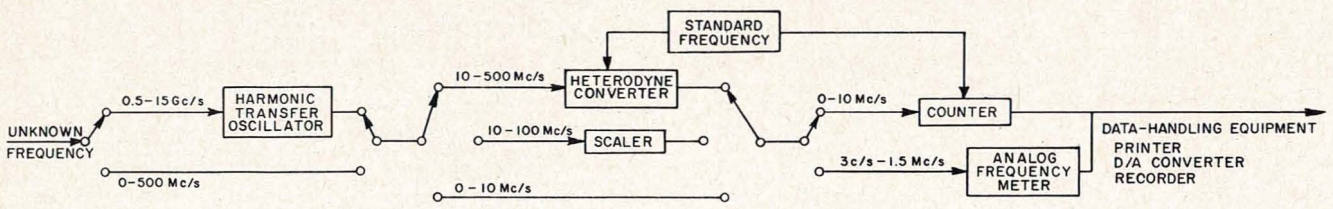


Figure 1. Frequency measurement techniques. Frequencies shown are approximate upper limits for the various systems.

Counter-extension unit combinations are available as complete assemblies with all necessary accessories.

TABLE II — Extended-Range Combinations

Type	*Frequency Range*	*Page*	*Price*
1144-A	dc to 100 Mc/s	124	$1995
1143-A	dc to 500 Mc/s	124	3090

ANALOG FREQUENCY METER

The Type 1142-A Frequency Meter and Discriminator described on page 127 is a pulse-count-discriminator type of frequency meter with an over-all accuracy of 0.2% and a range of 3 c/s to 1.5 Mc/s. With the Type 1156-A Decade Scaler, its range is increased to 15 Mc/s. In addition to its use as a frequency meter, it operates as a highly linear discriminator for measurements of fm deviation, either the wide swings characteristic of fm systems or the very small swings encountered in measurements of incidental fm and of short-term frequency stability of oscillators.

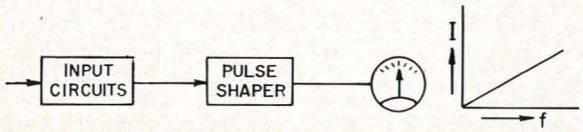
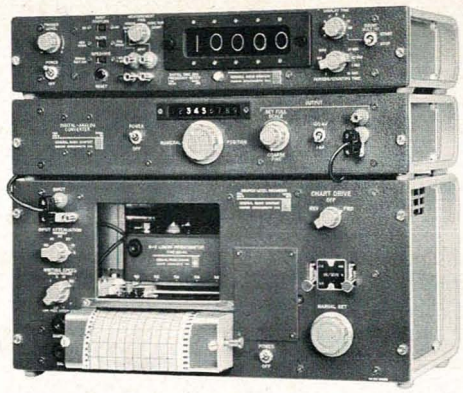


Figure 3. Elementary block diagram of an analog frequency meter.

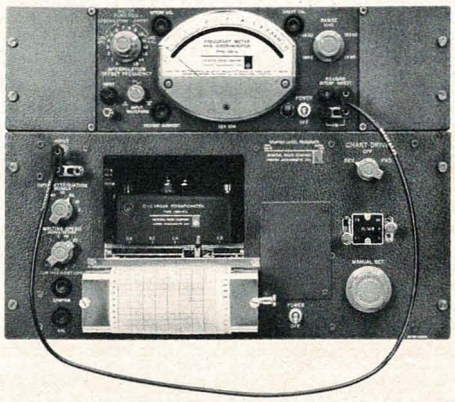
ACCESSORY EQUIPMENT

Data-handling equipment — D/A converter, data printer, and graphic recorder — is available for use with GR digital frequency meters and is described on pages 177 to 183. Combinations of frequency meter and auxiliary equipment can be assembled to meet the user's requirements. Several possibilities are illustrated here.

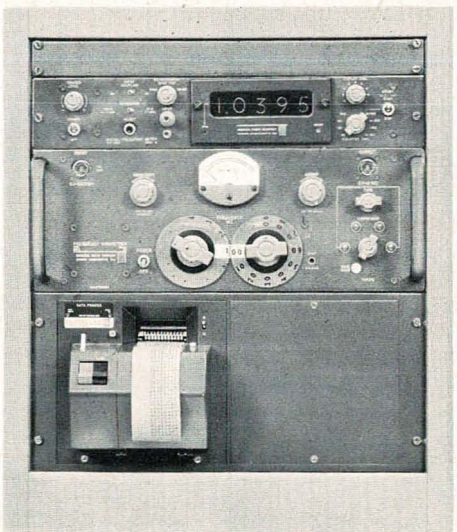
Each assembly can be supplied with individual units bolted together for bench use, with hardware for rack mount, or mounted in bench-type racks. We shall be glad to quote on combinations to meet your needs.



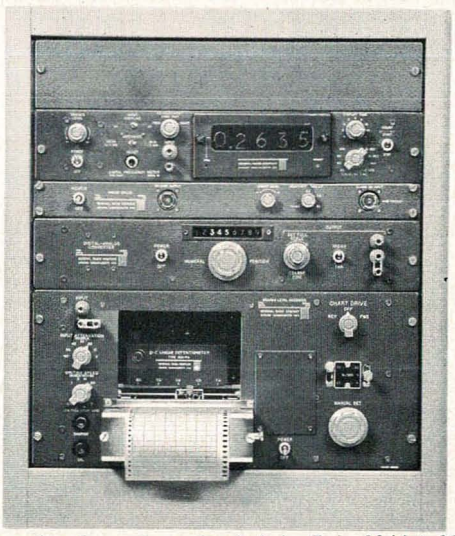
Recording frequency and period meter. Includes Type 1151-A Digital Time and Frequency Meter and Type 1510-A Digital-to-Graphic Recording Assembly.



Recording frequency meter, 0–1.5 Mc/s. Consists of Type 1142-A Frequency Meter and Discriminator and Type 1521-B Graphic Level Recorder (with linear potentiometer).



500-Mc frequency meter, with printer. Includes Type 1143-A Frequency-Measuring Assembly and Type 1137-A Data Printer.



100-Mc recording frequency meter. Includes Type 1144-A 100-Mc Digital Frequency Meter and Type 1510-A Digital-to-Graphic Recording Assembly.

Type 1150-B, -BH DIGITAL FREQUENCY METERS

10 c/s TO 400 kc/s 10 c/s TO 1 Mc/s

FEATURES:
Cumulative count or frequency measurements.
Bright-light, in-line readout.
High accuracy — stable, temperature-controlled crystal-oscillator time base.

USES: The TYPE 1150 Digital Frequency Meters are basic general-purpose counters for laboratory and industrial use. B models measure to 400 kc/s, BH models to 1 Mc/s. They can be used to calibrate oscillators, to monitor frequencies, and to measure frequencies with high resolution for measurements on precision filters and other frequency-selective devices.

With appropriate transducers, the counters can be used to measure pressure, temperature, strain, weight, production-line output, number of particles in liquids, and other quantities or events that may or may not be periodic. Used with the TYPE 1536-A Photoelectric Pickoff, the counters easily measure high rotational speeds.

DESCRIPTION: These instruments count the number of cycles of the input signal occurring in a precise time interval of 0.01, 0.1, 1, or 10 seconds, established by the quartz-crystal oscillator. The counting circuits are ring-of-ten units.

A triggering level control optimizes input sensitivity for all waveforms and reduces the possibility of erroneous indications from noise or other unwanted signals.

The -BP and -BPH models include data-output provision for use with the TYPE 1137-A Data Printer, the TYPE 1510-A Digital-to-Graphic Recording Assembly, the TYPE 1136-A Digital-to-Analog Converter, and other recording or data-processing equipment.

SPECIFICATIONS

INPUT

Frequency Range	*Accuracy*	*Sensitivity (p-to-p), Impedance*
10 c/s to 400 kc/s for Types 1150-B, -BP 10 c/s to 1 Mc/s for Types 1150-BH, -BPH	±1 count ±time-base stability	Better than 1 V at 1 MΩ and 80 pF; ac coupled. **Maximum input:** ±300 V.

Self Test: TEST position of measurement switch disconnects input and applies 100 kc/s to check all functions.

Display: 5-digit, in-line readout, incandescent-lamp operated. Display time of 0.16, 0.32, 0.64, 1.28, 2.56, 5.12, 10.24 seconds, or infinity.

Counting Interval: 0.01, 0.1, 1, or 10 seconds, extendible by multiplier switch, or as set manually.

TIME BASE	*Internal Oscillator Stability*
100 kc/s, internal or external. Internal oscillator crystal-controlled; adjustment provided, adjusted to within 10 ppm when shipped.	**Short term:** <0.5 ppm. **Cycling:** Less than counter resolution. **Temp effects:** <2.5 ppm, 0 to 50°C ambient rise. **Warmup:** Within 1 ppm after 15 min. **Aging:** <1 ppm per week after 4 weeks, decreasing thereafter.

AUXILIARY CONNECTIONS (rear-mounted connectors)

Time-Base Output: 100 kc/s, 20 V, p-to-p, behind 100 kΩ.

External Time-Base Input: 100 kc/s at 1 V, p-to-p, into 1 kΩ.

Auxiliary Connector: Inputs — reset, start-stop. Outputs — carry pulse from last decade, print command, zero-set, 100 kc/s, +20-V test point.

Photoelectric Pickoff Input Connector: 3-terminal telephone jack with +20 V dc and connection to main input.

Data-Output Connector (Types 1150-BP and -BPH only): 10-line decimal for each digit, one wire binary 1 (+14-V level) and nine wires binary 0 (0 to +4-V level), source impedance 2.4 kΩ; +20-V power; and print command pulse.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 45 W.

Accessories Supplied: TYPE CAP-22 Power Cord, eight replacement incandescent lamps, spare fuses.

Accessories Available: TYPE 1536-A Photoelectric Pickoff (page 216). For TYPE 1150-BP and -BPH only — TYPE 1136-A Digital-to-Analog Converter (page 182), TYPE 1137-A Data Printer (page 183), TYPE 1510-A Digital-to-Graphic Recording Assembly (page 182).

MECHANICAL DATA Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	3⅞	99	12½	320	17½	8	27	12.5
Rack	19	485	3½	90	11⅝*	298	17½	8	27	12.5

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, August 1964.

Catalog No.	*Description*	*Price*
1150-9802	**Type 1150-B Digital Frequency Meter,** 400 kc/s, Bench Model	**$ 995.00**
1150-9812	**Type 1150-B Digital Frequency Meter,** 400 kc/s, Rack Model	**995.00**
1150-9909	**Type 1150-BP Digital Frequency Meter,** 400 kc/s, with data output, Bench Model	**1050.00**
1150-9910	**Type 1150-BP Digital Frequency Meter,** 400 kc/s, with data output, Rack Model	**1050.00**
1150-9505	**Type 1150-BH Digital Frequency Meter,** 1 Mc/s, Bench Model	**1095.00**
1150-9515	**Type 1150-BH Digital Frequency Meter,** 1 Mc/s, Rack Model	**1095.00**
1150-9563	**Type 1150-BPH Digital Frequency Meter,** with data output, 1 Mc/s, Bench Model	**1150.00**
1150-9564	**Type 1150-BPH Digital Frequency Meter,** with data output, 1 Mc/s, Rack Model	**1150.00**

NEW MODEL
in catalog S

Type 1151-A DIGITAL TIME AND FREQUENCY METER

DC TO 400 kc/s

FEATURES:
Cumulative count, frequency, period, or ratio measurements.
Bright-light, in-line readout.
High accuracy — temperature-controlled crystal oscillator time base.
High reliability — ring counters operate with wide range of transistor characteristics.

USES: The TYPE 1151-A is, like the TYPE 1150-B, a general-purpose counter for the laboratory or production line, but with a full complement of input controls and with the program needed for period, multiple-period, and ratio measurements. The ability to make period measurements up to 1000 periods is especially useful for accurate measurement of low frequencies.

DESCRIPTION: The input circuits provide choices between ac or dc coupling, negative- or positive-going slope, and two sensitivities.

For frequency measurement, the main gate is opened and closed by a 100-kc crystal-oscillator signal divided down to 0.1, 1, 10, or 100 c/s.

For period measurement, the main gate is opened and closed by the signal of unknown frequency, and the clock pulses are supplied by the 100-kc crystal oscillator.

For ratio measurement, the counter is programmed as for period measurement, except that the internally generated 100-kc clock signal is replaced by the signal from an input channel. Ratio measurements can be made over the full frequency-resolution range of the counter.

The -AP models include data-output provision for use with the TYPE 1137-A Data Printer, the TYPE 1510-A Digital-to-Graphic Recording Assembly, the TYPE 1136-A Digital-to-Analog Converter, and other recording or data-processing equipment.

SPECIFICATIONS

Measurement	*Accuracy*		*Sensitivity*
Frequency: Dc to 400 kc/s	± 1 count ± time-base stability	**Counting interval:** 0.01, 0.1, 1, or 10s, extendible by multiplier switch, or as set manually.	0.2 V, p-to-p, at 200 kΩ and 40 pF or 1 V at 1 MΩ and 100 pF, switch selected. Maximum input, ± 200 V ac coupled; 500 V dc coupled, at 1 MΩ.
Period: 1, 10, 100, or 1000 periods. Dc to 20 kc/s	± 1 count ± time-base stability ± noise error	**Equivalent open-circuit noise:** 5 mV, p-to-p, at 1 MΩ, less at 200 kΩ. **Counted Frequency:** 100 kc/s	
Ratio: B/A, 10 B/A, 100 B/A, or 1000 B/A		**Input A:** dc to 20 kc/s; **Input B:** dc to 400 kc/s	**Input B:** 1 V at 100 kΩ.

Input Trigger: Ac or dc coupled, positive- or negative-going. Trigger level range is adequate to permit triggering on zero crossings of signals twice minimum amplitude and on narrow pulses of either polarity.

Self Test: TEST position of measurement switch disconnects input and applies 100 kc/s to check all functions.

DISPLAY 5-digit, in-line readout, incandescent-lamp operated. Display time of 0.16, 0.32, 0.64, 1.28, 2.56, 5.12, 10.24 seconds, or infinity.

TIME BASE	*Internal Oscillator Stability*
100 kc/s, internal or external. Internal quartz-crystal oscillator; adjustment provided, adjusted to within 10 ppm when shipped.	**Short term:** <0.5 ppm. **Cycling:** Less than counter resolution. **Temp effects:** <2.5 ppm, 0 to 50°C ambient rise. **Warmup:** Within 1 ppm after 15 min. **Aging:** <1 ppm per week after 4 weeks, decreasing thereafter.

AUXILIARY CONNECTIONS (rear-mounted connectors)
Time-Base Output: 100 kc/s, 20 V, p-to-p, behind 100 kΩ.
External Time-Base Input: 100 kc/s at 1 V, p-to-p, into 1 kΩ.

Auxiliary Connector: Inputs — reset, start-stop. Outputs — carry pulse from last decade, print command, zero-set, 100 kc/s, +20-V test point.

Photoelectric Pickoff Input Connector: 3-terminal telephone jack with +20 V dc and connection to main input.

Data-Output Connector (Type 1151-AP only): 10-line decimal for each digit, one wire binary 1 (+14-V level), and nine wires binary 0 (0 to +4-V level), source impedance 2.4 kΩ; +20-V power; and print-command pulse.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 50 W.

Accessories Supplied: TYPE CAP-22 Power Cord, eight replacement incandescent lamps, spare fuses.

Accessories Available: TYPE 1536-A Photoelectric Pickoff (page 216). For TYPE 1151-AP only — TYPE 1136-A Digital-to-Analog Converter (page 182), TYPE 1137-A Data Printer (page 183), TYPE 1510-A Digital-to-Graphic Recording Assembly (page 182).

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	3⅞	99	12½	320	19	9	27	12.5
Rack	19	485	3½	90	11⅝*	298	19	9	27	12.5

* Behind panel.

See also *General Radio Experimenter*, June 1963.

Catalog No.	*Description*	*Price*
1151-9801	**Type 1151-A Digital Time and Frequency Meter, Bench Model**	**$1195.00**
1151-9811	**Type 1151-A Digital Time and Frequency Meter, Rack Model**	**1195.00**
1151-9871	**Type 1151-AP Digital Time and Frequency Meter, with data output, Bench Model**	**1250.00**
1151-9981	**Type 1151-AP Digital Time and Frequency Meter, with data output, Rack Model**	**1250.00**

Type 1153-A DIGITAL FREQUENCY METER

DC TO 10 Mc/s

FEATURES: Bright-light, in-line readout with decimal point and spill lamp.
High sensitivity — 100 millivolts, peak-to-peak.
Input controls for triggering adjustments. All-solid-state circuitry.

USES: The TYPE 1153-A Digital Frequency Meter is a compact, inexpensive laboratory or industrial counter for frequency measurements from dc to 10 Mc/s. With the TYPE 1156-A Decade Scaler, the range is extended to 100 Mc/s, and, with the TYPE 1133-A Frequency Converter, to 500 Mc/s. Assemblies of these instruments are listed on page 124.

The -AP models include data-output provision for use with the TYPE 1137-A Data Printer, the TYPE 1510-A Digital-to-Graphic Recording Assembly, the TYPE 1136-A Digital-to-Analog Converter, and other recording or data-processing equipment.

DESCRIPTION: The TYPE 1153-A Digital Frequency Meter measures frequency by counting the number of zero-crossings of the input signal during a time interval established by an internal 100-kc time-base. Provision is also made for an external time-base.

The input controls provide a choice of sensitivity, ac or dc coupling, and triggering level and permit operation with input signals as small as 100 millivolts, peak-to-peak.

The readout includes a spill lamp, which provides an indication when the register capacity has been filled. A stable, GT-cut, room-temperature crystal is incorporated in the time-base oscillator. Since the time-base crystal operates at room temperature, there is no frequency shift due to oven cycling. This is most important when the counter is used with the TYPE 1133-A Frequency Converter for measurements up to 500 Mc/s.

SPECIFICATIONS

INPUT

Frequency: Dc to 10 Mc/s.

Accuracy: ±1 count ± time-base stability.

Sensitivity: 0.1 V, p-to-p, at 100 kΩ and 50 pF; 1.0 V at 1 MΩ and 20 pF. For narrow pulses, 0.1 V at 100 kΩ and >30-ns duration; 0.2 V at 100 kΩ and >15 ns; 1.0 V at 1 MΩ and >30 ns; 2.0 V at 1 MΩ and >15 ns. Max allowable input is ±400 V (at 1 MΩ).

Counting Interval: 0.01, 0.1, 1, or 10 s, extendible by multiplier switch, or as set manually.

Input Trigger: Ac or dc coupled. Trigger level range is ±1 V at 0.1-V sensitivity, ±10 V at 1-V sensitivity. Trigger-level drift is typically 0.05 V, p-to-p, at 0.1-V sensitivity, 0.5 V, at 1-V sensitivity, from 0°C to 50°C.

Self Test: TEST position of measurement switch disconnects input and applies 100 kc/s to check all functions.

DISPLAY 5-digit, in-line readout with decimal point and spill lamp, incandescent-lamp operated. Display time of 0.16, 0.32, 0.64, 1.28, 2.56, 5.12, 10.24 seconds, or infinity.

TIME BASE	*Stability*
100 kc/s, internal or external. Internal frequency derived from 200-kc, GT-cut, room temperature crystal; adjustment provided, adjusted to within 1 ppm when shipped.	**Cycling:** None **Temp Effects:** <6 ppm, 0 to 50°C ambient rise; <±0.1 ppm per °C, 20° to 30°C ambient rise. **Aging:** <0.1 ppm per week.

AUXILIARY CONNECTIONS (rear-mounted connectors)

Time-Base Output: 100 kc/s, 4 V, p-to-p, behind 2 kΩ.

External Time-Base Input: 100 kc/s at 1 V, p-to-p, into 1 kΩ.

Auxiliary Connector: Inputs — reset, start-stop. Outputs — carry pulse from last decade, print command, zero set, 100 kc/s, +20-V test point.

Photoelectric Pickoff Input Connector: 3-terminal telephone jack with +20 V dc and connection to main input.

Data-Output Connector (Type 1153-AP only): 10-line decimal for each digit — one wire binary 1 (+14-V level) and nine wires binary 0 (0 to +4-V level); source impedance 2.4 kΩ; +20-V power; ground; and print-command pulse.

GENERAL

Operating Temp: 0° to +50°C.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 70 W.

Accessories Supplied: TYPE CAP-22 Power Cord, 8 replacement incandescent lamps, spare fuses.

Accessories Available: TYPE 1536-A Photoelectric Pickoff, TYPE 1133-A Frequency Converter and TYPE 1153-P1 Frequency Multiplier to extend range to 500 Mc/s, TYPE 1156-A Decade Scaler to extend range to 100 Mc/s. For TYPE 1153-AP only — TYPE 1136-A Digital-to-Analog Converter (page 182), TYPE 1137-A Data Printer (page 183), TYPE 1510-A Digital-to-Graphic Recording Assembly (page 182).

MECHANICAL DATA Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	3⅞	99	12½	320	20	9.5	28	13
Rack	19	485	3½	89	11⅝*	298	20	9.5	28	13

* Behind panel.

Catalog No.	*Description*	*Price*
1153-9801	**Type 1153-A Digital Frequency Meter, Bench Model**	**$1495.00**
1153-9811	**Type 1153-A Digital Frequency Meter, Rack Model**	**1495.00**
1153-9871	**Type 1153-AP Digital Frequency Meter, with data output, Bench Model**	**1550.00**
1153-9981	**Type 1153-AP Digital Frequency Meter, with data output, Rack Model**	**1550.00**
1153-9601	**Type 1153-P1 Frequency Multiplier**	**70.00**

NEW
in catalog S

FREQUENCY-MEASURING ASSEMBLIES

These assemblies combine the TYPE 1153 Digital Frequency Meter with range-extension devices to cover wide ranges of frequency. They are shipped completely assembled for bench use and are easy to operate. Hardware for rack mount is supplied. They can also be furnished in bench-type relay racks. Quotations on request.

Each assembly is available with or without data-output provision for use with auxiliary equipment such as printers, digital-to-analog converters, and data-processing equipment.

Type 1144-A 100-Mc DIGITAL FREQUENCY METER

DC TO 100 Mc/s

This assembly gives a direct indication of frequency up to 100 Mc/s at low cost and with a minimum of panel space. It consists of the TYPE 1153 Digital Frequency Meter and the TYPE 1156-A Decade Scaler. The scaler divides the input frequency by 10 and provides 100-millivolt, peak-to-peak, sensitivity.

Mechanical Data:

Width		Height		Depth		Net Wt		Ship Wt	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
19	485	5⅞	150	12½	320	46	21	61	28

Catalog No.	*Description*	*Price*
1144-9701	**Type 1144-A 100-Mc Digital Frequency Meter**	**$1995.00**
1144-9829	**Type 1144-AP 100-Mc Digital Frequency Meter, with data output**	**2050.00**

PATENT NOTICE. See Note 4, page 11.

NEW
in catalog S

Type 1143-A FREQUENCY-MEASURING ASSEMBLY

DC TO 500 Mc/s

For 500-Mc coverage this assembly combines the TYPE 1153 Digital Frequency Meter and the TYPE 1133-A Frequency Converter. Sensitivity is better than 10 millivolts above 100 kc/s, and signal-to-noise ratio is high. The assembly includes a TYPE 1153-P1 Frequency Multiplier, which converts the 100-kc time-base output of the frequency meter to the 5-Mc reference frequency signal required by the converter. The unknown frequency is the sum of the frequency meter and converter indication. All scales are direct reading.

Mechanical Data:

Width		Height		Depth		Net Wt		Ship Wt	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
19	485	11¼	290	19	485	54	24.5	84	39

Catalog No.	*Description*	*Price*
1143-9701	**Type 1143-A Frequency-Measuring Assembly, dc to 500 Mc/s**	**$3090.00**
1143-9829	**Type 1143-AP Frequency-Measuring Assembly, dc to 500 Mc/s, with data output**	**3145.00**

PATENT NOTICE. See Note 4, page 11.

NEW
in catalog S

Type 1156-A DECADE SCALER

DC TO 100 Mc/s

FEATURES:

High sensitivity — better than 100 millivolts, peak-to-peak.
Good input termination; VSWR less than 1.1 at 100 Mc/s; reflection less than 10% for 0.4-ns rise-time pulses.
High output drive — 5 volts, peak-to-peak, open-circuit; 1 volt, peak-to-peak, into 50 ohms.
Compact — 1¾-inch panel height.

USES: The TYPE 1156-A Decade Scaler extends the upper frequency limit of the TYPE 1153-A Digital Frequency Meter to 100 Mc/s, by direct counting. The combination is available as the TYPE 1144-A Frequency-Measurement Assembly, described on page 123. The scaler can also be used with any General Radio counter, counters of other makes, oscilloscope trigger circuits, analog frequency meters, or any instrument requiring 10-to-1 frequency division. Combined with TYPE 1142-A Frequency Meter and Discriminator, it forms a direct-reading analog-type frequency meter capable of measuring frequencies up to 15 Mc/s.

DESCRIPTION: The TYPE 1156-A Decade Scaler is a completely self-contained, 100-Mc, direct-counting frequency divider.

The input circuitry consists of a GR874 locking connector, an attenuator with four 50-ohm positions and one 500-ohm position, and an input amplifier, which provides 100-millivolt sensitivity and also isolates the input from noise generated by the switching circuits. The input amplifier is followed by two Schmitt circuits, a self-clearing ring that scales by five, and a flip-flop that scales by two. This flip-flop drives a high-current Schmitt circuit, which delivers 20-milliampere square waves to a GR874 locking connector.

A level control permits optimum triggering with a variety of inputs including sine waves, pulses, and noisy signals. The input and output connectors can be attached to either the front or the rear of the instrument.

SPECIFICATIONS

	Frequency	*Impedance*	*Remarks*
INPUT	Dc to 100 Mc/s	50 or 500 Ω	**VSWR:** 1.1 max at 100 Mc/s (50 Ω). **Reflection:** 10% max with 0.4-ns step (50 Ω).
OUTPUT	Dc to 10 Mc/s	250 Ω	Approximately square-wave output, 20 mA; 1 V into 50 Ω, over 5 V open circuit, all p-to-p.

Sensitivity: 0.1, 0.2, 0.5, and 1 V, p-to-p, at 50 Ω; 1 V, p-to-p, at 500 Ω. Maximum input is 20 times sensitivity or ½ W, whichever is smaller.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 15 W.

Terminals: GR874 Locking Connectors. For connection to other types of coaxial connectors, use a locking adaptor, which locks securely in place, yet is easily removed. See page 81.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Accessories Available: TYPE 874-K Coupling Capacitor for ac coupling to input or output connectors. See page 92.

Mechanical Data: Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	2⅛	54	12¼	315	10¾	4.9	25	11.5
Rack	19	485	1¾	45	11⅜₁₆*	288	10¾	4.9	25	11.5

* Behind panel.

Catalog Number	*Description*	*Price*
1156-9801	**Type 1156-A Decade Scaler,** Bench Model	**$490.00**
1156-9811	**Type 1156-A Decade Scaler,** Rack Model	**490.00**

PATENT NOTICE. See Note 4, page 11.

NEW

in catalog S

Type 1133-A FREQUENCY CONVERTER

100 kc/s TO 500 Mc/s

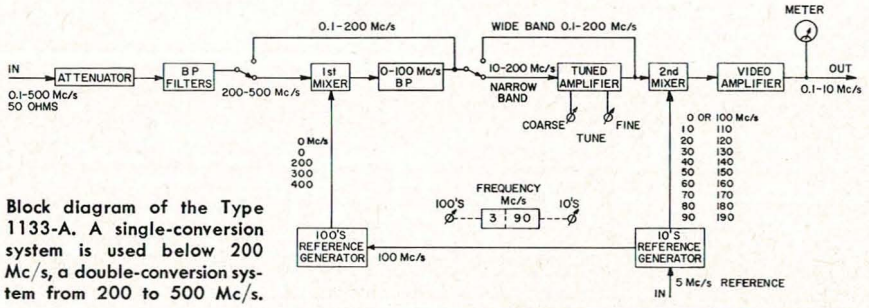
FEATURES: Wide frequency range — 100 kc/s to 500 Mc/s.
High sensitivity. ■ Tuned amplifier provides selectivity.
Easy to use; in-line digital readout.

USES: This converter extends the frequency range of the TYPE 1153-A Digital Frequency Meter to 500 Mc/s. It also increases the sensitivity to about 10 millivolts. The converter can be used with other 10-Mc counters if a reference frequency of 5-Mc/s is available or can be derived from the counter. Models for use with other reference frequencies can be supplied on special order.

DESCRIPTION: The converter heterodynes the unknown input frequency against a 10-Mc multiple of a standard frequency, derived from the time-base of the counter, and applies the difference frequency to the counter. The unknown frequency is indicated by the sum of the counter display and the in-line readout on the converter.

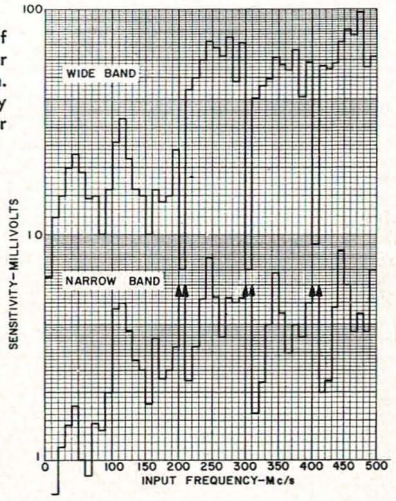
Use of linear mixing circuits in the converter results in high signal-to-noise ratio under a wide range of measurement conditions. The tuned amplifier in the converter can be switched in for measurement of low-level or noisy signals, or out for simplified wide-band operation.

The TYPE 1133-A Frequency Converter requires a reference frequency of 5 Mc/s. When the converter is used in the TYPE 1143-A Frequency Measurement Assembly, the 5-Mc reference is supplied by a TYPE 1153-P1 Frequency Multiplier, which multiplies the 100-kc output of the counter to 5 Mc/s. If the counter has a 5-Mc output, the multiplier is not required.



Block diagram of the Type 1133-A. A single-conversion system is used below 200 Mc/s, a double-conversion system from 200 to 500 Mc/s.

Typical over-all sensitivity of converter and counter for 10.1-Mc counter indication. This is worst case. Sensitivity is better for lower converter output frequencies.



SPECIFICATIONS

	Frequency	*Impedance*	*Remarks*
INPUT	100 kc/s to 500 Mc/s	50 Ω	**Reference frequency required:** 5 Mc/s, 15 mV, rms, into 50 Ω.
OUTPUT	100 kc/s to 10.1 Mc/s	100 Ω (approx)	**Output amplitude:** 0.25 to 1 V (approx). Narrow-band operation provides filtering to reduce noise. Linear mixer preserves signal-to-noise ratio during conversion.

Sensitivity (with Type 1153-A Counter): Better than 10 mV on narrow band, better than 100 mV on wide band (see plot).

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 70 W.

Accessories Supplied: Two coaxial patch cords for connection to counter; one TYPE CAP-22 Power Cord; spare fuses.

MECHANICAL DATA Rack-Bench Cabinet *(see page 258)*

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7½	190	17¾	450	34	15.5	50	23
Rack	19	485	7	180	15*	380	34	15.5	50	23

* Behind panel.

See also *General Radio Experimenter*, May 1961.

Catalog No.	*Description*	*Price*
1133-9801	**Type 1133-A Frequency Converter, Bench Model**	**$1525.00**
1133-9811	**Type 1133-A Frequency Converter, Rack Model**	**1525.00**

PATENT NOTICE. See Note 4, page 11.

Type 1142-A FREQUENCY METER AND DISCRIMINATOR

3 c/s TO 1.5 Mc/s

FEATURES:
- 0.2% accuracy
- 20-mV sensitivity
- High resolution through scale expansion.
- Highly linear, low-noise discriminator for fm measurements.

USES: Frequency measurement from 3 c/s to 1.5 Mc/s; to 15 Mc/s with TYPE 1156-A Decade Scaler.

Frequency drift measurements (with TYPE 1521-B Graphic Level Recorder).

Fm deviation (with TYPE 1806-A Electronic Voltmeter).

Fm components (with TYPE 1900-A Wave Analyzer).

The usable frequency range can be extended upwards if the unknown frequency is heterodyned against a stable frequency. This gives a proportionate increase in resolution. At 100 Mc/s, frequency drift and incidental fm can be measured to at least one part in 10^9.

DESCRIPTION: This instrument is a pulse-count discriminator. The input signal is clipped and amplified. It then triggers a pulse of constant amplitude and duration for each input cycle. The average dc component of the pulse train actuates the meter. With fm input, the time spacing of the pulses varies, producing an ac component that reproduces the modulating frequency and whose amplitude is a measure of the deviation.

SPECIFICATIONS

INPUT

Frequency	*Maximum Voltage*	*Sensitivity (rms), Impedance*
3 c/s to 1.5 Mc/s in 5 ranges; full-scale values of 150 c/s to 1.5 Mc/s.	300 V, p-to-p, up to 150 kc/s, 70 V, p-to-p, above 150 kc/s.	20 mV, 20 c/s to 150 kc/s; rising to 200 mV at 3 c/s and 1.5 Mc/s. Up to 5 V for narrow pulses (1 ns). 100-kΩ impedance dropping to minimum of 5 kΩ above 500 kc/s.

INTERPOLATION: A calibrated interpolation feature expands meter scale by a factor of 10 so that 1/10 of any range covers the full scale, providing a readout precision of 0.1%.

ACCURACY 0.2%, nominal. Internal calibration at twice line frequency to standardize output current. Over-all accuracy is the sum of recorder output current accuracy and any of the other errors that are applicable.

Recorder Output Current: Below 15 kc/s, 0.05% of full scale +0.05% of reading; above 15 kc/s, 0.1% of full scale +0.1% of reading.

Meter: Direct reading, 1% of reading above 10% of full scale (0.1% of full scale below 10% of full scale). Interpolating, 0.1% of full scale (range switch setting).

Line-Voltage Effect: ±10% change produces approximately ±0.2% change in reading (±0.5% on 1.5-Mc range).

Warmup Drift: Less than 0.2% of reading after a few minutes, substantially complete within 30 minutes.

Ambient-Temperature Effect: Output current changes less than 0.01%/°C (0.02%/°C on 1.5-Mc range).

DISCRIMINATOR CHARACTERISTICS

Output Voltage: 15 V dc full scale (1.5) on all ranges.

Residual FM Noise: Below 1 Mc/s, more than 100 dB below full output. (With 400-cycle power, 90 dB down.) Narrow-band residual noise at frequencies other than 60 or 120 c/s is more than 120 dB down from full output.

Linearity: Below 15 kc/s, 0.05% of full scale (15 V) ± 0.05% of output voltage; above 15 kc/s, 0.1% of full scale (15 V) ±0.1% of output voltage.

RECORDER OUTPUT

Direct: Output current adjustable to drive recorders from 1 mA (2.7 kΩ max) to 5 mA (190 Ω max).

Interpolate: Full scale, 0.64 V behind 4.8 kΩ.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s, 85 W.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Accessories Available: TYPE 1156-A Decade Scaler (page 125); TYPE 480-P312 Relay-Rack Adaptor Set, panel height 5¼ in.

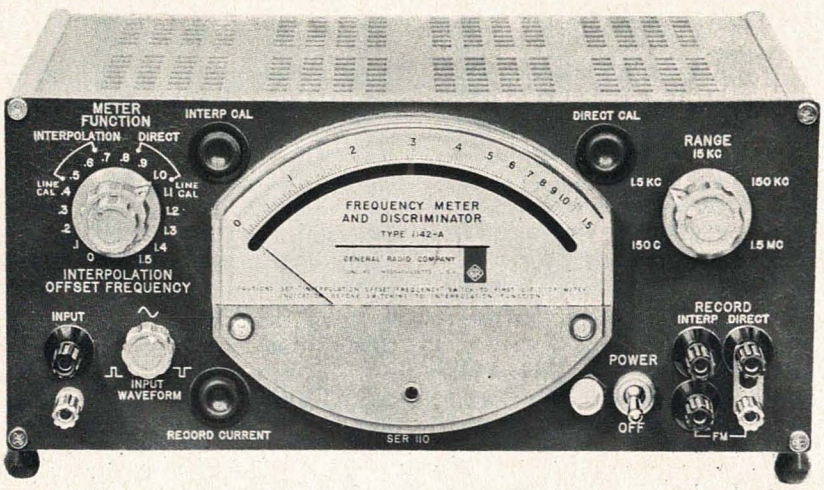
MECHANICAL DATA Convertible-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
12	305	5⅞	150	12	305	16	7.5	23	10.5

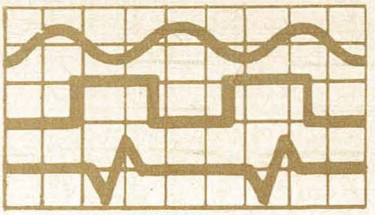
For a more detailed description, see *General Radio Experimenter*, January 1961.

Catalog No.	*Description*	*Price*
1142-9701	**Type 1142-A Frequency Meter and Discriminator**	**$565.00**
0480-9632	**Type 480-P312 Relay-Rack Adaptor Set**	**6.50**

PATENT NOTICE. See Notes 15 and 16, page 11.



GENERATORS (SIGNAL SOURCES)



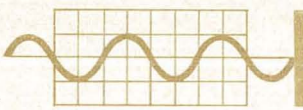
A signal source is essential in any electrical measuring system; it provides the stimulus that creates the response to be measured. This source is usually an oscillator or standard-signal generator of known characteristics, which can be adjusted to establish a known set of conditions. These characteristics comprise the frequency, the output voltage and impedance, the carrier-signal waveform, which may typically be sine-wave, square-wave, pulse or random-noise, and the modulation, which carries the system information through variation of phase, frequency, amplitude, or timing of the carrier waveform.

Signal sources can be classified functionally as to whether the information that they yield is readily usable in frequency-domain or in time-domain analysis. Sine-wave techniques form the basis of power-generation and transmission systems and most communication systems, leading to ready frequency-domain analysis. Many newer developments in information transmission and data handling, however, such as radar systems, digital computers, telemetry, and even the more venerable wire telegraphy, are based upon pulse techniques, which yield most easily to time-domain analysis.

Common to all these systems are ultimate performance limitations determined by system bandwidths and noise. Bandwidth and transient performance are the two sides of a coin; they convert one into the other and can be measured as phenomena in either the frequency or the time domain, at the convenience of the analyst. Noise is most easily measured by comparison with a noise source of known characteristics.

General Radio Company manufactures signal sources in all these categories:

1. OSCILLATORS, or sine-wave generators, embracing frequencies from 0.01 c/s to 7 Gc/s, with maximum output levels from a few milliwatts to 200 watts.
2. STANDARD-SIGNAL GENERATORS — sine-wave oscillators with accurately calibrated output voltage behind a standard impedance and with calibrated modulation capabilities. For wide-band measurements, a sweep-frequency model, Type 1025-A, provides calibrated sweep bands as well as calibrated output. Mechanical sweep devices are also available for converting conventional signal generators and oscillators to sweep generators.
3. FREQUENCY SYNTHESIZERS produce output frequencies continuously adjustable over wide ranges and all coherently derived from a quartz-crystal oscillator. Three basic models are offered, with optional degrees of resolution from one part in 10^3 to one part in 10^9, with either manual or programmable control.
4. PULSE GENERATORS — for time-domain measurements, three high-performance pulse generators are listed, plus a pulse amplifier for higher-power applications, and a tone-burst generator.
5. RANDOM-NOISE GENERATOR — produces wide-band noise of uniform spectrum level and approximately Gaussian energy distribution for noise and vibration testing in mechanical systems, noise measurements in communicative circuits, and applications in psychological, probability, and information-theory research.



OSCILLATORS

The variable-frequency, sine-wave oscillator is the basic general-purpose signal source. With it one can make a series of measurements at uniquely specified frequencies, which can be combined to specify performance in the frequency domain. These measurements may be made by manual settings, point by point, or by a frequency swept automatically over the desired range to display the system response on a chart recorder or a cathode-ray oscilloscope.

The oscillators whose characteristics are summarized on the page opposite are of four types: LC, RC, beat-frequency, and klystron.

LC OSCILLATORS At radio frequencies where tuning can be accomplished by air capacitors, the LC circuit is the best and most economical frequency-determining system. The Type 1330-A Bridge Oscillator uses tuned circuits to cover a frequency range of 10,000:1. The Types 1211, 1208, 1215, 1209, and 1361 Oscillators cover frequencies from 500 kc/s to 960 Mc/s. All of these employ unique tuned circuits, in which the inductance and capacitance are varied simultaneously. Many of them use the General-Radio-developed butterfly circuit,[1] which has no sliding or wiping contacts.

At frequencies above 1,000 Mc/s, circuits with distributed constants are used. The Type 1218-B Unit Oscillator covers a frequency range of 900 to 2,000 Mc/s with ganged transmission lines.

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[1] Eduard Karplus, "Wide-Range Tuned Circuits and Oscillators for High Frequencies," *Proceedings of the Institute of Radio Engineers*, July, 1945.
Eduard Karplus, "The Butterfly Circuit," *General Radio Experimenter*, October, 1944.

In RC OSCILLATORS the frequency is determined by resistive and capacitive elements.[2] The RC degenerative circuit, of which the Type 1311-A and the Type 1310-A are examples, is an original, patented, General Radio development. A Wien-bridge network is the tuning element in these two, as well as in the Type 1210-C, a small, versatile instrument, which produces either sine-wave or square-wave output over a wide frequency range. The Type 1305-A, a phase-shift oscillator, generates frequencies as low as 0.01 c/s with single-phase, three-phase, and four-phase output, as well as an output continuously variable in phase over 360°.

The BEAT-FREQUENCY OSCILLATOR was mentioned as early as 1920 by Van der Bijl.[3] In this oscillator the output frequency is the difference between the frequencies of a variable-frequency and a fixed-frequency oscillator. Several decades of frequency can be covered in one band with a single control.

The first commercial beat-frequency oscillator was produced by General Radio in the middle 1920's. As the development of components and circuits has progressed, increasingly better models have been developed, culminating in the present Type 1304-B Beat-Frequency Audio Generator, whose logarithmic scale greatly facilitates frequency-response measurements and which can be driven by the Type 1521-B Graphic Level Recorder for automatic plotting.

In KLYSTRON OSCILLATORS, first described by the Varians,[4] the frequency is determined by a velocity-modulated electron stream, which excites a resonant cavity. The Type 1360-B Microwave Oscillator uses a reflex klystron in a coaxial cavity with a noncontacting plunger to cover frequencies from 1.7 to 4.1 Gc/s. Internal square-wave and frequency modulation are provided.

The Type 1220-A Unit Klystron Oscillator is a klystron power supply that covers frequencies from 2700 to 7425 Mc/s with plug-in klystron tubes, each of which is adjustable over a narrow band of frequencies.

MODULATION

The rf oscillators can all be amplitude modulated with sine waves, and the Type 1218-B, Type 1361-A, and Type 1220-A can be directly square-wave and pulse modulated as well.

The Unit Oscillators operating above 50 Mc/s can, except for the Type 1208-C, be pulse or square-wave modulated by the Type 1264-A Modulating Power Supply, and can be held to a constant output amplitude with the Type 1263 Amplitude-Regulating Power Supply.

SWEEPING FREQUENCY

Specific provision for automatic display is incorporated in many General Radio sources.[5] Electronic sweeping systems are particularly suited to microwave sources and are incorporated in the Type 1220-A Unit Klystron Oscillator and the Type 1360-B Microwave Oscillator to cover frequencies from 1.7 Gc/s to 7 Gc/s.

To convert to automatic operation the many existing manually operated devices that have given, and are still giving, good service, the Type 1750-A Sweep Drive provides a mechanical hand that will grasp and rotate knobs and dials of assorted sizes and varieties and provide dc voltages that define their angular positions. The Type 908-P and 908-R Dial Drives perform similar functions for instruments using General Radio Precision Dials.

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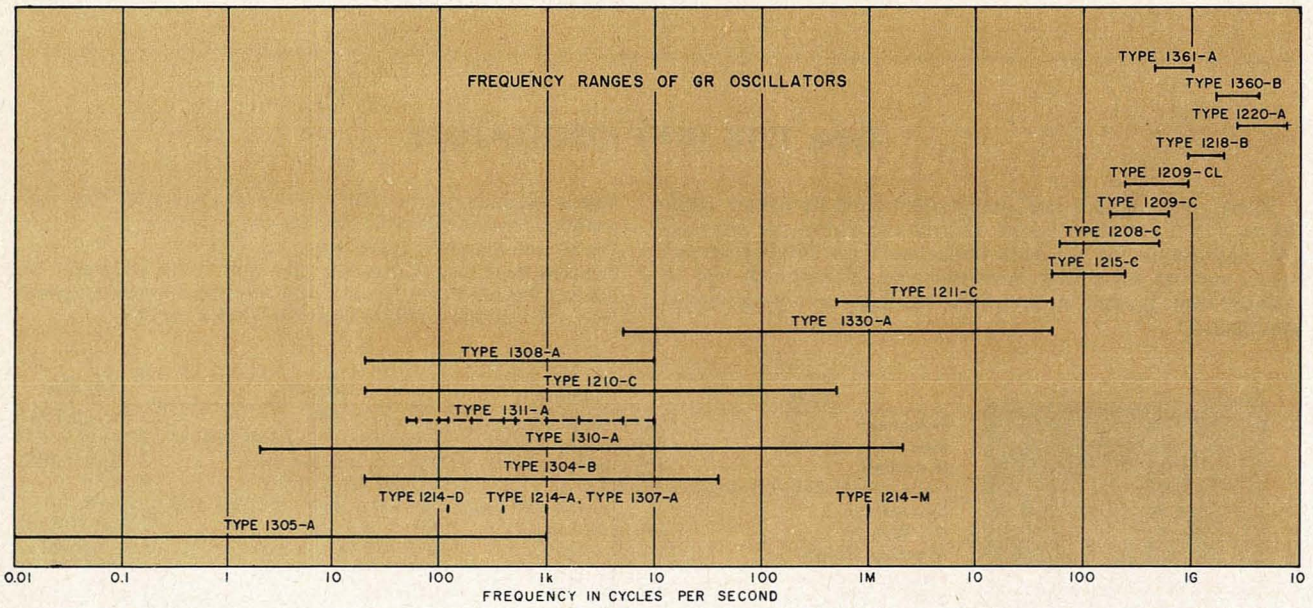
[2] First described by Nichols in 1921; see U.S. Patent 1,442,781.
[3] H. J. Van der Bijl, "Thermionic Vacuum Tube," McGraw-Hill Book Company, 1920 (first edition), p 377.
[4] Russell H. and Sigurd F. Varian, "A High-Frequency Oscillator and Amplifier," *Journal of Applied Physics*, May, 1939, p 321.
[5] See also the TYPE 1025-A Standard Sweep-Frequency Generator, which has the accurately calibrated output and other features of the standard-signal generator.



OSCILLATORS

	Type	Name	Class	Frequency Range	Maximum Output	Open-Circuit Volts	Nominal Load Impedance-ohms	Harmonic Distortion	Power Supply	See Page
Audio and Sub-Audio Frequency	**1305-A**	**Low-Frequency Oscillator**	RC	0.01–1000 c/s	170 mW per phase	10	600	<2%	AC Line	131
	1214-D	**Unit Oscillator**	Tuned Circuit	120 c/s	400 mW	45	1, 10, 100, 1000	<3%	AC Line	130
	1307-A	**Transistor Oscillator**	Tuned Circuit	400 and 1000 c/s	6 mW	2	600	<5%	Mercury Cells	21
	1214-A	**Unit Oscillator**	Tuned Circuit	400 and 1000 c/s	200 mW	60	8000	<3%	AC Line	130
	1304-B	**Beat-Frequency Audio Generator**	Beat-Frequency	20 c/s–20 kc/s 20–40 kc/s	1 W	50	600	<1%	AC Line	132
	1210-C	**Unit RC Oscillator**	RC	20 c/s–0.5 Mc/s	80 mW	7 45 30	>500 >10,000 >1000	<1.5% <5% Square Wave	AC Line with Unit Power Supply	134
	1310-A	**Oscillator**	RC	2 c/s–2 Mc/s	160 mW	20	600	<0.25%	AC Line	135
	1311-A	**Audio Oscillator**	RC	11 frequencies 50 c/s–10 kc/s	1 W	1, 3, 10, 30, 100	0.1–10,000	<0.5%	AC Line	136
	1308-A	**Audio Oscillator and Power Amplifier**	RC	20 c/s–10 kc/s	200 W	4, 12.5, 40, 125, 400	0.8, 2.5, 8, 80, 800	1% to 2%	AC Line	137
Medium and High Frequency	**1214-M**	**Unit Oscillator**	Tuned Circuit	1 Mc/s	300 mW	7	50	<3.5%	AC Line	130
	1330-A	**Bridge Oscillator**	Tuned Circuit	60, 400, 1000 c/s 5 kc/s–50 Mc/s	0.75 W 1 W	12 10	50 20–80	<5%	AC Line	138
	1211-C	**Unit Oscillator**	Tuned Circuit	0.5–5 Mc/s 5–50 Mc/s	1 W 200 mW		50		AC Line with Unit Power Supply	
	1215-C	**Unit Oscillator**	Semi-Butterfly	50–250 Mc/s	80 mW		50		AC Line with Unit Power Supply	
VHF and UHF	**1208-C**	**Unit Oscillator**	Sliding-Contact Tuned Circuit	65–500 Mc/s	100 mW		50		AC Line with Unit Power Supply	139
	1209-CL	**Unit Oscillator**	Butterfly Tuned Circuit	180–600 Mc/s	300 mW		50		AC Line with Unit Power Supply	to
	1209-C	**Unit Oscillator**	Butterfly Tuned Circuit	250–920 Mc/s	200 mW		50		AC Line with Unit Power Supply	144
	1361-A	**UHF Oscillator**	Butterfly Tuned Circuit	450–1050 Mc/s	150 mW		50		AC Line with Unit Power Supply	
	1218-B	**Unit Oscillator**	Coaxial-Line Tuned Circuit	900–2000 Mc/s	140 mW		50		AC Line with Unit Power Supply	
SHF	**1220-A**	**Unit Klystron Oscillator**	Velocity-Modulated	2700–7425 Mc/s	75–100 mW		50		AC Line with Unit Power Supply	146
	1360-B	**Microwave Oscillator**	Velocity-Modulated	1.7–4.1 Gc/s	100 mW		50		AC Line	145

Type 1214 UNIT OSCILLATORS

These are compact and inexpensive fixed-frequency oscillators. The TYPE 1214-A and -D Unit Oscillators are convenient modulators for the high-frequency Unit Oscillators and power sources for bridge measurements. The output can be isolated from ground for use of the oscillator as a plate-circuit modulator.

Power Required: 105 to 125 V, 50 to 60 c/s, 15 W. Can also operate on frequencies up to 400 c/s.

Accessories Supplied: Spare fuses.

Cabinet: Unit Instrument (see page 258). TYPE 480-P4U1 Relay-Rack Adaptor Panel Set available to mount oscillator (panel 19 by 7 in); catalog number: 0480-9984; price: $11.00.

Type 1214-A

TYPE	1214-A	1214-D	1214-M
Frequency	400 and 1000 c/s ± 2%	120 c/s ± 5%	1 Mc/s ± 1%
Maximum Output*	200 mW into 8000 Ω	400 mW into 1, 10, 100, 1000 Ω	300 mW into 50 Ω
Distortion	3% into 8000 Ω	3% into matched load	3.5% into 50Ω
Open-Circuit Output Voltage*	0 to 60 V	45, 13, 4.5, or 1.3 V	0 to 7 V
Dimensions	Panel width 4¾, height 5¼, depth 6 in (120, 135, 155 mm)		
Net Weight	4½ lb (2.1 kg)	4½ lb (2.1 kg)	2¾ lb (1.3 kg)
Shipping Weight	5 lb (2.3 kg)	5 lb (2.3 kg)	4 lb (1.9 kg)
Catalog Number	1214-9701	1214-9704	1214-9713
Price	$85.00	$115.00	$85.00

* Output voltage changes by about 12% per 10% change in line voltage. Power and voltage values given are for 115-V input.

Type 1305-A LOW-FREQUENCY OSCILLATOR

0.01 TO 1000 c/s

FEATURES:

Frequencies down to 0.01 cycle per second (36 cycles per hour).
0 to 360° variable phase output.
Known output levels over 80-dB range. ■ Excellent amplitude stability.
Logarithmic frequency scale. ■ 1-, 2-, 3-, or 4-phase output.

USES: This generator has many uses in the development and testing of servomechanisms, low-frequency amplifiers, recorders, geophysical equipment, medical instruments, analogs of 3-phase power systems, and electrical analogs of mechanical systems. With suitable amplifiers it can serve as a variable-frequency drive for low-power, two-phase or three-phase machines.

In addition to its three-phase output (0°, 120°, 240°), any phase of which can be used singly, an adaptor produces four-phase output at 0°, 90°, 180°, 270° for such applications as circular oscilloscope sweeps and component resolution (with phase detectors).

The variable phase output is useful for measurements of phase with Lissajous-pattern techniques, gain and phase-shift of four-terminal devices, and transfer characteristics of amplifiers and servomechanisms.

DESCRIPTION: Three independent, RC phase-shift networks, connected as low-pass filters, are used in a direct-coupled, phase-shift oscillator circuit. Miller-effect amplifiers increase the effective size of the polystyrene capacitors for operation at the lowest frequencies. The amplitude regulator provides an extremely high degree of amplitude stability, independent of frequency. Cathode-follower circuits provide low-distortion, low-impedance outputs.

A purely resistive network produces the constant amplitude, variable phase output.

SPECIFICATIONS

FREQUENCY

Range: 0.01 to 1000 c/s in five decade ranges, continuously adjustable with logarithmic dial.

Accuracy: ±2% of reading. Warmup drift less than 1% in first 10 min, less than 0.2% in next hour.

OUTPUT

	Phase Diff	*Per Phase (line to neutral) Voltage*	*Impedance*	*Notes*
Three-Phase	120° ±2° between adjacent phases.	At least 10 V, rms, open-circuit; constant with frequency to ±5%. Phase voltages equal within ±2%.	600 Ω; 75 Ω on DIRECT output.	Max power, 167 mW per phase into 600-Ω wye. Distortion < 2%. On DIRECT output, load impedance should be at least 600 Ω, wye, or 1800 Ω, delta.
Four-Phase	90° ± 3° between adjacent phases.	At least 5 V, rms, open-circuit.	600 Ω	From plug-in adaptor.
Variable-Phase	0° to 360°, accuracy ±3°.	Approx 0.8 V, rms, open-circuit, constant with frequency to ±5%.	Variable, 15 kΩ max.	Distortion less than 5%.

GENERAL

Hum: More than 60 dB down, OUTPUT AMPLITUDE control at max.

Output Meter: 6-phase detector minimizes ripple; indication fluctuations +5% to −10% of true rms at lowest output frequencies.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 165 W.

Accessories Supplied: TYPE 1305-P1 Four-Phase Adaptor, TYPE CAP-22 Power Cord, 3 TYPE 274-MB Double Plugs, spare fuses.

Accessories Available: Dial drives (see pages 153 and 154).

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

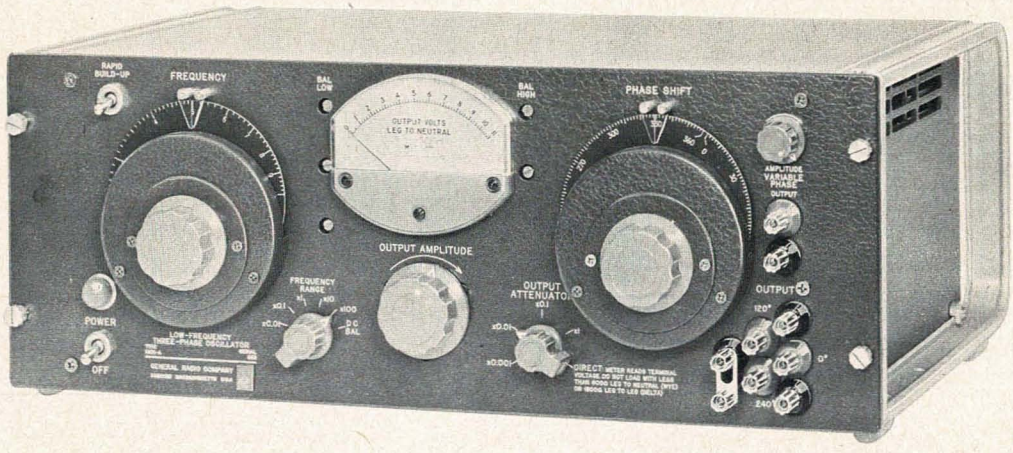
Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7⅜	190	15½	395	35	16	43	20
Rack	19	485	7	180	13½*	345	33	15	43	20

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, August-September, 1959.

Catalog No.	*Description*	*Price*
1305-9801	**Type 1305-A Low-Frequency Oscillator,** Bench Model	**$940.00**
1305-9811	**Type 1305-A Low-Frequency Oscillator,** Rack Model	**940.00**

PATENT NOTICE. See Note 15, page 11.



Type 1304-B BEAT-FREQUENCY AUDIO GENERATOR

20 c/s TO 40 kc/s

FEATURES:

Covers entire audio range in one sweep of dial.
Logarithmic frequency scale and linear frequency-increment dial.
One watt into 600 ohms.
Output voltage constant with frequency.
Known output over 80-dB range.
Low distortion and hum.
Easily adaptable to automatic audio-frequency testing.

USES: The many features of this generator make it especially well suited for amplitude-frequency tests on audio-frequency equipment — lines, amplifiers, filters, equalizers, transducers, and other networks. It finds constant use in the electronics laboratory as a power source for acoustical tests, as a power source for bridge measurements, and as a modulator for rf signal generators.

Frequency-response characteristics of circuits and devices can be recorded by either the TYPE 1521-B Graphic Level Recorder or by an XY recorder. The graphic level recorder drives the generator dial through a chain-and-gear system, and the response is plotted on chart paper whose frequency scale matches that of the oscillator. For XY plotting, the drive can be the TYPE 908-R96 Dial Drive.

An assembly of generator and graphic level recorder is listed on the next page.

DESCRIPTION: This instrument has a number of unusual design features that contribute to superior performance and ease of operation. Two radio-frequency oscillators, one fixed and one variable, feed a pentagrid converter through buffer amplifiers. The resulting difference frequency, after passing through a low-pass filter, is amplified in a degenerative amplifier. The output stage of this amplifier is the unique, low-distortion, single-ended, push-pull circuit.*

The oscillator output level is continuously adjustable, and the output can be either balanced or grounded. The unbalanced circuit contains a three-step calibrated attenuator. The output voltmeter is calibrated in dBm and open-circuit output volts.

The frequency dial carries a logarithmic frequency scale for the range 20 c/s to 20 kc/s and is driven by a slow-motion gear-reduction drive, essentially free from backlash.

Rotation is continuous over 360°, to facilitate automatic recording. A cycles-increment dial varies the frequency over a range of ±50 c/s at any setting of the main dial and can be swept by the TYPE 1750-A Sweep Drive.

The 20- to 40-kc range is selected by a single panel switch.

*A. P. G. Peterson and D. B. Sinclair, "A Single-Ended Push-Pull Audio Amplifier," *Proceedings of the IRE*, Vol 40, pp 7–11, January 1952.

SPECIFICATIONS

FREQUENCY

Range: 20 c/s to 40 kc/s in two ranges, 20 c/s to 20 kc/s and 20 kc/s to 40 kc/s.

Controls: Main dial has precision 10:1 reduction gear drive, and can be rotated continuously for automatic drive. Frequency-increment dial is direct drive. Two-position switch changes frequency range.

Calibration: Main scale, logarithmic from 20 c/s to 20 kc/s, 80° per decade. High-range position of switch adds 20 kc/s to main scale calibration. Frequency-increment dial, linear, −50 to +50 c/s.

Accuracy: Main dial, ±(1% + 0.5 c/s) after standardization by zero-beat or line-frequency setting. The 20-kc increment for high range is accurate to ±0.5%. Frequency-increment dial, ±1 c/s.

Stability: At zero beat, drift from a cold start is less than 7 c/s in the first hour and is essentially completed within two hours.

OUTPUT

Voltage: Continuously variable from below 5 mV to 50 V, open circuit. Full-scale, open-circuit output voltages of 50 mV, 500 mV, 5 V, and 50 V.

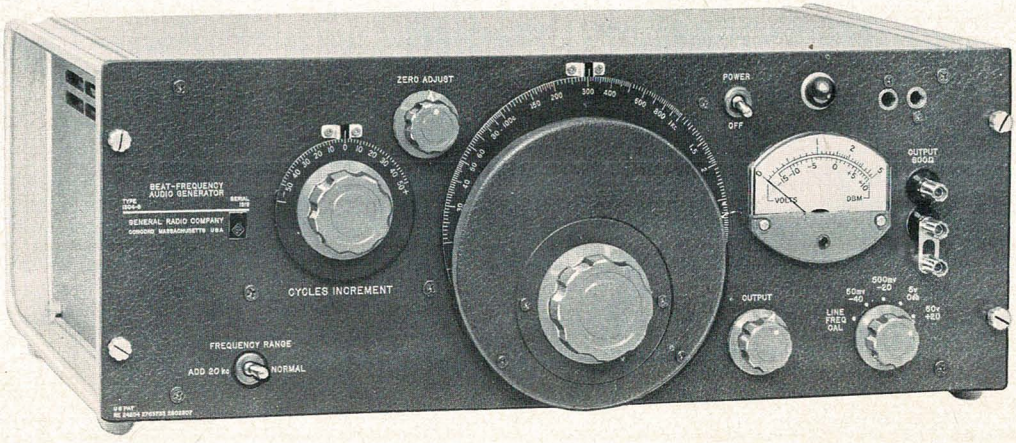
Frequency Characteristic: For a 600-Ω resistive load, NORMAL range, 20 to 20,000 c/s, ±0.25 dB; ADD 20 KC range, 20 to 30 kc/s, ±0.5 dB; 30 to 40 kc/s, ±1.0 dB.

The open-circuit voltage rises at the higher frequencies.

Impedance: 600 Ω, resistive, ±2%. At +20 dBm setting of attenuator, the output may be used either balanced or grounded. With grounded output, the attenuator can be used throughout its entire range.

Power: 1 W, maximum, into a 600-Ω resistive load.

Distortion: Less than 0.25% from 100 to 10,000 c/s. Below 100 c/s, harmonics increase and may reach 0.5% at 50 c/s. Above 10,000 c/s, the harmonic content is less than 1%.



Ac Hum: Less than 0.1% of output voltage for meter readings above 10% of full scale.

Voltmeter: Calibrated in volts output at open circuit, and in dBm. Above 10% of full scale, the calibration is accurate within ±5% of indication.

Attenuator: Used only with single-ended output; has three steps of 20 dB each, accurate to ±1% of the nominal attenuation.

Control: For each step of the attenuator, output voltage can be varied continuously from zero to maximum.

Zero-Beat Indicator: The output voltmeter indicates zero beat.

GENERATOR

Terminals: TYPE 938 Binding Posts and Western Electric double output jack on panel; a four-terminal socket at rear.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s; approximately 90 W.

Accessories Supplied: TYPE CAP-22 Power Cord, 4-terminal plug, spare fuses.

Accessories Available: Dial Drives (page 154); TYPE 1304-P1 Muting Switch; TYPE 1521-B Graphic Level Recorder (page 178).

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7½	190	15¼	390	39	18	43	20
Rack	19	485	7	180	13¼ *	340	39	18	43	20

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, June 1954.

Catalog Number	*Description*	*Price*
1304-9802	**Type 1304-B Beat-Frequency Audio Generator,** Bench Model	**$850.00**
1304-9812	**Type 1304-B Beat-Frequency Audio Generator,** Rack Model	**850.00**

PATENT NOTICE. See Notes 5, 9, 14, and 15, page 11.

Type 1350-A GENERATOR-RECORDER ASSEMBLY

This automatic, audio-frequency measuring system combines the TYPE 1304-B Beat-Frequency Audio Generator and TYPE 1521-B Graphic Level Recorder in a single assembly for the automatic plotting of frequency-response data. The recorder is a fully transistorized, single-channel, servo-type with a 40-dB, dynamic range plug-in potentiometer (20-dB, 80-dB, and linear potentiometers are also available).

Constant generator output and uniform recorder response make this an excellent assembly for measuring the response of filters, attenuators, networks, loud-speakers, amplifiers, microphones, transducers, and complete acoustic systems.

The complete assembly includes the following:

TYPE 1304-B Beat-Frequency Audio Generator with accessories, end frames and rack supports.

TYPE 1521-B Graphic Level Recorder (page 178) with accessories (including a 40-dB potentiometer), TYPE 1521-P19 motor, end frames and rack supports.

1521-9427 Chart Paper, 10 rolls
TYPE 274-NP Patch Cord
TYPE 1521-P10B Drive Unit
TYPE 1521-P15 Link Unit
TYPE 1521-P16 Sprocket Kit
TYPE 1560-P95 Adaptor Cable
TYPE 1304-P1 Muting Switch

The blank parts on the chart paper correspond to the length of the blank portion on the generator dial so that many charts can be recorded with complete synchronization of the chart and the dial frequency.

Power Required: 105 to 125 or 210 to 250 V, 60 or 50 c/s (see price list below), 135 W.

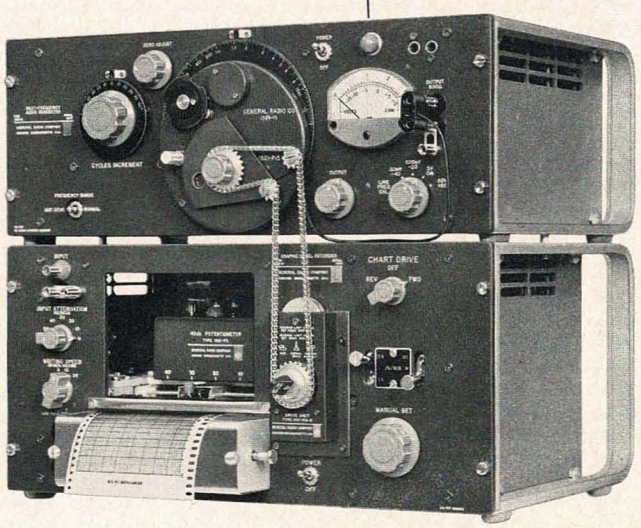
Mechanical Data:

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
19	485	16½	420	15¼	390	89	41	165	76

For a more detailed description, see *General Radio Experimenter*, September 1964.

Catalog No.	*Description*	*Price*
1350-9701	**Type 1350-A Generator-Recorder Assembly,** for 60-cycle supply	**$2055.00**
1350-9494	**Type 1350-AQ1 Generator-Recorder Assembly,** for 50-cycle supply	**on request**

NEW
in catalog S



Type 1304-P1 MUTING SWITCH

The muting switch short circuits the generator output during rotation through the blank portion of the dial and thus eliminates any low-frequency signals that might damage the recorder or the device under test when the recorder is swept continuously. The switch can be adjusted to mute the blank portion of the dial plus any range of frequencies from 0 c/s to 1.5 kc/s.

The switch mounts on the main-dial assembly of the generator and connects to the generator output terminals by means of a cable and plug.

Net Weight: 6½ oz (185 g). **Shipping Weight:** 3 lb (1.4 kg).

Catalog No.	*Description*	*Price*
1304-9601	**Type 1304-P1 Muting Switch**	**$37.50**

Type 1210-C UNIT R-C OSCILLATOR

SINE AND SQUARE WAVES — 20 c/s TO 0.5 Mc/s

FEATURES:

Wide frequency range — audio, ultrasonic, and radio frequencies.
High output voltage, constant with frequency.
Small — inexpensive — compact and rugged.
Precision frequency-control dial. ■ Sweepable, with dial drive.

USES: This compact, inexpensive oscillator offers outstanding performance per dollar and per cubic inch of space. It can be used as:

A sine-wave power source for measurements.

A square-wave source for network steady-state and transient response measurements.

A sine- or square-wave modulator for rf generators.

A square-wave trigger for pulse generators.

A swept oscillator for displaying amplitude-frequency characteristics (with the TYPE 907-R144 Dial Drive) on a graphic recorder.

A 3-watt oscillator, when combined with the TYPE 1206-B Unit Amplifier.

DESCRIPTION: An RC network determines the frequency of the oscillator. A fast-response AVC system holds the amplitude of oscillation constant despite changes in frequency or line voltage.

The oscillator has three different outputs that contribute to its versatility and usefulness:

1. A low-impedance, low-voltage, low-distortion output from a cathode-follower amplifier.

2. A high-impedance output from a high-voltage amplifier. Output impedance is independent of attenuator setting.

3. A square-wave output of 30 volts, peak-to-peak, (open-circuit) with $\frac{1}{3}$-μs rise time.

SPECIFICATIONS

FREQUENCY

Range: 20–500,000 c/s in five ranges: 20–200, 200–2000, 2000–20,000, 20,000–200,000, and 50,000–500,000 c/s. Dial has two scales and covers each decade in about 4½ turns.

Accuracy: ±3%.

Stability: Warmup drift is less than 1%, complete in 1 to 2 hours.

OUTPUT

Control: Logarithmic, calibrated 0 to 50 dB.

Low-Impedance: (for loads of 500 Ω and higher) 0 to 7 V, ±1 dB up to 200 kc/s, open circuit. Output impedance 50 Ω at full output, 1250 Ω at half output. No-load distortion less than 1%, 200 c/s to 10 kc/s, less than 1.5% at all frequencies. Hum at least 60 dB below output. Attenuator calibration reliable for loads of 12 kΩ and higher.

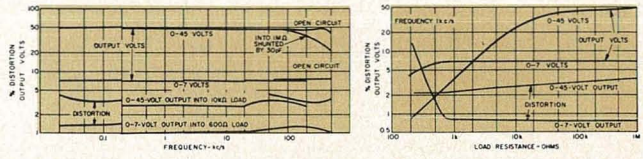
High-Impedance: (for loads of 10 kΩ and higher) 0 to 45 V, ±1 dB, 200 c/s to 150 kc/s, open circuit. Output impedance 14 kΩ, constant with attenuator setting. No-load distortion less than 5%, 200 c/s to 200 kc/s; reduced under load. Hum at least 50 dB below maximum output.

Square-wave: 0 to 30 V, p-to-p, open circuit. Output impedance 2500 Ω. Rise time about ⅓ μs, no load; 0.15 μs, 1-kΩ load. Overshoot about 1%. Hum at least 60 dB below output.

GENERAL

Power Required: TYPE 1203 Unit Power Supply, 50 to 400 c/s.

Accessories Available: TYPE 1206-B Unit Amplifier for 3-W output, TYPE 907-R144 Dial Drive, adaptor panel for rack mounting.



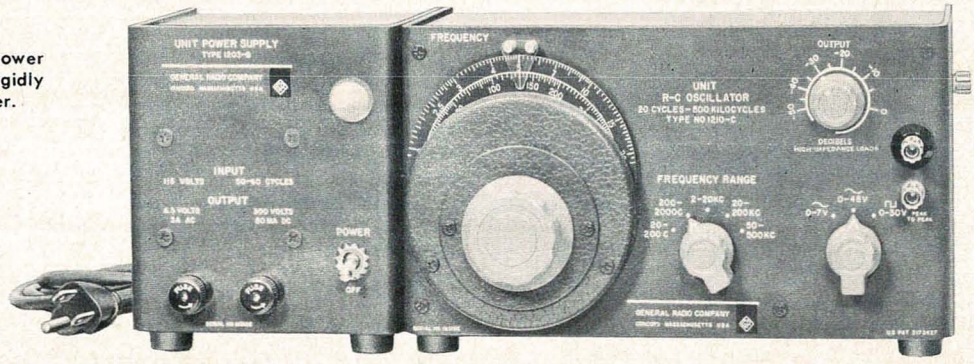
Typical sine-wave output and harmonic distortion characteristics of the Type 1210-C Unit R-C Oscillator as functions of frequency and load.

MECHANICAL DATA Unit-Instrument Cabinet (*see page 258*)

	Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
With power supply	15	385	5¾	150	7	180	10½	4.8	18	8.3

For a more detailed description, see *General Radio Experimenter*, April 1958.

Catalog No.	*Description*	*Price*
1210-9703	**Type 1210-C Unit R-C Oscillator**	**$185.00**
1203-9702	**Type 1203-B Unit Power Supply, 105–125 V**	**55.00**
1203-9818	**Type 1203-BQ18 Unit Power Supply, 195–250V**	**on request**
0480-9986	**Type 480-P4U3 Relay-Rack Adaptor Panel (panel height, 7 in)**	**12.00**



Oscillator and power supply can be rigidly clamped together.

TYPE 1310-A OSCILLATOR

2 c/s TO 2 Mc/s

FEATURES: Very wide frequency range. ■ Low distortion. ■ Constant output.
Rugged, compact; transistorized circuitry.
Can be synchronized with external source.

USES: The superior characteristics of this oscillator make it an exceptionally useful laboratory signal source.

Constant output over a very wide frequency range facilitates frequency-response measurements.

High-resolution dial, and exceptional amplitude and frequency stability are important for measurements in filters and narrow-band devices.

Equally useful in 600-ohm and 50-ohm circuits, since distortion is independent of load, even a short circuit.

When phase-locked to a frequency standard, the oscillator can deliver a high-level standard-frequency output with adjustable amplitude and low distortion.

DESCRIPTION: A capacitance-tuned, RC Wien-bridge oscillator drives a low-distortion output amplifier, which isolates the oscillator from the load and delivers a constant voltage behind 600 ohms.

A jack is provided for introduction of a synchronizing signal for phase locking or to furnish a signal, independent of the output attenuator setting, to operate a counter, or to synchronize an oscilloscope or another oscillator.

Seven transistors, one nuvistor, and ingenious design make the Type 1310-A Oscillator not only rugged, reliable, and insensitive to mechanical vibration but also compact and light in weight.

SPECIFICATIONS

FREQUENCY

Range: 2 c/s to 2 Mc/s in 6 decade ranges; continuously adjustable, one-turn, high-resolution dial with 4¼:1 drive.

Accuracy: ±2% of reading. **Stability:** Typical warmup drift, under 0.1%; typical drift after warmup, 0.001% short term (1 min), 0.03% long term (12 hr); all at 1 kc/s.

Synchronization: Telephone jack provided for external phase-locking signal. Locking range is about ±3% for 1-V, rms, input reference signal.

OUTPUT

Power: 160 mW into 600 Ω.

Voltage: Over 20 V, open circuit; continuously adjustable attenuator (approximately 50 dB).

Amplitude Stability: Typical drift after warmup, 0.02% short term (1 min), 1.0% long term (12 hr); both at 1 kc/s.

Frequency Characteristic: ±2%, 20 c/s to 200 kc/s, open circuit or 600-Ω resistive load. (See curve.)

Impedance: Approximately 600 Ω.

Distortion: <0.25%, 50 c/s to 50 kc/s, with linear loads; see curve. Hum <0.02% independent of attenuator setting.

Synchronization: High-impedance, constant-amplitude, 1-V, rms, output for use with oscilloscope, counter, or other oscillators.

GENERAL

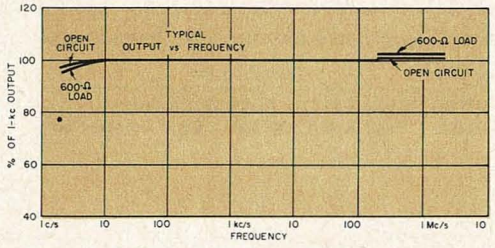
Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 c/s, 12 W.

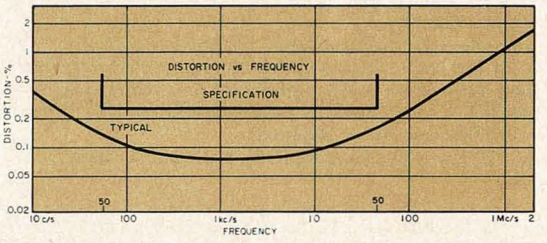
Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

MECHANICAL DATA Convertible-Bench Cabinet *(see page 258)*

Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
8¼	210	6	155	8⅛	210	7¾	3.6	10	4.6

Catalog No.	*Description*	*Price*
1310-9701	**Type 1310-A Oscillator**	**$295.00**





NEW
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Type 1311-A AUDIO OSCILLATOR

FEATURES:

One-watt output at 11 audio frequencies. ■ Output up to 4 amperes or 100 volts.
Low distortion, even on short circuit. ■ Low noise.
Drives balanced or grounded circuits. ■ All-solid-state circuitry.
Excellent frequency and amplitude stability.
Can be synchronized with external signal.

USES: The many features and superior performance of this instrument make it well suited for almost any application requiring a high-quality audio oscillator. For bridge measurements, the shielded output-transformer secondary minimizes circulating ground currents and matches loads over a wide impedance range. The frequency can be synchronized with that of an external standard for precise measurement of frequency-sensitive parameters.

Its short-term amplitude stability and frequency stability are advantageous for the calibration of high-speed level recorders and analog-to-digital convertors. Its ability to drive any load impedance with low waveform distortion makes it an outstanding general-purpose oscillator.

DESCRIPTION: The frequency is determined by a Wien-bridge network. A multi-stage, Class-B, six-transistor circuit delivers an output of one watt. A tapped output transformer makes available a wide range of voltages and short-circuit currents. Feedback around the whole amplifier makes the distortion practically independent of load impedance, even under short-circuit conditions.

The convertible bench-type cabinet can be easily mounted in a relay rack by means of adaptor panels.

SPECIFICATIONS

FREQUENCY

Range: 11 fixed frequencies, 50, 60, 100, 120, 200, 400, 500, 1000, 2000, 5000, 10,000 c/s. ΔF control provides ±2% adjustment. One other frequency can be added by the installation of two resistors at an unused switch position.

Accuracy: ±1% when ΔF control is at zero.

Frequency Stability: 0.1%, typical, long-term, after warmup.

Synchronization: Telephone jack provided for external synchronizing signal. Locking range is about ±3% for 1-V, rms, reference signal. ΔF control can be used for phase adjustment.

OUTPUT

Power: 1 W into matched load (taps provide at least 0.5 W into any resistive load between 80 mΩ and 8 kΩ.)

Voltage: Continuously adjustable from 0 to 1, 3, 10, 30, or 100 V, open circuit.

Current: Continuously adjustable from 0 to 40, 130, 400, 1300, 4000 mA, short circuit (approximately).

Impedance: Between one and two times matched load, depending on control setting. Output circuit is isolated from ground.

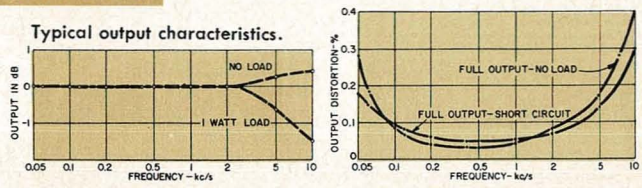
Amplitude Stability: Better than 1% long term, 0.01% short term, typical after warmup.

Synchronization: High-impedance, constant-amplitude, 1-V, rms, output for use with oscilloscope, counter, or other oscillator.

Distortion: Less than 0.5% under any load condition. Typically less than 0.1% over much of range. Oscillator will drive a short circuit without waveform clipping.

Ac Hum: Typically less than 0.003% of output voltage.

Typical output characteristics.



GENERAL

Terminals: TYPE 938 Binding Posts. Separate ground terminal holds shorting link, which can be used to ground adjacent OUTPUT binding post.

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s. 22 W.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Accessories Available: Rack-mounting set (panel 5¼ in high).

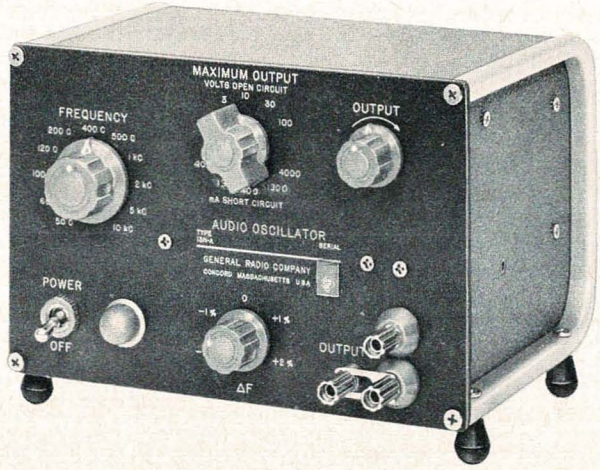
MECHANICAL DATA Convertible-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
8	205	6	155	7¾	200	6	2.8	9	4.1

See also *General Radio Experimenter*, August-September 1962.

Catalog No.	*Description*	*Price*
1311-9701	**Type 1311-A Audio Oscillator**	**$215.00**
0480-9638	**Type 480-P308 Relay-Rack Adaptor Set**	**7.00**

PATENT NOTICE. See Note 1, page 11.



Type 1308-A AUDIO OSCILLATOR AND POWER AMPLIFIER

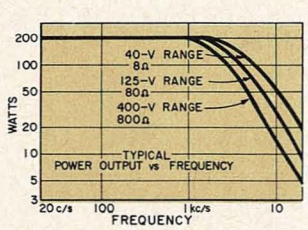
200-WATT, VARIABLE-FREQUENCY POWER SUPPLY

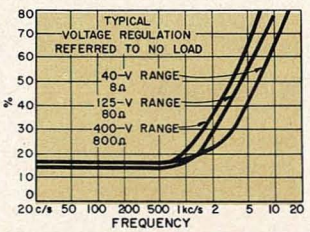
FEATURES: Wide frequency range — 20 c/s to 20 kc/s. All-solid-state circuitry. ■ Output transformer will pass dc. Matches wide range of loads. ■ Delivers up to 5 amperes or 400 volts. Power amplifier can be used separately.

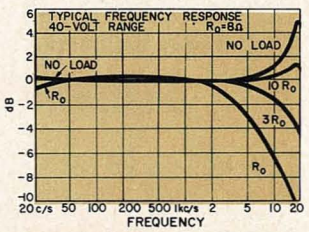
USES: The TYPE 1308-A Audio Oscillator and Power Amplifier is an ac power source covering the audio range. It is an excellent power source for the TYPE 1633-A Incremental-Inductance Bridge. Its low dynamic output impedance enhances its usefulness as a power source for testing other devices over a wide range of supply frequencies. This instrument will provide a low-distortion signal (not clipped) to nonlinear loads, such as capacitor-input rectifier systems. It can also be used to drive small shake tables and to isolate sensitive equipment from power-line transients.

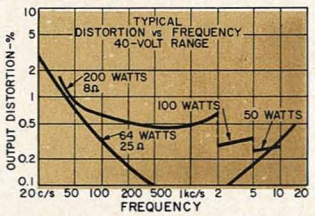
This instrument also finds many uses as an audio-frequency power amplifier. When it is used with the TYPE 1396-A Tone-Burst Generator, high-power tone bursts are provided for testing sonar projectors, amplifiers, etc.

DESCRIPTION: This instrument combines a capacitor-tuned, Wien-bridge oscillator, a low-distortion power amplifier, and a tapped output transformer. The output is monitored by an overload circuit, which turns off the output when it exceeds safe limits.









SPECIFICATIONS

FREQUENCY

Range: 20 to 20,000 c/s in 3 decade ranges. **Accuracy:** ±3%.

Stability: Approx 0.1% from no load to full load; short-term, approx 0.03%; warm-up drift at full load, 100 c/s, 1.5%; 1 kc/s and 10 kc/s, 0.03%.

OUTPUT

Power: 200 VA, 50 c/s to 1 kc/s; see curves.

Load Power Factor: (At full ratings) any for continuous operation to 30°C ambient or intermittent operation to 50°C ambient. 0.7 to 1.0 for continuous operation to 50°C ambient.

Overload Protector: Electronic overload circuit trips at about 1½ full-scale current (manual reset); thermal protection on transistor heat sink (automatic reset).

Voltage: 0 to 400 V, rms, in 5 ranges of 0 to 4, 12.5, 40, 125, and 400 V. Regulation (see curves) less than 20%, no load to full load, 20 c/s to 1 kc/s (bandwidth greater than 10 kc/s provides essentially instantaneous regulation).

Output Voltmeter: 0 to 5, 15, 50, 150, 500 V, full scale.

Current: 0 to 5 A, rms, in 6 ranges of 0 to 0.016, 0.05, 0.16, 0.5, 1.6, and 5 A. Ammeter output monitor, 0 to 0.05, 0.16, 0.5, 1.6, and 5 A full scale.

Optimum Load Impedances: 0.8, 2.5, 8, 80, 800 Ω. Operates satisfactorily with higher impedance or nonlinear loads. Output transformer passes dc equal to rated ac. Amplifier output impedance is approximately 0.3, 0.3, 1.6, 19, and 220 ohms, respectively, below 1 kc/s.

Harmonic Distortion: 1%, 100 c/s to 10 kc/s (with linear loads at rated output, see curves); 2%, 50 c/s to 100 c/s, with linear loads. With non-linear loads additional distortion in the load voltage is caused by the voltage drop in the amplifier output impedance.

Hum: 50 dB or more below max output.

AMPLIFIER

Sensitivity: About 2 V for full output. **Input Impedance:** 10 kΩ.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 70 to 500 W depending on load. For 50-cycle supply, maximum output must be reduced slightly.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

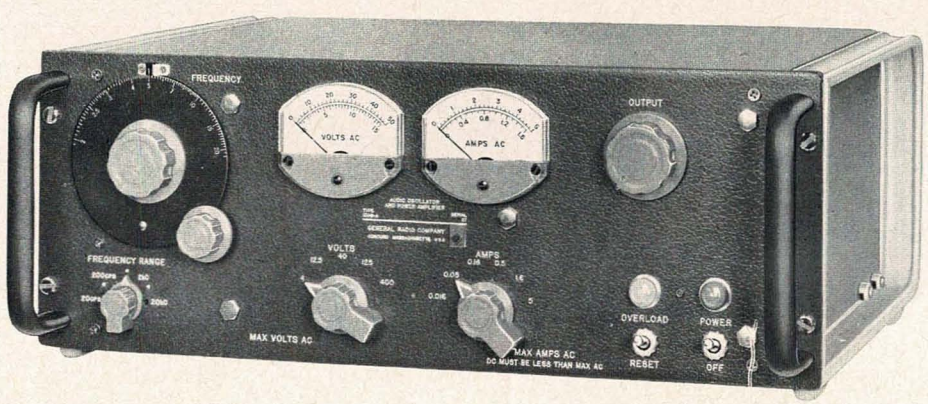
Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7	180	16¼	414	91	42	145	67
Rack	19	485	7	180	15*	385	91	42	145	67

* Behind panel.

See also *General Radio Experimenter*, January 1964.

Catalog No.	*Description*	*Price*
1308-9801	**Type 1308-A Audio Oscillator and Power Amplifier,** Bench Model	**$1150.00**
1308-9811	**Type 1308-A Audio Oscillator and Power Amplifier,** Rack Model	**1150.00**

PATENT NOTICE. See Note 1, page 11.



Type 1330-A BRIDGE OSCILLATOR

400 c/s TO 50 Mc/s

FEATURES:

Wide frequency range. ■ Good frequency stability.
Internal modulation available.
One-watt output over much of the radio-frequency range.
Excellent shielding.
Rugged and compact construction.

USES: The TYPE 1330-A Bridge Oscillator is an economical, general-purpose laboratory source of audio and radio frequencies. It covers the major part of the frequency range of the TYPE 1606-A and TYPE 916-AL Radio-Frequency Bridges and the TYPE 716-CS1 Capacitance Bridge. It also supplies 400 and 1000 c/s for bridge measurements. Its power output is adequate for most direct-deflection-type measurements with resonant circuits.

By means of adaptors (page 81) its coaxial output connectors can be made to fit all commonly used types.

DESCRIPTION: The circuit and the mechanical construction are similar to those of the TYPE 1001-A Standard-Signal Generator (page 150), but a higher-power oscillator tube is used, and the aperiodic output stage has been omitted. Tuning capacitor and inductors are ruggedly constructed to assure frequency stability, the oscillator circuits are doubly shielded to minimize stray fields, and a modulating circuit of unusual design provides excellent modulation characteristics over the radio-frequency range.

Modulation is available at two audio frequencies and at two levels, selected by switches.

SPECIFICATIONS

FREQUENCY

Range: 5 kc/s to 50 Mc/s, continuous, plus 1000 c/s, 400 c/s, and the power-line frequency.

Calibration: Direct reading for eight 3:1 ranges. Calibration is logarithmic, and vernier dial indicates increments of 0.1% per division from 5 kc/s to 15 Mc/s.

Accuracy: 400 and 1000 c/s, ±5%; frequencies below 150 kc/s, ±3%; above 150 kc/s, ±2%, all at no load. Frequency shift with 50-Ω load, 5% at low carrier frequencies; less than 1% above 150 kc/s.

OUTPUT

Voltage: Open-circuit audio, 12 V; rf, adjustable, approximately 10 V over the mid-frequency range, less at ends of range.

Power (Into 50-Ω load): Audio, approximately ¾ W; rf, 1 W, over most of range.

Impedance: Audio jack, 50 Ω; rf, 20 to 80 Ω, depending upon frequency, when output control is at maximum setting.

GENERAL

Distortion: Rf, with maximum output into 50 Ω, about 3.5%, except at the lower frequencies, where it reaches 7%. Audio, 5%.

Leakage: Stray fields are less than 50 μV/m at 2 ft from the oscillator.

Modulation: Internal only, at 400 and 1000 c/s, 25% and 50%.

Envelope Distortion: Less than 6% at 50% modulation; less than 4% at 25% modulation.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s; 30 W, approximately.

Terminals: GR874 Coaxial Connectors, locking. For connection to type N, BNC, TNC, SC, or C connector, use a locking adaptor (page 81), which locks securely in place yet is easily removed.

Accessories Supplied: TYPE 874-R22LA Coaxial Cable, TYPE 874-Q2 Adaptor, TYPE TO-44 Adjustment Tool (mounted on rf shield cover), TYPE CAP-22 Power Cord, and spare fuses.

MECHANICAL DATA Lab-Bench Cabinet (*see page 58*)

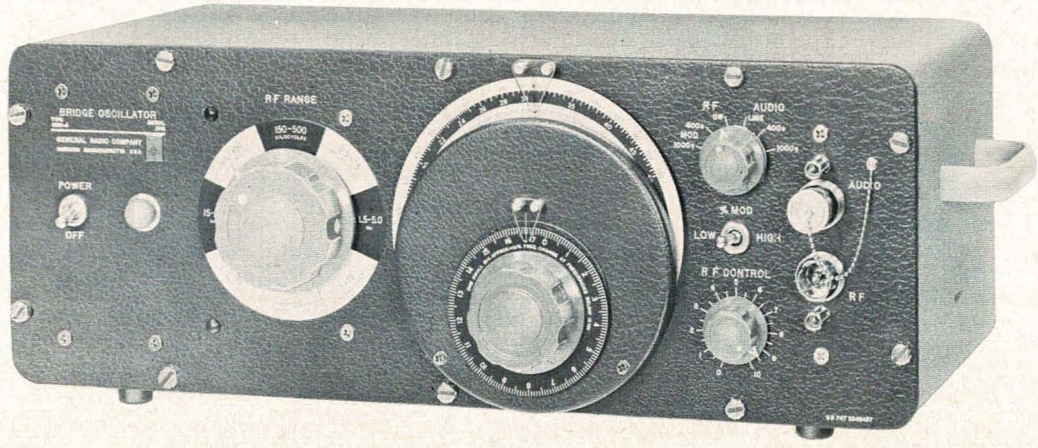
Cabinet can be removed for rack mounting (panel 19 by 7 in).

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
21¾	555	7½	190	11¼	285	37½	17	50	23

For a more detailed description, see *General Radio Experimenter*, December 1950.

Catalog Number	*Description*	*Price*
1330-9701	**Type 1330-A Bridge Oscillator**	**$735.00**

PATENT NOTICE. See Note 4, page 11.



HIGH-FREQUENCY OSCILLATORS

0.5 TO 2000 Mc/s

These compact, low-priced oscillators provide continuous coverage from 500 kc/s to 2000 Mc/s with single-dial control and output in the order of several hundred milliwatts. A complete listing of their characteristics will be found on pages 140 and 141. Additional coverage to 7425 Mc/s is provided by a group of microwave oscillators (see pages 145 and 146). In conjunction with one of the companion group of power supplies (see page 142), any oscillator becomes a complete signal source with characteristics adapted to the customer's application. By appropriate choice of power supply, the oscillator can deliver (1) maximum power, (2) optimum frequency stability with minimum residual fm and a-m, (3) pulse and square-wave modulated output, (4) amplitude-regulated output for sweeping applications, or (5) can be incorporated into a heterodyne detector system (see page 109). Power supplies and oscillators are designed for semi-permanent attachment for bench use or relay-rack mounting. Accessories suitable for use with these oscillators are listed on page 143.

GENERAL SPECIFICATIONS

for 500-kc — 2000-Mc Oscillators

Frequency Control: Gear-driven precision dials.

Output Power: Output power obtainable with TYPES 1203 or 1269, and 1201, 1264, or 1267 Power Supplies is shown in the figure accompanying the description of each oscillator. With TYPE 1216-A Unit I-F Amplifier, multiply the power shown for the TYPE 1203 or 1269 by about 0.4.

With the TYPE 1263-B Amplitude-Regulating Power Supply, the maximum useful power output is 20 milliwatts. The available power is adequate for practically all laboratory measurements with bridges, slotted lines, admittance and transfer-function meters, tuned circuits, etc.

Output System: A short coaxial line brings the output from an adjustable coupling loop (in the TYPE 1211-C, from a fixed loop and potentiometer) to a locking GR874 Coaxial Connector. The output connector is located at the rear of the oscillator except on the TYPE 1361-A, which has it on the front panel. Maximum power can be delivered to load impedances normally encountered in coaxial systems. Adaptors are available to convert the GR874 Connector to any other common type (see page 81). These adaptors lock securely in place, yet are easily removed.

Power Supply: The external power supply should be chosen from the group listed in the Summary of Power-Supply Characteristics, page 142. Operation from 400-cycle lines is permissible with many of these power supplies with all oscillators except the TYPE 1208-C.

Modulation: For amplitude modulation over the audio range, a modulating voltage is imposed on the plate supply. A jack is provided for this purpose. The audio source must be capable of carrying the dc plate current of the oscillator. The inexpensive TYPE 1214 fixed-frequency oscillators are recommended as modulators. For 30% a-m, incidental fm in this system is of the order of 0.01% at the lower part of the tuning range, and increases to about 0.05% at the high-frequency end. Approximately 40 volts across 8000 ohms is adequate to produce 30% modulation.

Square-wave or pulse modulation can be obtained on all oscillators, except the TYPE 1211-C and TYPE 1208-C, by use of the TYPE 1264-A Modulating Power Supply. All oscillators except the TYPE 1208-C can be square-wave modulated at 1 kc/s supplied by the TYPE 1263-B Amplitude-Regulating Power Supply.

Sweep Applications: Mechanical sweep at speeds suitable for oscilloscopic display can be obtained by use of the TYPE 1750-A Sweep Drive with the TYPES 1209-C, 1209-CL, 1211-C, 1215-C and 1361-A. The TYPES 1208-C and 1218-B are not recommended for this service because of the sliding contacts in their tuned circuits.

Slower mechanical sweep for use with XY recorders is possible with the TYPE 907-R144 or 908-R96 Dial Drives. The TYPE 1218-B is not recommended for use with these drives, but the TYPE 1208-C can be driven intermittently for short periods.

The TYPE 1263-B Amplitude-Regulating Power Supply is recommended to hold the oscillator output constant as the frequency is varied, particularly when mechanical sweep is employed. It can be used with all oscillators except TYPE 1208-C.

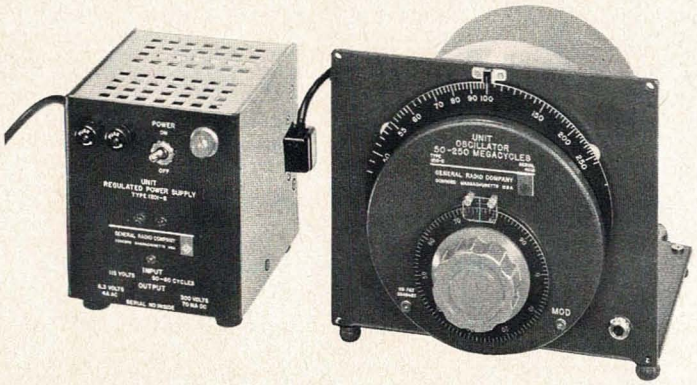
Mounting:

Bench Use — Any of the oscillators can be used on the bench with any of the recommended power supplies; interconnecting cables are supplied. All oscillators and all power supplies, except the TYPES 1203 and 1201, are 7 inches high and can be attached to each other with the hardware supplied to form a rigid assembly.

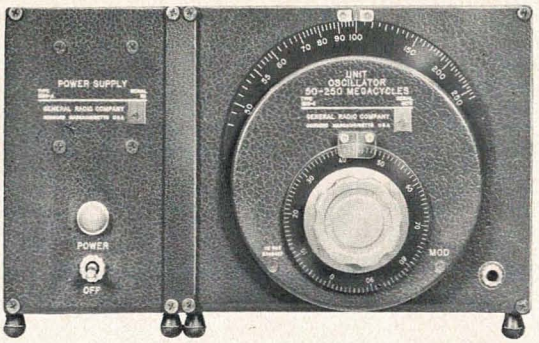
Relay-Rack Use — Any oscillator except the TYPE 1218-B can be relay-rack mounted together with a TYPE 1263, 1264, 1267, or 1269 Power Supply in 7 inches of rack height. The TYPE 1218-B requires 7 inches of rack height when mounted with a TYPE 1267 or 1269 Power Supply, or 14 inches of rack height when used with TYPE 1263 or 1264 Power Supply. Accessories required for rack mounting are listed on page 143. When the TYPE 1201 or TYPE 1203 Power Supply is used, separate rack-adaptor panels are necessary. For complete assemblies of oscillator and power supply for either rack mount or bench mount, see page 144.

See pages 140, 141, and 144 for individual listings

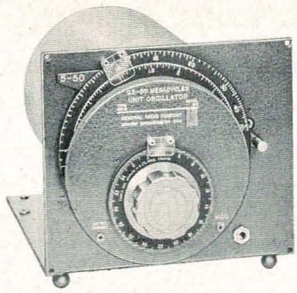
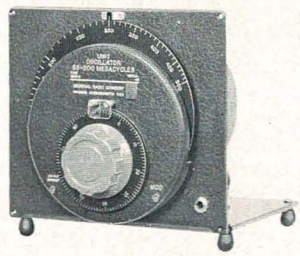
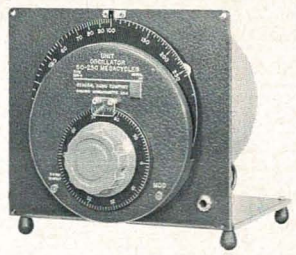
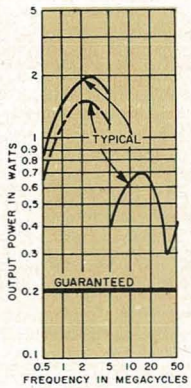
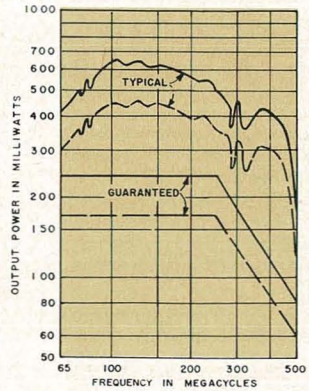
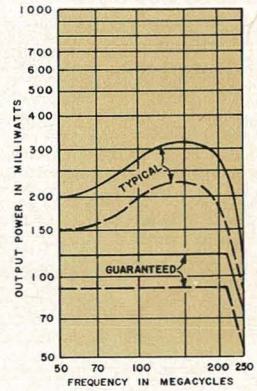
Oscillator with Unit-type power supply (Type 1201 or Type 1203).



Oscillator with Type 1269 or Type 1267 Power Supply. Oscillator with Type 1264 Power Supply is shown on page 144.



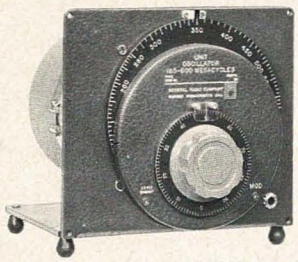
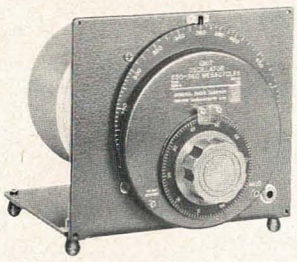
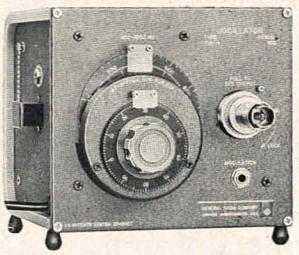
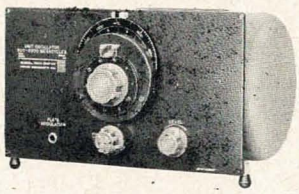
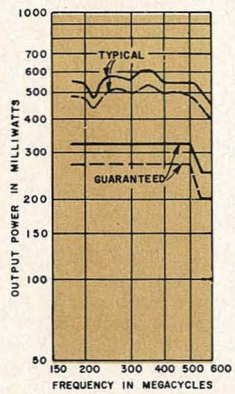
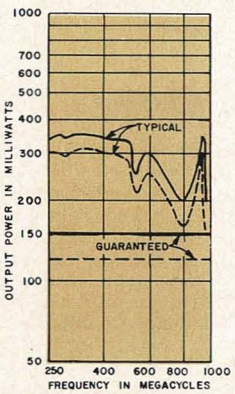
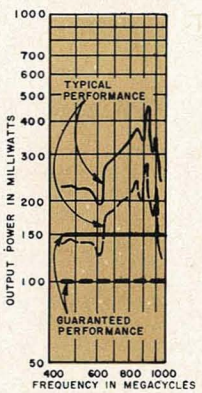
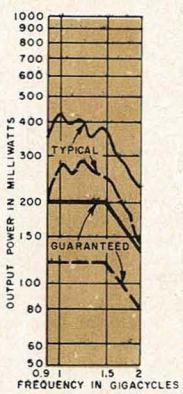
HF, VHF, UHF OSCILLATORS

Supplied with each oscillator, except as noted under "Remarks": Type 874-R22LA Patch Cord Telephone Plug			
Catalog Number	1211-9703	1208-9703	1215-9703
	Type 1211-C Unit Oscillator	Type 1208-C Unit Oscillator	Type 1215-C Unit Oscillator
Frequency	0.5 to 50 Mc/s	65 to 500 Mc/s	50 to 250 Mc/s
Tuned Circuit	Variable *L* and C	Variable *L* and C	Semi-Butterfly
Calibration Accuracy	±2%	±2%	±1%
Warmup Frequency Drift (typical)	0.4%	0.5%	0.2%
Power Output into 50 ohms using Power Supply: *—Type 1203 or 1269* *---Type 1201, 1264 or 1267.* *(See also page 142)*			
Cabinet[1] *(see page 258)*	Unit	Unit	Unit
Panel Dimensions	8 × 7 in (180, 205 mm)	8 × 7 in (180, 205 mm)	8 × 7 in (180, 205 mm)
Depth Behind Panel	9¾ in (250 mm)	7⅜ in (190 mm)	7½ in (190 mm)
Net Weight	11½ pounds (5.5 kg)	6 pounds (2.8 kg)	7¼ pounds (3.3 kg)
Shipping Weight	19 pounds (9 kg)	9 pounds (4.1 kg)	10 pounds (4.6 kg)
Price	**$340.00**	**$265.00**	**$225.00**
ACCESSORIES AVAILABLE			
Modulating Power Supply See pages 142 and 221.	No	No	Yes[2]
Amplitude-Regulating Power Supply See pages 143 and 220.	Yes	No	Yes
Dial Drives (page 154)	Types 908-P1, -P2, -R96	Types 908-P1, -R96	Types 908-P1, -P2, -R96
Sweep Drive (page 153)	Yes	Not recommended	Yes
Remarks	Type 874-Q2 Adaptor supplied	Sliding Contact	No Sliding Contact

[1] Relay-rack mount, see page 144. [2] Requires Adaptor Cable, TYPE 1264-P1 (see page 151).

See Page 144 for complete

HF, VHF, UHF OSCILLATORS

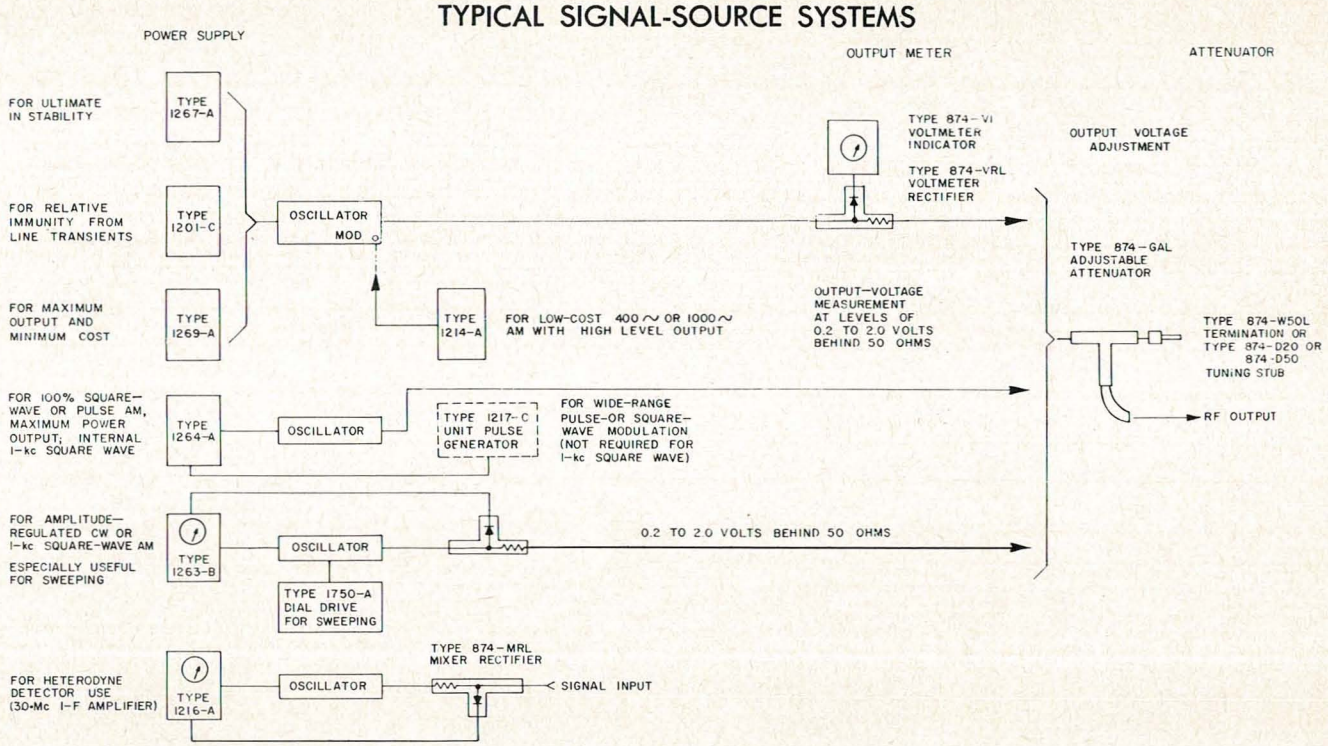
			NEW 
1209-9933	1209-9703	1361-9701	1218-9702
Type 1209-CL Unit Oscillator	Type 1209-C Unit Oscillator	Type 1361-A UHF Oscillator	Type 1218-B Unit Oscillator
180 to 600 Mc/s	250 to 960 Mc/s	450 to 1050 Mc/s	900 to 2000 Mc/s
Butterfly	Butterfly	Butterfly	Adjustable Lines
±1%	±1%	±1%	±1%
0.2%	0.2%	0.2%	0.1%
			
Unit	Unit	Convertible Bench	Unit
8 × 7 in (180, 205 mm)	8 × 7 in (180, 205 mm)	8 × 7 in (180, 205 mm)	12 × 7 in (305, 205 mm)
7⅜ in (190 mm)	7⅜ in (190 mm)	8¼ in (210 mm)	7½ in (190 mm)
6 pounds (2.8 kg)	6 pounds (2.8 kg)	7 pounds (3.2 kg)	15 pounds (7 kg)
9 pounds (4.1 kg)	9 pounds (4.1 kg)	11 pounds (5 kg)	26 pounds (12 kg)
$300.00	**$300.00**	**$300.00**	**$465.00**
ACCESSORIES AVAILABLE			
Yes[2]	Yes[2]	Yes	Yes
Yes	Yes	Yes	Yes
Types 908-P1, -P2, -R96	Types 908-P1, -P2, -R96	Types 908-P1, -P2, 907-R144	Not recommended
Yes	Yes	Yes	No
No Sliding Contact	No Sliding Contact	Logarithmic frequency scale. Low external field. Calibrated attenuator. No sliding contact.	Sliding Contacts. Fine frequency control. Low external field.

See page 139 for general specifications

combinations of Oscillators and Power Supplies.

HF OSCILLATORS

TYPICAL SIGNAL-SOURCE SYSTEMS



OSCILLATOR POWER SUPPLIES

Power-supply characteristics are frequently a determining factor in the performance of an oscillator. For such applications as parametric-amplifier pumps, oscillators must be stable against all power-line variations and free of modulation from power-supply ripple. For these extreme requirements, both plate and heater supplies should be regulated, well-filtered dc, as in the TYPE 1267 Power Supply.

Where relative freedom from line transients is required without ultimate reduction in longer term drifts and hum modulation, regulated plate supply is desirable, but unregulated ac may be used for the heater supply. This need is met by the TYPE 1201 Power Supply.

For many noncritical applications, unregulated dc plate and ac heater supplies are entirely adequate and represent considerable economy. The TYPE 1269-A and TYPE 1203 Power Supplies are of this type.

Other applications require power supplies in which the plate-supply voltage is controllable to modulate or to regulate the oscillator output. The TYPE 1264-A Modulating Power Supply provides 100% amplitude modulation at high level by square waves or pulses as well as CW operation. The TYPE 1263-B Amplitude-Regulating Power Supply includes a feedback loop to maintain constant oscillator output as the oscillator frequency is varied. Constant output not only speeds and simplifies measurements where the oscillator is tuned manually but is essential when making sweep measurements. The TYPE 1263-B Amplitude-Regulating Power Supply has an internal 1-kc oscillator for square-wave modulation.

SUMMARY OF OSCILLATOR POWER-SUPPLY CHARACTERISTICS

Type	*Applications*	*Input Line 50 to 60 c/s*	*Dc Plate Supply*	*Heater Supply*	*Panel Width*	*Page Ref*	*Price*
1267-A[1]	Ultimate stability for CW	105 to 125 V	300 V @ 70 mA, regulated	6.3 V dc @ 1 A, reg	4″	219	**$170.00**
1267-AQ18[1]		195 to 250 V					**on request**
1201-C[1]	Relative freedom from line transients	105 to 125 V	300 V @ 70 mA, regulated	6.3 V ac @ 4 A	*	219	**95.00**
1201-CQ18[1]		195 to 250 V					**on request**
1269-A[1]	Maximum output and low cost	105 to 125 V or 195 to 250 V	380 V open circuit; 300 V @ 50 mA	6.3 V ac @ 3 A	4″	219	**75.00**
1203-B	Maximum output and minimum cost	105 to 125 V			*	219	**55.00**
1203-BQ18		195 to 250 V					**on request**
1264-A[1,2,3]	100% square wave and pulse a-m	105 to 125 V or 210 to 250 V	200 to 300 V @ 50 mA, reg	6.3 V ac @ 2.1 A	8″	221	**285.00**
1263-B[2]	Amplitude-regulated CW or 1-kc square-wave output		0 to 300 V @ 30 mA	6.3 V dc @ 0.5 A	8″	220	**425.00**
1216-A[1]	Heterodyne detector		300 V @ 30 mA	6.3 V ac @ 1 A	*	107	**375.00**

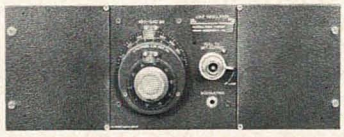
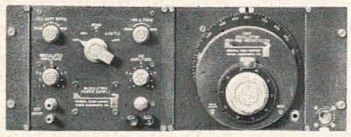
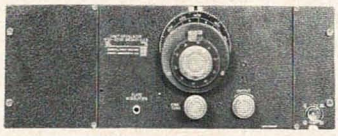
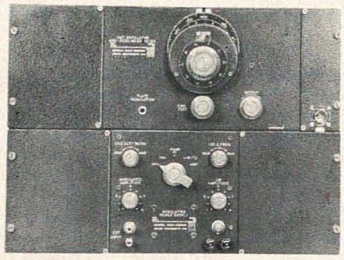
* Unit-Instrument Cabinet; see page referenced.
[1] May be operated from 400-cycle supply, except with TYPE 1208-C Unit Oscillator.
[2] Not for use with TYPE 1208-C Unit Oscillator.
[3] Requires TYPE 1264-P1 Adaptor Cable when used with TYPES 1215-C, 1209-CL, and 1209-C Unit Oscillators (see pages 140 and 141). Not recommended for use with TYPE 1211-C.

For complete combinations of Oscillator and Power Supply, see page 144.

RF OSCILLATOR ACCESSORIES

RACK-ADAPTOR SETS For mounting Oscillators and Power Supplies in a 19-inch rack

These adaptor sets include the necessary flanges and hardware for combining oscillator and power supply into a rigid assembly and for extending the panel width to rack size. A coaxial cable with panel connector is supplied for mounting on the right-hand adaptor panel to provide alternate front or rear output connections.*

Oscillator Type	*Adaptor Set for Oscillator only*	*Adaptor Set for Oscillator and either Type 1267 or Type 1269-A Power Supply*	*Adaptor Set for Oscillator and either Type 1263-B or Type 1264-A Power Supply*
1211-C **1215-C** **1208-C** **1209-C** **1209-CL** **1361-A**	 Catalog No. 0480-9608 Type 480-P408 **Price: $8.00**	 Catalog No. 0481-9642 Type 481-P412 **Price: $20.00**	 Catalog No. 0481-9646 Type 481-P416 **Price: $21.00**
1218-B	 Catalog No. 0481-9642 Type 481-P412 **Price: $20.00**	 Catalog No. 0481-9646 Type 481-P416 **Price: $21.00**	 Catalog No. 0482-9642 Type 482-P412† **Price: $24.00**

* Not supplied with TYPE 480-P408. † Consists of one set for oscillator and one set for power supply.

DIAL DRIVES Descriptions and specifications will be found on pages 153 and 154.

Type	*Name*	*Primary Characteristics*
908-P1	Synchronous Dial Drive	will drive TYPES 1330-A, 1211-C, 1215-C, 1208-C, 1209-CL, 1209-C, 1361-A, 1360-B.
908-P2	Synchronous Dial Drive	will drive TYPES 1211-C, 1330-A, 1215-C, 1209-CL, -C, 1361-A, 1360-B.
907-R144	Dial Drive	144° per minute; 20-kΩ potentiometer; use with TYPE 1361-A, 1360-B.
908-R96	Dial Drive	96° per minute; 20-kΩ potentiometer; use with TYPES 1211-C, 1215-C, 1208-C, 1209-CL, 1209-C, 1330-A.
1750-A	Sweep Drive	Sweep speed: 0.5-5 c/s; sweep arc: 30-300°; sweep voltage output to oscilloscope: 2.5 V, peak-to-peak. Will drive any GR oscillator or signal generator.

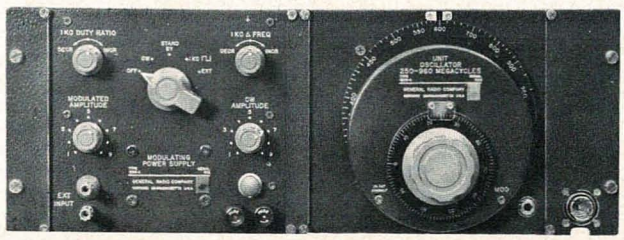
COAXIAL ELEMENTS

Name	*Type Number*	*Page Ref*
Adaptors, coaxial connector to type N, BNC, TNC, SC, C, or UHF connector	874-Q	81
Attenuator, adjustable	874-GA	88
Attenuator, fixed pads	874-G	88
Coaxial Cables	874-A2, A3	85
Detector, voltmeter (crystal)	874-VQ	86
Balun	874-UBL	94
Filters	874-F	87
Lines, air, fixed	874-L	90
Mixer Rectifier (crystal)	874-MR	87
Stub, adjustable (tuning)	874-D	91
Terminations	874-W	89
Line Stretchers	874-LT	90
Voltmeter	874-VI	86
Patch Cords	874-R	85

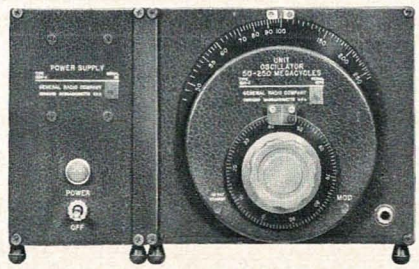
For complete combinations of Oscillator and Power Supply for both bench and rack mount, see page 144.

OSCILLATOR-POWER-SUPPLY COMBINATIONS

Frequency Range and (Oscillator Type) ↓	Performance → / (Power Supply Type) ↓		*Maximum power; lowest cost* (1269-A)	*Ultimate CW stability; very low residual fm* (1267-A)	(1267-AQ18)	*Stable CW; 100% square-wave & pulse modulation; internal 1-kc square-wave* (1264-A)	*Amplitude-leveled output behind 50-Ω source impedance; metered output level; 1-kc square-wave modulation, or CW* (1263-B)
	Input Line Voltage		105 to 125 V or 195 to 250 V	105 to 125 V	195 to 250 V	105 to 125 V or 210 to 250 V	105 to 125 V or 210 to 250 V
500 kc/s-50 Mc/s (Type 1211-C)	*Bench Mount*	*Catalog No.*	1211-9439	1211-9437	1211-9438	Not Available	1211-9433
		Type	1211-C9	1211-C7	1211-C7Q18		1211-C3
		Price	**$415.00**	**$510.00**	**on request**		**$765.00**
	Rack Mount	*Catalog No.*	1211-9579	1211-9577	1211-9578		1211-9573
		Type	1211-C9R	1211-C7R	1211-C7RQ18		1211-C3R
		Price	**$435.00**	**$530.00**	**on request**		**$786.00**
50-250 Mc/s (Type 1215-C)	*Bench Mount*	*Catalog No.*	1215-9439	1215-9437	1215-9438	1215-9434	1215-9433
		Type	1215-C9	1215-C7	1215-C7Q18	1215-C4	1215-C3
		Price	**$300.00**	**$395.00**	**on request**	**$525.00**	**$650.00**
	Rack Mount	*Catalog No.*	1215-9579	1215-9577	1215-9578	1215-9574	1215-9573
		Type	1215-C9R	1215-C7R	1215-C7RQ18	1215-C4R	1215-C3R
		Price	**$320.00**	**$415.00**	**on request**	**$546.00**	**$671.00**
65-500 Mc/s (Type 1208-C)	*Bench Mount*	*Catalog No.*	1208-9439	1208-9437	1208-9438	Not Available	Not Available
		Type	1208-C9	1208-C7	1208-C7Q18		
		Price	**$340.00**	**$435.00**	**on request**		
	Rack Mount	*Catalog No.*	1208-9579	1208-9577	1208-9578		
		Type	1208-C9R	1208-C7R	1208-C7RQ18		
		Price	**$360.00**	**$455.00**	**on request**		
180-600 Mc/s (Type 1209-CL)	*Bench Mount*	*Catalog No.*	1209-9539	1209-9537	1209-9538	1209-9534	1209-9533
		Type	1209-CL9	1209-CL7	1209-CL7Q18	1209-CL4	1209-CL3
		Price	**$375.00**	**$470.00**	**on request**	**$600.00**	**$725.00**
	Rack Mount	*Catalog No.*	1209-9589	1209-9587	1209-9588	1209-9584	1209-9583
		Type	1209-CL9R	1209-CL7R	1209-CL7RQ18	1209-CL4R	1209-CL3R
		Price	**$395.00**	**$490.00**	**on request**	**$621.00**	**$746.00**
250-960 Mc/s (Type 1209-C)	*Bench Mount*	*Catalog No.*	1209-9439	1209-9437	1209-9438	1209-9434	1209-9433
		Type	1209-C9	1209-C7	1209-C7Q18	1209-C4	1209-C3
		Price	**$375.00**	**$470.00**	**on request**	**$600.00**	**$725.00**
	Rack Mount	*Catalog No.*	1209-9579	1209-9577	1209-9578	1209-9574	1209-9573
		Type	1209-C9R	1209-C7R	1209-C7RQ18	1209-C4R	1209-C3R
		Price	**$395.00**	**$490.00**	**on request**	**$621.00**	**$746.00**
450-1050 Mc/s (Type 1361-A)	*Bench Mount*	*Catalog No.*	1361-9419	1361-9417	1361-9418	1361-9414	1361-9413
		Type	1361-A9	1361-A7	1361-A7Q18	1361-A4	1361-A3
		Price	**$375.00**	**$470.00**	**on request**	**$585.00**	**$725.00**
	Rack Mount	*Catalog No.*	1361-9509	1361-9507	1361-9508	1361-9504	1361-9503
		Type	1361-A9R	1361-A7R	1361-A7RQ18	1361-A4R	1361-A3R
		Price	**$395.00**	**$490.00**	**on request**	**$606.00**	**$746.00**
900-2000 Mc/s (Type 1218-B)	*Bench Mount*	*Catalog No.*	1218-9429	1218-9427	1218-9428	1218-9424	1218-9423
		Type	1218-B9	1218-B7	1218-B7Q18	1218-B4	1218-B3
		Price	**$540.00**	**$635.00**	**on request**	**$750.00**	**$890.00**
	Rack Mount	*Catalog No.*	1218-9549	1218-9547	1218-9548	1218-9544	1218-9543
		Type	1218-B9R	1218-B7R	1218-B7RQ18	1218-B4R	1218-B3R
		Price	**$561.00**	**$656.00**	**on request**	**$774.00**	**$914.00**



Type 1209-C4R



Type 1215-C9

Type 1360-B MICROWAVE OSCILLATOR

FEATURES:

Excellent frequency stability.
At least 50-milliwatt output over most of range — typically 100 milliwatt or more.
Output monitor permits maximum output setting for any frequency and load.
Internal linear sweep over 1- to 3-Mc bands; sync pulses also provided.
DB scale on attenuator, particularly useful at low output levels.
Modulation — internal 1-kc square wave; external fm, pulse, or square wave.

USES: The many modulation capabilities of this oscillator make it a most useful power source for microwave measurements. It is a suitable driver for slotted lines and a stable local oscillator for heterodyne detectors.

DESCRIPTION: The oscillator is a reflex klystron in a coaxial cavity with a non-contacting plunger. The two frequency ranges, 1.7 to 2.8 Gc/s and 2.6 to 4.1 Gc/s, are selected automatically by the main frequency dial. The scales are in different colors; a pilot light indicates the scale in use.

The output is adjustable and monitored against overcoupling.

Cathode, repeller, and bias voltages are well regulated, and the klystron heater supply is dc. Tube replacements, including the klystron, require no tools. Long-life Teflon* bearings are used for the plunger.

* Registered trademark of the E. I. duPont de Nemours and Company.

SPECIFICATIONS

FREQUENCY

Range: 1.7 to 4.1 Gc/s in two ranges, 1.7 to 2.8 Gc/s, covered in 5½ turns of tuning control, and 2.6 to 4.1 Gc/s, covered in 9 turns; 100-division interpolation scale.

Fine Frequency Control (ΔF): Order of 1 Mc/s, but not functioning for square-wave modulation.

Accuracy: ±1%.

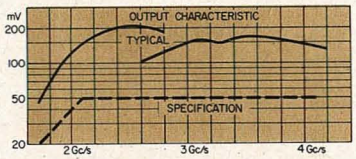
Stability: Warmup drift under laboratory conditions is approximately 0.15% during the first hour, total drift approximately 0.25%. After warmup, average frequency observed in a 1-second measurement interval is stable within approximately 5 ppm over a 10-minute period.

Residual FM: Approximately 0.5 ppm in the lower frequency range and 0.2 ppm in the higher. Dominant frequencies are 60 and 120 c/s (with 60-cycle line frequency.)

OUTPUT

Power: At least 20 mW from 1.7 to 2.1 Gc/s; at least 50 mW from 2.1 to 4.1 Gc/s. Individual instruments may vary 2:1 from typical curve.

Attenuator: Relative calibration only.



Output-power characteristic.

Terminal: GR874 Coaxial Connector, recessed, locking. For connection to type N, BNC, TNC, SC, or C connector, use a locking adaptor (page 81), which locks securely in place, yet is easily removed. Panel connector is recessed, and adaptor projects only about an inch from panel.

INTERNAL MODULATION

Narrow-Band Sweep: At least 0 to 1 Mc/s at either 1 kc/s or line-frequency rate. Maximum sweep width up to 3 Mc/s depends on carrier frequency. Negative pulse for oscilloscope synchronization provided.

Square-Wave: 1 kc/s, adjustable approximately ±5%.

EXTERNAL MODULATION

FM: Sensitivity approximately 0.2 Mc/s per V, input impedance, 400 kΩ and 70 pF (ac only).

Square-Wave: 50 c/s to 200 kc/s, 12 V, rms, sine wave or 20 V p-to-p, square wave; 20% minimum duty cycle from external source. Input impedance greater than 100 kΩ.

Pulse: Rise and fall times approximately 0.2 μs, minimum length approximately 0.5 μs. Input impedance 100 kΩ; driving-pulse amplitude, 20 V, p-to-p; maximum duty cycle 20%.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 85 W. Instrument will operate satisfactorily (except for line-frequency sweep) at power-line frequencies up to 400 c/s.

Accessories Supplied: TYPE 874-R22LA Patch Cord, TYPE CAP-22 Power Cord, spare fuses.

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

Model	Width		Height		Depth		Net Weight		Shipping Weight	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7½	195	15½	395	38	17.5	75	35
Rack	19	485	7	180	13*	330	38	17.5	75	35

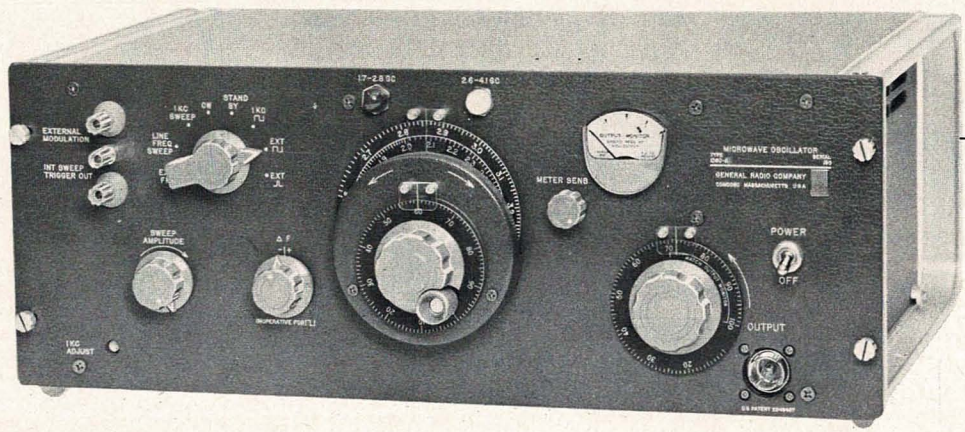
* Behind panel

For a more detailed description, see *General Radio Experimenter*, February 1962 and August 1964.

Catalog No.	*Description*	*Price*
1360-9802	**Type 1360-B Microwave Oscillator, Bench Model**	**$1175.00**
1360-9812	**Type 1360-B Microwave Oscillator, Rack Model**	**1175.00**

PATENT NOTICE. See Note 4, page 11.

1.7 TO 4.1 Gc/s



NEW MODEL
in catalog S

Type 1220-A UNIT KLYSTRON OSCILLATOR

2700 TO 7425 Mc/s

FEATURES:
Versatile, microwave power source.
Wide range of frequencies and modulation capabilities.
Small — compact — inexpensive.

USES: The Unit Klystron Oscillator generates fixed frequencies between 2700 and 7425 Mc/s which can be swept and can be amplitude modulated by either square waves or pulses, with low incidental fm.

Because of its relatively high output, low cost, small size, and rugged construction, it is equally useful in the laboratory, on the production line, and in classroom demonstrations. It is an excellent source for slotted-line measurements of impedance and VSWR, measurements of bandwidth, and attenuation measurements on cables, lines, and pads.

DESCRIPTION: This instrument includes an adjustable, regulated source of repeller voltage, a Schmitt squaring circuit, a 1000-cycle RC oscillator, and a socket for a reflex klystron tube.

Eight plug-in klystrons cover the frequency range. The oscillator is listed with each single klystron; additional klystrons can be ordered as desired.

The frequency range listed for each klystron can be covered by screw adjustment at the rear of the instrument.

SPECIFICATIONS

Frequency Range: Depends on klystron type (see table below); frequency range of any unit can be changed to that of any other by the insertion of the appropriate klystron.

Amplitude Modulation:

Internal: 1-kc square wave, adjustable ±15 c/s.

External: Square wave — 50 c/s to 200 kc/s; sine or square-wave modulating signal of at least 15 volts, rms, required — TYPE 1210-C Unit R-C Oscillator recommended.

Pulse: 1- to 10,000-μs duration, less than 0.2-μs rise and fall times, 50-cycle to 200-kc repetition rate; at least 20-V peak pulse voltage required — TYPE 1217-C Unit Pulse Generator recommended.

Frequency Modulation: At least 15-Mc excursion with less than 3-dB change in output at 60 c/s and rms-input of the order of 10 V.

Output Terminal: Locking GR874 Coaxial Connector. This instrument can be equipped with type N, BNC, TNC, SC, or C connectors through the use of locking adaptors, listed on page 81.

Power Required: TYPE 1201-C (or -CQ18) Unit Power Supply as shown below is required. Ac line connection to the oscillator chassis is made through this power supply. Normal power-line frequency is 50 to 60 c/s, but can be 400 c/s, provided that the line voltage is between 115 and 125 (230 and 250) V.

Accessories Recommended: Fixed attenuator pad for isolating oscillator from load (page 88); TYPE 874-VQ or -VR for facilitating tuning adjustments (page 86).

Mechanical Data: Unit-Instrument Cabinet *(see page 258)*

	Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
With power supply	15	380	5¾	145	6¼	160	12	5.5	16	7.5

For a more detailed description, see *General Radio Experimenter*, March 1957.

Catalog Number	*Description*	*Nominal Output in mW*	*Price*	*Tube only Type*	*Catalog Number*	*Price*
	Klystron Oscillator with Klystron, for					
1220-9411	**Type 1220-A1 2700-2960 Mc/s,**	100	**$385.00**	**726-C**	1220-9601	**$ 65.00**
1220-9412	**Type 1220-A2 2950-3275 Mc/s**	90	**408.25**	**6043**	1220-9602	**88.25**
1220-9413	**Type 1220-A3 3400-3960 Mc/s**	90	**415.00**	**2K29**	1220-9603	**95.00**
1220-9414	**Type 1220-A4 3840-4460 Mc/s**	75	**422.50**	**2K56**	1220-9604	**102.50**
1220-9415	**Type 1220-A5 4240-4910 Mc/s**	100	**415.00**	**2K22**	1220-9605	**95.00**
1220-9416	**Type 1220-A6 5100-5900 Mc/s**	80	**412.00**	**6115**	1220-9606	**92.00**
1220-9417	**Type 1220-A7 5925-6450 Mc/s**	100	**388.00**	**QK404**	1220-9607	**68.00**
1220-9418	**Type 1220-A8 6200-7425 Mc/s**	90	**388.00**	**5976**	1220-9608	**68.00**
1220-9701	**Type 1220-A Klystron Oscillator** (without Tube)		**320.00**			
1201-9703	**Type 1201-C Unit Regulated Power Supply** (105 to 125 V)		**95.00**			
1201-9824	**Type 1201-CQ18 Unit Regulated Power Supply** (210 to 250 V)		**on request**			
0480-9986	**Type 480-P4U3 Relay-Rack Adaptor Panel** (holds both oscillator and power supply)		**12.00**			

All klystron tubes except the 6043 are designed for relatively infrequent tuning. With most of the klystrons listed, tuning can be accomplished without removal of shield.

PATENT NOTICE. See Note 4, page 11.

Power for the klystron cathode and for the internal 1-kc modulator is furnished by an external Unit Power Supply, shown here with the oscillator.

STANDARD-SIGNAL GENERATORS

A standard-signal generator is a source of alternating-current energy of accurately known characteristics. The carrier, or center, frequency is indicated by a dial setting, the output voltage by a meter reading and associated attenuator setting, and the modulation by a meter reading set by appropriate control knobs. Common types of modulation signals are sine-wave, square-wave, and pulse; the output signal may be either frequency- or amplitude-modulated by these signals. When the frequency-modulation system produces a considerable excursion in frequency at a relatively low cyclical rate, the instrument is known as a sweep-frequency generator and is particularly useful for automatic data display. Standard-signal generators are used for testing radio receivers, as voltage standards over the range from a few microvolts to about a volt, and generally as power sources in measurement of gain, bandwidth, signal-to-noise ratio, standing-wave ratio, and other circuit properties.

For use as a standard-signal generator, the oscillator must be stable, have reasonably constant output over any one frequency range, have good waveform, and have no appreciable hum or noise modulation. Careful over-all shielding of the generator is essential in order to minimize stray fields.

The elements of an amplitude-modulated standard-signal generator are shown in Figure 1. An amplifier may be added readily at lower frequencies, as shown in Figure 2, to isolate the oscillator from the load and to minimize the incidental frequency modulation that usually results from amplitude modulation. The elements of a standard sweep-frequency generator are shown in Figure 3.

Amplitude-Modulated Signal Generators

The three General Radio amplitude-modulated standard-signal generators are general-purpose, wide-tuning-range instruments covering the range from 5 kc/s to 940 Mc/s. Amplitude modulation is provided from an internal, fixed-frequency, sine-wave generator or from an external audio-frequency source. This provision is omitted for sweep-frequency generators. Amplitude modulation is generally accompanied by incidental frequency modulation. This can be minimized by an amplifier, as mentioned above.

Sweep-Frequency Generators

The Type 1025-A Standard Sweep-Frequency Generator covers the range from 700 kc/s to 230 Mc/s in ten octave bands and has in addition bandspread ranges at 450 kc/s and 10.7 Mc/s. This instrument employs a rotating tuning capacitor to bring the precision and stability of conventional, manually tuned signal generators to the field of sweep measurement. It sweeps 20 times per second over complete octave ranges and is fast enough to eliminate flicker. This generator includes a very effective automatic level control so that the full advantage may be taken of the use of sweep techniques.

Sweep-Frequency Operation of Conventional Signal Generators

Conventional manual signal generators can also be swept over limited ranges through the use of the Type 1750-A Sweep Drive, which can impart reciprocating rotation up to 300 degrees at rates of 1 to 5 c/s to the tuning control (see Figure 2). The corresponding frequency variation is listed in the specifications for the individual instruments.

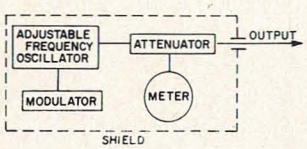


Figure 1. Elements of a standard-signal generator.

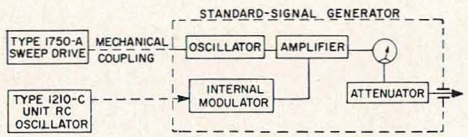


Figure 2. Modulation (and sweep) methods.

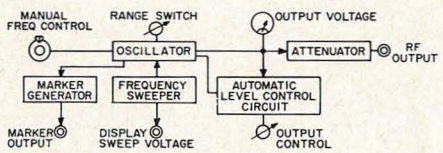


Figure 3. Elements of a standard sweep-frequency generator.

STANDARD-SIGNAL GENERATORS

Type	*Frequency Range*	*Open-Circuit Voltage*	*Output Impedance*	*Modulation %*	*Page*
1001-A	5 kc/s–50 Mc/s	0.1 μv–200 mV	10 Ω, 50 Ω	0–80%	150
1021-AV	40–250 Mc/s	0.5 μv–1 V	50 Ω	0–50%	151
1021-AU	250–940 Mc/s	0.5 μv–1 V	50 Ω	0–50%	151

STANDARD SWEEP-FREQUENCY GENERATOR

1025-A	0.7 to 230 Mc/s 0.45 and 10.7 Mc/s	0.3 μV–1 V	50 Ω	Sweep, all bands	148

ACCESSORIES

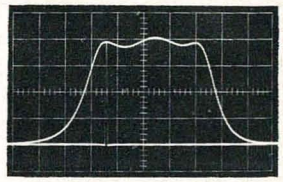
1000-P4	Dummy Antenna	152
1000-P5	VHF Transformer (50 ohms grounded to 300 ohms balanced)	152
1000-P10	Test Loop	152

Type 1025-A STANDARD SWEEP-FREQUENCY GENERATOR

FEATURES:

Wide frequency range, plus bandspread ranges for 450 kc/s and 10.7 Mc/s.
Rf output from 1 μV to 1 V, accurately calibrated.
Quiet, reliable motor-driven sweep provides drift-free display.
Display can cover any portion of selected frequency range from 1/10 to full range.
Single, continuously variable marker is accurately calibrated in both frequency and amplitude — does not interfere with displayed response.
Converts easily from sweep to true cw operation.
Separate high-level output to operate a counter without disturbance to cw output.
Low leakage makes possible accurate measurements at low signal levels.

USES: The standard sweep-frequency generator is an accurately calibrated source for sweep-frequency measurements on tuned circuits, filters, i-f amplifiers, and other networks. Amplitude and frequency data can be taken directly from the oscilloscope display by use of the calibrated marker. The instrument can be easily switched to cw operation, so that the response can be displayed point-by-point without changes in the test setup.



Marker is accurately calibrated in frequency and amplitude.

DESCRIPTION: This instrument combines the characteristics of the standard-signal generator and the swept oscillator.

The frequency of the sinusoidal output is varied smoothly and continuously over a frequency band in repetitive cycles by a motor-driven tuning capacitor. Thus, the amplitude response of a network or device as a function of frequency can be displayed automatically on an oscilloscope. A synchronously varying horizontal deflection voltage is provided. The large dial indicates the frequency of a manually positioned marker on the display. The amplitude of the marker is adjustable and is monitored by a panel meter, thus providing frequency and amplitude calibration of the displayed response.

The frequency range is covered in 10, step-switched, octave bands plus 2 bandspread ranges.

The entire selected range is swept, but, by means of EXPAND DISPLAY and DISPLAY START controls, as little as one-tenth of any range can be set to occupy the full width of the oscilloscope screen.

Manual and slow-speed (with auxiliary dial drive) operation is also possible, for XY recording and point-by-point measurements. A detector probe is supplied, but the dc output of devices with built-in detectors can also be utilized.

SPECIFICATIONS

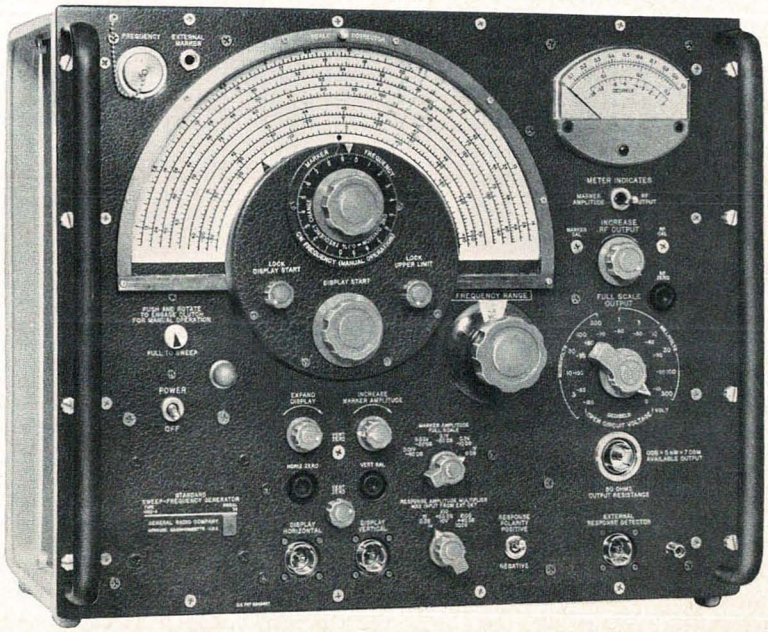
FREQUENCY

Range: 0.7 to 230 Mc/s in 10 ranges (0.7 to 1.4, 1.3 to 2.6, 2.4 to 4.8, 4 to 8, 7 to 14, 13 to 26, 24 to 48, 40 to 80, 65 to 140, and 100 to 230 Mc/s) and bandspread ranges of 400 to 500 kc/s and 10.7 ± 0.3 Mc/s.

Alternate range* sectors can be substituted in the range-selector turret. Those presently available are: 0.4 to 0.8 Mc/s, 2 ± 0.1 Mc/s, 2.8 ± 0.1 Mc/s, 4 to 5 Mc/s, 5 ± 0.3 Mc/s, 16 ± 0.3 Mc/s, 19 ± 1 Mc/s, and 40 to 50 Mc/s. Special bandspread ranges* can be provided as follows:

Specified Center Frequency	*Bandwidth*
Between 0.4 and 0.5 Mc/s	±0.01 Mc/s
0.45 and 1.6 Mc/s	±0.03 Mc/s
1.4 and 5 Mc/s	±0.1 Mc/s
4.5 and 16 Mc/s	±0.3 Mc/s

* Prices on request.



Control: 11-in semicircular dial, logarithmic scales for octave bands up to 80 Mc/s, quasi-logarithmic between 65 and 230 Mc/s, essentially linear for all bandspread ranges. One division on the slow-motion dial represents approximately 0.1% frequency difference on the octave frequency bands.

Calibration Accuracy: ± 0.5% of reading at output voltages less than 0.3 V when scale corrector is set to bring dial to index line. Frequency changes up to ± 0.5% can be caused by load changes at output voltages over 0.3V. With an external frequency meter, scale corrector can be used to bring dial into agreement, for frequency resolution within ± 0.1%.

Drift: 0.3%, or less, for 3 h after 1-h warmup.

Sweeping Rate: 20 times per second, 22.2 ms from low- to high-frequency end; output blanked for return sweep.

Sawtooth Sweep Voltage: 100 V, p-to-p, max; amplitude and starting point in frequency band both adjustable.

Marker: 3 mV to 1 V, adjustable, internally generated, half-sinusoidal waveform, at any frequency within sweep range; response amplitude multiplier effectively extends range up to 100 V; amplitude is indicated to an accuracy of ± 10%.

External Marker Input Voltage: 1 V, p-to-p, into 50 kΩ. Birdie-type markers can be applied, which are controlled in amplitude and added to the response displayed.

RF OUTPUT

Voltage: 0.3 μV to 1 V (-123 to 7 dBm power) behind 50 Ω, adjustable.

Accuracy: ± 14% of reading, over-all, up to 100 Mc/s; harmonics may add additional ±3% error above 100 Mc/s. Over-all accuracy is sum of voltmeter error of ± 2% of reading + 2% of full scale and attenuator error of 1% per step up to a maximum of 6%.

Stability: Output constant within ± 1% (0.1 dB) up to 100 Mc/s, ± 3% (0.25 dB) up to 230 Mc/s. Output variations due to band switching and line-voltage changes will not exceed ±3% (0.25 dB) max. TYPE 874-R22LA Patch Cord reduces output 5% (0.4 dB) at 230 Mc/s.

Effective Generator Impedance: 50 Ω resistive, VSWR less than 1.01 at panel jack; less than 1.1 at output of TYPE 874-R22LA Patch Cord, over the frequency range of the active generator.

Leakage: External rf field produces negligible interference with measurements down to lowest output levels.

RESPONSE AMPLIFIER

Input Voltage: 1, 10, or 100 V, max, as selected by response-amplifier switch. Noise level (with 100-kΩ source) varies with multiplier-switch setting — 1 mV max, p-to-p, at ×1 (1V), 10 mV at ×10 (10 V), and 100 mV at ×100 (100 V), referred to input.

Input Impedance: 1 MΩ parallel with 30 to 45 pF.

Gain: Approximate dc amplification between external response input connector and vertical display output connector varies with multiplier-switch setting — ×8 (18 dB) at ×1, ×0.8 at ×10, ×0.08 at ×100.

Bandwidth: 10 kc/s or greater; sufficient to pass all details of any response that can be resolved at maximum sweep rate.

Polarity: Switch provided to give positive display output voltage with either positive or negative inputs from external response detector.

OTHER OUTPUT VOLTAGES

Display, Vertical: Up to + 8 V into 100-kΩ load, consisting of marker plus response to be displayed.

Display, Horizontal: Up to + 100 V dc or sawtooth peak into 100-kΩ load.

Frequency Output Voltage: 0.1 to 0.3 V into 50 Ω for operating external frequency counter or external marker generator.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 60 c/s, 145 W. 50-cycle model available.

Terminals: GR874 Coaxial Connector, recessed, locking, except EXTERNAL MARKER input connector, which is a standard telephone jack. For connection to type N, BNC, TNC, SC, C, or UHF connector, use a locking adaptor (page 81), which locks securely in place, yet is easily removed. Panel connector is recessed, and adaptor projects only about an inch from panel. See also page 80.

Accessories Supplied: TYPE 1025-P1 Detector Probe, 2 TYPE 874-R22A Patch Cords, TYPE 874-R22LA Patch Cord, 3 TYPE 874-R33 Patch Cords, 2 TYPE 874-C58A Cable Connectors, 6 TYPE 838-B Alligator Clips, TYPE CAP-22 Power Cord, phone plug, spare fuses.

Accessories Available: TYPE 874-VQ Voltmeter Detector, TYPE 874-WM 50-ohm Termination, TYPE 908-P3 Synchronous Dial Drive. Dial drive provides 125° per min dial speed (at 60 c/s), manually reversible, for slow-speed XY recording. It is powered by a 50- to 60-cycle synchronous motor and is installed in place of the frequency control knob.

MECHANICAL DATA Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	16	410	13¾	350	73	34	152	70
Rack	19	485	15¾	400	11⅛ *	290	73	34	152	70

* Behind panel

For a more detailed description, see *General Radio Experimenter*, January 1963. "Sweep-Frequency Measurement Techniques" (General Radio Reprint A-109) is also available, free on request.

TYPE 1025-P1 DETECTOR PROBE
(supplied with instrument)

Frequency: 0.4 to 250 Mc/s, flat within 5% (0.4 dB).

Fall Time: 150 μs, or less, sufficiently short to follow all details of any response that can be resolved at maximum sweep rate of generator.

RF Voltage: 3 V, rms

Input Impedance: 25 kΩ in parallel with 1.5 pF up to 10 Mc/s, decreases to 6 kΩ at 250 Mc/s.

Transfer Characteristic: Positive polarity; dc output voltage equals rms rf voltage above 0.5-V input; essentially square-law characteristic below 50 mV input.

Catalog Number	*Description*	*Price*
1025-9801	**Type 1025-A Standard Sweep-Frequency Generator** (for 60-cycle supply), Bench Model	**$3250.00**
1025-9811	**Type 1025-A Standard Sweep-Frequency Generator** (for 60-cycle supply), Rack Model	**3250.00**
1025-9495	**Type 1025-AQ1 Standard Sweep-Frequency Generator** (for 50-cycle supply), Bench Model	**on request**
1025-9496	**Type 1025-AQ1 Standard Sweep-Frequency Generator** (for 50-cycle supply), Rack Model	**on request**
0908-9603	**Type 908-P3 Synchronous Dial Drive**	**40.00**

PATENT NOTICE. See Note 4, page 11.

Type 1001-A STANDARD-SIGNAL GENERATOR

FEATURES:

Low cost. ■ Small, light, and sturdy — the result of design and construction simplicity.
Excellent frequency stability — both short-term and long-term.
Very low residual output and stray field.
Frequency relatively unaffected by load or attenuator setting.
Output amplifier avoids sideband clipping and isolates oscillator from load.
Output can be matched into a 50-ohm system.

USES: The TYPE 1001-A Standard-Signal Generator is a laboratory instrument for use in determining the performance of receivers and other equipment at ultrasonic and radio frequencies. Its sturdy construction and simplicity of operation make it suitable for production testing. Because of its small size, light weight, and low power consumption, it can be adapted for use in field-strength measurements.

The frequency can be swept by the TYPE 1750-A Sweep Drive.

DESCRIPTION: The oscillator frequency varies logarithmically with dial rotation, so that the precision of frequency setting is constant; the vernier dial is calibrated directly in percentage frequency increments.

A buffer amplifier between the oscillator and the low-impedance output circuits can be amplitude modulated from zero to 80%. Loose coupling between the oscillator and the amplifier minimizes incidental frequency modulation. The output circuit is coupled to the amplifier through a high-pass filter, to reduce modulation-frequency voltages in the output.

The output voltage is determined by a carrier-level control and two output controls. The carrier-level control adjusts the plate-supply voltage of the oscillator, and the output controls set the attenuation of a continuously adjustable, L-network attenuator, and a decade step attenuator.

A 400-cycle RC oscillator supplies internal modulation voltage. The panel meter can be switched to monitor either carrier-level input to the attenuator or modulation percentage.

SPECIFICATIONS

CARRIER FREQUENCY

Range: 5 kc/s to 50 Mc/s in 8 ranges of 5 to 15 kc/s, 15 to 50 kc/s, 50 to 150 kc/s, 150 to 500 kc/s, 0.5 to 1.5 Mc/s, 1.5 to 5 Mc/s, 5 to 15 Mc/s, and 15 to 50 Mc/s. Logarithmic scale up to 15 Mc/s, departs slightly from logarithmic at higher frequencies. Vernier-dial frequency increment is 0.1% per dial division up to 15 Mc/s.

Accuracy: ±1% of reading.

Stability: Warmup drift is of the order of 0.25%. Half the maximum drift is reached in approximately 1½ hours.

Sweep: Maximum range with TYPE 1750-A Sweep Drive is 14%.

Distortion and Noise Level:

Envelope Distortion: Less than 8% at 80% amplitude modulation.

Carrier Noise Level: Corresponds to about 0.1% modulation.

Carrier Distortion: Of the order of 7% on all except 5 to 15 kc/s range, where it may increase to approximately 15%.

Leakage: Stray fields at 1 Mc/s are less than one microvolt per meter two feet from the generator.

Amplitude Modulation: 0 to 80%, continuously variable, indicated on the panel meter to ±10% of reading with possible additional error of 2% modulation.

Internal modulation frequency, 400 c/s ± 5%.

External modulation characteristic, 20 c/s to 15 kc/s, flat within ±1 dB; 12 V into 4 kΩ required for 80% modulation.

Incidental Frequency Modulation: 30 to 300 ppm at 80% amplitude modulation, over all ranges except 15 to 50 Mc/s where it may be 3 times as great; approximately proportional to modulation percentage at low modulation percentages.

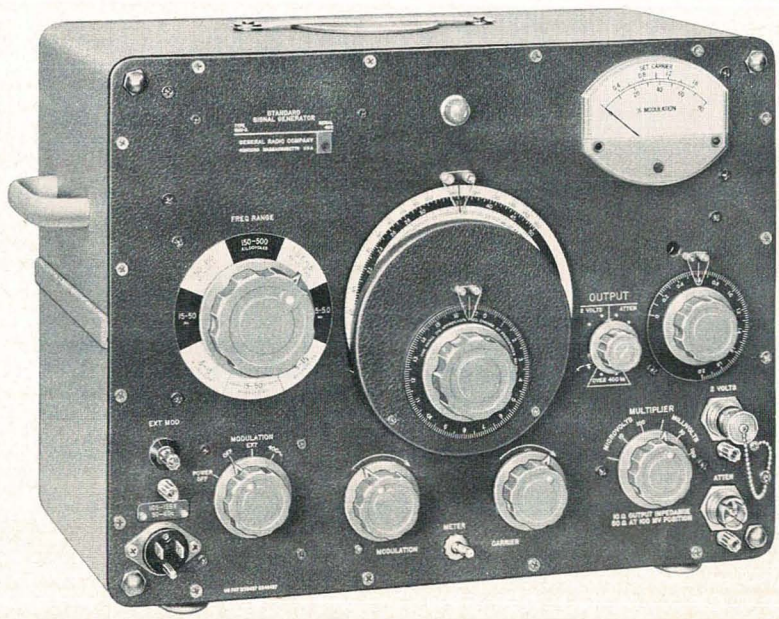
OUTPUT

Output	*Voltage*	*Impedance*
2 VOLTS Terminal	2 V, open circuit, up to at least 15 Mc/s, with output meter set to reference mark. Accuracy: ±3% at mid-frequencies.	300Ω
ATTEN Terminal	0.1 μV to 200 mV, open circuit; 0.05 μV to 100 mV with output cable terminated at both ends; continuously variable. Accuracy: ±(6% + 0.1 μV), 150 kc/s to 10 Mc/s with output dial near full scale or 1/10 full scale (error may be 4% greater with output dial set to mid-scale region); ±(10% +0.3 μV) above 10 Mc/s with output dial near full scale (error may be 10% larger or smaller at other output dial settings).	10Ω; 50Ω when series unit is used; 50Ω at highest output position of attenuator; 25Ω at end of terminated cable.

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 40 to 60 c/s, 65 W; 115 to 125 V up to 400 c/s.

Terminals: GR874 Coaxial Connectors, recessed, locking. For



5 kc/s TO 50 Mc/s

connection to type N, BNC, TNC, SC, C, or UHF connector, use a locking adaptor (page 81), which locks securely in place, yet is easily removed. Panel connector is recessed, and adaptor projects only about an inch from panel.

Accessories Supplied: TYPE 874-R22LA Coaxial Cable, TYPE 1000-P1 50-Ohm Termination Unit, TYPE 1000-P2 40-Ohm Series Unit, TYPE 874-Q2 Adaptor, TYPE TO-44 Adjustment Tool (stored in cabinet), TYPE 274-MB Plug, TYPE CAP-22 Power Cord, spare fuses.

Accessories Available: TYPE 1000-P4 Standard Dummy Antenna, the TYPE 1000-P10 Test Loop, TYPE 1750-A Sweep Drive. (Pages 152 and 153.)

MECHANICAL DATA Lab-Bench Cabinet *(see page 258)*

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
20¼	515	13¾	350	11	280	54	25	67	31

See also *General Radio Experimenter*, September 1949.

Catalog Number	*Description*	*Price*
1001-9701	**Type 1001-A Standard-Signal Generator**	**$995.00**

PATENT NOTICE. See Note 4, page 11.

Type 1021 STANDARD-SIGNAL GENERATOR

FEATURES:

Simplicity; reliability; low cost. ■ Ease of operation.
Wide frequency coverage in single dial range. ■ Good frequency stability.
Accurately known output voltage, frequency, and impedance.
Auxiliary calibration in dB below one milliwatt.
High output. ■ Excellent shielding.

USES: These reliable vhf and uhf generators can be used to determine radio receiver and amplifier characteristics in the engineering laboratory and in production, as well as to supply power at very-high and ultra-high frequencies for bridges, slotted lines, and other measuring devices.

The frequency can be swept by the TYPE 1750-A Sweep Drive.

DESCRIPTION: Each TYPE 1021 Standard-Signal Generator is made up of two units mounted in a single cabinet. One unit consists of the power supply, modulator, and metering system; the other is one of the readily interchangeable carrier oscillators.

Individual tuning units can be furnished for use with one common power supply and cabinet assembly. Power supply and cabinet assembly can also be purchased separately.

The frequency-determining elements are butterfly circuits. A mutual-inductance-type attenuator, with a dial calibrated in both open-circuit voltage and dB below one milliwatt, is used. Provision is made for external and 1000-cycle, sine-wave, internal amplitude modulation.

SPECIFICATIONS

Type	*Frequency Range*	*Accuracy*	*Sweep Range (with Type 1750-A)*
1021-AV	40 to 250 Mc/s in two bands — 40 to 50 Mc/s, 50 to 250 Mc/s	±1% of reading. Approx 8 turns of 100-division slow-motion dial cover range of main dial.	Approx 4% at 40 Mc/s, 9% at 50 Mc/s and 20% at 250 Mc/s
1021-AU	250 to 940 Mc/s in one band		Approx 5% at low end of range and 15% at high end.

OUTPUT

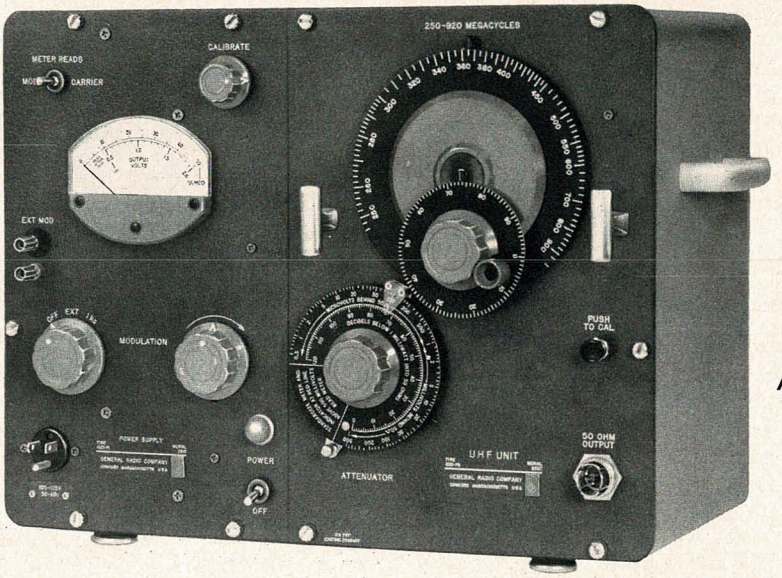
Power: 0 to 126 dB below 1 mW into 50 Ω, directly calibrated.

Voltage: 0.5 μV to 1 V behind 50 Ω, continuously variable.

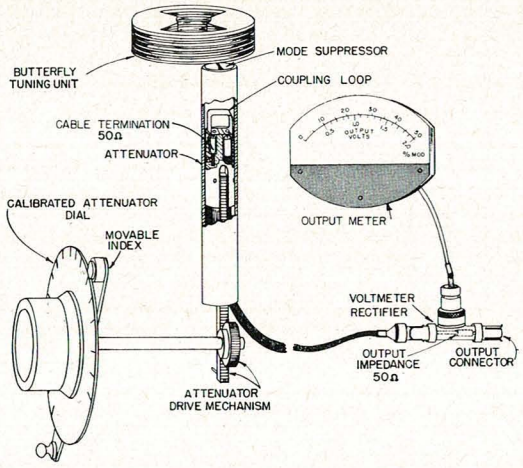
Voltage Accuracy: ±2 dB over-all; voltmeter calibration, ±1 dB between 0.5 and 1.0 V; attenuator calibration, ±0.5 dB between 1 μV and 0.1 V and ±1 dB between 0.1 V and 0.5 V.

Impedance: 50 Ω ± 10%, following output meter.

Amplitude Modulation: 0 to 50%. Internal, 1000 c/s ± 5%. External, 30 c/s to 15 kc/s, flat within ±3 dB; 18 V into 100 kΩ for 50% modulation. TYPE 1310-A Oscillator is recommended.



40 TO 250 Mc/s AND 250 TO 940 Mc/s



Functional diagram of output system.

The output voltmeter is connected across the output of the attenuator. The accuracy of the output voltage at the reference point is determined by the voltmeter alone and is unaffected by the length of cable between the pickup loop in the attenuator and the point where the voltage is measured. Open-circuit output voltages between 0.5 and 2 volts are indicated by the meter; the output impedance is 50 ohms. For lower voltages, the output is first set to 0.5 volt, and the movable attenuator index is set to the 0.5-volt point on the attenuator dial. Voltages are then indicated by the attenuator dial, as long as the load is unchanged.

Incidental FM at 50% Amplitude Modulation (approximate):
TYPE 1021-AV, 100 ppm up to 100 Mc/s; 500 ppm up to 250 Mc/s.
TYPE 1021-AU, 100 ppm up to 400 Mc/s; 1000 ppm up to 920 Mc/s.

Distortion and Noise Level:
Envelope Distortion: Approximately 5% at 50% modulation.
Carrier Noise Level: Corresponds to about 0.2% modulation.

Leakage: Stray fields and residual output voltage are sufficiently low for measurements on receivers of 1-μV sensitivity.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 50 W; 110 to 125 or 220 to 250 V, 400 c/s.
Terminal: GR874 Coaxial Connector. This instrument can be equipped with type N, BNC, TNC, SC, C, or UHF connector through the use of locking adaptors, listed on page 81.
Accessories Supplied: TYPE 874-R22LA Patch Cord, TYPE CAP-22 Power Cord, spare fuses.
Accessories Available: GR874 Coaxial Elements, TYPE 1750-A Sweep Drive, TYPE 1000-P5 VHF Transformer.

MECHANICAL DATA Lab-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
20¼	515	13½	345	11	280	37½	17.5	50	23

See also *General Radio Experimenter*, March 1950.

Catalog Number	*Description*	*Price*
1021-9827	**Type 1021-AV VHF Standard-Signal Generator,** 40 to 250 Mc/s	**$795.00**
1021-9939	**Type 1021-AU UHF Standard-Signal Generator,** 250 to 940 Mc/s	**795.00**
1021-9602	**Type 1021-P2 UHF Oscillator Unit* only,** 250 to 940 Mc/s	**475.00**
1021-9920	**Type 1021-P3B VHF Oscillator Unit* only,** 40 to 250 Mc/s	**475.00**
1021-9601	**Type 1021-P1 Power Supply** (includes modulator unit and cabinet)	**320.00**

* Less power supply unit and cabinet. Can replace oscillator unit in signal generator listed above, to provide additional frequency range.

PATENT NOTICE. See Notes 4 and 10, page 11.

Type 1000-P4 DUMMY ANTENNA

Connected to the terminated output of a 50-ohm generator, this dummy antenna provides the output characteristics specified by the IRE (IEEE) in "Standards on Radio Receivers, Methods of Testing Amplitude-Modulation Broadcast Receivers," 1948.
Dimensions: Diameter ⅞, length 4⅜ in (23, 115 mm).
Net Weight: 3¼ oz (0.1 kg). **Shipping Weight:** 1 lb (0.5 kg).

Type 1000-P10 TEST LOOP

For testing radio receivers with loop antennas by the preferred method of the 1948 "Standards on Radio Receivers, Methods of Testing Amplitude-Modulation Broadcast Receivers," published by the IRE (IEEE). The 3-turn loop is enclosed in aluminum tubing for electrostatic shielding. The field strength in volts per meter, 19 inches from the loop, is one-tenth the generator output in volts, with a 50-ohm generator.
Frequency: 3 Mc/s, max.
Accuracy: ±10% (±5% is typical); with TYPE 1001-A Standard-Signal Generator, ±15% (±10% is typical).
Dimensions: Width 11¾, height 16½, depth 3½ in (300, 420, 89 mm), over-all.
Net Weight: 4½ lb (2.1 kg). **Shipping Weight:** 6 lb (2.8 kg).

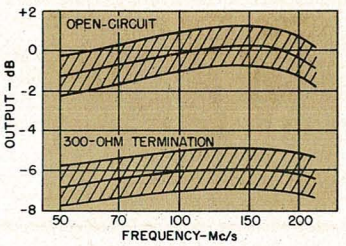
Catalog Number	*Description*	*Price*
1000-9604	**Type 1000-P4 Dummy Antenna**	**$16.00**
1000-9605	**Type 1000-P5 VHF Transformer**	**27.50**
1000-9610	**Type 1000-P10 Test Loop**	**50.00**

TYPE 1000-P5 VHF TRANSFORMER

50 TO 220 Mc/s

The TYPE 1000-P5 VHF Transformer plugs into a 50-ohm standard-signal generator to produce an equal, balanced, open-circuit voltage behind a 300-ohm balanced impedance for measurements of fm and TV receivers.
One terminal fits the Alden HA902P Connector for standard 300-ohm line, the other a GR874 Coaxial Connector.
Dimensions: Diameter ⅞, length 4⅜ in (23, 115 mm).
Net Weight: 3½ oz (0.1 kg). **Shipping Weight:** 1 lb (0.5 kg).

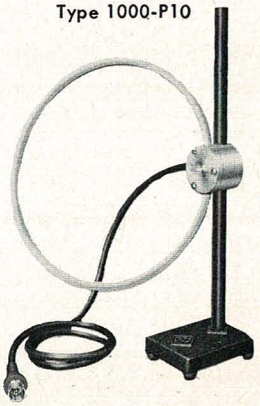
See also *General Radio Experimenter*, November 1949.



Type 1000-P4

Type 1000-P5

Type 1000-P10



Type 1750-A SWEEP DRIVE

MECHANICAL HAND FOR AUTOMATIC SWEEPING

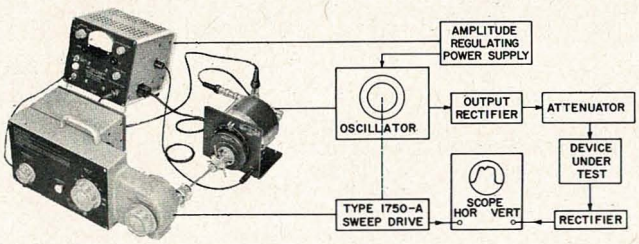
FEATURES:

Provides narrow- and wide-range automatic data display.
Converts mechanically tunable oscillators or generators to swept-signal sources.
Attaches easily to most knobs, dials or shafts.
Sweeps any arc from 30° to 300° at rates up to 5 per second.

USES: The TYPE 1750-A Sweep Drive adapts manually operated equipment to sweep operation. It can be used in the display of electrical quantities as a function of the shaft angle of the device being swept and can be adjusted to sweep, in reciprocating motion, any arc from 30 to 300 degrees, at rates up to 5 per second. In conjunction with GR Unit Oscillators, it makes available an extremely versatile system of swept signal sources covering a frequency span from 20 c/s to 2000 Mc/s. For constant output over the entire frequency range of any one of the Unit Oscillators, the TYPE 1263-B Amplitude-Regulating Power Supply is used. See pages 139 and 221.

DESCRIPTION: The output shaft is driven through an adjustable rack and a differential. Sweep frequency, arc, and center position are all adjustable while the drive is in motion. An adjustable limit switch can be set to stop the drive when predetermined limits of motion of the driven shaft are exceeded.

An oscilloscope-deflection-voltage circuit provides horizontal deflection that is proportional to shaft angle. A blanking circuit is included to eliminate the oscilloscope return trace and to produce a base line. At low sweep rates, memory or storage oscilloscopes are desirable.



A constant-amplitude sweeping system consisting of a Type 1750-A Sweep Drive, a Unit Oscillator, an amplitude-regulating power supply, and GR874 coaxial accessories.

SPECIFICATIONS

Output Shaft

Center Position: Adjustable over 9-turn range.

Sweep Arc: Adjustable 30 to 300 degrees.

Sweep Rate: Adjustable 0.5 to 5 per second. Moment of inertia of driven device determines upper limit.

Torque: 24 ounce-inches, max. Will drive TYPES 1209-C, 1209-CL, 1211-C, 1215-C Unit Oscillators, TYPE 1361-A UHF Oscillator, TYPE 1360-B Microwave Oscillator, TYPE 1304-B Beat-Frequency Audio Generator, TYPE 1308-A Audio Oscillator and Power Amplifier, TYPES 1305-A, 1310-A, and 1330-A Oscillators, TYPE 1564-A Sound and Vibration Analyzer, TYPES 1001-A and 1021-A Standard-Signal Generators.

Height of Shaft: Adjustable, 2½ to 4⅞ in over bench.

Flexible Coupling: 5¾ in long. Couples to ¼- and ⅜-in shafts; knobs and dials 1 to 4 in in diameter.

Limit Switch: Adjustable within 9 turns.

Sweep Voltage: 2.5 V, peak-to-peak, ungrounded.

Blanking: Shorting contact closed during clockwise rotation of driven shaft, ungrounded.

Power Required: 105 to 125 volts, 50 to 60 c/s, 60 W. On 400-cycle supply, maximum sweep speed is reduced 25%. A 210- to 250-volt model, TYPE 1750-AQ18, is also available.

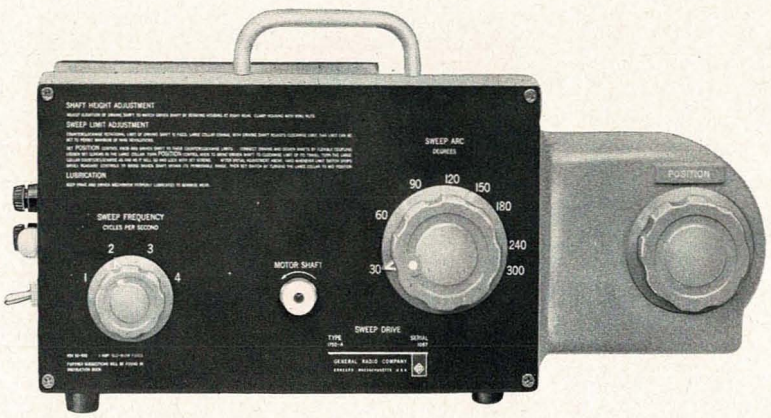
Accessories Supplied: Couplings, lubricant, spare fuses.

Mechanical Data:

Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
17½	445	9	230	8¼	210	22½	10.5	33	15

For a more detailed description, see *General Radio Experimenter*, April 1955. For a discussion of sweep measurements, ask for a copy of "Sweep-Frequency Measurement Techniques" (Reprint A-109), free on request.

Catalog No.	*Description*	*Price*
1750-9701	**Type 1750-A Sweep Drive, for 115-volt Model**	**$595.00**
1750-9911	**Type 1750-AQ18 Sweep Drive, for 230-volt Model**	**on request**



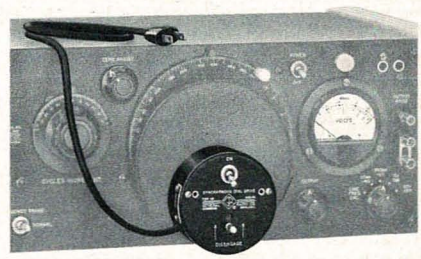
Type 907, 908 DIAL DRIVES

FEATURES:

- Inexpensive mechanical sweep device.
- Attaches directly on oscillator dial.
- R-models furnish a horizontal deflection voltage.
- Convenient sweep means for use with storage scopes.

DESCRIPTION: These dial drives are an inexpensive means for adapting manually operated equipment to sweep operation. They can be installed directly in place of the vernier knob on TYPE 908 Dials and on the TYPE 907 dials used on GR high-frequency Unit Oscillators.

Each drive is powered by a synchronous motor. When the drive encounters a mechanical stop, the TYPE 908-P3 stops; the others reverse automatically. Adjustable stops that clamp on the dial are furnished; power switch and power cord are included.



Type 907-R144 Dial Drive installed on the Type 1304-B Beat-Frequency Audio Generator.

SPECIFICATIONS

Power Required: 105 to 125 V, 50 to 60 c/s, 3 W. For 210- to 250-volt supply, an external 2:1 step-down transformer must be used. On 50-cycle lines, dial speeds are reduced 20%.

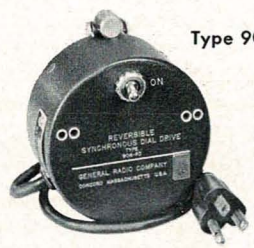
TYPE 908-P SYNCHRONOUS DIAL DRIVES: Can be used on all TYPE 907 and 908 Precision Dials. The synchronous-motor drive supplies the equivalent of a horizontal time calibration.

TYPE 907-R and 908-R DIAL DRIVES supply a sweep voltage proportional to angle of rotation. One knob engages the motor, the other permits manual setting at any point and direct manual drive. A dc voltage, applied to an internal 20-kΩ potentiometer (10 mA, max), permits use with a wide range of dc output levels. Binding posts for the position-signal output are provided.

Drive Type	**908-P1**		**908-P2**		**908-P3**	**908-R96**	**907-R144**
Dial Type	907	908	907	908		908	907
**Dial Speed °/min*	144	96	1080	720	135	96	144
Resolution						0.2°	0.4°
Recommended Display	Graphic Recorder		Oscilloscope		XY Recorder	XY Recorder	XY Recorder
Will Drive These Instruments	1208-C, 1209-C, 1209-CL, 1211-C, 1215-C, 1330-A, 1304-B, 1210-C, 1360-B, 1361-A		1209-C, 1209-CL, 1211-C, 1215-C, 1304-B, 1360-B, 1361-A		1025-A	1208-C, 1209-C, 1209-CL, 1211-C, 1215-C, 1304-B, 1305-A, 1330-A	1210-C, 1564-A 1360-B, 1361-A
Dimensions	Depth 3, dia 3⅝ in (76, 92 mm)					Depth 3⅞, dia 5⅞ in (100, 150 mm)	Depth 3⅞, dia 4 in (100, 105 mm)
Net Weight	1¼ lb (0.6 kg)					2 lb (0.9 kg)	1¾ lb (0.8 kg)
Shipping Weight	3 lb (1.4 kg)					3 lb (1.4 kg)	3 lb (1.4 kg)
Catalog Number	0908-9601		0908-9602		0908-9603	0908-9859	0907-9885
Price	**$40.00**		**$40.00**		**$40.00**	**$85.00**	**$75.00**

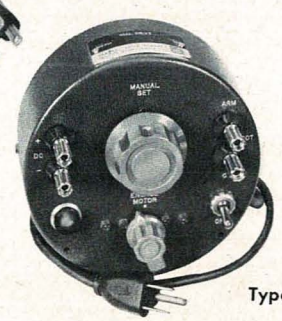
* For 60-cycle power. With 50-cycle power, dial speeds are reduced 20%.

Type 908-P1



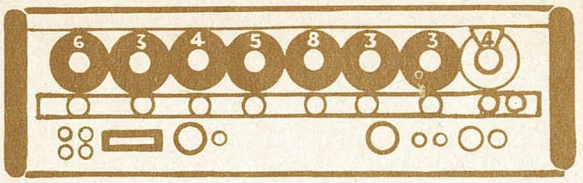
Type 908-P3

Type 908-P2



Type 908-R96

Type 907-R144



FREQUENCY SYNTHESIZERS

Appearing for the first time in this catalog are three new precision frequency sources, the Types 1161-A, 1162-A, and 1163-A Coherent Decade Frequency Synthesizers. They deliver 2 volts at accurately known, stable, sine-wave frequencies, selectable on a decimal-digit basis, from 0 c/s* to a maximum of 0.1, 1, or 12 Mc/s. Any chosen output frequency is coherently derived from a single, internal, quartz-crystal oscillator.

The output frequency is synthesized directly by repetitive arithmetic manipulations of frequency in a series of identical modules.

All three synthesizers are equipped for direct, front-panel, digit selection, and each is available in 20 models. Choice of model depends upon the user's requirements for resolution, versatility, and remote programming.

*30 c/s for TYPE 1163-A.

COHERENT DECADE FREQUENCY SYNTHESIZERS

NEW in catalog S

FEATURES:

Sine-wave outputs of quartz-crystal frequency stability.
Settable to any frequency within the specified ranges.
Resolution to at least 9 significant figures — bright, in-line digital frequency display.
Frequency-adjustable, digit-by-digit or continuously.
Low cost — 60 models to meet exact needs for frequency range and resolution.
Programmable/manual or manual only.
All-solid-state; plug-in modules for system expansion and ease of maintenance.
Internally calibratable electronic sweep.
Ac or battery power.

USES: The Coherent Decade Frequency Synthesizer is an excellent source of accurately known, stable, sine-wave signals for precise measurements. No external frequency counter is needed.

GR synthesizers are well suited for repeatable, high-precision, frequency-response measurements on amplifiers, filters, transducers, and similar electronic devices, by either point-by-point or sweep techniques. Models equipped with a Continuously Adjustable Decade can furnish swept-frequency output signals over frequency bands selectable in width from hundreds of kilocycles per second to a fraction of a millicycle per second. Precise frequency markers can also be derived with the help of simple external circuits.

GR frequency synthesizers are also stable, operational signal sources for sophisticated radar, telemetry, single-sideband communications, and data-handling systems.

Large illuminated digits on the decade controls eliminate errors in reading and ensure precise frequency adjustment and accurate resettability in production-line applications.

Programmed adjustment is available to speed repetitive testing, to ensure exact frequency reproduction, and to allow for remote operation.

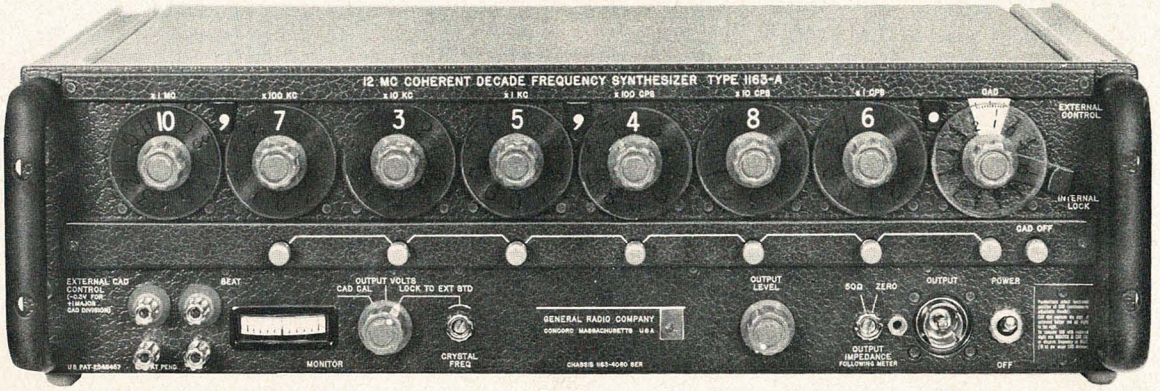
DESCRIPTION:

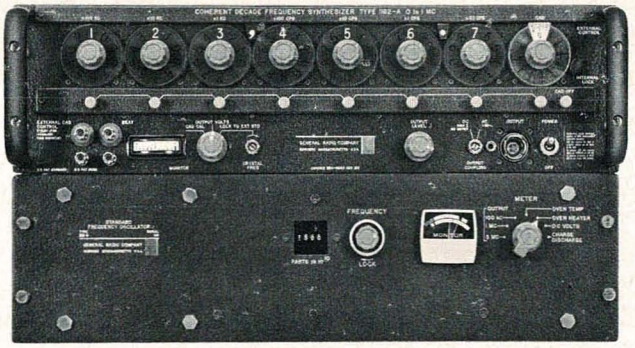
MODULAR CONSTRUCTION

The new synthesizer designs are based on identical, iterative circuits in the frequency-derivation chain. These compact, all-solid-state instruments are made up of interchangeable, plug-in modules. This results in minimum cost to the user, inasmuch as he can buy originally only the resolution that he needs. Yet, he can always easily add modules for increased resolution.

These modules combine in several ways to form a large variety of synthesizer models, with differing numbers of digits. Models may have simple manual control only, or manual control combined with remote-programming capability.

A minimal system consists of a relay-rack-width chassis into which are plugged power-supply, frequency-source, and output-mixer modules, plus three step-





For extremely exacting frequency requirements, the internal crystal oscillator can be conveniently phase-locked to an external standard. With the Type 1115-B Standard-Frequency Oscillator (page 114), the synthesizer yields a full range of frequency outputs that vary typically less than 5 parts in 10^{10} per day.

decade digit modules. Each chassis contains all necessary switching, wiring, and connectors and requires no alteration for expansion, even to change from manual to programmable operation. Additional modules plug into the instrument in minutes.

Quartz-Crystal Frequency Source

All frequencies are synthesized, coherently, from a primary oscillator employing a hermetically sealed AT-cut crystal, without oven. Temperature coefficient is low in the normal operating range. In the many applications where extreme precision is not required, substantial savings in cost, space, and weight are achieved.

When maximum stability is required, the oscillator can readily be phase-locked to any external standard frequency of 100 kc/s, 1 Mc/s, 2.5 Mc/s, or 5 Mc/s. The Type 1115-B Standard-Frequency Oscillator is recommended.

Step-Decade Modules

The basic building block of the new synthesizers is a step decade called the Digital Insertion Unit, DI for short. Up to seven of these can be combined to produce a decade-frequency synthesizer with in-line, digital readout. The signal flows through the train of DI units from right to left. Each DI divides by ten the frequency of the signal received from the unit to its right and inserts its own digit information at the head of the train of numbers created by previous synthesis.

Continuously Adjustable Decade Module

A second type of module, a Continuously Adjustable Decade (CAD), is recommended for initial inclusion in any of the synthesizers but, alternatively, can be added later. With this unit the output frequency can be continuously adjusted, and any portion of the frequency range can be electronically swept. The CAD also adds at least 2 digits of resolution (3 digits if it is set by comparison with digit dials) beyond the last of the digitally stepped dials.

Frequency Search

The CAD can functionally replace one or more of the DI units. For example, if the push-button switch beneath a ×10CPS decade is operated, the CAD replaces that decade and all decades to the right. The CAD thus automatically controls the synthesizer output frequency through a 100-cycle range in the frequency region selected by the dials to the left of the button. This process can be used to replace any number of DI step decades for continuous manual frequency search over a wide or a narrow range.

Sweeping

The CAD frequency can also be swept, through a range at least as great as the range of manual control, by an external voltage introduced at front-panel jacks. The sweep range of the synthesizer output can be made very small, if the CAD is substituted for a decade at the far right, or progressively larger, as step decades toward the left are replaced. The CAD can generate precision frequency markers with a minimum of external equipment. A marker at center frequency, as displayed on all the digit dials, plus side markers, at any chosen spacing about center, can easily be formed.

Increased Resolution

The CAD can also be used to extend the number of significant figures in the readout. It can add two places by direct dial reading. Or, the CAD can be calibrated in terms of a selected series of step decades (by observation of a zero-beat on a front-panel monitor meter) and then switched back to the end position to add three or more significant figures to the readout. The known digital setting of the step decades is transferred to the CAD in this operation.

Precise frequency offsets from the digit-dial reading can be produced by a similar technique. The Type 1142-A Frequency Meter (page 127) can be used to present a highly magnified indication of the departure of the actual output frequency from that set on the digit dials, as the CAD is varied.

Programmable Step-Decade Module

Programmable versions of the synthesizer offer, at the operator's choice, direct manual frequency selection by the local knobs, remote programming, or a mixture of the two. In the RDI-1 programmable decades, digits are selected by internal switching circuits, actuated by simple, external circuit closure, in either a biquinary or 10-line code.

RANGE AND RESOLUTION OPTIONS

*Type Number Suffix** (see page 158)*	*Calibrated Digits*		*0–100 kc/s Type 1161*	*0–1 Mc/s Type 1162*	*30 c/s–12 Mc/s Type 1163†*
	Decades Only	*Decades Plus CAD***	*Smallest Step (Step Decades Only)*	*Smallest Step (Step Decades Only)*	*Smallest Step (Step Decades Only)*
-A(R)7C	7	9	0.01 c/s	0.1 c/s	1 c/s
-A(R)6C	6	8	0.1 c/s	1.0 c/s	10 c/s
-A(R)5C	5	7	1.0 c/s	10 c/s	100 c/s
-A(R)4C	4	6	10 c/s	100 c/s	1 kc/s
-A(R)3C	3	5	100 c/s	1 kc/s	10 kc/s
-A(R)7	7		0.01 c/s	0.1 c/s	1 c/s
-A(R)6	6		0.1 c/s	1.0 c/s	10 c/s
-A(R)5	5		1.0 c/s	10 c/s	100 c/s
-A(R)4	4		10 c/s	100 c/s	1 kc/s
-A(R)3	3		100 c/s	1 kc/s	10 kc/s

* Letter R, when present, denotes a programmable model.
** Direct reading (without calibration check of CAD). If CAD is calibrated in terms of step decades, at least one more significant figure can be added.
† First decade not programmable.

General Characteristics

In these synthesizers the simplicity and resettability of step adjustment can be combined with the ease of search and comparison characteristic of continuous adjustment.

In addition, on CAD-equipped models a rapid self-check of the synthesizer operation is made with front-panel controls and indicators.

Operation of the synthesizers is simple and straightforward. The frequency determined by the step-decade rotary switches is displayed in line, in high-contrast characters, with comma and decimal point. The digits are rear-lighted in active decades and darkened (but still readable) in decades replaced by the CAD. In programmable models, control is transferred from the local dial to the remote-control circuit (connected to the rear of any RDI-1) when the dial is set in its "R" position. The CAD dial is illuminated when that module is in use and dark when it is not in circuit.

When not active, both the DI units and the CAD are in a stand-by state and ready for instant use. The CAD dial is a continuous rotary type with 120 fiducial marks (−1.0 to +11.0).

Several auxiliary frequency outputs are available at rear-apron connectors (see specifications); one important application of these is to phase-lock multiple-synthesizer installations.

The level of the output signal is continuously adjustable and indicated on the panel meter.

SPECIFICATIONS

	Type 1161-A	Type 1162-A	Type 1163-A
Frequency Range:	0-100 kc/s	0-1 Mc/s	30 c/s-12 Mc/s
Smallest Digital Step:	0.01 c/s	0.1 c/s	1 c/s
Smallest Direct-Calibrated CAD Increments (A7C-models only):	0.0001 c/s	0.001 c/s	0.01 c/s
Max Bandwidth Controllable by CAD:	100 kc/s	1 Mc/s	1 Mc/s
RDI-1 Units may be used in:	All digit positions		All except 1-Mc step position
Spurious Frequency Outputs: Harmonic (at max output):	< −40 dB	< −40 dB	< −34 dB
Nonharmonic:	< −80 dB	< −60 dB	< −60 dB
Output:	**Coupling switch at AC:** Adjustable, 0 to 2 V, rms; metered at output receptacle (internal impedance ≈ 7 Ω; min load impedance for full power = 50 Ω).		**Output impedance switch at 50 Ω:** 0 to 2 V, rms; metered; behind 50 Ω.
	Coupling switch at DC: Adjustable, 0 to 0.8 V, rms; not metered. (Source impedance variable up to about 4 kΩ with level setting.)		**Output impedance switch at 0:** 0 to 2 V, rms; metered at output receptacle after low impedance.
Output Frequency Characteristic:	±1 dB max, 50 c/s to max frequency (across 50-Ω or higher load, ac-coupled). ±0.2 dB max, 0 to 10 kc/s (dc-coupled).		±1.5 dB max, 50 c/s to 12 Mc/s; 50-Ω load.

AVAILABLE AUXILIARY OUTPUTS (rear of instruments)

Primary Outputs, All Three Types: 100 kc/s and 5 Mc/s (0.5 V, rms, min, across 50 Ω).

Secondary Outputs: 0.1 V, min, across 1 kΩ.

All Three Types	*Type 1162-A*	*Type 1163-A*
1.0 Mc/s 5/5.1 Mc/s 42 Mc/s +18 V dc (test point or limited-current source)	50 Mc/s 50/51 Mc/s	39 to 50 Mc/s (1-Mc steps); 50/51 Mc/s

FOR ALL THREE TYPES

Operating Temperature Range: 0 to 50°C.

Internal Frequency Standard: Room-temperature, quartz-crystal oscillator. Temperature coefficient of frequency is typically less than 2×10^{-7}/°C from 20°C to 50°C. A front-panel frequency adjustment is provided. Crystal can easily be phase-locked to an external standard.

Lock Signal Input from external standard (if used): 0.25 V, rms, to 5 V, rms, 5 Mc/s, or any submultiple down to 100 kc/s. Input impedance is approximately 1 kΩ for low-level signals; drops to approximately 50 Ω effective at high level.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 c/s, 55 W; or 20 to 28 V dc, 1.8 A.

Accessories Supplied: Type 874-R22LA Coaxial Patch Cord, Bridging Unit (maintenance substitute for DI), Panel Insert for use with Bridging Unit, Type CAP-22 3-wire power cord, spare dial lamps and fuses.

Terminals: Locking GR874 coaxial, Type 938 Binding Post, and miniature coaxial.

Cabinet: Rack-bench; end frames for bench mount and fittings for rack mount are included.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	5¼	135	15½	395	38	17.5	45	20.5
Rack	19	485	5¼	135	13*	330	38	17.5	45	20.5

* Behind panel.

See also *General Radio Experimenter*, September 1964.

PATENT NOTICE. See Notes 4 and 8, page 11.

STANDARD MODELS

Type 1161-A

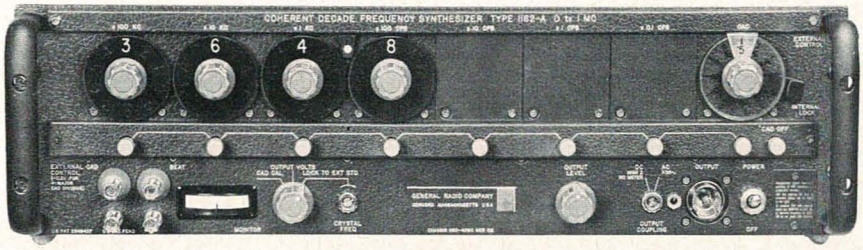
0–100 kc/s

Type 1161-A7C

MANUAL OPERATION				REMOTE/MANUAL OPERATION			
Catalog No.	*Type*	*Units Included**	*Price*	*Catalog No.*	*Type*	*Units Included**	*Price*
1161-9597	1161-A7C	7 DI Units + CAD	$5460.00	1161-9527	1161-AR7C	7 RDI Units + CAD	$6055.00
1161-9596	1161-A6C	6 DI Units + CAD	5020.00	1161-9526	1161-AR6C	6 RDI Units + CAD	5530.00
1161-9595	1161-A5C	5 DI Units + CAD	4580.00	1161-9525	1161-AR5C	5 RDI Units + CAD	5005.00
1161-9594	1161-A4C	4 DI Units + CAD	4140.00	1161-9524	1161-AR4C	4 RDI Units + CAD	4480.00
1161-9593	1161-A3C	3 DI Units + CAD	3700.00	1161-9523	1161-AR3C	3 RDI Units + CAD	3955.00
1161-9417	1161-A7	7 DI Units	4960.00	1161-9507	1161-AR7	7 RDI Units	5555.00
1161-9416	1161-A6	6 DI Units	4520.00	1161-9506	1161-AR6	6 RDI Units	5030.00
1161-9415	1161-A5	5 DI Units	4080.00	1161-9505	1161-AR5	5 RDI Units	4505.00
1161-9414	1161-A4	4 DI Units	3640.00	1161-9504	1161-AR4	4 RDI Units	3980.00
1161-9413	1161-A3	3 DI Units	3200.00	1161-9503	1161-AR3	3 RDI Units	3455.00

Type 1162-A

0–1 Mc/s



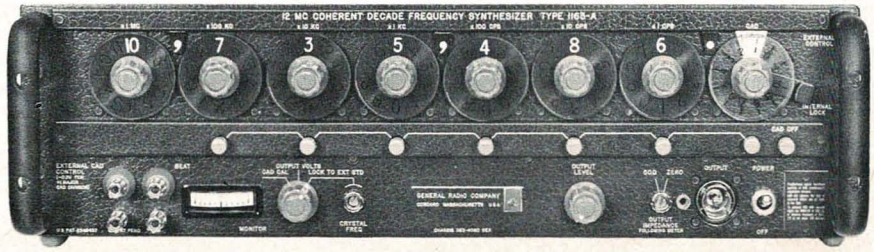
Type 1162-A4C

1162-9597	1162-A7C	7 DI Units + CAD	$5600.00	1162-9527	1162-AR7C	7 RDI Units + CAD	$6195.00
1162-9596	1162-A6C	6 DI Units + CAD	5160.00	1162-9526	1162-AR6C	6 RDI Units + CAD	5670.00
1162-9595	1162-A5C	5 DI Units + CAD	4720.00	1162-9525	1162-AR5C	5 RDI Units + CAD	5145.00
1162-9594	1162-A4C	4 DI Units + CAD	4280.00	1162-9524	1162-AR4C	4 RDI Units + CAD	4620.00
1162-9593	1162-A3C	3 DI Units + CAD	3840.00	1162-9523	1162-AR3C	3 RDI Units + CAD	4095.00
1162-9417	1162-A7	7 DI Units	5100.00	1162-9507	1162-AR7	7 RDI Units	5695.00
1162-9416	1162-A6	6 DI Units	4660.00	1162-9506	1162-AR6	6 RDI Units	5170.00
1162-9415	1162-A5	5 DI Units	4220.00	1162-9505	1162-AR5	5 RDI Units	4645.00
1162-9414	1162-A4	4 DI Units	3780.00	1162-9504	1162-AR4	4 RDI Units	4120.00
1162-9413	1162-A3	3 DI Units	3340.00	1162-9503	1162-AR3	3 RDI Units	3595.00

Type 1163-A

30 c/s–12 Mc/s

AVAILABLE 4th QUARTER 1965

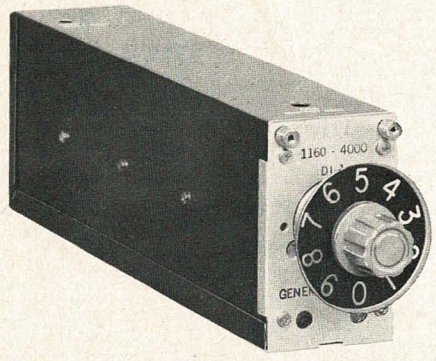


Type 1163-A7C

1163-9597	1163-A7C	7 DI Units + CAD	$5600.00	1163-9527	1163-AR7C	1 DI + 6 RDI Units + CAD	$6110.00
1163-9596	1163-A6C	6 DI Units + CAD	5160.00	1163-9526	1163-AR6C	1 DI + 5 RDI Units + CAD	5585.00
1163-9595	1163-A5C	5 DI Units + CAD	4720.00	1163-9525	1163-AR5C	1 DI + 4 RDI Units + CAD	5060.00
1163-9594	1163-A4C	4 DI Units + CAD	4280.00	1163-9524	1163-AR4C	1 DI + 3 RDI Units + CAD	4535.00
1163-9593	1163-A3C	3 DI Units + CAD	3840.00	1163-9523	1163-AR3C	1 DI + 2 RDI Units + CAD	4010.00
1163-9417	1163-A7	7 DI Units	5100.00	1163-9507	1163-AR7	1 DI + 6 RDI Units	5610.00
1163-9416	1163-A6	6 DI Units	4660.00	1163-9506	1163-AR6	1 DI + 5 RDI Units	5085.00
1163-9415	1163-A5	5 DI Units	4220.00	1163-9505	1163-AR5	1 DI + 4 RDI Units	4560.00
1163-9414	1163-A4	4 DI Units	3780.00	1163-9504	1163-AR4	1 DI + 3 RDI Units	4035.00
1163-9413	1163-A3	3 DI Units	3340.00	1163-9503	1163-AR3	1 DI + 2 RDI Units	3510.00

* All DI units are TYPE 1160-DI-1, except in the TYPE 1163-A, which always contains one TYPE 1160-DI-4 unit (non-programmable) in the ×1MC station. All RDI units are TYPE 1160-RDI-1.

SYNTHESIZER MODULES



Sold only as replacements or to fill out partially equipped synthesizers.

MANUAL STEP-DECADE MODULE

Digit-Insertion Units, TYPE 1160-DI-1, are available singly or in multiples, to expand the resolution capability of less-than-fully equipped synthesizers, or as spares. The modules are complete and ready to plug in. The change takes only minutes and requires no special tools. The DI-1 module functions identically in any step-decade station of *any* synthesizer, except for the ×1MC station on the TYPE 1163-A.

A plug-in bridging unit, which completes the signal path in the empty decade station, must first be removed. All ancillary controls are preinstalled for every station, even in minimally equipped synthesizers.

Net Weight: 1½ lb (0.7 kg).

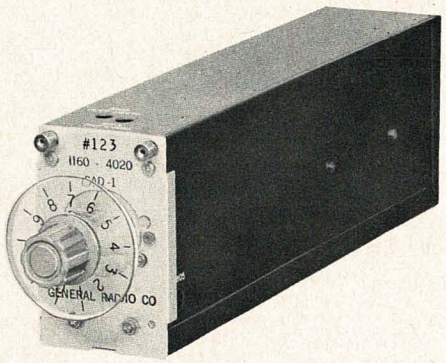
Catalog No.	*Description*	*Price*
1160-9439	**Type 1160-DI-1 Digit-Insertion Unit** (Manual control)	**$450.00**

CONTINUOUSLY ADJUSTABLE DECADE MODULE

The TYPE 1160-CAD-1 Continuously Adjustable Decade module is available to add increased versatility and extended resolution to *any* synthesizer purchased without this decade. The CAD adds two calibrated digits to the readout directly and three or more if it is first calibrated against the step decades. It can convert any step decade (and all to its right) to continuously adjustable operation at the push of a button. The capability of instantaneous self-check is another advantage furnished a synthesizer to which the CAD is added. The module is complete and ready to plug into the decade station at the right-hand end of any of the synthesizers. The change takes only minutes and requires no special tools.

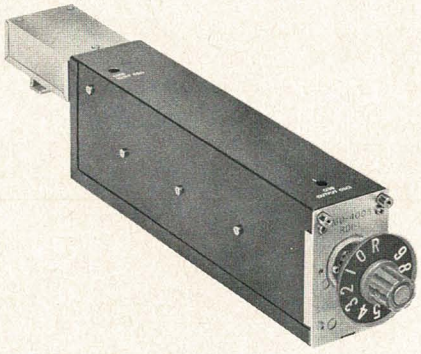
Net Weight: 1¾ lb (0.8 kg).

Catalog No.	*Description*	*Price*
1160-9432	**Type 1160-CAD-1 Continuously Adjustable Decade,** including Calibrating Mixer Unit	**$510.00**



Sold only as replacements or to fill out partially equipped synthesizers.

PROGRAMMABLE STEP-DECADE MODULE



Sold only as replacements or to fill out partially equipped synthesizers.

The TYPE 1160-RDI-1 Digit-Insertion Unit (remote or manual control) is offered singly or in multiples, to permit programmed frequency selection in the step decades of *any* of the synthesizers, except in the ×1MC decade of the TYPE 1163-A. It can fill out partially complete programmable synthesizers or convert manual instruments, partially or fully, to programmed operation. The modules are complete and ready to plug in. The change takes only minutes and requires no special tools. A 12-pin filter-plug at the rear can be cabled to either a biquinary or 10-line coded programmer for fast, automatic operation. Control-cable filtering circuits are included in the plug.

For local-control override of any decade, the operator has merely to turn the dial from the program position, "R," to the desired digit.

For 10-line operation, each digit is remotely selected by the connection of the corresponding line to "common". Biquinary operation permits duplication of the digit-circuit closures for digits 0–4 and 5–9, with choice provided by a high-low circuit closure.

Except for the programmed-operation capability, the module is identical to the DI-1 module.

Net Weight: 1½ lb (0.7 kg).

Catalog No.	*Description*	*Price*
1160-9479	**Type 1160-RDI-1 Digit-Insertion Unit** (Remote or manual control), including Filter Plug	**$535.00**

HOOK-UP CABLE FOR RDI-1

A special, 12-conductor, shielded cable is recommended for connection of the 12-pin filter-plug to remote equipment. One 50-foot roll of cable is furnished with each synthesizer containing an RDI-1 unit but is not supplied with an individually purchased RDI-1. Additional 50-foot lengths can be ordered.

Net Weight: 2½ lb (1.2 kg).

Catalog No.	*Description*	*Price*
1160-9650	**Hook-up Cable** for RDI-1, 50 feet	**$15.00**

PULSE GENERATORS

Much of today's electronic engineering effort is devoted to the development of circuits and systems operating in the time domain. Switching, pulse, and digital circuits predominate in modern computing, navigation, and data-communication systems. In the laboratory, the oscilloscope as the detector and the pulse generator as the signal source replace the voltmeter and sinusoidal oscillator of yesterday.

A pulse generator is, in essence, a highly versatile and controllable switch. Two parameters of interest, and which must be controlled, are the pulse repetition frequency, or switching rate, and the pulse duration, or length of time the switch is closed (or open). The rise time, or speed of switching, is also an important parameter. In addition to the characteristics of the switch, specific applications will require particular characteristics for the energy source switched. The output impedance, open-circuit voltage, and available current must all be known and specified to fit a given pulse generator to a specific application.

Computational and data rates rise as rapidly as device development will permit. Pulse repetition rates can now range from nearly dc to over 100 Mc/s, and durations from seconds to less than 1 nanosecond. For computation and data-transmission systems, most of the applications can be served by relatively low power outputs, while radar and certain magnetic data-storage systems may require pulses of extremely high energy. It appears that a pulse generator that will meet all requirements, even in the laboratory, is out of the question.

The series of pulse generators offered in this catalog are pulse-signal sources of as general a type as economics will permit. The Type 1217-C produces pulses ranging from 0.1 μs to 1 s over a repetition rate range from dc to 2 Mc/s. It, like all the General Radio pulse-generator line, contains an internal prf oscillator with continuous range from 3 c/s to 1.2 Mc/s. Both pulse polarities are simultaneously available, and output circuits are dc coupled, an absolutely necessary characteristic when pulses of long duration must be produced. This high level of performance is achieved at nominal cost because the output power level is low. The Type 1397-A Pulse Amplifier can be used to translate this performance to 1-ampere output levels.

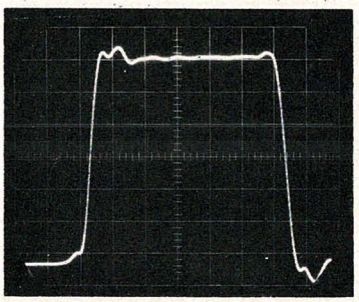
The Type 1398-A Pulse Generator is very similar in electrical characteristics to the Type 1217-C but produces faster pulses (5-ns rise time) at high current (60 mA).

For the utmost in flexibility we offer the Type 1395-A Modular Pulse Generator. This hybrid system has duration ranges, rise times, and prf ranges similar to the Type 1217-C but permits, in one package, interconnection of various modules to produce a pulse generator of almost infinite variety. An input circuit module either serves as a prf oscillator or processes an external driving signal from dc to 2 Mc/s to produce a standardized system-synchronizing pulse. A second module produces pulses or delayed 0.1-μs synchronizing pulses in the range from 0.1 to 1 s with rise times of 15 ns. A single input module and three pulse/delay modules will form an excellent double-pulse generator, while 5 pulse/delay modules will provide a triple-pulse. A third module, timed from a pulse/delay module, will produce pulses with linear and independently variable rise and fall times over a range from 0.1 μs to 1 s. A fourth module produces up to 16-bit pulse words. A power amplifier with up to 0.4-ampere output at limited duty-ratio is the fifth module.

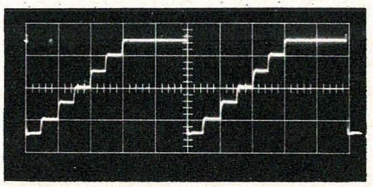
The Type 1396-A Tone-Burst Generator, a new type of pulse instrument, operates as a coherent gate for an externally introduced signal. It has many applications in sonar, the design and test of amplifiers, transducers, filters, meters, as well as in acoustical measurements.

PULSE GENERATORS

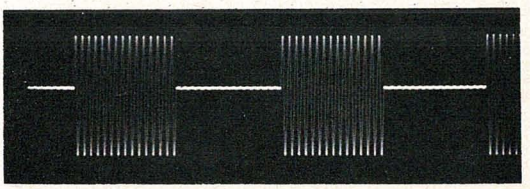
Type	*Name*	*Remarks*	*Page*
1217-C	**Unit Pulse Generator**	Low cost — high performance	164
1398-A	**Pulse Generator**	60-mA pulse output	166
1395-A	**Modular Pulse Generator**	Generates complex pulse waveforms — ultimate in flexibility	161
1397-A	**Pulse Amplifier**	1-A output pulses into 50 Ω	165
1396-A	**Tone-Burst Generator**	Coherent gate — adjustable on and off intervals	167



0.12-μs pulse from Type 1217-C Unit Pulse Generator.



Staircase waveform generated by Type 1395-A Modular Pulse Generator.



Tone-burst pattern from Type 1396-A Tone-Burst Generator. Input, 3 kc/s;16 cycles on; 16 cycles off.

Type 1395-A MODULAR PULSE GENERATOR

FEATURES:

Generates wide variety of complex pulse waveforms.
Five different modules available.
Total of seven modules can be used at one time in variety of combinations.
Designed for maximum flexibility, convenience, and economy.

USES: This instrument is used principally as a means for simulating the signals commonly associated with radar, telemetry, and moderate-speed digital-data handling. By selecting the appropriate number and types of plug-in modules, a user actually builds his own special-purpose instrument. Some typical applications for this generator include:

- Generation of staircase or ramp waveforms for testing analog-to-digital converters and allied equipment.
- Generation of pulse bursts for radar video-circuit testing and simulation.
- Generation of waveforms suitable for testing or simulating pulse-duration modulation in telemetry circuits.
- Physiological and geophysical tests using the low prf's and long time delays and pulse durations available.
- Synthesis of special pulses used as sync signals, such as pedestals, doublets, etc.

DESCRIPTION: The main frame of the TYPE 1395-A Modular Pulse Generator contains the power supply to operate the seven modules that the main frame can accommodate, two ADDER busses with their corresponding output controls and jacks, and a bias control (labeled PULSE DC COMPONENT) for varying the level of the output-pulse base line. Through suitable programming of the individual module-selector switches, positive, negative, or simultaneous positive and negative outputs representing the "sum" of the waveforms generated by the respective modules are available at the ADDER output jacks. The output level at each of these jacks is adjustable by a 100-ohm potentiometer.

Five types of modules are available plus a skeleton-frame module in which the user can install his own circuitry. The five modules can be used in any combination up to a total of seven, of which only one may be a Power Amplifier and a maximum of three may be Pulse Shapers. To satisfy power-supply limitations, Pulse Shaper Units fit only in the three right-hand slots and the Power Amplifier only in the farthest right-hand slot.

SPECIFICATIONS

MAIN FRAME

ADDER Output Level: 0 to 1 V or more, depending on number of modules used (continuously adjustable).

ADDER Output Impedance: 100 Ω or less (100-Ω pot).

PULSE DC COMPONENT Range: 0 to +20 V (continuously adjustable).

Power Required: 105 to 125 V, 195 to 235 V, or 210 to 250 V, 50 to 60 c/s; approximately 250 W, depending on quantity and type of plug-ins.

Accessories Supplied: TYPE CAP-22 Power Cord; spare fuses; six patch cords — one each TYPES 274-LMB and 274-LMR, two each TYPES 274-LSB and 274-LSR; four blank cover panels; one 14-conductor module extension cable.

Accessories Available: All modules in the TYPE 1395 series, TYPE 1217-P2 Single-Pulse Trigger (see page 164).

Mechanical Data: Rack-Bench Cabinet *(see page 258)*

Model	Width		Height		Depth		Net Wt*		Ship Wt*	
	in	mm	in	mm	in	mm	lb	kg	lb	kg
Bench	19	485	9⅛	230	14½	370	29	13.2	42	19.5
Rack	19	485	8¾	220	13¼†	340	27	12.3	42	19.5

* Without modules. † Behind panel.

TYPE 1395-P1 PRF UNIT

This module generates the pulses that trigger the Pulse/Delay Units and provides the synchronization necessary for synthesizing complex waveforms. The maximum repetition rate is 1.2 Mc/s when generated internally, and at least 2 Mc/s with external drive. The PRF Unit acts as a synchronous divider when a signal of higher frequency is applied to the LOCK SIG jack, and a stable division of up to about 20:1 is possible. When a positive pulse is applied to the GATE IN jack, the PRF Unit is disabled for the duration of the pulse. Varying the time of occurrence and duration of this gating pulse, which can be generated by other modules, controls when and how long the PRF Unit is inoperative.

SPECIFICATIONS

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 c/s to 1.2 Mc/s with 12-position switch and uncalibrated ΔF control.

Externally Controlled: After adjustment for maximum sensitivity, sine-wave input of 0.5 V, rms, required for prf from dc to 0.5 Mc/s, rising to 1.5 V, rms, at 2 Mc/s. Input impedance at 0.5 V is approx 100 kΩ shunted by 50 pF. Non-sinusoidal signal requires a negative-going step of 1 V.

INPUT AND OUTPUT SIGNALS

Sync Out Pulses: At least 10 V, positive, with duration between 75 and 150 ns (nominally 100 ns); rise time approx 25 ns and output impedance approx 35 Ω.

Lock Signal: PRF Unit operating at 1 kc/s can be locked to a frequency of 10 kc/s by 10-V positive pulses with 100-ns duration or with a sine wave of 7 V, rms. Required positive-pulse

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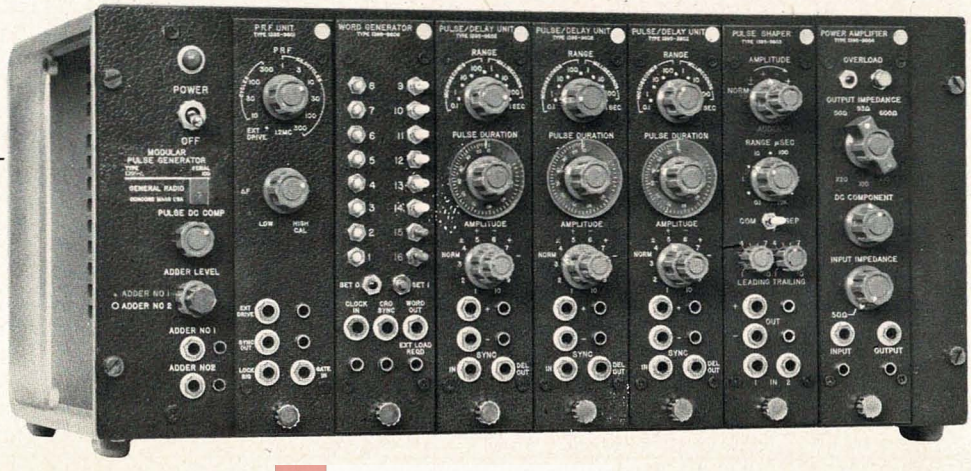
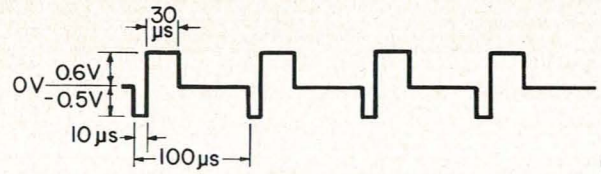
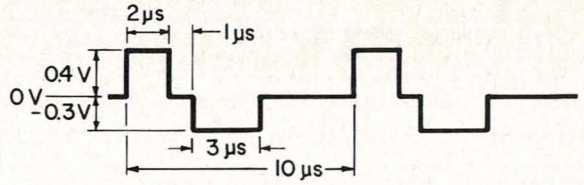




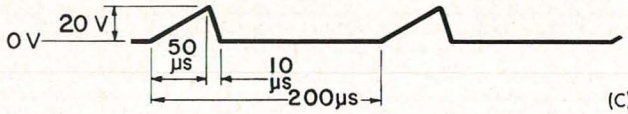
(A)

Waveform that appears at the ADDER No. 1 terminal with one PRF Unit driving two Pulse/Delay Units at 10 kc/s. Amplitudes and durations of positive and negative pulses can be independently adjusted.



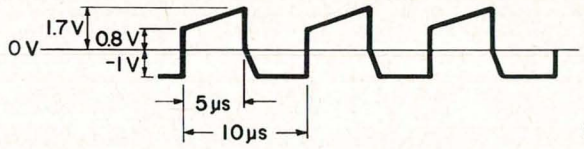
(B)

Pulse train produced by one PRF Unit and three Pulse/Delay Units operating at 100 kc/s. The amplitude and duration of the positive pulse are controlled by one Pulse/Delay Unit whose delayed output triggers a second Pulse/Delay Unit. This second unit provides the delay between the positive and negative pulses, and its delayed output triggers the third unit to produce the negative pulse.



(C)

One PRF Unit, one Pulse/Delay Unit, and one Pulse Shaper are used to form this train of triangular waveforms. The PRF Unit is set for 5 kc/s. The positive-going ramp rises linearly to 20 V in 50 µs while the negative-going ramp falls to zero in 10 µs. Rise and fall times are independently variable.



(D)

This train of ramp pulses is produced with one PRF Unit, one Pulse/Delay Unit, and one Pulse Shaper. Prf is 100 kc/s, and the zero-volt level is adjusted by the main chassis PULSE DC COMPONENT control.

Pattern produced when a word generator is connected between PRF Unit and the first Pulse/Delay Unit in (A), above, with switches set as shown.

amplitude increases to about 12 V to lock the 1 kc/s to a frequency of 2 kc/s.

Gate Input: A potential more positive than −1 V at this terminal stops the generation of SYNC OUT pulses.

Stability: Prf jitter is 0.05% when the PRF Unit is operated from the power supply in the TYPE 1395-A main frame.

GENERAL

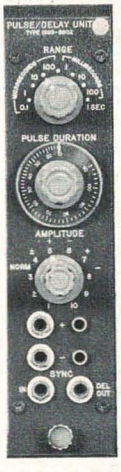
Power Consumption: +150 V at 25 mA; −150 V at 5 mA; +15 V at 5 mA; 6.3 V, 60 c/s, 1 A. Power supplied by frame.

Accessories Supplied: Six patch cords — one each TYPES 274-LMB and 274-LMR, two each TYPES 274-LSB and 274-LSR; two insulated plugs, one each TYPES 274-DB1 and 274-DB2.

Accessories Available: TYPE 1217-P2 Single-Pulse Trigger, other TYPE 1395 modules.

Net Weight: 1½ lb (0.7 kg).

Shipping Weight: 4½ lb (2.1 kg).



TYPE 1395-P2 PULSE/DELAY UNIT

Each Pulse/Delay Unit receives its input signal from a PRF Unit or other external source. The output pulses are then adjusted for the desired amplitude, polarity, duration, and delay time by the front-panel controls. If further shaping is required, the pulses are fed into a Pulse Shaper module. If they are to be combined with other pulses, they are fed to the ADDER busses on the Type 1395-A main frame. Alternatively the output can be applied directly to the circuit under test through the front-panel jacks. Maximum output current is 20 milliamperes, and the dc reference level of the output pulse can be varied by the PULSE DC COMPONENT control on the main frame.

SPECIFICATIONS

Pulse and Delay Durations: 100 ns to 1 s, accurate to ±5% of reading or ±2% of full scale, or ±35 ns, whichever is greater.

Pulse Repetition Frequency: Determined by input sync signal — range dc to 2.4 Mc/s. Input signals can be randomly spaced if separated by at least 400 ns.

Rise and Fall Times: Less than 15 ns with 50-Ω load. On high-voltage output (20 V into 1 kΩ), transitions are typically 80 ns + 2 ns/pF of load capacitance.

Output Voltage: ±20 V pulses into 1-kΩ internal load impedance (±1 V into 50-Ω load).

Input Sync Requirements: Positive-going pulse, 10 to 20 V, with 75- to 150-ns duration.

Delayed Output: Positive pulse of at least 10-V amplitude and 75- to 150-ns duration. Output impedance approx 125 Ω. Time between SYNC IN and DEL OUT pulses set by PULSE DURATION control.

Stability: Pulse-duration jitter is 0.05% when Pulse/Delay Unit is operated in the TYPE 1395-A main frame.

Power Consumption: +150 V at 15 mA; −150 V at 30 mA; 6.3 V, 60 c/s, 0.7 A; 6.3 V, 60 c/s, 1.3 A; +15 V at 5 mA; 0 to +20 V, variable, at 25 mA. Power supplied by frame.

Accessories Supplied: Five patch cords — two each TYPES 274-LSB and 274-LSR, one TYPE 274-LMR; two insulated plugs, one each TYPES 274-DB1 and 274-DB2.

Net Weight: 1¾ lb (0.8 kg).

Shipping Weight: 4¾ lb (2.2 kg).

TYPE 1395-P3 PULSE SHAPER

This unit produces pulses with straight-line leading and trailing edges whose rise and fall times can be adjusted individually by separate controls or simultaneously by a single control. The leading edge starts with the pulse that is applied to the IN 1 jack; the trailing edge starts with the pulse that is applied to the IN 2 jack. Therefore, the output-pulse duration is always greater than the time interval between input pulses. If input pulses are applied only to the IN 1 jack, the leading edge of the output pulse starts with the first input pulse and the trailing edge starts with the second pulse. Both positive and negative output pulses are produced, and the dc reference level can be varied by the PULSE DC COMPONENT control on the main frame. The output can be switched to the ADDER busses.

SPECIFICATIONS

INPUT PULSES: 10 V to 20 V in amplitude and 75 ns minimum duration.

OUTPUT PULSES

Duration: Time between pulses at IN 1 and IN 2 plus duration of trailing edge.

Rise and Fall Times: 100 ns to 10 ms in five decade ranges, ±10% of full scale, from the 0 to 100% points. Rise and fall times can be adjusted, independently by separate controls or simultaneously by a single control, within the same decade range. To obtain times less than a few hundred nanoseconds, output must be terminated in 50 to 100 Ω.

Linearity: A leading or trailing edge voltage $e(t)$ making a transition of E volts in time T will not at any time t depart from the equation $e = \frac{Et}{T}$ $(0 \leq t \leq T)$ by more than $0.1\ E$ (typically better than $0.05\ E$). The fastest transitions will not yield this performance unless outputs are terminated in 50 to 100 Ω.

Voltage: ±20-V pulses into 1-kΩ internal load impedance (±1 V into 50-Ω load).

GENERAL

Power Consumption: +150 V at 45 mA; −150 V at 55 mA; 6.3 V, 60 c/s, 0.15 A; 6.3 V, 60 c/s, 0.6 A; 0 to +20 V, variable, at 30 mA. Power supplied by frame.

Accessories Supplied: Five patch cords — two each TYPES 274-LSB and 274-LSR, one TYPE 274-LMR; two insulated plugs, one each TYPES 274-DB1 and 274-DB2.

Net Weight: 1¾ lb (0.8 kg). **Shipping Weight:** 4¾ lb (2.2 kg).

TYPE 1395-P4 POWER AMPLIFIER

This amplifier is designed primarily for pulse amplification in applications where extremely fast rise time is not necessary. It delivers a 20-volt, minimum, pulse of either polarity into a 50-ohm load, and can amplify the signals from the ADDER busses or the output of any TYPE 1395 module. As a sine-wave amplifier it is useful for frequencies in the audio range and up to 1.5 Mc/s, or 5 Mc/s, depending upon the termination. Output power as a sine-wave amplifier is approximately two watts, and distortion is 5% or less. It is a suitable coupling element between the outputs of the various pulse-forming modules and the most commonly encountered impedances used in radar, video, and telephone practice.

SPECIFICATIONS

Output Impedances: 50, 93, and 600 Ω, all ±10%.

Gains: 20, 20, and 26 dB, respectively, at the above impedances and with matched loads, all ±2 dB.

Pulse Output Voltage: ±20 V pulses into 50-Ω load with 10% duty cycle. Larger duty cycles may be used at lower output levels.

Rise and Fall Times: Less than 60 ns on all transitions with a 50-Ω load and selector switch set for 50-Ω impedance.

Sine-Wave Amplifier: Power output into 50- and 93-Ω loads is at least 2.5 W (3% distortion typical); into 600-Ω load, at least 1.5 W (distortion, 1.5% typical).

Frequency Response: Down less than 3 dB at 20 c/s and 5 Mc/s with 50- and 93-Ω loads; 20 c/s and 1.5 Mc/s with 600-Ω load.

Dc Level: Dc baseline of pulses and centerline of sine waves can be moved at least ±1.5 V dc with 50-Ω loads, and more with higher impedance loads.

Input Impedance: Adjustable from 50 to 1050 Ω, shunted by approx 45 pF.

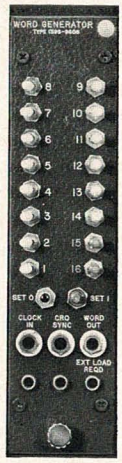
Power Consumption: +150 V at 150 mA, max; −150 V at 150 mA, max; 6.3 V, 60 c/s, 2.2 A; 6.3 V, 60 c/s, 1.9 A. Power supplied by frame.

Accessories Supplied: Four patch cords — one each TYPES 274-LMB, 274-LMR, 274-LSB, and 274-LSR; two insulated plugs, one each TYPES 274-DB1 and 274-DB2.

Net Weight: 2 lb (1 kg).

Shipping Weight: 5 lb (2.3 kg).

TYPE 1395-P6 WORD GENERATOR



This module produces a pattern of 16 binary digits (BITS) in accordance with the settings of the switches on the module front panel. As many as seven Word Generators can be connected in cascade, utilizing the full capacity of the TYPE 1395-A main frame, to provide an 112-bit capability in one binary word. Rear-panel switching provides conversion of the 16-bit-per-generator capacity to 14-bit capacity. Numerous options are provided by the interconnection of two or more Word Generators in cascade, or by a change in the internal wiring of a Word Generator with a patch cord.

The output pulses are trigger signals designed to operate other TYPE 1395 modules. In addition, each Word Generator provides a sync pulse coincident with the time when an output pulse would occur from switch #1, whether or not that switch is actually engaged.

SPECIFICATIONS

INPUT

Pulse Repetition Frequency: Dc to 2.5 Mc/s, externally controlled by TYPE 1395-P1 PRF Unit (or similar unit).

Trigger-Pulse Requirements: 10- to 20-V positive-going pulses of 75- to 150-ns duration. Square waves can be used above 10 kc/s; sine waves, above 500 kc/s.

Impedance: 400 to 600 Ω, depending upon trigger amplitude.

OUTPUTS

Oscilloscope Sync: Rectangular pulse of 2-V min amplitude and duration equal to period of driving-signal prf. Occurs approx 50 ns before the switch #1 output pulse, whether or not the switch is on.

Word Out: 10- to 20-V positive-going pulses of 75- to 150-ns duration. Output impedance approx 150 Ω, but termination in 500 to 1000 Ω is recommended.

Pattern: Set by front-panel switches. Choice of 16-bit or 14-bit capacity by rear-panel switch. One can achieve capacities other than 14 and 16 by modification of internal wiring. Interconnection of up to seven units provided by the TYPE 1395-A main frame.

GENERAL

Power Consumption: +15 V at 5 mA; 6.3 V, 60 c/s, 0.8 A. Power supplied by frame.

Accessories Supplied: Five patch cords — one each TYPES 274-LSB, 274-LSR, 274-LMB, 274-LMR, and 274-LLR; two insulated plugs, one each TYPES 274-DB1 and 274-DB2.

Net Weight: 2½ lb (1.2 kg). **Shipping Weight:** 5½ lb (2.5 kg).

TYPE 1395-P7 SKELETON FRAME

A blank module suitable for mounting the components of a user-designed circuit.

Net Weight: ½ lb (0.3 kg). **Shipping Weight:** 3½ lb (1.6 kg).

Dimensions: Width 2⅛, height 8½, depth 5 in (55, 220, 130 mm), over-all.

Catalog No.	*Description*	*Price*
1395-9801	**Type 1395-A Modular Pulse Generator, Bench Model**	**$500.00**
1395-9811	**Type 1395-A Modular Pulse Generator, Rack Model**	**500.00**
1395-9601	**Type 1395-P1 PRF Unit**	**150.00**
1395-9602	**Type 1395-P2 Pulse/Delay Unit**	**165.00**
1395-9603	**Type 1395-P3 Shaper Unit**	**375.00**
1395-9604	**Type 1395-P4 Power Amplifier**	**250.00**
1395-9606	**Type 1395-P6 Word Generator**	**400.00**
1395-9607	**Type 1395-P7 Skeleton Frame**	**12.00**

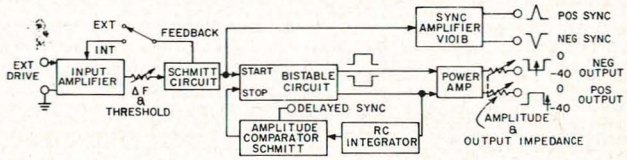
Type 1217-C UNIT PULSE GENERATOR

FEATURES:

Fast rise and fall time — less than 10 ns.
Duration adjustment over more than seven decades, 0.1 μs to 1.1 s.
Repetition rate from 2.5 c/s to 1.2 Mc/s, continuous, internal.
40-volt output pulses of either polarity simultaneously available.

USES: This simple, reliable pulse generator has many applications in the laboratory and on the test bench. Its wide ranges of pulse-duration and repetition rate and its excellent output characteristics fit it for any application where an oscilloscope can be used as an indicator. Applications range from high-speed computing circuits through radar to geophysical and physiological pulse simulation. It is an excellent, low-cost instrument for the student laboratory.

DESCRIPTION: Circuit functions are shown in the block diagram. The input circuits can be switched to act either as an aperiodic amplifier with adjustable sensitivity or as a stable prf oscillator. The pulse-timing circuits consist of a transistor bistable circuit, an RC integrator, and a Schmitt amplitude comparator. The bistable circuit switches a pair of pentode tubes in the output circuit. The pentode output stage is direct coupled to the output terminals so that the pulse dc component is retained. Efficient circuit design has resulted in a 40-mA output with only 60-mA total plate input.



Block diagram of the circuit system.

SPECIFICATIONS

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 c/s to 1.2 Mc/s, with calibrated points in a 1-3 sequence from 10 c/s to 300 kc/s, and 1.2 Mc/s, all ±5%. Continuous coverage with an uncalibrated control.

Externally Controlled: Aperiodic, dc to 2.4 Mc/s with 1 V, rms, input (0.5 V at 1 Mc/s and lower); input impedance at 0.5 V, rms, approximately 100 kΩ shunted by 50 pF. Output pulse is started by negative-going input transition.

OUTPUT-PULSE CHARACTERISTICS

Duration: 100 ns to 1 s in 7 decade ranges, ±5% of reading or ±2% of full scale or ±35 ns, whichever is greater.

Rise and Fall Times: Less than 10 ns into 50 or 100 Ω; typically 60 ns + 2 ns/pF external load capacitance into 1 kΩ (40 V).

Voltage: Positive and negative 40-mA current pulses available simultaneously. Dc coupled, dc component negative with respect to ground. 40 V, peak, into 1-kΩ internal load impedance for both negative and positive pulses. Output control marked in approximate output impedance.

Overshoot: Overshoot and noise in pulse, less than 10% of amplitude with correct termination. **Ramp-off:** Less than 1%.

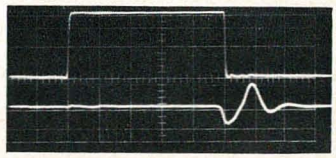
Synchronizing Pulses:

Pre-pulse: Positive and negative 8-V pulses of 150-ns duration. If positive sync terminal is shorted, negative pulse can be increased to 50 V. Sync-pulse source impedance:

positive — approx 300 Ω; negative — approx 1 kΩ.

Delayed Sync Pulse: Consists of a negative-going transition of approximately 5 V and 100-ns duration coincident with the late edge of the main pulse. Duration control reads time between prepulse and delayed sync pulse. This negative transition is immediately followed by a positive transition of approximately 5 V and 150 ns to reset the input circuits of a following pulse generator. (See oscillogram).

Stability: Prf and pulse-duration jitter are dependent on power-supply ripple and regulation. With TYPE 1201 Power Supply external-drive terminals short-circuited, prf jitter and pulse-duration jitter are each 0.01%. With TYPE 1203 Power Supply, they are 0.05% and 0.03%, respectively. (Jitter figures may vary somewhat with range switch settings, magnetic fields, etc.)



1-μs pulse into 50 ohms with delayed sync pulse.

GENERAL

Power Required: TYPE 1203 or TYPE 1201 Unit Power Supply is recommended.

Accessories Available: TYPE 1217-P2 Single-Pulse Trigger, rack-adaptor panel for both generator and power supply (19 by 7 in).

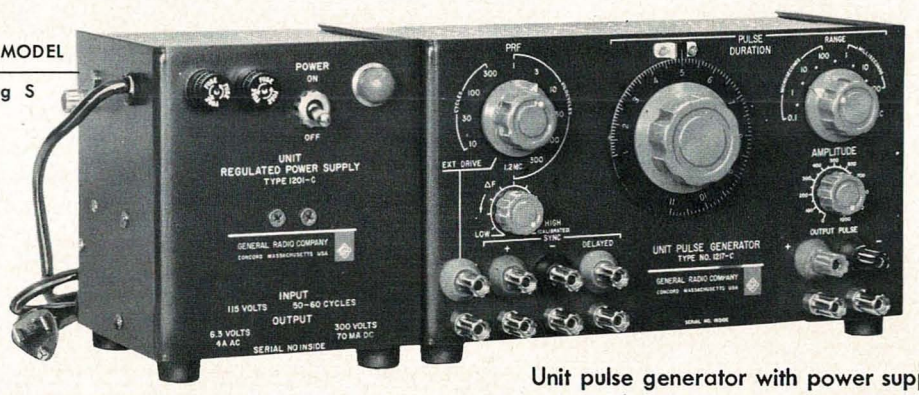
MECHANICAL DATA Unit-Instrument Cabinet (*see page 258*)

With power supply	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
	15	385	5¾	150	6½	165	9½	4.4	12	5.5

See also *General Radio Experimenter*, December 1964.

Catalog No.	*Description*	*Price*
1217-9703	**Type 1217-C Unit Pulse Generator**	**$275.00**
1217-9602	**Type 1217-P2 Single-Pulse Trigger**	**25.00**
1203-9702	**Type 1203-B Unit Power Supply (for 115-volt supply)**	**55.00**
1203-9818	**Type 1203-BQ18 Unit Power Supply (for 230-volt supply)**	**on request**
0480-9986	**Type 480-P4U3 Relay-Rack Adaptor Panel**	**12.00**

NEW MODEL in catalog S



Unit pulse generator with power supply.

Single-pulse trigger

Type 1397-A PULSE AMPLIFIER

1.2-AMPERE OUTPUT, PEAK-TO-PEAK

FEATURES:

60 volts, positive or negative, into 50 ohms, direct-coupled.
Rise and fall times less than 50 nanoseconds or continuously adjustable from 0.1 to 100 microseconds.
Operates as substantially linear amplifier or as pulse shaper.
Automatic overload protection.

USES: The TYPE 1397-A Pulse Amplifier can be used with any pulse generator capable of supplying negative input pulses, particularly the TYPES 1217-B and -C and the TYPE 1398-A Pulse Generators.

Such combinations are excellent for testing radar circuits, which often require pulses up to 50 volts into 50 ohms, with transitions less than 50 nanoseconds and repetition rates up to one megacycle per second. The high output is also valuable for testing switching arrays and the thin-film or core memories used in computers. The variable-transition-time feature provides a rapid means for determination of the rise-time ranges over which these devices will operate.

Additional uses include the testing of inductors, semiconductors, and other components. The linearly increasing output current is especially useful for testing pulse transformers.

DESCRIPTION: The TYPE 1397-A Pulse Amplifier has two modes of operation: normal and variable transition time. In the normal mode, the input pulses are fed directly to the output amplifier. This mode provides the fastest rise and fall times, typically 30 ns. In the variable transition-time mode, exponential transitions are obtained by applying the input pulses to an RC network that slows the leading and trailing edges. Linear transitions are obtained by applying a higher-level input pulse to overdrive the RC network. The output of the RC network is followed by a diode circuit, which provides the linear transitions. Transition times are continuously adjustable from approximately 0.1 to 100 μs.

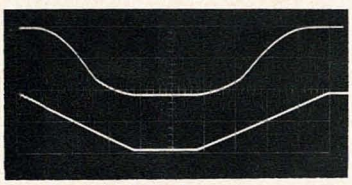
The output amplifier consists of three parallel-connected pentodes. In the POSITIVE position of the PULSE POLARITY switch, the pentodes operate as cathode followers to produce a ground-based, positive pulse into an internal shunt of 50 ohms or infinity. In the NEGATIVE position, the pentodes operate as inverters and produce ground-based, negative pulses into an internal shunt of 50 ohms, 100 ohms, or infinity.

SPECIFICATIONS

Mode	*Input Impedance*	*Drive Required*	*Rise and Fall Times*	*Output (ground reference; dc coupled)*
NORMAL	100 Ω or 100 kΩ shunted by approx 50 pF, switch selected	−2 V, p-to-p, minimum	<50 ns (typically 30 ns) with input rise and fall times of <20 ns	**Rampoff:** Approx 20% with 5-ms pulse duration **Amplitude:** 1.2 A, p-to-p, max (60 V into 50 Ω). 1 A, p-to-p, with 10% duty ratio. Automatic overload protector with manual reset. **Amplitude Variation:** ±10% for duty ratio changes from minimum to 10%. With ±10% line-voltage changes, positive output variation is ±10%, negative output is ±5%. **Internal Shunt:** Positive output, 50 Ω or open circuit; negative output, 50, 100 Ω, or open circuit.
VARIABLE Linear	30 kΩ, approx	−30 V, p-to-p, approx, minimum	0.1 to 100 μs, approx, linear, continuously adjustable	
Exponential	100 Ω	−2 to −4 V, p-to-p, approx	0.1 to 100 μs, approx, exponential, continuously adjustable	

TRANSFER CHARACTERISTICS: Operation approximates linear amplifier in normal mode.

Transfer Function:



Negative output (*top*) resulting from 2-V, linearly rising input; (*bottom*) in normal, 100-Ω, input mode.

Transconductance: 0.5 ʊ (2 V in produces 1 A out).
Inherent Delay: <50 ns between input pulse and output pulse.
Max Duty Ratio: 10%.

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 c/s, 100 W.

Terminals: Input, TYPE 938 Binding Posts; output, GR874 recessed, locking connector.
Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.
Accessories Available: Relay-rack adaptor set, panel 19 by 5¼ in (485, 135 mm), depth behind panel 9 in (230 mm).
Mechanical Data: Convertible-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
14	355	5⅞	150	10¼	260	18	8.5	24	11

Catalog No.	*Description*	*Price*
1397-9701	**Type 1397-A Pulse Amplifier**	**$495.00**
0480-9634	**Type 480-P314 Relay-Rack Adaptor Set**	**6.00**

AVAILABLE 4TH QUARTER 1965

NEW
in catalog S

Type 1398-A PULSE GENERATOR

FEATURES:

Rise and fall times less than 5 ns.
60-mA positive and negative current pulses available simultaneously.
Pulse duration adjustable from 0.1 μs to 1.1 s.
Repetition rate from 2.5 c/s to 1.2 Mc/s, continuous, internal.
Self-contained power supply.

DESCRIPTION: The TYPE 1398-A Pulse Generator is basically a TYPE 1217-C Unit Pulse Generator (see page 164) with a self-contained power supply, higher output, and improved output-pulse characteristics. Rise and fall times are less than 5 nanoseconds, one-half those of the TYPE 1217-C. Power output has been increased to provide positive and negative 60-mA current pulses, producing 60-V pulses across the 1-kΩ internal load impedance.

SPECIFICATIONS

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 c/s to 1.2 Mc/s, with calibrated points in a 1–3 sequence from 10 c/s to 300 kc/s, and 1.2 Mc/s, all ±5%. Continuous coverage with an uncalibrated control.

Externally Controlled: Aperiodic, dc to 2.4 Mc/s with 1-V, rms, input (0.5 V at 1 Mc/s and lower); input impedance at 0.5 V, rms, approximately 100 kΩ shunted by 50 pF. Output pulse is started by negative-going input transition.

OUTPUT-PULSE CHARACTERISTICS

Duration: 100 ns to 1 s in 7 decade ranges, ±5% of reading or ±2% of full scale or ±35 ns, whichever is greater.

Rise and Fall Times: Less than 5 ns into 50 or 100 Ω; typically 60 ns + 2 ns/pF external load capacitance into 1 kΩ (60 V).

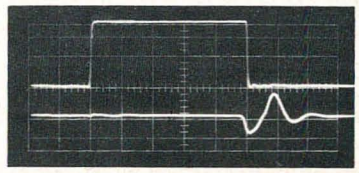
Voltage: Positive and negative 60-mA current pulses available simultaneously. Dc coupled, dc component negative with respect to ground. 60 V, peak, into 1-kΩ internal load impedance for both negative and positive pulses. Output control marked in approximate output impedance.

Overshoot: Overshoot and noise in pulse, less than 10% of amplitude with correct termination.

Ramp-off: Less than 1%.

Synchronizing Pulses:

Prepulse: Positive and negative 8-V, approx, pulses of 150-ns duration. If positive sync terminal is shorted, negative pulse can be increased to 100 V. **Sync-pulse source impedance:**
positive — approx 300 Ω;
negative — approx 1 kΩ.



1-μs pulse into 50 ohms with delayed sync pulse.

Delay-Sync Pulse: Consists of a negative-going transition of approximately 5 V and 100-ns duration, coincident with the late edge of the main pulse. Duration control reads time between prepulse and delayed sync pulse. This negative transition is immediately followed by a positive transition of approximately 5 V and 150 ns to reset the input circuits of a following pulse generator. (See oscillogram.)

Stability: With external-drive terminals short-circuited, prf jitter and pulse-duration jitter are each 0.04%. (Jitter figures may vary somewhat with range switch settings, magnetic fields, etc.)

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 c/s, 90 W.

Accessories Available: TYPE 1217-P2 Single-Pulse Trigger (see page 164), rack-adaptor panel.

MECHANICAL DATA Convertible-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
12	305	5¼	135	8¼	210	14½	7.0	18	8.5

AVAILABLE 4th QUARTER 1965

Catalog Number	*Description*	*Price*
1398-9701	**Type 1398-A Pulse Generator**	**$535.00**
0480-9632	**Type 480-P312 Relay-Rack Adaptor Panel**	**6.50**

NEW

in catalog S

Type 1396-A TONE-BURST GENERATOR

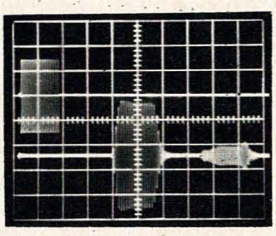
FEATURES:

Functions as a phase-coherent gate for any input waveform. Alternately passes and blocks a selected number of cycles of any input frequency from dc to 500 kc/s.
Number of cycles in each burst and interval between bursts are individually adjustable.
Starting and stopping point of the burst is adjustable.

USES: The TYPE 1396-A Tone-Burst Generator is the first commercial instrument of its kind; it provides an instrumentation bridge for the gap between continuous-wave testing and step-function, or pulse, testing. It is ideally suited for applications such as the test and calibration of sonar transducers and amplifiers, the measurement of distortion and transient response of amplifiers and loudspeakers, and routine testing of filters and ac meters. Still other uses are found in the measurement of room acoustics and automatic-gain-control circuits, in the synthesis of time ticks on standard-time radio transmissions, and in psychoacoustic instrumentation.

DESCRIPTION: A binary scaler is used to establish both the number of cycles in a burst and the time duration between bursts. Separate front-panel controls select the number of cycles of the timing-input signal during which the gate will be opened and closed. Additional features of the Tone-Burst Generator are a switch that holds the gate open for preliminary alignment of external equipment (if necessary); trigger controls, which allow control of the relative phase of the gate and input signal; the ability to use separate input signals for the gate timing and gated signals; and a timed mode for extremely long periods between bursts.

The Tone-Burst Generator is also useful with pulse and aperiodic signals. If pulses are applied to its input, the TYPE 1396-A performs as a word generator or a frequency divider.



Typical waveform produced by the Type 1396-A/Type 1308-A combination with a 15-kc signal turned on for 16 cycles and off for one-half second. Upper trace shows input to sonar projector; lower trace shows output from projector and subsequent echo return from wall of test tank.

SPECIFICATIONS

SIGNAL INPUT (signal to be gated)
Frequency Range: dc to 500 kc/s.
Maximum Voltage Level: ±7 V (5 V, rms).
Input Impedance: Approximately 10 kΩ.
TIMING SIGNAL (signal that controls gate timing)
Frequency Range: dc to 500 kc/s.
Maximum Voltage Level: ±10 V.
Minimum Voltage Level: 1 V, p-to-p.
Input Impedance: Approximately 7 kΩ.
Triggering: Slope selectable, trigger level adjustable from −7 to +7 V.

GATE TIMING: Gate-open and -closed intervals can be independently set to 2, 4, 8, 16, 32, 64, or 128 cycles (periods) of timing signal. By means of a MINUS ONE switch, intervals can be set to 1, 3, 7, 15, 31, 63, or 127 cycles. The gate-closed intervals can also be timed in increments of one period of timing signal from 1 ms to 10 s. Fixed timing errors are less than 0.5 μs.

GATED SIGNAL OUTPUT
Gate-Open Output: Maximum signal level is ±7 V. Total distortion is less than −60 dB (compared to maximum level) at 1 kc/s and 10 kc/s.
Gate-Closed Output: Less than 140 mV, p-to-p, (−40 dB) with maximum signal input.
Pedestal Output (dc potential difference between open- and closed-gate output): Can be nulled from front panel. Less than 50-mV change with line voltage.
Switching Transients: Less than 140 mV, p-to-p, (−40 dB compared to maximum signal input), with 120-pF load.
Output Impedance: 600 Ω.
Gating Voltage Output (signal for triggering oscilloscope): Rectangular waveform of approximately +12 V at 10-kΩ source when the gate is closed and approximately −12 V at 20 kΩ when the gate is open.

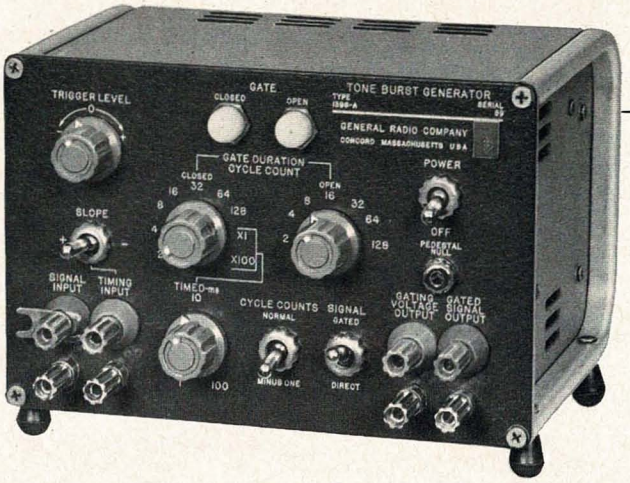
GENERAL
Ambient Operating Temperature: 0 to 50°C (32° to 122°F).
Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 c/s, 15 W, approximately.
Accessories Supplied: TYPE CAP-22 Power Cord.
Accessories Required: External source for any desired frequency range between 0 and 500 kc/s.
Accessories Available: Relay-rack adaptor set (panel height 5¼ in).

MECHANICAL DATA Convertible-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
8	205	5⅞	150	7½	195	6½	3	9	4.1

See also *General Radio Experimenter*, May 1964.

Catalog No.	*Description*	*Price*
1396-9701	**Type 1396-A Tone-Burst Generator**	**$490.00**
0480-9638	**Type 480-P308 Relay-Rack Adaptor Set**	**7.00**



NEW
in catalog S

VARIABLE DELAY LINES

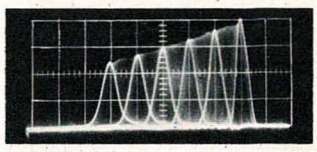
Type 314-S86 VARIABLE DELAY LINE 0 TO 0.5 μs

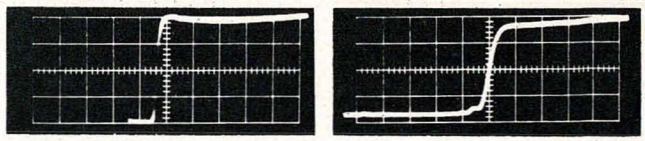
This variable delay line finds general application as a wide-band phase-shifting device, particularly when it is desired to delay a wide-band signal without the introduction of phase distortion.

Good transient response is obtained by a skewed-turn method of delay equalization. The "baseline ripple," caused by variation in characteristic impedance along the line, has been reduced to 5% or less of the signal amplitude. End reflections have been minimized by the use of tapered capacitance elements at the ends of the winding. Materials are chosen for reliable operation under varying conditions of temperature and humidity.

There is no "ringing" or overshoot, and the delay is constant over a wide frequency range.

Oscillogram showing pulse shape and amplitude as delay setting is varied. Tektronix 541 Oscilloscope, 53K/54K Pre-Amplifiers; sweep, 0.1 μs/cm.





Step response of 0.5-μs, 200-Ω variable delay line with skewed winding; (*left*) step input, (*right*) step output at 0.5-μs delay. Scope photos taken on Tektronix 541 Oscilloscope, 0.1-μs/cm sweep.

SPECIFICATIONS

Delay Range: 0 to 0.5 μs (±10%).
Characteristic Impedance: 200 Ω, ±15% up to 4.5 Mc/s.
Dc Resistance: Not over 20 Ω.
Delay vs Frequency (with respect to delay at 1 Mc/s): ±1% at 10 Mc/s; ±2% at 15 Mc/s; ±4% at 20 Mc/s measured at maximum delay.
Amplitude Response vs Frequency: Loss at max delay, 9% (0.8 dB) at dc; 30% (3 dB) at 6 Mc/s; 60% (8 dB) at 10 Mc/s; 90% (20 dB) at 25 Mc/s.
Pulse and Step Response: See accompanying oscillograms.
Resolution: 1 ns.
Voltage: Rating 1500 V, peak, winding to ground.
Dimensions: Diameter, including terminals, 3¼ in (83 mm); depth 1½ in (39 mm), exclusive of shaft; shaft diameter ⅜ in (10 mm); shaft extends beyond body ¾ in (20 mm). Knob is furnished.
Net Weight: 6 oz (0.2 kg).
Shipping Weight: 1 lb (0.5 kg).

See also *General Radio Experimenter*, October 1956.

Catalog No.	*Description*	*Price*
0314-9917	**Type 314-S86 Variable Delay Line**	**$60.00**

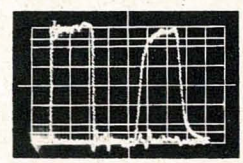
PATENT NOTICE. See Note 20, page 11.

Type 301-S104 VARIABLE DELAY LINE

0 TO 25 ns

The TYPE 301-S104 Variable Delay Line is a small distributed-winding unit with a sliding tap for adjustment of delay. Precious-metal wire is used in the winding to ensure reliable contact. Capacitive coupling between the terminals is minimized by shielding.

Applications for this line will be found in such fields as computers, nuclear physics, radar, and any place where an adjustable, linear phase shifter or wide-band, pulse-delay network is useful.



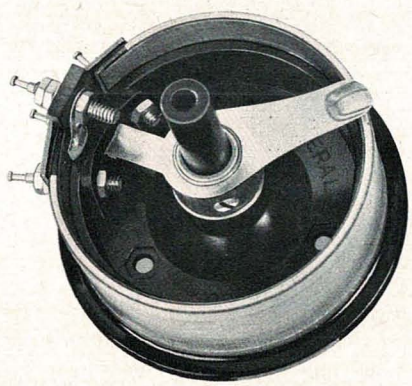
Photograph taken from the screen of a Lumatron 112 oscilloscope. The sweep speed is 5 ns/cm. The photograph shows two sweeps superposed, the first with the delay line set for minimum delay, and the second trace with the line set for maximum delay. Delay, rise time, baseline ripple, and pulse distortion can be measured from the photograph. Attenuation may differ slightly among units.

SPECIFICATIONS

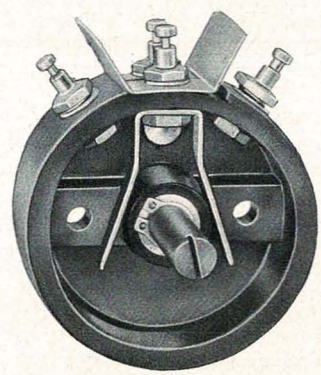
Delay Range: 0 (approximately) to 25 ns (±10%).
Resolution: 0.06 ns.
Characteristic Impedance: 190 Ω ± 15%.
Pulse Rise Time: 2.4 ns (approx) at maximum delay.
Dc Resistance: 5.5 Ω (±20%).
Voltage Rating: 1500 V, peak, winding to ground.
Dimensions: Diameter, including terminals, 2 in (51 mm); thickness, exclusive of shaft, 15/16 in (24 mm); shaft diameter, ¼ in (7 mm); shaft extension beyond body ¾ in (20 mm).
Net Weight: 1½ oz (43 g).
Shipping Weight: 1 lb (0.5 kg).

See also *General Radio Experimenter*, October 1961.

Catalog No.	*Description*	*Price*
0301-9489	**Type 301-S104 Variable Delay Line**	**$48.00**



TYPE 314-S86



TYPE 301-S104

NOISE GENERATOR

Electrical noise is, by definition, an unwanted disturbance, and its reduction in communication circuits is a constant aim of the electronics engineer. When supplied by a properly controlled generator, however, noise becomes a remarkably useful test signal, which has, for many measurements, properties that are more useful than those of a single-frequency signal.

Broad-band electrical noise is often called random noise, because it has a random, or Gaussian, distribution of amplitudes as a function of time. When used as a test signal, it also usually has a uniform spectrum level over its specified frequency range. The random-noise signal, embracing a wide range of frequencies and having a randomly varying instantaneous amplitude, closely approximates the signals normally encountered in many electronic circuits and particularly in busy communication systems. The General Radio Type 1390-B Random-Noise Generator provides a high level of random electrical noise at its output terminals, and its many possible uses make it an indispensable item in the equipment of the modern electronics laboratory.

Type 1390-B RANDOM-NOISE GENERATOR

5 c/s TO 5 Mc/s

FEATURES: Wide frequency range — 5 c/s to 5 Mc/s. ■ Uniform spectrum level over audio range. Output variable from 30 microvolts to 3 volts. ■ Built-in attenuator. Low hum level by use of dc heater supply. ■ Low external noise field. Regulated heater for gas tube stabilizes output level.

USES: This instrument generates wide-band noise of uniform spectrum level, particularly useful for noise and vibration testing in electrical and mechanical systems. Some of its many uses are:

AS A BROAD-BAND SIGNAL SOURCE FOR

- intermodulation and cross-talk tests.
- simulation of telephone-line noise.
- measurements on servo amplifiers.
- noise interference tests on radar.
- determining meter response characteristics.
- setting transmission levels in communication circuits.
- frequency-response measurements. When the random-noise generator is used for frequency-response measurements, either the TYPE 1900-A Wave Analyzer or the TYPE 1564-A Sound and Vibration Analyzer is a satisfactory narrow-band detector. The one-third-octave band of the latter permits measurements to very low frequencies. With the TYPE 1521-B Graphic Level Recorder, continuous records of level vs frequency can be plotted from the output of the analyzer.

AS A SIGNAL SOURCE FOR MEASUREMENTS OF

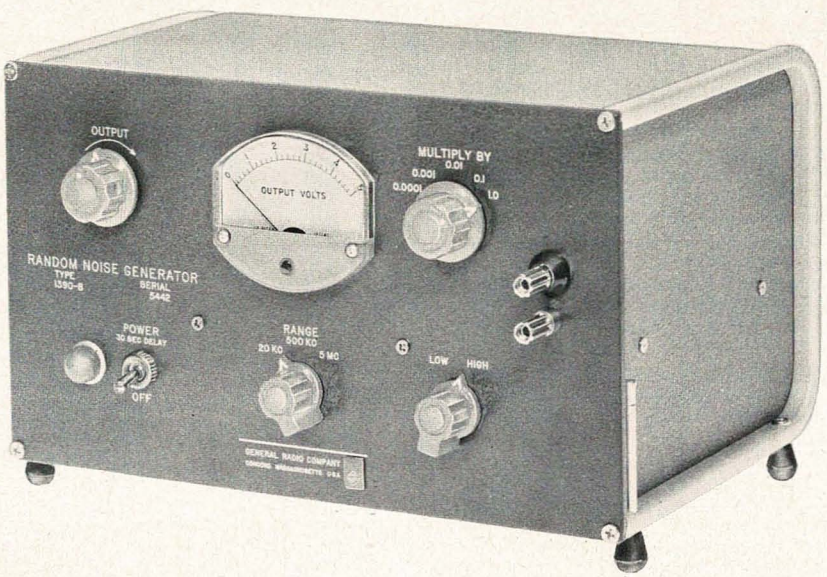
- reverberation. The TYPE 1900-A Wave Analyzer and the TYPE 1564-A Sound and Vibration Analyzer can be used with this generator to produce narrow bands of noise for acoustical measurements.
- sound attenuation of ducts, walls, panels, or floors.
- acoustical properties of materials.
- room acoustics.
- and for classroom or laboratory demonstrations.

WITH A SUITABLE POWER AMPLIFIER

- to drive a loudspeaker to produce high-level acoustic noise for fatigue testing of structures or components.
- to drive a vibration shaker for structural tests of components or assemblies.

DESCRIPTION: A gas-discharge tube, with a transverse magnetic field applied, is used as a noise source in this instrument. The noise output of the tube is amplified in a two-stage amplifier. Between the two stages, the noise spectrum is shaped with low-pass filters to provide ranges to 20 kc/s, to 500 kc/s, and to 5 Mc/s.

The output system consists of a continuous attenuator control followed by a 4-step attenuator of 20 dB per step. Metered levels from over 3 volts to below 30 microvolts are conveniently obtained. When the attenuator is used, the output impedance remains essentially constant as the output level is adjusted.



SPECIFICATIONS

Frequency Range: 5 c/s to 5 Mc/s.

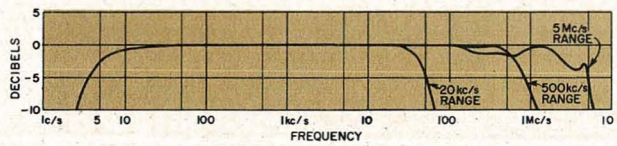
Output Voltage: Maximum open-circuit output is at least 3 V for 20-kc range, 2 V for 500-kc range, and 1 V for 5-Mc range.

Output Impedance: Source impedance for maximum output is approximately 900 Ω. Output is taken from a 2500-Ω potentiometer. Source impedance for attenuated output is 200 Ω. One output terminal is grounded.

Range	*Typical Spectrum Level (with 1-V, rms, output)*	*Spectrum Level Uniformity**
20 kc/s	5 mV for 1-cycle band	within ±1 dB, 20 c/s to 20 kc/s
500 kc/s	1.2 mV for 1-cycle band	within ±3 dB, 20 c/s to 500 kc/s
5 Mc/s	0.6 mV for 1-cycle band	within ±3 dB, 20 c/s to 500 kc/s; within ±8 dB, 500 kc/s to 5 Mc/s

*Noise energy also present beyond these limits. Level is down 3 dB at 5 c/s. See plot.

Waveform: Noise source has good normal, or Gaussian, distribution of amplitudes for ranges of the frequency spectrum that are narrow compared to the band selected. Over wide ranges the distribution is less symmetrical because of dissymmetry introduced by the gas tube. Some clipping occurs on the 500-kc and 5-Mc ranges.



Typical spectrum-level characteristics.

Voltmeter: Rectifier-type averaging meter measures output. It is calibrated to read rms value of noise.

Attenuator: Multiplying factors of 1.0, 0.1, 0.01, 0.001, and 0.0001. Accurate to ±3% to 100 kc/s, within ±10% to 5 Mc/s.

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s, 50 W.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Accessories Available: Rack-adaptor panel (panel height 7 in).

Mechanical Data: Convertible-Bench Cabinet (*see page 258*)

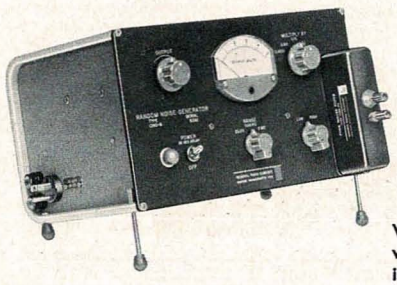
Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
12¾	325	7½	190	9¾	250	12	5.5	16	7.5

For additional information, ask for General Radio Reprint E-110.

Catalog No.	*Description*	*Price*
1390-9702	**Type 1390-B Random-Noise Generator**	**$295.00**
0480-9642	**Type 480-P412 Relay-Rack Adaptor Set**	**7.00**

PATENT NOTICE. See Note 15, page 11.

Type 1390-P2 PINK-NOISE FILTER



View of the noise generator with pink-noise filter plugged into the output terminals.

When white noise is used for frequency-response measurements in conjunction with a constant-percentage bandwidth analyzer (such as the TYPE 1564-A Sound and Vibration Analyzer), the amplitude-frequency characteristic of a flat system appears to slope upward with increasing frequency at a rate of 3 dB per octave, owing to the constantly increasing bandwidth (in cycles) of the analyzer. The TYPE 1390-P2 Pink-Noise Filter converts the output of the random-noise generator in the audio-frequency range from white noise to pink noise, which has constant energy per octave. It plugs into the output terminals of the TYPE 1390-B Random-Noise Generator.

SPECIFICATIONS

Frequency Response: Sloping −3 dB per octave from 20 c/s to 20 kc/s, −6 dB per octave above 20 kc/s. Output voltage is approximately −5 dB with respect to the input voltage at 20 c/s and −35 dB at 20 kc/s. It lies within 1 dB of the straight line connecting these two points on a graph of output in decibels vs log frequency.

Over-all Output Level: When the filter is used with the random-noise generator set for the 20-kc range, the output voltage of the filter is approximately 30 dB below its input, and the voltage level in each one-third-octave band is approximately 17 dB below that. Thus, when the output meter of the generator indicates 3 V, the output of the filter is approximately 0.1 V, and the level in each one-third-octave band is approximately 15 mV.

Input Impedance: The filter should be driven from a source whose impedance is 1 kΩ or less. Input impedance is variable from 6.5 kΩ + load resistance at zero frequency to 6.7 kΩ at high frequencies.

Output Impedance: The filter should not be operated into a load of less than 20 kΩ. Internal output impedance is variable from 6.5 kΩ + source resistance at low frequencies to approximately 200 Ω at high frequencies.

Input Voltage: 15 V, rms, max.

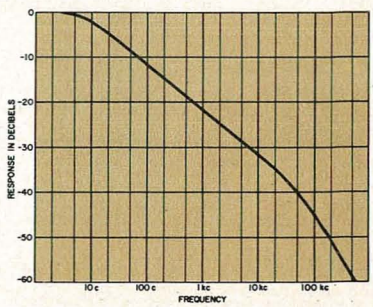
Terminals: Input terminals are recessed banana pins on ¾-in spacing at rear of unit. Output terminals are jack-top binding posts with ¾-in spacing.

Dimensions: Width 1⅜, height 5, depth 2⅞ in (35, 127, 73 mm), over-all.

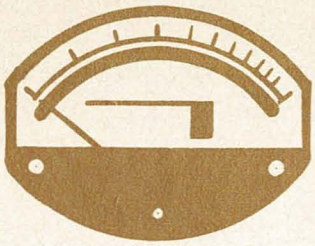
Net Weight: 6 oz (0.2 kg).

Shipping Weight: 4 lb (1.9 kg).

Catalog No.	*Description*	*Price*
1390-9602	**Type 1390-P2 Pink-Noise Filter**	**$45.00**



Response-frequency characteristic of the pink-noise filter.



METERS

Described in this section are a vacuum-tube voltmeter usable up into the gigacycle range, measuring also dc volts and resistance; an electrometer instrument measuring dc millivolts, femtoamperes, and teraohms; and a new output power meter for audio frequencies. The ranges of these instruments, collectively, cover most of the magnitudes usually encountered in the electronics laboratory.

VOLTMETER

The high-vacuum rectifier was first used as a voltmeter to measure power-system voltages.[1] The combination of rectifier and degenerative dc amplifier was introduced by General Radio in 1937.[2] The modern descendant of that pioneer instrument is the Type 1806-A Electronic Voltmeter, which surpasses in frequency range and accuracy the best of previously available types. It has also many other features that contribute to operating convenience and over-all utility — high input impedance, logarithmic meter scale, excellent zero stability, and a small high-frequency probe with a variety of connector accessories.

ELECTROMETER

The Type 1230-A Electrometer and DC Amplifier is a high-stability, direct-coupled amplifier, which can be used not only for direct-reading measurements of small voltages and currents and high resistances but also for amplifying weak currents and voltages to operate recorders, relays, and other equipment.

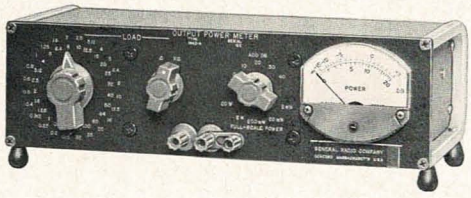
Electronic Voltmeter, Rack Model

OUTPUT POWER METER

The output power meter, an original General Radio development,[3] is now available for use over wider ranges than ever before. This indispensable laboratory and test-bench device measures power into an adjustable resistive load and thus can determine both the maximum power output and the internal impedance of oscillators and amplifiers.

[1] C. H. Sharp and C. D. Doyle, "Crest Voltmeters," *Trans. AIEE*, Vol 35, February, 1916, pp 99–107.
[2] W. N. Tuttle, "Type 726-A Vacuum-Tube Voltmeter," *General Radio Experimenter*, May, 1937.
[3] "A Direct-Reading Meter for Power and Impedance Measurements," *General Radio Experimenter*, November, 1932.

Output Power Meter



Electronic Voltmeter, Portable Model

Electrometer

IN THIS SECTION

Type	*Name*	*Quantity Measured*	*Range of Measurement*	*Nominal Frequency Range*	*Basic Accuracy*	*Remarks*	*Page*
1806-A, -AR	**Electronic Voltmeter**	Ac Voltage	0.1 to 1500 V	20 c/s to 1.5 Gc/s	±2% of indication	2 models, portable and rack	172
		Dc Voltage	0.005 to 1500 V	dc	±2% of indication		
		Resistance	0.2 Ω to 10^9 Ω		±5% of indication		
1230-A, -AE	**Electrometer and DC Amplifier**	Voltage	0.5 mV to 10 V	dc	±2% of full scale	Also a sensitive amplifier	174
		Current	5×10^{-15} A to $\pm10^{-3}$ A		±3% of full scale		
		Resistance	3×10^5 Ω to 5×10^{14} Ω		±3% at full scale		
1840-A	**Output Power Meter**	Power	0.1 mW to 20 W	20 c/s to 20 kc/s	±0.5 dB at mid-range		176
		Impedance	0.6 Ω to 32 kΩ		±6% at mid-range		

IN OTHER SECTIONS

1932-A	**Distortion and Noise Meter**	Distortion	0.1% to 30%	50 c/s to 18 kc/s, (harmonics and noise to 55 kc/s)	±5% of full scale	Excellent for signal-to-noise ratio measurement	35
		Noise Level	−10 to −80 dB				
1900-A	**Wave Analyzer**	Voltage	30 μV to 300 V	20 c/s to 54 kc/s	±(3% + 2% of full scale + 3 μV)	3, 10, and 50-cycle bandwidths	28
1564-A	**Sound and Vibration Analyzer**	Voltage	0.1 mV to 30 V	2.5 c/s to 25 kc/s	±5% of full scale		30
1862-C	**Megohmmeter**	Resistance	5×10^5 to 2×10^{12} Ω	dc	3% to 12%	500 V and 100 V	75
546-C	**Microvolter**	Voltage	0.5 μV to 1 V	20 c/s to 20 kc/s	±(3% + 0.5 μV)	For use with oscillator as a calibrated source	38
				up to 100 kc/s	±5% above 0.1 V		
874-VR 874-VI	**Voltmeter Rectifier Voltmeter Indicator**	Voltage	0.1 to 2 V	15 Mc/s to 2.5 Gc/s	±0.05 V	Substitution measurement	86

Type 1806-A ELECTRONIC VOLTMETER

FEATURES:

- Measures ac and dc voltages, and resistance.
- High accuracy: ±2% *of indicated value* over most of the range.
- Wide frequency range — up to 1500 Mc/s.
- Measures up to 1500 volts in only four ranges, each with a 10-to-1 span.
- A single scale for all voltages, except the lowest ac range.
- Small ac probe for easy connection to small components.
- Meter has taut-band suspension.
- An internal socket and reel store the probe and its cable.

USES: This versatile instrument is indispensable in the modern electronics laboratory. It will measure dc voltage from millivolts to 1500 volts; with "open-grid" impedance, up to 150 volts. It will measure ac voltage from 0.1 to 1500 volts. A small probe allows convenient connection to circuit points for high-frequency measurements up to 150 volts, or up to 1500 volts with the new TYPE 1806-P2 Range Multiplier. The probe can be used with the TYPE 1806-P1 Tee Connector to measure voltage on a closed coaxial system at frequencies up to 1500 Mc/s. As an ohmmeter, the TYPE 1806-A will measure resistance from 0.2 ohm to 1000 megohms.

DESCRIPTION: The heart of this instrument is a new, highly stable, tube-and-transistor, dc amplifier. Its balanced circuit and regulated heater voltages provide zero stability. Calibration stability is excellent because there is so much feedback that changes in tube transconductance or transistor current gain have negligible effect. For measurement of ac voltages, a ceramic thermionic diode with extremely short electron transit time is used in a small, convenient probe with a variety of connector accessories.

The small physical size and close electrode spacing of the diode give it a high resonant frequency and low transit time, both of which contribute to the excellent high-frequency performance.

This instrument is available in both a portable bench model and a relay-rack model. The panel of the portable model can be adjusted to any desired angle for convenient viewing.

SPECIFICATIONS

DC VOLTMETER

Voltage Range: Four ranges, 1.5, 15, 150, and 1500 V, full scale, positive or negative. Minimum reading is 0.005 V.

Input Resistance: 100 MΩ, ±5%; also "open grid" on all but the 1500-V range. Grid current is less than 10^{-10} A.

Accuracy: ±2% of indicated value from one-tenth of full scale to full scale; ±0.2% of full scale from one-tenth of full scale to zero. Scale is logarithmic from one-tenth of full scale to full scale, permitting constant-percentage readability over that range.

AC VOLTMETER

Voltage Range: Four ranges, 1.5, 15, 150, and 1500 V, full scale. Minimum reading on most sensitive range is 0.1 V.

Input Impedance: Probe, approximately 25 MΩ in parallel with 2 pF; with TYPE 1806-P2 Range Multiplier, 2500 MΩ in parallel with 2 pF; at binding post on panel, 25 MΩ in parallel with 30 pF.

Accuracy: At 400 c/s, ±2% of indicated value from 1.5 V to 1500 V; ±3% of indicated value from 0.1 V to 1.5 V.

Waveform Error: On the higher ac-voltage ranges, the instrument operates as a peak voltmeter, calibrated to read rms values of a sine wave or 0.707 of the peak value of a complex wave. On distorted waveforms the percentage deviation of the reading from the rms value may be as large as the percentage of harmonics present. On the lowest range the instrument approaches rms operation.

Portable model, Type 1806-A.

Frequency Characteristic: Low-frequency roll-off is less than 3% at 20 c/s. Above 150 V with internal voltage divider, there is an additional error of not more than ±2% for frequencies below 500 kc/s.

Probe resonant frequency is above 3000 Mc/s. Above several hundred megacycles per second, probe should be used in a 50-Ω coaxial system with the TYPE 1806-P1 Tee Connector. Low-frequency roll-off is then less than 3% at 1 kc/s. At high frequencies and low voltages, the error is a function of input voltage level, owing to transit-time effects, as shown in the accompanying plot. Total error is less than ±3 dB below 1500 Mc/s.

Low-frequency roll-off of the combined voltmeter and multiplier is less than 3% at 10 kc/s. At high frequencies, the multiplier does not affect the over-all voltmeter response.

OHMMETER

Range: 0.2 Ω to 1000 MΩ in four ranges with center scale values of 10 Ω, 1 kΩ, 100 kΩ, and 10 MΩ.

Test Voltage: The dc test voltage is positive and never exceeds 1.5 V. The maximum current (which is delivered to a short circuit on the lowest resistance range) is approximately 43 mA. The maximum available power from the ohmmeter circuit is 16 mW.

Accuracy: ±5% of indicated value from 1 to 10 on scale, approaching ±10% of indicated value at 100 on scale.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s, 20 W approximately. The case is grounded by the third wire in the power cord. The voltmeter circuit can be disconnected from the case and operated as much as 300 V dc off ground. The low input terminal remains by-passed to the case.

Type 1806-P1 TEE CONNECTOR

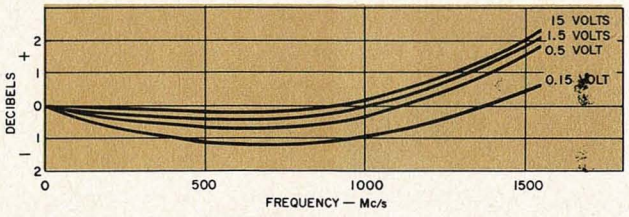
A necessary attachment to the ac probe to realize the full 1500-Mc frequency range of the voltmeter. Screws onto the probe in place of the probe tip.

VSWR: The VSWR of the tee connector and probe is less than 1.1 below 1000 Mc/s.

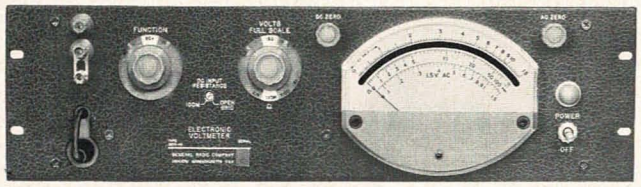
Connectors: Locking GR874 Connectors are used. Adaptors to other coaxial systems are available (see page 81).

Dimensions: 4 by 1 by 1⅛ in (102, 25, 28 mm).

Net Weight: 3½ oz (100 g). **Shipping Weight:** 1 lb (0.5 kg).



Typical high-frequency response characteristics of the probe and tee connector operating in a 50-ohm system.



Rack model, Type 1806-AR.

Probe Storage: A socket and reel store both probe and cable.

Accessories Supplied: Spare fuses, CAP-22 Power Cord (on rack model only), an assortment of probe tips for various types of connections.

MECHANICAL DATA Flip-Tilt Case (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Portable	7½	190	8½	220	11½	295	10	4.6	13	6
Rack	19	485	5¼	135	9¼*	235	10	4.6	17	8

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, July 1963.

Type 1806-P2 10:1 RANGE MULTIPLIER

This is a capacitive voltage divider, which screws onto the ac probe in place of the probe tip. It permits direct use of the probe to 1500 volts ac, and the voltage applied to the probe is one-tenth of that applied to the multiplier.

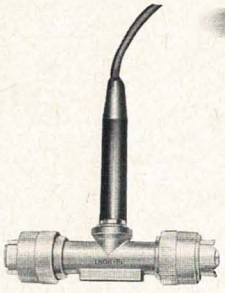
Multiplication Ratio: 10:1 ±5%. An adjustment is provided for matching the multiplier to the voltmeter within ±2%.

Input Impedance: Equivalent input resistance of the probe-multiplier combination is 100 times that of the probe alone. Equivalent parallel capacitance is approx 2 pF.

Dimensions: ⅝ in dia by 1¼ in long (16, 32 mm).

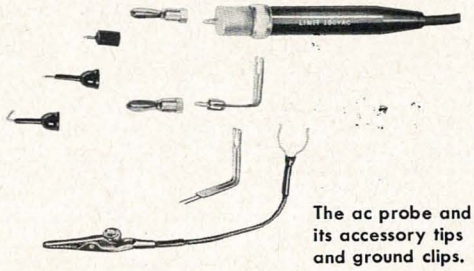
Net Weight: ½ oz (15 g). **Shipping Weight:** 3 oz (85 g).

Catalog Number	*Description*	*Price*
1806-9701	**Type 1806-A Electronic Voltmeter,** Portable Model	**$490.00**
1806-9811	**Type 1806-AR Electronic Voltmeter,** Rack Model	**490.00**
1806-9601	**Type 1806-P1 Tee Connector**	**35.00**
1806-9602	**Type 1806-P2 10:1 Range Multiplier**	**20.00**



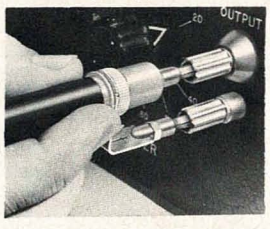
Type 1806-P1

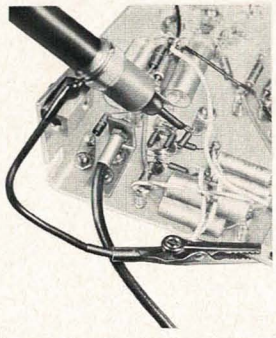
Range multiplier installed on probe.



The ac probe and its accessory tips and ground clips.

Various methods of using the ac probe with different combinations of the tips and ground clips supplied.





Type 1230-A ELECTROMETER AND DC AMPLIFIER

FEATURES:

Extremely high input resistance, even in humid environment.
High sensitivity and excellent stability.
Shielded input circuits and component shield permit shielding to be extended to the unit under test.
Guard terminals — the low-potential input terminal can be grounded or floating.
Large meter with two voltage scales and two resistance scales.
Output terminals for connecting an external meter, oscilloscope, or recorder.
Amplifies weak dc voltages for recording and control.

USES: The Electrometer and DC Amplifier has a wide variety of applications in physics, chemistry, engineering, and industry. Typical uses include the measurement of

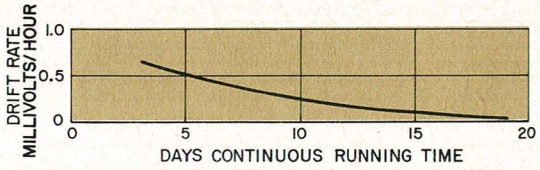
Currents: Ionization currents, photo currents, grid currents in electron tubes, leakage currents in semiconductors and insulators, and time-current curves of capacitors during charge and discharge.

Voltages: Piezoelectric potentials, bioelectric potentials, contact potentials, electrostatic-field potentials, and PH indications.

Resistances: Back resistance of silicon-junction diodes, insulation resistance of electrical equipment, and voltage coefficient of resistance.

DESCRIPTION: The Electrometer and DC Amplifier is basically a millivoltmeter with a three-stage, direct-coupled amplifier that acts as a highly degenerated cathode follower with high over-all transconductance. It measures *voltage* (0.5 millivolt to 10 volts) directly; *current* (5×10^{-15} to 10^{-3} amperes) in terms of the voltage drop across a standard resistor; and *resistance* (3×10^{5} to 5×10^{14} ohms) directly.

To achieve a high degree of stability, all power-supply voltages are regulated, and all components are carefully selected and pre-aged. Chassis and subassemblies are shockmounted. See graph for typical drift characteristics.



Typical drift after tubes are changed.

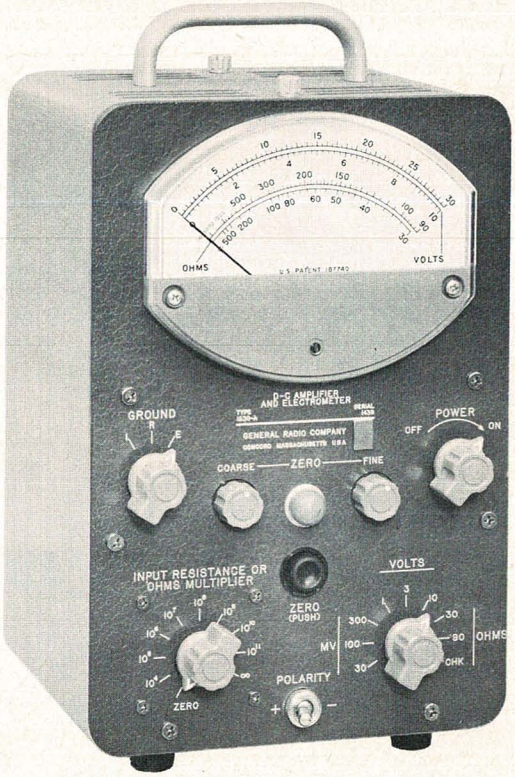
For high input resistance, unaffected by humidity, the input grid lead of the electrometer tube is enclosed in silicone-treated glass. The input-resistance selector has switch contacts that are mounted on individual Teflon* bushings set in a metal base that connects to a guard point.

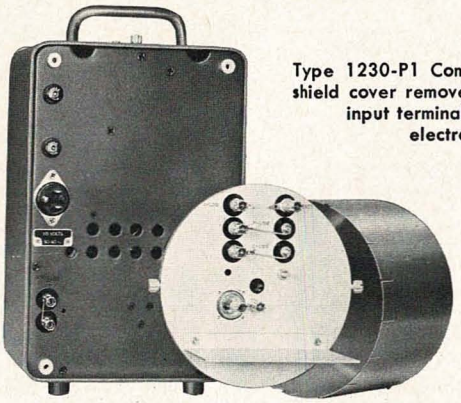
A completely shielded chamber, the TYPE 1230-P1 Component Shield, is available as an accessory within which the components to be measured can be conveniently connected.

The Esterline-Angus (or equivalent) 5-milliampere graphic recorder is recommended. The TYPE 1230-AE model has a matching Esterline-Angus case. More sensitive recorders, such as the TYPE 1521 Graphic Level Recorder, can be shunted for 5-milliampere operation.

* Registered trademark of the E. I. duPont de Nemours and Company.

FOR VOLTAGE, CURRENT, AND RESISTANCE MEASUREMENTS





Type 1230-P1 Component Shield (with shield cover removed) plugged into the input terminal at the rear of the electrometer.

Type 1230-AE Electrometer and DC Amplifier with a recorder.

SPECIFICATIONS

RANGES OF MEASUREMENT

Voltage: ±30, 100, and 300 mV, ±1, 3, and 10 V, dc, full scale.

Current: ±1 mA (10^{-3} A) dc, full scale, to ±300 fA (3×10^{-13} A) full scale.

Resistance: Direct reading from 300 kΩ to 10 MMΩ (10^{13} Ω) full scale (5×10^{14} Ω at smallest meter division). There are 16 ranges, two per decade. Voltage across the unknown resistance is 9.1 V.

Extensions of Range: With batteries, or other suitable external supply, the resistance range can be extended, the voltage across the unknown can be increased, and the voltage coefficient of resistors can be measured.

With a 300-V battery, the highest resistance range is 10^{15} Ω full scale (6×10^{16} Ω at the smallest meter division). The full battery voltage appears across the unknown resistance. The maximum permissible voltage is 600 V if the external supply is grounded; somewhat greater if ungrounded.

ACCURACY

Voltage: ±2% of full scale on the five highest ranges, ±4% of full scale on the 30-mV range.

Current: ±3% of full scale from 10^{-3} to 10^{-9} A, ±10% of full scale from 3×10^{-10} to 3×10^{-13} A.

Resistance: ±3% from 3×10^{5} to 10^{10} Ω at full scale (low-resistance end), ±8% from 3×10^{10} to 10^{13} Ω.

Resistance Standards: 10^{4}, 10^{5}, 10^{6}, 10^{7}, 10^{8}, 10^{9}, 10^{10}, and 10^{11} Ω. The switch also includes zero and infinity positions. The 10^{4}- and 10^{5}-Ω resistors are wire wound and are accurate to ±0.25%. The 10^{6}-, 10^{7}-, and 10^{8}-Ω resistors are of deposited-carbon construction and are accurate to ±1%. The 10^{9}-, 10^{10}-, and 10^{11}-Ω resistors are carbon, have been treated to prevent adverse humidity effects, and are accurate to ±5%. A switch position permits quick checking of the higher-resistance standards in terms of the wire-wound units.

INPUT

Resistance: The input resistance is determined by the setting of the resistance standards switch. In the infinity position, it is approximately 10^{14} Ω.

Capacitance: Less than 35 pF.

Terminals: The input is connected through a GR874 coaxial terminal assembly at the rear of the instrument. In addition, there are three low terminals to provide versatility in guard and ground connections, as required, for example, in three-terminal network measurements. These are low-thermal-emf binding posts.

Switch: A panel switch permits disconnection of the unknown without transient electrical disturbances in either the unknown or the measuring circuit.

Insulation: Entirely Teflon or silicone-treated glass.

OUTPUT

Indication: Voltage, current, and resistance are indicated on a panel meter.

Recorder: Terminals are available for connecting a recorder (such as the Esterline-Angus 5-mA or 1-mA graphic recorder).

AMPLIFIER CHARACTERISTICS

Maximum Transconductance: 167 m℧ (for 30-mV input, the output current is 5 mA).

Output Load: Maximum allowable recorder resistance is 1500 Ω.

Drift: Less than 2 mV per hour after one-hour warmup.

FREQUENCY CHARACTERISTICS

With a 1500-Ω load at the output terminals, the frequency characteristic is flat within 5% from zero to 10, 30, 100, 300, 1000, and 3000 c/s at the 30-, 100-, 300-mV, 1-, 3-, and 10-V ranges, respectively.

GENERAL

Humidity, Line-Voltage Effects: Negligible.

Accessories Supplied: One adaptor to GR874 Connector, one panel-adaptor assembly, one TYPE 274-SB Plug, TYPE CAP-22 Power Cord, and spare fuses.

Accessories Available: TYPE 1230-P1 Component Shield, TYPE 1521-B Graphic Level Recorder.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 c/s, approximately 45 W. Instruments will operate satisfactorily on power-supply frequencies up to 400 c/s.

MECHANICAL DATA Lab-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
7⅝	195	13¼	340	9	230	15¼	7	24	11

Catalog Number	*Description*	*Price*
1230-9701	**Type 1230-A Electrometer and DC Amplifier**	**$460.00**
1230-9816	**Type 1230-AE Electrometer and DC Amplifier (in Esterline-Angus Case)**	**540.00**
1230-9601	**Type 1230-P1 Component Shield**	**40.00**

PATENT NOTICE. See Notes 4 and 15, page 11.

Type 1840-A OUTPUT POWER METER

FEATURES:

Wide frequency response — 20 c/s to 20 kc/s.
Rms indication — reads rms with harmonics up to 20%.
48 different impedances — 0.6 ohm to 30 kilohms.
Measures power from 0.1 milliwatt to 20 watts.

USES: The TYPE 1840-A Output Power Meter measures audio-frequency power into any desired load. Its important uses include the measurement of:

Power output of oscillators, amplifiers, preamplifiers, transformers, transducers, and low-frequency lines.

Output impedance, by adjustment of the load seen by the device under test to yield maximum power indication on the meter.

Frequency-response characteristics of amplifiers, transformers, and other audio-frequency devices.

DESCRIPTION: This instrument is basically a multi-tapped audio-frequency transformer with a fixed secondary load. Its two front-panel load switches connect eight identical primary windings and six secondary taps in various combinations to provide a total of 48 different primary impedances.

The use of grain-oriented silicon steel in a laminated core yields a 20-watt rating with a relatively small core. The range can be extended to 200 watts for any particular impedance with the addition of a simple T-network attenuator. Details are given in the instruction book.

SPECIFICATIONS

RANGES

Power: 0.1 mW to 20 W, except as noted on the accompanying derating curves and table. Auxiliary dB scale reads from −15 to +43 dB re 1 mW.

Impedance Setting of Type 1840-A

Ohms	0.6	0.8	1	1.25	1.6	2
	2.5	3.12	4	5	6.4	8
	10	12.5	16	20	25	32
	40	50	64	80	100	128
Kilohms	0.15	0.2	0.25	0.312	0.4	0.5
	0.6	0.8	1	1.25	1.6	2
	2.5	3.12	4	5	6.4	8
	10	12.5	16	20	25	32
	A	B	C	D	E	F

(Refer to curves at right)

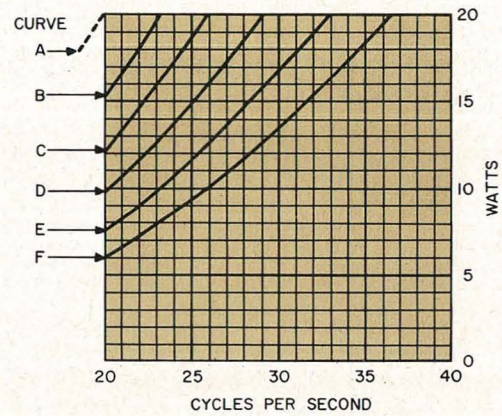
Impedance: 0.6 Ω to 32 kΩ in two ranges; yielding 48 individual impedances spaced approximately $\sqrt[3]{2}$ apart.

ACCURACY

Power: At 1 kc/s, ±0.3 dB; from 50 to 6000 c/s, ±0.5 dB; from 30 to 10,000 c/s, ±1 dB; at 20 c/s, −1.5 dB max, −1 dB average; at 20,000 c/s, −5 dB max, ±1.5 dB average.

Impedance: At 1 kc/s, ±6% max, −0.5% average; from 70 to 5000 c/s, ±7% for values below 10,000 Ω (7% from 70 to 2500 c/s for 10,000 Ω and above); at 20 c/s, −15% max, −8% average; at 20,000 c/s, ±50% max, ±12% average.

Waveform Error: Meter will indicate true rms with as much as 20% second and third harmonics present in the input signal.

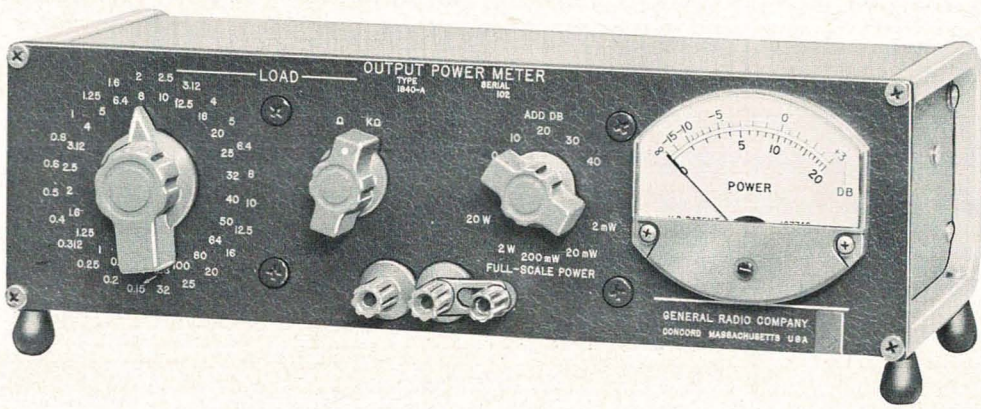


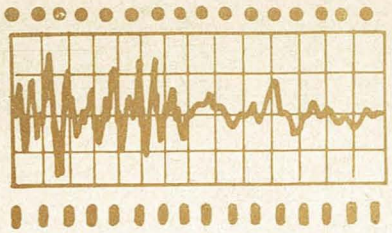
Derating vs impedance setting and frequency.

MECHANICAL DATA Convertible-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
12	305	4	105	8	205	10¾	4.9	17	8

Catalog Number	*Description*	*Price*
1840-9701	**Type 1840-A Output Power Meter**	**$240.00**
0480-9622	**Type 480-P212 Relay-Rack Adaptor Set** (panel height, 3½ in)	**6.00**





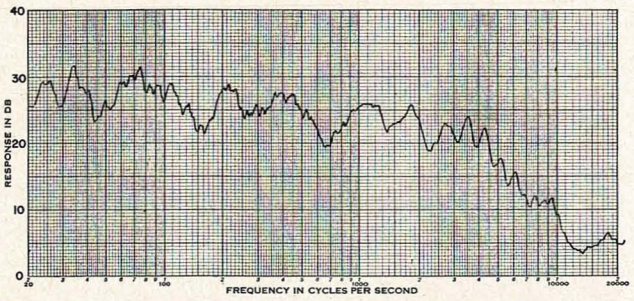
RECORDERS, PRINTERS CONVERTERS

The automatic recording of data has replaced manual methods wherever measurement is continuous or a long series of measurements is made. The analog recorder (also called "graphic" or "strip-chart") produces a permanent record of a voltage or current that is an analog of the quantity under observation. The record is usually in ink, on a moving strip of paper, whose motion is either a function of time or of an independent variable in the measurement program.

The digital recorders or printers, operating from binary-coded data, furnish a numerical record on paper tape. Digital data can be transformed into analog data by a digital-to-analog converter. Listed in this section are two graphic recorders, a printer, a digital-to-analog converter, and a combination converter and recorder.

GRAPHIC LEVEL RECORDER

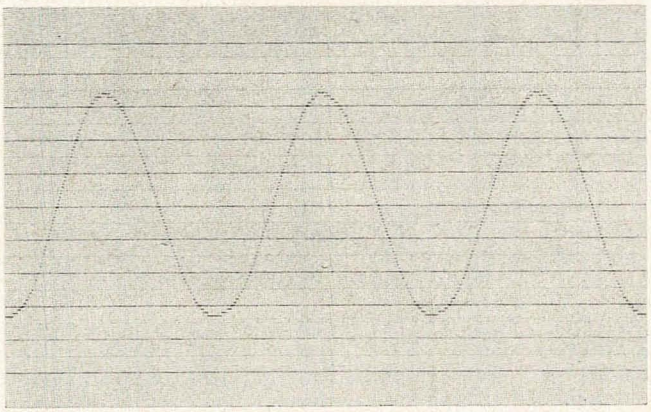
The Type 1521-B Graphic Level Recorder is a servo-type device, producing an ink record on moving paper. It plots linearly in decibels the rms level of ac voltage up to 200 kc/s. Interchangeable potentiometers give full-scale values of 20, 40, and 80 dB, as well as a linear dc range. This recorder can plot the output level of electrical and electro-acoustic devices as a function of time. It is available in combination with wave analyzers for automatic plotting of frequency spectra, with the beat-frequency audio-generator for automatic frequency-response plotting, and with a d/a converter for the analog recording of digital data.



Response of a public address system as plotted automatically by the Type 1521-B Graphic Level Recorder.

SAMPLING RECORDER

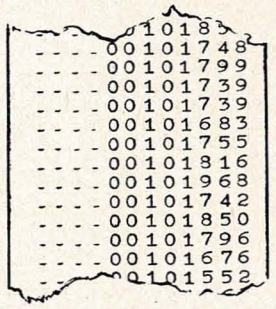
The Type 1520-A Sampling Recorder uses 117 fixed pens, spaced along the vertical scale of a moving chart paper, each of which prints a dot whenever the voltage level of the input function, which is scanned at a 3-kc rate, equals the level of an internally generated linear ramp voltage. Such a system has no frequency response limitation for the recording of transients except that which is imposed by the sampling rate.



Trace of a one-cycle-per-second sine wave as plotted on the Type 1520-A Sampling Recorder.

DATA PRINTER

The Type 1137-A Data Printer operates from BCD input data and prints a permanent numerical record. Models are available with plug-in code modules to accept data from General Radio frequency counters and from the Type 1680-A Automatic Capacitance Bridge Assembly. The printer can also be used with digital devices of other manufacture.



Sample of digital record produced by the Type 1137-A Data Printer.

DIGITAL-TO-ANALOG CONVERTER

The Type 1136-A Digital-to-Analog Converter transforms BCD data to an analog voltage, which can be fed into the Type 1521-B Graphic Level Recorder, the Type 1520-A Sampling Recorder, or other strip-chart recorder to produce a chart record in analog form. The converter and graphic level recorder are available in combination as the Type 1510-A Digital-to-Graphic Recording Assembly.

Type 1521-B GRAPHIC LEVEL RECORDER

FEATURES: Plots rms level of ac voltage, 7 c/s to 200 kc/s. ■ Completely transistorized. Fast writing speed with optimum ballistics. ■ Wide range of paper speeds. Calibrated in absolute level. ■ Interchangeable logarithmic potentiometers. Mechanical coupling available for driving oscillator or analyzer. Simple to operate — three basic controls. ■ Easily converted to dc linear recorder.

USES: The TYPE 1521-B Graphic Level Recorder has a wide variety of uses in physical science and engineering. It produces permanent ink records of the response of electrical or electro-acoustical devices and systems as a function of time or frequency. Owing to the high stability of its reference voltage and amplifier gain, it can be calibrated and used as a recorder of absolute level.

AMPLITUDE-FREQUENCY PLOTTING. The paper drive can be coupled by means of drive and link units to the frequency-control shaft of an oscillator or analyzer for completely automatic recording. The combination of recorder and audio generator (see TYPE 1350-A Generator-Recorder Assembly, page 133) produces records having a true logarithmic frequency scale and is ideal for plotting frequency characteristics of analyzers, recording systems, networks, filters, and equalizers, as well as of loudspeakers, microphones, vibration pick-ups, and other transducers.

ACOUSTICAL MEASUREMENTS. The combination of recorder and analyzer (see TYPE 1910-A Recording Wave Analyzer, page 29, and TYPE 1911-A Recording Sound and Vibration Analyzer, page 31) makes possible automatic analysis of sound spectra and response measurements on devices excited by white noise.

With a sound-level meter (pages 14–16), the recorder can plot sound levels over a wide dynamic range as a function of time. The writing speed is sufficiently high for the measurement of reverberation time and other transient phenomena.

The wide range of paper speed facilitates long-period studies of the noise produced by traffic and machinery, as well as of short-duration transients.

DESCRIPTION: The TYPE 1521-B Graphic Level Recorder is a completely transistorized, single-channel, servo-type recorder. It produces a strip-chart record with ink on white paper, suitable for reproduction. The pen is attached to a coil, which moves linearly over a 4-inch distance in a uniform magnetic field. A contact attached to the coil rides on a straight potentiometer, which is the balancing element for the servo. The position of the contact is determined by the input signal, and the exponential potentiometer characteristic produces a linear dB scale.

The ac voltage at the potentiometer contact is amplified and then rectified in an rms detector.

The difference between the detector output and a one-volt reference is amplified and used to position the coil, which carries the potentiometer contact and pen. A velocity-feedback coil mounted on the drive-coil frame provides appropriate damping. The response is, for all commonly encountered wave-forms, very close to true rms.

The frequency response can be extended downward to 7 c/s at the slower writing speeds. Writing speeds and low-frequency cutoff are selected by a single switch.

Changes of range are easily accomplished by use of a 20-dB or an 80-dB potentiometer in place of the standard 40-dB unit. With the 80-dB unit, the maximum writing speed is 300 dB/second. The slow writing speeds filter out abrupt level variations, yielding a smoothed plot without loss of accuracy.

For dc recording, a linear potentiometer provides a balancing voltage in series with the input voltage, and the combined voltage is balanced against the 1-volt reference.

SPECIFICATIONS

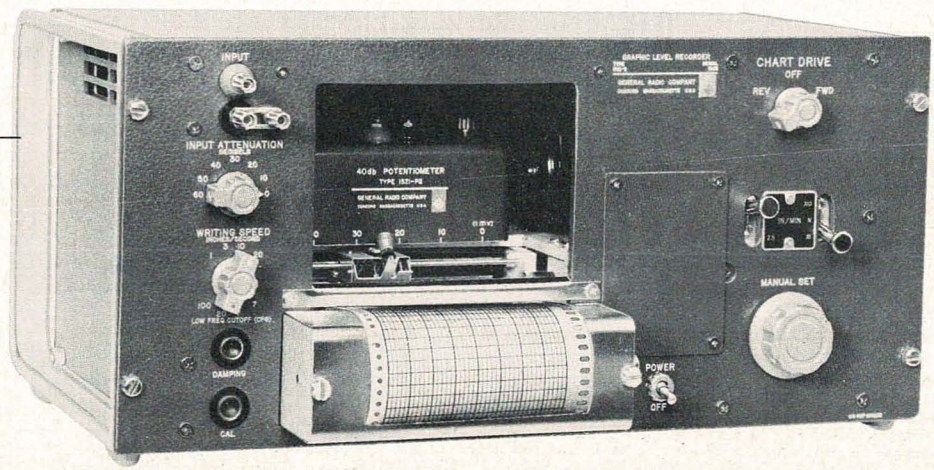
Recording Range: As supplied, 40 dB full-scale; 20-dB and 80-dB ranges are also available. For dc recording, 0.8 to 1 V (0.8 to 1.0 mA) full-scale, with zero position adjustable over full scale.

Frequency Response and Writing Speed:

Level Recording: High-frequency response ±2 dB to 200 kc/s. Low-frequency sine-wave response depends on writing speed, as shown in following table:

Writing Speed (approx) in/s with 0.1-inch overshoot	*Low-Frequency Cutoff c/s (less than 1 dB down)*
20	100
10	20
3	7 (3 dB down at 4.5 c/s)
1	7 (3 dB down at 4.5 c/s)

NEW MODEL
in catalog S



Dc Recording: 3 dB down at 8 c/s (peak-to-peak amplitude less than 25% of full scale).

Potentiometer Linearity:

20-, 40-, 80-dB Potentiometers: ±1% of full-scale dB value plus a frequency error of 0.5 dB at 100 kc/s and 1.5 dB at 200 kc/s.

Linear Potentiometer: ±1% of full scale.

Resolution: ±0.25% of full scale.

Maximum Input Voltage: 100 V ac.

Input Attenuator: 60 dB in 10-dB steps.

Input Impedance: 10,000 Ω for ac level recording; 1000 Ω for dc recording.

Maximum Sensitivity: 1 mV at 0 dB for level recording; 0.8 or 1 V full-scale for dc recording.

Paper Speeds:

High-speed motor (normally supplied): Paper speeds of 2.5, 7.5, 25, 75 in/min. Used for high-speed-transient measurements and with TYPE 1304 Beat-Frequency Audio Generator.

Medium-speed motor (supplied on request): Paper speeds of 0.5, 1.5, 5, 15 in/min. Used with analyzers and in level-vs-time plots.

Low-speed motor (supplied on request): Paper speeds of 2.5, 7.5, 25, 75 in/h. Used for level-vs-time measurements from 1 to 24 h.

External Dc Reference: An external dc reference voltage of from 0.5 to 1.5 V can be applied internally to correct for variations of up to 3 to 1 in the signal source of the system under test.

Detector Response: Rms within 0.25 dB for multiple sine waves, square waves, or noise. Detector operating level is 1 V.

Chart Paper: 4-inch recording width on 5-inch paper. All rolls are 100 feet long. See full list of charts below.

Accessories Supplied: 40-dB potentiometer, 2 pens, 2-ounce bottle of red ink, 2-ounce bottle of green ink, bottle of potentiometer cleaner, 1 roll of No. 1521-9428 paper, droppers for filling pens, Type CAP-22 Power Cord, spare fuses, adaptor cable for connection to devices having telephone jacks.

Accessories Available: Potentiometers, charts, ink, high-, medium- and slow-speed motors, drive and link units, as listed in price table.

Power Required: 105 to 125 or 210 to 250 V, 50 or 60 c/s, 35 W.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	9	230	13½	350	50	23	62	29
Rack	19	485	8¾	225	11¼*	290	50	23	62	29

* Behind panel.

See also *General Radio Experimenter*, September 1964.

Catalog No.		*Mounting*	*Supply Frequency*	*Paper Speed*	*Price*
1521-9812	**Type 1521-B**	Rack	60 c/s	2.5-75 in/min	**$995.00**
1521-9802	**Type 1521-B**	Bench	60 c/s	2.5-75 in/min	**995.00**
1521-9507	**Type 1521-BQ1**	Rack	50 c/s	2.5-75 in/min	**on request**
1521-9506	**Type 1521-BQ1**	Bench	50 c/s	2.5-75 in/min	**on request**

PATENT NOTICE. See Notes 1 and 18, page 11.

OPTIONAL MOTORS†

Catalog No.	*Description*	*Price*
1521-9619	**Type 1521-P19 High-Speed Motor** (60 c/s) for paper speeds of 2.5-75 in/min (normally supplied in recorder)††	**$59.00**
1521-9921	**Type 1521-P21B High-Speed Motor** (50 c/s) for paper speeds of 2.5-75 in/min††	**on request**
1521-9623	**Type 1521-P23 Medium-Speed Motor** (60 c/s) for paper speeds of 0.5-15 in/min	**59.00**
1521-9624	**Type 1521-P24 Medium-Speed Motor** (50 c/s) for paper speeds of 0.5-15 in/min	**on request**
1521-9513	**Type 1521-P20B Low-Speed Motor** (60 c/s) for paper speeds of 2.5-75 in/h	**59.00**
1521-9622	**Type 1521-P22 Low-Speed Motor** (50 c/s) for paper speeds of 2.5-75 in/h	**on request**

† Recorder can be supplied with low-speed or medium-speed motor installed, at same price as with standard motor.
†† Not for use with TYPE 1900-A and TYPE 1564-A Analyzers. Use -P23, -P24.

CHART PAPERS

Catalog No.	*Calibration Horizontal*	*Calibration Vertical (Div)*	*Chart Length (in) Calibrated*	*Chart Length (in) Blank*	*Associated Instrument*	*Price*
1521-9427	20 c/s-20 kc/s, log	80	9	4½	1304-B Generator	**$2.75**
1521-9464	0-10 kc/s, linear	40	20	0	1900-A Analyzer	**2.75**
1521-9465	0-50 kc/s, linear	40	16	0	1900-A Analyzer	**2.75**
1521-9493	2.5-25 normalized, log	40	7½	1½	1564-A Analyzer	**2.75**
1521-9469	2.5-25 normalized, log	40	5	1	1564-A Analyzer	**2.75**
1521-9463	2.5 c/s-25 kc/s, log	40	18	3	1554-A Analyzer	**2.75**
1521-9429	25-7500 c/s, log	40	12½	1	760-B Analyzer	**2.75**
1521-9428	Continuous ¼-in div	40	continuous			**2.75**
1521-9466	Continuous ⅝-in div	50	continuous		1134-A, 1136-A D/A Converters	**2.75**

POTENTIOMETERS

Catalog No.	*Description*	*Price*
1521-9601	**Type 1521-P1 20-dB Potentiometer**	**$ 55.00**
1521-9602	**Type 1521-P2 40-dB Potentiometer**§	**70.00**
1521-9603	**Type 1521-P3 80-dB Potentiometer**	**155.00**
1521-9604	**Type 1521-P4 Linear Potentiometer** (for dc)	**55.00**

§ Normally supplied with the recorder.

PEN AND INK

Catalog No.	*Description*	*Price*
1521-9992	**Red Ink, 16-oz bottle**	**$ 5.50**
1521-9993	**Green Ink, 16-oz bottle**	**5.50**
1521-9349	**Replacement Pen**	**3.50**

DRIVE AND LINK UNITS FOR COUPLING TO GENERATOR AND ANALYZERS

Catalog No.	*Description*	*Price*
1521-9467	**Type 1521-P10B Drive Unit** to operate any link unit	**$72.00**
1521-9615	**Type 1521-P15 Link Unit** for coupling to Type 1304-B Beat-Frequency Audio Generator or to Type 1564-A Sound and Vibration Analyzer	**26.00**
1521-9616	**Type 1521-P16 Sprocket Kit** for above link unit. These sprockets offer a choice of the following scale factors (ratio of dB/inch vertical scale to decades/inch on horizontal scale): 20, 25, 45, and 50 dB/decade.	**15.00**
1900-9601	**Type 1900-P1 Link Unit** for coupling to Type 1900-A Wave Analyzer	**35.00**

Type 1520-A SAMPLING RECORDER

FEATURES:

- Fast transient response — no waveform distortion.
- Quantized record — 3-kc sampling rate.
- No moving pen — 101 fixed styli.
- Prints its own coordinates, as well as voltage range and time scale.
- Resolution 1% of full scale.
- Two independent input channels, each with nine linear and two logarithmic ranges, calibrated.
- Uses inexpensive electro-sensitive paper.

USES: This unique recorder can be used for most of the purposes for which a moving-pen or moving-mirror recorder is used. For the recording of transients, it is usually superior to those types. There is no amplitude or phase distortion of high-speed transients. The practical response limitation is imposed, not by frequency, but by the sampling rate and the paper speed. An input waveform can be satisfactorily reproduced if 3000 samples per second will yield sufficient information and if a chart speed of 10 inches per second will yield sufficient horizontal resolution.

DESCRIPTION: The sampling recorder operates on entirely different principles from those of the well-known moving-coil or moving-mirror devices. Instead of a moving pen, it has 101 fixed styli, spaced at equal intervals along the vertical scale of the chart paper.

The input voltage is measured 3000 times per second. The stylus corresponding to the level of each measured voltage is energized, and a point is plotted. There are 100 discrete levels, each corresponding to one stylus position. The quantization is accomplished by means of an amplitude comparator and a voltage ramp — a linear ramp for linear scales, an exponential ramp for logarithmic scales. A complete scan-print cycle takes about 150 μs for each channel, or about 300 μs for both. The sampling time is thus about 300 μs, corresponding to a 3-kc sampling rate for each channel, with the two channels sampled alternately. With the same input applied to both channels in parallel, the sampling rate is doubled.

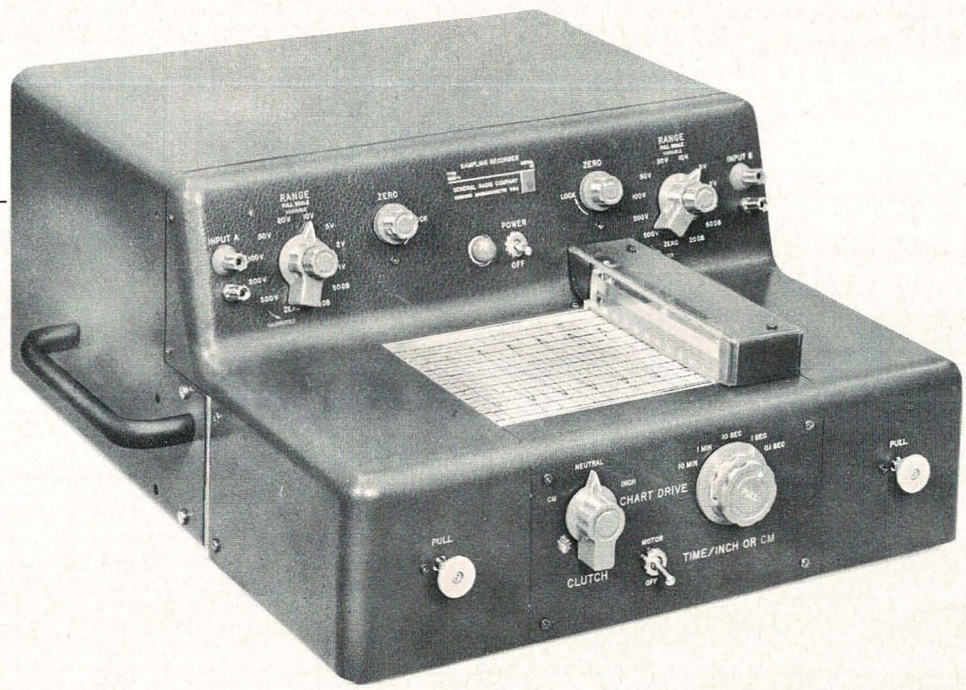
Since the voltage-level information in the input signal is converted into the timing of a pulse, the only frequency limitations are those set by paper speed and sampling rate.

For the recording of sine-waves and other simple periodic waveforms, paper speed is the frequency limiting factor, since it determines the horizontal resolution. At maximum speed (10 inches/second), one cycle of a 50-cycle sine wave occupies 1/5 inch on the horizontal scale. On the other hand, a single step function, which, in conventional recorders, requires a wide frequency band and high paper speed even to approximate faithful reproduction, is accurately reproduced by the Sampling Recorder with little or no motion of the paper. As can be seen from the sample charts reproduced here, the record consists of a series of dots. It is the spacing of individual dots that determines the vertical resolution. A vertical rise time as short as 300 microseconds can be accurately determined from the chart, since at least two dots will be printed during the rise. There can be no amplitude or phase distortion of high-speed transients — no lagging response, overshoot, ringing, or other common distortions introduced by a moving-coil system. There is no amplitude "shrinkage" with increasing frequency ("velocity saturation") or roll off, and the full width of the chart paper can always be used, if desired.

The charts illustrate the differences in response between the Sampling Recorder and the moving-pen type on a composite pulse.

NEW

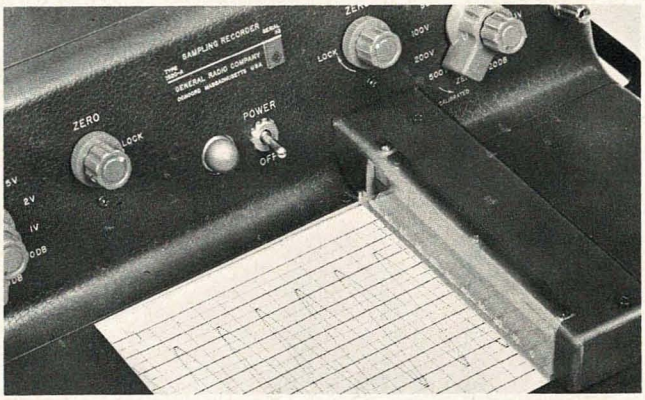
in catalog S



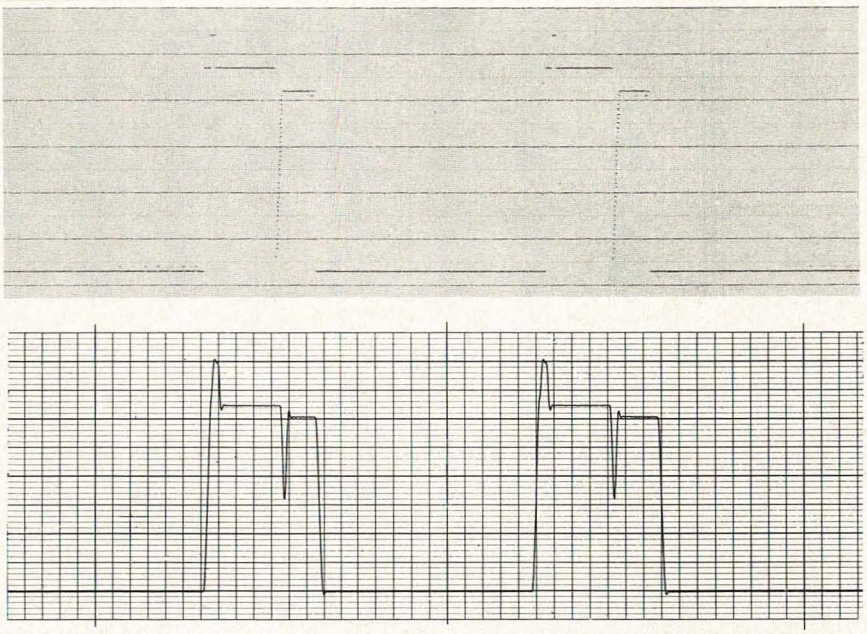
The recorder prints its own coordinates simultaneously with the recording of the input signals. These consist of eleven dark and ten lighter horizontal lines marking intervals of 10% and 5% of full scale, which can easily be read to the nearest percent of full scale. Vertical lines are printed every half inch or every centimeter of paper motion, dependent upon the setting of the paper drive clutch. This system for printing graph paper during recording gives the following advantages:

a) Only one type of paper must be stocked for all recording uses — a plain, inexpensive paper.

b) Any dimensional changes of the paper with age or humidity have no effect whatever on accuracy of recording, since the graph paper is printed by the same styli that print the recorded variable.



Close-up view of the 101-styli enclosed in a transparent plastic housing.



Recording of a composite pulse as plotted on (*above, left*) the Type 1520-A Sampling Recorder and (*below, left*) a fast pen-type recorder. Note that the pen recorder cannot follow the rapid step changes and shows overshoot, while the sampling recorder shows neither of these defects. The composite pulse consists of a 0.1-second pulse, with a 10-millisecond pulse superposed 10 milliseconds after the leading edge (pulses have 20-nanosecond rise and fall times), followed immediately by a 0.05-second pulse with a 20-millisecond linear rise and 20-nanosecond fall time.

SPECIFICATIONS

Number of Input: Channels: 2.

Number of Styli: 117, 101 over 5-inch recording.

Calibrated Voltage Ranges: 1 V to 500 V, full scale, in 1, 2, 5 steps for each channel.

Uncalibrated Voltage Ranges: Any value from 0.3 V to 350 V, full scale, for each channel.

Event Marking: External contact closure or dc voltage actuates one stylus along the lower chart-paper margin to mark the chart in accordance with an external event or condition related to the other signals being recorded.

Logarithmic Ranges: 20 dB and 50 dB, full scale, for each channel.

Resolution: 1% of full scale.

Over-all Accuracy: ±1%.

Sampling Rate: Approximately 3 kc/s for each channel; 6 kc/s if both channels are in parallel.

Time Scales: 10 min, 1 min, 10 s, 1 s, or 0.1 s per centimeter or per inch.

Scale Factors: Full-scale voltage setting and values of time scale are automatically printed along the upper and lower margins of the paper.

Chart Width: 5-inch recording on 6-inch paper.

Paper Type: Electric-writing paper.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 or 60 c/s, 300 W.

Accessories Supplied: CAP-22 Power Cord, spare fuses, one roll chart paper, and hardware for rack mount.

Dimensions: Bench, width (including handles), 21 in, height 8¾ in, depth 22 in (540, 225, 560 mm), over-all; rack, width 19 in, depth behind panel 11 in, projection in front of panel, 11 in (485, 280, 280 mm).

Net Weight: Approximately 45 lb (20.5 kg).

AVAILABLE 4th QUARTER 1965

Catalog Number	*Description*	*Price*
1520-9701	**Type 1520-A Sampling Recorder,** for 60-cycle supply	**$2950.00**
1520-9494	**Type 1520-AQ1 Sampling Recorder,** for 50-cycle supply	**on request**
1520-9301	**Chart Paper,** 200-foot roll	**6.00**

Type 1136-A DIGITAL-TO-ANALOG CONVERTER

WITH HIGH-SPEED STORAGE SYSTEM

FEATURES: Excellent stability and linearity. ■ Self-contained data storage. Versatile — accepts 1-2-4-2, 1-2-2-4, or (with modification) 1-2-4-8 coding. 1-mA or 100-mV output. ■ All-solid-state circuitry. High conversion rate — up to 10,000 conversions per second.

USES: The TYPE 1136-A Digital-to-Analog Converter translates the data output from a digital instrument into a dc voltage or current for analog recording.

DESCRIPTION: The converter selects any three consecutive, or the last two, columns from an input of up to nine columns. A command pulse from the data source transfers the input data into the storage circuits of the converter. Jam transfer into storage is used so that the analog output changes only when the input data changes (no zero-set between transfers). Storage circuits in the converter permit use with intermittent as well as continuous BCD inputs.

SPECIFICATIONS

Data Input: BCD weighted 1-2-4-2 or 1-2-2-4. Minor modification adapts for 1-2-4-8 input. Binary 1 at least 6 V positive with respect to binary 0. Input impedance 50 kΩ. Binary 0 can be offset from ground by ±150 V.

Conversion Rate: Up to 10,000 conversions per second (controlled by digital-measuring instrument).

Over-all Accuracy: ±0.1% of full scale ± 0.0001% × conversion rate in pps (includes repeatability, long-term stability, linearity, ±10% line variation, and ±15°C ambient-temperature variations around normal 25°C).

Storage Transfer: 50-μs transfer time.

Storage-Command Pulse: Amplitude, 6 V min; duration, 5 μs min; leading-edge slope, 6 V/μs min; polarity, + or − controlled by rear-mounted switch; ac coupled.

Output: 15 to 18 V behind 15 kΩ, or 100 mV with 100-Ω source impedance. Negative side grounded if binary 0 of input not more than 20 V from ground. Output floating if offset voltage is larger than 20 V.

Load: 2 kΩ max for 1-mA output. 1 kΩ min for 100-mV output.

Linearity: ±0.05% of full scale.

Stability: ±0.02% for ±10% line voltage; ±0.003% of fs/°C.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses, input cable for connection to the digital instrument.

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s, 7 W.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	4	105	12	305	13	6	21	10
Rack	19	485	3½	89	11*	280	13	6	21	10

* Behind panel.

See also *General Radio Experimenter*, December 1963.

Type 1510-A DIGITAL-TO-GRAPHIC RECORDING ASSEMBLY

This convenient assembly of the TYPE 1136-A Digital-to-Analog Converter and the TYPE 1521-B Graphic Level Recorder will operate from the output of General Radio digital instruments to produce a strip-chart record that is the analog of the digital data as a function of time. It is equally usable with other digital equipment that is coded for 1-2-4-2, 1-2-2-4, or 1-2-4-8 output.

Shipped assembled, as shown, with 10 rolls of chart paper and input cable. Rack-mount hardware also supplied.

See specifications for TYPE 1136-A Digital-to-Analog Converter (above) and TYPE 1521-B Graphic Level Recorder (page 178).

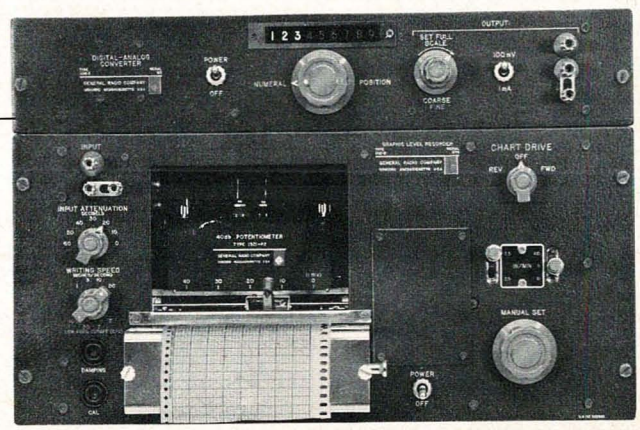
Catalog No.	*Description*	*Use**	*Price*
1136-9401 1136-9501	**Type 1136-A Digital-to-Analog Converter**, Bench Model **Type 1136-A Digital-to-Analog Converter**, Rack Model	For use with Types 1143-AP, 1144-AP, 1150-BP,-BPH, 1151-AP, 1153-AP	**$ 810.00** **810.00**
1136-9402 1136-9502	**Type 1136-A Digital-to-Analog Converter**, Bench Model **Type 1136-A Digital-to-Analog Converter**, Rack Model	For use with Type 1680-A	**680.00** **680.00**
1510-9401 1510-9571	**Type 1510-A Digital-to-Graphic Recording Assembly** (60-cycle operation) **Type 1510-AQ1 Digital-to-Graphic Recording Assembly** (50-cycle operation)	For use with Types 1143-AP, 1144-AP, 1150-BP, -BPH, 1151-AP, 1153-AP	**1855.00** **on request**
1510-9402 1510-9572	**Type 1510-A Digital-to-Graphic Recording Assembly** (60-cycle operation) **Type 1510-AQ1 Digital-to-Graphic Recording Assembly** (50-cycle operation)	For use with Type 1680-A	**1725.00** **on request**

* Converters and cables for use with other digital instruments are available on special order. Write for information.

NEW

in catalog S

TYPE 1136-A



TYPE 1510-A

Type 1137-A DATA PRINTER

FOR USE WITH GENERAL RADIO DIGITAL INSTRUMENTS

FEATURES:

Prints from 4-line BCD or 10-line code inputs.
Precise, compact, economical; all-solid-state circuitry.
Convenient — standard 2¼-inch tape is easy to read and easy to write on.
Reliable — time-proven printing mechanism designed for continuous-duty operation with minimum of maintenance.

USES: The printer provides a precise, compact, and economical means of converting decimal-coded information into permanent, printed form.

It is equipped with plug-in code modules, which accept 10-line data or 4-line 1-2-2-4, 1-2-4-8, or 1-2-4-2 BCD inputs. A two-color ribbon can be electrically or manually controlled to print red or black on standard 2¼-inch paper.

DESCRIPTION: The printing mechanism is a reliable 10-key tabulator with stop-pawls and electromagnets. The use of solid-state circuits and the absence of power-consuming keyboard actuators keep power requirements to a minimum. By fast, parallel entry of four-line BCD or 10-line inputs, the printer can operate at a rate of three prints per second, with up to 12 digits per print.

The capacity of the printer is 12 columns, not all of which are used for data from the associated GR instruments. Additional plug-in modules and accessory cable are available for printing other data. Both portable and rack models are listed.

SPECIFICATIONS

Capacity: 12 columns.
Digits: 0 through 9 or blank (column suppression).
Printing Rate: 3 lines per second maximum.
Accuracy: Identical to input.
Input:

Logic Levels	*Source Resistance*	*Binary 0*	*Binary 1*
(with respect to reference):	100 kΩ	−8 to −50 V	0 to +50 V
	2 MΩ	−12 to −50 V	0 to +50 V

Code: 10-line code (one wire is binary 1, eight wires binary 0) or four-line BCD (1-2-2-4, 1-2-4-8, or 1-2-4-2) input, depending on modules used.

Resistance: Approximately 10 MΩ for minus input, 200 kΩ for plus input.

Internal Ground: Isolated from chassis. May be biased to ±100 V.

Color-Control:

Manual: Two-position lever selects red or black print-out.

Remote: Red, binary 1 or open circuit; black, binary 0. Input resistance approximately 2 MΩ.

Column Suppression: Single line grounded for each column suppressed (3 mA max, +10 V open circuit).

Print Command: Change from binary 1 to binary 0. Binary 0, 100 ms minimum after print command; binary 1, 15 ms minimum before next print command. Source resistance 1 MΩ max.

Inhibit Reset Output: Occurs within 50 ms after print command; 200 ms max duration.

Printing Ribbon: 7/16-in two-color adding-machine ribbon.

Paper: Standard 2¼-in roll tape.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 45 W.

Accessories Supplied: Cable assembly for connection to counter, spare fuses.

Accessories Available: Additional plug-in code modules and accessory cables. Printer will handle up to 12 columns. With Catalog Numbers 1137-9743 and 1137-9744, 6 modules are supplied; cable furnished with printer will handle up to 11 columns (5 additional modules); for 12 columns order Catalog Number 1137-9607 Cable. With Catalog Numbers 1137-9735 and 1137-9736, 5 modules are supplied; cable furnished will handle 5 columns; for 6 to 12 columns, order Catalog Number 1137-9607 Cable, as well as additional modules needed.

Mechanical Data:

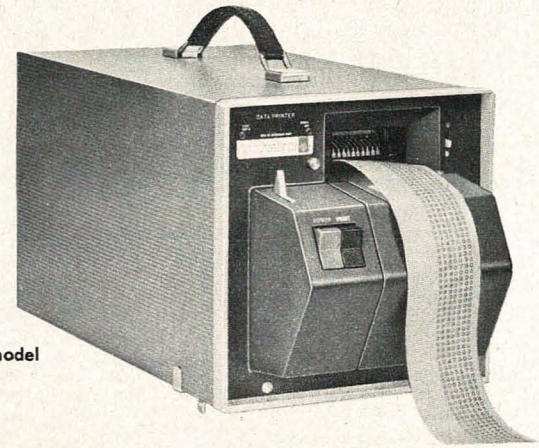
Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Portable	8¾	225	9	230	21	540	35	16	45	20.5
Rack	19	485	8¾	225	17½*	445	45	20.5	55	25

* Behind panel.

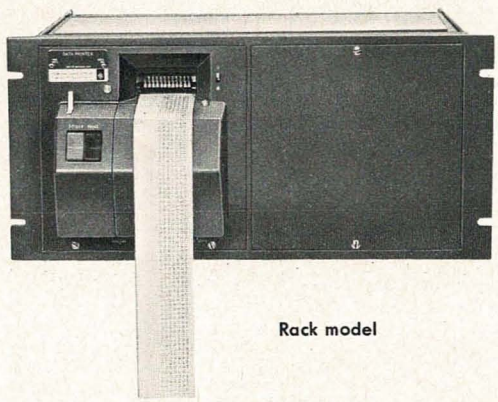
See also *General Radio Experimenter*, June 1963.

Catalog No.	*Description*	*Use†*	*Price*
1137-9735	**Type 1137-A Data Printer**, 5-column, 10-line decimal, Portable Model	For use with Types 1143-AP, 1144-AP, 1150-BP, 1150-BPH, 1151-AP, 1153-AP	**$1500.00**
1137-9736	**Type 1137-A Data Printer**, 5-column, 10-line decimal, Rack Model		**1550.00**
1137-9743	**Type 1137-A Data Printer**, 6-column BCD, Portable Model	For use with Types 1123-A, 1680-A	**1515.00**
1137-9744	**Type 1137-A Data Printer**, 6-column BCD, Rack Model		**1565.00**
1137-9604	**Plug-In Code Module**, 4-line BCD	Extends number of columns up to a maximum of 12	**65.00** (each)
1137-9605	**Plug-In Code Module**, 10-line decimal		**75.00** (each)
1137-9607	**Accessory Cable**		**35.00**

† Connectors and cables for use with other digital instruments are available on special order. Write for information.



Portable model



Rack model

STANDARD CAPACITORS

Choice of Capacitor Type

A properly designed air capacitor approaches the ideal standard reactance in that it has very low loss and very small changes with time, frequency, and environment. Capacitance changes with changes in atmospheric pressure (about 18 ppm per inch Hg) and in relative humidity (about 2 ppm per % RH) can be eliminated by hermetic sealing of the capacitor. Changes with temperature can be reduced to a few ppm per °C by the use of low-temperature-coefficient materials in the capacitor. The maximum capacitance for an air-dielectric unit of practical size is of the order of 1000 pF. (See Types 1404, 1401, 1403.)

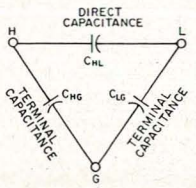
For higher capacitance, solid dielectrics are used. The preferred dielectric for standard capacitors is high-quality mica, because of its dimensional stability, low loss, and high dielectric strength. The temperature coefficient of a mica capacitor is of the order of +35 ppm per °C. At dc or extremely low frequencies the mica dielectric has the disadvantage of relatively large change of capacitance with frequency. (See Types 1409, 1423.)

Polystyrene has a dielectric constant and dissipation factor very nearly constant with frequency, so that the capacitance change from dc to 1 kc/s is a small fraction of a percent. The temperature coefficient of a polystyrene capacitor is, however, of the order of −140 ppm per °C. (See Type 1424-A.)

Two-Terminal and Three-Terminal Connections

Most capacitors can be represented by the three capacitances shown in Figure 1: the direct capacitance, C_{HL}, capacitance between the plates of the capacitor and the two terminal capacitances, C_{HG} and C_{LG}, which are capacitances from the corresponding terminals and plates to the capacitor case, surrounding objects, and to ground (to which the case is connected either conductively or by its relatively high capacitance to ground).

Figure 1.



In the two-terminal connection, the capacitor has the L and G terminals connected together, i.e., the L terminal is connected to the case. The terminal capacitance, C_{LG}, is thus shorted, and the total capacitance is the sum of C_{HL} and C_{HG}. Since one component of the terminal capacitance C_{HG} is the capacitance between the H terminal and surrounding objects, the total capacitance can be changed by changes in the environment, particularly by the introduction of connecting wires.

The uncertainties in the calibrated value of a two-terminal capacitor can be of the order of tenths of a picofarad if the geometry, not only of the capacitor plates but of the environment and of the connections, is not defined and specified with sufficient precision. For capacitors of 100 pF and more, the capacitance is usually adequately defined for an accuracy of a few hundredths percent if the terminals and method of connection used for calibration are specified. For smaller capacitances or for higher accuracy, the two-terminal capacitor is seldom practical and the three-terminal arrangement is preferred.*

A three-terminal capacitor has connected to the G terminal a shield that completely surrounds at least one of the terminals (H), its connecting wires, and its plates except for the area that produces the desired direct capacitance to the other terminal (L). Changes in the environment and the connections can vary the terminal capacitances, C_{HG} and C_{LG}, but the direct capacitance C_{HL} is determined only by the internal geometry.

This direct capacitance can be calibrated by three-terminal measurement methods, which use guard circuits or transformer-ratio-arm bridges to exclude the terminal capacitances.

The direct capacitance can be made as small as desired, since the shield between terminals can be complete except for a suitably small aperture. The losses in the direct capacitance can also be made very low because the dielectric losses in the insulating materials can be made a part of the terminal impedances. When the three-terminal capacitor is connected as a two-terminal, the two-terminal capacitance will exceed the calibrated three-terminal value (C_{HL}) by at least the terminal capacitance C_{HG}.

Frequency Characteristics

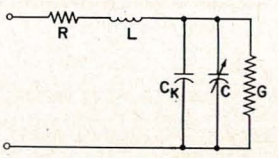
Although the characteristics of the high-quality capacitors used as standards closely approach those of the ideal capacitor, to obtain high accuracy the small deviations from ideal performance must be examined and evaluated. The residual parameters that cause such deviations are shown in the lumped-constant, two-terminal equivalent circuit of Figure 2. R represents the metallic resistance in the leads, supports and plates; L, the series inductance of the leads and plates; C, the capacitance between the plates; C_k the capacitance of the supporting structure. The conductance, G, represents the dielectric losses in the supporting insulators, the losses in the air or solid dielectric between capacitor plates, and the dc leakage conductance.

The effective terminal capacitance C_e of the capacitor becomes greater than the electrostatic or zero-frequency capacitance C_o as the frequency increases because of the inductance L. When the frequency, f, is well below the resonance frequency f_r (defined by $\omega_r^2 LC_o = 1$), the fractional increase in capacitance is approximately

$$\frac{\Delta C}{C_o} \approx \omega^2 LC_o = \left(\frac{f}{f_r}\right)^2 \qquad (1)$$

* John F. Hersh, "A Close Look at Connection Errors in Capacitance Measurements," *General Radio Experimenter*, July 1959.

Figure 2.



This change in capacitance with frequency for the capacitors described on the following pages is given either as a plot on logarithmic co-ordinates of the percent increase, $\Delta C/C$, versus frequency or as a tabulation of the values of L or f_r. Since the inductance is largely concentrated in the leads and supports, it is nearly independent of the setting of a variable capacitor. With this information, the increase in capacitance at, for example, a frequency of 1 Mc/s can be computed from the calibrated value at 1 kc/s with high accuracy. For small increases, the accuracy may be greater than that of a measurement at 1 Mc/s because of the difficulties in determining the measurement errors produced by residuals in the connecting leads outside the capacitor.

The three-terminal capacitor has a similar increase in capacitance produced by inductance. The lowest resonance is determined not solely by the calibrated direct capacitance but also by the terminal capacitances, which may be much larger than the direct capacitances (see equivalent circuit of Type 1403 Capacitors, page 190).

When the capacitor has a solid dielectric, such as mica, there is another source of capacitance change with frequency. The capacitance increases at low frequencies as the result of dielectric absorption caused by interfacial polarization in the dielectric. The change in capacitance with frequency of a 1000-pF capacitor with mica dielectric is shown in Figure 3. The dotted line slanting downward to the right represents the change in the dielectric constant of mica resulting from interfacial polarization; that slanting upward to the right shows the change in effective capacitance resulting from series inductance. The magnitude of the change at low frequencies depends upon the dielectric material and is, for example, much smaller for polystyrene than for mica.

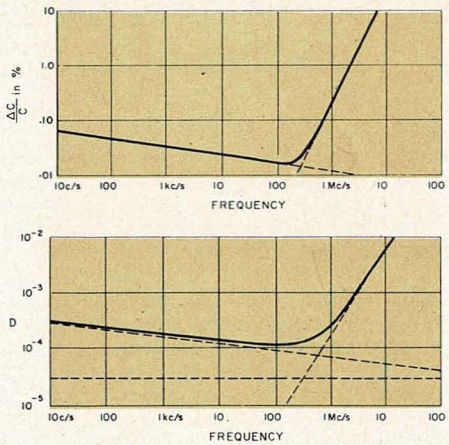


Figure 3. Variation with frequency of capacitance and dissipation factor for a mica capacitor.

Dissipation Factor

The dissipation factor of a capacitor (defined on page 41) is determined by the losses represented in Figure 2 by R and G. The resistance R is not usually significant until the frequency is high enough for the skin effect to be essentially complete. At such frequencies the resistance varies as the square root of frequency and may be expressed as $R_1\sqrt{f}$, where R_1 is the resistance at one Mc/s and f is the frequency in Mc/s. The total dissipation factor at high frequencies is then

$$D = \frac{G}{\omega C} + R_1\sqrt{f}\,\omega C \qquad (2)$$

At low frequencies only the losses represented by G are important. The leakage conductance component is negligible at frequencies above a few cycles per second and is important only when the capacitor is used at dc for charge storage. The dominant components at audio frequencies are the dielectric losses in the insulating structure and in the dielectric material between the plates,

In the air capacitor the losses in the air dielectric and on the plate surfaces are negligible under conditions of moderate humidity and temperature. The loss is, therefore, largely in the insulating supports. When good-quality, low-loss materials, such as quartz, ceramics, and polystyrene, are used for insulation, the conductance varies approximately linearly with frequency and the dissipation factor, D_k, of the supports is nearly constant with frequency. The total low-frequency dissipation factor of an air capacitor whose equivalent circuit is that of Figure 2 may be expressed as

$$D = \frac{G}{\omega(C + C_k)} = \frac{D_k C_k}{C + C_k} \qquad (3)$$

When the capacitance C is variable, this D is then inversely proportional to the total terminal capacitance. Since the quantity D_kC_k is nearly independent of both frequency and capacitance setting, it is a convenient figure of merit for a variable capacitor.

In a capacitor with a solid dielectric the dominant component of the conductance G is the loss in the dielectric, which varies with frequency. The resulting variation of D with frequency, shown for a mica capacitor in Figure 3, is the sum of three principal components: a constant dissipation factor caused by residual polarizations; a loss produced by interfacial polarizations, which decreases with frequency; and an ohmic loss in the leads and plates, which results in a D proportional to the 3/2 power of frequency. The total dissipation factor has a minimum value at a frequency that varies inversely with capacitance and which ranges from 1 kc/s to 1 Mc/s for capacitance values from 1 μF to 100 pF.

The capacitors described in these pages include air-dielectric reference standards, both fixed and variable, both fixed and decade mica-dielectric, and other decades with polystyrene, mica, and paper dielectric.

Type	*Name*	*Capacitance*	*Page*
1422	Precision Capacitor (2- and 3-terminal, variable)	8 models, 1.1 to 1150 pF, full scale	186
1401	Standard Air Capacitor (2-terminal, fixed)	100, 200, 500, 1000 pF	191
1403	Standard Air Capacitor (3-terminal, fixed)	0.01, 0.1, 1, 10, 100, 1000 pF	190
1404	Reference Standard Capacitor (3-terminal, fixed)	1000 pF	188
1409	Standard Capacitor (Fixed, mica)	0.001 to 1 μF in 10 models	192
1423	Standard Decade Capacitor (mica)	100 pF to 1.111 μF	189
1424-A	Standard Polystyrene Decade Capacitor (Single decade)	0 to 10 μF	194
1424-M	Decade Capacitor (Single decade, paper)	0 to 10 μF	194
1425-A	100-μF Polystyrene Dielectric Decade Capacitor (Single decade)	0 to 100 μF	194
1412-BC	Decade Capacitor (2- and 3-terminal)	0 to 1 μF	195
1419	Decade Capacitor (3- and 4-dial boxes)	0 to 1 μF	196
980	Decade Capacitor Unit	0.001, 0.01, 0.1, and 1 μF, full scale	196
505	Capacitor (Fixed, mica)	100 pF to 0.5 μF in 12 models	193
1429	Fuel-Gage Tester	20 to 6220 pF	191

Type 1422 PRECISION CAPACITOR

FEATURES:

High stability. ■ High accuracy. ■ Low backlash.
High precision of setting — one part in 25,000 of full scale; total scale length is 20 feet.
Low temperature coefficient of capacitance. ■ Low dielectric losses.
Large transparent knob skirt to facilitate fine setting.

USES: The TYPE 1422 Precision Capacitor is a stable and precise variable air capacitor intended for use as a continuously adjustable standard of capacitance.

One of its most important applications is in ac bridge measurements, either as a built-in standard or as an external standard for substitution measurements.

DESCRIPTION: The capacitor assembly is mounted in a cast frame, which gives the unit rigidity. The frame, spacers, stator rods, and rotor shaft are made of selected alloys of aluminum, which combine the high mechanical strength of brass with the low weight of aluminum. The plates of most models are also of aluminum, so that all parts have the same temperature coefficient of linear expansion.

A worm drive is used to obtain high precision of setting. To avoid eccentricity, the shaft and the worm are accurately machined as one piece. The worm and worm wheel are also lapped into each other to improve smoothness. The dial end of the worm shaft runs in a self-aligning ball bearing, while the other end is supported by an adjustable spring mounting, which gives positive longitudinal anchoring to the worm shaft through the use of a pair of sealed, self-lubricating, preloaded ball bearings. Similar pairs of preloaded ball bearings provide positive and invariant axial location for the main or rotor shaft. Electrical connection to the rotor is made by means of a silver-alloy brush bearing on a silver-overlay drum to assure a low-noise electrical contact.

Stator insulation in all models is a cross-linked thermosetting modified polystyrene having very low dielectric losses and very high insulation resistance. Rotor insulation, where used (TYPES 1422-CB, -CL, and -N), is grade L-4 steatite, silicone treated.

TYPE 1422-D is a two-section, two-terminal capacitor, direct reading in total capacitance at the terminals.

TYPE 1422-N is similar to the TYPE 1422-D high-capacitance section but is designed for use at higher frequencies. To minimize residual inductance and resistance, the connections are made through ribbon leads to the center of the stator and to the center of the rotor through silver-alloy brushes bearing on a silver-overlay disk.

TYPES 1422-MD and -ME are two-section, two-terminal capacitors with scales reading the capacitance removed, i.e., the capacitance is maximum at the zero reading. This scale is particularly convenient for substitution measurements.

TYPES 1422-CB, -CC, -CL, and -CD are three-terminal capacitors with shielded coaxial terminals for use in three-terminal measurements. The calibrated direct capacitance is independent of terminal capacitances to ground, and losses are very low. The TYPE 1422-CL has approximately the same maximum capacitance as the -CC model, but constant and much lower terminal capacitances, so that it can be used in measurement circuits where high capacitance to ground can not be tolerated. This low value of stray capacitance, however, is achieved at the expense of minimum calibrated capacitance, which is 10 pF for the -CL model, as contrasted to 5 pF for the -CC model.

SPECIFICATIONS

Initial Accuracy: See table. The errors tabulated are possible errors, i.e., the sum of error contributions from setting, adjustment, calibration, interpolation, and standards. When the capacitor is in its normal position with the panel horizontal, the actual errors are almost always smaller. The accuracy is improved when the readings are corrected using the 12 calibrated values of capacitance given on the correction chart on the capacitor panel and interpolating linearly between calibrated points. Better accuracy can be obtained from a precision calibration of approximately 100 points on the capacitor dial, which permits correction for slight residual eccentricities of the worm drive and requires interpolation over only short intervals. This precision calibration is available for all models at an extra charge. Models so calibrated are listed with the additional suffix letter, P, in the type number. A plastic-enclosed certificate of calibration is supplied, giving corrections to one more figure than the tabulated accuracy.

Stability: The capacitance change with time is less than 1 scale division (0.02% of full scale) per year. The long-term accuracy can be estimated from the stability and the initial accuracy specifications.

Calibration: The measured values are obtained by comparison at 1 kc/s, to a precision better than $\pm(0.01\% + 0.00001\ \text{pF})$, with working standards whose absolute values are known to an accuracy typically $\pm 0.01\%$, determined and maintained in terms of reference standards periodically certified by the National Bureau of Standards.

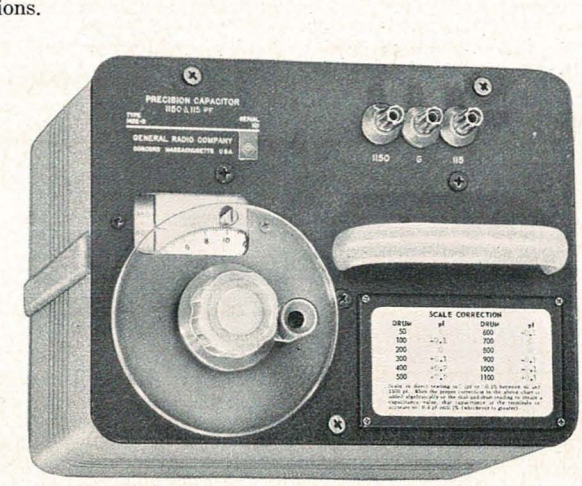
The indicated value of total capacitance of a two-terminal capacitor is the capacitance added when the TYPE 1422 Capacitor is plugged into a TYPE 874-Q9 Adaptor. The uncertainty of this method of connection is approximately ± 0.03 pF.*

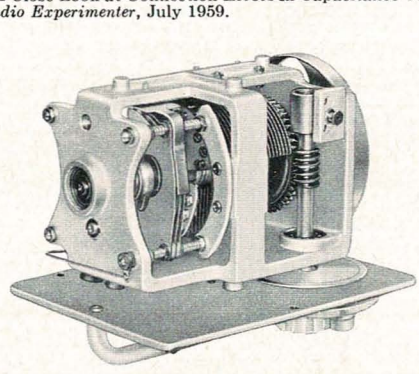
Resolution: The dial can easily be read and set to 1/5 of a small division.

The backlash is less than 1/5 small division, corresponding to 0.004% of full-scale value. If the desired setting is always approached in the direction of increasing scale reading, no error from this cause will result.

Temperature Coefficient: Approximately +20 ppm/°C, for small temperature changes.

* John F. Hersh, "A Close Look at Connection Errors in Capacitance Measurements," *General Radio Experimenter*, July 1959.





Panel and interior views of
Type 1422-D Precision Capacitor.

Residual Parameters: See table. The series resistance varies as the square root of the frequency above 100 kc/s. Its effect is negligible below this frequency.

Frequency Characteristic: See plots above, for two-terminal models. The resonance frequency for the -CB and -CC models is approximately 20 Mc/s; for the -CD model, 60 Mc/s for each section; -CL, 40 Mc/s.

Dissipation Factor: The losses in the two-terminal capacitors are primarily in the stator supports, which are of low-loss polystyrene ($DC = 0.01 \times 10^{-12}$).

The very small dissipation factor of the direct capacitance of the three-terminal capacitors is difficult to measure and is estimated to be not greater than 20×10^{-6} for -CB and -CL, and 10×10^{-6} for -CC and -CD.

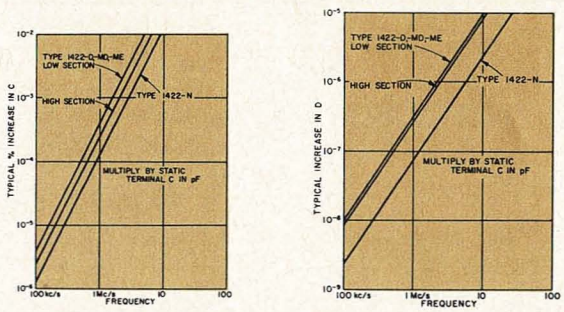
Insulation Resistance: Under standard conditions (23°C, less than 50% RH), greater than 10^{12} ohms.

Maximum Voltage: All models, 1000 V, peak.

Terminals: Jack-top binding posts are provided on 2-terminal models; standard ¾-inch spacing is used. The rotor terminal is connected to the panel and shield. Locking GR874 Coaxial Connectors are used on three-terminal models.

Accessories Required: For connection to 3-terminal models, 2 GR874 Patch Cords (page 85) or equivalent.

Accessories Available: TYPE 874-Q9 Adaptor (see Calibration, above), for terminal units.



Variation with frequency of effective capacitance and dissipation factor per pF of capacitance for two-terminal Type 1422 Precision Capacitors.

Cabinet: Lab bench (see page 258).

Dimensions: Width 9½, height 7, depth 8½ inches (245, 180, 220 mm), over-all.

Net Weight: 10½ to 12½ lb (4.8 to 5.7 kg), depending upon model.

Shipping Weight: All models, 15 lb (7 kg).

		Two-Terminal							*Three-Terminal*				
				RF	*Reads Capacitance Removed*								
TYPE 1422		**-D**		**-N**	**-MD**		**-ME**		**-CB**	**-CC**	**-CL**	**-CD**	
CAPACITANCE	Min	100	35	100	0	0	0	0	50	5	10	0.5	0.05
RANGE, pF	Max	1150	115	1150	1050	105	105	10.5	1100	110	110	11	1.1
SCALE, pF/Division:		0.2	0.02	0.2	0.2	0.02	0.02	0.002	0.2	0.02	0.02	0.002	0.0002
INITIAL ACCURACY: ± Picofarads listed below. Direct-Reading (Adjustment): Total Capacitance		0.6*	0.1*	0.6*	Differences from Zero				0.6	0.15	0.1	0.04	0.008
Capacitance Difference		1.2	0.2	1.2	1	0.2	0.2	0.05	1.2	0.3	0.2	0.08	0.016
With Corrections from Calibration Chart (supplied): Total Capacitance		0.3*	0.04*	0.3*					0.3	0.04	0.04	0.01	0.002
Capacitance Difference†		0.6	0.08	0.6	0.6	0.08	0.08	0.02	0.6	0.08	0.08	0.02	0.004
With Corrections from Precision Calibration (extra charge): Total Capacitance		0.1*	0.01*	0.1*					0.1	0.01	0.01	0.001	0.0002
Capacitance Difference†		0.2	0.02	0.2	0.2	0.02	0.02	0.004	0.2	0.02	0.02	0.002	0.0004
RESIDUALS (typical values): Series Inductance, μH		0.06	0.10	0.032	0.06	0.10	0.06	0.10	0.14	0.17	0.13	0.17	0.17
Series Resistance, ohms at 1 Mc/s		0.04	0.05	0.012	0.04	0.05	0.04	0.05	0.1		0.1		
Terminal Capacitance, pF:		high terminal to case					min scale		36	850	34	98	25
							max scale		35	560	33	74	23
		low terminal to case					min scale		58	920	58	117	115
							max scale		53	600	55	92	93
Capacitance at Zero Scale Setting, pF:					1140	135	145	35					

* Total capacitance is the capacitance added when the capacitor is plugged into a TYPE 874-Q9 Adaptor. † Divide error by 2 when one setting is made at a calibrated point.

Catalog Number	*Description*	*Price*
1422-9704	**Type 1422-D Precision Capacitor**	**$350.00**
1422-9904	**Type 1422-DP Precision Capacitor** (with precision calibration)	**440.00**
1422-9854	**Type 1422-MD Precision Capacitor**	**350.00**
1422-9913	**Type 1422-MDP Precision Capacitor** (with precision calibration)	**440.00**
1422-9855	**Type 1422-ME Precision Capacitor**	**350.00**
1422-9955	**Type 1422-MEP Precision Capacitor** (with precision calibration)	**440.00**
1422-9714	**Type 1422-N Precision Capacitor**	**340.00**
1422-9880	**Type 1422-NP Precision Capacitor** (with precision calibration)	**390.00**
1422-9916	**Type 1422-CB Precision Capacitor**	**340.00**
1422-9902	**Type 1422-CBP Precision Capacitor** (with precision calibration)	**390.00**
1422-9809	**Type 1422-CC Precision Capacitor**	**340.00**
1422-9903	**Type 1422-CCP Precision Capacitor** (with precision calibration)	**390.00**
1422-9933	**Type 1422-CL Precision Capacitor**	**340.00**
1422-9508	**Type 1422-CLP Precision Capacitor** (with precision calibration)	**390.00**
1422-9823	**Type 1422-CD Precision Capacitor**	**310.00**
1422-9925	**Type 1422-CDP Precision Capacitor** (with precision calibration)	**400.00**
0874-9874	**Type 874-Q9 Adaptor**	**6.00**

Type 1404 REFERENCE STANDARD CAPACITOR

3-TERMINAL — HERMETICALLY SEALED — GAS-FILLED

FEATURES:

Excellent stability — better than 20 parts per million per year.
Accurate adjustment — within ±5 parts per million of nominal value.
Low temperature coefficient.
Hermetically sealed, with dry-nitrogen dielectric.
Inner sealed container easily adaptable to oil immersion.
Capacitance to ground less than 50 pF from either terminal.
Can be easily used as a dissipation-factor standard.

USES: These capacitors have been designed as primary reference standards of capacitance with which working standards can be compared. The TYPE 1615-A Capacitance Bridge (page 58) is particularly well suited for this purpose and can be conveniently used to calibrate accurately a wide range of working standards in terms of a TYPE 1404 Reference Standard Capacitor. A single 1000- or 100-picofarad standard is also the only standard necessary to calibrate the bridge itself.

In combination with an accurately known external resistor, this capacitor becomes a standard of dissipation factor.

DESCRIPTION: All critical parts of the plate assembly are made of Invar for stability and low temperature coefficient. After heat cycling and adjustment, the assembly is mounted in a heavy brass container, which, after evacuation, is filled with dry nitrogen under pressure slightly above atmospheric and sealed. The container is mounted on an aluminum panel and protected by an outer aluminum case. Each capacitor is subjected to a series of temperature cycles to determine hysteresis and temperature coefficients and to stabilize the capacitance.

Two locking GR874 Coaxial Connectors are used as terminals. The outer shell of one is connected to the case, but the outer shell of the other is left unconnected to permit the capacitor to be used with an external resistor as a dissipation-factor standard.

SPECIFICATIONS

Calibration: A certificate of calibration is supplied with each capacitor, giving the measured direct capacitance at 1 kc/s and at 23° ± 1°C. The measured value is obtained by a comparison to a precision better than ±1 ppm with working standards whose absolute values are known to an accuracy of ±20 ppm, determined and maintained in terms of reference standards periodically measured by the National Bureau of Standards.

Adjustment Accuracy: The capacitance is adjusted before calibration with an accuracy of ±5 ppm to a capacitance about 5 ppm above the nominal value relative to the capacitance unit maintained by the General Radio reference standards.

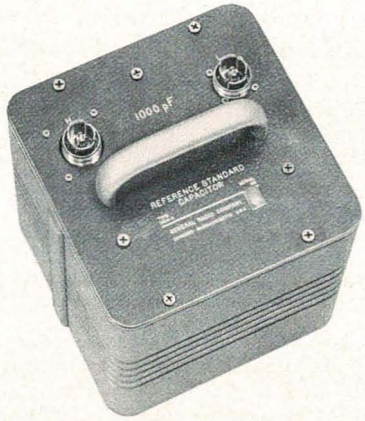
Stability: Long-term drift is less than 20 parts per million per year. Maximum change with orientation is 10 ppm and is completely reversible.

Temperature Coefficient of Capacitance: 2 ± 2 ppm/°C from −20°C to +65°C. A measured value with an accuracy of ±1 ppm/°C is given on the certificate.

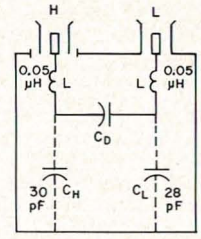
Temperature Cycling: For temperature cycling over range from −20°C to +65°C, hysteresis (retraceable) is less than 20 ppm at 23°C.

Dissipation Factor: Less than 10^{-5} at 1 kc/s.

Residual Impedances: See equivalent circuit for typical values of internal series inductances and terminal capacitances.



Equivalent circuit showing direct capacitance, C_d, and average values of residual inductance, L, and terminal capacitances, C_a and C_b. C_d = 1000 pF for Type 1404-A. C_d = 100 pF for Type 1404-B.



Maximum Voltage: 750 volts.

Terminals: Two locking GR874 Coaxial Connectors; easily convertible to other types of connectors by attachment of locking adaptors. Outer shell of one connector is ungrounded to permit capacitor to be used with external resistor as a dissipation-factor standard.

Accessories Required: For connection to TYPE 1615-A Capacitance Bridge, 2 TYPE 874-R20A or TYPE 874-R22LA Patch Cords.

Mechanical Data:

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
6¾	175	6⅝	170	8	205	8½	3.9	14	6.5

For a more detailed description, see *General Radio Experimenter*, August 1963.

Catalog No.	*Description*	*Price*
1404-9701	**Type 1404-A Reference Standard Capacitor,** 1000 pF	**$225.00**
1404-9702	**Type 1404-B Reference Standard Capacitor,** 100 pF	**$225.00**

PATENT NOTICE. See Note 4, page 11.

Type 1423-A PRECISION DECADE CAPACITOR

100 pF TO 1.111 μF

FEATURES:

Direct-reading accuracy ±(0.05% + 0.05 pF).
Long-term stability ±(0.01% + 0.05 pF) per year.
Easily readjusted in terms of reference standards.
Accurate for either two- or three-terminal use.

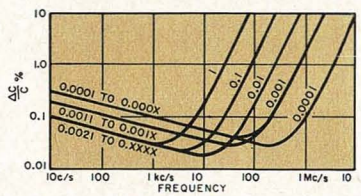
USES: This capacitor is a very useful and versatile tool for calibration laboratories and for production-line measurements. Any value of capacitance between 100 pF and 1.111 μF, in steps of 100 pF, can be set on the four decades and will be known to an accuracy of 0.05%. Thus a bridge can be standardized quickly to an accuracy exceeded only by that of individually certified laboratory standards of the highest available quality such as the TYPE 1404-A Reference Standard Capacitor.

In conjunction with a limit bridge, such as the TYPE 1605-A Impedance Comparator, production-line measurements of arbitrary values of capacitance (such as EIA preferred values) can be made rapidly and accurately, with a minimum of setup time.

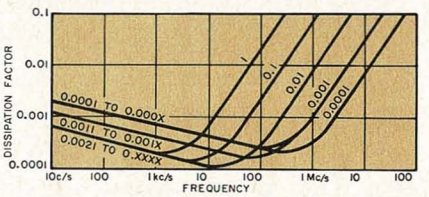
DESCRIPTION: This is a doubly shielded decade capacitor consisting of four decades of high-quality silvered-mica capacitors similar to those used in the TYPE 1409 Standard Capacitors. It is housed in a standard relay-rack-type cabinet with aluminum end frames for bench use. A new, in-line readout displays the selected value in large, bold numbers for maximum readability.

The decade switches and associated capacitors are mounted in an insulated metal compartment, which in turn is mounted in a complete metal cabinet. This double-shielded construction ensures that capacitance at the terminals is the same for either the three-terminal or the two-terminal method of connection (except for a constant difference of about one picofarad). This external capacitance can be included in the two-terminal calibration by the adjustment of a single trimmer.

The terminal capacitance values are adjusted precisely to nominal value by independent means and can subsequently be readjusted at calibration intervals, if necessary, without disturbance of the main capacitors.



(Left) Change in capacitance as a function of frequency. These changes are referred to the values that the capacitors would have if there were neither interfacial polarization nor series inductance. The 1-kc value on the plot should be used as a basis of reference in estimating frequency errors. *(Right)* Dissipation factor as a function of frequency.



SPECIFICATIONS

Nominal Values: 100 pF to 1.111 μF in steps of 100 pF.

Accuracy: ±(0.05% + 0.05pF) at 1 kc/s, calibrated in the three-terminal connection. Two-terminal connection (capacitor inserted into TYPE 874-Q9 Adaptor) adds about 1.3 pF reading.

Certificate: A certificate is supplied certifying that each component capacitor was adjusted by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically certified by the National Bureau of Standards.

Frequency: Adjusted at 1 kc/s. The behavior of each individual capacitor is similar to that of a TYPE 505 Capacitor.

Dissipation Factor: Not greater than 0.001, 0.0005, and 0.0003 for capacitances of 100 to 1000 pF, 1100 to 2000 pF, and 2100 pF to 1.1110 μF, respectively.

Temperature Coefficient of Capacitance: Approximately +35 ppm per degree between 10° and 50°C.

Insulation Resistance: Greater than 50 GΩ to 0.1 μF and greater than 5 GΩ from 0.1 μF to 1.111 μF.

Maximum Voltage: 500 V peak, up to 10 kc/s.

Accessories Supplied: Two TYPE 874-Q9 Adaptors.

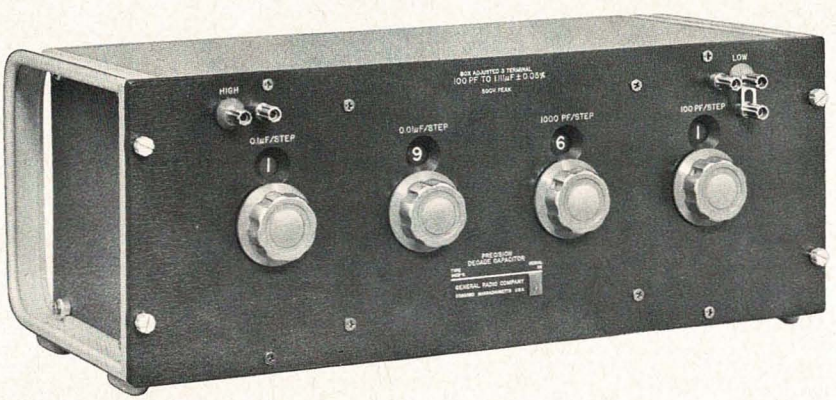
Cabinet: Rack-bench; rack model supplied without metal supports.

Mechanical Data: Rack-Bench Cabinet (*see page 258*).

Model	Width		Height		Depth		Net Weight		Shipping Weight	
	in	mm	in	mm	in	mm	lb	kg	lb	kg
Bench	19	485	7¼	185	10½	270	26	12.0	39	18
Rack	19	485	7	180	8½*	220	26	12.0	39	18

* Behind panel.

Catalog No.	Description	Price
1423-9801	**Type 1423-A Precision Decade Capacitor, Bench Model**	**$695.00**
1423-9811	**Type 1423-A Precision Decade Capacitor, Rack Model**	**695.00**



Type 1403 STANDARD AIR CAPACITOR (Three-Terminal)

USES: For measurement at 100 pF and below, a three-terminal connection increases the accuracy by eliminating the uncertainty in the measurement introduced by the capacitances between the capacitor terminals and ground. The TYPE 1403 Standard Air Capacitors are stable, three-terminal standards in decimal values from 0.001 to 1000 pF. Their terminals are arranged to plug directly into the UNKNOWN terminals of the TYPE 1615-A Capacitance Bridge.

DESCRIPTION: The three largest sizes are similar in construction to the TYPE 1401. The smaller capacitance units are made up of two plates, with a grounded plate between them; an aperture in the grounded plate determines the magnitude of the direct capacitance. Dielectric losses are not detectable; there is no solid dielectric in the direct-capacitance field. All have shielded terminals, both of which are insulated from the case.

SPECIFICATIONS

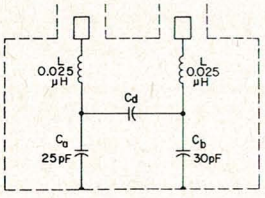
Calibration: A certificate of calibration is supplied with each unit giving the measured capacitance at 1 kc/s and at a specified temperature. The measured value is the direct capacitance between shielded terminals when the capacitor has at least one lead completely shielded and its case connected to a guard point. This value is obtained by comparison, to a precision better than $\pm(0.01\% + 0.00001$ pF), with working standards whose absolute values are known to an accuracy typically $\pm 0.01\%$, determined and maintained in terms of reference standards periodically certified by the National Bureau of Standards.

Stability: Capacitance change is less than 0.05% per year.

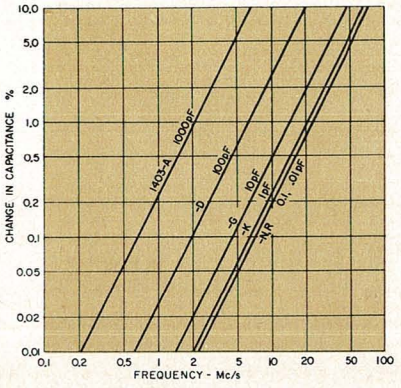
Residual Impedances: See equivalent circuit and plot.

Temperature Coefficient of Direct Capacitance: Typically 20 to 40 ppm per degree between 20° and 70°C. The larger coefficients apply to the smaller capacitance values.

Terminals: GR874 Coaxial Connectors, which provide complete shielding of the leads.



Equivalent circuit showing direct capacitance, C_d, and typical values of residual inductance, L, and terminal capacitances, C_a and C_b.



Change (percent) in effective direct capacitance, with frequency, produced by residual inductance.

Mounting: Aluminum panel and cylindrical case.

Accessories Supplied: Two TYPE 874-C58A Cable Connectors.

Dimensions: Diameter 3 1/16 in (78 mm), height 4 7/8 in (125 mm), over-all.

Net Weight: 1 lb (0.5 kg). **Shipping Weight:** 4 lb (1.9 kg).

Catalog Number		*Nominal Capacitance*	*Adjustment Accuracy*	*Peak Volts*	*Dissipation Factor*	*Price*
1403-9701	**Type 1403-A**	1000 pF	0.1%	700	20×10^{-6}	**$80.00**
1403-9704	**Type 1403-D**	100 pF	0.1%	1500	20×10^{-6}	**65.00**
1403-9707	**Type 1403-G**	10 pF	0.1%	1500	30×10^{-6}	**55.00**
1403-9711	**Type 1403-K**	1.0 pF	0.1%	1500	20×10^{-6}	**45.00**
1403-9714	**Type 1403-N**	0.1 pF	0.1%	1500	20×10^{-6}	**45.00**
1403-9718	**Type 1403-R**	0.01 pF	0.3%	1500	20×10^{-6}	**45.00**
1403-9722	**Type 1403-V**	0.001 pF	1.0%	1500	20×10^{-6}	**45.00**

PATENT NOTICE. See Note 4, page 11.

Type 1401 STANDARD AIR CAPACITOR (Two-Terminal)

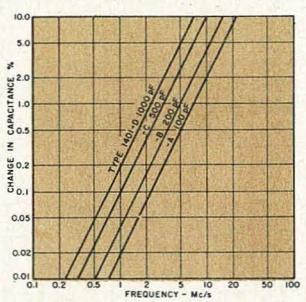
FEATURES:
- High accuracy and stability.
- Low losses.
- Low temperature coefficient.
- Convenient size.

USES: The TYPE 1401 Standard Air Capacitors are accurate and stable two-terminal capacitors for laboratory use as reference or working standards. They supplement the TYPE 1409 series of fixed mica capacitors by providing standards of lower loss and lower capacitance.

DESCRIPTION: The aluminum plate assemblies are supported by a mounting plate attached to an aluminum casting. This casting, together with the cylindrical aluminum case, provides a dust-free enclosure and a complete shield. The low, or ground, terminal of the capacitor is connected to this shield. Three supporting rods are used for each of the plate assemblies, ensuring a high degree of rigidity and stability, and all plates, rods, and spacers are aluminum, to minimize thermal stresses. Terminals are insulated by polystyrene bushings and spaced to plug directly into General Radio binding posts, such as the UNKNOWN terminals of the TYPE 716-C Capacitance Bridge.

SPECIFICATIONS

Calibration: A certificate of calibration is supplied with each unit, giving the measured capacitance at 1 kc/s and at a specified temperature. The measured capacitance is the capacitance added when the standard is plugged directly into General Radio binding posts. This value is obtained by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically certified by the National Bureau of Standards.



Change (percent) in effective terminal capacitance, with frequency, produced by residual inductance.

Stability: Capacitance change is less than 0.05% per year.

Residual Impedances: The series inductance of all units is approximately 0.05 μH. See plot.

The metallic resistance of all units is approximately 0.027 Ω at 1 Mc/s. The series resistance varies as the square root of frequency above about 100 kc/s.

Temperature Coefficient of Capacitance: Typically 10 to 20 ppm/°C between 20° and 70°C.

Terminals: TYPE 274 Plugs, spaced ¾ inch on centers, to plug into TYPE 938 Binding Posts.

Mounting: Aluminum panel and cylindrical case.

Dimensions: Dia 3 1/16 in (78 mm), height 4 7/8 in (125 mm), over-all.

Net Weight: 1⅛ lb (0.6 kg). **Shipping Weight:** 4 lb (1.9 kg).

Catalog No.		*Insertion Capacitance*	*Initial Accuracy*	*Peak Volts*	*Dissipation Factor*	*Price*
1401-9701	**Type 1401-A**	100 pF	0.2%	1500	100×10^{-6}	**$50.00**
1401-9702	**Type 1401-B**	200 pF	0.15%	1200	50×10^{-6}	**54.00**
1401-9703	**Type 1401-C**	500 pF	0.12%	900	20×10^{-6}	**57.00**
1401-9704	**Type 1401-D**	1000 pF	0.1%	700	10×10^{-6}	**65.00**

Type 1429-A FUEL-GAGE TESTER

The TYPE 1429-A Fuel-Gage Tester is an adjustable standard capacitor for testing and calibrating modern capacitance-type fuel-gage systems in both reciprocating-engine and jet-engine planes.

Catalog No.	*Description*	*Price*
1429-9701	**Type 1429-A Fuel-Gage Tester**	**$975.00**

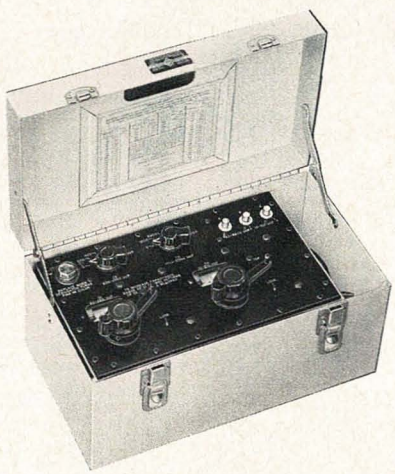
DESCRIPTION: This tester fulfills the same function as the military MD-1 Tester but has smaller dimensions and lower weight. External connections are made through keyed coaxial connectors. Cables and adaptors as required by specification MIL-T-8579 (USAF) are supplied.

All capacitors and a renewable desiccant cartridge are mounted on an aluminum panel and enclosed in a moisture-sealed aluminum cabinet. The latter is shock-mounted in an aluminum transit case with a compartment to hold nine connecting cables and three tee adaptors.

Dimensions: Width 17½, height 10½, depth 10½ in (445, 270, 270 mm), over-all.

Net Weight: 29 lb (13.5 kg). **Shipping Weight:** 34 lb (15.5 kg).

ASK FOR COMPLETE SPECIFICATIONS



Type 1409 STANDARD CAPACITOR

FEATURES:
Stable within ±0.01% per year.
Calibrated for both two-terminal and three-terminal connections.
Plug-in terminals permit several units to be stacked one upon the other without leads.

USES: The TYPE 1409 Standard Capacitors are fixed mica capacitors of very high stability for use as two- or three-terminal reference or working standards in the laboratory.

Typical capacitors, observed over more than eight years, have shown random fluctuations of less than ±0.01% in measured capacitance with no evidence of systematic drift.

DESCRIPTION: These capacitor units consist of a silvered-mica and foil pile, spring-held in a heavy metal clamping structure for mechanical stability. The units are selected for low dissipation factor and are stabilized by heat cycling. They are housed, with silica gel to provide continuous desiccation, in cast aluminum cases, sealed with high-temperature potting wax. A well is provided in the wall of the case for the insertion of a dial-type thermometer. Three jack-top binding posts are provided on the top of the case and removable plugs on the bottom, for convenient parallel connection without error.

SPECIFICATIONS

Accuracy: Within ±0.05% of the nominal capacitance value (two-terminal) marked on the case. Accuracy is guaranteed for two years under the terms of our standard warranty if the capacitor has not been damaged by excessive current or voltage.

Calibration: A certificate of calibration is supplied with each unit, giving both two- and three-terminal measured capacitances at 1 kc/s and at a specified temperature. The measured value is the capacitance added when the standard is plugged directly into General Radio binding posts. This value is obtained by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically certified by the National Bureau of Standards.

Stability: Capacitance change is less than 0.01% per year.

Temperature Coefficient of Capacitance: +35 ± 10 ppm per degree between 10° and 70°C.

Dissipation Factor: Less than 0.0003 at 1 kc/s and 23°C (see curves, next page). Measured dissipation factor at 1000 c/s is stated in the certificate to an accuracy of ±0.00005.

Frequency Characteristics: See typical curves on page 193. Values of series inductance and series resistance at 1 Mc/s are given in the table. This resistance varies as the square root of the frequency for frequencies above 100 kc/s.

Approximate Terminal Capacitance: From H terminal to case (G), 12 to 50 pF. From L terminal (outside foils of capacitor) to case, 300 to 1300 pF.

Leakage Resistance: 5000 ohm-farads or 100 GΩ, whichever is the lesser.

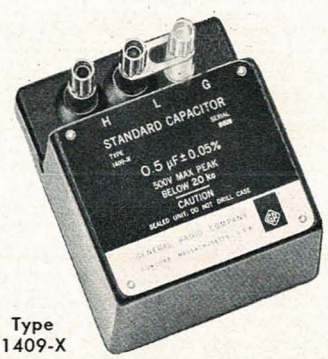
Maximum Voltage: 500 V, peak, below the limiting frequencies tabulated below. At high frequencies the allowable voltage is inversely proportional to frequency, approximately. These limits correspond to a temperature rise of 40°C for power dissipations of 5, 6, and 7.5 W for the small, medium, and large cases, respectively.

Dimensions: Small case, 3¼ by 4 by 2 in (85, 105, 50 mm); medium case, 3¼ by 4 by 2 11/16 in (85, 105, 70 mm); large case, 3¼ by 5⅝ by 2 11/16 in (85, 145, 70 mm) over-all.

Catalog Number		*Nominal Capacitance μF*	*Maximum Peak Volts*	*Frequency Limit for Max Volts*	*Series Inductance μH*	*Resistance in Ohms at 1 Mc/s*	*Net Weight*	*Shipping Weight*	*Price*
1409-9706	**Type 1409-F**	0.001	500	4.7 Mc/s	0.050	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**$ 32.00**
1409-9707	**Type 1409-G**	0.002	500	2.7 Mc/s	0.050	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**32.00**
1409-9711	**Type 1409-K**	0.005	500	1.3 Mc/s	0.050	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**34.00**
1409-9712	**Type 1409-L**	0.01	500	750 kc/s	0.050	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**34.00**
1409-9713	**Type 1409-M**	0.02	500	430 kc/s	0.050	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**36.00**
1409-9718	**Type 1409-R**	0.05	500	210 kc/s	0.055	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**39.00**
1409-9720	**Type 1409-T**	0.1	500	120 kc/s	0.055	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**42.00**
1409-9721	**Type 1409-U**	0.2	500	70 kc/s	0.055	0.02	1¼ lb (0.6 kg)	4 lb (1.9 kg)	**55.00**
1409-9724	**Type 1409-X***	0.5	500	35 kc/s	0.055	0.02	1¾ lb (0.8 kg)	4½ lb (2.1 kg)	**105.00**
1409-9725	**Type 1409-Y†**	1.0	500	17 kc/s	0.070	0.03	2½ lb (1.1 kg)	5 lb (2.3 kg)	**175.00**

*Mounted in medium case. †Mounted in large case.

Type 1409-T



Type 1409-X

Type 1409-Y

Type 505 CAPACITOR

FEATURES:
- Small, convenient, stable, and accurate.
- Low-loss phenolic case to minimize dielectric loss and leakage conductance.
- Low temperature coefficient of capacitance.

USES: The TYPE 505 Capacitors are stable, low-loss mica capacitors for use as high-quality circuit elements and as secondary standards where the higher accuracy, complete shielding, and lower loss of the TYPE 1409 Standard Capacitors are not required.

DESCRIPTION: The TYPE 505 unit uses the same silvered-mica and foil pile used in the TYPE 1409 and has almost equally high stability. Each unit is sealed with wax in a low-loss phenolic case. Silica gel is included for continuous desiccation, and granulated polyethylene is provided to absorb shock.

SPECIFICATIONS

Accuracy: At 1 kc/s, ±0.5% or ±3 pF, whichever is the larger.

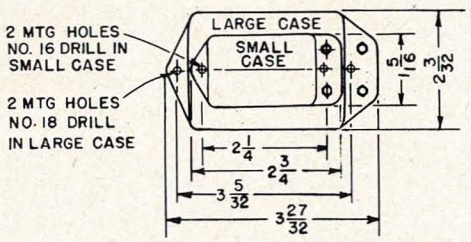
Temperature Coefficient: Approximately +35 ppm per degree between 10° and 50°C. Calibration is made at 23°C, at a frequency of 1 kc/s.

Dissipation Factor: 0.0003 for 1000 pF and higher; 500 pF, 0.00035; 200 pF, 0.0004; 100 pF, 0.0006.

Frequency Characteristics: Similar to those for TYPE 1409. Series inductance is approximately 0.055 μH for units in small case and 0.085 μH for large case. Series resistance at 1 Mc/s is approximately 0.03 Ω for small case and 0.05 Ω for large case, varying as square root of frequency above 100 kc/s.

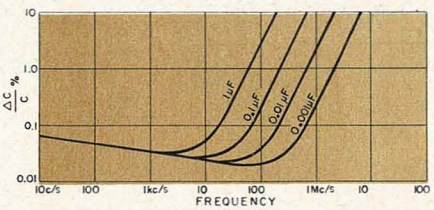
Leakage Resistance: Greater than 100 GΩ when measured at 500 V except for the TYPES 505-T, 505-U, and 505-X, for which it is greater than 50, 25, and 10 GΩ, respectively.

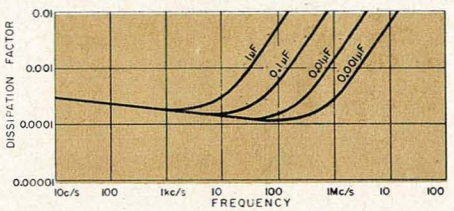
Maximum Voltage: See table. At higher frequencies, the allowable voltage decreases and is inversely proportional to the square root of the frequency. These limits correspond to a temperature rise of 40°C for a power dissipation of 1 W for the small case and 2.5 W for the large case.



Terminals: Two screw terminals spaced ¾ inch apart, with two removable plug bottoms, TYPE 274-P. High terminal (inside foil) is marked H.

Dimensions: See sketch; dimensions shown are in inches. Over-all height, 1⅝ inches for large case, 1 inch for small case, exclusive of plugs. To convert inches to mm, multiply by 25.4.

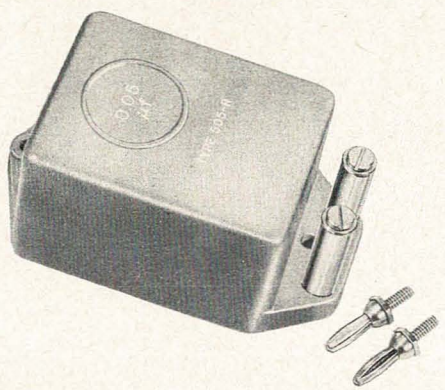


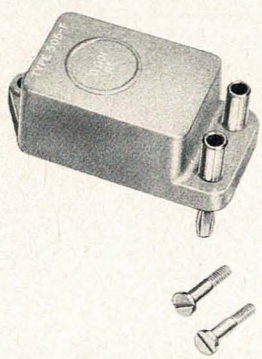


(Left) Change in capacitance as a function of frequency for typical Type 1409 and Type 505 Capacitors. The 1-kc value on the plot should be used as a basis of reference in estimating frequency errors. *(Right)* Dissipation factor as a function of frequency.

Catalog No.		*Capacitance*	*Maximum Peak Volts*	*Frequency Limit For Max Volts*	*Net Weight*	*Shipping Weight*	*Price*
0505-9701	**Type 505-A**	100 pF	700	10 Mc/s	4 oz (115 g)	8 oz (230 g)	**$10.00**
0505-9702	**Type 505-B**	200 pF	700	6 Mc/s	4 oz (115 g)	8 oz (230 g)	**7.50**
0505-9705	**Type 505-E**	500 pF	500	4 Mc/s	4 oz (115 g)	8 oz (230 g)	**7.50**
0505-9706	**Type 505-F**	0.001 μF	500	2.3 Mc/s	4 oz (115 g)	8 oz (230 g)	**7.50**
0505-9707	**Type 505-G**	0.002 μF	500	1.3 Mc/s	5 oz (145 g)	8 oz (230 g)	**7.50**
0505-9711	**Type 505-K**	0.005 μF	500	630 kc/s	5 oz (145 g)	8 oz (230 g)	**7.50**
0505-9712	**Type 505-L**	0.01 μF	500	360 kc/s	5 oz (145 g)	8 oz (230 g)	**9.00**
0505-9713	**Type 505-M**	0.02 μF	500	210 kc/s	6 oz (170 g)	8 oz (230 g)	**11.50**
0505-9718	**Type *505-R**	0.05 μF	500	100 kc/s	11 oz (315 g)	1 lb (0.5 kg)	**18.00**
0505-9720	**Type *505-T**	0.1 μF	500	50 kc/s	12 oz (340 g)	1 lb (0.5 kg)	**22.00**
0505-9721	**Type *505-U**	0.2 μF	500	20 kc/s	13 oz (370 g)	1 lb (0.5 kg)	**35.00**
0505-9724	**Type *505-X**	0.5 μF	500	10 kc/s	15 oz (425 g)	1¼ lb (0.6 kg)	**75.00**

*Mounted in large case.





DECADE CAPACITORS

TYPE 1424-A STANDARD POLYSTYRENE-DECADE DIELECTRIC CAPACITOR — 10 μF
TYPE 1425-A STANDARD POLYSTYRENE-DECADE DIELECTRIC CAPACITOR — 100 μF
TYPE 1424-M DECADE CAPACITOR — 10 μF, PAPER DIELECTRIC

These single-decade capacitors find many uses as standards and circuit elements where high values of capacitance are required.

TYPE 1424-A — 20 polystyrene capacitors, paired to give 10 1-μF units, are housed in two hermetically sealed, nonferrous metal cases with Teflon*-insulated high terminals, the cases being the common (LOW) terminal. The aluminum outer cabinet and panel are insulated from both capacitor terminals, so that either two- or three-terminal connections can be used.

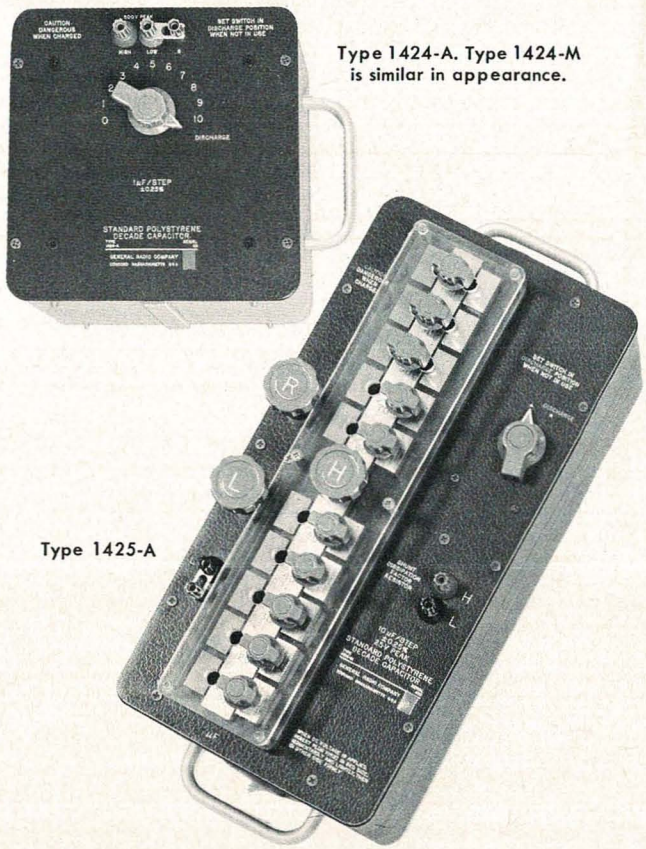
Residual series inductance and resistance have been minimized by the use of current-sheet conductors, ribbon leads, and multiple switch contacts.

A discharge position is provided on the switch to minimize the danger of electrical shock to the operator. To avoid damage to the capacitor, charging current is also limited by the switching arrangement.

TYPE 1424-M — This capacitor is a 1-microfarad-per-step decade, which has less rigorous performance specifications than the TYPE 1424-A and a correspondingly lower price. Sealed foil-paper capacitors of non-inductive extended-foil construction are used with a viscous impregnant to improve stability.

TYPE 1425-A — Contains 100 capacitors of 1 μF, combined in tens. The configuration and dimensions of binding posts, bus, studs, and current-sheet connectors are arranged to minimize residuals. Switching resistance is kept low through the use of tapered plug connectors, rather than rotary switches. Binding posts have large contact areas and are easily tightened by hand to minimize contact resistance.

This capacitor is an excellent reference standard for checking the calibration of bridges for the measurement of electrolytic capacitors. To obtain the high dissipation factors needed for that purpose, a decade or other resistor can be connected in parallel or series with the capacitor.



Type 1424-A. Type 1424-M is similar in appearance.

Type 1425-A

* Registered trademark of E. I. duPont de Nemours and Company.

SPECIFICATIONS

Accuracy: The accuracy stated in the table below is guaranteed for two years under the terms of our standard warranty, if the capacitor has not been damaged by excessive current or voltage.

Certificate: For TYPES 1424-A and 1425-A, a certificate is supplied giving measured values obtained by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy better than ±0.05%, determined and maintained in terms of reference standards periodically measured by the National Bureau of Standards.

For TYPE 1424-M, a certificate is supplied, certifying the accuracy of adjustment in terms of reference standards, periodically measured by the National Bureau of Standards.

Frequency Characteristic: Calibration and adjustment is made at 1 kc/s. Plots of typical change in capacitance and dissipation factor with frequency are given in the calibration certificate.

Type	**1424-A**	**1425-A**	**1424-M**
Total Capacitance	10 μF	100 μF	10 μF
Capacitance per Step	1 μF	10 μF	1 μF
Dielectric	Polystyrene	Polystyrene	Paper
Adjustment Accuracy at 1 kc/s	±0.25%	±0.25%	±1%
Stability	±0.05%/year	±0.05%/year	±0.35%/year
Dissipation Factor at 1 kc/s	<0.0003	<0.0004	<0.005
Insulation Resistance	$>10^6$ ΩF	$>10^6$ ΩF	$>10^4$ ΩF
*Voltage Recovery**	<0.1%	<0.1%	<5%
Temp Coefficient of Capacitance (typical) ppm/°C	−140	−140	+180
Max Operating Temperature °C	65	65	90
Max Safe Voltage	500 V, peak, below 10 kc/s	25 V, peak, below 10 kc/s	500 V, peak, up to 2 kc/s
Dimensions Width, height, depth, inches (mm)	9½, 7¾, 8 (245, 195, 205)	9⅜, 19⅛, 8⅛ (240, 485, 205)	9½, 6, 8 (245, 150, 205)
Net Weight lb (kg)	16½ (7.5)	46½ (21.5)	7¾ (3.6)
Shipping Weight lb (kg)	19 (9)	67 (31)	11 (5)
Catalog Number	1424-9701	1425-9701	1424-9713
Price	**$325.00**	**$1400.00**	**$195.00**

* Dielectric absorption.

Type 1412-BC DECADE CAPACITOR

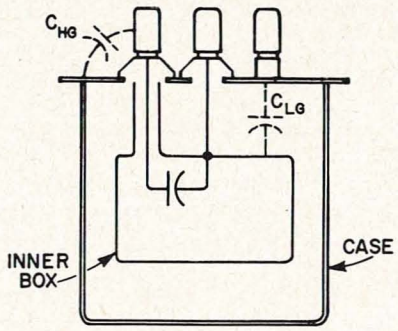
50 pF TO 1.11115 μF

FEATURES:

Variable air capacitor provides continuous capacitance adjustment between polystyrene decade steps.
Capacitance is the same (within about 1 pF) for both 2-terminal and 3-terminal connections.
Available for either lab-bench or relay-rack mounting.
In-line readout with large white numerals against a dark background.
High insulation resistance, low dielectric absorption, and low losses.

USES: The wide capacitance range and high resolution of this decade capacitance box make it exceptionally useful in both laboratory and test shop. Owing to its fine adjustment of capacitance, it is a convenient variable capacitor to use with the TYPE 1605-A Impedance Comparator. The polystyrene dielectric used in the decade steps is necessary for applications requiring low dielectric absorption and constancy of both capacitance and dissipation factor with frequency.

DESCRIPTION: Four decades of polystyrene capacitors and a variable air capacitor are used, mounted in a double-shield box. The double shielding provides 2-terminal and 3-terminal capacitances that are the same except for the capacitance between the terminals. The variable air capacitor with a linear ΔC of 100 pF and a resolution of better than 1 pF provides continuous adjustment between the 100-pF steps of the smallest decade. Brackets are provided for rack mounting.



The double shielding used in the Type 1412-BC Decade Capacitor keeps C_{HG} very small. This capacitance is the difference between the 3-terminal and 2-terminal capacitance of the box; C_{LG} is approximately 125 pF.

SPECIFICATIONS

Capacitance: 50 pF to 1.11115 μF in steps of 100 pF with a 0- to 100-pF variable air capacitor providing continuous adjustment to better than 1 pF between steps. Capacitance for 2- and 3-terminal connection differs by about 1 pF.

Dielectric: Polystyrene for decade steps.

Accuracy: ±(1.0% +5 pF) at 1 kc/s.

Temperature Coefficient: −140 ppm/°C (nominal).

Frequency Characteristics: Dc Cap/1-kc Cap < 1.001. At higher frequencies the increase is approximately $\Delta C/C = (f/f_r)^2$. The resonant frequency, f_r, varies from over 400 kc/s for a capacitance of 1 μF to about 27 Mc/s for a capacitance of 150 pF when connections are made to the front terminals. f_r is about 300 kc/s and 70 Mc/s for rear connections and the same capacitances.

Maximum Operating Temperature: 65°C.

Dielectric Absorption (Voltage Recovery): 0.1% maximum.

Dissipation Factor: 150 to 1000 pF, 0.001, max at 1 kc/s; over 1000 pF, 0.0002, max, at 1 kc/s.

Insulation Resistance: 10^{12} ohms, minimum, after 2 minutes at 500 V dc.

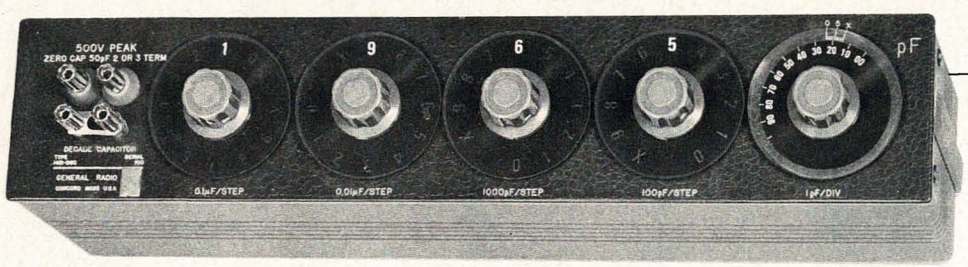
Maximum Voltage: 500 V peak up to 35 kc/s.

Terminals: Four TYPE 938 Binding Posts with grounding link are provided on the panel. Two of the binding posts are connected to the case and located for convenient use with patch cords in 3-terminal applications. Access is also provided to rear terminals for relay-rack applications.

Mechanical Data: Lab-Bench Cabinet *(see page 258)*

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
17⅝	440	3½	89	6	155	8½	3.9	10	4.6

Catalog Number	*Description*	*Price*
1412-9410	**Type 1412-BC Decade Capacitor**	**$170.00**

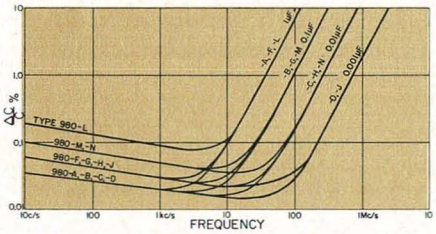


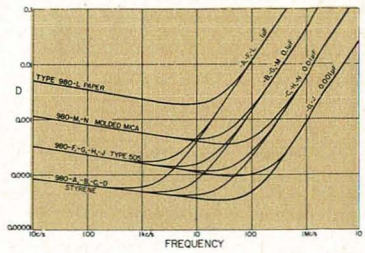
NEW in catalog S

Type 1419 DECADE CAPACITOR

Type 980 DECADE CAPACITOR UNIT

FEATURES: Choice of three dielectric materials: polystyrene, mica, or paper.
Three-terminal construction provided on all decades.





(Left) Typical plot of change in capacitance at maximum setting of each decade as a function of frequency. The capacitance curves are referred to the value the capacitor would have if there were no interfacial polarization and no series inductance. Since the capacitors are adjusted to their rated accuracy at 1 kc, the 1-kc value on the plots should be used as a basis of reference in estimating the frequency error. *(Right)* Typical plot of dissipation factor as a function of frequency.

USES: General Radio decade capacitors have a multiplicity of uses in the electronics laboratory as circuit elements in resonant circuits, bridges, filters, oscillators, analyzers, equalizers, and other networks. They are available as multidecade units in shielded cabinets (TYPE 1419) for experimental laboratory use and as single decades (TYPE 980) for building into other equipment. Decades are available in three different dielectric materials: paper, for economy in uses where dissipation factor is not critical; silvered mica, for higher accuracy, better dissipation factor, and use in higher ambient temperature; and polystyrene, for applications requiring very low dielectric absorption and constancy of both capacitance and dissipation factor with frequency.

DESCRIPTION: Each decade consists of four capacitors of magnitudes in the ratio of 1, 2, 2, 5. The switch selects parallel combinations to give all integral values between 1 and 10. Terminals are provided for both two-terminal and three-terminal connections on all decades and decade boxes.

The low-capacitance and low-loss switch includes a detent mechanism for positive location of position. The switch dielectric, including the shaft, is heat-resistant, cross-linked, modified polystyrene. Contacts are made by heavily silverplated cams riding on tinned phosphor-bronze springs.

Polystyrene Decades (Types 980-A, -B, -C, -D, and Types 1419-A and -B)

Capacitor units are designed to be essentially non-inductive and are heat stabilized.

The dielectric is specially prepared of purified high-molecular-weight polystyrene, having very high resistance and freedom from interfacial polarization. Moisture sealing with Teflon* feed-through insulators assures high performance even under adverse humidity conditions.

Silvered-Mica Decades (Types 980-F, -G, -H, and Type 1419-K)

The individual capacitors are General Radio TYPE 505 Capacitors (page 193), which are assembled from selected sheets of silvered mica.

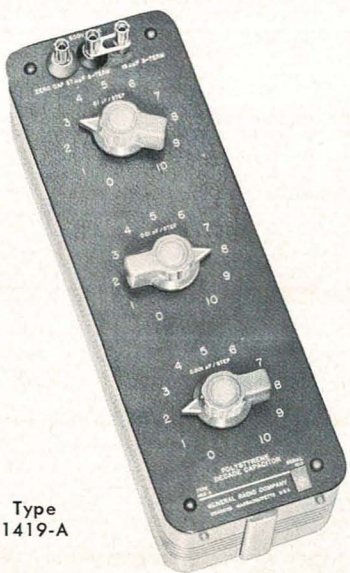
Molded Units (Types 980-M, -N; used in Type 1419-M)

These molded, silvered-mica units are EIA Characteristic-C types, offering excellent performance at low cost.

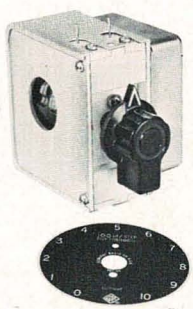
Paper Dielectric Units (Type 980-L; used in Type 1419-M)

These units are highly stable, sealed, tubular, foil-and-paper capacitors, with a viscous impregnant.

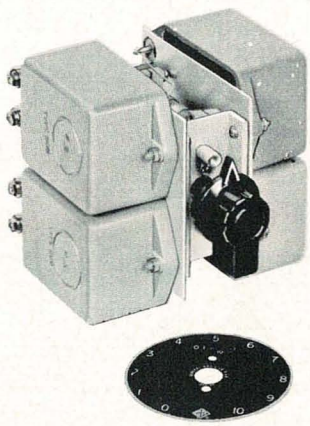
* Registered trademark of the E. I. duPont de Nemours and Company.



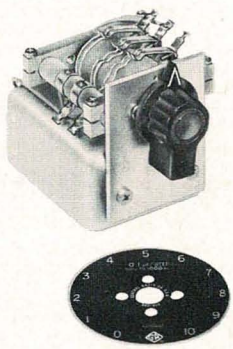
Type 1419-A



Type 980-D



Type 980-F



Type 980-L

SPECIFICATIONS

DECADE CAPACITOR UNITS

Dielectric	*Polystyrene*				*Silvered Mica — GR Type 505*			*Paper*	*Silvered Mica (Molded)*	
TYPE NUMBER	**980-A**	**980-B**	**980-C**	**980-D**	**980-F**	**980-G**	**980-H**	**980-L**	**980-M**	**980-N**
Maximum Capacitance (μF)	1.0	0.1	0.01	0.001	1.0	0.1	0.01	1.0	0.1	0.01
Capacitance per Step (μF)	0.1	0.01	0.001	0.0001	0.1	0.01	0.001	0.1	0.01	0.001
Zero Capacitance — 2-terminal connection	Approximately 11 pF									
Zero Capacitance — 3-terminal connection	5 pF									
Accuracy[1] — 2-terminal connection[2]	±1%			±(1% +2 pF)	±0.5%			±1.5%	±1%	
Accuracy[1] — 3-terminal connection	±1%	±1%	±1.5%	+1% −(2% +4 pF)	±0.5%	±0.5%	±1%	±1.5%	±1%	±1%
Dissipation Factor	<0.0002				<0.0003			<0.005	<0.001	
Insulation Resistance at 100 V, 25°C, 50% RH (ohms)	10^{12}				5×10^9	25×10^9	25×10^9	10^{10}	10^9	10^9
Temperature Coefficient of Capacitance (ppm/°C)	−140 nominal				+35 ± 10			+180 nominal	EIA Characteristic C	
Max Voltage[3] (dc or peak)	500				500			500	500	
Frequency Limit for Maximum Voltage[3]	35 kc/s	125 kc/s	800 kc/s	5 Mc/s	10 kc/s	100 kc/s	600 kc/s	1 kc/s	50 kc/s	400 kc/s
Maximum Operating Temperature (C)	65				90				90	90
Voltage Recovery[4]	<0.1%				<3%			<5%	—	
Terminals	Bus wire				Flexible leads					
Mounting Hardware Supplied	Knob, dial plate, switch stops, and machine screws									
Width, height, depth behind panel — inches (multiply by 25.4 for mm)	3⅞, 3⅜, 3⅛	2¾, 3⅜, 3⅛			4⅞, 4¼, 4⅛	4¼, 4, 4⅛	3⅝, 3⅝, 4⅛	2¾, 3¼, 3½		
Net Weight — lb (kg)	2⅛ (1)				3¾ (1.7)	2 (0.9)	1⅝ (0.8)	1⅝ (0.8)	1½ (0.7)	1½ (0.7)
Shipping Weight — lb (kg)	6 (2.8)				8 (3.7)	6 (2.8)	6 (2.8)	6 (2.8)	6 (2.8)	6 (2.8)
Catalog Number	0980-9701	0980-9702	0980-9703	0980-9704	0980-9706	0980-9707	0980-9708	0980-9712	0980-9713	0980-9714
Price	**$66.00**	**$45.00**	**$45.00**	**$50.00**	**$200.00**	**$77.00**	**$52.00**	**$49.00**	**$57.00**	**$35.00**

DECADE CAPACITORS

TYPE NUMBER	**1419-A**	**1419-B**	**1419-K**	**1419-M**
Type 980 Decades Used	A, B, C	A, B, C, D	F, G, H	L, M, N
Maximum Capacitance of Box (μF)	1.110	1.1110	1.110	1.110
In Steps of (μF)	0.001	0.0001	0.001	0.001
Zero Capacitance — 2-terminal connection	37 pF	50 pF	41 pF	35 pF
Zero Capacitance — 3-terminal connection	15 pF	20 pF	13 pF	16 pF
Frequency Characteristic	Similar to those for the Type 980 Decade Capacitor Units, modified by the additional inductance and resistance at the box terminals and wiring.			
Dc Cap/1-kc Cap	<1.001		Typically 1.03	
Cabinet	Lab-bench (see page 258)			
Over-all Dimensions — in (mm)	13, 4⅝, 5 (330, 110, 130)	16⅝, 4⅝, 5 (415, 110, 130)	14⅛, 5½, 6 (359, 140, 153)	14⅛, 5½, 6 (359, 140, 153)
Net Weight — lb (kg)	8⅜ (3.8)	10½ (4.8)	11¼ (5.5)	6¼ (2.9)
Shipping Weight — lb (kg)	10 (4.6)	11 (5)	18 (8.5)	8 (3.7)
Catalog Number	1419-9701	1419-9702	1419-9711	1419-9713
Price	**$180.00**	**$230.00**	**$360.00**	**$170.00**

[1] Capacitance increments from zero position are within this percentage of the indicated value for any setting at 1 kc/s.
[2] Units are checked with switch mechanism high, electrically, and the common lead and case grounded.
[3] At frequencies above the indicated maximum, the allowable voltage decreases and is (approximately) inversely proportional to frequency. These limits correspond to a temperature of 40°C.
[4] Final % of original charging voltage after a charging period of one hour and a 10-second discharge through a resistance equal to one ohm per volt of charging.

Decade Resistors and Decade Inductors are described on pages 203 and 208, respectively.

Because of its accuracy of adjustment, long-term stability, low- and uniform-temperature coefficient, and relative immunity to ambient humidity conditions, the wire-wound resistor is the most suitable type for use as a laboratory standard at audio and low radio frequencies, as well as at dc. In the resistance range from a fraction of an ohm to over one megohm, such resistors have been developed to a high state of refinement through improvements in design and manufacturing techniques.

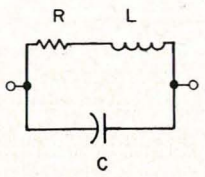


Figure 1.

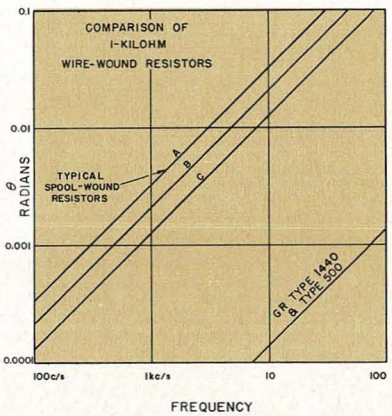


Figure 2.

Resistors designed for ac use differ from those intended for use only at dc in that low series reactance and constancy of resistance as frequency is varied are important design objectives. The residual capacitance and inductance become increasingly important as the frequency is raised, acting to change the terminal resistance from its low-frequency value.

For frequencies where the resistance and its associated residual reactances behave as lumped parameters, the equivalent circuit of a resistor can be represented as shown in Figure 1. L is the equivalent inductance in series with the resistance, and C is the equivalent capacitance across the terminals of the resistor.

It is necessary to differentiate clearly between the concepts of equivalent series and equivalent parallel circuits. The two-terminal circuit of Figure 1 can be described as an impedance $R_s + jX_s$ or as an admittance $G + jB = \frac{1}{R_p} + \frac{1}{jX_p}$, wherein the parameters are a function of frequency. This distinction between series and parallel components is more than a mathematical exercise — the use to which the resistor is to be put will frequently determine which component is of principal interest.

The expression for the effective series impedance is:

$$Z_s = R_s + jX_s = \frac{R + j\omega\left[L\left(1 - \frac{\omega^2}{\omega_r^2}\right) - R^2C\right]}{\left(1 - \frac{\omega^2}{\omega_r^2}\right)^2 + (\omega RC)^2}$$

where $\omega_r = \frac{1}{\sqrt{LC}}$ and $\frac{\omega^2}{\omega_r^2} = \omega^2 LC$.

The effective parallel admittance is given by:

$$Y = G + jB = \frac{1}{R_p} + \frac{1}{jX_p} = \frac{\frac{1}{R} + j\omega\left[C - \frac{L}{R^2}\left(1 - \frac{\omega^2}{\omega_r^2}\right)\right]}{1 + \left(\frac{\omega L}{R}\right)^2}$$

At low frequencies where terms in ω^2 are negligible, the resistor may be represented by a two-element network consisting of the dc resistance, R, in series with an inductance equal to $L - R^2C$ or in parallel with a capacitance equal to $C - L/R^2$. Because of the presence of the R^2 term in the equivalent reactive parameters, shunt capacitance is the dominating residual for high values of resistance, while for low values the series inductance invariably predominates. Generally, individual wire-wound resistors above a few kilohms are capacitive, while decades are capacitive at somewhat lower values.

In the simplified circuit above, the effective parallel resistance of a high-valued resistor in which shunt capacitance dominates would be independent of frequency. Actually, other effects may cause the parallel resistance to decrease with frequency. For example, dielectric losses in the shunt capacitance, C, of Figure 1 are equivalent to a resistance

$$R_d = \frac{1}{D\omega C}$$

(where D is the dissipation factor of the distributed capacitance), which decreases with frequency and causes the effective parallel resistance to decrease rapidly beyond a certain frequency. In addition, distributed capacitance along the winding causes a similar rapid decrease in resistance even if its dielectric loss is negligible. The equations above indicate that the effective series resistance of low-valued resistors would be independent of frequency up to quite high frequencies. In practice, if the residual inductance and capacitance are kept small, skin effect becomes the main cause for departure from the low-frequency value of these resistors.

General Radio wire-wound resistance elements are designed to minimize inductance in low-resistance values and to minimize capacitance for high values of resistance. All units up through 200 ohms utilize an Ayrton-Perry winding, in which each resistor consists of two windings in opposite directions, such that their magnetic fields are opposed and largely

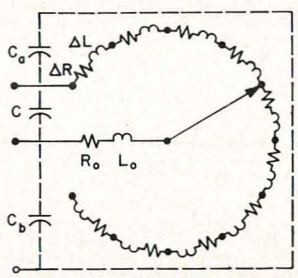


Figure 3. Equivalent circuit of a resistance decade, showing location and nature of residual impedances.

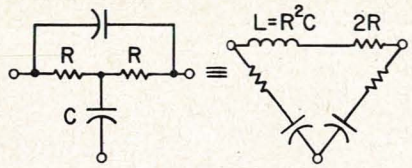


Figure 4. Equivalent wye and delta networks for a resistor with capacitance to shield. The presence of the capacitance, C, gives the resistor an apparent inductive component, $L = R^2C$.

cancel. For very low-valued units, the residual inductance of such a winding is of the order of 1% of that of a corresponding single winding.

Elements having 500-ohm resistance or higher are unifilar-wound on flat rectangular "cards," and have inherently less inductance than so-called "noninductive" spool-wound types because of the low cross-sectional area of the winding (refer to Figure 2). The capacitance of a card-type resistor is also much lower than that of a spool type because the turns of wire are not piled up but are evenly wound in one layer.

These wire-wound resistors exhibit a negligible frequency error in resistance up to about 500 kc/s for values up to 500 ohms, and only moderate errors at 1Mc/s.

In decade boxes, the residual impedances of the switches, wiring, and cabinet are added to those of the resistors themselves. The equivalent circuit is then that of Figure 3, which represents a single Type 510 decade. For multiple-decade boxes, the series inductances are additive, but the capacitance is approximately that across the highest valued decade used (see specifications for each type).

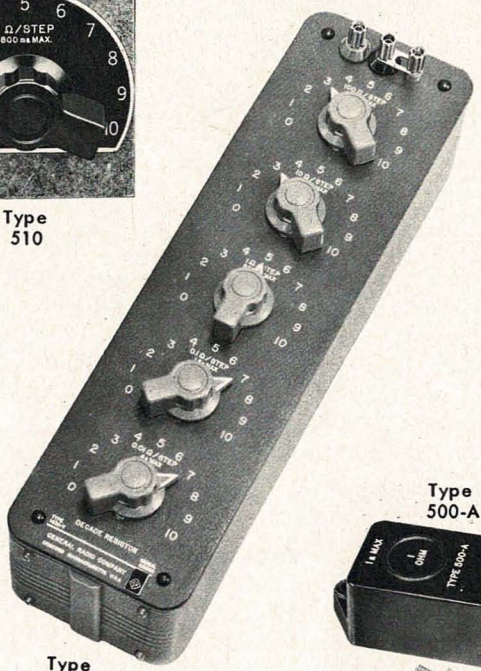
The effect of the residual reactance depends greatly upon the way the resistor is connected in the circuit. For example, parallel capacitance can often be compensated for when the resistor is connected in parallel with a capacitor. For high-valued resistors, the upper frequency limit for a given error is some ten times higher in the effective parallel resistance than it is for the series connection.

General Radio decade boxes have a separate terminal for the case. With a three-terminal connection, the capacitance is reduced because capacitance from the resistor terminals to the case (C_a and C_b in Figure 3) are guarded and do not shunt the resistance. Moreover, this direct impedance can appear slightly inductive due to distributed capacitance from resistor to case, as explained by the wye-delta transformation of Figure 4.

The resistance material used for most General Radio units is Evanohm,* an alloy with excellent stability, very low and constant temperature coefficient, low thermal emf with copper, and high tensile strength. It is relatively insensitive to humidity and strain. For resistance units of less than 5 ohms, the older, well-known manganin alloy is used because its lower resistivity allows wire dimensions that are easier to work with and to adjust.

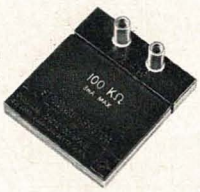
* Registered trademark of the Wilbur B. Driver Company.

Type 510

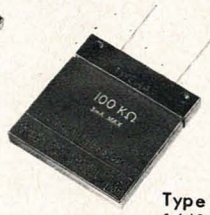


Type 1432

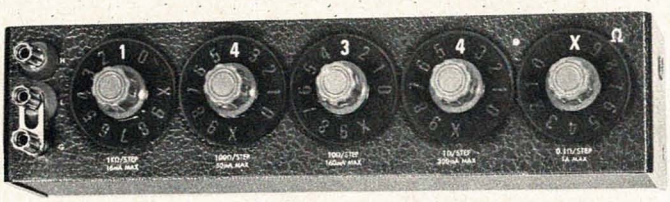
Type 500-A



Type 1440



Type 1441



Type 1434

Type	*Name*	*Use*	*Page*
1440	Standard Resistor	Laboratory standard	**200**
1441	Standard Resistor	Precision component	**200**
500	Resistor	Utility standard	**201**
1434	Decade Resistor	Resistance box, small, compact	**202**
1432	Decade Resistor	Resistance box, highest accuracy	**203**
510	Decade-Resistance Unit	Circuit component	**203**

Types 1440 and 1441 STANDARD RESISTORS

FEATURES: Excellent long-time stability. Low thermal emf to copper. ■ High accuracy.

USES: These extremely stable standard resistors are designed in two styles:

TYPE 1440, a laboratory or production standard for calibrating resistance bridges and for substitution measurements.

TYPE 1441, which can be built into precision measuring equipment. It is recommended as a component in test instruments or in production equipment that requires resistors of high accuracy and stability.

DESCRIPTION: These standards are card-type, wire-wound resistors, carefully wound and adjusted. Low-temperature-coefficient Evanohm* wire is used for values above 10 ohms, manganin for the lower-resistance units. All units are heat cycled to reduce strains and are repeatedly checked to eliminate any that show abnormal behavior. They are encased in sealed, oil-filled, diallyl-phthalate boxes to promote long-term stability and to provide mechanical protection.

The TYPE 1440 resistors have low-thermal-emf binding posts and removable banana plugs to provide the four terminals necessary for accurate measurements at low values of resistance. A label on the reverse side lists initial calibration and date, space for future calibration data, and serial number.

The TYPE 1441 resistors have heavy wire leads, holes for horizontal mounting, and hardware for vertical mounting.

* Registered trademark of the Wilbur B. Driver Company.

SPECIFICATIONS

Accuracy: ±0.01% for all units except those of 1 Ω, which are ±0.02%. This accuracy is guaranteed for our standard warranty period of two years, unless the resistor has been damaged by excessive current. Measurements on the low-value TYPE 1440 units should be made with a four terminal connection and on the TYPE 1441's at ½ inch from the case. All measurements at 23°C.

Calibration Accuracy: TYPE 1440 Resistors are calibrated by comparison, to a precision of ±20 ppm, with working standards whose absolute values are known typically to ±10 ppm as determined and measured in terms of reference standards periodically measured by the National Bureau of Standards. The measured deviation from nominal value, at 23°C and 0.01 watt, is entered on the label on the reverse side of the resistor.

Stability: ±30 ppm per year.

Temperature Coefficient (Max): ±10 ppm/°C for resistances above 10 Ω; ±20 ppm/°C for 10 Ω and below.

Power Rating: 1 W. The corresponding current is indicated on the resistor and in the table below. This dissipation will cause a temperature rise of approximately 25°C and a resulting temporary resistance change due to the temperature coefficient. If this rating is exceeded, permanent changes may result.

Residual Impedances: Approximate shunt capacitance (2-terminal measurement), TYPE 1440, 2.5 pF; TYPE 1441, 1.5 pF; less for 3-terminal measurement. Typical series inductance, see table.

Approximate Frequency Characteristic: See table.

Terminals: TYPE 1440 — gold-plated jack-top copper binding posts (¾-in spacing) with banana plugs that are removable and can be replaced by 6-32 screws for installation of soldering lugs. TYPE 1441 — #16 tinned copper wire. See sketch.

Mechanical Data:

Type	*Dimensions**	*Net Wt†*	*Ship Wt†*
1440	2¼, 2½, ⅜ in (58, 64, 10 mm)	2 oz (60 g)	10 oz (0.3 kg)
1441	2¼, 2⁵⁄₁₆, ⅜ in (58, 59, 10 mm)	1½ oz (45 g)	10 oz (0.3 kg)

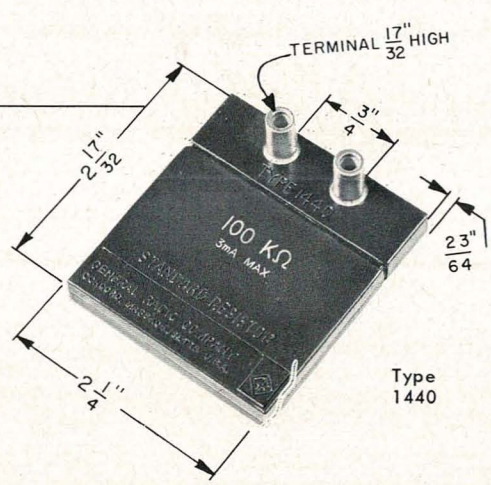
* Less terminals. † Approximate.

Resistance	*Max Current*	*Typical Inductance*	*Approx Frequency for 0.1% Resistance Change* Series R	Parallel R	*Type 1440 Standard Catalog Number*	*Resistor Price*	*Type 1441 Standard Catalog Number*	*Resistor Price*
1 Ω	1.0 A	0.12 μH	300 kc/s	30 kc/s	1440-9601	**$10.50**	1441-9601	**$ 6.50**
10 Ω	310 mA	0.13 μH	1 Mc/s	300 kc/s	1440-9611	**10.50**	1441-9611	**6.50**
100 Ω	100 mA	0.20 μH	3 Mc/s	1 Mc/s	1440-9621	**10.50**	1441-9621	**6.50**
1 kΩ	30 mA	2.5 μH	2 Mc/s	1 Mc/s	1440-9631	**10.50**	1441-9631	**6.50**
10 kΩ	10 mA		200 kc/s	1 Mc/s	1440-9641	**10.50**	1441-9641	**6.50**
100 kΩ	3 mA		20 kc/s	100 kc/s	1440-9651	**12.50**	1441-9651	**8.50**
1 MΩ	1 mA		2 kc/s	10 kc/s	1440-9661	**21.50**	1441-9661	**17.50**

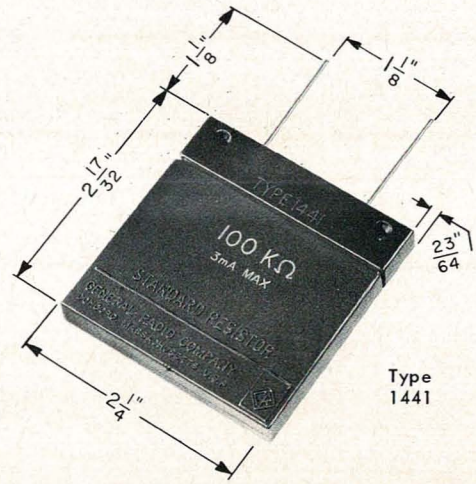
When ordering, please specify catalog number, type number and name, resistance value, and price. Any other resistance value between 0.1 Ω and 1 MΩ can be supplied. Please ask for a quotation.

NEW

in catalog S



Type 1440



Type 1441

Type 500 RESISTORS

FEATURES: Convenient and accurate. ■ Excellent high-frequency characteristics. Low temperature coefficient of resistance. Standard plug-in terminals.

USES: The TYPE 500 Resistors are particularly recommended as resistance standards for use in impedance bridges and as secondary standards for laboratory use. The plug-type terminals make them readily interchangeable in experimental equipment. Screw terminals are also supplied for more permanent installations.

DESCRIPTION: This resistor is an accurately adjusted resistance unit wax-sealed in a phenolic case to exclude moisture and to provide protection from mechanical damage. The resistance units are similar in construction to those used in the TYPE 510 Decade-Resistance Units (page 204).

SPECIFICATIONS

Accuracy: See table below. This accuracy is guaranteed for our standard warranty period of two years, unless the resistor has been damaged by excessive current.

Frequency Characteristics: Similar to those of the TYPE 510 Decade-Resistance Units for resistance values up to 600 Ω; somewhat better for higher resistances, because of the relatively small shunt capacitance of an isolated resistor.

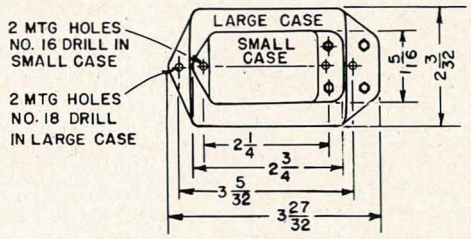
Maximum Power and Current: One watt for a temperature rise of 40°C. The corresponding current is given in the table below and is engraved on each unit.

Temperature Coefficient: Less than ±20 ppm per degree C at normal room temperature.

Type of Winding: Less than 500 Ω, Ayrton-Perry; 500 Ω and higher, unifilar on thin mica cards. TYPES 500-Y, Z, and ZZ are made up of multiple mica cards in series.

Terminals: Both terminal screws and plugs are supplied. Each terminal stud is recessed as a jack to accommodate a plug. Standard ¾-in spacing is used. High terminal is marked H.

Mounting: Black molded phenolic case is used for all units having a resistance of less than 1000 Ω. For units having a resistance value



of 1000 Ω or higher, a low-loss mica-filled phenolic case is used. Both types are sealed with a high-melting-point wax. TYPES 500-A through -V are in small case; TYPES 500-W, -X, -Y and -Z in large case.

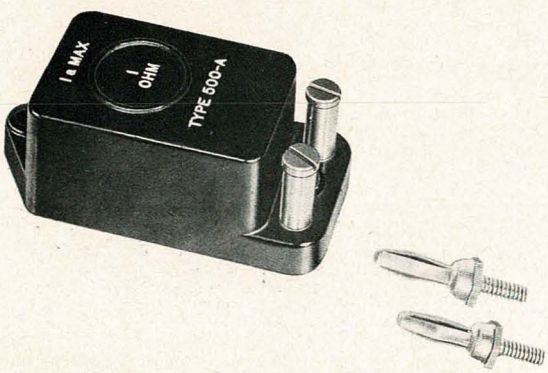
Dimensions: See sketch, dimensions are in inches. Over-all height, 1⅝ in for large case, 1 in for small case, exclusive of plugs. To convert inches to mm, multiply by 25.4.

Net Weight: 2 oz (60 g).

Shipping Weight: 8 oz (230 g).

Catalog No.		*Resistance in Ohms*	*Accuracy*	*Maximum Current*	*Price*
0500-9701	**Type 500-A**	1	0.1%	1.0 A	**$ 6.00**
0500-9702	**Type 500-B**	10	0.05%	310 mA	**6.00**
0500-9711	**Type 500-K**	20	0.05%	220 mA	**6.00**
0500-9703	**Type 500-C**	50	0.035%	140 mA	**6.00**
0500-9704	**Type 500-D**	100	0.025%	100 mA	**6.00**
0500-9705	**Type 500-E**	200	0.025%	70 mA	**6.00**
0500-9706	**Type 500-F**	500	0.025%	45 mA	**6.00**
0500-9707	**Type 500-G**	600	0.025%	40 mA	**6.00**
0500-9708	**Type 500-H**	1000	0.025%	30 mA	**6.00**
0500-9712	**Type 500-L**	2000	0.025%	22 mA	**6.00**
0500-9713	**Type 500-M**	5000	0.025%	14 mA	**6.00**
0500-9710	**Type 500-J**	10,000	0.025%	10 mA	**6.00**
0500-9718	**Type 500-R**	20,000	0.025%	7 mA	**6.00**
0500-9720	**Type 500-T**	50,000	0.025%	4.5 mA	**6.00**
0500-9721	**Type 500-U**	100,000	0.025%	3 mA	**6.00**
0500-9722	**Type 500-V**	200,000	0.025%	2.2 mA	**7.50**
0500-9723	**Type 500-W**	500,000	0.025%	1.4 mA	**11.00**
0500-9724	**Type 500-X**	1 Megohm	0.025%	1.0 mA	**16.00**
0500-9725	**Type 500-Y**	2 Megohms	0.025%	1.1 mA	**28.00**
0500-9726	**Type 500-Z**	5 Megohms	0.025%	0.7 mA	**62.00**
0500-9504	**Type 500-ZZ**	10 Megohms	0.025%	0.5 mA	**95.00**

POTENTIOMETERS: *General Radio 970-series potentiometers are listed on page 250.*



Type 1434 DECADE RESISTOR

FEATURES:

High accuracy at low cost.
Low temperature coefficient.
Accurate increments as well as accurate total value.
Excellent stability.

USES: These laboratory-quality, budget-priced decade boxes are designed for maximum usefulness and economy in laboratory measurement, testing, and development work. Their accuracy is adequate for all but the most exacting applications, their small size and clear readout should be particularly useful in experimental setups using small, modern components, and their moderate price will be welcomed by the educational laboratory.

DESCRIPTION: High-quality, wire-wound resistors are used in these decades. The low price is made possible by the use of only six resistors per decade instead of ten. These are combined by switching in such a way that there are no discontinuities, that is, the resistance increases stepwise just as if ten resistors were used. The switches have multiple, solid-silver-alloy contacts for low resistance and long life.

The TYPES 1434-M, -N, and -P contain five step decades of resistance in a small cabinet. The TYPE 1434-QC, a "best buy," has four step decades plus a rheostat to provide 1-ohm resolution in a 1-megohm box. The larger, seven-decade, TYPE 1434-G box is easily converted into a 3½-inch relay-rack unit by the addition of angle brackets and dress strips, which are furnished. This box has lug terminals available at the rear, as well as at panel binding posts.

Resistors are of low temperature-coefficient Evanohm* wire, except the 1-ohm/step decade, which uses manganin wire and the 0.1-ohm/step decade, which uses manganin ribbon. The resistors of the 100-ohm/step, 10-ohm/step, and 1-ohm/step decades are Ayrton-Perry wound to minimize inductance.

* Registered trademark of the Wilbur B. Driver Company.

SPECIFICATIONS

Long-Term Accuracy: See Table I. Our general two-year warranty applies to these tolerances unless the resistor is damaged by excessive current. Tolerance shown applies to both resistance increments and total resistance after correction for zero resistance.

Zero Resistance: Approximately 2 mΩ per dial at low frequencies except for the TYPE 1434-QC for which it is approximately 20 mΩ.

Maximum Current: See table; these values also appear on the panel of each decade box. When this maximum current is passed through a decade, the temporary change in value will be less than the accuracy specification. Currents appreciably higher than this will cause permanent changes.

TABLE I

Total Resistance of Decade	*Resistance Per Step*	*Accuracy**	*Maximum Current*
1 Ω	0.1 Ω	±2.0%	1 A
10 Ω	1.0 Ω	±0.25%	0.3 A
100 Ω	10 Ω	±0.07%	160 mA
1 kΩ	100 Ω	±0.05%	50 mA
10 kΩ	1 kΩ	±0.05%	16 mA
100 kΩ	10 kΩ	±0.05%	5 mA
1 MΩ	100 kΩ	±0.05%	1.6 mA
100-Ω Rheostat**	1 Ω/div	±1 Ω	200 mA

* At low currents and low frequencies.
** Used in TYPE 1434-QC.

Temperature Coefficient: Less than ±10 ppm/°C at room temperature, except for the low-valued units where the 0.4%/°C temperature coefficient of the zero resistance must be added.

Frequency Characteristics: Generally similar to those of the TYPE 1432 Decades.

Switches: Multiple, solid-silver-alloy switches are used to obtain low and stable zero resistance.

Terminals: Jack-top binding posts (TYPE 938-A) on standard ¾" spacing. A shield terminal is also provided. The TYPE 1434-G has lug connections accessible from the rear.

Mounting: All types except the TYPE 1434-G are in small cabinets for bench use. The TYPE 1434-G is also designed for bench use but, with the addition of mounting hardware, becomes a 3½-in high, 19-in relay-rack unit.

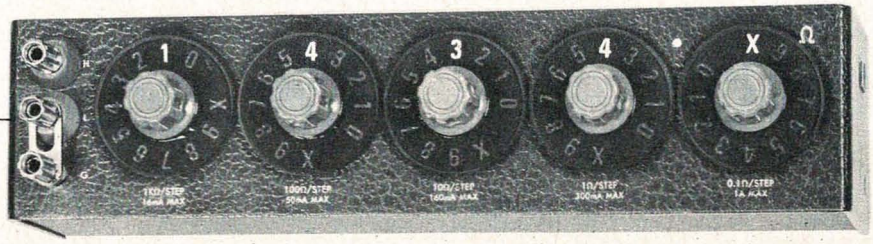
Mechanical Data:

Models	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
M,N,P,QC	11⅝	298	2¾	70	4¼	110	3	1.4	4	1.9
G (bench)	17⅜₁₆	442	3½	89	5	130	6	2.8	7	3.2
G (rack)	19	485	3½	89	3½*	89	6	2.8	7	3.2

* Behind panel.

Catalog Number	*Description*	*Total Resistance*	*Resistance Per Step*	*Number of Decades*	*Price*
1434-9714	**Type 1434-N Decade Resistor**	11,111	0.1 Ω	5	**$ 99.00**
1434-9713	**Type 1434-M Decade Resistor**	111,110	1.0 Ω	5	**109.00**
1434-9716	**Type 1434-P Decade Resistor**	1,111,100	10 Ω	5	**113.00**
1434-9576	**Type 1434-QC Decade Resistor**	1,111,105	1 Ω/div	4 + rheostat	**101.00**
1434-9707	**Type 1434-G Decade Resistor**	1,111,111	0.1 Ω	7	**155.00**

NEW
in catalog S



Type 1432 DECADE RESISTOR

Type 510 DECADE-RESISTANCE UNIT

FEATURES: ±0.025% accuracy. ■ Low thermal emf to copper. Low zero resistance. ■ Low temperature coefficient of resistance. Resistance increments, as well as total value, are always correctly indicated. Good frequency characteristics. ■ Residual reactances are small and known. Excellent stability. ■ Unaffected by high humidity.

USES: The TYPE 1432 Decade Resistors are primarily intended for precision measurement applications where their excellent accuracy, stability, and low zero resistance are important. They are convenient resistance standards for checking the accuracy of resistance measuring devices and are used as components in dc and audio-frequency impedance bridges. Many of the models can be used up into the radio frequency range. While they are also useful as substitution boxes for optimizing electronic circuitry, the less expensive TYPE 1434 Decade Resistors are recommended for such less exacting applications.

The individual decades (TYPE 510 Decade-Resistance Units) are available for applications requiring only one decade or as components to be built into experimental equipment, production test equipment, or commercial instruments.

DESCRIPTION: Each TYPE 510 Decade-Resistance Unit is enclosed in an aluminum shield, and a knob and etched-metal dial plate are supplied. The switch assemblies, less resistors, are also available as the TYPE 510-P4 and -P4L Switches.

The TYPE 1432 Decade Resistor is an assembly of TYPE 510 Decade-Resistance Units in a single cabinet. Mechanical as well as electrical shielding of the units and switch contacts is provided by the attractive aluminum cabinet and panel. The resistance elements have no electrical connection to the cabinet and panel, for which a separate shield terminal is provided.

Each decade has eleven contact studs and ten resistors in series. All the contact studs in the lower-valued decades have a silver overlay to ensure stability of resistance, and all the decades have a silver contact on the zero setting to give low and constant zero resistance.

Winding methods are chosen to reduce the effects of residual reactances. The 1-, 10-, and 100-ohm steps use winding techniques that minimize inductance. The 0.01- and 0.1-ohm steps are straight wire and hairpin-shaped ribbon respectively, and the high valued units are straight wound on mica forms.

SPECIFICATIONS

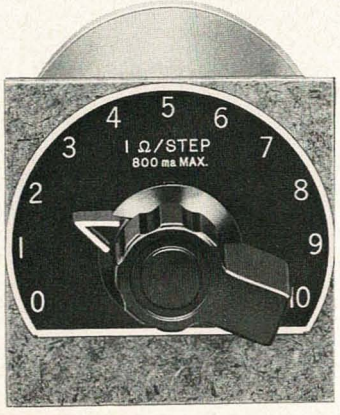
Long-Term Accuracy: ±0.025% for resistance settings on decades above 100 Ω per step. For lower resistance settings, see table. Our general two-year warranty applies to these tolerances unless the unit is damaged by excessive current. Tolerance shown applies to both resistance increments and total resistance after correction for zero resistance.

Maximum Current: The maximum current for each decade is given in the table below and also appears on the panel of each decade box and on the dial plate of each decade resistance unit.

Frequency Characteristic: The accompanying plot shows the maximum percentage change in effective series resistance, as a function of frequency for the individual decade units. For low-resistance decades the error is due almost entirely to skin effect and is independent of switch setting, while for the high-resistance units the error is due almost entirely to the shunt capacitance and its losses and is approximately proportional to the square of the resistance setting.

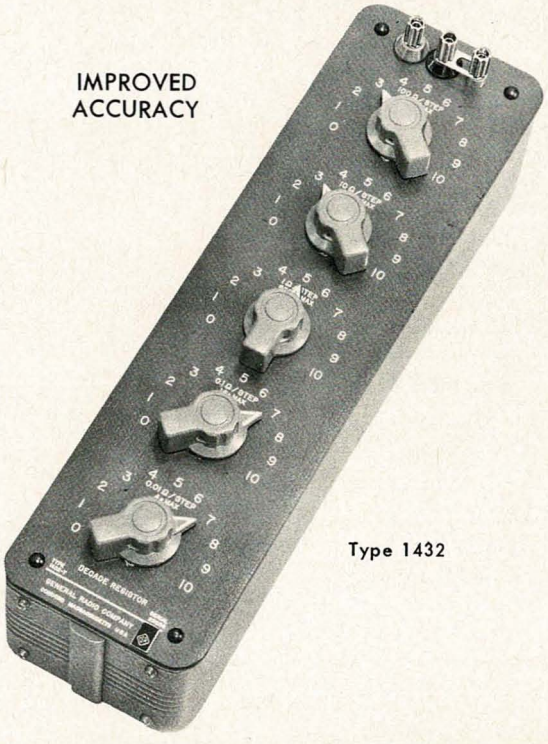
The high-resistance decades (TYPES 510-E, -F, -G, and -H) are very commonly used as parallel resistance elements in resonant circuits, in which the shunt capacitance of the decades becomes part of the tuning capacitance. The parallel resistance changes by only a fraction (between a tenth and a hundredth) of the series-resistance change, depending on frequency and the insulating material in the switch.

Characteristics of the TYPE 1432 Decade Resistors are similar to those of the individual TYPE 510 units, modified by the increased series inductance, L_o, and shunt capacitance, C, due to the wiring and the presence of more than one decade in the assembly. At total resistance settings of approximately 1000 ohms or less, the frequency characteristics of any of these decade resistors are substantially the same as those shown for the TYPE 510 units. At higher settings, shunt capacitance becomes the controlling factor, and the effective value of this capacitance depends upon the settings of the individual decades.

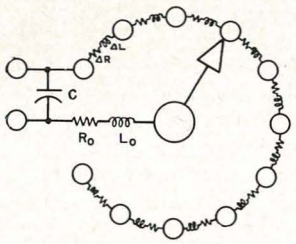


Type 510

IMPROVED ACCURACY

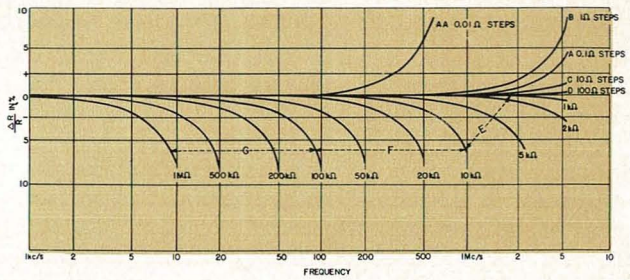


Type 1432



(Left) Equivalent circuit of a resistance decade, showing location and nature of residual impedances.

(Right) Maximum percentage change in series resistance as a function of frequency for Type 510 Decade-Resistance Units.



Typical Values of R_o, L_o, and C for the Decade Resistors:

Zero Resistance (R_o): 0.001 Ω per dial at dc; 0.04 Ω per dial at 1 Mc/s; proportional to square root of frequency at all frequencies above 100 kc/s.

Zero Inductance (L_o): 0.1 μH per dial.

Effective Shunt Capacitance (C): This value is determined largely by the highest decade in use. With the low terminal connected to shield, a value of 15 to 10 pF per decade may be assumed, counting decades down from the highest. Thus, if the third decade from the top is the highest resistance decade in circuit (i.e., not set at zero), the shunting terminal capacitance is 45 to 30 pF. If the highest decade in the assembly is in use, the effective capacitance is 15 to 10 pF, regardless of the settings of the lower-resistance decades.

Temperature Coefficient of Resistance: Less than ±10 ppm per degree C for values above 100 Ω and ±20 ppm per degree C for 100 Ω and below, at room temperatures. For the TYPE 1432 Decade Resistors, the box wiring will increase the over-all temperature coefficient of the 0.1- and 0.01-Ω decades.

Switches: Quadruple-leaf brushes bear on lubricated contact studs of ⅜-in diameter in such a manner as to avoid cutting but yet give a good wiping action. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive). The switch resistance is less than 0.0005 Ω. The effective capacitance is of the order of 5 pF, with a dissipation factor of 0.06 at 1 kc/s for the standard cellulose-filled molded phenolic switch form and 0.01 on the mica-filled phenolic form used in the TYPE 510-G and 510-H units.

Maximum Voltage to Case: 2000 V peak.

Terminals: For TYPE 1432, low-thermal-emf jack-top binding posts on standard ¾-in spacing. Shield terminal is provided. TYPE 510 units have soldering lugs.

Mounting: TYPE 1432, lab-bench cabinet (see page 258); TYPE 510, complete with dial plate, knob, template, and mounting screws.

Mechanical Data:

Type 1432	*Width*		*Height*		*Length*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
4-Dial	4 5/16	110	4 ¾	125	13	330	5 ¼	2.4	6	2.8
5-Dial	4 5/16	110	4 ¾	125	15 ¾	400	6 ¼	2.9	7	3.2
6-Dial	4 5/16	110	4 ¾	125	18 ¼	465	7 ½	3.5	9	4.1

Type 510	*Diameter*		*Depth Behind Panel*		*oz*	*kg*	*lb*	*kg*
	3 1/16	78	3 5/16	85	11	0.4	2	1

DECADE RESISTORS

Catalog Number		*Total Ohms*	*Multiple of*	*No. of Dials*	*Type 510 Decades Used*	*Price*
1432-9721	**Type 1432-U**	111.1	0.01 ohm	4	AA, A, B, C	**$ 98.00**
1432-9711	**Type 1432-K**	1111	0.1	4	A, B, C, D	**102.00**
1432-9710	**Type 1432-J**	11,110	1	4	B, C, D, E	**110.00**
1432-9712	**Type 1432-L**	111,100	10	4	C, D, E, F	**116.00**
1432-9717	**Type 1432-Q**	1,111,000	100	4	D, E, F, G	**127.00**
1432-9720	**Type 1432-T**	1111.1	0.01	5	AA, A, B, C, D	**124.00**
1432-9714	**Type 1432-N**	11,111	0.1	5	A, B, C, D, E	**128.00**
1423-9713	**Type 1432-M**	111,110	1	5	B, C, D, E, F	**139.00**
1432-9716	**Type 1432-P**	1,111,100	10	5	C, D, E, F, G	**154.00**
1432-9725	**Type 1432-Y**	11,111,000	100	5	D, E, F, G, H	**229.00**
1432-9724	**Type 1432-X**	111,111	0.1	6	A, B, C, D, E, F	**165.00**
1432-9726	**Type 1432-Z**	11,111,100	10	6	C, D, E, F, G, H	**262.00**
1432-9702	**Type 1432-B**	1,111,110	1	6	B, C, D, E, F, G	**185.00**
1432-9723	**Type 1432-W**	11,111.1	0.01	6	AA, A, B, C, D, E	**158.00**

DECADE-RESISTANCE UNITS

Catalog Number		*Total Resistance Ohms*	*Resistance Per Step (ΔR) Ohms*	*Accuracy of Resistance Increments*	*Maximum Current 40° C Rise*	*Power Per Step Watts*	*ΔL μH*	*C** pF*	*L_o μH*	*Price*
0510-9806	**Type 510-AA**	0.1	0.01	±2%	4 A	0.16	0.01	7.7–4.5	0.023	**$19.50**
0510-9701	**Type 510-A**	1	0.1	±0.5%	1.6 A	0.25	0.014	7.7–4.5	0.023	**15.00**
0510-9702	**Type 510-B**	10	1	±0.15%	800 mA	0.6	0.056	7.7–4.5	0.023	**21.50**
0510-9703	**Type 510-C**	100	10	±0.05%	250 mA	0.6	0.11	7.7–4.5	0.023	**23.50**
0510-9704	**Type 510-D**	1000	100	±0.025%	80 mA	0.6	0.29	7.7–4.5	0.023	**24.00**
0510-9705	**Type 510-E**	10,000	1000	±0.025%	23 mA	0.5	3.3	7.7–4.5	0.023	**24.00**
0510-9706	**Type 510-F**	100,000	10,000	±0.025%	7 mA	0.5	9.5	7.7–4.5	0.023	**27.00**
0510-9707	**Type 510-G**	1,000,000	100,000	±0.025%	2.3 mA	0.5	—	7.7–4.5	0.023	**35.00**
0510-9708	**Type 510-H**	10,000,000	1,000,000	±0.025%	0.7* mA	0.5	—	13.5–5.0	0.023	**98.00**
0510-9604	**Type 510-P4**	Switch only	(Black Phenolic Frame)							**11.00**
0510-9511	**Type 510-P4L**	Switch only	(Low-Loss Phenolic Frame)							**12.00**

* Or a maximum of 4000 V, peak.
** The larger capacitance occurs at the lowest setting of the decade. The values given are for units without the shield cans in place. With the shield cans in place, the shunt capacitance is from 10 to 20 pF greater than indicated here, depending on whether the shield is tied to the switch or to the zero end of the decade.

STANDARD INDUCTORS

An inductor used as a standard should have the smallest possible changes with time, frequency, current, temperature, external fields, or environment. The residual impedances should be as low as possible. For best accuracy, the connections to the inductor must not affect the calibrated value.

Construction: For minimum generation of, or pickup from, external magnetic fields, the toroidal inductor is preferable to the solenoid. The symmetry of the toroid contributes both to stability and to a constant temperature coefficient.

An air core in the inductor results in the highest stability and a negligible variation of inductance with current, but at the expense of a relatively low Q. Because stability is the prime requirement in a laboratory standard, the Type 1482 Standard Inductors have air cores.

For a given volume, a larger inductance and Q can be obtained from a core of the high-permeability ferromagnetic materials, often termed "iron," although they usually are special alloys. Since the permeability of the material can change with age and particularly with current, the iron-core inductor is inherently less stable than the air-core type. Good stability can still be realized in iron-core inductors by proper design and choice of core materials, as in the Type 940 Decade Inductors.

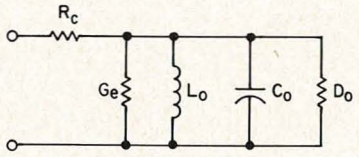


Figure 1. Equivalent circuit of an air-core inductor. R_c is the series resistance, G_e is the conductance due to eddy-current loss, and D_o is the dissipation factor of the distributed capacitance.

Inductance Changes: The inductance depends not only upon the geometry and the permeability of the core, but upon the residual impedances, which are shown in the equivalent circuit of Figure 1. The largest changes of inductance with frequency are produced by the effective shunt capacitance, C_o, of the winding and the terminals. When the frequency, f, is well below the resonance frequency, f_r, the fractional increase in inductance is approximately

$$\frac{\Delta L}{L_o} \simeq \omega^2 L_o C_o = \left(\frac{f}{f_r}\right)^2, \qquad (1)$$

where L_o is the zero-frequency inductance.

There is also a decrease in L with increasing frequency, produced by eddy currents in the winding and in ferromagnetic cores; this change can be kept relatively small by the use of stranded wire (Litzendraht) and of powdered core materials.

There is practically no change in inductance with current when the core is air, but ferromagnetic core materials have a permeability that changes with magnetizing force, and the change is usually appreciable. The curves shown on page 209 for the Type 940 Inductors are typical. The inductance increases linearly over a small region near zero current, then rises rapidly to a maximum followed by a sudden decrease as saturation is approached. To make these curves independent of the inductance magnitude, the current has been normalized to a value, I_1, which is that current which produces a specified fractional increase in inductance at a specified permeability.

Q Changes: The storage factor, $Q = \omega L/R$, of an inductor is simply proportional to frequency when L and R are constant. But, as noted above, L can vary with frequency, and the losses are also functions of frequency. The components of loss are best described in terms of dissipation factor, $D = 1/Q$, since the total D is the sum of the component D's and these can be plotted as straight lines in logarithmic co-ordinates, as shown in Figure 2.

$$D \simeq \frac{1}{1-\left(\frac{f}{f_r}\right)^2}\left[\frac{R_c}{\omega L_o} + G_e \omega L_o + \left(\frac{f}{f_r}\right)^2 D_o\right] \qquad (2)$$

Resonance Factor | Ohmic Loss, D_c | Eddy-Current Loss, D_e | Dielectric Loss, D_d

The higher permeability of an iron core makes possible lower values of D_c and D_e, while f_r is slightly reduced and D_o is not changed. The core adds three more components to the dissipation factor: one from eddy currents in the core, proportional to frequency, another from hysteresis loss in the core, independent of frequency, and a third from residual losses in the core, constant with frequency and relatively small. The effects of these losses are shown in the plots of Q versus frequency for Type 940 Decade Inductors.

Calibration: The calibrated inductance of a standard inductor is the change in the measured inductance of a circuit when a portion of that circuit is removed and replaced by the inductor. This measured inductance includes small and variable mutual inductances between the inductor and the rest of the circuit, which are negligible when the calibrated inductance is larger than, say, 100 microhenrys, but which can introduce accuracy-limiting uncertainties into the calibration of smaller inductances. These uncertainties can be reduced to less than one nanohenry to permit accurate calibrations down to one microhenry, if the mutual components are made a definite part of the calibrated inductance. One method of achieving this, used in the Type 1482 Standard Inductors of 200 microhenrys and less, is to provide, on the inductor, a switching link, which connects either the inductor coil or a short circuit through internal leads to the external connection terminals. The calibrated inductance, which is the measured difference at the connection terminals when the switch is moved from coil to short, is to a high degree independent of the external connections or environment.*

Since the inductance usually varies with frequency, an accurate calibration requires that the frequency be specified. When, as in inductors with iron cores, the inductance also varies with current, the calibration must also specify a corresponding current or voltage. Since the frequency or current at which the inductor will be used is not usually known, a convenient reference level is zero frequency and zero current (initial permeability). For example, each Type 940 Decade Inductor is measured at a frequency considerably lower than its resonance frequency, and the measured value is corrected for the increase of L with frequency to obtain the value as frequency approaches zero; measurements are made at two currents within the linear range (less than I_1), and the measured values are extrapolated to obtain the inductance at zero current and initial permeability of the core material.

The inductors described in this section are intended for use in standards and measurement laboratories. They include highly stable air-core reference standards, continuously variable (variometer) types, and decade assemblies of fixed-value units with ferromagnetic cores.

*John F. Hersh, "Connection Errors in Inductance Measurement," *General Radio Experimenter*, 34, 10, October, 1960.

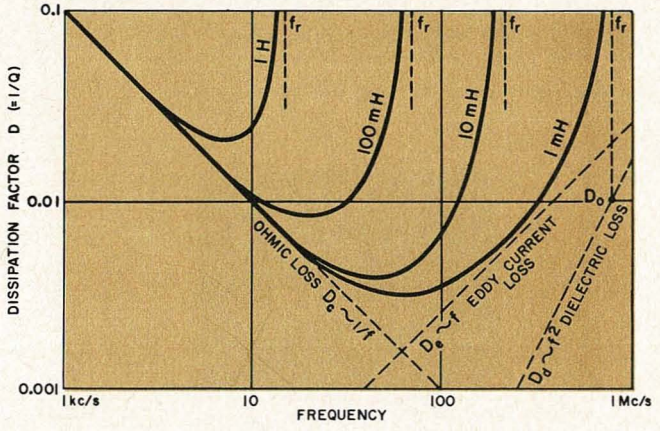


Figure 2. Dissipation-factor variation with frequency in typical air-core Type 1482 Standard Inductors.

Type 1482 STANDARD INDUCTOR

FEATURES:

Stable within ±0.01% per year. ■ Precisely adjusted and accurately calibrated. Inductance independent of voltage. Connection errors minimized. ■ Low external field. Low and known temperature coefficient. ■ Free from humidity errors.

USES: The TYPE 1482 Standard Inductor is an accurate, highly stable standard of self inductance for use as a low-frequency reference or working standard in the laboratory. Records extending over 11 years, and including inductors that traveled to national laboratories in several countries for calibration, show long-term stabilities well within ±0.01%.

DESCRIPTION: Each inductor is a uniformly wound toroid on a ceramic core. It has a negligible external magnetic field and hence essentially no pickup from external fields. The inductor is resiliently supported in a mixture of ground cork and silica gel, after which the whole assembly is cast with a potting compound into a cubical aluminum case.

Sizes of 500 μH and above have three terminals, two for the inductor leads and the third connected to the case, to provide either a two- or three-terminal standard. The 50-, 100-, and 200-μH sizes have three additional terminals for the switching used to minimize connection errors, as described on page 205.

For comparing other inductors with these standards, the TYPE 1632-A Inductance Bridge (page 68) is recommended.

SPECIFICATIONS

Inductance Range: See table.

Accuracy of Adjustment: See table.

Calibration: A certificate of calibration is provided with each unit, giving measured values of inductance at 100, 200, 400, and 1000 c/s, with temperature and method of measurement specified. These values are obtained by comparison, to a precision, typically, of better than ±0.005%, with working standards whose absolute values, determined and maintained in terms of reference standards periodically certified by the National Bureau of Standards, are known to an accuracy typically ±(0.02% + 0.1 μH) at 100 c/s.

Stability: Inductance change is less than ±0.01% per year.

Dc Resistance: See table for representative values. A measured value of resistance at a specified temperature is given on the certificate of calibration.

Low-Frequency Storage Factor Q: See table for representative values of Q at 100 c/s (essentially from dc resistance). An individual value of Q, calculated from the measured dc resistance, is given on each certificate of calibration.

Temperature Coefficient of Inductance: Approximately 30 ppm per °C. Minute temperature corrections may be computed from dc resistance changes. A 1% increase in resistance, produced by a temperature increase of 2.54°C, corresponds to 0.0076% increase in inductance.

Resonant Frequency: See table for representative values. A measured value is given on the certificate of calibration.

Maximum Input Power: For a rise of 20°C, 3 W; for precise work, a rise of 1.5°C, 200 mW. See table for corresponding current limits.

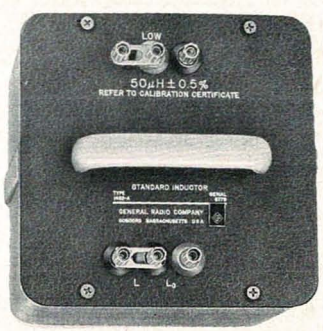
Terminals: Jack-top binding posts on ¾-in spacing with removable ground strap.

Cabinet: Aluminum lab-bench cabinet with carrying handle and rubber feet.

Dimensions: 6½ by 6½ by 8 in high (165, 165, 205 mm), over-all. **Net Weight:** 11½ lb (5.5 kg). **Shipping Weight:** 13 lb (6 kg).

Catalog Number	*Description*	*Nominal Inductance*	*Adjustment Accuracy (Percent)*	**Resonant Frequency (kc/s)*	**Dc Resistance (Ohms)*	**Q at 100 c/s*	*Milliamperes, rms for, 200 mW*	*3 W*	*Price*
1482-9701	**Type 1482-A Standard Inductor**	50 μH	±0.5	3100	0.039	0.81	2260	8770	**$125.00**
1482-9702	**Type 1482-B Standard Inductor**	100 μH	±0.25	2250	0.083	0.76	1550	6010	**125.00**
1482-9703	**Type 1482-C Standard Inductor**	200 μH	±0.25	1400	0.15	0.84	1150	4470	**125.00**
1482-9704	**Type 1482-D Standard Inductor**	500 μH	±0.1	960	0.38	0.83	725	2810	**125.00**
1482-9705	**Type 1482-E Standard Inductor**	1 mH	±0.1	800	0.84	0.75	490	1890	**110.00**
1482-9706	**Type 1482-F Standard Inductor**	2 mH	±0.1	580	1.52	0.83	360	1400	**110.00**
1482-9707	**Type 1482-G Standard Inductor**	5 mH	±0.1	320	3.8	0.83	230	890	**110.00**
1482-9708	**Type 1482-H Standard Inductor**	10 mH	±0.1	220	8.2	0.77	156	600	**110.00**
1482-9710	**Type 1482-J Standard Inductor**	20 mH	±0.1	145	14.5	0.87	117	450	**110.00**
1482-9711	**Type 1482-K Standard Inductor**	50 mH	±0.1	84	36.8	0.85	74	280	**110.00**
1482-9712	**Type 1482-L Standard Inductor**	100 mH	±0.1	71	81	0.78	50	192	**110.00**
1482-9713	**Type 1482-M Standard Inductor**	200 mH	±0.1	39.0	109	1.15	43	166	**110.00**
1482-9714	**Type 1482-N Standard Inductor**	500 mH	±0.1	24.5	280	1.12	27	103	**110.00**
1482-9716	**Type 1482-P Standard Inductor**	1 H	±0.1	14.6	616	1.02	18	70	**117.50**
1482-9717	**Type 1482-Q Standard Inductor**	2 H	±0.1	10.6	1125	1.12	13.3	52	**140.00**
1482-9718	**Type 1482-R Standard Inductor**	5 H	±0.1	6.8	2920	1.08	8.3	32	**170.00**
1482-9720	**Type 1482-T Standard Inductor**	10 H	±0.1	4.9	6400	0.98	5.6	22	**225.00**

* Representative values. Actual values given on certificate.



Type 1482-A

Type 1482-D

Type 107 VARIABLE INDUCTOR

FEATURES:

Continuous variation of inductance over a 20-to-1 range.
Separate terminals for rotor and stator permit either series or parallel connection.
Calibrated in mutual as well as self inductance.
Rotor and stator inductances are made closely equal, to minimize circulating currents in the parallel connection.

USES: The TYPE 107 Variable Inductors find their greatest uses in the laboratory as adjustable standards of moderate accuracy for measurements of self and mutual inductance, and as circuit elements in bridges, oscillators, and similar equipment.

DESCRIPTION: Rotor and stator coils are mounted concentrically. The effective inductance depends upon the position of the rotor with respect to the stator.

In most models stranded wire is used, in which the separate strands are insulated from one another. The coils are impregnated and baked in a synthetic varnish before being securely mounted on the phenolic panel.

Dial is direct reading in inductance for the series connection of the coils. Inductance for the parallel connection is one-fourth the value shown by the dial.

SPECIFICATIONS

Inductance Range: See table below. Dial is direct reading in inductance for the series connection.

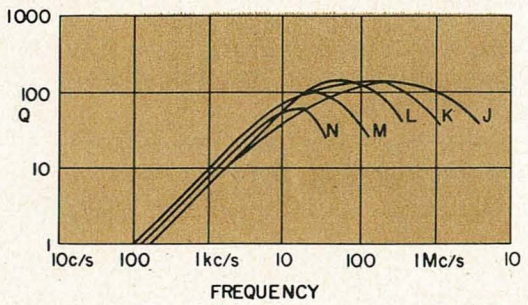
Accuracy: Series connection, ±1% of full scale at 1 kc/s. Inductance for parallel connection is one-fourth the series value within ±(1% + 0.01 μH) of the former. Mutual-inductance accuracy is ±2.5% of full-scale (mutual) value. The formula for mutual inductance is engraved on the nameplate. Under our standard warranty, this accuracy is guaranteed for 2 years if the inductor has not been damaged.

Frequency Characteristics: The fractional increase in inductance with frequency will be f^2/f_r^2 where f is the operating frequency and f_r the natural frequency, which can be calculated from $f_r = \frac{1}{2\pi\sqrt{LC_o}}$. Values of C_o are tabulated below. See plot for change in Q with frequency.

Maximum Power and Current: Current for 15 W maximum dissipation, corresponding to a temperature rise of 40°C, is given in the table below and is engraved on the nameplate.

Dc Resistance: See table below. These series-connection values are engraved on the nameplate. For parallel connections the resistance is closely ¼ the tabulated values.

Terminals: Standard ¾-in spacing, jack-top binding posts provide separate connections to rotor and stator. Series and parallel connections are made by means of links.



Storage factor, Q, versus frequency at full-scale series connection.

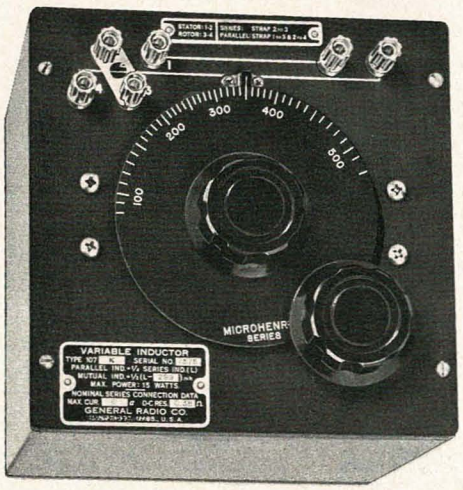
Cabinet: All units are mounted on phenolic panels and enclosed in unshielded hardwood cabinets.

Dimensions: 6½ by 6½ by 8¾ in high, over-all (165, 165, 220 mm).

Net Weight: 5 lb (2.3 kg), all ranges.

Shipping Weight: 10 lb (4.6 kg).

Catalog Number	*Description*	*Self-Inductance*		*Mutual Inductance*	*Typical C_o Values*		*Dc Resistance ohms*	*Maximum Current amperes*	*Price*
		Series	*Parallel*		*Series*	*Parallel*			
0107-9710	**Type 107-J Inductor**	9-50 μH	2.25-12.5 μH	0-10.8 μH	35 pF	57 pF	0.05	16	**$110.00**
0107-9711	**Type 107-K Inductor**	90-500 μH	22.5-125 μH	0-110 μH	40 pF	72 pF	0.38	6	**110.00**
0107-9712	**Type 107-L Inductor**	0.9-5 mH	0.225-1.25 mH	0-1.1 mH	39 pF	73 pF	5.0	1.7	**110.00**
0107-9713	**Type 107-M Inductor**	9-50 mH	2.25-12.5 mH	0-11 mH	34 pF	41 pF	36	0.65	**110.00**
0107-9714	**Type 107-N Inductor**	90-500 mH	22.5-125 mH	0-110 mH	34 pF	41 pF	450	0.17	**110.00**



Type 1490 DECADE INDUCTOR

Type 940 DECADE-INDUCTOR UNIT

FEATURES:

High values of storage factor Q, with maximum values above 200.
Toroidal construction minimizes external magnetic fields, so that the coils can be stacked without errors from mutual inductance. The toroids are nearly astatic to external magnetic fields.
Aluminum covers provide electrostatic shielding and mechanical protection.
Wax dipping protects against moisture.
The switch is inherently reliable in extensive use and should not require bothersome cleaning or adjustment in service.

USES: These inductance decades are convenient elements for use in wave filters, equalizers, and tuned circuits throughout the range of audio and low radio frequencies. As components in oscillators, analyzers, and similar equipment, they are especially useful during the preliminary design period, when the ability to vary circuit elements over relatively wide ranges is necessary to determine optimum operating values. As moderately precise standards of inductance they have values of low-frequency storage factor, Q, that are much larger than those of air-core coils.

DESCRIPTION: Each TYPE 940 Decade-Inductor Unit is an assembly of four inductors (relative values, 1, 2, 2, 5) wound on molybdenum-permalloy dust cores, which are combined by switching to give the eleven successive values from 0 to 10. The decade switch has high-quality ceramic stator-and-rotor members and utilizes a well-defined ball-and-socket detent. All contacts are made of a silver alloy and have a positive wiping action.

The TYPE 1490 Decade Inductor is an assembly of three or four TYPE 940 Decade-Inductor Units in a single metal cabinet. The units have no electrical connection to the panel, but a separate ground terminal is provided, which can be connected to the adjacent low terminal, leading to the smallest decade.

SPECIFICATIONS

Accuracy: Each unit is adjusted so that its inductance at zero frequency and initial permeability will be the nominal value within the accuracy tolerance given in the following table:

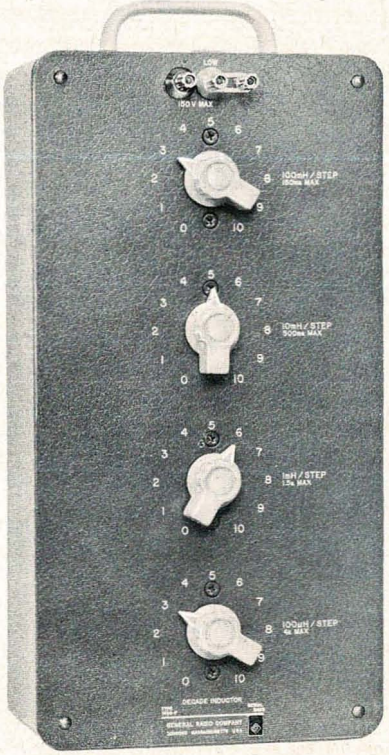
Inductance per step	100 μH	1 mH	10 mH	100 mH	1 H
Accuracy	±2%	±2%	±1%	±0.6%	±0.6%

Under our standard warranty, this accuracy is guaranteed for 2 years if the inductor has not been damaged.

Frequency Characteristics: For any specific operating frequency, Figure 2 shows the percentage increase in effective series inductance (above the value when $f = 0$), which is encountered with the extreme settings of each of the five decade-inductor units when the chassis is floating. Interpolation may be used for intermediate settings.

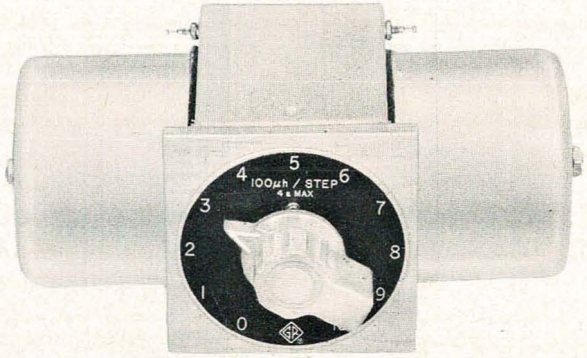
For the TYPE 1490 Decade Inductors, the percentage increase in effective series inductance (above the zero-frequency value, L_o) may be obtained by interpolation in Figure 3 for any setting of the highest-valued decade used, when the LOW terminal is ground to the cabinet.

Change in Inductance with Current: Fractional change in initial inductance with ac current for each type of toroid is shown in the normal curves, Figure 1, in terms of the ratio of the operating current, I, to I_1, the current for 0.25% change, solid line (0.1%, broken line). For ratios below unity, inductance change is directly proportional to current. Values of I_1, listed below, are approximate and are based on the largest inductor in the circuit for each setting.



Type 1490-F

Type 940-DD



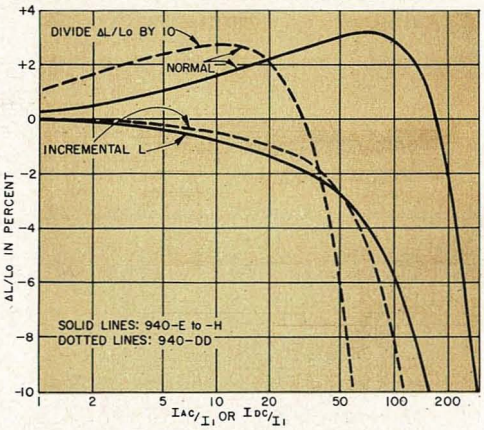


Figure 1. Percentage change in normal and incremental inductance with ac and bias current. Incremental curve is limited to an ac excitation less than I_1.

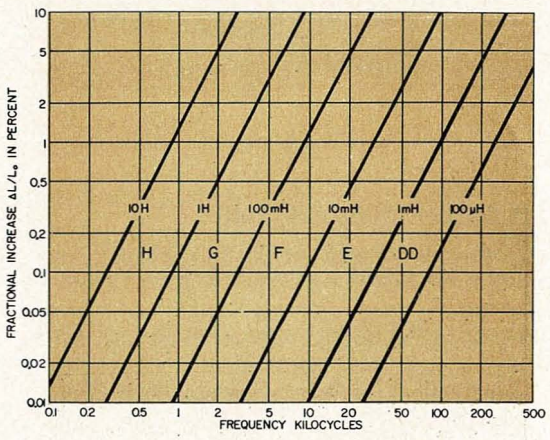


Figure 2. Change in effective inductance with frequency for the Type 940 Decade-Inductor Units.

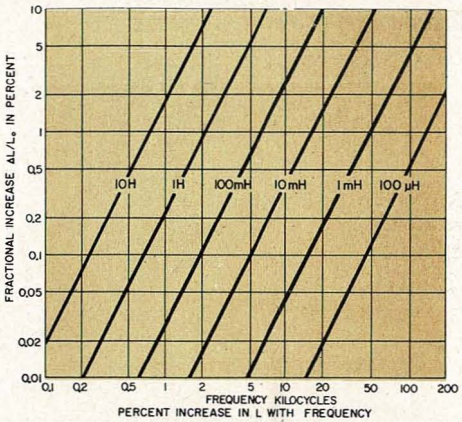


Figure 3. Variation of inductance with frequency, for the Type 1490 Decade Inductors.

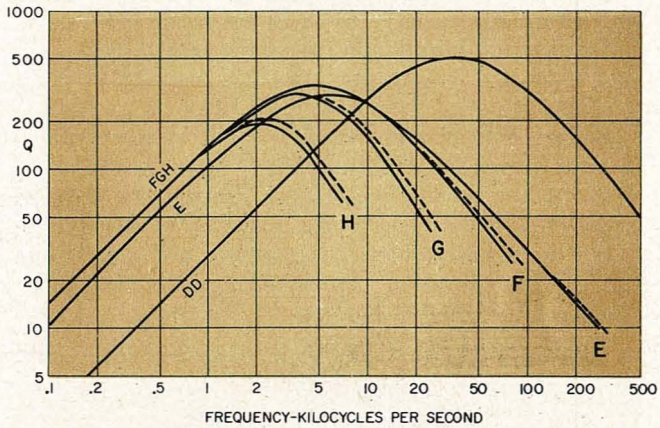


Figure 4. Variation of Q for the maximum inductance of each Type 940 Decade-Inductor Unit at low excitation levels. Dashed curves correspond to use with chassis floating.

Incremental Inductance: Dc bias current I_b will reduce the initial inductance as shown in the incremental curves, Figure 1.

Switch Setting	*RMS I_1 (mA)*				
	0.1% Increase	*0.25% Increase*			
	940-DD	*940-E*	*940-F*	*940-G*	*940-H*
1	141	17	5.4	1.7	0.54
2, 3 ,4	100	12	3.8	1.2	0.38
5, 6, 7, 8, 9, 10	63	8	2.4	0.8	0.24

Zero Inductance: Approximately 1 μH for the decade boxes.

Storage Factor, Q: See Figure 4.

Dc Resistance: Approximately 45 Ω per henry.

Temperature Coefficient: Approximately −25 ppm per degree C between 16° and 32°C.

Maximum Voltage: 500 V, rms. The switch will break the circuit at 500 V if turned rapidly to the new setting, but voltages above 150 may cause destructive arcing if the switch is set between detent positions.

Maximum Safe Current: Approx 200 times the pertinent I_1 value (30 times for the TYPE 940-DD). Maximum current engraved on dial.

Terminals: TYPE 1490, jack-top binding posts on standard ¾-in spacing; separate ground terminal provided. TYPE 940 Units have soldering lugs. Circuit insulated from chassis.

Mounting: TYPE 1490, lab-bench cabinet (see page 258); TYPE 940, complete with dial plate, knob, and mounting screws.

Dimensions: TYPE 940 — width 8, height 3½, depth 4¼ in (205, 90, 110 mm), over-all. TYPE 1490-C — width 8½, height 12¾, depth 5½ in (215, 325, 140 mm), over-all; TYPES 1490-D and -F — width 8½, height 16¾, depth 5½ in (215, 425, 140 mm), over-all.

Net Weight: TYPE 940 — 3½ lb (1.6 kg); TYPE 1490-C — 17 lb (8 kg); TYPES 1490-D and -F — 22 lb (10 kg).

Shipping Weight: TYPE 940 — 6 lb (2.8 kg); TYPE 1490-C — 24 lb (11 kg); TYPES 1490-D and -F — 29 lb (13.5 kg).

Catalog Number	*Description*	*Inductance*	*No. of Dials*	*Price*
0940-9810	**Type 940-DD Decade Inductor**	1 mH; in 100-μH steps		**$130.00**
0940-9705	**Type 940-E Decade Inductor**	0.01 H; in 0.001-H steps		**120.00**
0940-9706	**Type 940-F Decade Inductor**	0.1 H; in 0.01-H steps		**110.00**
0940-9707	**Type 940-G Decade Inductor**	1 H; in 0.1-H steps		**120.00**
0940-9708	**Type 940-H Decade Inductor**	10 H; in 1-H steps		**130.00**
1490-9703	**Type 1490-C Decade Inductor**	1.11 H, total; in steps of 0.001 H	3	**370.00**
1490-9704	**Type 1490-D Decade Inductor**	11.11 H, total; in steps of 0.001 H	4	**520.00**
1490-9706	**Type 1490-F Decade Inductor**	1.111 H, total; in steps of 100 μH	4	**520.00**

STROBOSCOPES

THE ELECTRONIC STROBOSCOPE

The electronic stroboscope is a bright-light source with an oscillator and triggering circuits that turn the light on and off at accurately known flashing rates. The flashing light of the stroboscope, when used to illuminate a cyclically moving object, can produce the optical illusion of stopping or slowing down the motion. Motion is "stopped" when the flashing rate of the stroboscope and the cyclic rate of the object being observed are the same; from this principle stems the stroboscope's well known value as a tachometer. Motion is "slowed" when the flashing rate is offset slightly from the cyclic rate of the object. The apparent slow motion, moreover, is an exact replica of the actual high-speed motion, and the stroboscope is thus an important tool in motion and fluid-flow analysis.

The short flash of a stroboscope offers the photographer a means of reducing exposure time to about a millionth of a second, and so the stroboscope has become standard equipment in the field of ultra-high-speed photography. This subject, of increasing interest to scientists and engineers as well as to photographers, is covered fully in the *Handbook of High-Speed Photography*, available free on request.

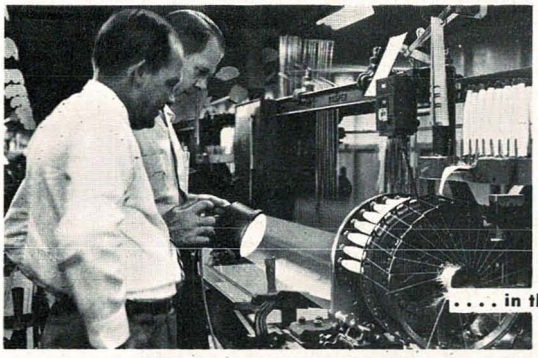
THE GENERAL RADIO LINE OF STROBOSCOPES

General Radio's stroboscopic instruments are the result of over 30 years of continuous development engineering in this area. A major step forward in this program was the development, a few years ago, of the Type 1531-A STROBOTAC® electronic stroboscope, which is much faster, much brighter, and yet smaller than earlier models. Thousands of these instruments are now in use in schoolrooms, research laboratories, printing plants, textile mills, chemical plants, and in virtually every type of manufacturing activity. The Type 1531-A remains an outstanding stroboscope at a low price.

Another milestone in stroboscopy is the announcement, in this catalog, of the Type 1538-A STROBOTAC® electronic stroboscope. With a flashing-rate range of up to 150,000 flashes per minute, the Type 1538-A will easily keep pace with the fastest machines known. With battery or ac-line operation, the new stroboscope goes wherever the action is. And with an accessory plug-in storage capacitor, this stroboscope can produce single, short flashes of light at an intensity of 44 million beam candles (at a distance of one meter). Any one of these features — speed, battery operation, intensity — alone would make the new STROBOTAC noteworthy. Together they put it in a class by itself.

Another new member of our line of stroboscopes is the Type 1539-A Stroboslave, a stroboscopic light source that requires external control of its flashing rate. The Stroboslave, whose light output is the same as that of the Type 1531-A STROBOTAC stroboscope, was designed specifically for the many applications where motion study or photog-

THE STROBOSCOPE AT WORK....

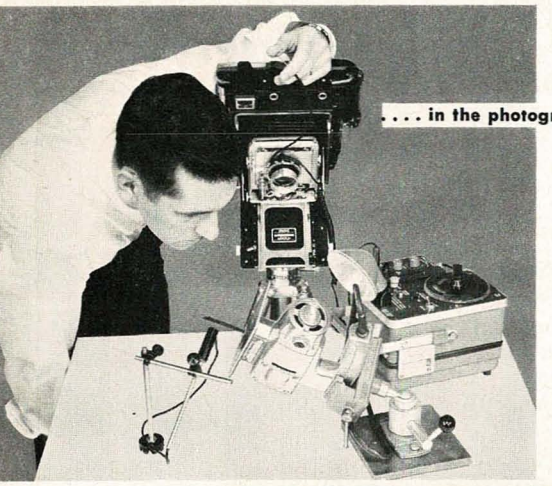


.... in the textile plant

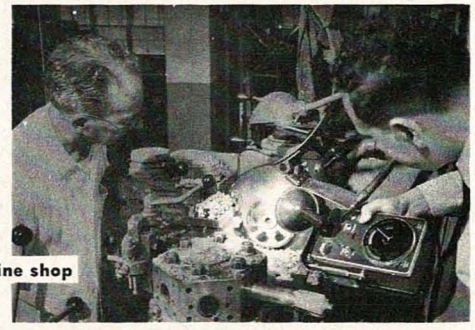
.... at the printing press

.... in the air-moving industry

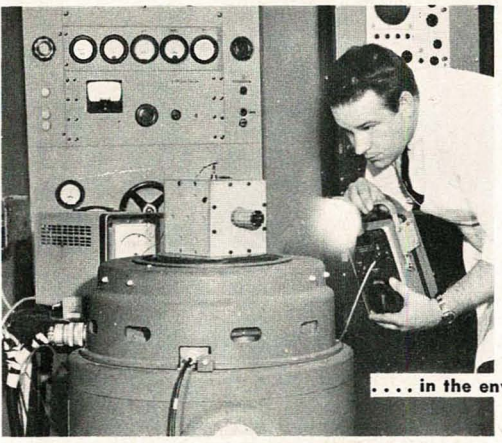
.... in the medical research lab



. . . . in the photographer's studio



. . . . in the machine shop



. . . . in the environmental test lab

. . . . in the classroom

raphy, rather than speed measurement, is required. Because of its compact size, it can easily be built into machines and systems requiring continuous stroboscopic light.

The Type 1532-D Strobolume is an excellent auxiliary source of flashes ten times as bright as those from the STROBOTAC. Like the Stroboslave, it requires external control of flashing rate.

STROBOSCOPE ACCESSORIES

The usefulness of a stroboscope can be multiplied many fold by a small additional investment in accessories. The Type 1536-A or Type 1537-A Photoelectric Pickoff, for example, can synchronize the stroboscope flash with almost any kind of motion, without physical connection to the object being observed. A mechanical contactor, the Type 1535-B, is also available. The addition of a Type 1531-P2 Flash Delay further extends the usefulness of the stroboscope by permitting observation of aperiodic repetitive motion at any point in its cycle. An inexpensive set of nylon disks (Type 1531-P3 Surface-Speed Wheel) converts linear speed (as, for instance, of belts, rollers, etc) into rpm for tachometric measurement with the stroboscope.

STROBOSCOPE APPLICATIONS

The applications for the stroboscope are beyond enumeration. Wherever motion is too fast for the human eye, there is a place for a stroboscope. Here are just a few of the ways in which stroboscopes are paying for themselves many times over:

Stroboscopes are widely used by educators to demonstrate certain laws of physics, such as the relation between frequency and wavelength, the finite velocity of light, the effects of combining colors, the properties of standing waves, the laws of gravity, the principle of stroboscopy itself, etc.

Stroboscopes are used to calibrate mechanical tachometers.

Stroboscopes are used in the development of loudspeakers and of other audio devices.

Stroboscopes are used to check registration on fast-moving printing presses.

Stroboscopes are used to measure the amount of slip between two shafts, between motor and belt, etc.

Stroboscopes are used throughout the textile industry to help design, monitor, and trouble-shoot looms, knitting machines, spinning frames, etc.

A stroboscope, combined with simple accessories, can be used to measure torque, belt tension, and horsepower.

Stroboscopes are used to study the effects of cavitation on turbine blades and on other hydraulic equipment.

Stroboscopes are used in high-speed motion-picture, as well as still, photography.

Stroboscopes are used in the design, production-line checkout, and servicing of electric motors, appliances, and virtually all kinds of production, handling, and packaging machinery.

Stroboscopes are used to help design and trouble-shoot data-processing equipment, such as sorters, punches, etc.

A stroboscope is a versatile instrument, made even more versatile by the ingenious user. Few industries can afford to be without it.

Type 1531-A STROBOTAC® ELECTRONIC STROBOSCOPE

FEATURES:

High-intensity flash — up to 18 million beam candles (peak) for a single flash.
High flashing rates up to 25,000 per minute — speed measurements to 250,000 rpm.
Short flash duration — "stops" rapid motion and permits ultra-high-speed photography.
High accuracy — rpm measurements can be made to ±1%.
Convenience — small Flip-Tilt case and swivel-mounted lamp.
Simplicity — dials are easy to set and easy to read.

USES: The STROBOTAC® electronic stroboscope is a small portable flashing-light source used to measure the speed of fast-moving devices or to produce the optical effect of stopping or slowing down high-speed motion for observation. A few of this instrument's many uses are:

- Observation and speed measurement of gears, cams, linkages, shuttles, spindles, motor rotors, and any other elements having repetitive motion.
- Observation of vibrating members, fuel-nozzle spray patterns, and vibrations of components under test in wind tunnels.
- High-speed photography of repetitive or non-repetitive motion (see photos on page 210).

DESCRIPTION: The STROBOTAC electronic stroboscope includes a strobotron lamp and reflector assembly, an electronic pulse generator that controls the flashing rate, and a line-operated power supply.

The flashing-rate range of 110 to 25,000 flashes per minute is divided into three direct-reading ranges; to avoid reading errors, only the particular range in use is illuminated. The rpm control is concentric with the range selector, and its large diameter provides precise control of the flashing rate. The flash lamp can be triggered externally to "stop" motion for photography. The combination of the TYPE 1531-P2 Flash Delay and the TYPE 1536-A Photoelectric Pickoff can be used as an external triggering source, which also provides an adjustable delay of the stroboscope flash with respect to the triggering pulse from the photoelectric pickoff. The TYPE 1535-B Contactor can also be used for triggering. These accessory instruments are described on page 216.

A built-in calibration system uses the power-line frequency for quick, easy check and readjustment of the flashing-rate calibration.

The strobotron flash lamp and reflector assembly pivots in a plane perpendicular to the panel and swivels 360 degrees on its own axis. The case is equipped with a ¼ x 20 socket for mounting the instrument on a tripod.

SPECIFICATIONS

Flashing-Rate Range: 110 to 25,000 flashes per minute in three direct-reading ranges: 110 to 690, 670 to 4170, and 4000 to 25,000. Speeds up to 250,000 rpm can be measured.

Accuracy: ±1% of dial reading after calibration on middle range.

Calibration: Two panel adjustments permit calibration against power-line frequency.

Flash Duration: Approximately 0.8, 1.2, and 3 μs for high-, medium-, and low-speed ranges, respectively, measured at ⅓ peak intensity.

Peak Light Intensity: Typical on high-, medium-, and low-speed ranges, respectively, 0.6, 3.5, and 11 million beam candles (6×10^5, 3.5×10^6, and 11×10^6 lux at 1 meter distance at the center of the beam); for single flash, 18 million beam candles (18×10^6 lux at 1 meter distance at the center of the beam).

Reflector Beam Angle: 10° at half-intensity points.

Output Trigger: 600- to 800-V negative pulse available at panel jack.

External Triggering: The flash can be triggered by the opening of a mechanical contactor or by a 6-V, peak-to-peak, signal (2-V, rms, sine-wave signal down to 5 c/s).

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s. Maximum power input is 35 W.

Accessories Supplied: Adjustable neck strap, plug to fit input and output jacks, spare fuses.

Accessories Available: TYPE 1531-P2 Flash Delay and TYPE 1536-A Photoelectric Pickoff (page 216), TYPE 1539-A Stroboslave with TYPE 1531-P4 Trigger Cable (page 214), and TYPE 1532-D Strobolume with TYPE 1532-P3 Trigger Cable (page 215).

Mechanical Data: Flip-Tilt Case (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
10⅝†	270	6⅝	170	6⅛	160	7¼	3.3	9	4.1

† Includes handle.

This instrument is listed by the CSA Testing Laboratories as approved.

See also *General Radio Experimenter*, September 1960.

Catalog No.	*Description*	*Price*
1531-9701	**Type 1531-A Strobotac® electronic stroboscope**	**$290.00**
1531-9601	**Type 1531-P1 Replacement Strobotron Lamp**	**15.00**

PATENT NOTICE. See Notes 6 and 22, page 11.

Type 1538-A STROBOTAC® ELECTRONIC STROBOSCOPE

FEATURES:

- High flashing rates — up to 150,000 flashes per minute, direct reading.
- Operates from either power line or rechargeable batteries.
- Accessory extension lamp operates up to 6 feet from STROBOTAC.
- Accessory energy-storage capacitor for very short single flashes.
- Can be externally triggered by a contact closure or by photoelectric pickoff.

USES: This newest addition to the GR line of stroboscopic equipment is a more versatile instrument than the TYPE 1531-A STROBOTAC® electronic stroboscope. In addition to providing a much higher maximum flashing rate, the TYPE 1538-A also incorporates many features and user conveniences. It can be operated from a power line, or, if there is no power outlet nearby, from the rechargeable battery pack. The accessory extension lamp is useful in illuminating hard-to-reach areas.

This new stroboscope is ideally suited for photographic applications requiring a high light intensity. With the TYPE 1538-P4 Energy-Storage Capacitor, it is possible to produce very short flashes of light of 44 million beam candles at one meter distance.

DESCRIPTION: The circuitry and mechanical design of the TYPE 1538-A STROBOTAC electronic stroboscope are similar to those used in the TYPE 1531-A. The flashing rate is controlled by an internal calibrated generator and is adjustable from 110 to 150,000 flashes per minute. This over-all range is divided into four direct-reading ranges on the large, illuminated range-control knob. To avoid reading errors, only the range in use is illuminated. A large-diameter flashing-rate control, concentric with the range knob, provides precise setting of the flashing rate.

The flash can be triggered externally by a simple contact closure across the input terminals, by a positive pulse, or by a sine wave. With a photoelectric pickoff (page 216), the flash can be triggered by pulses that are synchronized with a mechanical motion. The TYPE 1537-A Photoelectric Pickoff contains a light-activated switch, with no light source, which connects directly to the STROBOTAC. The TYPE 1536-A Photoelectric Pickoff contains a similar device but also includes a light source, for which power is supplied by the TYPE 1531-P2 Flash Delay (page 216). With this combination, an adjustable delay is introduced between the time a selected point on a moving object passes the pickoff and the time at which the STROBOTAC flashes. Three-way synchronization of the camera shutter, the mechanical motion, and the STROBOTAC firing is a very useful feature of this Pickoff/Flash Delay combination. Both the STROBOTAC and the TYPE 1538-P4 Energy-Storage Capacitor are equipped with sockets for attaching the two together and for tripod mounting.

SPECIFICATIONS

Flashing-Rate Range: 110 to 150,000 flashes per minute in four direct-reading ranges: 110 to 690, 670 to 4170, 4000 to 25,000, and 24,000 to 150,000 rpm. Speeds to 1 million rpm can be measured.

Accuracy: ±1% on all ranges after calibration on 670- to 4170-rpm range against 50- or 60-cycle line frequency.

Flash Duration: Approximately 0.5, 0.8, 1.2, and 3 μs for high-to-low speed ranges, respectively, measured at ⅓ peak intensity; for single flashes with TYPE 1538-P4 Energy-Storage Capacitor, 8 μs.

Peak Light Intensity: Typically 0.16, 1, 5, and 15 million beam candles (0.16, 1, 5, and 15 × 10^6 lux measured at 1 meter distance at the beam candle center) for high-to-low speed ranges, respectively; 44 million beam candles at 1 meter for single flash, with TYPE 1538-P4 Energy-Storage Capacitor.

Reflector Beam Angle: 10° at half intensity points.

Output Trigger: Greater than 7 V positive pulse behind 300 Ω.

External Triggering: Either a switch closure across the input jack terminals, a 1-V (peak) positive pulse, or a 0.35 V (rms) sine wave.

Power Required: 100 to 125 or 195 to 250 V, 50 to 400 c/s, 15 W (max) or 20 to 30 V dc, 12 W (max).

Accessories Supplied: Adjustable neck strap, phone plug for input and output jacks, spare fuses.

Accessories Available: TYPE 1538-P2 Extension Lamp, TYPE 1538-P3 Battery and Charger, TYPE 1538-P4 Energy-Storage Capacitor, TYPE 1531-P2 Flash Delay, TYPES 1536-A Photoelectric Pickoff (for use with Flash Delay), TYPE 1537-A Photoelectric Pickoff, and TYPE 1539-A Stroboslave.

Catalog No.	*Description*	*Price*
1538-9701	**Type 1538-A Strobotac® electronic stroboscope**	**$465.00**
1538-9601	**Type 1538-P1 Replacement Strobotron Lamp**	**15.00**
1538-9602	**Type 1538-P2 Extension Lamp**	**55.00**
1538-9603	**Type 1538-P3 Battery and Charger**	**225.00**
1538-9604	**Type 1538-P4 Energy-Storage Capacitor**	**75.00**

Mechanical Data: Flip-Tilt Case (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
10⅝†	270	6⅝	170	6⅛	160	7¼	3.3	10	4.6

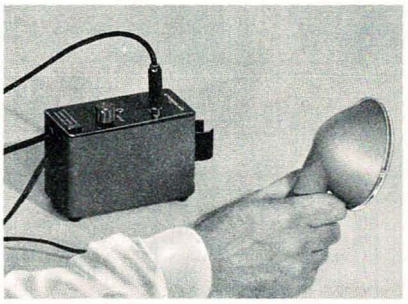
† Includes handle.

Type 1539-A STROBOSLAVE

FEATURES:

Low cost.
Small size and light weight.
Light source on flexible cable for convenient positioning.
Same light output as TYPE 1531-A STROBOTAC® electronic stroboscope.
Can be triggered by several methods.

USES: The TYPE 1539-A Stroboslave is a stroboscopic light source that satisfies the basic requirements for motion studies and high-speed photography. It is suitable for all stroboscope applications except tachometry. More than one Stroboslave can be used where there is a need for multiple light sources. When the reflector is removed from the end of the extension cord, the strobotron lamp assembly can be inserted through a hole as small as one inch, making it possible to observe objects in otherwise inaccessible areas.



Lamp, at end of five-foot cable, can be held in hand as shown here or attached to case as shown below, left.

DESCRIPTION: The Stroboslave is a miniature electronic stroboscope without an internal oscillator for setting the flashing rate; hence, its inability to function as a tachometer. It will operate directly from a switch closure, a TYPE 1537-A Photoelectric Pickoff, a TYPE 1531-P2 Flash Delay (with a TYPE 1536-A Photoelectric Pickoff), or an electrical positive pulse of at least 2 volts peak. In addition, it will operate directly from the output of the TYPE 1538-A STROBOTAC or from the TYPE 1531-A STROBOTAC through a TYPE 1531-P4 Trigger Cable.

The Stroboslave produces the same light output as the TYPE 1531-A STROBOTAC and operates over the same three basic ranges from 0 to 25,000 flashes per minute. The strobotron lamp and reflector are connected to the unit by a five-foot flexible cable so that the light can be positioned close to the subject to be observed.

SPECIFICATIONS

Flashing-Rate Ranges: 0 to 700, 0 to 4200, 0 to 25,000 flashes per min on high-, medium-, and low-intensity ranges, respectively.

Flash Duration: Approx 0.8, 1.2, and 3 μs, measured at ⅓ peak intensity, for the low-, medium-, and high-intensity ranges, respectively.

Peak Light Intensity: Typically 0.6, 3.5, and 11 million beam candles (0.6, 3.5, and 11 × 10^6 lux measured at 1-m distance at the beam center), for low-, medium-, and high-intensity ranges, respectively. For single flash, 18 million beam candles at 1 meter.

Reflector Beam Angle: 10° at half-intensity points.

External Triggering: Either a switch closure across the input jack terminals or a 2-V (peak) positive pulse.

Power Required: 100 to 125 or 195 to 250 V, 50 to 400 c/s, 16 W (max) at 115 V.

Accessories Supplied: Phone plug for input, mounting bracket.

Accessories Available: TYPE 1537-A Photoelectric Pickoff, TYPE 1531-P2 Flash Delay (with a TYPE 1536-A Photoelectric Pickoff), TYPE 1535-B Contactor. (See pages 216 and 217.)

Mechanical Data:

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
2½	64	8⅜	215	4⅛	105	2¾	1.3	8	3.7

Catalog No.	*Description*	*Price*
1539-9701	**Type 1539-A Stroboslave**	**$165.00**
1531-9604	**Type 1531-P4 Trigger Cable** (for use with Type 1531-A Strobotac)	**15.00**

NEW
in catalog S

Tripod socket is provided on Stroboslave case.

Type 1532-D STROBOLUME

FEATURES:

High-intensity short flash. ■ Wide beam angle.
Operates from TYPE 1531-A STROBOTAC® electronic stroboscope or TYPE 1535-B Contactor.
Compact, lightweight assembly.
Lamp assembly is removable, with 14-foot extension cable.
Lamp housing has socket with standard tripod thread.
Long-life sealed-beam lamp.

USES: The Strobolume produces a brilliant white light flash useful for studying motions of machines operating at relatively low speeds. At low flashing rates the Strobolume's light is of a higher intensity than that of the TYPE 1531-A STROBATAC electronic stroboscope.

The Strobolume can be triggered by a spring-loaded toggle switch on the control panel, by an external contactor such as the TYPE 1535-B, or by the electronic stroboscope. It is a useful light source for single- and multiple-flash photography, when the motion of the subject is too fast to be stopped by conventional strobe lights.

DESCRIPTION: The Strobolume consists of a high-voltage transformer and rectifiers, a capacitor that is charged to about 2500 volts from the rectifiers, and a lamp through which the capacitor is discharged to produce the flash. The discharge is initiated by a special strobotron tripped by an external impulse. Two ranges of intensity and flashing rate are provided.

SPECIFICATIONS

Flashing Speed Range:

High Intensity: Up to 60 flashes per minute continuous, up to 1200 per minute intermittent.

Low Intensity: Up to 3000 flashes per minute continuous.

Peak Light Intensity: 10 million beam candles (10^7 lux measured at 1 meter distance at the center of the beam) from single flash to 60 flashes per minute; 0.14 million beam candles (1.4×10^5 lux at 1 meter distance at the center of the beam) at 3000 flashes per minute.

Flash Duration: Approximately 30 μs at high intensity, 10 μs at low intensity.

Beam Width: 45° at half-intensity points.

Guide Number: The guide number (distance in feet times aperture) for high intensity is approximately 25 with film speed of 100 (ASA).

Flashing Control: TYPE 1535-B Contactor, or TYPE 1531-A STROBOTAC electronic stroboscope with TYPE 1532-P3 Trigger Cable.

Accessories Supplied: TYPE CAP-22 Power Cord, Contactor Cable Assembly, and plug for connection to contactor.

Accessories Required: None if lamp is to be flashed manually by pushbutton. For stroboscopic work a TYPE 1535-B Contactor, or a TYPE 1531-A STROBOTAC electronic stroboscope with TYPE 1532-P3 Trigger Cable, is needed. For use with older TYPE 631-BL STROBOTAC, a TYPE 1532-P2B Transformer Cable is required.

Cabinet: Metal case. Lamp assembly is removable. Storage space for lamp cable is provided in case. Lamp housing has ¼-20 threaded socket for tripod.

Power Required: 105 to 125 V, 50 to 60 c/s; 230-V model, TYPE 1532-DQ18, is available. Power consumption on high intensity is 105 W at 60 flashes per minute, 500 W at 1200 flashes per minute; at low intensity, 120 W at 3000 flashes per minute.

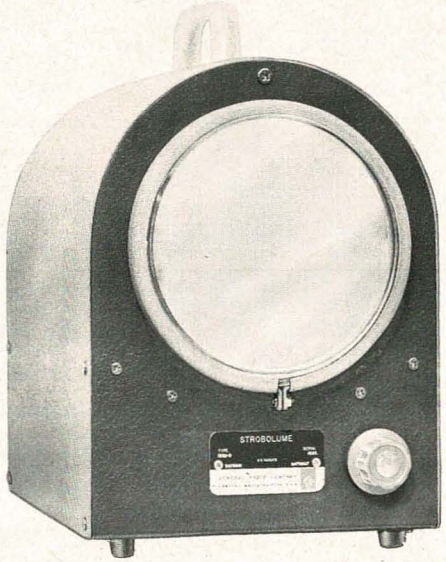
Mechanical Data:

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
7½	190	11½	295	13	330	18½	8.5	26	12

See also *General Radio Experimenter*, May 1949 and September 1960.

Catalog No.	*Description*	*Price*
1532-9704	**Type 1532-D Strobolume** (for 105-to-125-V supply)	**$375.00**
1532-9825	**Type 1532-DQ18 Strobolume** (for 210-to-250-V supply)	**on request**
1532-9601	**Type 1532-P1 Replacement Lamp**	**25.00**
1532-9941	**Type 1532-P2B Transformer Cable**	**17.00**
1532-9603	**Type 1532-P3 Trigger Cable**	**15.00**

PATENT NOTICE. See Note 6, page 11.

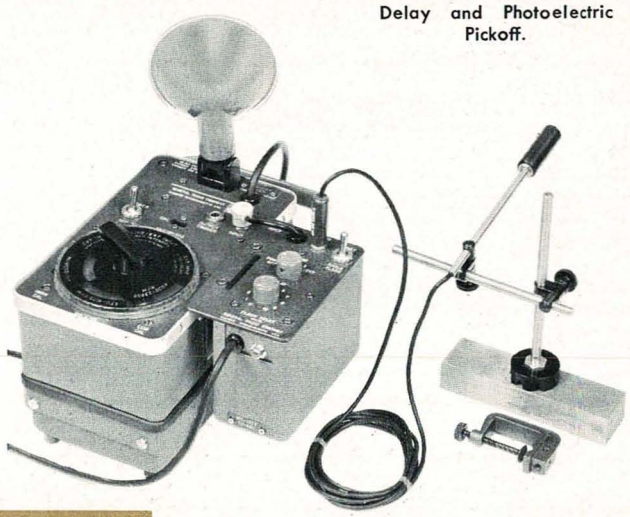


HIGH-INTENSITY STROBOSCOPE

Type 1531-P2 FLASH DELAY

USES: The combination of flash delay, photoelectric pickoff, and electronic stroboscope is used for visual analysis over a complete cycle of repetitive motion whose period is not constant. In addition, these instruments can be used to provide precise synchronization of camera shutter, stroboscopic flash, and subject for high-speed photographs previously almost impossible to take because of variations in subject speed.

DESCRIPTION: The TYPE 1531-P2 Flash Delay, when used with an external triggering device such as the TYPE 1536-A Photoelectric Pickoff, will provide a continuously adjustable time delay between the triggering pulse and the light flash. The external triggering device may be an oscillator, photocell, or other transducer. A jack is provided for camera shutter synchronization in single-flash photography.



Strobotac shown with Flash Delay and Photoelectric Pickoff.

SPECIFICATIONS

Time-Delay Range: Approximately 100 μs to 0.8 s in three ranges.
Output Pulse: Better than 13 V available for triggering the TYPES 1531-A and 1538-A STROBOTAC® electronic stroboscopes and the TYPE 1539-A Stroboslave.
Sensitivity: As little as 0.3-V input will produce sufficient output to trigger the stroboscope.
Inputs: Phone jack for triggering; jack for camera synchronization.
Accessories Available: TYPE 1536-A Photoelectric Pickoff.
Power Required: 105 to 125 or 210 to 250 V, 50 to 400 c/s, 5 W with TYPE 1536-A connected.
Mounting: Aluminum case with bracket, which clips directly onto the STROBOTAC electronic stroboscope.

Mechanical Data:

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
5⅛	135	3⅛	80	3¾	96	2	1	5	2.3

See also *General Radio Experimenter*, August 1963.

Catalog No.	*Description*	*Price*
1531-9602	**Type 1531-P2 Flash Delay**	**$175.00**

Type 1536-A PHOTOELECTRIC PICKOFF

- Small size.
- Maneuverable double-jointed linkage.
- Firm mounting with C-clamp or magnet.
- High pulse rate — speeds up to 150,000 rpm.

USES: The TYPE 1536-A Photoelectric Pickoff is powered by the TYPE 1531-P2 Flash Delay, the TYPE 1150-B Digital Frequency Meter, or the TYPE 1151-A Digital Time and Frequency Meter. It produces a voltage pulse whenever its photocell senses a difference in reflected light. If a piece of reflective tape is attached to a moving object, the pickoff will produce a positive pulse whenever the tape passes by the pickoff. When used in combination with the TYPE 1531-P2 Flash Delay and a STROBOTAC® electronic stroboscope or the Stroboslave, the photoelectric pickoff will flash the stroboscope in synchronism with a rotating object but at a time, determined by the flash-delay setting, after the synchronizing pulse from the photocell. This permits all phases of the motion to be studied. For photography, the camera shutter, the motion of the subject, and the STROBOTAC firing can all be synchronized.

For precise measurement of speed, the pulse from the photoelectric pickoff will operate the TYPES 1150-B and 1151-A Digital Frequency Meters. In combination with the TYPE 1531-P2 Flash Delay, the pickoff also permits continuous measurement or recording of speed with the TYPE 1142-A Frequency Meter and Discriminator.

DESCRIPTION: This photoelectric pickoff contains a light source, a concentrating lens, a photocell, an output cable, and an adjustable mounting system. Light from the internal lamp is reflected from a rotating object back to the photocell.

SPECIFICATIONS

Maximum Pulse Rate: Approximately 2500 pulses/s as limited by the 200-μs time constant of the photocell and cable combination.

Power Required: 20 to 28 V dc, 40 mA. Power is supplied by the TYPE 1531-P2 Flash Delay or the TYPE 1150-B (or TYPE 1151-A) Digital Frequency Meter.

Accessories Supplied: 10-ft roll of ⅜-in black tape; 10-ft roll of ⅜-in silver tape; carrying case.

Mounting: C-clamp (capacity 1 5/16 in, flat or round) or 1½-in magnet, both supplied.

Dimensions: Pickoff head, 1 1/16-in dia, 2 in long. Linkage consists of two 5/16-in diameter stainless-steel rods, 6 and 6¼ in long, and adjustable connecting clamp. Cable is 8 ft long, terminated in phone plug.
Net Weight: 1¼ lb (0.6 kg). **Shipping Weight:** 4 lb (1.9 kg).

See also *General Radio Experimenter*, October 1962.

Catalog No.	*Description*	*Price*
1536-9701	**Type 1536-A Photoelectric Pickoff**	**$75.00**

Type 1537-A PHOTOELECTRIC PICKOFF

The TYPE 1537-A Photoelectric Pickoff differs from the TYPE 1536-A in that no light source is included. The photosensitive element is a silicon light-activated switch. This pickoff will trigger directly the TYPE 1538-A STROBOTAC and the TYPE 1539-A Stroboslave.

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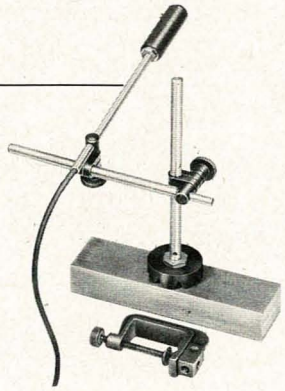
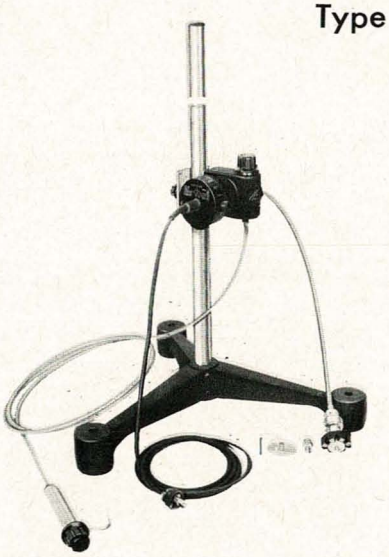


SPECIFICATIONS

Operating Rate: Greater than 2500 pulses/s.
Power Required: 3 to 25 V dc; 0 to 100 μA depending on operating rate. Power is supplied by instrument with which it is used.
Accessories Supplied: 10-ft roll of ⅜-in black tape, 10-ft roll of ⅜-in silver tape, carrying case.
Mounting: C-clamp (capacity 1 5/16 in, flat or round) or 1½-in magnet, both supplied.
Dimensions: Same as TYPE 1536-A Photoelectric Pickoff.
Net Weight: 1½ lb (0.7 kg). **Shipping Weight:** 4½ lb (2.1 kg).

Catalog No.	*Description*	*Price*
1537-9701	**Type 1537-A Photoelectric Pickoff**	**$55.00**

Type 1535-B CONTACTOR



- Easily attached to or removed from machine in motion.
- Mounted permanently on machine.
- Ball bearings are used on rotating parts.
- Flexible drive coupling shaft can be bent through 90° angle for work in crowded locations.

USES: The TYPE 1535-B Contactor permits synchronization of a stroboscope with a rotating shaft, so that motion can be observed as a function of shaft angle. With the aid of the contactor, the stroboscope can be used in the observation of machines with varying speed.

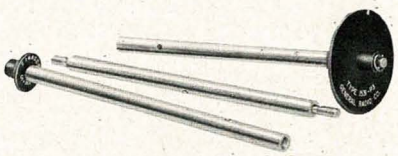
DESCRIPTION: The electrical contact system consists of a rotating cam and a low-inertia breaker arm. The phasing control permits adjustment of the contact position with respect to the rotating shaft. The coupling system uses a powerful magnet with a centering device to ensure positive drive from a centered steel or iron shaft. Auxiliary devices are supplied for permanent coupling or for use as nonmagnetic shafts.

SPECIFICATIONS

Speed Range: 0 to 1000 rpm.
Contacts per Revolution: One.
Range of Phase Adjustment: 360°; scale graduated in 5-degree intervals.
Range of Height Adjustment: 6 in to 4 ft.
Diameter of Base: 18 in.
Accessories Supplied: Hex wrench and auxiliary coupling devices.
Net Weight: 20 lb (9.5 kg). **Shipping Weight:** 28 lb (13 kg).

Catalog No.	*Description*	*Price*
1535-9702	**Type 1535-B Contactor**	**$185.00**

Type 1531-P3 SURFACE-SPEED WHEEL



USES: The TYPE 1531-P3 is used with the TYPES 1531-A and 1538-A STROBOTAC® electronic stroboscopes to make accurate measurements of the linear surface speed of belts, pulleys, wheels, drums, rollers, etc.

DESCRIPTION: Two black nylon wheels of different diameters are mounted on the ends of a sectioned steel rod. The selected wheel is held against the moving object and observed with the stroboscope to determine directly the surface speed.

SPECIFICATIONS

Speed Range: 10 to 2500 ft/min with small wheel and 50 to 12,500 ft/min with large wheel.
Dimensions: Wheels are 0.764 and 1.910 in dia, respectively. Three-section shaft totals 20 in in length.
Net Weight: 8 oz (0.3 kg). **Shipping Weight:** 2 lb (1 kg).

See also *General Radio Experimenter*, August 1963.

Catalog No.	*Description*	*Price*
1531-9603	**Type 1531-P3 Surface-Speed Wheel**	**$15.00**

POWER SUPPLIES

Although most General Radio instruments have their own self-contained power supplies, some have been designed for use with separate power supplies for versatility and economy. These power supplies are described in this section.

GENERAL PURPOSE: The Type 1205-B Adjustable Regulated Power Supply is a general-purpose instrument with a regulated output adjustable from 0 to 300 volts at a maximum current of 200 milliamperes.

FOR UNIT INSTRUMENTS: The general-purpose Type 1203 Unit Power Supply or the Type 1201 Unit Regulated Power Supply can be used with any of the Unit Instruments and are recommended for the rectangular-case Unit Instruments, Type 1206-B Unit Amplifier, Type 1210-C Unit R-C Oscillator, Type 1212-A Unit Null Detector, Type 1217-C Unit Pulse Generator, and Type 1220-A Unit Klystron Oscillator.

FOR HIGH-FREQUENCY OSCILLATORS: With the rf, vhf, and uhf oscillators described on pages 129 to 146 one of the following four power supplies is recommended:

Type 1263-B Amplitude Regulating Power Supply for CW or 1-kc square-wave modulated output at a fixed level adjustable between 0.1 and 2.0 volts behind 50 ohms.

Type 1264-A Modulating Power Supply for CW, 1-kc square-wave modulated, or pulse-modulated output adjustable over a wide range.

Type 1267-A Regulated Power Supply for CW operation with highest stability.

Type 1269-A Power Supply for CW operation with highest output at low cost.

FOR THE TYPE 1633-A INCREMENTAL-INDUCTANCE BRIDGE: The Type 1265-A Adjustable DC Power Supply and the Type 1266-A Adjustable AC Power Supply have been designed primarily for use with the Type 1633-A Incremental-Inductance Bridge.

Type 1205-B ADJUSTABLE REGULATED POWER SUPPLY

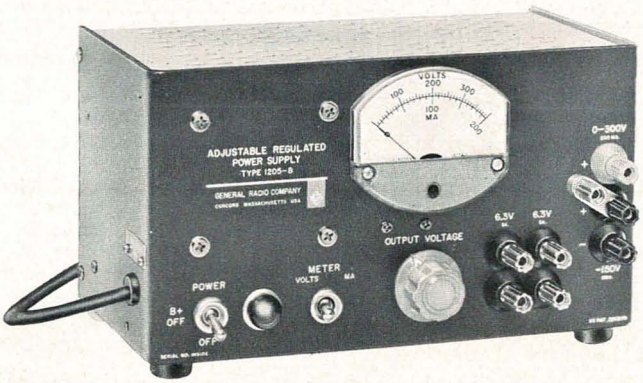
GENERAL-PURPOSE POWER SUPPLY

FEATURES:

- Adjustable output voltage from 0 to 300 volts dc.
- Excellent regulation down to zero output.
- Low hum level.
- Small size — over-all volume is less than ¼ cubic foot.
- High power output — 120 watts.

DESCRIPTION: The Type 1205-B Adjustable Regulated Power Supply combines the features of a fast-acting series regulator, which provides a low output impedance over a wide bandwidth, and a high-efficiency controlled rectifier, which limits the range of voltage drop across the regulator. Thus the regulator always operates at the optimum point, and the power dissipation is held to a minimum value for all output and line voltage values.

In addition to the 0- to 300-volt regulated dc output, the instrument provides a −150-volt regulated dc bias voltage and two unregulated ac outputs.



The output voltages are available at panel binding posts and at a multipoint connector in the side of the cabinet. Both the dc output voltage and the output current are indicated on a panel meter.

SPECIFICATIONS

Dc Output

Voltage: 0 to 300 V continuously adjustable, at 200 mA max.

Regulation: No load to full load, 0.1 V; ±0.75-V change for ±10% change in line voltage.

Bias Output

Voltage: −150 V dc fixed, at 5 mA max.

Regulation: No load to full load, 0.5 V; 2-V max change for ±10% change in line voltage.

Unregulated Ac Voltage: 2 circuits, each 6.3 V nominal, at 5 A, can be connected in series or parallel.

Meter Accuracy: Voltage, 2%; current, 5%.

120-cycle Ripple: Less than 1 mV.

Internal Impedance: Approximately 0.3 Ω + 2 μH shunted by 4 μF.

Power Required: 105 to 125 V, 60 c/s; 250 W at full load.

Accessories Supplied: Adaptor plug, spare fuses.

Mechanical Data: Unit-Instrument Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
9½	245	5¼	135	8¼	210	15	7	26	12

Catalog No.	*Description*	*Price*
1205-9702	**Type 1205-B Adjustable Regulated Power Supply**	**$365.00**
0480-9985	**Type 480-P4U2 Relay-Rack Adaptor Panel**	**11.00**

PATENT NOTICE. See Notes 15 and 21, page 11.

POWER SUPPLIES

TYPE 1203 UNIT POWER SUPPLY

Type 1201 UNIT REGULATED POWER SUPPLY

These two supplies have been designed to provide plate and heater power for Unit Instruments. The TYPE 1203 is a general-purpose, unregulated, 300-volt dc and 6.3-volt ac supply, while the TYPE 1201 has a regulated plate voltage supply to minimize the effects of line-voltage fluctuations on oscillator amplitude and frequency, amplifier hum level, or pulse-generator jitter. Both supplies are primarily for bench use but can be rack-mounted with other Unit Instruments.

Type 1269-A POWER SUPPLY

Type 1267 REGULATED POWER SUPPLY

These two supplies have been designed primarily for use with the Unit RF Oscillators where the power supply and the oscillator are to be bolted together or mounted in a relay rack. The TYPE 1269-A is a general-purpose, unregulated 300-volt dc and 6.3-volt ac supply. In the TYPE 1267, both heater and plate supplies are regulated to provide complete freedom from line-voltage variations and minimum residual modulation and frequency drift.

SPECIFICATIONS

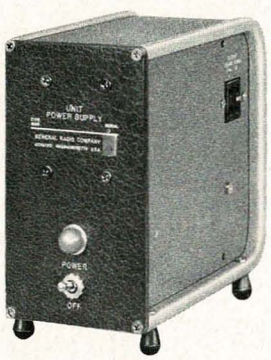
		TYPE 1203-B	TYPE 1203-BQ18	TYPE 1201-C	TYPE 1201-CQ18
Output	*Dc*	At nominal input line voltage, 300 V ± 5% at 50 mA; approx 410 V at no load; 50 mA, max.		300 V, regulated to ±0.25% for line and load changes; 70 mA, max.	
	Ripple	Less than 80 mV, rms, at full load		Less than 1 mV, rms, at full load	
	Low Voltage	6.3 V ac, unregulated, at 3 A		6.3 V ac, unregulated; 4 A max	
Input	*V*	105 to 125	195 to 235 or 210 to 250	105 to 125	195 to 235 or 210 to 250
	c/s	50 to 60 or 400*		50 to 60 or 400*	
	W	50		90	
Connectors		Permanently attached 3-wire line cord, 4-terminal output socket			
Accessories Supplied		Mating plug for output, spare fuses			
Unit-Instrument Cabinet (see page 258)	*Dimensions*	Width 5, height 5¾, depth 6¼ inches (130, 150, 160 mm), over-all			
	Weight	Net, 5 lb (2.3 kg); shipping, 6 lb (2.8 kg)		Net, 6 lb (2.8 kg); shipping, 7 lb (3.2 kg)	
Catalog Number		1203-9702	1203-9818	1201-9703	1201-9824
Price		**$55.00**	**on request**	**$95.00**	**on request**

		TYPE 1269-A	TYPE 1267-A	TYPE 1267-AQ18
Output	*Dc*	At nominal input line voltage, 300 V ± 5% at 50 mA; approx 410 V at no load; 50 mA, max.	300 V, 70 mA max; can be disconnected by standby switch. Regulation, ±0.25% for line and load changes.	
	Ripple	Less than 80 mV, rms, at full load	Less than 1 mV, rms, at full load	
	Low Voltage	6.3 V ac, unregulated, at 3 A	6.3 V dc at 1 A; regulation, ±0.25% for line voltage changes. Output resistance 35 mΩ, approx.	
Input	*V*	105 to 125, 195 to 235, or 210 to 250	105 to 125	195 to 235 or 210 to 250
	c/s	50 to 60 or 400*	50 to 60 or 400*	
	W	50	90	
Connectors		Permanently attached 3-wire line cord, 4-terminal output socket	4-terminal output socket	
Accessories Supplied		Mating plug for output, spare fuses	3-wire line cord, mating plug for output, spare fuses	
Convertible-Bench Cabinet (see page 258)	*Dimensions*	Width 4¼, height 7⅝, depth 9¼ (110, 195, 235 mm), over-all		
	Weight	Net, 5¾ lb (2.7 kg); shipping, 8 lb (3.7 kg)	Net, 7¾ lb (3.6 kg); shipping, 10 lb (4.6 kg)	
Catalog Number		1269-9701	1267-9701	1267-9911
Price		**$75.00**	**$170.00**	**on request**

* At 400 c/s, minimum input line-voltage requirements are increased 5%.

TYPE 1203-B

TYPE 1201-C



TYPE 1269-A

TYPE 1267-A

Type 1263-B AMPLITUDE-REGULATING POWER SUPPLY

FOR USE WITH GR HIGH-FREQUENCY OSCILLATORS

FEATURES:
- Levels oscillator output within 0.5 dB.
- Provides internal 1-kc square-wave modulation.
- Meter indicates rms oscillator output voltage.

USES: The TYPE 1263-B Amplitude-Regulating Power Supply automatically maintains the output of General Radio vhf and uhf oscillators (page 139) at a preset value in spite of incidental amplitude variations that may occur both with supply-voltage variations and with changes in oscillator frequency.

Its very-high-speed response is particularly useful when the oscillator dial is mechanically driven by a TYPE 1750-A Sweep Drive.

This power supply will modulate a Unit Oscillator with 1-kc square waves, thus eliminating incidental frequency modulation and permitting the use of an untuned detector with a sensitive audio amplifier. Regulation of average output level is maintained in this mode of operation so that swept measurements at very low rf detector levels can be made.

DESCRIPTION: The dc potential developed by the oscillator output rectifier (TYPE 874-VRL) is compared with an adjustable dc reference in a feedback system. A rapid correction is applied to the plate current to hold the oscillator output to a preset level. Rf blanking can be accomplished by external shorting of the reference potential.

For 1-kc modulation, the voltage regulated is the average value of the square-wave envelope. An external synchronous detector can be gated from a voltage provided, to maintain a high signal-to-noise ratio in low-level measurements.

SPECIFICATIONS

Rf Output Voltage: 0.2 to 2.0 V behind 50 Ω for any recommended oscillator (see below). With 1-kc square-wave modulation, 0.2 to 1.0 V (average value of rms carrier level) behind 50 Ω.

Rf Output Regulation: Below 500 Mc/s, rf output of recommended Unit Oscillators is held to within ±5% including the effects of harmonics. This regulation can be attained up to 2000 Mc/s if proper low-pass rf filters (see page 87) are used and a correction applied for the rectifier frequency characteristic.

Modulation:

Frequency: 1-kc square-wave, adjustable ±5%, stable within 5 c/s over the rated range of line voltage.

Duty Ratio: 0.5 to 0.53, adjustable to compensate for oscillator-starting delay.

Rise and Decay Times: 50 μs each.

Overshoot: None. **Ramp-off:** Less than 0.5%.

Gate Voltage: Synchronized with "off" interval of modulation, exceeds 1 V into the recommended load of 30 kΩ shunted by 300 pF. Rise and decay times are less than 50 μs. Gate output during "on" interval of modulation is less than 0.01 V.

Plate Supply Output: 0 to 300 V at 30 mA.

Heater Supply Output: 6 V ±10% at 0.5 A, 5.4 V ±10% at 0.7 A.

Response Time: For a 2-to-1 step variation in oscillator output, correction is completed within 0.5 ms with cw operation, 50 ms with 1-kc modulation. Recovery time after blanking is less than 2 ms with cw operation, 200 ms with 1-kc square-wave modulation.

Hum and Noise: Peak residual hum and noise modulation, less than ±0.3% on cw, ±3% with 1-kc square-wave modulation.

Output Voltmeter: With 1-kc square-wave modulation, meter reads average value of rms carrier level. Internal standardizing circuit is provided. Accuracy after standardization is better than ±10% of indication when a correction is applied for rectifier characteristic at extremely high frequencies.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 55 W.

Accessories Supplied: TYPE 874-VRL Voltmeter Rectifier, TYPE 874-R22LA Patch Cord for connecting output rectifier, and TYPE CAP-22 Power Cord, connector cable for modulation jack on oscillator, spare fuses.

Accessories Required: TYPE 874-T Tee for monitoring oscilloscope connection in sweeping applications.

Recommended Oscillators (page 140): TYPE 1215-C (50 to 250 Mc/s), TYPE 1209-CL (180 to 600 Mc/s), TYPE 1209-C (250 to 920 Mc/s), TYPE 1361-A (450 to 1050 Mc/s), TYPE 1218-B (900 to 2000 Mc/s); for cw operation only, TYPE 1211-C (0.5 to 50 Mc/s). See page 144 for complete oscillator-power supply combinations.

Accessories Available: The TYPE 1750-A Sweep Drive (page 153) for automatic operation; coaxial accessories (pages 76 to 94). Panel adaptor plate sets for 19-in relay-rack mounting, panel height 7 in (see page 143).

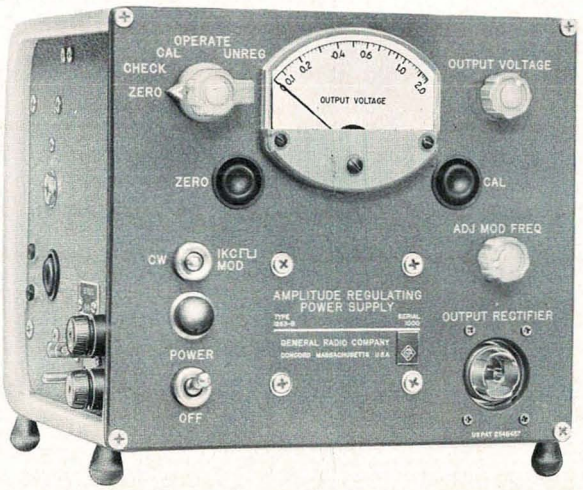
Mechanical Data: Convertible-Bench Cabinet (*see page 258*)

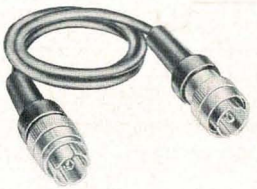
Width		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
8	205	7	180	9¼	235	14½	7	18	8.5

See also *General Radio Experimenter*, September 1961.

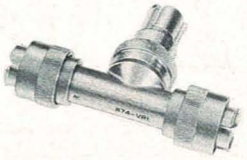
Catalog No.	*Description*	*Price*
1263-9702	**Type 1263-B Amplitude-Regulating Power Supply**	**$425.00**

PATENT NOTICE. See Notes 4 and 15, page 11.





Type 874-R22LA



Type 874-VRL

Rectifier and patch cord are included

Type 1264-A MODULATING POWER SUPPLY

FOR USE WITH GR HIGH-FREQUENCY OSCILLATORS

FEATURES:

Clean, stable, high-level output pulses. ■ Stable internal 1-kc square-wave generator.
Synchronization to wide range of input signals.
With an external pulse source, repetition rates from 20 c/s to 100 kc/s are available.
Adjustable well-regulated dc output for cw operation.
Standby switch position cuts off oscillator output while keeping heater on.

USES: The TYPE 1264-A Modulating Power Supply produces 100% pulse and square-wave modulation of vhf and uhf Unit Oscillators, TYPES 1361-A, 1209-C, 1209-CL, 1215-C, and 1218-B. In addition, it can be used as an adjustable regulated supply for the oscillator plate and as a source of unregulated heater power.

It is available in combination with the above oscillators, as listed on page 144.

DESCRIPTION: The TYPE 1264-A comprises an electronically regulated, adjustable-output, high-voltage, dc supply; a dc-coupled, series-type power modulator driven by a Schmitt trigger circuit; and a 1-kc multivibrator. A switch permits selection of cw, standby (only heaters energized), 1-kc square-wave modulated (internally generated), or externally modulated operation. Independent panel controls vary the regulated supply voltage for cw operation and the modulator amplitude for square-wave and pulse operation. Controls are also provided to adjust the frequency of the internal 1-kc multivibrator and the duty ratio to produce a true square wave.

The input trigger circuit accepts single or multiple positive pulses, which are reproduced at the modulator output. It also accepts square waves at rates up to 100 kc/s, or sine waves up to 50 kc/s, from any 20-volt source such as the TYPE 1217-C Unit Pulse Generator or the TYPE 1210-C Unit R-C Oscillator and produces square waves at the modulator output. No adjustment of triggering is necessary. The stable 1-kc multivibrator provides ideal square-wave modulation for use with sharply selective amplifiers following the signal detector.

SPECIFICATIONS

Regulated Dc Output (Unmodulated)

Output: Adjustable from 200 to 300 V; 50 mA, max.

Stability: Output voltage at any rated load will change less than 0.5 V for ±10% line-voltage change.

Ripple: Less than 1 mV, rms, with B− grounded; less than 5 mV, rms, with B+ grounded.

Heater Power Output (Unregulated): 6.3 V ac; 2.1 A, max.

Square-Wave Output (Internally Generated)

Amplitude: Adjustable from approximately 160 to 210 V.

Frequency: Adjustable from 850 to 1150 c/s.

Stability: Frequency will change less than 0.5% for ±10% line-voltage change.

Duty Ratio: 0.5, adjustable ±5%.

Square-Wave Output (from External Sine-Wave Generator)

Amplitude: Adjustable from approximately 160 to 210 V.

Driver Requirements: 20 to 50 V, rms, 20 to 50,000 c/s.

Pulse Output (Externally Generated)

Amplitude: Adjustable from approximately 160 to 210 V.

Duration (between half-amplitude points): 1.5 μs to square waves, duration determined by external generator.

Rise and Decay Times (between 10% and 90% of maximum amplitude): Less than 1.5 μs when driving a load capacitance of 300 pF in shunt with a resistance of 15,000 Ω or less.

Ramp-off: None.

Driver Requirements: +20 to +50 volts peak, positive polarity, 20 to 100,000 pulses per second.

Power Required: 105 to 125 or 210 to 250 V, 50 to 1000 c/s, 85 W.

Accessories Supplied: TYPE CAP-22 Power Cord, connector plug.

Recommended Oscillators: TYPE 1361-A (450 to 1050 Mc/s); TYPES 1215-C (50 to 250 Mc/s), 1209-C (250 to 920 Mc/s), 1209-CL (180 to 600 Mc/s), and 1218-B (900 to 2000 Mc/s) (pages 139 to 144). An adaptor cable (see below) is required for all except TYPES 1218-B and 1361-A.

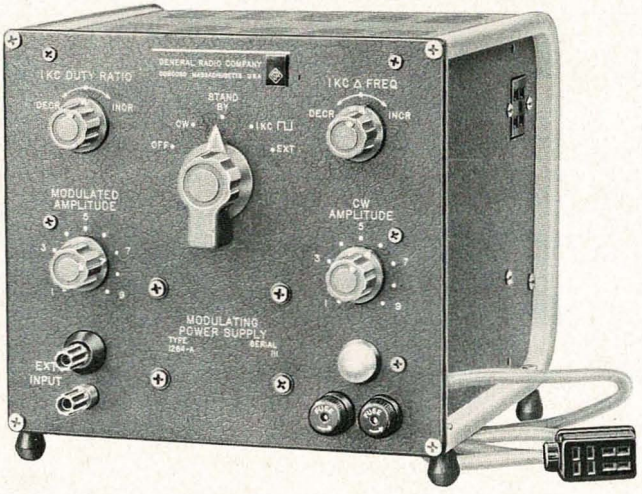
Accessories Available: TYPE 1264-P1 Adaptor Cable to connect to TYPES 1209-C, 1209-CL, and 1215-C Unit Oscillators. Panel-adaptor plate sets for 19-in relay-rack-mounting, panel height 7 in (see page 143).

Mechanical Data: Convertible-Bench Cabinet (*see page 258*)

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
8	205	7	180	9¼	235	12	5.5	15	7

See also *General Radio Experimenter*, March 1961.

Catalog No.	*Description*	*Price*
1264-9701	**Type 1264-A Modulating Power Supply**	**$285.00**
1264-9601	**Type 1264-P1 Adaptor Cable**	**15.00**



Type 1265-A ADJUSTABLE DC POWER SUPPLY

FEATURES: Continuously adjustable metered outputs up to 400 volts or 5 amperes.
Low-impedance output circuit will pass high ac current.
Current-regulated or voltage-regulated source.

USES: The TYPE 1265-A Adjustable DC Power Supply supplies dc bias for the TYPE 1633-A Incremental-Inductance Bridge. Its characteristics include wide ranges of current and voltage, a passive low-impedance output circuit that will pass high alternating currents, and a choice of voltage or current regulation.

DESCRIPTION: The instrument has four voltage ranges and four current ranges and will deliver its maximum rated power of 200 watts to 8, 80, or 800 ohms. Ranges are interconnected to prevent overloading. Damage from overloads is prevented by an electronic overload circuit.

The output voltage (or current) is sampled, amplified, and used to control the conduction angle of two power-transistor, controlled rectifiers. These rectifiers control the current into the output transformer whose several taps provide a choice of output voltages. The selected voltage is rectified and then filtered by passive components.

SPECIFICATIONS

Full-Scale Output Ranges: 12.5, 40, 125, 400 V, dc; 0.16, 0.5, 1.6, 5 A, dc; in any combination up to 200 W.

Meters: Voltage and current; ranges switch with output ranges.

Overload Protection: Overload circuit trips at approximately 1½ times full-scale current.

Regulation (Voltage or Current): 0.2% for 10% line-voltage change; 1% for 100% load change.

Speed of Response: Approximately 0.1 second.

Hum Level (rms): Approximately 70 dB below full-scale dc output (55 dB on 5-A ranges).

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 380 W at rated load. (Specify if for 50 c/s.)

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7½	190	17¼	440	70	32	124	57
Rack	19	485	7	180	15*	385	70	32	124	57

* Behind panel.

See also *General Radio Experimenter*, May 1962.

Catalog Number	*Description*	*Price*
1265-9801	**Type 1265-A Adjustable DC Power Supply,** Bench Model	**$1050.00**
1265-9811	**Type 1265-A Adjustable DC Power Supply,** Rack Model	**1050.00**

PATENT NOTICE. See Notes 1 and 15, page 11.

Type 1266-A ADJUSTABLE AC POWER SOURCE

FEATURES: Continuously adjustable metered output up to 1250 volts or 5 amperes.
Will tolerate dc current equivalent to maximum ac current in each range.

USES: The TYPE 1266-A Adjustable AC Power Source is compatible with the TYPE 1265-A Adjustable DC Power Supply to produce high-power composite waveforms for the TYPE 1633-A Incremental-Inductance Bridge.

DESCRIPTION: There are six voltage ranges and five current ranges. These are selected by rotary panel switches, which are mechanically interlocked to prevent any combination that might exceed the 200 voltampere capacity of the supply. Voltage, in each range, is continuously adjustable from zero to the maximum value selected, by means of a VARIAC® adjustable autotransformer. An automatic trip circuit, with manual reset, protects against unintentional overload.

SPECIFICATIONS

Frequency: Power-line frequency.

Full-Scale Output Ranges: 4, 12.5, 40, 125, 400, 1250 V, rms; 0.05, 0.16, 0.5, 1.6, 5 A; in any combination up to 200 VA. Dc currents up to the rated ac current may be superimposed on output from external source. Maximum voltage derated 20% at 50 c/s.

Meters: Voltage and current; ranges switch with output ranges.

Overload Protection: Overload circuit trips at approximately 1½ times full scale of current meters; can be reset by panel switch.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 230 VA.

Accessories Supplied: TYPE CAP-22 Power Cord and spare fuses.

Mechanical Data: Rack-Bench Cabinet (*see page 258*)

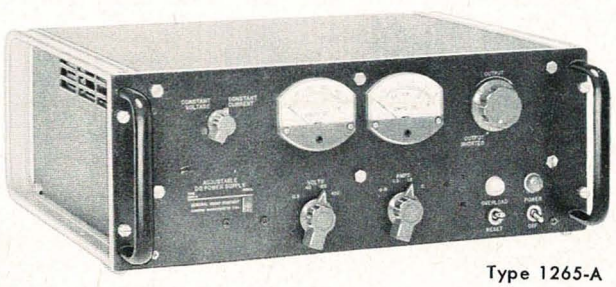
Model	*Width*		*Height*		*Depth*		*Net Wt*		*Ship Wt*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	7½	190	17¼	440	46	21	83	38
Rack	19	485	7	180	15*	385	46	21	83	38

* Behind panel.

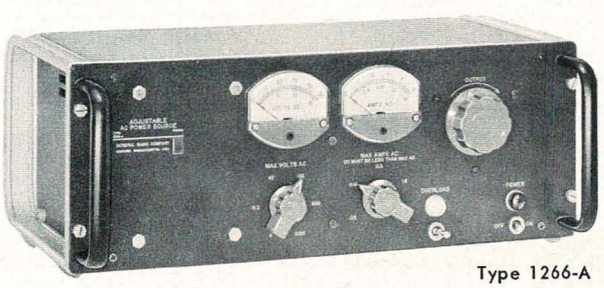
See also *General Radio Experimenter*, May 1962.

Catalog Number	*Description*	*Price*
1266-9801	**Type 1266-A Adjustable AC Power Supply,** Bench Model	**$360.00**
1266-9811	**Type 1266-A Adjustable AC Power Supply,** Rack Model	**360.00**

PATENT NOTICE. See Note 15, page 11.



Type 1265-A



Type 1266-A

VARIAC®
voltage regulators

General Radio Variac® automatic voltage regulators have many advantages for both laboratory and industrial use in any application where controlled line voltage is needed.

Variac regulators

Regulate to 0.25%.

Are not load sensitive; they work equally well on all loads from open circuit to maximum rating for continuous service.

Up to 10 times rating for transients.

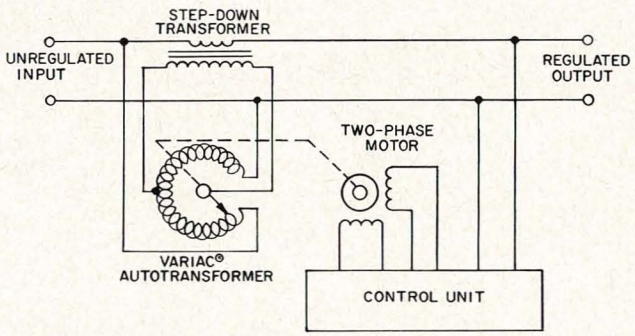
Introduce no distortion.

Have no power-factor restrictions.

Have high response speed — comparable with magnetic types.

Use all-solid-state control circuits.

Are available in many models, differing in power rating, correction range voltage, frequency, and packaging.



Elementary schematic diagram of General Radio's voltage regulators.

PRINCIPLE OF OPERATION

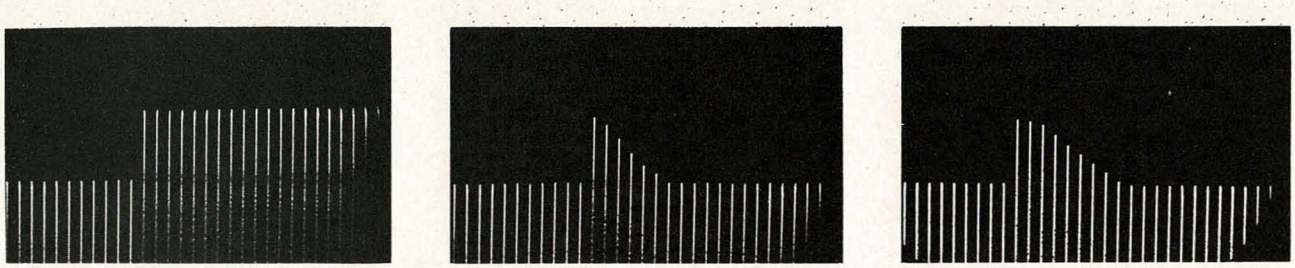
The regulator comprises a motor-driven Variac® adjustable autotransformer, an auxiliary step-down transformer, which multiplies the power rating of the autotransformer, and a solid-state control unit, which automatically positions the autotransformer to hold the output voltage constant.

The rms output voltage is converted to a dc signal, which is compared to a reference voltage. The resultant error signal controls a servo motor, providing a true proportional-control system, rather than an on-off circuit. The loop phase and amplitude characteristics are shaped to provide optimum closed-loop transient response. The accompanying oscillograms illustrate a typical response to a 2% step change in line voltage. The traces are greatly expanded and show only the ac voltage peaks.

The use of a true proportional control system provides not only fast correction but also smooth control of voltage, completely free of the voltage jumps introduced by the more usual on-off control system. The absence of relays provides long trouble-free life, and tolerance of 1000% transient overloads is made possible by the Duratrak® commutator surface of the Variac autotransformer, a General Radio development described on page 230.

Three basic models are available: Type 1571, a militarized version, and Types 1581 and 1582, which differ primarily in power rating, for general use. Ratings, closeness of regulation, correction range, and response speed are interdependent; ratings listed below are for 115-volt nominal input, 90 to 110% regulation range, and 0.25% regulation accuracy. For complete detailed listings, see the following pages.

Type	*Load Rating KVA*	*Line Frequency c/s*	*Page*
1581	**5.8**	**50 to 60, 400**	**224**
1582	**9.8**	**50 to 60, 400**	**224**
1571	**5.8**	**50 to 60, 400**	**226**



Oscillograms of line-voltage peaks show response speed of Variac® automatic voltage regulators: *left*, 2% step change in line voltage; *center* and *right*, resulting output transients for Type 1581 and Type 1582 Regulators, respectively.

Types 1581-A AND 1582-A VARIAC® AUTOMATIC VOLTAGE REGULATORS

FEATURES:

All-solid-state circuits.
High response speed comparable with magnetic regulators.
No distortion added.
High accuracy.
No power-factor restrictions.
Tolerates transient overloads up to ten times rated.
Large power-handling capacity.
Output voltage independent of load.

USES: The TYPES 1581-A and 1582-A VARIAC® automatic voltage regulators automatically compensate for ac line-voltage fluctuations to provide a reliable constant-voltage source over a specified correction range. These units combine high accuracy with large capacity, making them suitable for both laboratory use and industrial installations. Typical uses include the regulation of line voltage for computers, measurement systems, transmitter supplies, and carefully controlled industrial processes.

These regulators operate on the principle described on page 223. They are supplied in four different mounting styles: bench, rack, wall, or without case.

Power output of the standard models ranges from 2 to 20 kVA, depending upon the model selected. Several models are available in each of the 115-, 230-, and 460-volt classifications to accommodate a wide variety of requirements concerning output current, frequency, correction range, and mounting or cabinet arrangement.

Any of the 60-cycle models can be connected for 50- to 60-cycle operation by a connection change on the VARIAC autotransformer. This will affect the correction ranges, as indicated on the chart on page 225.

The TYPE 1571-A, military version of the TYPE 1581-A, is described on page 226. In addition to the standard and military models listed in this catalog, special models are available for other current ratings and correction ranges. Tell us your requirements.

SPECIFICATIONS

Frequency: 60-cycle models operate from 57 to 63 c/s but can be modified by a connection change to operate from 48 to 63 c/s (50 to 60, nominal); 400-cycle models operate from 350 to 450 c/s. **Response:** Rms. **Distortion:** None added. **Efficiency:** >98%.

Power Required: TYPE 1581-A — no load, 25 W; full load, 115 W. TYPE 1582-A — no load, 45 W; full load, 120 W.

Ambient Temperature: Operating, −20° to +52°C; in storage, −54° to 85°C.

Mechanical Data:

TYPE 1581

	Width		Height		Depth		Net Wt		Ship Wt	
	in	mm	in	mm	in	mm	lb	kg	lb	kg
Without case	19	485	7	180	10½	270	41½	19	92	42
Bench	19	485	7⅜	190	12	305	51	23.5	100	46
Rack	19	485	7	180	11¾*	300	51	23.5	100	46
Wall	19½	495	8⅛	210	11¼	290	54	24.5	104	48

* Behind panel.

TYPE 1582

	Width		Height		Depth		Net Wt		Ship Wt	
	in	mm	in	mm	in	mm	lb	kg	lb	kg
Without case	19	485	7	180	14¼	365	61	28	110	50
Bench	19	485	7⅜	190	16	410	71	33	121	55
Rack	19	485	7	180	15¾*	400	71	33	121	55
Wall	19½	495	8⅛	210	14¾	375	77	35	126	58

* Behind panel.

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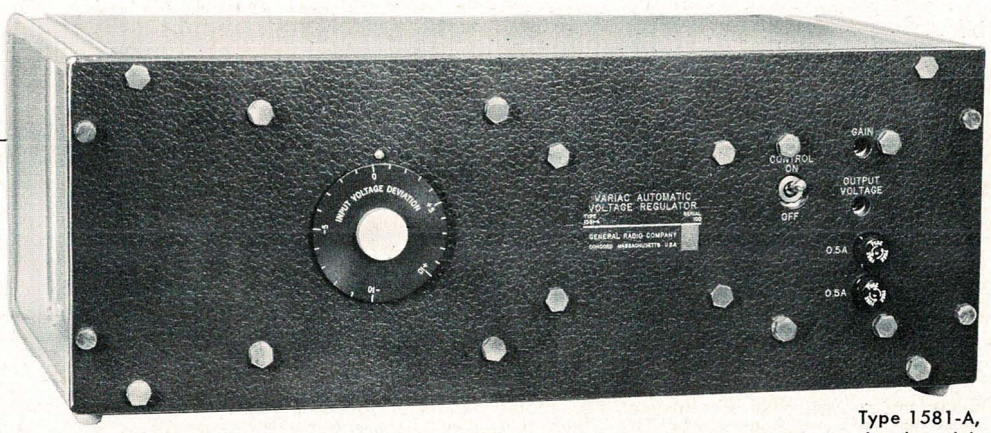
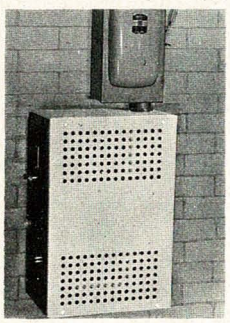


Type 1581-A, bench model

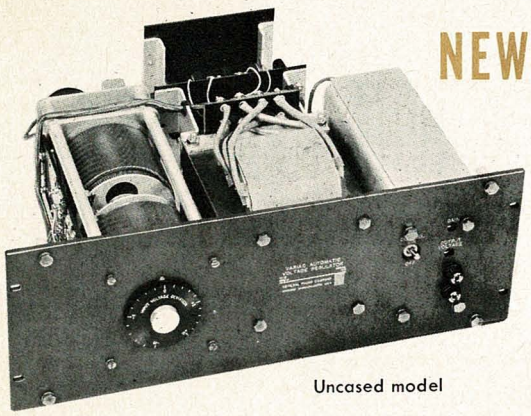
Output Voltage	Correction Range* %	Output Current (A)	KVA	Max Response Speed (V/s)	Accuracy (% of output V)	Mounting or Style	400 c/s Type Number	400 c/s Catalog Number	400 c/s Price	60 c/s* Type Number	60 c/s* Catalog Number	60 c/s* Price
115 V Adjustable ±10%	90 to 110	50	5.8	40	0.25	No cabinet	**1581-ALJ**	1581-9551	**$540.00**	**1581-AL**	1581-9831	**$495.00**
						Bench	**1581-ALMJ**	1581-9552	**575.00**	**1581-ALM**	1581-9964	**530.00**
						Rack	**1581-ALRJ**	1581-9554	**575.00**	**1581-ALR**	1581-9974	**530.00**
						Wall	**1581-ALWJ**	1581-9555	**560.00**	**1581-ALW**	1581-9980	**515.00**
		85	9.8	20	0.25	No Cabinet	**1582-ALJ**	1582-9551	**600.00**	**1582-AL**	1582-9831	**555.00**
						Bench	**1582-ALMJ**	1582-9552	**635.00**	**1582-ALM**	1582-9964	**590.00**
						Rack	**1582-ALRJ**	1582-9554	**635.00**	**1582-ALR**	1582-9974	**590.00**
						Wall	**1582-ALWJ**	1582-9555	**620.00**	**1582-ALW**	1582-9980	**575.00**
	82 to 124	25	2.9	80	0.5	No cabinet	**1581-AL2J**	1581-9556	**540.00**	**1581-AL2**	1581-9898	**495.00**
						Bench	**1581-ALM2J**	1581-9557	**575.00**	**1581-ALM2**	1581-9901	**530.00**
						Rack	**1581-ALR2J**	1581-9558	**575.00**	**1581-ALR2**	1581-9923	**530.00**
						Wall	**1581-ALW2J**	1581-9559	**560.00**	**1581-ALW2**	1581-9924	**515.00**
		42.5	4.9	40	0.5	No cabinet	**1582-AL2J**	1582-9556	**600.00**	**1582-AL2**	1582-9898	**555.00**
						Bench	**1582-ALM2J**	1582-9557	**635.00**	**1582-ALM2**	1582-9901	**590.00**
						Rack	**1582-ALR2J**	1582-9558	**635.00**	**1582-ALR2**	1582-9923	**590.00**
						Wall	**1582-ALW2J**	1582-9559	**620.00**	**1582-ALW2**	1582-9924	**575.00**
230 V Adjustable ±10%	95 to 105	40	9.2	40	0.25	No cabinet	**1581-AH5J**	1581-9530	**540.00**	**1581-AH5**	1581-9516	**495.00**
						Bench	**1581-AHM5J**	1581-9531	**575.00**	**1581-AHM5**	1581-9517	**530.00**
						Rack	**1581-AHR5J**	1581-9532	**575.00**	**1581-AHR5**	1581-9518	**530.00**
						Wall	**1581-AHW5J**	1581-9533	**560.00**	**1581-AHW5**	1581-9521	**515.00**
		85	19.7	20	0.25	No cabinet	**1582-AH5J**	1582-9530	**600.00**	**1582-AH5**	1582-9516	**555.00**
						Bench	**1582-AHM5J**	1582-9531	**635.00**	**1582-AHM5**	1582-9517	**590.00**
						Rack	**1582-AHR5J**	1582-9532	**635.00**	**1582-AHR5**	1582-9518	**590.00**
						Wall	**1582-AHW5J**	1582-9533	**620.00**	**1582-AHW5**	1582-9521	**575.00**
	90 to 110	20	4.6	80	0.25	No cabinet	**1581-AHJ**	1581-9522	**540.00**	**1581-AH**	1581-9817	**495.00**
						Bench	**1581-AHMJ**	1581-9523	**575.00**	**1581-AHM**	1581-9951	**530.00**
						Rack	**1581-AHRJ**	1581-9524	**575.00**	**1581-AHR**	1581-9961	**530.00**
						Wall	**1581-AHWJ**	1581-9525	**560.00**	**1581-AHW**	1581-9971	**515.00**
		42.5	9.8	40	0.25	No cabinet	**1582-AHJ**	1582-9522	**600.00**	**1582-AH**	1582-9817	**555.00**
						Bench	**1582-AHMJ**	1582-9523	**635.00**	**1582-AHM**	1582-9951	**590.00**
						Rack	**1582-AHRJ**	1582-9524	**635.00**	**1582-AHR**	1582-9961	**590.00**
						Wall	**1582-AHWJ**	1582-9525	**620.00**	**1582-AHW**	1582-9971	**575.00**
	82 to 124	10	2.3	160	0.5	No cabinet	**1581-AH2J**	1581-9526	**540.00**	**1581-AH2**	1581-9770	**495.00**
						Bench	**1581-AHM2J**	1581-9527	**575.00**	**1581-AHM2**	1581-9771	**530.00**
						Rack	**1581-AHR2J**	1581-9528	**575.00**	**1581-AHR2**	1581-9772	**530.00**
						Wall	**1581-AHW2J**	1581-9529	**560.00**	**1581-AHW2**	1581-9773	**515.00**
		21.3	4.9	80	0.5	No cabinet	**1582-AH2J**	1582-9526	**600.00**	**1582-AH2**	1582-9770	**555.00**
						Bench	**1582-AHM2J**	1582-9527	**635.00**	**1582-AHM2**	1582-9771	**590.00**
						Rack	**1582-AHR2J**	1582-9528	**635.00**	**1582-AHR2**	1582-9772	**590.00**
						Wall	**1582-AHW2J**	1582-9529	**620.00**	**1582-AHW2**	1582-9773	**575.00**
460 V Adjustable ±10%	95 to 105	34	15.6	40	0.25	No cabinet	**1582-AK5J**	1582-9546	**600.00**	**1582-AK5**	1582-9535	**555.00**
						Bench	**1582-AKM5J**	1582-9547	**635.00**	**1582-AKM5**	1582-9536	**590.00**
						Rack	**1582-AKR5J**	1582-9548	**635.00**	**1582-AKR5**	1582-9537	**590.00**
						Wall	**1582-AKW5J**	1582-9549	**620.00**	**1582-AKW5**	1582-9538	**575.00**
	90 to 110	17	7.8	80	0.25	No cabinet	**1582-AKJ**	1582-9541	**600.00**	**1582-AK**	1582-9819	**555.00**
						Bench	**1582-AKMJ**	1582-9542	**635.00**	**1582-AKM**	1582-9534	**590.00**
						Rack	**1582-AKRJ**	1582-9544	**635.00**	**1582-AKR**	1582-9426	**590.00**
						Wall	**1582-AKWJ**	1582-9545	**620.00**	**1582-AKW**	1582-9821	**575.00**
	82 to 124	8.5	3.9	160	0.5	No cabinet	**1582-AK2J**	1582-9395	**600.00**	**1582-AK2**	1582-9391	**555.00**
						Bench	**1582-AKM2J**	1582-9396	**635.00**	**1582-AKM2**	1582-9392	**590.00**
						Rack	**1582-AKR2J**	1582-9397	**635.00**	**1582-AKR2**	1582-9393	**590.00**
						Wall	**1582-AKW2J**	1582-9398	**620.00**	**1582-AKW2**	1582-9394	**575.00**

* Ranges listed are for 57- to 63-cycle operation; for 48- to 63-cycle operation, corresponding correction ranges are 95 to 105%, 91 to 109%, and 84 to 119%.



View of wall-mounted regulator. This model is used to regulate line voltages in the General Radio development and testing laboratories.

NEW



Type 1582-A
Available 4th quarter 1965

Uncased model

Type 1571-A VARIAC® AUTOMATIC VOLTAGE REGULATOR

FEATURES:

- Designed to MIL-E-4158B and MIL-E-16400C.
- All-solid-state control circuits.
- High response speed — comparable with that of magnetic regulators.
- No distortion added by regulator.
- High accuracy.
- No power-factor restrictions.
- Tolerates transient overloads up to 10 times rating.
- High power-handling capacity.
- Output voltage independent of load.

The TYPE 1571-A VARIAC® automatic voltage regulator is a militarized version of the TYPE 1581-A described on pages 224 and 225. It is designed to meet the requirements of military specifications MIL-E-4158B and MIL-E-16400C. These models are particularly useful where mechanical shock or vibration is encountered. Models are available for use on both 115- and 230-volt ac lines, 400 c/s or 60 c/s (50 to 60 c/s by a change in connection on the autotransformer), and with various output currents and correction ranges. All units are designed for relay-rack mounting.

SPECIFICATIONS

Output Voltage: Adjustable over a range of ±10% from a base value of 115 V (for TYPE 1571-AL) or 230 V (for TYPE 1571-AH), set by a front-panel screwdriver adjustment.

Frequency: 60-cycle models operate from 57 to 63 c/s but can be modified by connection change to operate from 48 to 63 c/s; 400-cycle models operate from 350 to 450 c/s.

Power Required: No load, 25 W; full load, 115 W.

Ambient Temperature: Operating, −29° to +52°C; in storage, −54° to 85°C.

Mechanical Data:

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
19	485	7	180	12*	305	52½	24.5	103	47

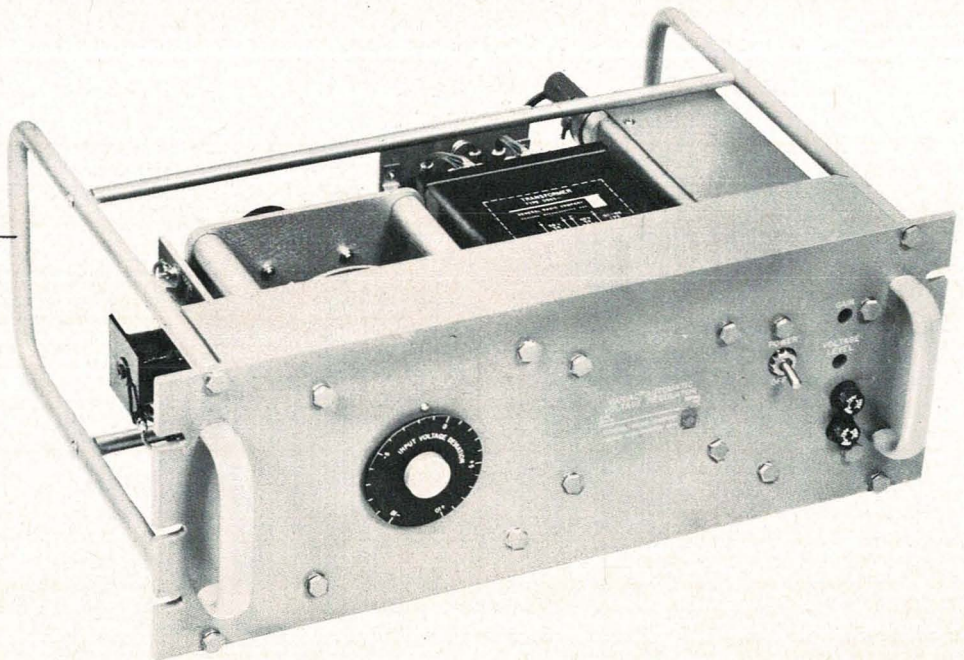
* Behind panel.

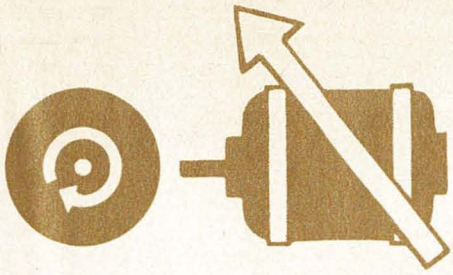
Output Voltage	*Correction Range* %*	*Output Current (A)*	*KVA*	*Max Response Speed (V/s)*	*Accuracy (% of output V)*	*Mounting*	400 c/s *Type Number*	400 c/s *Catalog Number*	400 c/s *Price*	60 c/s* *Type Number*	60 c/s* *Catalog Number*	60 c/s* *Price*
115 V Adjustable ±10%	90 to 110	50	5.8	40	0.25	Rack	**1571-ALJ**	1571-9551	**$695.00**	**1571-AL**	1571-9831	**$650.00**
	82 to 124	25	2.9	80	0.5	Rack	**1571-AL2J**	1571-9556	**695.00**	**1571-AL2**	1571-9898	**650.00**
230 V Adjustable ±10%	95 to 105	40	9.2	40	0.25	Rack	**1571-AH5J**	1571-9530	**695.00**	**1571-AH5**	1571-9516	**650.00**
	90 to 110	20	4.6	80	0.25	Rack	**1571-AHJ**	1571-9522	**695.00**	**1571-AH**	1571-9817	**650.00**
	82 to 124	10	2.3	160	0.5	Rack	**1571-AH2J**	1571-9526	**695.00**	**1571-AH2**	1571-9770	**650.00**

* Ranges given are for 57- to 63-cycle operation. For 48- to 63-cycle operation, corresponding correction ranges are 95 to 105%, 91 to 109%, and 84 to 119%.

NEW

in catalog S





VARIAC® speed controls

FOR OPERATING DC MOTORS FROM AC LINES

Refer to pages 228 and 229 for specifications and prices.

FEATURES:

- Smooth speed control — 10:1 for most applications; up to 100:1 or more with light loads.
- Full torque at any speed.
- Instant starting; quick reversing.
- Smooth controlled starting for delicate loads; fast high-torque starting for heavy loads.
- Dynamic braking in all models 1/6 hp and higher, to bring the armature to a quick stop.
- Economical, easy to install, require minimum of maintenance.

VARIAC® speed controls are compact, high-performance motor speed controls, designed to operate dc shunt, compound, or series motors from an ac line. The motors are operated with constant field excitation and adjustable armature voltage. A VARIAC® autotransformer, in the input to the armature-supply rectifier, provides smooth continuous adjustment of the armature voltage (and hence of the speed) from rated value down to zero. Regulation is 15 to 30 percent at base speed. A choke in the armature circuit minimizes ac ripple, thus eliminating the need to derate the motor. A resistor, connected across the armature when the switch is in the STOP position, provides dynamic breaking except on 1/15-hp models.

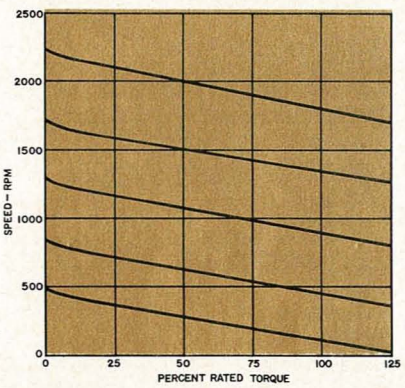
These controls are completely solid state (no electron tubes are used).

The basic circuit is shown in the diagram. Long-life selenium rectifiers are employed in both armature and field circuits. These are self-protecting against transient voltage surges. Armature overload protection is accomplished with slow-blow fuses in the 1/15- and 1/6-hp models, and with magnetic circuit breakers in the 1/3- and 3/4-hp models.

Curves of the speed-torque characteristics for a typical installation are shown in the diagram.

The VARIAC speed control is available in any of four power ratings: 1/15, 1/6, 1/3, or 3/4 horsepower. Each rating may be had in either of two models. The cabinet model is complete with all necessary switches and protective devices. The basic model (identified by the suffix "W" in the type number) is electrically identical with the corresponding cabinet model, but it contains only the essential components, including the VARIAC autotransformer mounted separately. No switches or overload protectors are supplied with the basic models. A switch or drum control is available as a separate item (see below).

The table on the following pages gives the specifications and prices for both the cabinet and the basic models.



Speed-torque characteristics of a typical motor-and-speed-control installation.

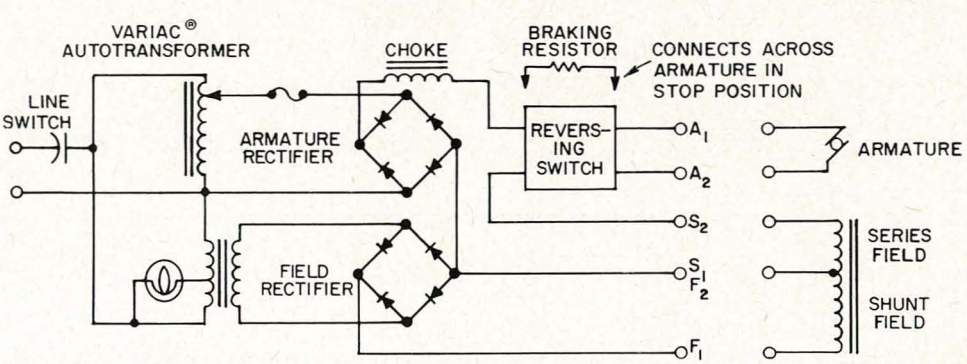
SWITCH AND CONTROLLER

for Use with 1/6-HP, 1/3-HP, and 3/4-HP Basic (W) Models

The TYPE 1702-P3 appliance-type switch, supplied with the cabinet models, is available for the W models as a separate item. This switch is designed to break the ac and dc circuits simultaneously and handle reversing and dynamic braking. The escutcheon plate (supplied) is engraved FORWARD, STOP, and REVERSE.

A drum-type Controller, TYPE 1705-P1, is also available separately for use with the basic models in machine-shop production work.

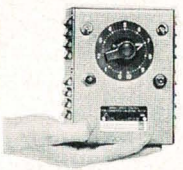
For prices of the switch and controller, see page 228.



Circuit diagram of a Variac speed control.

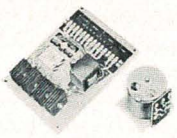
VARIAC® MOTOR SPEED CONTROLS

These speed controls are simple and rugged and have good regulation. They have given excellent performance in many types of industrial applications and are particularly well suited for use in the shop and the laboratory. See page 227 for general description and circuit.



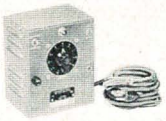
Type 1701-AK
Cabinet Model
Two speed ranges

1/15 hp and less for shunt motors



Type 1701-AKW
Basic Model

1/15 hp and less for series or universal motors



Type 1701-AU
Available only in cabinet model

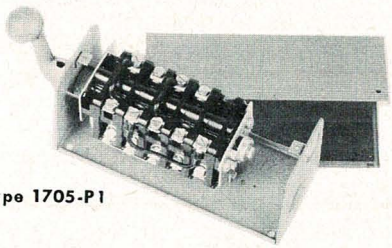
Field and armature leads must be separate to provide constant field excitation

			1701-AK Cabinet	1701-AKW Basic	1701-AU
Ac Input	Power supply single phase	Volts	115		115
		Full-load amperes	1.5		1.5
	Line voltage limits	at 60 cycles	105—125		105—125
		at 50 cycles	105—120		105—120
	Input power, watts	Full load	175		175
		Stand-by	None		None
Dc Output	Armature	Amperes	0.8		0.8
		Volts	0—115		0—115
	Field	Amperes	0.2		1.25 or 1.0
		Volts	115 or 38		10 or 16
	Speed range		0 to rated or 0 to 2 × rated		0 to rated or 0 to 2 × rated
Model			Cabinet	Basic	Cabinet
Dimensions (inches)	Cabinet (w × h × d)		5⅞ × 6¾ × 3¾	6⅛ × 9 × 2¾	5⅞ × 6¾ × 3¾
	Variac (w × h × d)		in cabinet	3¼ × 3 11/16 × 4⅜	in cabinet
Weight (pounds)	Net		6	5¾	6
	Shipping		11	11	11
Catalog Number			1701-9819	1701-9821	1701-9939
Prices net FOB factory	1-4		**$95.00**	**$72.00**	**$95.00**
	5-19		**93.00**	**68.50**	**93.00**
	20 and up		**91.00**	**65.50**	**91.00**

RECOMMENDED MOTORS FOR USE WITH ABOVE VARIAC® MOTOR SPEED CONTROLS

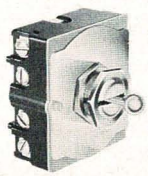
Motors not sold separately

Motor ratings: open, drip proof, electrically reversible, 40° C rise continuous, horizontal, rigid base. Any motor within control ratings can be used.	Shunt	Series or Universal
Catalog Number	1701-9621	1701-9604
Type Number	MOD-21	MOD-4
Horsepower	1/15	1/15
Speed RPM	1725	8800
Frame Size	68	NSE-12
Leads (brought out separately)	4	4
Bearings	Ball	Sleeve
Weight	Net — 6½ lb Shipping — 14 lb	Net — 3½ lb Shipping — 6 lb
Price	**$38.00**	**$21.50**

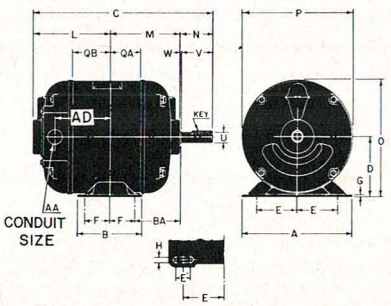


Type 1705-P1

Type 1702-P3 three-position Switch for use with Types 1700-CW, 1702-BW, and 1703-BW.
Type 1705-P1 drum-type Controller, especially suitable for machine-shop production work. For descriptions, refer to page 227.



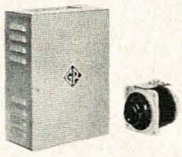
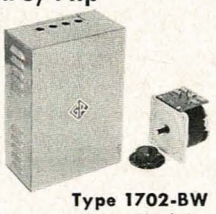
Type 1702-P3



Catalog No.	Description	Price
1702-9603	**Type 1702-P3 Switch**	**$11.00**
1705-9601	**Type 1705-P1 Controller**	**30.00**

SPECIFICATIONS AND PRICES

For description of these models, refer to page 227

	1/12 to 1/6 hp		1/4 and 1/3 hp		1/2 and 3/4 hp	
						
	Type 1703-A Cabinet Model	**Type 1703-BW** Basic Model	**Type 1700-B** Cabinet Model	**Type 1700-CW** Basic Model	**Type 1702-A** Cabinet Model	**Type 1702-BW** Basic Model
Input Voltage	115		115		115	
Input Amperes	2.2		5		10	
Output Voltage	105—125		105—125		105—125	
Output Amperes	105—125		on Special Order only		on Special Order only	
Volt-Amperes	325		560		1150	
Watts	30		38		65	
Max. Hp	1.5		3.0		6.5	
Output Voltage Range	0—115		0—115		0—115	
Output Frequency	0.2		0.4		0.4	
Input Frequency	115 or 66 or 48		115 or 75		115 or 75	
Output Voltage Control	0 to rated or 0 to 1.25 × rated or 0 to 1.5 × rated		0 to rated or 0 to 1.15 × rated		0 to rated or 0 to 1.15 × rated	
	Cabinet	Basic	Cabinet	Basic	Cabinet	Basic
Dimensions	7⅛ × 7¾ × 4¾	6⅞ × 10⅛ × 3½	12⅞ × 9⅛ × 4⅝	12½ × 9 3/16 × 4⅞	13½ × 14⅞ × 5⅛	15 3/16 × 10 11/16 × 5 13/16
	in cabinet	3¼ × 3 11/16 × 4⅜	in cabinet	4½ × 4 15/16 × 5½	in cabinet	5¾ × 6¼ × 5
Net Weight	9	8	23½	23½	41	38¾
Shipping Weight	11	15	30	40	49	51
Catalog Number	1703-9701	1703-9826	1700-9702	1700-9828	1702-9701	1702-9826
List Price	**$110.00**	**$90.00**	**$180.00**	**$155.00**	**$255.00**	**$215.00**
Quantity Price	**107.00**	**87.50**	**176.00**	**151.50**	**245.00**	**206.00**
Dealer Price	**104.00**	**85.00**	**172.00**	**148.00**	**235.00**	**197.00**

RECOMMENDED MOTORS FOR USE WITH ABOVE VARIAC® MOTOR SPEED CONTROLS

Motors not sold separately

Compound with separate series - field leads	Compound with interpoles	Compound with interpoles
1703-9611	1700-9603	1702-9625
MOD-11	MOD-3	MOD-25
⅛	⅓	¾
1725	1725	1725
G-56	G-56	J-56
6	6	6
Ball	Ball	Ball
Net — 30 lb Shipping — 35 lb	Net — 33 lb Shipping — 37 lb	Net — 45 lb Shipping — 49 lb
$62.00	**$76.00**	**$115.00**

DIMENSIONS OF MOTORS USED WITH VARIAC® MOTOR SPEED CONTROLS

Catalog Number	Frame Size	A	B	C	D	E	E′	F	G	H	L	M	N	O	P	U Min	U Max	KEY Sq	KEY Lgt	V	W	AA	AD	BA
5760-9603	G-56	6⅝	4⅛	10¾	3½	2 7/16	⅝	1½	¼	11/32	4 13/32	4 13/32	1 15/16	6 31/32	6 15/16	.6245	.6250	3/16	1¼	1⅞	1/16	½	3 3/32	2¾
5760-9604	NSE-12	3 9/16	2¼	5 11/16	2	1 15/32	7/16	⅝	..	¼	2⅜	2⅜	15/16	3 21/32	3 21/64	.3119	.3122	..	..	..	..	..	..	1¾
5760-9611	G-56	6⅝	3⅞	10¾	3½	2 7/16	⅞	1½	¼	11/32	4 13/32	4 13/32	1 15/16	6 31/32	6 15/16	.6245	.6250	3/16	1¼	1⅞	1/16	½	3 5/16	2¾
5760-9621	68	4	5	7¾	2 1/16	1 19/32	9/32	1 19/32	⅛	9/32	3 7/16	3⅜	15/16	3 31/32	4¼	.3120	.3125	..	..	..	..	..	..	1¼
5760-9625	J-56	6⅝	4⅛	12½	3½	2 7/16	⅝	1½	¼	11/32	6¼	4¼	1 15/16	6 31/32	6 15/16	.6245	.6250	3/16	1¼	..	..	½	5	2¾

VARIAC®
adjustable autotransformers

Since General Radio introduced the first adjustable autotransformer 32 years ago and branded it "Variac,"* over a million of these units have seen service in virtually every industry. They control ac voltage and thus in turn anything powered by ac voltage. Light, heat, motor speed — all are controlled smoothly, dependably, by VARIAC® autotransformers.

The autotransformer has important advantages over other methods of voltage control: It does not waste power by dissipating heat; it can withstand as high as 1000 percent short-term overload; and it does not affect waveform or power factor. To these basic advantages the VARIAC adds the value of 32 years of continuous refinement by General Radio and 32 years of proved performance in industry.

Wherever ac voltage is to be adjusted, there is a use for the VARIAC autotransformer. Some typical applications are:

- Lighting control in theaters, auditoriums, photographic studios, and darkrooms.
- Control of electric heaters and ovens in laboratory, pilot plant, and production line.
- Motor-speed control.
- Control of ac voltage in test and development work.
- Overvoltage and undervoltage tests.
- Meter calibration by voltage control.

The VARIAC autotransformer consists of a single-layer winding on a toroidal silicon-steel core. As the control knob is rotated, a graphitic brush traverses the winding, tapping a portion of the total voltage across the winding. The brush is in continuous contact with the winding, and the voltage between turns is always less than 1 volt, even in the largest model; in the smallest model it is only about 0.3 volt. The brush always spans more than one turn, and the change in voltage as the brush moves is practically continuous. The brush is so designed that excessive heating cannot occur in the turns that it spans.

Duratrak®† All VARIAC autotransformers feature the DURATRAK contact surface, a uniform silver-alloy coating to prevent injurious high-temperature oxidation and resultant brush-track deterioration. The track shows no significant wear after 1,000,000 cycles of brush operation from zero to maximum and return. Because of DURATRAK contact surface, the life of a VARIAC autotransformer is essentially the same as that of a fixed-ratio power transformer.

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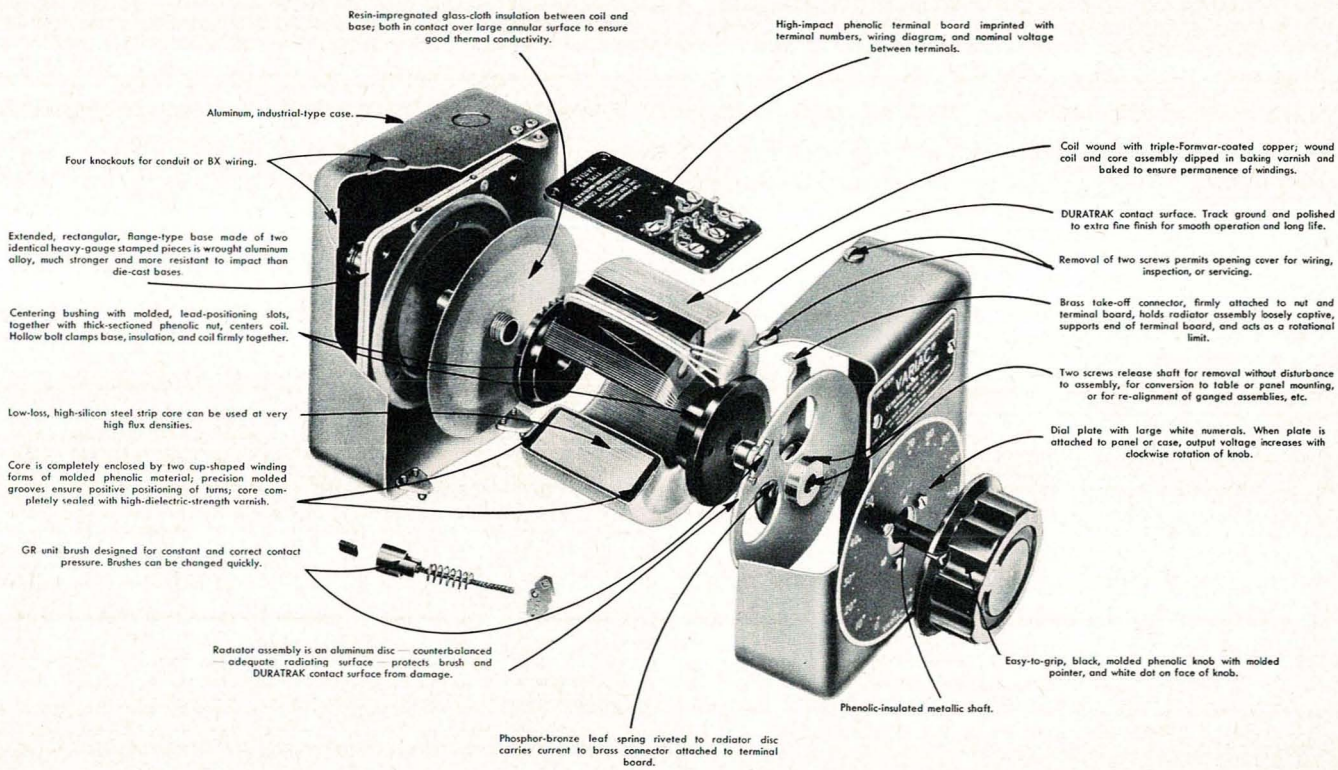
* "Variac" is the registered trade name of the General Radio brand of adjustable autotransformers and associated control equipment in which these adjustable autotransformers are used.

† "Duratrak" is the registered trade name for the contact surface applied to the brush tracks of Variac autotransformers.



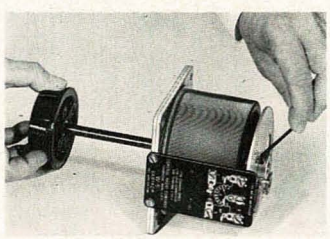
W-SERIES VARIAC® AUTOTRANSFORMER

There are seven basic sizes in the W series: W2, W5, W8, W10, W20, W30, and W50. (The numbers correspond approximately to rated current in amperes for 120-volt models; for exact specifications, see the following pages.) All sizes except W2 and W8 are available in both 120- and 240-volt models. In addition, several mounting options are offered (uncased, cased, and portable), plus many optional features, such as ball bearings, motor drive, full 360-degree rotation, and two separate brush tracks.

Portable models have carrying handle, built-in overload protector, and either two- or three-wire power cord.

Cased models are totally enclosed, with easily removed covers. Power connections enter case through standard conduit knockouts.

Uncased models have square mounting bases for convenient installation. On all models, wiring diagram and ratings are stamped on terminal plates.



Shaft can be easily adjusted or replaced without disturbing other parts of the assembly.

Overload protector, an important feature on portable models, is quickly reset from front panel.

FEATURES:

- *Regulation:* Output voltage is substantially independent of load.
- *Smooth Control:* Can be set very closely to any voltage in its range. Output voltage is continuously adjustable from zero to maximum.
- *Efficiency:* Low losses under all load conditions.
- *Long Life:* Life is essentially the same as that of a fixed-ratio transformer.
- *Linear Output Voltage:* Output voltage varies linearly with dial rotation.
- *Overvoltage:* Maximum output voltage is greater than input voltage.
- *Low Maintenance:* Occasional cleaning of the contact surface ensures long, trouble-free operation.

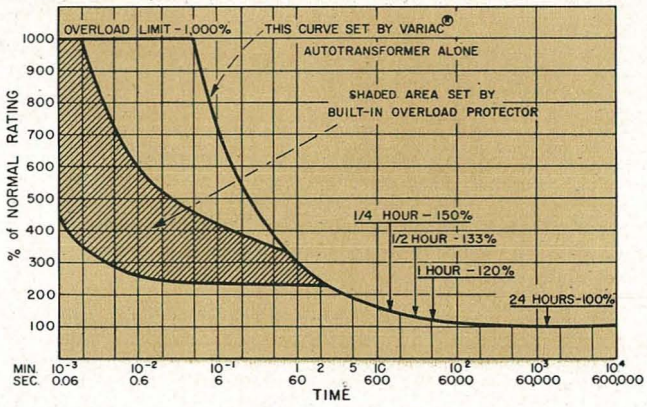
TYPE NUMBERS

Type numbers for VARIAC autotransformers consist of a letter prefix (W for 50- to 60-cycle units, M for 350- to 1200-cycle models), a number, and a letter suffix that indicates exactly what elements are included in the assembly. The following is the legend for suffixes.

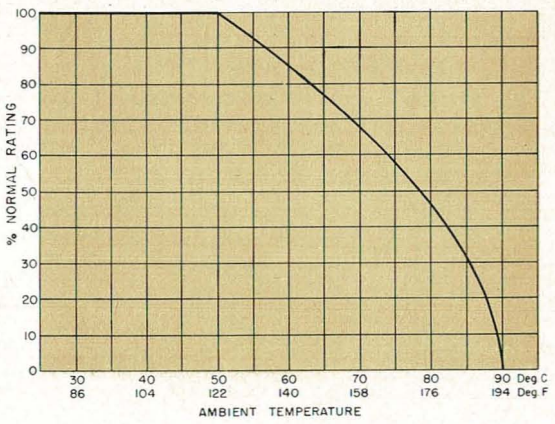
A — includes voltmeter and ammeter.
BB — includes ball bearings.
C — includes motor capacitor.
D — motor-driven unit (number following indicates seconds for full traverse of 320°).
G — ganged (digit following indicates number of units in gang).
H — 240-volt (input) unit.
K — includes limit switches.
L — higher than nominal current rating; no overvoltage connection; 60 c/s only.
M — cased unit.
T — portable case with carrying handle and two-wire power cord.
T3 — same as T, but three-wire cord.
W — includes voltmeter and wattmeter.

For example, a TYPE W5HG3D16CKM is a motor-driven, three-gang, 240-volt W5 model, with motor capacitor, limit switches, and case. The driving speed is such that a 320-degree traverse takes 16 seconds.

INDEX



Short-time overload limits. For high initial surge current (as with motors, incandescent lamps, etc.) and other short-time overloads, the rated current may be exceeded as shown, when line-voltage connection is used.



For ambient temperatures above 50°C, ratings should be decreased according to this curve.

GENERAL SPECIFICATIONS AND TERMINOLOGY

Frequency: W series, 50 to 60 c/s; M series, 350 to 1200 c/s, except as otherwise noted. Most W models can also be operated at rated current and voltage at line frequencies of 50 to 400 c/s. Models designed for 240-volt, 50- to 60-cycle service can be used on a 25-cycle supply at full current rating and one-half their voltage and kva ratings.

Protective Devices: MT and MT3 types have built-in circuit breakers with manual resets. TYPES W5L, W20H, W30, W30H, W50, and W50H have built-in fuse-type protectors. However, these should not be considered a substitute for normal fusing practices.

Overload Ratings: Rated currents can be safely exceeded with short-term overloads (see curves above). The shaded area shows the limits for models with built-in fuse-type protective devices.

Temperature Effects: Ratings are based on a temperature rise of not more than 50°C above ambient temperature. For operation in ambient temperatures above 50°C, see derating chart above.

Dials: Dial plates are reversible: 0 to 120 volts on one side, 0 to 140 volts on the other. Dials on H models are marked 0 to 240 and 0 to 280. Dials for ganged assemblies are marked 0 to 10. All models have 320-degree rotation and include knob and dial unless otherwise specified.

Terminals: The following types have combination soldering and screw-type terminals: W2, W5, W5L, W8, W8L, W10, W10H, W30H, and W50H. The W30 and W50 models use clamp-type terminals to accommodate the larger conductors required. MT types have NEMA-standard three-wire connectors.

Overvoltage Connection is that connection which gives an output voltage range of zero to 117 percent of input voltage.

Line-Voltage Connection is that connection which gives an output voltage range of zero to input (line) voltage.

Rated Current is the current that can be drawn at any output voltage.

Maximum Current is the current that can be drawn at maximum output voltage when the line-voltage connection is used.

Output Voltage Range is the range of voltage available at the output terminals when the stated input voltage is applied to the input terminals.

KVA Load Rating is the maximum current multiplied by the nominal input line voltage. At any lower voltage setting, a VARIAC autotransformer can handle a constant-impedance load that draws a current no greater than maximum current with rated input voltage.

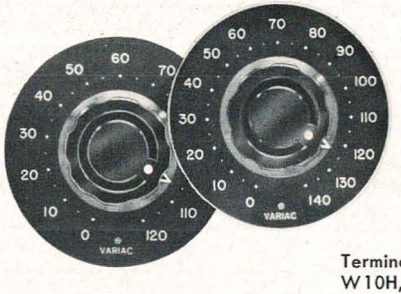
No-Load Loss is the power consumed at rated line voltage and frequency, with the load disconnected. This loss will not exceed the stated value.

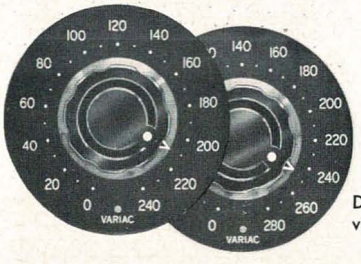
Driving Torque is the torque required to turn the shaft.

For a complete description of principles, circuits, and uses, refer to *The Handbook of Voltage Control*, available free on request from General Radio Company.

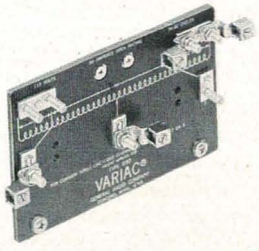
Dials for 120-volt models read 0-120 for line voltage output connection; reverse side reads 0-140 volts for 'overvoltage' output connection.

All ganged assemblies are equipped with dials of this type, calibrated on one side only.

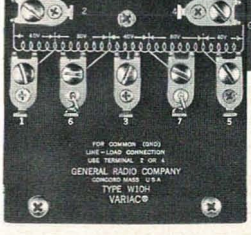




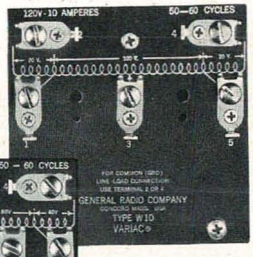
Dials for "H" models read 0-240 volts one side, 0-280 volts reverse side.



Terminal plate of Type W50. Note clamp-type terminals.

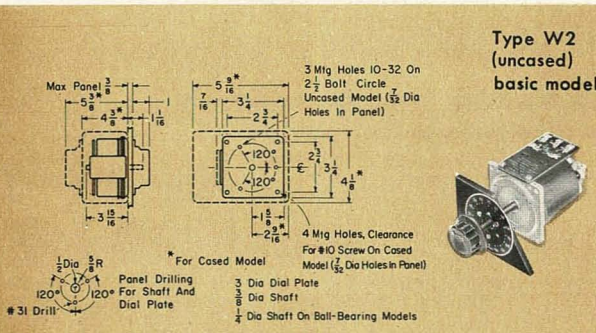


Terminal plate of Type W10H, 240-volt input. Note 7 terminals, screw- and solder-type terminal lugs, and circuit diagram.



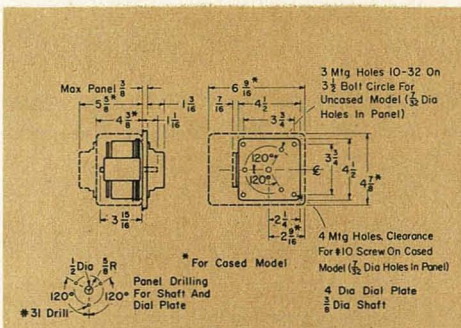
Terminal plate of Type W10, 120-volt input and 5 terminals.

DIMENSIONS† OF SINGLE-UNIT W-SERIES VARIAC® ADJUSTABLE AUTOTRANSFORMERS



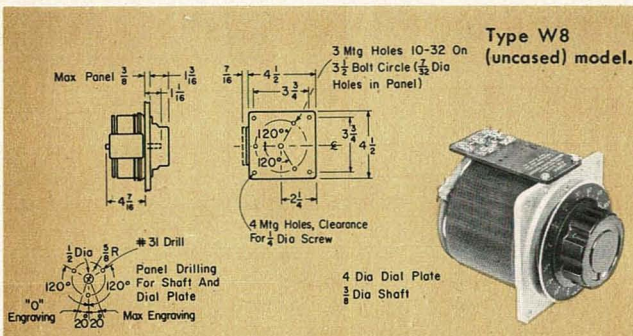
Type W2 (uncased) basic model.

Types W2 and W2M.



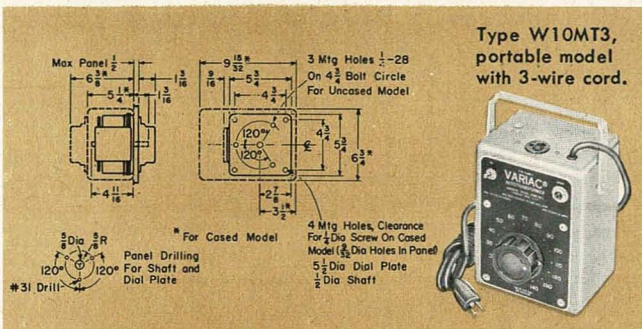
Type W5M (cased) model.

Types W5, W5L, W5M, W5LM, W5MT, W5MT3, W5LMT3, W5H, W5HM, and W5HMT.



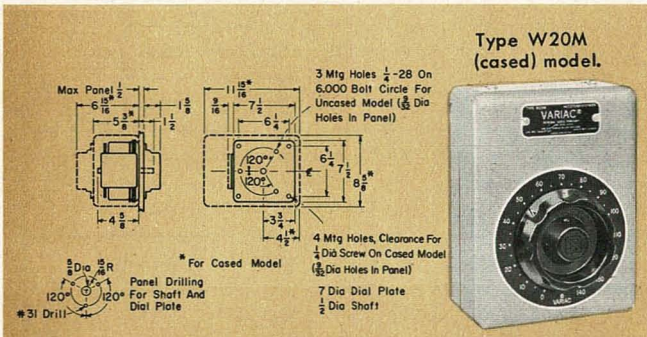
Type W8 (uncased) model.

Types W8 and W8L.



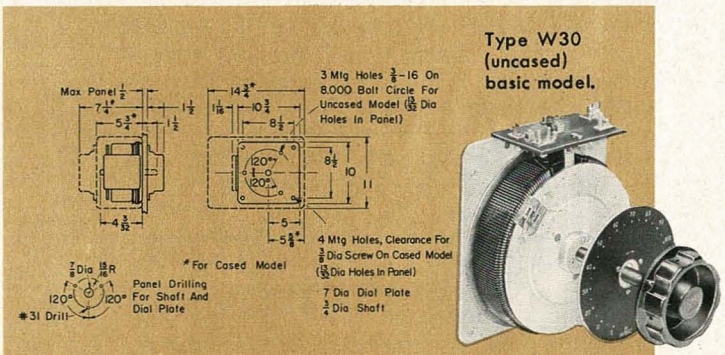
Type W10MT3, portable model with 3-wire cord.

Types W10, W10M, W10MT, W10MT3, W10H, W10HM, W10HMT, and W10HMT3.



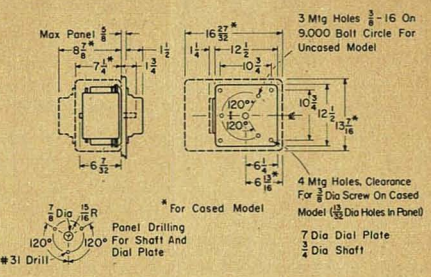
Type W20M (cased) model.

Types W20, W20M, W20MT3, W20H, W20HM, and W20HMT3.



Type W30 (uncased) basic model.

Types W30, W30M, W30H, and W30HM.



Types W50, W50M, W50H, and W50HM.

Type W50M (cased) model.

† Given in inches; to convert to mm, multiply by 25.4.

RATINGS AND PRICES for 120-VOLT SINGLE-UNIT W-SERIES

VARIAC® ADJUSTABLE AUTOTRANSFORMERS

with DURATRAK® CONTACT SURFACE

This table lists commonly used single units and does not include all possible applications.
Dimensions for these models are given on page 233.

Input Voltage	Output: Line-Voltage Connection: kVA Load Rating (See Note A)	Output: Line-Voltage Connection: Voltage Range	Output: Line-Voltage Connection: Rated Current Amperes	Output: Line-Voltage Connection: Maximum Current Amperes (See Note A)	Output: Overvoltage Connection: Voltage Range	Output: Overvoltage Connection: Rated Current Amperes (See Note B)	Type	60-Cycle No-Load Loss Watts	Driving Torque Ounce—Inches	Net Weight Pounds	Approximate Shipping Weight—Pounds	Catalog Number	Price	Replacement Brush	Add for Ball Bearings (Note E)
120	**0.31**	0–120	2.0	2.6	0–140	2.0	**W2M† (With case)**	3.5	5–10	4¼	9	3010-5111	**21.50**	Type VB1 80¢	**$8.00**
120	**0.37**	0–120	2.4	3.1	0–140	2.4	**W2† (Uncased)**	3.5	5–10	3½	4	3010-5110	**15.00**		
120	See Note C				0–140	5	**W5MT*† (Portable 2-wire)**	9	10–20	8¼	15	3030-5118	**31.50**	Type VB2 80¢	**$8.00**
120	See Note C				0–140	5	**W5MT3*† (Portable 3-wire)**	9	10–20	8¼	15	3030-5119	**33.00**		
120	**0.78**	0–120	5.0	6.5	0–140	5	**W5M*† (With case)**	9	10–20	7¼	13	3030-5111	**26.00**		
120	**0.94**	0–120	6.0	7.8	0–140	6	**W5*† (Uncased)**	9	10–20	6½	8	3030-5110	**18.00**		
120	**1.1**	0–120	7.1	9.2	See Note D		**W5LM (With case)**	12	10–20	7¼	8	3050-5111	**25.50**		
120	**1.1**	0–120	7.1	9.2	See Note D		**W5LMT3 (Portable 3-wire)**	12	10–20	8½	18	3050-5119	**32.50**		
120	**1.32**	0–120	8.5	11	See Note D		**W5L* (Uncased)**	12	10–20	6¾	8	3050-5110	**17.50**		
120	**1.32**	0–120	8.5	11	0–140	8.5	**W8 (Uncased)**	12	10–20	8	9	3038-5110	**21.00**	Type VB3 90¢	**$8.00**
120	**1.56**	0–120	10	13	See Note D		**W8L (Uncased)**	12	10–20	8¼	9	3058-5110	**21.00**		
120	**1.56**	0–120	10	13	0–140	10	**W10*† (Uncased)**	17	15–30	12	13	3060-5110	**33.00**	Type VBT10 $1.35	**$9.00**
120	**1.56**	0–120	10	13	0–140	10	**W10M*† (With case)**	17	15–30	15½	17	3060-5111	**46.00**		
120	See Note C				0–140	10	**W10MT† (Portable 2-wire)**	17	15–30	16	24	3060-5118	**56.00**		
120	See Note C				0–140	10	**W10MT3† (Portable 3-wire)**	17	15–30	16	24	3060-5119	**57.50**		
120	**3.12**	0–120	20	26	0–140	20	**W20*† (Uncased)**	27	45–90	21½	24	3090-5110	**48.00**	Type VBT8 $2.50	**$9.00**
120	**3.12**	0–120	20	26	0–140	20	**W20M† (With case)**	27	45–90	24½	29	3090-5111	**63.00**		
120	See Note C				0–140	20	**W20MT3† (Portable 3-wire)**	27	45–90	28	38	3090-5119	**96.00**		
120	**3.84**	0–120	28	32	0–140	28	**W30M (With case)**	35	50–100	37	47	3120-5111	**99.00**	Type VBT13 $4.00	**$12.00**
120	**4.32**	0–120	30	36	0–140	30	**W30 (Uncased)**	35	50–100	30	38	3120-5110	**81.00**		
120	**5.40**	0–120	40	45	0–140	40	**W50M*† (With case)**	50	150–300	57	74	3150-5111	**150.00**	Type VBT6 $7.50	**$12.00**
120	**6.00**	0–120	50	50	0–140	50	**W50*† (Uncased)**	50	150–300	50	57	3150-5110	**125.00**		

See footnotes on following page.

RATINGS AND PRICES for **240-VOLT** SINGLE-UNIT W-SERIES

VARIAC® ADJUSTABLE AUTOTRANSFORMERS

with DURATRAK® CONTACT SURFACE

This table lists commonly used single units and does not include all possible applications.

Dimensions for these models are given on page 233.

Input Voltage	Output: Line-Voltage Connection: kVA Load Rating (See Note A)	Output: Line-Voltage Connection: Voltage Range	Output: Line-Voltage Connection: Rated Current Amperes	Output: Line-Voltage Connection: Maximum Current Amperes (See Note A)	Output: Overvoltage Connection: Voltage Range	Output: Overvoltage Connection: Rated Current Amperes (See Note B)	Type	60-Cycle No-Load Loss Watts	Driving Torque Ounce—Inches	Net Weight Pounds	Approximate Shipping Weight—Pounds	Catalog Number	Price	Replacement Brush	Add for Ball Bearings (Note E)
240	See Note C				0–280	2	**W5HMT†** (Portable 2-wire)	9	10–20	8¼	15	3040-5118	**$35.00**	Type VB1 80¢	$8.00
240 120	**0.62** —	0–240 —	2.0 —	2.6 —	0–280 0–280	2 1	**W5H†** (Uncased)	9	10–20	6½	8	3040-5110	**21.50**		
240 120	**0.62** —	0–240 —	2.0 —	2.6 —	0–280 0–280	2 1	**W5HM†** (Cased)	9	10–20	7¼	13	3040-5111	**29.50**		
240 120	**1.25** —	0–240 —	4 —	5.2 —	0–280 0–280	4 2	**W10H†** (Uncased)	17	15–30	11	12	3070-5110	**35.00**	Type VBT11 $1.35	$9.00
240 120	**1.25** —	0–240 —	4 —	5.2 —	0–280 0–280	4 2	**W10HM†** (With Case)	17	15–30	14½	17	3070-5111	**48.00**		
240	See Note C				0–280	4	**W10HMT** (Portable 2-wire)	17	15–30	15½	24	3070-5118	**58.00**		
240	See Note C				0–280	4	**W10HMT3†** (Portable 3-wire)	17	15–30	15½	24	3070-5119	**60.00**		
240 120	**2.50** —	0–240 —	8 —	10.4 —	0–280 0–280	8 4	**W20H*†** (Uncased)	27	45–90	20½	23	3100-5110	**50.00**	Type VBT12 $3.00	$9.00
240 120	**2.50** —	0–240 —	8 —	10.4 —	0–280 0–280	8 4	**W20HM†** (With case)	27	45–90	23½	28	3100-5111	**65.00**		
240	See Note C				0–280	8	**W20HMT3†** (Portable 3-wire)	27	45–90	27	35	3100-5119	**98.00**		
240 120	**3.74** —	0–240 —	12 —	15.6 —	0–280 0–280	12 6	**W30H** (Uncased)	35	50–100	29	36	3130-5110	**81.00**	Type VBT14 $4.00	$12.00
240 120	**3.74** —	0–240 —	12 —	15.6 —	0–280 0–280	12 6	**W30HM** (With case)	35	50–100	36	45	3130-5111	**99.00**		
240 120	**7.45** —	0–240 —	20 —	31 —	0–280 0–280	20 10	**W50HM*†** (With case)	50	150–300	60	76	3160-5111	**150.00**	Type VBT 7 $7.50	$12.00
240 120	**7.80** —	0–240 —	25 —	32.5 —	0–280 0–280	25 12.5	**W50H*†** (Uncased)	50	150–300	53	60	3160-5110	**125.00**		

NOTES

A. Maximum current can be drawn at maximum voltage for the line-voltage connection only. KVA as listed = normal input line voltage times maximum current.

B. Rated current should not be exceeded for the overvoltage connection. Output kVA for overvoltage connection = output voltage times rated current.

C. Types MT and MT3 models have overvoltage connections and corresponding dial scales but can be supplied on special order with line-voltage connections and dial scales.

D. For 60-cycle use only; no overvoltage connection provided.

E. When ordering a unit with ball bearings, add the suffix "BB" to the type number and change the sixth digit of the catalog number to 2. Example: for Type W50 with ball bearings, order Type W50BB, catalog number 3150-5210.

* Listed under the Re-examination Service of the Underwriters' Laboratories.

† Approved by the Canadian Standards Association.

METERED **VARIAC®** AUTOTRANSFORMERS

Metered VARIAC® autotransformer assemblies are portable testing devices. Each consists of a VARIAC autotransformer and either a voltmeter, a voltmeter and an ammeter, a voltmeter and a wattmeter, or all three. These handy, compact assemblies have many uses both in the laboratory and on the test bench, among them overvoltage and undervoltage tests, measurements of voltage, current, power, and trouble shooting. The meter accuracy is ±3% of full scale.[1] A three-wire power cord and three-wire receptacle are included. The output circuit, containing the meters, is fused. A double-pole on-off switch disconnects both sides of the line. Make-before-break range switches permit the dual-range meters to be switched under load. All meters have expanded scales for easier reading. The metal case, which is equipped with a carrying handle, is finished in grey hammertone.

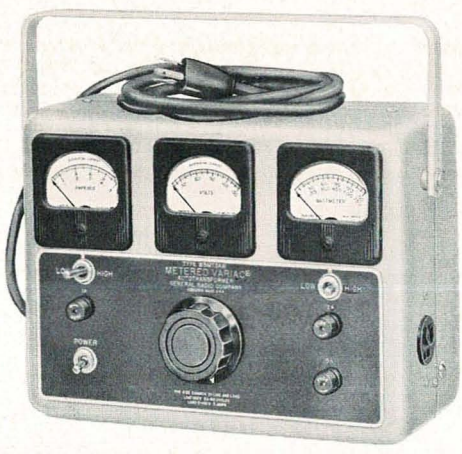
[1] For Types W20MT3A and W20HMT3A, ammeter accuracy is ± 5%.

RATINGS AND PRICES FOR METERED VARIAC® AUTOTRANSFORMERS

Catalog Number	*Type*	*Meters Included*	*Input Volts**	*Output Voltage Range*	*Rated Current Amperes*	*Ammeter Ranges*	*Wattmeter Ranges*	*60-Cycle No-Load Loss — Watts*	*Fusing Amperes*		*Weight Pounds*		*Dimensions Inches*			*Price*
									Low Range	*High Range*	*Net*	*Shipping*	*Width*	*Height*	*Depth*	
3030-5015	**W5MT3VM†**	V	120	0–140	5	—	—	9	—	—	8½	19	5½	6½	6	**$60.00**
3030-5012	**W5MT3A**	V, A	120	0–140	5	0–1, 0–5	—	9	1	5	11½	19	7½	9¾	6½	**93.00**
3030-5013	**W5MT3W**	V, W	120	0–140	5	—	0–150, 0–750	9	2	5	11¾	19	7½	9¾	6½	**120.00**
3030-5014	**W5MT3AW**	V, A, W	120	0–140	5	0–1, 0–5	0–150, 0–750	9	A = 1 W = 2	5	12½	21	12¾	9	6½	**150.00**
3060-5012	**W10MT3A**	V, A	120	0–140	10	0–2, 0–10	—	17	2	10	18¼	30	9¼	12	7	**110.00**
3060-5013	**W10MT3W**	V, W	120	0–140	10	—	0–300, 0–1500	17	4	10	18¼	30	9¼	12	7	**145.00**
3090-5012	**W20MT3A**	V, A	120	0–140	18	0–20	—	27	20		27½	33½	9¼	12	7	**140.00**
3100-5012	**W20HMT3A**	V, A	240	0–280	8	0–10	—	27	10		25	31	9¼	12	7	**140.00**

V = Voltmeter A = Ammeter W = Wattmeter * 50 to 60 c/s for all models. † Klixon-type overload protector.

TYPE W5MT3VM



TYPE W5MT3AW

TYPE W5MT3A

TYPE W10MT3W

TYPE W20MT3A

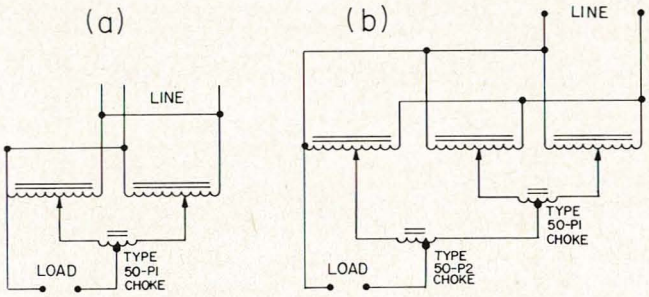
GANGED VARIAC® ADJUSTABLE AUTOTRANSFORMER ASSEMBLIES

Ganged assemblies of 2 to 6 VARIAC® autotransformers can be used to control several circuits from a single knob, or to control three-phase circuits, either wye- or open-delta-connected.

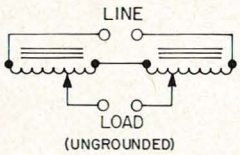
SINGLE-PHASE

PARALLEL COMBINATIONS

The larger models (TYPES W20, W30, and W50) can be operated in parallel if a TYPE 50-P1 Choke is used to limit circulating current, as shown in circuit (a). The load rating of two identical units in parallel is twice that of a single unit. Parallel operation is not usually recommended for smaller models, since the use of the next larger size is more economical. Where a load rating is in excess of two TYPE W50 units in parallel, a third unit can be added by use of a TYPE 50-P2 Choke, as shown in circuit (b). Four-gang and six-gang units can also be paralleled. See page 238 for prices of chokes and number required.



SERIES OPERATION

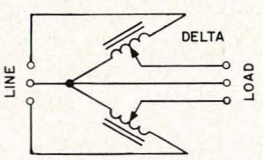


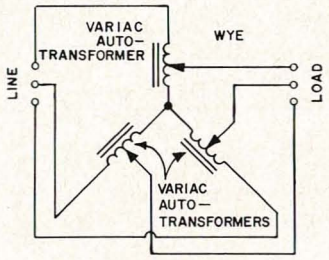
The series connection is useful in the operation of 120-volt units from 240-volt single-phase lines and 240-volt units from 480-volt single-phase lines. This circuit cannot be used, however, when a common connection between line and load is required, as, for instance, when the load is grounded.

THREE-PHASE

OPEN-DELTA CONNECTION

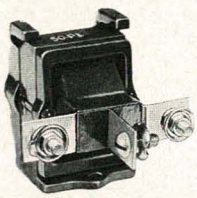
With this connection, two VARIAC autotransformers will control a three-phase load from a three-phase source. Maximum output voltage can be either line voltage or 17 percent above line voltage. The load rating of a two-gang, open-delta unit is $\sqrt{3}$ or 1.732 times that of a single unit. With 240-volt models, output voltages of more than double the supply voltage can be obtained, although current and power ratings are halved.





WYE CONNECTION

Wye-connected models can be operated from three-phase lines of twice the VARIAC voltage rating. This is possible because the voltage from line to neutral of a wye-connected assembly is the line voltage divided by $\sqrt{3}$; thus, in the case of a 240-volt, 3-phase line, the voltage across each coil will be 138 volts. Since 120-volt units are wound for 140 volts across the whole winding, three 120-volt units can be wye connected, if the over-voltage connection is omitted. Although the overvoltage feature is sacrificed, the kVA rating is increased by the ratio 138/120. The load rating of a wye-connected assembly is 3.47 times that of a single unit. Similarly, 240-volt units can be used on 480-volt, 3-phase systems.



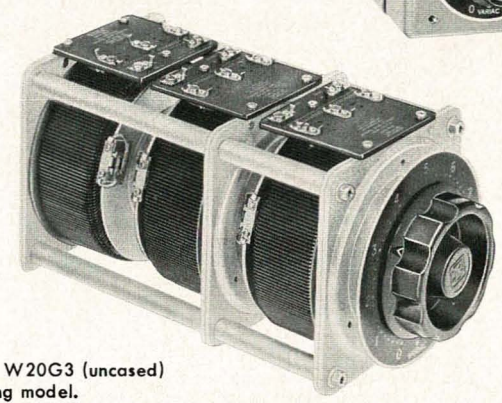
Type 50-P1 Choke to limit circulating current in parallel combinations.

Type W2G2M (cased) 2-gang model.

PARALLEL OPERATION

As with single-phase assemblies, VARIAC autotransformers can also be paralleled on three-phase circuits. A 4-gang open-delta connection requires two TYPE 50-P1 Chokes and a 6-gang open-delta connection requires two TYPE 50-P1 and two TYPE 50-P2 Chokes. A 6-gang wye requires three TYPE 50-P1 Chokes.

For ratings and prices of these assemblies, refer to pages 238 and 239. Dimensions will be found on pages 240 and 241.



Type W20G3 (uncased) 3-gang model.

RATINGS AND PRICES for SINGLE-PHASE W-SERIES GANGED

VARIAC® AUTOTRANSFORMER ASSEMBLIES

with DURATRAK® CONTACT SURFACE

This table lists commonly used ganged assemblies and does not include all possible applications.
Refer to pages 240 and 241 for dimensions of these models.

Input Voltage	Output				Type	Description (See Note B)	Number of Chokes Required		Net Weight Pounds	Approximate Shipping Weight—Pounds	Catalog Number	Price	Add for Ball Bearings (Note C)
	kVA Load Rating (See Note A)	Voltage Range	Rated Current Amperes	Maximum Current Amperes (See Note A)			Type 50-P1 $16.00	Type 50-P2 $16.00					
120	**2.2**	0–120	14.2	18.4	**W5LG2M***	2-Gang, cased (P)	1		15¼	23	3050-5121	**$53.00**	$13.00
120	**2.6**	0–120	17.0	22.0	**W5LG2***	2-Gang, uncased (P)	1		13¾	16	3050-5120	**41.00**	13.00
120	**3.1**	0–120	20.0	26.0	**W8LG2**	2-Gang, uncased (P)	1		16¾	19	3058-5120	**48.00**	13.00
120	**3.3**	0–120	21.3	27.6	**W5LG3M***	3-Gang, cased (P)	1	1	22½	32	3050-5131	**72.50**	15.00
120	**4.0**	0–120	25.5	33.0	**W5LG3***	3-Gang, uncased (P)	1	1	20½	22	3050-5130	**59.50**	15.00
120	**4.7**	0–120	30.0	39.0	**W8LG3**	3-Gang, uncased (P)	1	1	25¼	27	3058-5130	**70.00**	15.00
120	**6.2**	0–140	40.0	52.0	**W20G2M**	2-Gang, cased (P)	1		48	56	3090-5121	**130.00**	15.00
120	**6.2**	0–140	40.0	52.0	**W20G2**	2-Gang, uncased (P)	1		43½	48	3090-5120	**106.00**	15.00
120	**7.7**	0–140	56.0	64.0	**W30G2M**	2-Gang, cased (P)	1		67	90	3120-5121	**210.00**	18.00
120	**8.6**	0–140	60.0	72.0	**W30G2**	2-Gang, uncased (P)	1		61½	80	3120-5120	**180.00**	18.00
120	**9.4**	0–140	60.0	78.0	**W20G3M**	3-Gang, cased (P)	1	1	71	82	3090-5131	**182.00**	18.00
120	**9.4**	0–140	60.0	78.0	**W20G3**	3-Gang, uncased (P)	1	1	65	71	3090-5130	**156.00**	18.00
120	**10.8**	0–140	80.0	90.0	**W50G2M**	2-Gang, cased (P)	1		123	160	3150-5121	**308.00**	18.00
120	**11.5**	0–140	84.0	96.0	**W30G3M**	3-Gang, cased (P)	1	1	99	125	3120-5131	**299.00**	22.00
120	**12.0**	0–140	100.0	100.0	**W50G2**	2-Gang, uncased (P)	1		112	147	3150-5120	**268.00**	18.00
120	**13.0**	0–140	90.0	108.0	**W30G3**	3-Gang, uncased (P)	1	1	93	113	3120-5130	**264.00**	22.00
120	**16.2**	0–140	120.0	135.0	**W50G3M**	3-Gang, cased (P)	1	1	179	221	3150-5131	**442.00**	22.00
120	**18.0**	0–140	150.0	150.0	**W50G3**	3-Gang, uncased (P)	1	1	163	206	3150-5130	**397.00**	22.00
120	**21.6**	0–140	160.0	180.0	**W50G4BBM**	4-Gang, Ball Bearings, cased (P)	4		240	313	3150-5241	**604.00**	—
120	**24.0**	0–140	200.0	200.0	**W50G4BB**	4-Gang, Ball Bearings, uncased (P)	4		215	288	3150-5240	**556.00**	—
120	**32.4**	0–140	240.0	270.0	**W50G6BBM**	6-Gang, Ball Bearings, cased (P)	5	2	355	430	3150-5261	**887.00**	—
120	**36.0**	0–140	300.0	300.0	**W50G6BB**	6-Gang, Ball Bearings, uncased (P)	5	2	325	400	3150-5260	**833.00**	—
240	**0.62**	0–560	1.0	1.3	**W5HG2**	2-Gang, uncased (S)†			13¼	15	3040-5120	**49.00**	13.00
240	**0.62**	0–560	1.0	1.3	**W5HG2M**	2-Gang, cased (S)†			15	23	3040-5121	**61.00**	13.00
240	**0.62**	0–280	2.0	2.6	**W2G2M**	2-Gang, cased (S)†			8½	15	3010-5121	**46.00**	13.00
240	**0.74**	0–280	2.4	3.1	**W2G2**	2-Gang, uncased (S)†			7¼	9	3010-5120	**36.00**	13.00
240	**1.56**	0–280	5.0	6.5	**W5G2M**	2-Gang, cased (S)†			15	23	3030-5121	**54.00**	13.00
240	**1.87**	0–280	6.0	7.8	**W5G2**	2-Gang, uncased (S)†			13¾	15	3030-5120	**42.00**	13.00
240	**2.64**	0–280	8.5	11.0	**W8G2**	2-Gang, uncased (S)†			16¼	19	3038-5120	**48.00**	13.00
240	**3.12**	0–280	10.0	13.0	**W10G2**	2-Gang, uncased (S)†			25½	27	3060-5120	**73.00**	15.00
240	**3.12**	0–280	10.0	13.0	**W10G2M**	2-Gang, cased (S)†			29½	34	3060-5121	**93.00**	15.00
240	**4.99**	0–280	16.0	20.8	**W20HG2**	2-Gang, uncased (P)	1		41	46	3100-5120	**110.00**	15.00
240	**4.99**	0–280	16.0	20.8	**W20HG2M**	2-Gang, cased (P)	1		45	54	3100-5121	**134.00**	15.00
240	**6.24**	0–280	20.0	26.0	**W20G2**	2-Gang, uncased (S)†			43½	48	3090-5120	**106.00**	15.00
240	**6.24**	0–280	20.0	26.0	**W20G2M**	2-Gang, cased (S)†			48	56	3090-5121	**130.00**	15.00
240	**7.5**	0–280	24.0	31.2	**W30HG2**	2-Gang, uncased (P)	1		59	76	3130-5120	**180.00**	18.00
240	**7.5**	0–280	24.0	31.2	**W30HG2M**	2-Gang, cased (P)	1		64½	87	3130-5121	**210.00**	18.00
240	**7.7**	0–280	28.0	32.0	**W30G2M**	2-Gang, cased (S)†			67	90	3120-5121	**210.00**	18.00
240	**8.6**	0–280	30.0	36.0	**W30G2**	2-Gang, uncased (S)†			61½	80	3120-5120	**180.00**	18.00
240	**14.9**	0–280	40.0	62.0	**W50HG2M**	2-Gang, cased (P)	1		126	165	3160-5121	**308.00**	18.00
240	**15.6**	0–280	50.0	65.0	**W50HG2**	2-Gang, uncased (P)	1		116	153	3160-5120	**268.00**	18.00
240	**22.3**	0–280	60.0	93.0	**W50HG3M**	3-Gang, cased (P)	1	1	183	230	3160-5131	**442.00**	22.00
240	**23.4**	0–280	75.0	97.5	**W50HG3**	3-Gang, uncased (P)	1	1	167	214	3160-5130	**397.00**	22.00
240	**29.8**	0–280	80.0	124.0	**W50HG4BBM**	4-Gang, Ball Bearings, cased (P)	3		255	328	3160-5241	**604.00**	—
240	**31.2**	0–280	100.0	130.0	**W50HG4BB**	4-Gang, Ball Bearings, uncased (P)	3		230	300	3160-5240	**556.00**	—
240	**44.6**	0–280	120.0	186.0	**W50HG6BBM**	6-Gang, Ball Bearings, cased (P)	4	1	385	458	3160-5261	**887.00**	—
240	**46.8**	0–280	150.0	195.0	**W50HG6BB**	6-Gang, Ball Bearings, uncased (P)	4	1	355	428	3160-5260	**833.00**	—

See footnotes on following page.

RATINGS AND PRICES for THREE-PHASE W-SERIES GANGED

VARIAC® AUTOTRANSFORMER ASSEMBLIES

with DURATRAK® CONTACT SURFACE

This table lists commonly used ganged assemblies and does not include all possible applications.
Refer to pages 240 and 241 for dimensions of these models.

Input Voltage	*Output*				*Type*	*Description*	*Number of Chokes Required*	*Net Weight Pounds*	*Approximate Shipping Weight—Pounds*	*Catalog Number*	*Price*	*Add for Ball Bearings (Note C)*
	kVA Load Rating (See Note A)	*Voltage Range*	*Rated Current Amperes*	*Maximum Current Amperes (See Note A)*			*Type 50-P1 $16.00*					
208	**3.31**	0–208	7.1	9.2	**W5LG3M*§**	3-Gang, cased, Wye circuit		22½	32	3050-5131	**$72.50**	$15.00
208	**3.96**	0–208	8.5	11.0	**W5LG3*§**	3-Gang, uncased, Wye circuit		20½	23	3050-5130	**59.50**	15.00
208	**4.68**	0–208	10.0	13.0	**W8LG3*§**	3-Gang, uncased, Wye circuit		25¼	27	3058-5130	**70.00**	15.00
240	**1.08**	0–280	2.0	2.6	**W5HG2**	2-Gang, uncased, Open Delta		13½	15	3040-5120	**49.00**	13.00
240	**1.08**	0–280	2.0	2.6	**W5HG2M**	2-Gang, cased, Open Delta		15	23	3040-5121	**61.00**	13.00
240	**1.08**	0–240	2.0	2.6	**W2G3M‡**	3-Gang, cased, Wye circuit		12½	21	3010-5131	**63.00**	15.00
240	**1.29**	0–240	2.4	3.1	**W2G3‡**	3-Gang, uncased, Wye circuit		10¾	13	3010-5130	**52.00**	15.00
240	**2.16**	0–280	4.0	5.2	**W10HG2**	2-Gang, uncased, Open Delta		24½	27	3070-5120	**77.00**	15.00
240	**2.16**	0–280	4.0	5.2	**W10HG2M**	2-Gang, cased, Open Delta		29	33	3070-5121	**97.00**	15.00
240	**2.70**	0–240	5.0	6.5	**W5G3M‡**	3-Gang, cased, Wye circuit		22½	32	3030-5131	**74.00**	15.00
240	**3.24**	0–240	6.0	7.8	**W5G3‡**	3-Gang, uncased, Wye circuit		20	22	3030-5130	**61.00**	15.00
240	**4.57**	0–240	8.5	11.0	**W8G3‡**	3-Gang, uncased, Wye circuit		25½	27	3038-5130	**70.00**	15.00
240	**4.32**	0–280	8.0	10.4	**W20HG2**	2-Gang, uncased, Open Delta		41	46	3100-5120	**110.00**	15.00
240	**4.32**	0–280	8.0	10.4	**W20HG2M**	2-Gang, cased, Open Delta		45	54	3100-5121	**134.00**	15.00
240	**5.40**	0–240	10.0	13.0	**W10G3‡**	3-Gang, uncased, Wye circuit		37	40	3060-5130	**108.00**	18.00
240	**5.40**	0–240	10.0	13.0	**W10G3M‡**	3-Gang, cased, Wye circuit		43	47	3060-5131	**129.00**	18.00
240	**6.48**	0–280	12.0	15.6	**W30HG2**	2-Gang, uncased, Open Delta		59	76	3130-5120	**180.00**	18.00
240	**6.48**	0–280	12.0	15.6	**W30HG2M**	2-Gang, cased, Open Delta		64½	87	3130-5121	**210.00**	18.00
240	**10.8**	0–240	20.0	26.0	**W20G3‡**	3-Gang, uncased, Wye circuit		65	71	3090-5130	**156.00**	18.00
240	**10.8**	0–240	20.0	26 0	**W20G3M‡**	3-Gang, cased, Wye circuit		71	82	3090-5131	**182.00**	18.00
240	**12.9**	0–280	20.0	31.0	**W50HG2M**	2-Gang, cased, Open Delta		126	165	3160-5121	**308.00**	18.00
240	**13.3**	0–240	28.0	32.0	**W30G3M‡**	3-Gang, cased, Wye circuit		99	125	3120-5131	**299.00**	22.00
240	**13.5**	0–280	25.0	32.5	**W50HG2**	2-Gang, uncased, Open Delta		116	153	3160-5120	**268.00**	18.00
240	**15.0**	0–240	30.0	36.0	**W30G3‡**	3-Gang, uncased, Wye circuit		93	113	3120-5130	**264.00**	22.00
240	**18.7**	0–240	40.0	45.0	**W50G3M‡**	3-Gang, cased, Wye circuit		179	221	3150-5131	**442.00**	22.00
240	**20.8**	0–240	50.0	50.0	**W50G3‡**	3-Gang, uncased, Wye circuit		163	206	3150-5130	**397.00**	22.00
240	**25.8**	0–280	40.0	62.0	**W50HG4BBM**	4-Gang, cased, Open Delta	2	255	328	3160-5241	**604.00**	—
240	**27.0**	0–280	50.0	65.0	**W50HG4BB**	4-Gang, uncased, Open Delta	2	230	300	3160-5240	**556.00**	—
240	**37.4**	0–240	80.0	90.0	**W50G6BBM‡**	6-Gang, cased, Wye circuit	3	355	430	3150-5261	**887.00**	—
240	**41.6**	0–240	100.0	100.0	**W50G6BB‡**	6-Gang, uncased, Wye circuit	3	325	400	3150-5260	**833.00**	—
480	**2.16**	0–480	2.0	2.6	**W5HG3‡**	3-Gang, uncased, Wye circuit		20½	22	3040-5130	**71.50**	15.00
480	**2.16**	0–480	2.0	2.6	**W5HG3M‡**	3-Gang, cased, Wye circuit		22	31	3040-5131	**84.50**	15.00
480	**4.32**	0–480	4.0	5.2	**W10HG3‡**	3-Gang, uncased, Wye circuit		36	39	3070-5130	**114.00**	18.00
480	**4.32**	0–480	4.0	5.2	**W10HG3M‡**	3-Gang, cased, Wye circuit		42	46	3070-5131	**135.00**	18.00
480	**8.65**	0–480	8.0	10.4	**W20HG3‡**	3-Gang, uncased, Wye circuit		61	68	3100-5130	**162.00**	18.00
480	**8.65**	0–480	8.0	10.4	**W20HG3M‡**	3-Gang, cased, Wye circuit		67	79	3100-5131	**188.00**	18.00
480	**13.0**	0–480	12.0	15.6	**W30HG3‡**	3-Gang, uncased, Wye circuit		90½	107	3130-5130	**264.00**	22.00
480	**13.0**	0–480	12.0	15.6	**W30HG3M‡**	3-Gang, cased, Wye circuit		97	120	3130-5131	**299.00**	22.00
480	**25.8**	0–480	20.0	31.0	**W50HG3M‡**	3-Gang, cased, Wye circuit		183	230	3160-5131	**442.00**	22.00
480	**27.0**	0–480	25.0	32.5	**W50HG3‡**	3-Gang, uncased, Wye circuit		167	214	3160-5130	**397.00**	22.00
480	**51.5**	0–480	40.0	62.0	**W50HG6BBM‡**	6-Gang, cased, Wye circuit	3	385	458	3160-5261	**887.00**	—
480	**54.0**	0–480	50.0	65.0	**W50HG6BB‡**	6-Gang, uncased, Wye circuit	3	355	428	3160-5260	**833.00**	—

NOTES

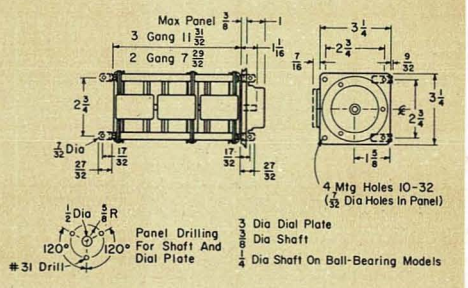
A. Maximum current can be drawn at maximum voltage for the line-voltage connection only. KVA, as listed, = normal input line voltage times maximum current.
B. P = parallel windings; S = series windings.
C. When ordering a unit with ball bearings, add the suffix "BB" to the type number and change the sixth digit of the catalog number to 2. Example: for Type W2G3 with ball bearings, order Type W2G3BB, catalog number 3010-5230.

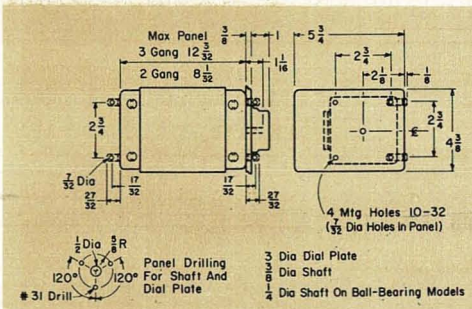
* For 60-cycle use only; no overvoltage connection provided.
† Do not use with grounded load.
‡ Overvoltage connection not recommended.
§ Can be used in wye connection on 208-volt, 60-cycle, 3-phase line.

DIMENSIONS† of W-SERIES GANGED VARIAC® AUTOTRANSFORMER ASSEMBLIES

W2

Ganged Types W2G2, W2G3 (uncased).

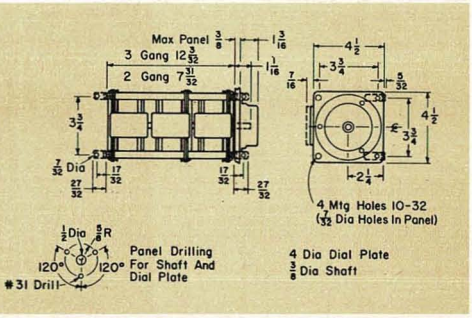


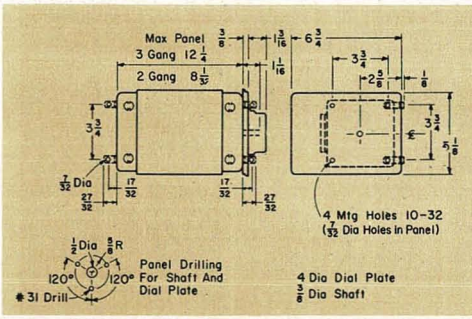


Ganged Types W2G2M, W2G3M (cased).

W5

Ganged Types W5G2, W5G3, W5HG2, W5HG3, W5LG2, W5LG3 (uncased).

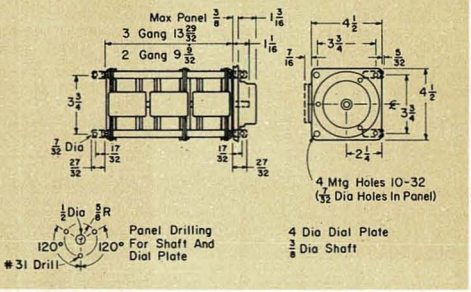




Ganged Types W5G2M, W5G3M, W5HG2M, W5HG3M, W5LG2M, W5LG3M (cased).

W8

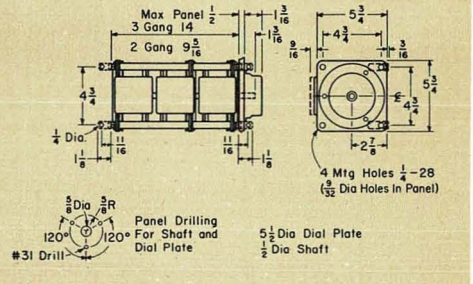
Ganged Types W8G2, W8G3, W8LG2, W8LG3 (uncased).

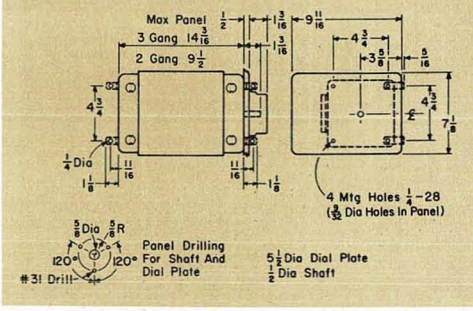


TYPES W8 and W8L VARIAC® autotransformers are available in uncased (basic) models only. They offer increased ratings over those of the TYPE W5 models but occupy the same panel space, with a slight increase in depth behind panel.

W10

Ganged Types W10G2, W10G3, W10HG2, W10HG3 (uncased).

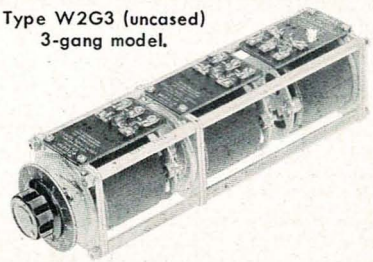


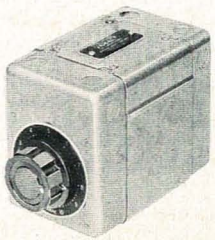


Ganged Types W10G2M, W10G3M, W10HG2M, W10HG3M (cased).

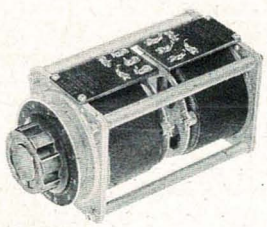
† Given in inches; to convert to mm, multiply by 25.4.

Type W2G3 (uncased) 3-gang model.





Type W5G2M (cased) 2-gang model.



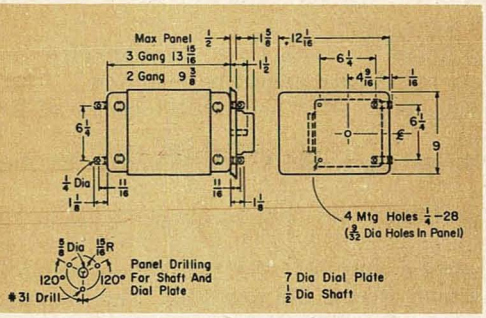
Type W8G2 (uncased) 2-gang model.

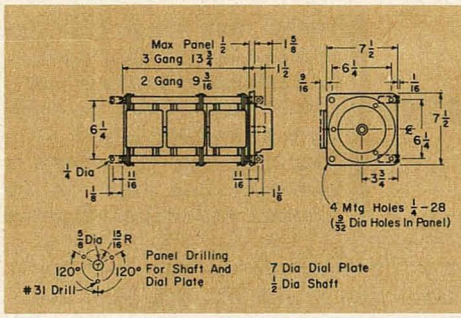
Type W10G3M (cased) 3-gang model.

DIMENSIONS† of W-SERIES GANGED VARIAC® AUTOTRANSFORMER ASSEMBLIES

W20

Ganged Types W20G2M, W20G3M, W20HG2M, W20HG3M (cased).

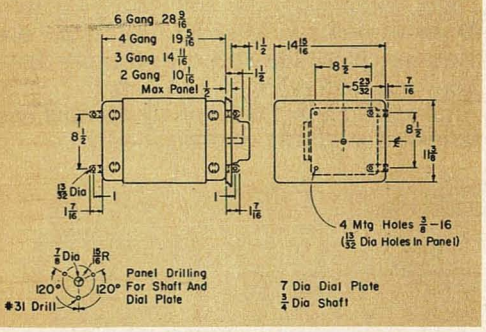


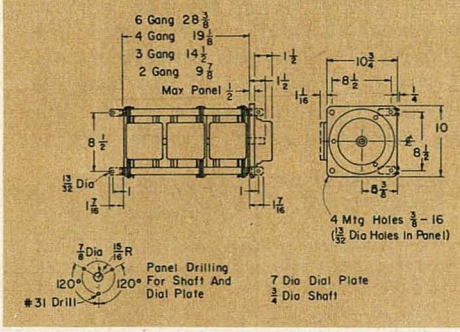


Ganged Types W20G2, W20G3, W20HG2, W20HG3 (uncased).

W30

Ganged Types W30G2M, W30G3M, W30G4M, W30G6M, W30HG2M, W30HG3M, W30HG4M, W30HG6M (cased).

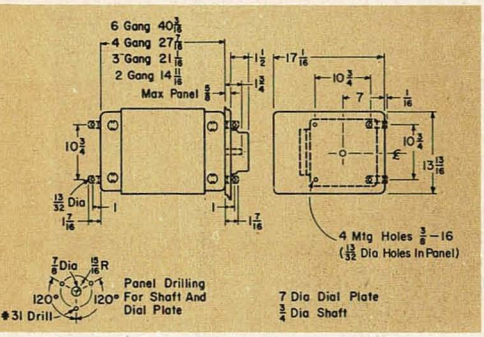


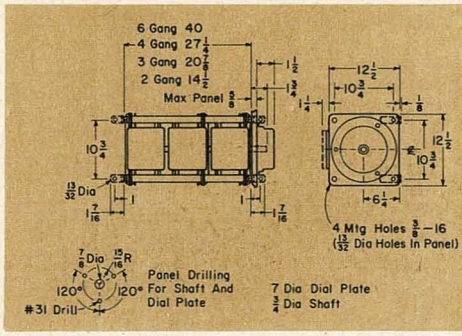


Ganged Types W30G2, W30G3, W30G4, W30G6, W30HG2, W30HG3, W30HG4, W30HG6 (uncased).

W50

Ganged Types W50G2M, W50G3M, W50G4M, W50G6M, W50HG2M, W50HG3M, W50HG4M, W50HG6M (cased).

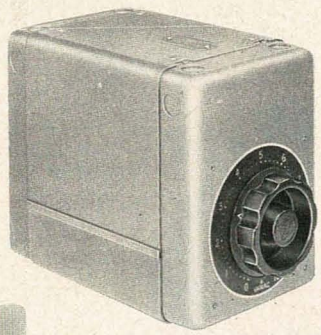




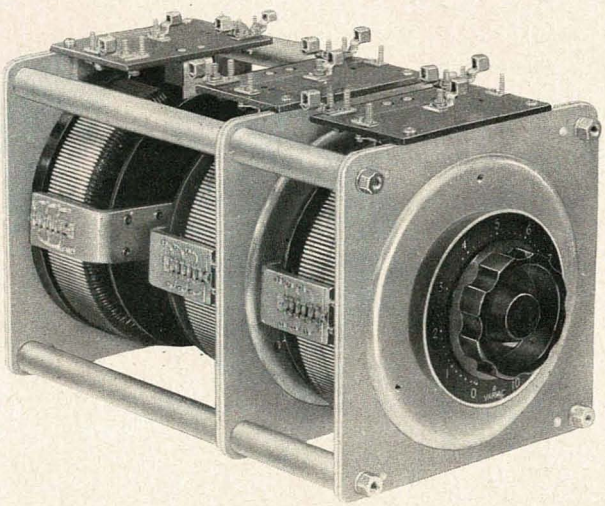
Ganged Types W50G2, W50G3, W50G4, W50G6, W50HG2, W50HG3, W50HG4, W50HG6 (uncased).

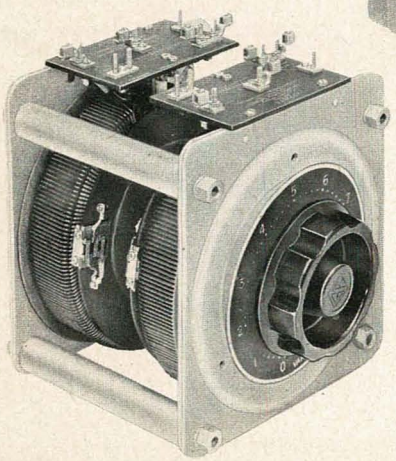
† Given in inches; to convert to mm, multiply by 25.4.

Type W20G3M (cased) 3-gang model.



Type W50G3 (uncased) 3-gang model.





Type W30G2 (uncased) 2-gang model.

M-SERIES VARIAC® ADJUSTABLE AUTOTRANSFORMERS

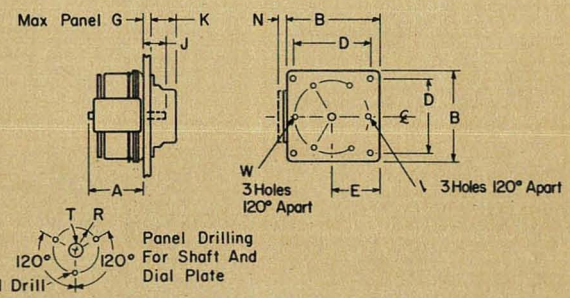
FOR 350- TO 1200-CYCLE SERVICE

FEATURES:

- Usable from 350 to 1200 cycles per second.
- DURATRAK® contact surface provides an extra factor of reliability under overloads.
- Instantaneous peaks of ten times rated current can be tolerated.
- Brush track shows no significant wear after one million cycles of brush operation (zero to maximum and return).
- Manufactured to conform with certain military specifications for shock, vibration, salt-spray, and tropicalization.
- Contain wide-temperature-range lubrication that meets most military specifications.

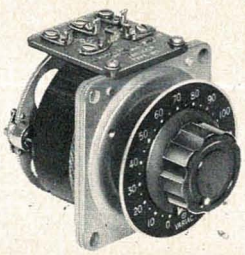
The M-series VARIAC® autotransformers are the high-frequency equivalents of the TYPES W2, W5, W10 and W20; they are designed for frequencies from 350 to 1200 c/s. Mechanically similar to the 60-cycle models, the M-series models are much smaller and lighter. The regulation obtained with the M-series models is considerably better at 400 c/s than that of the 60-cycle models operated at 400 c/s. Available in 2-, 5-, 10-, and 20-ampere single units or in gangs, M-series models can be supplied with ball bearings and 60-cycle motor drives (pages 248 and 244). The 2-ampere sizes (TYPE M2) have 400 turns, giving adequate resolution for many computing and controlling operations. Both the W-series and the M-series models are designed to provide excellent thermal conductivity between coil and base and between base and panel.

In addition to the regularly stocked models, modified units are available on special order.

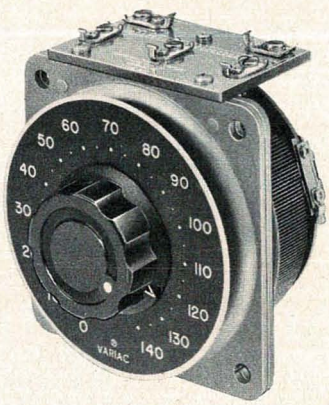


TYPE	A	B	D	E	G	J	K	N	P	R	T	V	W
M2	2 11/16"	3 1/4"	2 3/4"	1 5/8"	3/8"	1 1/16"	1"	7/16"	3/8"	5/8"	1/2"	10-32	—
M5	2 11/16"	4 1/2"	3 3/4"	2 1/4"	3/8"	1 1/16"	1 3/16"	7/16"	3/8"	5/8"	1/2"	—	10-32
M10	3 7/16"	5 3/4"	4 3/4"	2 7/8"	1/2"	1 3/16"	1 3/16"	9/16"	1/2"	5/8"	5/8"	—	1/4-28
M20	3 5/8"	7 1/2"	6 1/4"	3 3/4"	1/2"	1 1/2"	1 5/8"	9/16"	1/2"	15/16"	5/8"	—	1/4-28

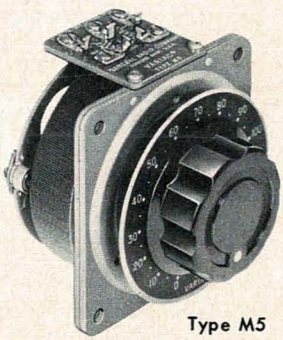
To convert to mm, multiply by 25.4.



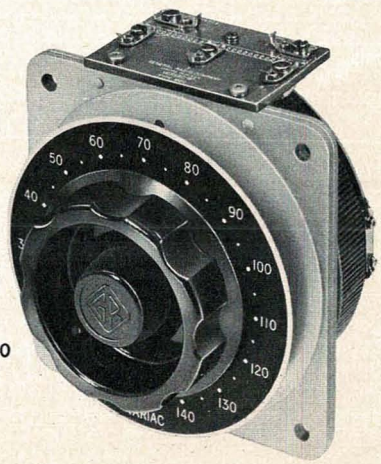
Type M2



Type M10



Type M5



Type M20

M-SERIES GANGED VARIAC® AUTOTRANSFORMER ASSEMBLIES

M-series models are available as two-gang assemblies for 120-volt, three-phase, open-delta connection (or for controlling two circuits from a single shaft) and as three-gang assemblies for 208- or 240-volt, three-phase, wye connection (or for controlling three circuits from a single shaft). Dials for ganged models are marked 0 to 10.

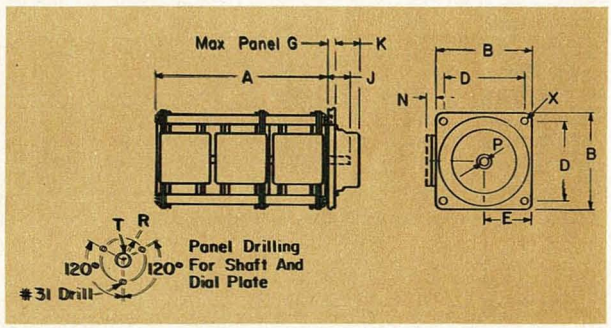
A TYPE 50-P1 Choke is required when a two-gang unit is to be operated in parallel; for three-gang parallel combinations, a TYPE 50-P2 Choke is required in addition to the TYPE 50-P1.

RATINGS AND PRICE LIST FOR M-SERIES SINGLE UNITS (UNCASED)

Catalog Number	Type	Rated Input Voltage	OUTPUT: Line-Voltage Connection: Output kV A at Maximum Output Voltage (Note A)	Line-Voltage Connection: Rated Output Current Amperes	Line-Voltage Connection: Output Voltage Range	Line-Voltage Connection: Maximum Output Current Amperes (Note A)	Overvoltage Connection: Output Voltage Range	Overvoltage Connection: Rated Current Amperes (Note B)	400-Cycle No-Load Loss Watts	Driving Torque Ounce-Inches	Net Weight Pounds	Shipping Weight Pounds (Approx)	Price	Add for Replacement Brush	Add for Ball Bearings*
3410-5110	**M2**†	120	0.37	2.4	0–120	3.1	0–140	2.4	3.5	5–10	2	3	**$15.50**	VB1 80¢	**$8.00**
3430-5110	**M5**†	120	0.94	6	0–120	7.8	0–140	6	9	10–20	3½	4	**18.50**	VB2 80¢	**$8.00**
3460-5110	**M10**†	120	1.56	10	0–120	13	0–140	10	17	15–30	6½	8	**35.00**	VBT10 $1.35	**$9.00**
3490-5110	**M20**†	120	3.12	20	0–120	26	0–140	20	27	45–90	13	15	**54.00**	VBT8 $2.50	**$9.00**

A. Maximum current can be drawn at maximum voltage for the line-voltage connection only. Maximum output voltage = line input voltage. KVA as listed = normal input line voltage × maximum current.
B. Rated current should not be exceeded for the overvoltage connection. Output kVA for overvoltage connection = output voltage × rated current.
• When ordering a unit with ball bearings, add the suffix "-BB" to the type number and change the sixth digit of the catalog number to 2. Example: for TYPE M20G3 with ball bearings, order TYPE M20G3BB, catalog number 3490-5230.
† Approved by Canadian Standards Association.

Type	A	B	D	E	G	J	K	N	P	R	T	X
M2G2	5 13/32"	3¼"	2¾"	1⅝"	⅜"	1 1/16"	1"	7/16"	⅜"	⅝"	½"	10-32
M2G3	8 7/32"	3¼"	2¾"	1⅝"	⅜"	1 1/16"	1"	7/16"	⅜"	⅝"	½"	10-32
M5G2	5 15/32"	4½"	3¾"	2¼"	⅜"	1 1/16"	1 3/16"	7/16"	⅜"	⅝"	½"	10-32
M5G3	8 11/32"	4½"	3¾"	2¼"	⅜"	1 1/16"	1 3/16"	7/16"	⅜"	⅝"	½"	10-32
M10G2	6 13/16"	5¾"	4¾"	2⅞"	½"	1 3/16"	1 3/16"	9/16"	½"	⅝"	⅝"	¼-28
M10G3	10¼"	5¾"	4¾"	2⅞"	½"	1 3/16"	1 3/16"	9/16"	½"	⅝"	⅝"	¼-28
M20G2	7 3/16"	7½"	6¼"	3¾"	½"	1½"	1⅝"	9/16"	½"	15/16"	⅝"	¼-28
M20G3	10¾"	7½"	6¼"	3¾"	½"	1½"	1⅝"	9/16"	½"	15/16"	⅝"	¼-28



PRICE LIST FOR M-SERIES GANGED ASSEMBLIES (UNCASED)

Catalog Number	Type	Description	Driving Torque (Oz-In)	Net Weight (Pounds)	Shipping Weight (Pounds)	Price	Add for Ball Bearings*
3410-5120	**M2G2**	2-Gang M2	10–20	3¾	5	**$37.00**	**$13.00**
3410-5130	**M2G3**	3-Gang M2	15–30	5½	7	**53.50**	**15.00**
3430-5120	**M5G2**	2-Gang M5	20–40	6¾	8	**43.00**	**13.00**
3430-5130	**M5G3**	3-Gang M5	30–60	10¼	12	**62.50**	**15.00**
3460-5120	**M10G2**	2-Gang M10	30–60	12¼	16	**77.00**	**15.00**
3460-5130	**M10G3**	3-Gang M10	45–90	19	23	**114.00**	**18.00**
3490-5120	**M20G2**	2-Gang M20	90–180	26½	30	**115.00**	**15.00**
3490-5130	**M20G3**	3-Gang M20	135–270	38	43	**171.00**	**18.00**
0050-9601	**Type 50-P1**	Choke	—	1¼	1¾	**16.00**	—
0050-9602	**Type 50-P2**	Choke	—	1¼	1¾	**16.00**	—

• When ordering a unit with ball bearings, add the suffix "BB" to the type number and change the sixth digit of the catalog number to 2. Example: for TYPE M20G3 with ball bearings, order TYPE M20G3BB, catalog number 3490-5230.

MOTOR-DRIVEN VARIAC® ADJUSTABLE AUTOTRANSFORMERS

For remote-adjustment applications, all W- and M-series VARIAC® autotransformers can be supplied with motor drives. The motor-driven assemblies include a totally enclosed, two-phase, gear-reduction motor of the servo type, limit switches, a phase-shift capacitor, and a VARIAC autotransformer equipped with ball bearings.

Limit switches are included on all models and are adjusted to limit the traverse to approximately 320°. If desired, the limit switches may be omitted from the 2-, 4-, 8-, and 16-second models.* The W-series, motor-driven models are available as either open or totally enclosed assemblies; the M-series models are available in open mounting only. Non-standard, motor-driven models are available on special order.

For remote-positioning applications, a packaged control, TYPE 1590-A, is available (see page 248).

The tables on pages 246 and 247 indicate the available combinations of the standard models. When less than five units of any one model are ordered, the indicated setup charge is to be prorated over the quantity of one to four.

* If limit switches are not desired, omit "K" from type number and subtract $7.00 from listed price.

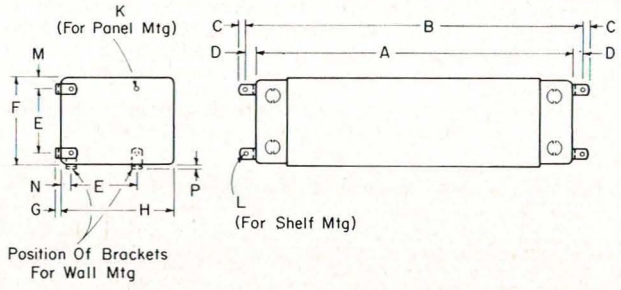
MOTOR SPECIFICATIONS

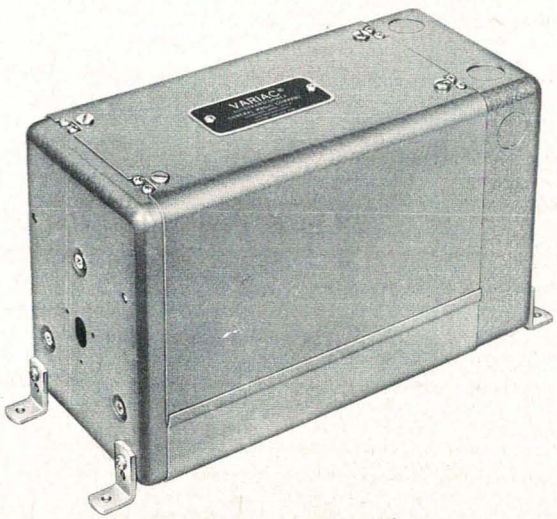
Supply: 120 V, 60 c/s.
Impedance: 2500 Ω
Inductive Reactance: 2200 Ω
Ac Resistance: 1300 Ω
} for each winding, at 60 c/s.
Dc Resistance: 575 Ω.
Traverse: 320°.
Traverse Times Available: 2, 4, 8, 16, 32, 64, and 128 seconds at 60 c/s. For 50-cycle supply, multiply by 5/6.

DIMENSIONS† OF MOTOR-DRIVEN MODELS (CASED)

	A	B	C	D	E	F	G	H	K	L	M	N	P
W2 Single	10 19/32	11 21/32	5/16	17/32	2 3/4	4 3/8	1/8	5 3/4	10–32	7/32 Drill	13/16	3/4	1/16
W2 2-Gang	13 23/32	14 25/32	5/16	17/32	2 3/4	4 3/8	1/8	5 3/4	10–32	7/32 Drill	13/16	3/4	1/16
W2 3-Gang	17 25/32	18 27/32	5/16	17/32	2 3/4	4 3/8	1/8	5 3/4	10–32	7/32 Drill	13/16	3/4	1/16
W5 Single	10 23/32	11 25/32	5/16	17/32	3 3/4	5 1/8	1/8	6 3/4	10–32	7/32 Drill	11/16	3/4	3/16
W5 2-Gang	13 27/32	14 29/32	5/16	17/32	3 3/4	5 1/8	1/8	6 3/4	10–32	7/32 Drill	11/16	3/4	3/16
W5 3-Gang	17 31/32	19 1/32	5/16	17/32	3 3/4	5 1/8	1/8	6 3/4	10–32	7/32 Drill	11/16	3/4	3/16
W10 Single	12 5/16	13 11/16	7/16	11/16	4 3/4	7 1/8	5/16	9 11/16	1/4–28	9/32 Drill	1 3/16	1 1/4	5/16
W10 2-Gang	15 7/8	17 1/4	7/16	11/16	4 3/4	7 1/8	5/16	9 11/16	1/4–28	9/32 Drill	1 3/16	1 1/4	5/16
W10 3-Gang	20 9/16	21 15/16	7/16	11/16	4 3/4	7 1/8	5/16	9 11/16	1/4–28	9/32 Drill	1 3/16	1 1/4	5/16
W20 Single	12 1/16	13 7/16	7/16	11/16	6 1/4	9	1/16	12 1/16	1/4–28	9/32 Drill	1 3/8	1 3/8	1/8
W20 2-Gang	15 5/8	17	7/16	11/16	6 1/4	9	1/16	12 1/16	1/4–28	9/32 Drill	1 3/8	1 3/8	1/8
W20 3-Gang	20 3/16	21 9/16	7/16	11/16	6 1/4	9	1/16	12 1/16	1/4–28	9/32 Drill	1 3/8	1 3/8	1/8
W30 Single	12 5/16	14 5/16	7/16	1	8 1/2	11 3/8	3/16	14 15/16	3/8–16	13/32 Drill	1 7/16	1 1/2	1/4
W30 2-Gang	15 15/16	17 15/16	7/16	1	8 1/2	11 3/8	3/16	14 15/16	3/8–16	13/32 Drill	1 7/16	1 1/2	1/4
W30 3-Gang	20 9/16	22 9/16	7/16	1	8 1/2	11 3/8	3/16	14 15/16	3/8–16	13/32 Drill	1 7/16	1 1/2	1/4
W50 Single	14 11/16	16 11/16	7/16	1	10 3/4	13 13/16	1/4	17 1/16	3/8–16	13/32 Drill	1 1/2	1 5/8	5/16
W50 2-Gang	21 1/16	23 1/16	7/16	1	10 3/4	13 13/16	1/4	17 1/16	3/8–16	13/32 Drill	1 1/2	1 5/8	5/16
W50 3-Gang	27 7/16	29 7/16	7/16	1	10 3/4	13 13/16	1/4	17 1/16	3/8–16	13/32 Drill	1 1/2	1 5/8	5/16

† Given in inches; to convert to mm, multiply by 25.4.



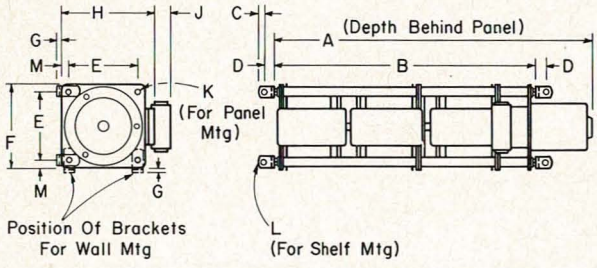


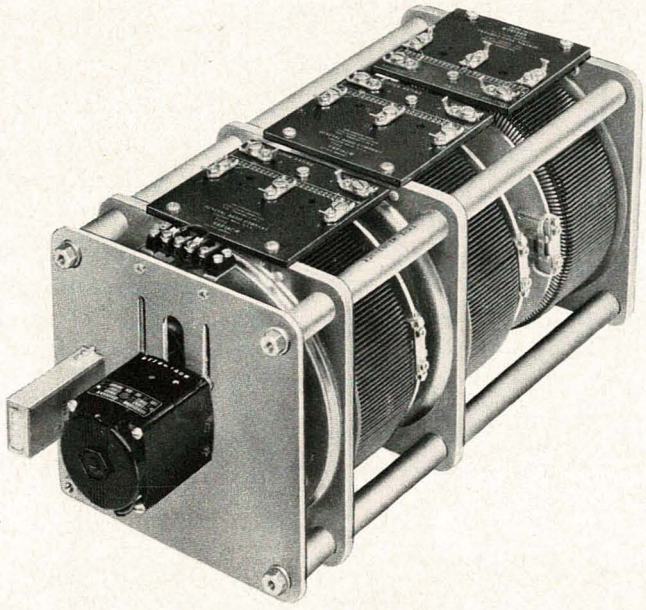
2-Gang W5 motor-driven model, with case.

DIMENSIONS† OF MOTOR-DRIVEN UNCASED MODELS

	A	B	C	D	E	F	G	H	J	K	L	M
W-SERIES MODELS												
W2 Single	9 3/8	6 13/16	5/16	17/32	2 3/4	3 1/4	9/32	3 11/16	7/8	10–32	7/32 Drill	1/4
W2 2-Gang	12 1/2	9 17/32	5/16	17/32	2 3/4	3 1/4	9/32	3 11/16	7/8	10–32	7/32 Drill	1/4
W2 3-Gang	16 9/16	13 19/32	5/16	17/32	2 3/4	3 1/4	9/32	3 11/16	7/8	10–32	7/32 Drill	1/4
W5 Single	9 7/16	6 15/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
W5 2-Gang	12 9/16	9 19/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
W5 3-Gang	16 11/16	13 23/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
W8 Single	9 15/16	6 31/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
W8 2-Gang	13 7/8	10 29/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
W8 3-Gang	18 1/2	15 17/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
W10 Single	10 9/32	7 7/16	7/16	11/16	4 3/4	5 3/4	3/16	6 5/16	—	1/4–28	9/32 Drill	1/2
W10 2-Gang	13 27/32	11	7/16	11/16	4 3/4	5 3/4	3/16	6 5/16	—	1/4–28	9/32 Drill	1/2
W10 3-Gang	18 17/32	15 11/16	7/16	11/16	4 3/4	5 3/4	3/16	6 5/16	—	1/4–28	9/32 Drill	1/2
W20 Single	10 5/32	7 5/16	7/16	11/16	6 1/4	7 1/2	1/16	8 1/16	—	1/4–28	9/32 Drill	5/8
W20 2-Gang	13 23/32	10 7/8	7/16	11/16	6 1/4	7 1/2	1/16	8 1/16	—	1/4–28	9/32 Drill	5/8
W20 3-Gang	18 9/32	15 7/16	7/16	11/16	6 1/4	7 1/2	1/16	8 1/16	—	1/4–28	9/32 Drill	5/8
W30 Single	10 3/4	6 1/4	7/16	1	8 1/2	10	1/8	11 13/16	—	3/8–16	13/32 Drill	3/4
W30 2-Gang	14 3/8	9 7/8	7/16	1	8 1/2	10	1/8	11 13/16	—	3/8–16	13/32 Drill	3/4
W30 3-Gang	19	14 1/2	7/16	1	8 1/2	10	1/8	11 13/16	—	3/8–16	13/32 Drill	3/4
W50 Single	12 5/8	8 1/16	7/16	1	10 3/4	12 1/2	1/8	13 3/4	—	3/8–16	13/32 Drill	7/8
W50 2-Gang	19 1/16	14 1/2	7/16	1	10 3/4	12 1/2	1/8	13 3/4	—	3/8–16	13/32 Drill	7/8
W50 3-Gang	25 7/16	20 7/8	7/16	1	10 3/4	12 1/2	1/8	13 3/4	—	3/8–16	13/32 Drill	7/8
M-SERIES MODELS												
M2 Single	8 1/8	5 5/32	5/16	17/32	2 3/4	3 1/4	9/32	3 11/16	7/8	10–32	7/32 Drill	1/4
M2 2-Gang	10	7 1/32	5/16	17/32	2 3/4	3 1/4	9/32	3 11/16	7/8	10–32	7/32 Drill	1/4
M2 3-Gang	12 13/16	9 27/32	5/16	17/32	2 3/4	3 1/4	9/32	3 11/16	7/8	10–32	7/32 Drill	1/4
M5 Single	8 3/16	5 7/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
M5 2-Gang	10 1/16	7 3/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
M5 3-Gang	12 15/16	9 31/32	5/16	17/32	3 3/4	4 1/2	5/32	4 15/16	—	10–32	7/32 Drill	3/8
M10 Single	9 1/32	6 3/16	7/16	11/16	4 3/4	5 3/4	3/16	6 5/16	—	1/4–28	9/32 Drill	1/2
M10 2-Gang	11 11/32	8 1/2	7/16	11/16	4 3/4	5 3/4	3/16	6 5/16	—	1/4–28	9/32 Drill	1/2
M10 3-Gang	14 25/32	11 15/16	7/16	11/16	4 3/4	5 3/4	3/16	6 5/16	—	1/4–28	9/32 Drill	1/2
M20 Single	9 5/32	6 5/16	7/16	11/16	6 1/4	7 1/2	1/16	8 1/16	—	1/4–28	9/32 Drill	5/8
M20 2-Gang	11 23/32	8 7/8	7/16	11/16	6 1/4	7 1/2	1/16	8 1/16	—	1/4–28	9/32 Drill	5/8
M20 3-Gang	15 9/32	12 7/16	7/16	11/16	6 1/4	7 1/2	1/16	8 1/16	—	1/4–28	9/32 Drill	5/8

Refer to following pages for prices of motor-driven models.
† Given in inches; to convert to mm, multiply by 25.4.





3-gang W20 motor-driven model.

SPECIFICATIONS AND PRICES[1] FOR MOTOR-DRIVEN **VARIAC®** AUTOTRANSFORMERS

MOTOR	*STANDARD EXTERNAL GEAR RATIOS*								*Add to Type Number*[3]				
All Motors Shown Are 60-Cycle A	2:1	4:1											
B			2:1	4:1	8:1								
C						2:1	4:1	8:1					
Seconds for 320° Traverse[2]	2	4	8	16	32	32	64	128					
Add to Type Number[3]	D2	D4	D8	D16	D32	D32	D64	D128	*Capacitor*	*Limit Switch*	*Cased Model*	*Set-Up Charge Prorated 1–4 Units*	*Add for Case*
TYPE[3]													
M2	$105.50	$105.50	$105.50	$105.50	NA	$105.50	$105.50	SO	C	K		$ 6.00	NA
M2G2	132.00	132.00	132.00	132.00	NA	132.00	132.00	SO	C	K		6.00	NA
M2G3	NA	150.50	150.50	150.50	NA	150.50	150.50	SO	C	K		6.00	NA
M5	108.50	108.50	108.50	108.50	NA	108.50	108.50	SO	C	K		6.00	NA
M5G2	138.00	138.00	138.00	138.00	NA	138.00	138.00	SO	C	K		6.00	NA
M5G3	NA	159.50	159.50	159.50	NA	159.50	159.50	SO	C	K		6.00	NA
M10	149.00	149.00	149.00	149.00	$149.00	NA	149.00	$149.00	C	K		12.00	NA
M10G2	NA	197.00	197.00	197.00	197.00	NA	197.00	197.00	C	K		12.00	NA
M10G3	NA	NA	237.00	237.00	237.00	NA	237.00	237.00	C	K		12.00	NA
M20	SO	173.00	173.00	173.00	173.00	NA	173.00	173.00	C	K		12.00	NA
M20G2	SO	SO	240.00	240.00	240.00	NA	240.00	240.00	C	K		12.00	NA
M20G3	NA	SO	299.00	299.00	299.00	NA	299.00	299.00	C	K		12.00	NA
W2	105.00	105.00	105.00	105.00	NA	105.00	105.00	SO	C	K	M	6.00	$12.00
W2G2	131.00	131.00	131.00	131.00	NA	131.00	131.00	SO	C	K	M	6.00	13.00
W2G3	NA	149.00	149.00	149.00	NA	149.00	149.00	SO	C	K	M	6.00	14.00
W5	108.00	108.00	108.00	108.00	NA	108.00	108.00	SO	C	K	M	6.00	16.00
W5G2	137.00	137.00	137.00	137.00	NA	137.00	137.00	SO	C	K	M	6.00	17.00
W5G3	NA	158.00	158.00	158.00	NA	158.00	158.00	SO	C	K	M	6.00	18.00
W5L	107.50	107.50	107.50	107.50	NA	107.50	107.50	SO	C	K	M	6.00	16.00
W5LG2	136.00	136.00	136.00	136.00	NA	136.00	136.00	SO	C	K	M	6.00	17.00
W5LG3	NA	156.50	156.50	156.50	NA	156.50	156.50	SO	C	K	M	6.00	18.00
W5H	111.50	111.50	111.50	111.50	NA	111.50	111.50	SO	C	K	M	6.00	16.00
W5HG2	144.00	144.00	144.00	144.00	NA	144.00	144.00	SO	C	K	M	6.00	17.00
W5HG3	NA	168.50	168.50	168.50	NA	168.50	168.50	SO	C	K	M	6.00	18.00
W8	111.00	111.00	111.00	111.00	NA	111.00	111.00	SO	C	K		6.00	NA
W8G2	143.00	143.00	143.00	143.00	NA	143.00	143.00	SO	C	K		6.00	NA
W8G3	NA	167.00	167.00	167.00	NA	167.00	167.00	SO	C	K		6.00	NA
W8L	111.00	111.00	111.00	111.00	NA	111.00	111.00	SO	C	K		6.00	NA
W8LG2	143.00	143.00	143.00	143.00	NA	143.00	143.00	SO	C	K		6.00	NA
W8LG3	NA	167.00	167.00	167.00	NA	167.00	167.00	SO	C	K		6.00	NA
W10	139.00	139.00	139.00	139.00	139.00	NA	139.00	139.00	C	K	M	12.00	32.00
W10G2	NA	185.00	185.00	185.00	185.00	NA	185.00	185.00	C	K	M	12.00	33.00
W10G3	NA	NA	223.00	223.00	223.00	NA	223.00	223.00	C	K	M	12.00	34.00
W10H	141.00	141.00	141.00	141.00	141.00	NA	141.00	141.00	C	K	M	12.00	32.00
W10HG2	NA	189.00	189.00	189.00	189.00	NA	189.00	189.00	C	K	M	12.00	33.00
W10HG3	NA	NA	229.00	229.00	229.00	NA	229.00	229.00	C	K	M	12.00	34.00
Torque — Ounce-Inches	30	60	120	240	480	240	480	960					

NOTES

NA = not available. SO = available on special order only; prices on request.
Note: Limit switches, capacitors, and ball bearings are included in the above prices. If limit switches are not desired, omit "K" from type number and subtract $7.00 from listed price. Limit switches are mandatory with C motor.

[1] Prices in table are for quantities of 5 or more. Add appropriate set-up charge for quantities of 1 to 4.
[2] Traverse speeds are nominal for 60-cycle supply. Actual speeds may vary ±15% from these values. Specify speed on order (e.g. D4, D32, etc.).
[3] See page 231 for example of type numbers.

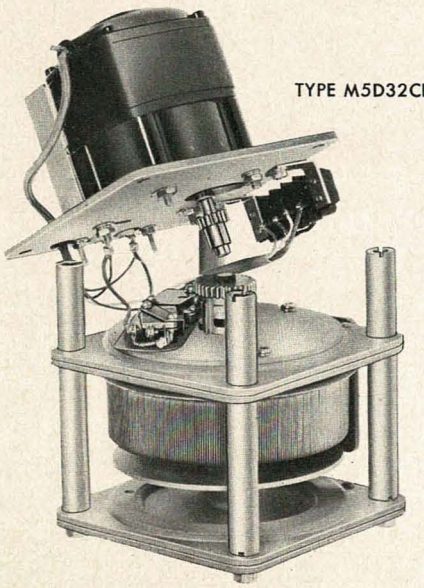
SPECIFICATIONS AND PRICES[1]
FOR MOTOR-DRIVEN MODELS (cont)

MOTOR	STANDARD EXTERNAL GEAR RATIOS								Add to Type Number[3]				
All Motors Shown Are 60-Cycle — A	2:1	4:1											
B			2:1	4:1	8:1								
C						2:1	4:1	8:1					
Seconds for 320° Traverse[2]	2	4	8	16	32	32	64	128					
Add to Type Number[3]	D2	D4	D8	D16	D32		D64	D128	Capacitor	Limit Switch	Cased Model	Set-Up Charge Prorated 1–4 Units	Add for Case
TYPE[3] W20	SO	$159.00	$159.00	$159.00	$159.00	NA	$159.00	$159.00	C	K	M	$12.00	$35.00
W20G2	SO	SO	223.00	223.00	223.00	NA	223.00	223.00	C	K	M	12.00	37.00
W20G3	NA	SO	276.00	276.00	276.00	NA	276.00	276.00	C	K	M	12.00	39.00
W20H	SO	161.00	161.00	161.00	161.00	NA	161.00	161.00	C	K	M	12.00	35.00
W20HG2	SO	SO	227.00	227.00	227.00	NA	227.00	227.00	C	K	M	12.00	37.00
W20HG3	NA	SO	282.00	282.00	282.00	NA	282.00	282.00	C	K	M	12.00	39.00
W30	SO	214.00	214.00	214.00	214.00	NA	214.00	214.00	C	K	M	12.00	49.00
W30G2	NA	SO	SO	311.00	311.00	NA	311.00	311.00	C	K	M	12.00	54.00
W30G3	NA	NA	SO	SO	395.50	NA	395.50	395.50	C	K	M	12.00	59.00
W30H	SO	214.00	214.00	214.00	214.00	NA	214.00	214.00	C	K	M	12.00	49.00
W30HG2	NA	SO	SO	311.00	311.00	NA	311.00	311.00	C	K	M	12.00	54.00
W30HG3	NA	NA	SO	SO	395.50	NA	395.50	395.50	C	K	M	12.00	59.00
W50	NA	SO	SO	262.00	262.00	NA	262.00	262.00	C	K	M	12.00	55.00
W50G2	NA	NA	SO	SO	396.00	NA	396.00	396.00	C	K	M	12.00	60.00
W50G3	NA	NA	SO	SO	529.00	NA	529.00	529.00	C	K	M	12.00	65.00
W50G4	NA	NA	NA	SO	SO	NA	SO	666.00	C	K	M	12.00	68.00
W50G6	NA	NA	NA	NA	SO	NA	SO	943.00	C	K	M	12.00	74.00
W50H	NA	SO	SO	262.00	262.00	NA	262.00	262.00	C	K	M	12.00	55.00
W50HG2	NA	NA	SO	SO	396.00	NA	396.00	396.00	C	K	M	12.00	60.00
W50HG3	NA	NA	SO	SO	529.00	NA	529.00	529.00	C	K	M	12.00	65.00
W50HG4	NA	NA	NA	SO	SO	NA	SO	666.00	C	K	M	12.00	68.00
W50HG6	NA	NA	NA	NA	SO	NA	SO	943.00	C	K	M	12.00	74.00
Torque — Ounce--Inches	30	60	120	240	480		480	960					

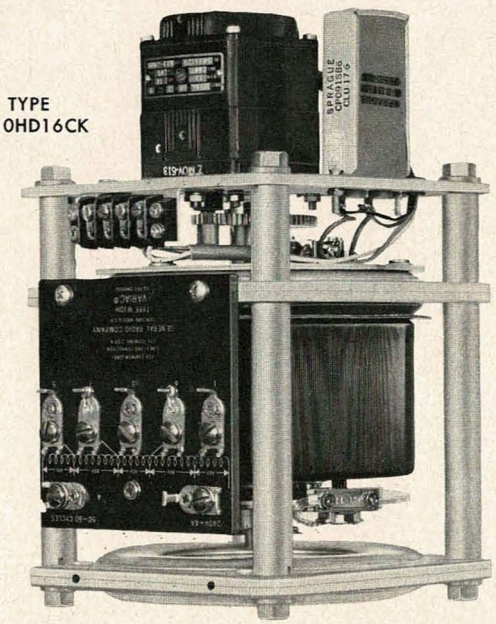
NOTES

NA = not available. SO = available on special order only; prices on request.
Note: Limit switches, capacitors, and ball bearings are included in the above prices. If limit switches are not desired, omit "K" from type number and subtract $7.00 from listed price. Limit switches are mandatory with C motor.

[1] Prices in table are for quantities of 5 or more. Add appropriate set-up charge for quantities of 1 to 4.
[2] Traverse speeds are nominal for 60-cycle supply. Actual speeds may vary ±15% from these values.
[3] See page 231 for example of type numbers.



TYPE M5D32CK



TYPE W10HD16CK

BALL BEARINGS

W-series and M-series models can be supplied with ball bearings, which provide more precise alignment with slightly lower and more nearly constant torque.

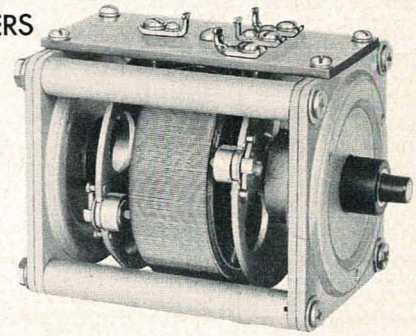
When ordering VARIAC® autotransformers equipped with ball bearings, add the suffix "BB" to the type number, and add the price shown in the tables.

Ball bearings are standard equipment on motor-driven units and on 4- and 6-gang, W30 and W50 models, and are included in the price.

SPECIAL VARIAC® AUTOTRANSFORMERS

Special models can be supplied to meet specific requirements, such as additional winding taps, fungicide treatment, special shaft lengths, or with voltage outputs or ranges differing from those of standard models. They can also be supplied on special order less knob, dial, etc., at lower net prices and with slightly extended delivery time.

The General Radio Company welcomes inquiries on special models, and is glad to furnish them when the quantities involved are sufficient to make production economically practicable.



Type M2S16

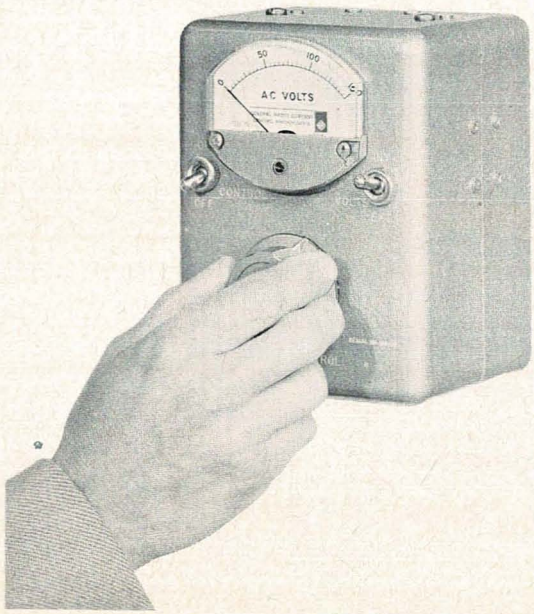
Type 1590-A REMOTE CONTROL

The TYPE 1590-A Remote Control is a simple, accurate, servo control for the remote positioning of a motor-driven VARIAC® autotransformer. It can be set for any desired voltage from zero to 140 volts. The remote, motor-driven autotransformer will automatically position itself for the same voltage, indicated on the panel meter.

Any change in output voltage due to VARIAC regulation is automatically corrected. The correction rate, up to 60 volts per second, depends on the size of the VARIAC autotransformer.

If a regulated line is available to supply up to 300 watts to operate the remote control, corrections can also be automatically obtained for fluctuations in line voltage at the remote autotransformer. This regulated line must have low impedance at 60 c/s and must have the same phase angle as the unregulated line to the remote unit. This combination can provide large amounts of power at a regulated voltage, adjustable from zero to 140 volts.

If continuous control is not required, one TYPE 1590-A can be switched to control any number of remote units, one at a time.



To order the proper motor-driven VARIAC autotransformer, see the chart below and use the same type-numbering system as for our standard motor-driven units (page 231). Except for 64-second models, where limit switches are mandatory, the motor capacitor and limit switches, specified by C and K in the type numbers for standard units, are not used with the TYPE 1590-A. These letters should be omitted from the type numbers.

TRAVERSE TIME AND CORRECTION RATE FOR 2% POSITIONING ERROR

DRIVEN VARIAC AUTO-TRANSFORMER MODEL	SINGLE UNIT		TWO-GANG (G2)		THREE-GANG (G3)	
	Traverse Time (Seconds)*	*Approximate Correction Rate (Volts/s)*	*Traverse Time* (Seconds)*	*Approximate Correction Rate (Volts/s)*	*Traverse Time* (Seconds)*	*Approximate Correction Rate (Volts/s)*
W2	2	60	2	60	4	30
W5	2	60	4	30	8	15
W8	2	60	4	30	8	15
W10	4	30	8	15	16	8
W20	8	15	16	8	32	4
W30	16	8	32	4	32†	4
W50	32	4	64‡	2	64†‡	2

* If half the positioning error is desired, the traverse time can be doubled, giving half the correction rate. Traverse times shorter than those listed or greater than 64 seconds should not be used.
† 3% positioning error.
‡ Exception: Limit switches are mandatory on 64-second models.

SPECIFICATIONS

Tracking Accuracy: ±2% of input line voltage, when used with motor speeds listed in the table. (Halving the speed increases the accuracy to ±1%.)

Correction Rate: See table.

Power Requirements: 105 to 125 volts, 50 to 60 c/s.

Accessories Required: Standard motor-driven VARIAC autotransformer less capacitor and limit switches. (Limit switches are mandatory on 64-second models.)

Dimensions: Width 4⅞, height 6⅝, depth 5¼ inches (125 by 170 by 135 mm), over-all.

Net Weight: 6½ pounds (3 kg).

Shipping Weight: 11 pounds (5 kg).

Catalog Number	*Description*	*Price*
1590-9701	**Type 1590-A Remote Control**	**$95.00**

PARTS & ACCESSORIES

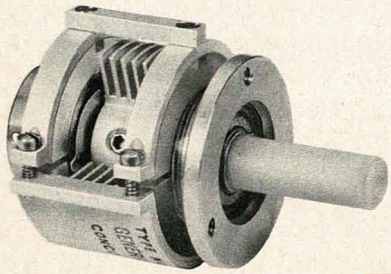
The General Radio Company has developed and is constantly improving a comprehensive line of parts for use in its laboratory and industrial instruments. Among the design objectives are maximum reliability, long life, convenience, attractive appearance, and known electrical characteristics. All General Radio parts are painstakingly designed, use high-quality materials, and are produced by methods that yield reasonable prices. One important design consideration is to produce integrated groups of basic elements that fit together electrically and have a unity of appearance.

Described in this section are capacitors, potentiometers, transformers, knobs, dials, binding posts, plugs and jacks, and patch cords. Two groups are new in this catalog: copper binding posts, fabricated from copper to minimize thermal emf to copper wires; and new single- and double-plug patch cords.

Additional parts will be found in other sections of this catalog. Decade capacitors, resistors, and inductors are listed in the section on standards, pages 184–209, variable delay lines on page 168, and coaxial connectors and parts on pages 76–102.

These are high-quality parts, designed for instrument use and fabricated from materials with superior electrical and mechanical properties.

Type 1420 VARIABLE AIR CAPACITORS



These capacitors were developed especially for use in laboratory instruments. The stator and insulated rotor are each machined from solid, shaped aluminum extrusions of identical alloy. Features include low dielectric losses, low inductance and resistance, good linearity, high mechanical and thermal stability, and sealed, long-life ball bearings.

SPECIFICATIONS

Capacitance Range: See table. The data in the table are for the capacitor used as a two-terminal device, with rotor grounded. If the stator is grounded, maximum and minimum capacitance values will be decreased by about 1 pF. The rotor-to-ground capacitance is about 1 pF. The stator-to-ground capacitance is about 1.5 pF.

Linearity: The variation of capacitance with angle of rotation is guaranteed linear within $\pm 0.3\%$ of full scale. The angular range of linear variation is 160°.

Typical independent linearity is better than $\pm 0.2\%$.

Dielectric Losses: For the grounded-rotor connection, the dielectric losses correspond to a *DC* product of less than 0.01×10^{-12}. The rotor-to-ground capacitance has a *DC* product of 0.1×10^{-12}. This loss component is in parallel with the main capacitance only for the grounded-stator connection.

Inductance: Approximately 0.006 μH.

Insulation Resistance: Greater than 10^{11} Ω under standard ASTM laboratory conditions (23°C, 50% RH).

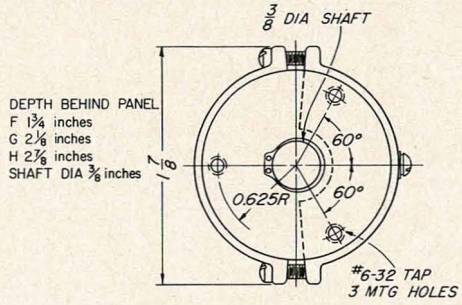
Temperature Coefficient of Capacitance: Approximately +0.003% per degree C.

Maximum Voltage: 700 V peak.

Torque: 2 ounce-inches maximum with shaft vertical.

Dimensions: See sketch below. To convert inches to mm, multiply by 25.4. Where dimensions are critical, write for a copy of the latest drawings.

Shock and Vibration: Will pass shock and vibration tests of MIL-T-945-A.



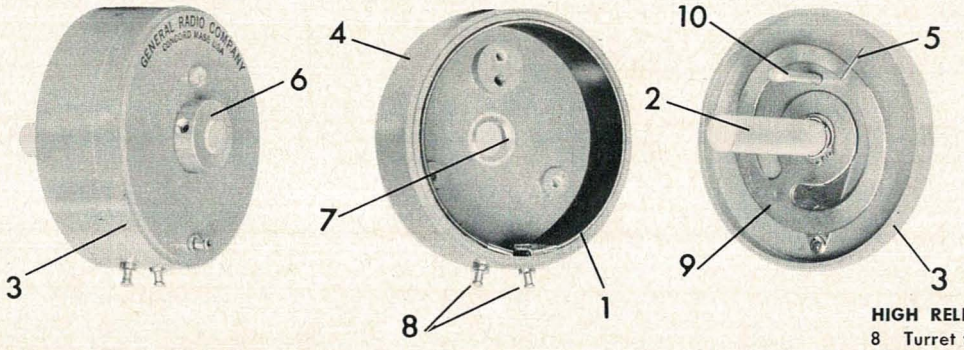
Catalog Number	Description	Nominal Range Max	Nominal Range Min	Range for Linear Variation	Net Weight oz	Net Weight g	Shipping Weight lb	Shipping Weight kg	Price
1420-9706	**Type 1420-F Variable Air Capacitor**	70 pF	13 pF	54 ± 5 pF	4	110	1	0.5	**$30.00**
1420-9707	**Type 1420-G Variable Air Capacitor**	130 pF	14 pF	108 ± 5 pF	4½	125	1	0.5	**32.00**
1420-9708	**Type 1420-H Variable Air Capacitor**	250 pF	16 pF	216 ± 5 pF	5½	155	1	0.5	**33.00**

970-SERIES POTENTIOMETERS

USES: These potentiometers are moderately priced controls with high-quality performance. They can be used at dc, throughout the audio- and ultrasonic-frequency ranges, and, in many applications, at low radio frequencies.

HIGH LEAKAGE RESISTANCE
LOW CAPACITANCE TO GROUND

2 Glass-reinforced-polyester shaft
3 New diallyl-phthalate dust-proof cover
4 New diallyl-phthalate body



HIGH RESOLUTION

5 Small-diameter brush of precious-metal alloy

LOW NOISE

1 Firm clean track
5 Precious metal contact
9 Uniform contact pressure

SIMPLE MECHANICAL ADJUSTMENT
EXCELLENT MECHANICAL STABILITY
EXCELLENT REPEATABILITY

6 Projecting hub permits adjustment of shaft with respect to contact brush while case is closed. Hub rotates in a recessed brass insert molded into cover to form a metal-to-metal bearing close to plane of brush.

7 A second bearing is provided by a nylon-graphite insert to guide shaft into base.

EXCELLENT LINEARITY
LOW TEMPERATURE COEFFICIENT
LOW INDUCTANCE

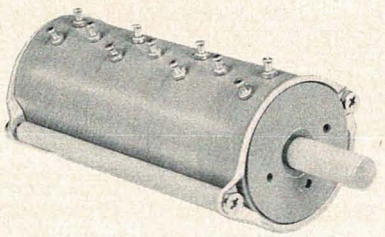
1 Low, uniformly wound, temperature-coefficient resistance element on a thin, phenolic-laminate mandrel firmly cemented into body molding.

HIGH RELIABILITY

8 Turret terminals are both riveted to end of clamps and soldered to ends of winding and to silver-plated, spring-bronze contact take-off in cover so that none of the fixed internal connections depends on pressure alone.

9 Brush arm and spring are combined into a single stamping of spring-temper phosphor-bronze.

10 Screw that holds cover to base passes through a horseshoe-shaped slot in brush arm to serve as a rotational stop that exerts no force on brush.



GANGING

When ganged, the 970-Series Potentiometers retain their low-capacitance characteristics. Units are designed to be nested with molded spacing rings, stacked on a long shaft, and held together with thin metal clamping rings and tie rods. This assembly allows units to be set in any desired phase relationship. Inquiries are welcomed on a special-design basis.

SPECIAL TYPES

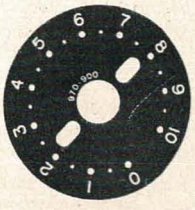
Units in the 970 design can be made on special order with: 360° mechanical rotation, taps as close as ¼ inch apart along the entire winding, resistance other than listed values, equivalent noise resistance lower than standard, resistance tapers, resistance tolerance, and linearity tolerances better than standard. For applications requiring maximum shaft rigidity, shafts of metal-cored phenolic or of metal can be supplied.

KNOBS

Recommended knobs are described on page 254.

DIAL PLATES

The TYPE 970-P1 (*below*) is a 2-inch dial plate for use with the TYPES 971, 972, 973, and 974 with a pointer-type knob. Scale covers 315°. The TYPE 970-P2 is a 2¾-inch reversible dial plate for use with the TYPES 975 and 976 with a pointer-type knob or attached to a knob. Scale covers 320°.



Type	*Catalog Number*	*Price*
970-P1	0970-9601	**$0.55**
970-P2	0970-9602	**0.55**

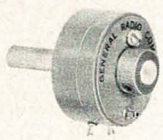
Type	*Effective Electrical Rotation*	*Total Mechanical Rotation*	*Standard Resistance Tolerance*	*Average Torque oz/in*	*Independent Linearity %*	*Power Rating at 0°C ambient temp**	
						Mounted on Alum Panel	*Suspended in Air*
971	315° ± 5°	330° ± 5°	±5%	1¾	±2	5.6	3.5
972	315° ± 5°	330° ± 5°	±5%	1¾	±2	7.8	5.8
973	320° ± 5°	330° ± 5°	±5%	2½	±1	8.4	5.9
974	320° ± 5°	330° ± 5°	±5%	2½	±1	12.0	9.4
975	320° ± 2°	330° ± 5°	±2%	4	±0.5	13.4	10.7
976	320° ± 2°	330° ± 5°	±2%	4	±0.5	19.0	16.8

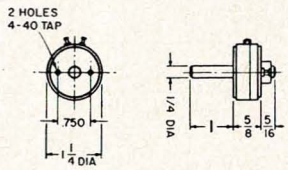
* Power rating in watts decreases linearly with rising ambient temperature to zero at 100°C.

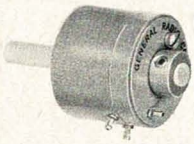
970-SERIES POTENTIOMETERS

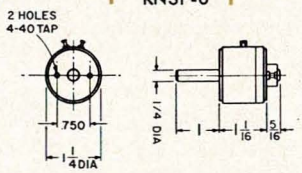
All dimensions in inches

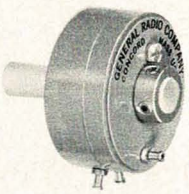
	Approx Weight	*Knobs*	*Dial Plate*	*Type*	*Nominal Resistance Ohms*	*Temperature Coefficient of Resistance %*	*Resolution %*	*Catalog Number*	*Price*
971	½ oz	KNS-6 KNSP-6	970-P1	**971-B**	2	±0.07	<1	0971-9702	$ 5.25
				971-C	5	±0.07	<1	0971-9703	5.25
				971-D	10	±0.002	<1	0971-9704	5.25
				971-E	20	±0.002	<1	0971-9705	5.25
				971-F	50	±0.002	<0.5	0971-9706	5.25
				971-G	100	±0.002	<0.5	0971-9707	5.25
				971-H	200	±0.002	<0.5	0971-9708	5.25
				971-J	500	±0.002	<0.5	0971-9710	5.25
				971-K	1000	±0.002	<0.5	0971-9711	5.25
				971-L	2000	±0.002	<0.5	0971-9712	5.25
				971-M	5000	±0.002	<0.2	0971-9713	5.25
				971-N	10,000	±0.002	<0.2	0971-9714	5.25
				971-P	20,000	±0.002	<0.2	0971-9716	5.25
972	¾ oz	KNS-6 KNSP-6	970-P1	**972-F**	50	±0.002	<1	0972-9706	5.75
				972-G	100	±0.002	<0.5	0972-9707	5.75
				972-H	200	±0.002	<0.5	0972-9708	5.75
				972-J	500	±0.002	<0.5	0972-9710	5.75
				972-K	1000	±0.002	<0.5	0972-9711	5.75
				972-L	2000	±0.002	<0.5	0972-9712	5.75
				972-M	5000	±0.002	<0.5	0972-9713	5.75
				972-N	10,000	±0.002	<0.2	0972-9714	5.75
				972-P	20,000	±0.002	<0.2	0972-9716	5.75
				972-Q	50,000	±0.002	<0.2	0972-9717	5.75
973	1 oz	KNS-6 KNSP-6	970-P1	**973-C**	5	±0.07	<0.5	0973-9703	6.25
				973-D	10	±0.07	<0.5	0973-9704	6.25
				973-E	20	±0.002	<0.5	0973-9705	6.25
				973-F	50	±0.002	<0.5	0973-9706	6.25
				973-G	100	±0.002	<0.5	0973-9707	6.25
				973-H	200	±0.002	<0.5	0973-9708	6.25
				973-J	500	±0.002	<0.2	0973-9710	6.25
				973-K	1000	±0.002	<0.2	0973-9711	6.25
				973-L	2000	±0.002	<0.2	0973-9712	6.25
				973-M	5000	±0.002	<0.2	0973-9713	6.25
				973-N	10,000	±0.002	<0.1	0973-9714	6.25
				973-P	20,000	±0.002	<0.1	0973-9716	6.25
				973-Q	50,000	±0.002	<0.1	0973-9717	6.25
974	1¾ oz	KNS-6 KNSP-6	970-P1	**974-D**	10	±0.07	<0.5	0974-9704	6.75
				974-E	20	±0.07	<0.5	0974-9705	6.75
				974-F	50	±0.002	<0.5	0974-9706	6.75
				974-G	100	±0.002	<0.5	0974-9707	6.75
				974-H	200	±0.002	<0.5	0974-9708	6.75
				974-J	500	±0.002	<0.5	0974-9710	6.75
				974-K	1000	±0.002	<0.2	0974-9711	6.75
				974-L	2000	±0.002	<0.2	0974-9712	6.75
				974-M	5000	±0.002	<0.2	0974-9713	6.75
				974-N	10,000	±0.002	<0.2	0974-9714	6.75
				974-P	20,000	±0.002	<0.1	0974-9716	6.75
				974-Q	50,000	±0.002	<0.1	0974-9717	6.75
				974-R	100,000	±0.002	<0.1	0974-9718	8.00
975	3 oz	KNS-8 KNSP-8	970-P2	**975-J**	500	±0.002	<0.2	0975-9710	7.25
				975-K	1000	±0.002	<0.2	0975-9711	7.25
				975-L	2000	±0.002	<0.2	0975-9712	7.25
				975-M	5000	±0.002	<0.2	0975-9713	7.25
				975-N	10,000	±0.002	<0.1	0975-9714	7.25
				975-P	20,000	±0.002	<0.1	0975-9716	7.25
				975-Q	50,000	±0.002	<0.05	0975-9717	8.25
				975-R	100,000	±0.002	<0.05	0975-9718	8.25
976	4 oz	KNS-8 KNSP-8	970-P2	**976-K**	1000	±0.002	<0.2	0976-9711	8.25
				976-L	2000	±0.002	<0.2	0976-9712	8.25
				976-M	5000	±0.002	<0.2	0976-9713	8.25
				976-N	10,000	±0.002	<0.2	0976-9714	9.00
				976-P	20,000	±0.002	<0.1	0976-9716	9.00
				976-Q	50,000	±0.002	<0.1	0976-9717	10.00
				976-R	100,000	±0.002	<0.05	0976-9718	10.00
				976-T	200,000	±0.002	<0.05	0976-9720	10.00

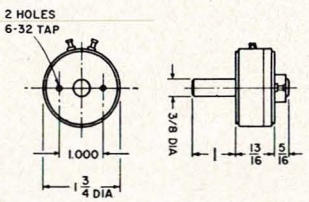


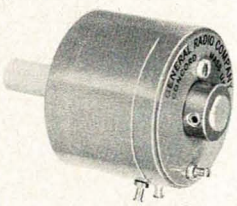


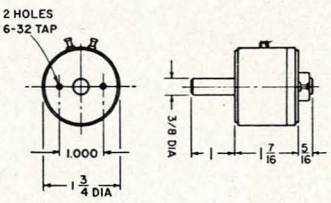


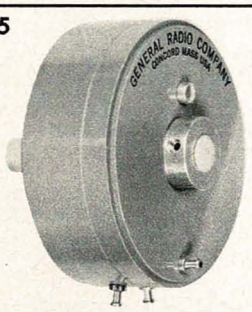


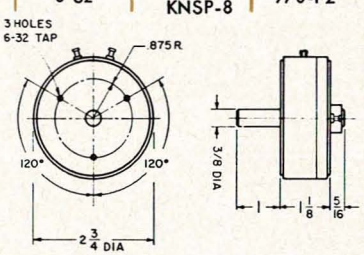


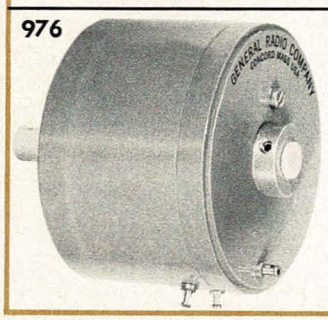


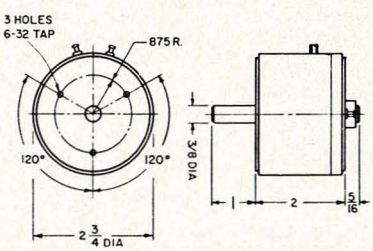












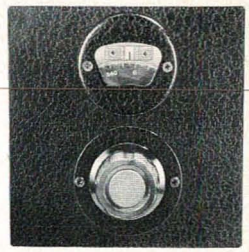
Type 907 GEAR-DRIVE PRECISION DIALS

These 4-inch diameter precision dials have aluminum dial plates with black enamel finish. Scales are individually engraved on an automatic, self-indexing engraving machine. The fine, radial, accurately located lines divide the complete circumference into 360 divisions numbered from 0 to 360.

Settings can be consistently duplicated to one-fifth of a division, allowing a precision of resetting of better than 0.06% of full scale. Parallax is eliminated by the use of an indicator that always remains flush with the surface of the dial and, at the same time, through the flexibility of its mounting, absorbs any slight eccentricities of the main shaft.

The ring gear and drive pinion are precision-cut gears, spring-pressed to eliminate any backlash. The drive ratio is 10:1, and it is possible to use a calibrated vernier or increment dial on the pinion shaft if desired. The drive pinion is held in a stainless-steel collet, which runs in a phosphor-bronze bushing. The collet allows the drive to be adjusted for any panel thickness up to 5/16 inch.

The main dials are set permanently and securely to their shafts through the use of two setscrews 90° apart; this procedure eliminates any dial backlash that might otherwise occur.



(Left) Front-of-panel-mounting Type 907-WA. *(Right)* Rear-of-panel-mounting Type 907-WB. Maximum panel thickness 5/16 in (8mm).

The dial hubs are bored to receive a 3/8-inch shaft, but a bushing is furnished for use with 1/4-inch shafts.

The dial indicator, knob, and all necessary mounting parts are supplied, as are complete drilling and mounting instructions. Motor drives are described on page 154.

Total Panel Area: 4 by 5 in (105, 130 mm).
Net Weight: 11 oz (0.4 kg). **Shipping Weight:** 3 lb (1.4 kg).

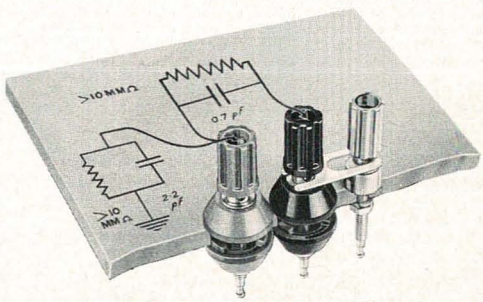
Catalog No.	*Description*	*Price*
0907-9857	**Type 907-WA Precision Dial**	**$12.00**
0907-9863	**Type 907-WB Precision Dial**	**12.00**

Type 938 BINDING POSTS

The excellent electrical properties and ingenious mechanical design of the TYPE 938 Binding Posts provide all the properties needed for modern electronic instruments. Two styles are available: nickel-plated brass for economy, and gold-plated copper for high conductivity and low thermal emf with connection to copper wires. Both styles are available with either metal or insulated tops designed for easy hand tightening. On the copper binding posts, 3/8-inch, 12-point wrenches can be used. The styrene insulation has high insulation resistance and low dissipation factor and is available either red or black for color coding.

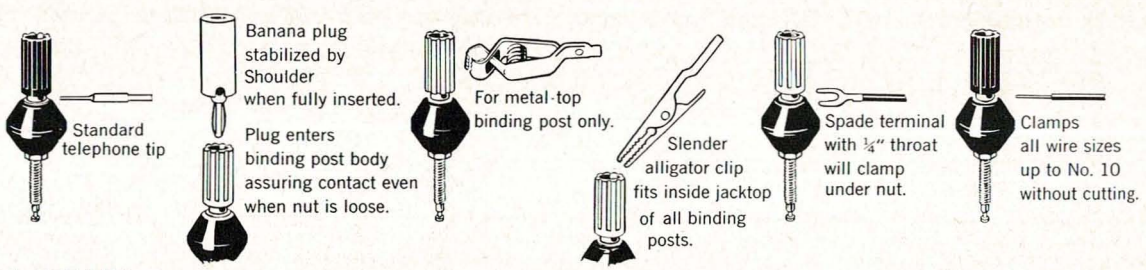
These binding posts can be mounted on metal or insulating panels of a thickness from zero to 5/16 inch. Mechanical details and methods of connection are shown below.

The binding post has the same height above panel as the nonlocking GR874 Coaxial Connector (see page 79), whose center contact will take a Type 274 Plug, so that a grounded binding post can be mounted adjacent to the coaxial connector to fit a TYPE 274-MB Double Plug.

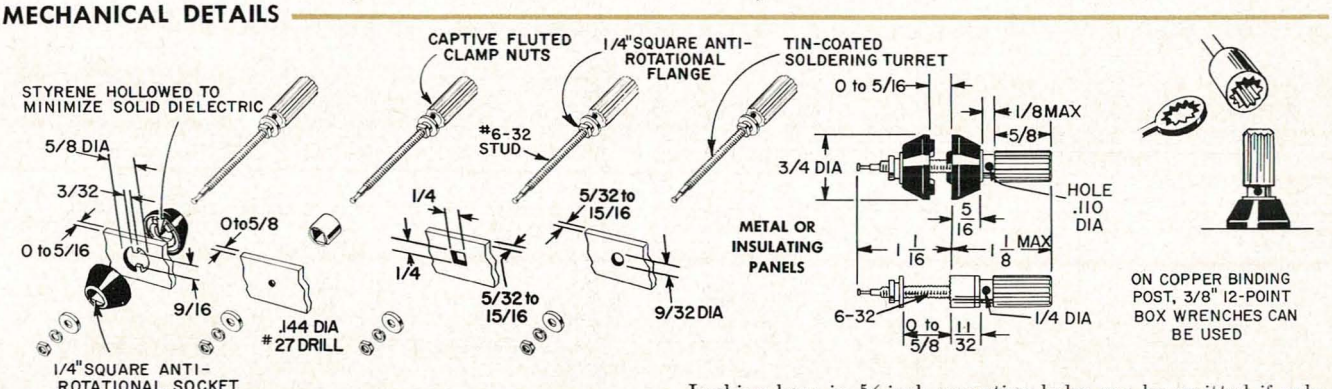


Rating: 30 A peak, 4 kV peak.
Breakdown: 10 kV peak.
Dissipation Factor: <0.0005 at 1 kc/s.

METHODS OF CONNECTION

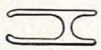
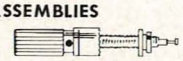
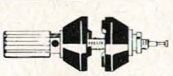


MECHANICAL DETAILS



To convert inches to mm, multiply by 25.4.

Locking keys in 5/8-inch mounting holes can be omitted if only moderate resistance to rotation is needed.

TYPE 938 BINDING POSTS	Type	☐ brass, nickel plated ▨ copper, gold plated	Net Weight for 10 oz	Net Weight for 10 g	Catalog Number	Unit Price* in Lots of 10† to 99	100 to 999	1000 to 1999	2000 up
BINDING POSTS									
	**938-A**	**Metal-Top Binding Post,** brass	4	115	0938-9701	$0.40	$0.29	$0.27	$0.25
	**938-C**	**Black-Top Binding Post,** brass	3	85	0938-9703	0.55	0.40	0.38	0.35
	**938-D**	**Red-Top Binding Post,** brass	3	85	0938-9704	0.55	0.40	0.38	0.35
	**938-G**	**Metal-Top Binding Post,** copper	5½	158	0938-9707	0.90	0.80	0.75	0.75
	**938-H**	**Black-Top Binding Post,** copper	4	115	0938-9708	0.80	0.71	0.67	0.67
	**938-K**	**Red-Top Binding Post,** copper	4	115	0938-9711	0.80	0.71	0.67	0.67
INSULATORS									
	**938-BB**	**Black Insulators,** pair	1	30	0938-9808	0.20	0.12	0.11	0.10
	**938-BR**	**Red Insulators,** pair	1	30	0938-9812	0.20	0.12	0.11	0.10
	**938-YB**	**Double Insulators.** Interlocking bosses permit mounting on very thin panels	2	60	0938-9873	0.30	0.18	0.16	0.15
ACCESSORIES									
	**938-F**	**Spacer,** brass. Square anti-rotational socket and anti-rotational teeth	1	30	0938-9706	0.12	0.09	0.09	0.09
	**938-FG**	**Spacer,** copper. Square anti-rotational socket and anti-rotational teeth	1	30	0938-9830	0.20	0.18	0.17	0.17
	**938-L**	**Shorting Link,** brass. For two binding posts mounted on ¾-in centers	1	30	0938-9712	0.10	0.09	0.09	0.09
	**938-LG**	**Shorting Link,** copper. For two binding posts mounted on ¾-in centers	1	30	0938-9503	0.25	0.22	0.20	0.20
	**838-B**	**Alligator Clip.** 15-A peak rating. Fits inside jack top of all binding posts	2	60	0838-9702	0.20	0.19	0.17	0.17
ASSEMBLIES									
	**938-P**	**Metal Top/Spacers,** brass. Assembly of 938-A, 938-F	5	145	0938-9716	0.52	0.38	0.36	0.34
	**938-W**	**Metal Top/Black Insulators,** brass. Assembly of 938-A, 938-BB	5	145	0938-9723	0.60	0.41	0.38	0.35
	**938-R**	**Metal Top/Red Insulators,** brass. Assembly of 938-A, 938-BR	5	145	0938-9718	0.60	0.41	0.38	0.35
	**938-WB**	**Black Top/Black Insulators,** brass. Assembly of 938-C, 938-BB	4	115	0938-9863	0.75	0.52	0.49	0.45
	**938-WR**	**Red Top/Red Insulators,** brass. Assembly of 938-D, 938-BR	4	115	0938-9864	0.75	0.52	0.49	0.45
	**938-GM**	**Metal Top/Spacers,** copper. Assembly of 938-G, 938-FG	6½	183	0938-9834	1.10	0.98	0.92	0.92
	**938-GB**	**Metal Top/Black Insulators,** copper. Assembly of 938-G, 938-BB	6½	183	0938-9832	1.10	0.92	0.86	0.86
	**938-GR**	**Metal Top/Red Insulators,** copper. Assembly of 938-G, 938-BR	6½	183	0938-9835	1.10	0.92	0.86	0.86
	**938-HB**	**Black Top/Black Insulators,** copper. Assembly of 938-H, 938-BB	5	145	0938-9434	1.00	0.83	0.78	0.78
	**938-KR**	**Red Top/Red Insulators,** copper. Assembly of 938-K, 938-BR	5	145	0938-9838	1.00	0.83	0.78	0.78

* Net Prices. No further quantity discounts. † Minimum quantity sold.

Prices for binding-post assemblies are for shipment unassembled. When assembly and/or individual packaging before shipment is required, add 10¢ per binding post for assembly, 8¢ for packaging.

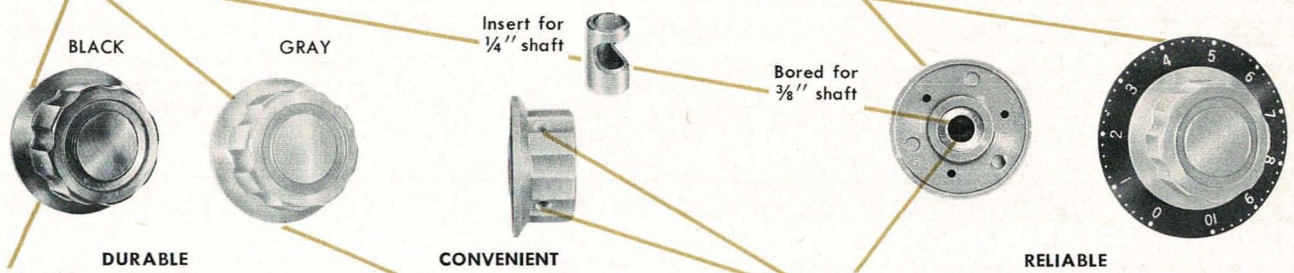
Type KN FLUTED KNOBS

Four styles. Skirtless KNU style can be used for coaxial knob arrangements.

VERSATILE
Most come in two colors to distinguish control functions or to match various panel colors.

All but smallest fit either ¼″ or ⅜″ shafts.

Large knobs have molded holes, which can be drilled deeper to allow a dial plate to be attached (see page 250).



DURABLE
Made of long-lasting thermo-setting plastic to resist cracking, wearing, or color fading.

CONVENIENT
Large flutes, easy-to-grasp

RELIABLE
Brass inserts for shaft are securely molded into body. Most have two hexagonal-socket set screws to assure slip-proof attachment to shaft.

	Catalog Number	Type	Dimensions: Skirt Diameter in	Skirt Diameter mm	Over-all Depth in	Over-all Depth mm	Shaft Size	Set Screws	Net Weight for five oz	Net Weight for five g	Unit Price† in Lots of: **5 to 19	20 to 99	100 to 499	500 to 1999	2000 up
	5500-9601	KNB-1	15/16	24	¾	20	Bored for ⅜″ (10 mm), bushing furnished to adapt to ¼″ (7 mm)	1	3¾	108	$0.90	$0.85	$0.79	$0.74	$0.68
	5505-9601	KNB-1GY	15/16	24	¾	20			3¾	108	1.00	0.95	0.88	0.81	0.75
	5500-9602	KNB-2	15/16	34	¾	20		2, 90° apart	6	170	0.95	0.90	0.84	0.78	0.72
	5505-9602	KNB-2GY	15/16	34	¾	20			6	170	1.05	0.99	0.92	0.85	0.79
	5505-9603	KNB-3GY no white dot	15/16	24	¾	20		1	3	85	1.05	0.99	0.92	0.85	0.79
	5505-9503	KNB-3DGY	15/16	24	¾	20			3	85	1.10	1.04	0.97	0.90	0.83
	5525-9601	KNS-1GY	15/16	24	¾	20	¼″ (7 mm)	2, 90° apart	6	170	0.80	0.75	0.70	0.65	0.60
	5520-9606	KNS-6	15/16	34	¾	20	Bored for ⅜″ (10 mm), bushing furnished to adapt to ¼″ (7 mm)	2, 135° apart	5½	183	0.80	0.75	0.70	0.65	0.60
	5525-9606	KNS-6GY	15/16	34	¾	20		2, 90° apart	5½	183	0.90	0.85	0.79	0.74	0.68
	5520-9608	*KNS-8	1 15/16	50	31/16	21			8	230	0.90	0.85	0.79	0.74	0.68
	5525-9608	*KNS-8GY	1 15/16	50	13/16	21			8	230	1.10	1.04	0.97	0.90	0.83
	5520-9610	*KNS-10	2⅜	61	29/32	23.5			12½	353	1.30	1.23	1.15	1.06	0.98
	5525-9610	*KNS-10GY	2⅜	61	29/32	23.5			12½	353	1.50	1.42	1.32	1.22	1.13
	5520-9612	*KNS-12	2⅞	73	1	26			17	485	1.40	1.32	1.23	1.14	1.05
	5525-9612	*KNS-12GY	2⅞	73	1	26			17	485	1.70	1.61	1.50	1.38	1.28
	5530-9601	KNSP-1	15/16	24	¾	20	¼″ (7 mm)	2, 90° apart	6	170	0.70	0.66	0.62	0.57	0.53
	5535-9601	KNSP-1GY	15/16	24	¾	20	Bored for ⅜″ (10 mm), bushing furnished to adapt to ¼″ (7 mm)	2, 135° apart	6	170	0.80	0.75	0.70	0.65	0.60
	5530-9606	KNSP-6	15/16	34	¾	20			5½	183	0.80	0.75	0.70	0.65	0.60
	5535-9606	KNSP-6GY	15/16	34	¾	20			5½	183	0.90	0.85	0.79	0.74	0.68
	5530-9608	*KNSP-8	1 15/16	50	13/16	21		2, 90° apart	8	230	0.90	0.85	0.79	0.74	0.68
	5535-9608	*KNSP-8GY	1 15/16	50	13/16	21			8	230	1.10	1.04	0.97	0.90	0.83
	5530-9610	*KNSP-10	2⅜	61	29/32	23.5			12½	353	1.30	1.23	1.15	1.06	0.98
	5535-9610	*KNSP-10GY	2⅜	61	29/32	23.5			12½	353	1.50	1.42	1.32	1.22	1.13
	5530-9612	*KNSP-12	2⅞	73	1	26			17	485	1.40	1.32	1.23	1.14	1.05
	5535-9612	KNSP-12GY	2⅞	73	1	26			17	485	1.70	1.61	1.50	1.38	1.28
	5545-9611	KNU-11GY no skirt, dia ¾″ (20 mm)			½	13	¼″ (7 mm) ⅛″ (4 mm)	1	2	60	0.75	0.71	0.66	0.62	0.57
	5545-9614	KNU-14GY no skirt, dia 9/16″ (15 mm)			½	13			1	30	0.75	0.71	0.66	0.62	0.57

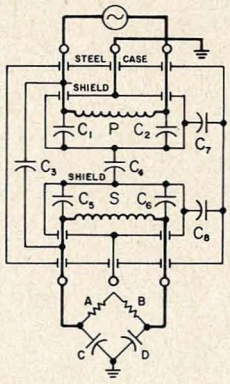
☐ black knobs ▩ gray knobs * Accept dial plate (see page 250). ** Minimum quantity sold. † Net prices. No further quantity discounts.

Type 578 SHIELDED TRANSFORMER

FOR BRIDGE ISOLATION

This transformer is used in direct-reading ac bridges to isolate the bridge circuit from changes in electrostatic potential in the generator (or detector) circuit and to reduce the effect of the capacitance of the external circuit to ground. It can also be used to isolate any measuring circuit from the generator or detector or to produce a balanced output from a grounded generator.

Three shields are used, one around each winding and a third to bring the core laminations to the potential of the case.



Grounded bridge supplied through a double-shielded transformer. When case is grounded, the capacitance placed across each capacitance arm is 40 pF. Note that the winding shield on the bridge side is not grounded but is floating.

SPECIFICATIONS

Turns Ratio: 4 to 1 or 1 to 4.

Ranges: See price table.

Nominal Capacitances: See drawing.

C_1, C_2, C_5, C_6.....each 200 pF C_4..... 30 pF
C_3..... 0.3 pF C_7, C_8.....each 70 pF

Winding Inductance: Turns squared (see table) multiplied by 3.5×10^{-6} H, approx.

Dc Resistance (in ohms): 30 times inductance in henrys, approx.

Voltage Limits: The high-impedance winding of TYPES 578-A or -B may be connected directly across a 115-V, 50- to 60-cycle line if the impedance connected to the other winding equals or exceeds the lowest value given under "low impedance" in the table below. The TYPE 578-B may be used at 25 c/s under the same conditions.

For TYPES 578-A or -B, the low-impedance winding may be connected directly to a 115-V, 50- to 60-cycle line provided that the resistance across the high-impedance winding exceeds 10,000 Ω. The TYPE 578-B may be used at 25 c/s under the same conditions.

Insulation: The insulation from winding to winding and from windings to case will withstand 1000 V, peak.

Dimensions: Base, $3\frac{1}{8} \times 2\frac{13}{16}$ in (80, 70 mm); height, $4\frac{1}{8}$ in (105 mm).

Net Weight: $2\frac{1}{2}$ lb (1.2 kg). **Shipping Weight:** 4 lb (1.9 kg).

Catalog Number	*Description*	*Turns*	*Frequency Range**	*Impedance Range**		*Price*
				Low-Impedance Winding	*High-Impedance Winding*	
0578-9701	**Type 578-A Shielded Transformer**	600:2400	50 c/s — 10 kc/s	50 Ω—5 kΩ	1 kΩ—100 kΩ	**$35.00**
0578-9702	**Type 578-B Shielded Transformer**	1000:4000	20 c/s — 5 kc/s	60 Ω—6 kΩ	1.2 kΩ—120 kΩ	**35.00**
0578-9703	**Type 578-C Shielded Transformer**	60:240	2 kc/s —500 kc/s	20 Ω—2 kΩ	0.4 kΩ— 40 kΩ	**35.00**

* These ranges are for transmission within 6 dB. At extremes of both impedance and frequency ranges, the transmission may be down by 12 dB.

Type 941-A TOROIDAL TRANSFORMER

FOR IMPEDANCE MATCHING OR BRIDGING

This transformer is for impedance matching or bridging in low-level, 600-ohm communications circuits. It has highly astatic windings and tight coupling. The toroidal core is a spiral of high-permeability-alloy tape. Identical pairs of windings on each half of the toroid minimize pickup and induction field, while close coupling between inner and outer windings keeps leakage reactance low and extends high-frequency response.

Operating Level and Distortion:

Watts	*DBM*	*Rms Distortion, 60 c/s*
1.26	31	<1%
1	30	<0.5%
0.5	27	<0.2%
0.032	15	<0.1%

SPECIFICATIONS

Frequency and Impedance Ranges:

Terminating Impedances		*Frequency for 1-DB Drop*	*Flat Insertion Loss Less Than*
600 Ω	9600 Ω	80 c/s—100 kc/s	0.3 dB
600 Ω	2400 Ω	20 c/s—135 kc/s	0.2 dB
600 Ω	2400 Ω	80 c/s—340 kc/s	0.2 dB
600 Ω	600 Ω	20 c/s—200 kc/s	0.1 dB
150 Ω	600 Ω	5 c/s— 50 kc/s	0.7 dB
150 Ω	600 Ω	20 c/s—200 kc/s	0.2 dB
37.5 Ω	600 Ω	5 c/s— 50 kc/s	0.8 dB

Zero-Signal Inductance: Inner windings, in series, at least 5 H; outer windings, in series, at least 20 H.

Voltage Matching: Inner windings, 0.015% or better; outer windings, 0.08% or better.

Resistance: Inner windings, in series, 9 Ω; outer windings, in series, 34 Ω (approximately).

Dimensions: Aluminum case, $3\frac{5}{8}$ by $3\frac{1}{8}$ by $1\frac{5}{8}$ in (95, 80, 40 mm). Mounting blocks project $\frac{9}{32}$ inch beyond case in $3\frac{1}{8}$-inch dimension. Mounting holes are $3\frac{3}{8}$ inches on centers and are drilled for clearance with 10–32 machine screws.

Net Weight: $13\frac{3}{8}$ oz (0.4 kg).

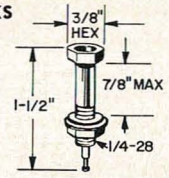
Shipping Weight: 2 lb (1 kg).

Catalog Number	*Description*	*Price*
0941-9701	**Type 941-A Toroidal Transformer**	**$55.00**

JACKS AND PLUGS

Dimensions in Inches

Catalog Number	Unit Price† in Lots of: each	5 to 9	10 to 19	20 to 99	100 to 199	200 to 999	1000 to 1999	2000 up
JACKS								
The Type 938 Jacks also fit Type 274 Plugs. The Type 938-J Jack has a longer shank than the Type 274 Jack. The Type 938-X Jack Assembly consists of the Type 938-J Jack and Type 938-B Insulators (page 252).								
0938-9710	—	—	0.32	0.32	0.27	0.27	0.25	0.22



TYPE 938-J JACK. Fits Type 274 Plugs, has long unthreaded shank that makes it suitable for mounting in Type 938-BB and Type 938-BR Insulators or Type 938-F Spacers (page 252). Net Weight for 10: 3 oz (85 g).

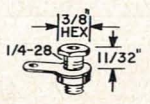
TYPE 938-XB JACK ASSEMBLY, black. Net Weight for 10: 4 oz (115 g).

0938-9868	—	—	0.52	0.52	0.39	0.39	0.36	0.32

TYPE 938-XR JACK ASSEMBLY, red. Net Weight for 10: 4 oz (115 g).

0938-9869	—	—	0.52	0.52	0.39	0.39	0.36	0.32

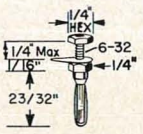
The Type 274 Jacks and Plugs, originated by General Radio in 1924, are widely used in electronics and communications laboratories for connecting equipment in temporary or semi-permanent setups and for connecting plug-in elements. All Type 274 Jacks and Plugs are rated at 15 amperes. Plugs have nickel-plated brass studs and beryllium copper springs. Jacks are nickel-plated brass. These plugs and jacks are designed for positive and reliable contact, typically 1 milliohm. The plug seats firmly in the jack so that the plug springs are not depended upon for mechanical stability.



TYPE 274-J JACK. Rated at 15 A, nickel-plated brass, fits Type 274 Plugs. Net Weight for 20: 3 oz (85 g).

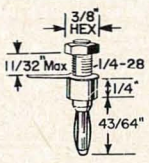
0274-9710	—	—	—	0.10	0.09	0.09	0.08	0.07

PLUGS



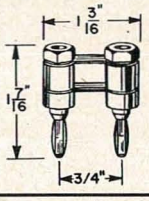
TYPE 274-P PLUG. Rated at 15 A, nickel-plated brass stud and beryllium copper springs, fits Type 274 and Type 938 Jacks. Net Weight for 20: 2 oz (60 g).

0274-9716	—	—	—	0.13	0.11	0.11	0.10	0.09



TYPE 274-U PLUG. Rated at 15 A, nickel-plated brass stud and beryllium copper springs, fits Type 274 and Type 938 Jacks. Net Weight for 10: 3 oz (85 g).

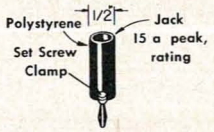
0274-9721	—	—	0.20	0.20	0.18	0.18	0.17	0.16



TYPE 274-SB SHORT-CIRCUIT PLUG. Consists of two Type 274-U plugs connected with metal links, fits Type 274 and Type 938 Jacks. Net Weight each: 1 oz (30 g).

0274-9887	0.95	—	—	—	—	—	—	—

The Type 274-DB Insulated Single Plug is a styrene-insulated plug with a jack top. A set-screw clamp is provided on the plug end.



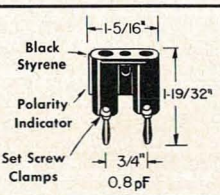
TYPE 274-DB1 INSULATED SINGLE PLUG, black. Net Weight for 5: 2 oz (60 g).

0274-9454	—	0.50	0.43	0.43	0.40	0.36	0.34	0.34

TYPE 274-DB2 INSULATED SINGLE PLUG: red. Net Weight for 5: 2 oz (60 g).

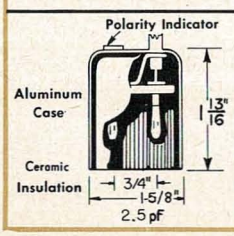
0274-9455	—	0.50	0.43	0.43	0.40	0.36	0.34	0.34

Rating:
15 A, peak; 4 kV, peak.
Breakdown:
23 kV, peak.
Dissipation Factor:
<0.0005 at 1 kc/s.



TYPE 274-MB INSULATED DOUBLE PLUG. Molded styrene double-plug assembly, which fits Type 938 Binding Posts or Type 274 Jacks on standard ¾-inch spacing. Jack top permits stacking for multiple connections. A cross hole through the center provides strain relief for attached cables up to 0.2-inch diameter. The plug is completely insulated. Net Weight for 5: 3 oz (85 g).

0274-9875	—	0.65	0.57	0.57	0.54	0.49	0.47	0.47



Rating:
15 A, peak;
1.2 kV, peak.
Breakdown:
3.4 kV, peak.
Dissipation Factor:
<0.0005 at 1 kc/s.

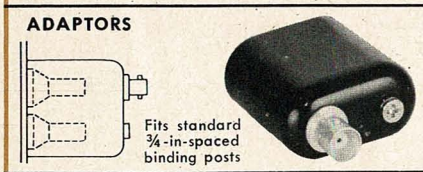
TYPE 274-NK SHIELDED DOUBLE PLUG. Double plug in an aluminum case with ceramic insulation for completely shielded connections to Type 938 Binding Posts. Strain relief for 0.2 and 0.25 inch OD is provided. This plug terminates the Type 274-NL Patch Cord (page 257) and Type 874-R34 Patch Cord (page 85). Net Weight each: 2 oz (60 g).

0274-9877	1.35	—	—	—	—	—	—	—

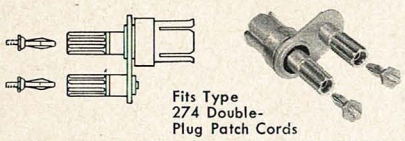
† Net prices. No further quantity discounts.

ADAPTORS AND CORDS

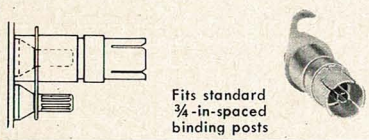
ADAPTORS



Shielded banana plugs in the Type 274-QBJ Adaptor provide connection from standard ¾-inch-spaced binding posts to a type BNC Plug. The shield is made of anodized aluminum with ceramic insulation and fits over the binding posts, snugly against the panel.

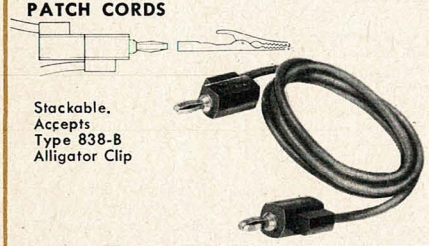


This adaptor provides connection from Type 274 Plugs to GR874 Coaxial Connectors. (See page 79 for description of the GR874 Accessories, including adaptors for nearly all types of military and commercial connectors.)

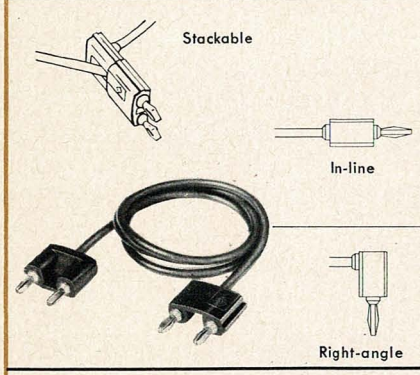


The Type 874-Q9 Adaptor permits connection from standard ¾-in-spaced Type 938 Binding Posts to GR874 Coaxial Connectors. This adaptor is used in the calibration of GR 2-terminal variable capacitors such as the Types 1422 and 1423 Precision Capacitors.

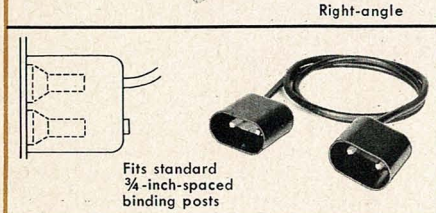
PATCH CORDS



The connector bodies are encapsulated first in polystyrene for its electrical properties and then in cellulose-acetate butyrate for its high-impact properties. They include a jack for stacking, and the plugs seat firmly in jacks so that plus springs are not depended on for mechanical stability. Contact resistance is in the order of one milliohm.

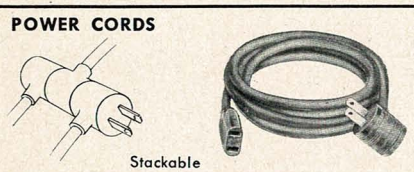


The connector bodies are encapsulated first in polystyrene for its electrical properties and then in cellulose-acetate butyrate for its high-impact properties. The configuration of the connectors is such that any double plug can be connected to any other — whether in-line or right-angle.

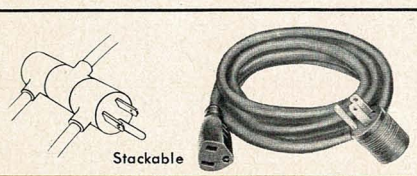


The Type 274-NK Shielded Double Plugs used on these cords are made of anodized aluminum with ceramic insulation and provide strain relief for the cable.

POWER CORDS



Made of plastic-covered number 18 conductor. Plug and connector bodies are molded integrally with the cord, and the hammerhead design permits stacking. Type SVT cord rated by Underwriters Laboratories at 7 amperes and 300 volts, rms. Female connector fits either 2-wire or 3-wire plug.



Made of plastic-covered number 18 conductor. Plug and connector bodies are molded integrally with the cord, and the hammerhead design permits stacking. Type SVT cord rated at 7 amperes and 230 volts. The connectors, designed for 125-volt operation, conform to the American Standard for Grounding Type Attachment Plug Caps and Receptacles, ASA C73.11-1963.

	Type	Length in	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price
274-QBJ	**Adaptor**	—	—	2	60	0274-9884	**$2.50**
874-Q2	**Adaptor**	—	—	2	60	0874-9870	**5.50**
874-Q9	**Adaptor**	—	—	2	60	0874-9874	**6.00**
274-LLB	**Single-Plug Patch Cord,** black	36	920	1½	45	0274-9468	**1.25**
274-LLR	**Single-Plug Patch Cord,** red	36	920	1½	45	0274-9492	**1.25**
274-LMB	**Single-Plug Patch Cord,** black	18	460	1	30	0274-9847	**1.25**
274-LMR	**Single-Plug Patch Cord,** red	18	460	1	30	0274-9848	**1.25**
274-LSB	**Single-Plug Patch Cord,** black	9	230	1	30	0274-9849	**1.25**
274-LSR	**Single-Plug Patch Cord,** red	9	230	1	30	0274-9850	**1.25**
274-NQ	**Double-Plug Patch Cord,** in-line cord	36	920	3	85	0274-9860	**3.50**
274-NQM	**Double-Plug Patch Cord,** in-line cord	24	610	2	60	0274-9896	**3.50**
274-NQS	**Double-Plug Patch Cord,** in-line cord	12	305	1½	45	0274-9861	**3.50**
274-NP	**Double-Plug Patch Cord,** right-angle cord	36	920	3	85	0274-9880	**3.50**
274-NPM	**Double-Plug Patch Cord,** right-angle cord	24	610	2	60	0274-9892	**3.50**
274-NPS	**Double-Plug Patch Cord,** right-angle cord	12	305	1½	45	0274-9852	**3.50**
274-NL	**Shielded Double-Plug Patch Cord**	36	920	4	115	0274-9883	**4.50**
274-NLM	**Shielded Double-Plug Patch Cord**	24	610	3	85	0274-9882	**4.50**
274-NLS	**Shielded Double-Plug Patch Cord**	12	305	2½	75	0274-9862	**4.50**
CAP-35	**2-Wire Power Cord**	7 feet	2.14 meters	7	200	4200-9635	**1.75**
CAP-22	**3-Wire Power Cord**	7 feet	2.14 meters	9	255	4200-9622	**2.50**

CABINETS

General Radio instrument cabinets are rugged, attractive, and versatile. Heavy-gauge aluminum and tough wrinkle finishes combine to keep GR instruments operating and looking like new through many years of hard service.

We use five basic cabinet types: (1) rack-bench cabinets, with standard rack-width panels and optional bench or rack-mounting accessories, (2) Flip-Tilt cases, for portable instruments, (3) convertible-bench cabinets, for smaller laboratory instruments, (4) Unit cabinets, for the GR line of Unit Instruments and power supplies, and (5) lab-bench cabinets, for laboratory standards, decade boxes, and similar instruments.

For bench use, the rack-bench cabinet is equipped with aluminum end frames.

RACK-BENCH CABINETS

A rack-bench cabinet consists of three major parts: a heavy-gauge aluminum cabinet comprising the top, bottom, sides, and rear of the instrument; a rack-width (19-inch) front panel, permanently attached to the instrument chassis; and either aluminum end frames, if the instrument is to be used on the bench, or two supports for rack mounting. The instrument is shipped with either type of mounting, as ordered. Subsequent conversion is, however, quite simple.

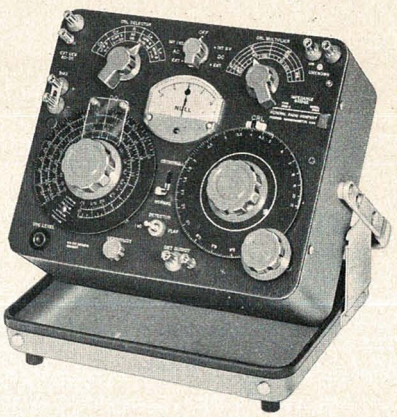
In bench models, the end frames serve several purposes. They allow instruments to be neatly stacked and bolted together. They also serve as supporting feet, carrying handles, and protective bumpers.

In relay-rack models, the front panel and the two supports are attached by screws to the front of the relay rack, and the supports to the cabinet. The cabinet acts as a drawer slide, and the resulting installation offers easy accessibility to the interior of the instrument. The panel and chassis may be withdrawn from the front of the rack, with the cabinet left stationary. Or the cabinet may be removed from the rear of the rack, with panel and chassis left stationary.

On certain instruments usually permanently installed in relay racks, supports and end frames are omitted.

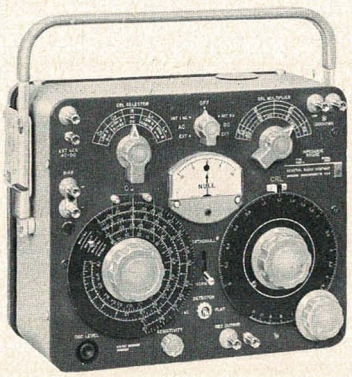
FLIP-TILT CASES

General Radio's exclusive Flip-Tilt case includes three main parts: the instrument cabinet, a captive cover, and a carrying-handle and lever assembly. When the instrument is

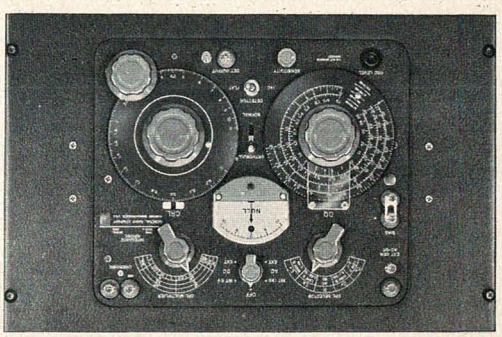


Flip-Tilt case in one of its many operating positions. Rubber gasket provides friction to allow almost any tilt angle.

Locked fully open, instrument is ready for either operation or transit.



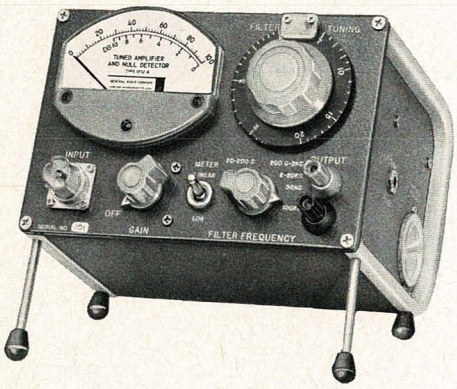
Locked closed, with accessories and instruction manual inside, the instrument is well protected against damage.



Another of the many faces of the versatile Flip-Tilt, which here has traded cover and handle for a rack adaptor panel.

closed for storage or transit, the cover is locked in place over the front panel by means of slide-buttons and latches on the carrying handle. To open the cabinet, the user slides the buttons out of the latches and pushes down on the carrying handle. The lever action of the handle raises the cabinet from the cover. The cabinet is then easily flipped into position for operation. The operating position may be fully open and locked squarely in the cover or tilted at almost any angle. A rubber seal around the edge of the cover provides friction to hold the cabinet in the tilted position. When the instrument is closed, the same gasket provides a tight seal for the enclosure. Accessories and instruction manual are conveniently stored in the Flip-Tilt cover.

Certain Flip-Tilt instruments are also available in standard relay-rack cabinets; most other Flip-Tilt instruments are available adapted for rack mounting. In such adaptations, the Flip-Tilt case (minus cover and handle) is neatly and securely mounted in a relay-rack adaptor panel.



Convertible-bench instruments with meters tilt on extendible legs for easy viewing of front panel. Panel extensions are used for rack mount.

CONVERTIBLE-BENCH CABINETS

Small and medium-sized instruments commonly used on the bench are housed in GR's unique convertible-bench cabinet, designed primarily for the bench but offering quick relay-rack adaptability.

The convertible-bench cabinet is made of sturdy aluminum finished in GR medium gray wrinkle. The U-shaped dust cover can be easily slipped off after removal of quick-action clamp fasteners. Instruments with panel meters can be tilted to the most convenient angle by means of extendible front legs.

Conversion for relay-rack mounting is easy: matching panel extensions are simply attached by means of screws to the instrument panel and to the relay rack.

LAB-BENCH AND UNIT CABINETS

Lab-bench cabinets are simple enclosures used primarily for laboratory standards and decade boxes. Two U-shaped pieces of $\frac{1}{8}$-inch extruded aluminum are strip-locked together to form the sides, and an aluminum bottom plate and

Two aluminum extrusions are strip-locked together to form the sides, heavy aluminum panel and bottom plate are added, and this precision capacitor is given the excellent shielding and trim appearance of the lab-bench cabinet.

3/16-inch aluminum panel complete the enclosure. The result is a cabinet well shielded, structurally solid, and efficiently manufactured.

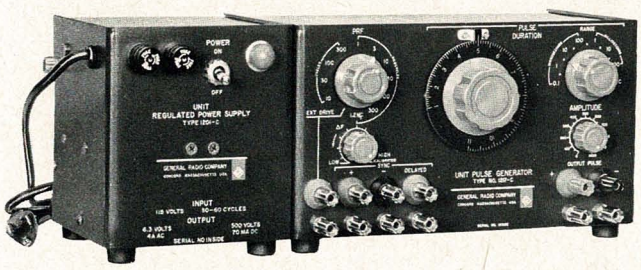
The Unit cabinet, used for general-purpose power supplies and other basic instruments, consists of two U-shaped aluminum pieces — one forming panel and sides and the other making up top, bottom, and rear of the instrument. The latter piece is a perforated dust cover that is easily withdrawn for access to the instrument chassis.

Unit Instruments are specially designed for use with each other, and mating connectors permit the neat, compact assembly of power supply and driven instrument. Adaptor panels are available for rack-mounting Unit Instruments.

OTHER CABINETS

While most General Radio instruments are housed in the five cabinets described above, several other types of mounting are used to serve the special demands of various instruments. These range from the pocket-sized cases used for certain portable sound-measuring instruments to the specialized structures of a slotted line or an admittance meter.

Accessory mounting hardware, such as end frames, relay-rack supports, and relay-rack adaptor panels, may be ordered separately by those customers wishing to convert from one type of mounting to another. Many of these accessories are listed along with the related instruments. Further information on such hardware, dimensions, etc., is available on request.



This Unit Instrument and power supply make a neat combination, with no wasted space. Chassis-mounted multipoint power connectors mate, and locking strips are supplied to make the union permanent, if desired.

REACTANCE CHART

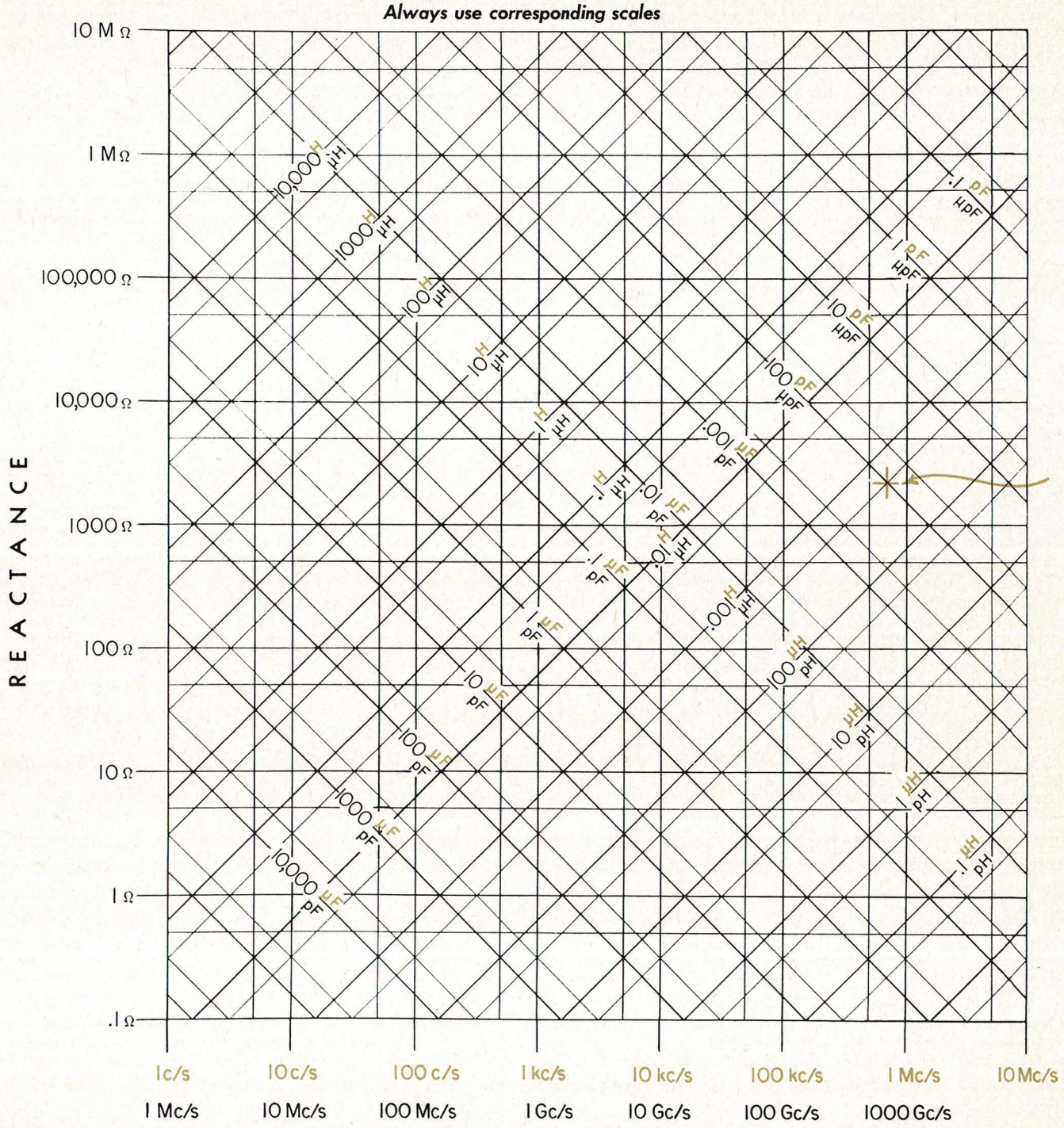


FIGURE 1

Figure 1 is the complete chart, used for rough calculations. Figure 2, which is a single decade of Figure 1 enlarged approximately 7 times, is used where two or three significant figures are to be determined.

TO FIND REACTANCE Enter the charts vertically from the bottom (FREQUENCY) and along the lines slanting upward to the left (CAPACITANCE) or to the right (INDUCTANCE). Corresponding scales (gold or black) must be used throughout. Project horizontally to the left from the intersection and read REACTANCE.

TO FIND RESONANT FREQUENCY Enter the slanting lines for the given inductance and capacitance. Project downward and read resonant frequency from the bottom scale. *Corresponding scales (gold or black) must be used throughout.*

REACTANCE CHART

Always obtain approximate value from Figure 1 before using Figure 2

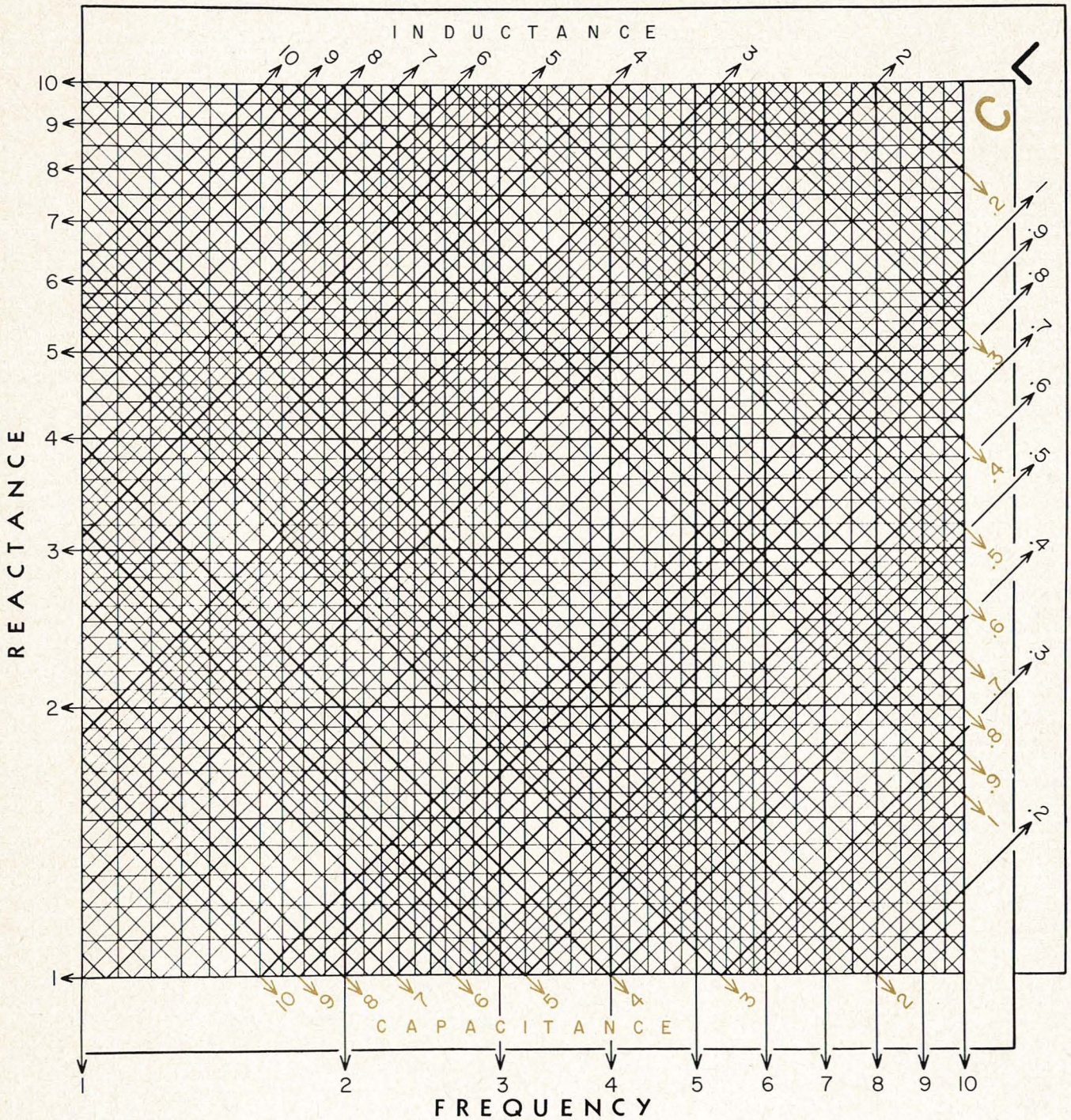


FIGURE 2

Example: The point indicated in Figure 1 corresponds to a frequency of about 700 kc/s and an inductance of 500 μH, or a capacitance of 100 pF, giving in either case a reactance of about 2000 ohms. The resonant frequency of a circuit containing these values of inductance and capacitance is, of course, 700 kc/s, approximately.

USE OF FIGURE 2 Figure 2 gives additional precision but does not place the decimal point, which must be located from a preliminary entry on Figure 1. Since the chart necessarily requires two logarithmic decades for inductance and capacitance for every single decade of frequency and reactance, unless the correct decade for L and C is chosen, the calculated values of reactance and frequency will be in error by a factor of 3.16. In Figure 2, the capacitance scale is gold; inductance scale is black.

Example: (Continued) The reactance corresponding to 500 μH or 100 pF is 2230 ohms at 712 kc/s, their resonant frequency.

DECIBEL CONVERSION TABLES

In communications systems the ratio between any two amounts of electric or acoustic power is usually expressed in units on a logarithmic scale. The *decibel* (1/10th of the *bel*) on the briggsian or base-10 scale and the *neper* on the napierian or base-*e* scale are in almost universal use for this purpose.

Since voltage and current are related to power by impedance, both the *decibel* and the *neper* can be used to express voltage and current ratios, if care is taken to account for the impedances associated with them. In a similar manner the corresponding acoustical quantities can be compared.

From Table I and Table II on the following pages conversions can be made in either direction between the number of *decibels* and the corresponding power, voltage, and current ratios. Both tables can also be used for *nepers* by application of a conversion factor.

Decibel — The number of decibels N_{dB} corresponding to the ratio between two amounts of power P_1 and P_2 is

$$N_{dB} = 10 \log_{10} \frac{P_1}{P_2}$$

When two voltages E_1 and E_2 or two currents I_1 and I_2 operate in identical impedances,

$$N_{dB} = 20 \log_{10} \frac{E_1}{E_2} \quad \text{and} \quad N_{dB} = 20 \log_{10} \frac{I_1}{I_2}.$$

If E_1 and E_2 or I_1 and I_2 operate in unequal impedances,

$$N_{dB} = 20 \log_{10} \frac{E_1}{E_2} + 10 \log_{10} \frac{Z_2}{Z_1} + 10 \log_{10} \frac{k_1}{k_2}$$

and $$N_{dB} = 20 \log_{10} \frac{I_1}{I_2} + 10 \log_{10} \frac{Z_1}{Z_2} + 10 \log_{10} \frac{k_1}{k_2},$$

where Z_1 and Z_2 are the absolute magnitudes of the corresponding impedances and k_1 and k_2 are the values of power factor for the impedances. E_1, E_2, I_1, and I_2 are also the absolute magnitudes of the corresponding quantities. Note that Table I and Table II can be used to evaluate the impedance and power factor terms, since both are similar to the expression for power ratio.

Neper — The number of nepers N_{nep} corresponding to a power ratio $\frac{P_1}{P_2}$ is

$$N_{nep} = \frac{1}{2} \log_e \frac{P_1}{P_2}.$$

For voltage ratios $\frac{E_1}{E_2}$ or current ratios $\frac{I_1}{I_2}$ working in identical impedances,

$$N_{nep} = \log_e \frac{E_1}{E_2} \quad \text{and} \quad N_{nep} = \log_e \frac{I_1}{I_2}.$$

Relations Between Decibels and Nepers

Multiply decibels *by* 0.1151 *to find* nepers
Multiply nepers *by* 8.686 *to find* decibels

TO FIND VALUES OUTSIDE THE RANGE OF CONVERSION TABLES

Table I: Decibels to Voltage and Power Ratios

Number of decibels positive (+): Subtract +20 decibels successively from the given number of decibels until the remainder falls within range of Table I. *To find the voltage ratio*, multiply the corresponding value from the right-hand voltage-ratio column by 10 for each time you subtracted 20 dB. *To find the power ratio*, multiply the corresponding value from the right-hand power-ratio column by 100 for each time you subtracted 20 dB.

Example — *Given:* 49.2 dB
49.2 dB − 20 dB − 20 dB = 9.2 dB

Voltage ratio: 9.2 dB → 2.884
2.884 × 10 × 10 = 288.4

Power ratio: 9.2 dB → 8.318
8.318 × 100 × 100 = 83180

Number of decibels negative (−): Add +20 decibels successively to the given number of decibels until the sum falls within the range of Table I. *For the voltage ratio*, divide the value from the left-hand voltage-ratio column by 10 for each time you added 20 dB. *For the power ratio*, divide the value from the left-hand power-ratio column by 100 for each time you added 20 dB.

Example — *Given:* −49.2 dB
−49.2 dB + 20 dB + 20 dB = −9.2 dB

Voltage ratio: −9.2 dB → 0.3467
0.3467 × 1/10 × 1/10 = 0.003467

Power ratio: −9.2 dB → 0.1202
0.1202 × 1/100 × 1/100 = 0.00001202

Table II: Voltage Ratios to Decibels

For ratios smaller than those in table — Multiply the given ratio by 10 successively until the product can be found in the table. From the number of decibels thus found, subtract +20 decibels for each time you multiplied by 10.

Example — *Given:* Voltage ratio = 0.0131
0.0131 × 10 × 10 = 1.31

From Table II, 1.31 → 2.345 dB
2.345 dB − 20 dB − 20 dB = −37.655 dB

For ratios greater than those in table — Divide the given ratio by 10 successively until the remainder can be found in the table. To the number of decibels thus found, add +20 dB for each time you divided by 10.

Example — *Given:* Voltage ratio = 712
712 × 1/10 × 1/10 = 7.12

From Table II, 7.12 → 17.050 dB
17.050 dB + 20 dB + 20 dB = 57.050 dB

TABLE I

GIVEN: Decibels **TO FIND: Power and {Voltage / Current} Ratios**

TO ACCOUNT FOR THE SIGN OF THE DECIBEL

For positive (+) values of the decibel — Both voltage and power ratios are greater than unity. Use the two right-hand columns.

For negative (−) values of the decibel — Both voltage and power ratios are less than unity. Use the two left-hand columns.

Example — *Given:* ±9.1 dB; *Find:*

	Power Ratio	*Voltage Ratio*
+9.1 dB	8.128	2.851
−9.1 dB	0.1230	0.3508

← *Voltage Ratio*	← *Power Ratio*	*dB*	*Voltage Ratio* →	*Power Ratio* →
1.0000	**1.0000**	**0**	**1.000**	**1.000**
.9886	.9772	.1	1.012	1.023
.9772	.9550	.2	1.023	1.047
.9661	.9333	.3	1.035	1.072
.9550	.9120	.4	1.047	1.096
.9441	.8913	.5	1.059	1.122
.9333	.8710	.6	1.072	1.148
.9226	.8511	.7	1.084	1.175
.9120	.8318	.8	1.096	1.202
.9016	.8128	.9	1.109	1.230
.8913	**.7943**	**1.0**	**1.122**	**1.259**
.8810	.7762	1.1	1.135	1.288
.8710	.7586	1.2	1.148	1.318
.8610	.7413	1.3	1.161	1.349
.8511	.7244	1.4	1.175	1.380
.8414	.7079	1.5	1.189	1.413
.8318	.6918	1.6	1.202	1.445
.8222	.6761	1.7	1.216	1.479
.8128	.6607	1.8	1.230	1.514
.8035	.6457	1.9	1.245	1.549
.7943	**.6310**	**2.0**	**1.259**	**1.585**
.7852	.6166	2.1	1.274	1.622
.7762	.6026	2.2	1.288	1.660
.7674	.5888	2.3	1.303	1.698
.7586	.5754	2.4	1.318	1.738
.7499	.5623	2.5	1.334	1.778
.7413	.5495	2.6	1.349	1.820
.7328	.5370	2.7	1.365	1.862
.7244	.5248	2.8	1.380	1.905
.7161	.5129	2.9	1.396	1.950
.7079	**.5012**	**3.0**	**1.413**	**1.995**
.6998	.4898	3.1	1.429	2.042
.6918	.4786	3.2	1.445	2.089
.6839	.4677	3.3	1.462	2.138
.6761	.4571	3.4	1.479	2.188
.6683	.4467	3.5	1.496	2.239
.6607	.4365	3.6	1.514	2.291
.6531	.4266	3.7	1.531	2.344
.6457	.4169	3.8	1.549	2.399
.6383	.4074	3.9	1.567	2.455
.6310	**.3981**	**4.0**	**1.585**	**2.512**
.6237	.3890	4.1	1.603	2.570
.6166	.3802	4.2	1.622	2.630
.6095	.3715	4.3	1.641	2.692
.6026	.3631	4.4	1.660	2.754
.5957	.3548	4.5	1.679	2.818
.5888	.3467	4.6	1.698	2.884
.5821	.3388	4.7	1.718	2.951
.5754	.3311	4.8	1.738	3.020
.5689	.3236	4.9	1.758	3.090

← *Voltage Ratio*	← *Power Ratio*	*dB*	*Voltage Ratio* →	*Power Ratio* →
.5623	**3162**	**5.0**	**1.778**	**3.162**
.5559	.3090	5.1	1.799	3.236
.5495	.3020	5.2	1.820	3.311
.5433	.2951	5.3	1.841	3.388
.5370	.2884	5.4	1.862	3.467
.5309	.2818	5.5	1.884	3.548
.5248	.2754	5.6	1.905	3.631
.5188	.2692	5.7	1.928	3.715
.5129	.2630	5.8	1.950	3.802
.5070	.2570	5.9	1.972	3.890
.5012	**.2512**	**6.0**	**1.995**	**3.981**
.4955	.2455	6.1	2.018	4.074
.4898	.2399	6.2	2.042	4.169
.4842	.2344	6.3	2.065	4.266
.4786	.2291	6.4	2.089	4.365
.4732	.2239	6.5	2.113	4.467
.4677	.2188	6.6	2.138	4.571
.4624	.2138	6.7	2.163	4.677
.4571	.2089	6.8	2.188	4.786
.4519	.2042	6.9	2.213	4.898
.4467	**.1995**	**7.0**	**2.239**	**5.012**
.4416	.1950	7.1	2.265	5.129
.4365	.1905	7.2	2.291	5.248
.4315	.1862	7.3	2.317	5.370
.4266	.1820	7.4	2.344	5.495
.4217	.1778	7.5	2.371	5.623
.4169	.1738	7.6	2.399	5.754
.4121	.1698	7.7	2.427	5.888
.4074	.1660	7.8	2.455	6.026
.4027	.1622	7.9	2.483	6.166
.3981	**.1585**	**8.0**	**2.512**	**6.310**
.3936	.1549	8.1	2.541	6.457
.3890	.1514	8.2	2.570	6.607
.3846	.1479	8.3	2.600	6.761
.3802	.1445	8.4	2.630	6.918
.3758	.1413	8.5	2.661	7.079
.3715	.1380	8.6	2.692	7.244
.3673	.1349	8.7	2.723	7.413
.3631	.1318	8.8	2.754	7.586
.3589	.1288	8.9	2.786	7.762
.3548	**.1259**	**9.0**	**2.818**	**7.943**
.3508	.1230	9.1	2.851	8.128
.3467	.1202	9.2	2.884	8.318
.3428	.1175	9.3	2.917	8.511
.3388	.1148	9.4	2.951	8.710
.3350	.1122	9.5	2.985	8.913
.3311	.1096	9.6	3.020	9.120
.3273	.1072	9.7	3.055	9.333
.3236	.1047	9.8	3.090	9.550
.3199	.1023	9.9	3.126	9.772

TABLE I (continued)

Voltage Ratio	Power Ratio	dB	Voltage Ratio	Power Ratio
.3162	**.1000**	**10.0**	**3.162**	**10.000**
.3126	.09772	10.1	3.199	10.23
.3090	.09550	10.2	3.236	10.47
.3055	.09333	10.3	3.273	10.72
.3020	.09120	10.4	3.311	10.96
.2985	.08913	10.5	3.350	11.22
.2951	.08710	10.6	3.388	11.48
.2917	.08511	10.7	3.428	11.75
.2884	.08318	10.8	3.467	12.02
.2851	.08128	10.9	3.508	12.30
.2818	**.07943**	**11.0**	**3.548**	**12.59**
.2786	.07762	11.1	3.589	12.88
.2754	.07586	11.2	3.631	13.18
.2723	.07413	11.3	3.673	13.49
.2692	.07244	11.4	3.715	13.80
.2661	.07079	11.5	3.758	14.13
.2630	.06918	11.6	3.802	14.45
.2600	.06761	11.7	3.846	14.79
.2570	.06607	11.8	3.890	15.14
.2541	.06457	11.9	3.936	15.49
2512	**.06310**	**12.0**	**3.981**	**15.85**
.2483	.06166	12.1	4.027	16.22
.2455	.06026	12.2	4.074	16.60
.2427	.05888	12.3	4.121	16.98
.2399	.05754	12.4	4.169	17.38
.2371	.05623	12.5	4.217	17.78
.2344	.05495	12.6	4.266	18.20
.2317	.05370	12.7	4.315	18.62
.2291	.05248	12.8	4.365	19.05
.2265	.05129	12.9	4.416	19.50
.2239	**.05012**	**13.0**	**4.467**	**19.95**
.2213	.04898	13.1	4.519	20.42
.2188	.04786	13.2	4.571	20.89
.2163	.04677	13.3	4.624	21.38
.2138	.04571	13.4	4.677	21.88
.2113	.04467	13.5	4.732	22.39
.2089	.04365	13.6	4.786	22.91
.2065	.04266	13.7	4.842	23.44
.2042	.04169	13.8	4.898	23.99
.2018	.04074	13.9	4.955	24.55
.1995	**.03981**	**14.0**	**5.012**	**25.12**
.1972	.03890	14.1	5.070	25.70
.1950	.03802	14.2	5.129	26.30
.1928	.03715	14.3	5.188	26.92
.1905	.03631	14.4	5.248	27.54
.1884	.03548	14.5	5.309	28.18
.1862	.03467	14.6	5.370	28.84
.1841	.03388	14.7	5.433	29.51
.1820	.03311	14.8	5.495	30.20
.1799	.03236	14.9	5.559	30.90
.1778	**.03162**	**15.0**	**5.623**	**31.62**
.1758	.03090	15.1	5.689	32.36
.1738	.03020	15.2	5.754	33.11
.1718	.02951	15.3	5.821	33.88
.1698	.02884	15.4	5.888	34.67
.1679	.02818	15.5	5.957	35.48
.1660	.02754	15.6	6.026	36.31
.1641	.02692	15.7	6.095	37.15
.1622	.02630	15.8	6.166	38.02
.1603	.02570	15.9	6.237	38.90

Voltage Ratio	Power Ratio	dB	Voltage Ratio	Power Ratio
.1585	**.02512**	**16.0**	**6.310**	**39.81**
.1567	.02455	16.1	6.383	40.74
.1549	.02399	16.2	6.457	41.69
.1531	.02344	16.3	6.531	42.66
.1514	.02291	16.4	6.607	43.65
.1496	.02239	16.5	6.683	44.67
.1479	.02188	16.6	6.761	45.71
.1462	.02138	16.7	6.839	46.77
.1445	.02089	16.8	6.918	47.86
.1429	.02042	16.9	6.998	48.98
.1413	**.01995**	**17.0**	**7.079**	**50.12**
.1396	.01950	17.1	7.161	51.29
.1380	.01905	17.2	7.244	52.48
.1365	.01862	17.3	7.328	53.70
.1349	.01820	17.4	7.413	54.95
.1334	.01778	17.5	7.499	56.23
.1318	.01738	17.6	7.586	57.54
.1303	.01698	17.7	7.674	58.88
.1288	.01660	17.8	7.762	60.26
.1274	.01622	17.9	7.852	61.66
.1259	**.01585**	**18.0**	**7.943**	**63.10**
.1245	.01549	18.1	8.035	64.57
.1230	.01514	18.2	8.128	66.07
.1216	.01479	18.3	8.222	67.61
.1202	.01445	18.4	8.318	69.18
.1189	.01413	18.5	8.414	70.79
.1175	.01380	18.6	8.511	72.44
.1161	.01349	18.7	8.610	74.13
.1148	.01318	18.8	8.710	75.86
.1135	.01288	18.9	8.811	77.62
.1122	**.01259**	**19.0**	**8.913**	**79.43**
.1109	.01230	19.1	9.016	81.28
.1096	.01202	19.2	9.120	83.18
.1084	.01175	19.3	9.226	85.11
.1072	.01148	19.4	9.333	87.10
.1059	.01122	19.5	9.441	89.13
.1047	.01096	19.6	9.550	91.20
.1035	.01072	19.7	9.661	93.33
.1023	.01047	19.8	9.772	95.50
.1012	.01023	19.9	9.886	97.72
.1000	**.01000**	**20.0**	**10.000**	**100.00**

Voltage Ratio	Power Ratio	dB	Voltage Ratio	Power Ratio
3.162×10^{-1}	**10^{-1}**	**10**	**3.162**	**10**
10^{-1}	10^{-2}	20	10	10^{2}
3.162×10^{-2}	10^{-3}	30	3.162×10	10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
3.162×10^{-3}	10^{-5}	50	3.162×10^{2}	10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
3.162×10^{-4}	10^{-7}	70	3.162×10^{3}	10^{7}
10^{-4}	10^{-8}	80	10^{4}	10^{8}
3.162×10^{-5}	10^{-9}	90	3.162×10^{4}	10^{9}
10^{-5}	**10^{-10}**	**100**	**10^{5}**	**10^{10}**

To find decibel values outside the range of this table, see page 262.

TABLE II

GIVEN: {Voltage / Current} **Ratio** — **TO FIND: Decibels**

POWER RATIOS

To find the number of decibels corresponding to a given power ratio — Assume the given power ratio to be a voltage ratio and find the corresponding number of decibels from the table. The desired result is exactly one-half of the number of decibels thus found.

Example — *Given:* a power ratio of 3.41.

Find: 3.41 in the table:

3.41 → 10.655 dB (voltage)

10.655 dB × ½ = 5.328 dB (power)

Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
1.0	**.000**	**.086**	**.172**	**.257**	**.341**	**.424**	**.506**	**.588**	**.668**	**.749**
1.1	.828	.906	.984	1.062	1.138	1.214	1.289	1.364	1.438	1.511
1.2	1.584	1.656	1.727	1.798	1.868	1.938	2.007	2.076	2.144	2.212
1.3	2.279	2.345	2.411	2.477	2.542	2.607	2.671	2.734	2.798	2.860
1.4	2.923	2.984	3.046	3.107	3.167	3.227	3.287	3.346	3.405	3.464
1.5	3.522	3.580	3.637	3.694	3.750	3.807	3.862	3.918	3.973	4.028
1.6	4.082	4.137	4.190	4.244	4.297	4.350	4.402	4.454	4.506	4.558
1.7	4.609	4.660	4.711	4.761	4.811	4.861	4.910	4.959	5.008	5.057
1.8	5.105	5.154	5.201	5.249	5.296	5.343	5.390	5.437	5.483	5.529
1.9	5.575	5.621	5.666	5.711	5.756	5.801	5.845	5.889	5.933	5.977
2.0	**6.021**	**6.064**	**6.107**	**6.150**	**6.193**	**6.235**	**6.277**	**6.319**	**6.361**	**6.403**
2.1	6.444	6.486	6.527	6.568	6.608	6.649	6.689	6.729	6.769	6.809
2.2	6.848	6.888	6.927	6.966	7.008	7.044	7.082	7.121	7.159	7.197
2.3	7.235	7.272	7.310	7.347	7.384	7.421	7.458	7.495	7.532	7.568
2.4	7.604	7.640	7.676	7.712	7.748	7.783	7.819	7.854	7.889	7.924
2.5	7.959	7.993	8.028	8.062	8.097	8.131	8.165	8.199	8.232	8.266
2.6	8.299	8.333	8.366	8.399	8.432	8.465	8.498	8.530	8.563	8.595
2.7	8.627	8.659	8.691	8.723	8.755	8.787	8.818	8.850	8.881	8.912
2.8	8.943	8.974	9.005	9.036	9.066	9.097	9.127	9.158	9.188	9.218
2.9	9.248	9.278	9.308	9.337	9.367	9.396	9.426	9.455	9.484	9.513
3.0	**9.542**	**9.571**	**9.600**	**9.629**	**9.657**	**9.686**	**9.714**	**9.743**	**9.771**	**9.799**
3.1	9.827	9.855	9.883	9.911	9.939	9.966	9.994	10.021	10.049	10.076
3.2	10.103	10.130	10.157	10.184	10.211	10.238	10.264	10.291	10.317	10.344
3.3	10.370	10.397	10.423	10.449	10.475	10.501	10.527	10.553	10.578	10.604
3.4	10.630	10.655	10.681	10.706	10.731	10.756	10.782	10.807	10.832	10.857
3.5	10.881	10.906	10.931	10.955	10.980	11.005	11.029	11.053	11.078	11.102
3.6	11.126	11.150	11.174	11.198	11.222	11.246	11.270	11.293	11.317	11.341
3.7	11.364	11.387	11.411	11.434	11.457	11.481	11.504	11.527	11.550	11.573
3.8	11.596	11.618	11.641	11.664	11.687	11.709	11.732	11.754	11.777	11.799
3.9	11.821	11.844	11.866	11.888	11.910	11.932	11.954	11.976	11.998	12.019
4.0	**12.041**	**12.063**	**12.085**	**12.106**	**12.128**	**12.149**	**12.171**	**12.192**	**12.213**	**12.234**
4.1	12.256	12.277	12.298	12.319	12.340	12.361	12.382	12.403	12.424	12.444
4.2	12.465	12.486	12.506	12.527	12.547	12.568	12.588	12.609	12.629	12.649
4.3	12.669	12.690	12.710	12.730	12.750	12.770	12.790	12.810	12.829	12.849
4.4	12.869	12.889	12.908	12.928	12.948	12.967	12.987	13.006	13.026	13.045
4.5	13.064	13.084	13.103	13.122	13.141	13.160	13.179	13.198	13.217	13.236
4.6	13.255	13.274	13.293	13.312	13.330	13.349	13.368	13.386	13.405	13.423
4.7	13.442	13.460	13.479	13.497	13.516	13.534	13.552	13.570	13.589	13.607
4.8	13.625	13.643	13.661	13.679	13.697	13.715	13.733	13.751	13.768	13.786
4.9	13.804	13.822	13.839	13.857	13.875	13.892	13.910	13.927	13.945	13.962
5.0	**13.979**	**13.997**	**14.014**	**14.031**	**14.049**	**14.066**	**14.083**	**14.100**	**14.117**	**14.134**
5.1	14.151	14.168	14.185	14.202	14.219	14.236	14.253	14.270	14.287	14.303
5.2	14.320	14.337	14.353	14.370	14.387	14.403	14.420	14.436	14.453	14.469
5.3	14.486	14.502	14.518	14.535	14.551	14.567	14.583	14.599	14.616	14.632
5.4	14.648	14.664	14.680	14.696	14.712	14.728	14.744	14.760	14.776	14.791
5.5	14.807	14.823	14.839	14.855	14.870	14.886	14.902	14.917	14.933	14.948
5.6	14.964	14.979	14.995	15.010	15.026	15.041	15.056	15.072	15.087	15.102
5.7	15.117	15.133	15.148	15.163	15.178	15.193	15.208	15.224	15.239	15.254
5.8	15.269	15.284	15.298	15.313	15.328	15.343	15.358	15.373	15.388	15.402
5.9	15.417	15.432	15.446	15.461	15.476	15.490	15.505	15.519	15.534	15.549

TABLE II (continued)

Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
6.0	**15.563**	**15.577**	**15.592**	**15.606**	**15.621**	**15.635**	**15.649**	**15.664**	**15.678**	**15.692**
6.1	15.707	15.721	15.735	15.749	15.763	15.778	15.792	15.806	15.820	15.834
6.2	15.848	15.862	15.876	15.890	15.904	15.918	15.931	15.945	15.959	15.973
6.3	15.987	16.001	16.014	16.028	16.042	16.055	16.069	16.083	16.096	16.110
6.4	16.124	16.137	16.151	16.164	16.178	16.191	16.205	16.218	16.232	16.245
6.5	16.258	16.272	16.285	16.298	16.312	16.325	16.338	16.351	16.365	16.378
6.6	16.391	16.404	16.417	16.430	16.443	16.456	16.469	16.483	16.496	16.509
6.7	16.521	16.534	16.547	16.560	16.573	16.586	16.599	16.612	16.625	16.637
6.8	16.650	16.663	16.676	16.688	16.701	16.714	16.726	16.739	16.752	16.764
6.9	16.777	16.790	16.802	16.815	16.827	16.840	16.852	16.865	16.877	16.890
7.0	**16.902**	**16.914**	**16.927**	**16.939**	**16.951**	**16.964**	**16.976**	**16.988**	**17.001**	**17.013**
7.1	17.025	17.037	17.050	17.062	17.074	17.086	17.098	17.110	17.122	17.135
7.2	17.147	17.159	17.171	17.183	17.195	17.207	17.219	17.231	17.243	17.255
7.3	17.266	17.278	17.290	17.302	17.314	17.326	17.338	17.349	17.361	17.373
7.4	17.385	17.396	17.408	17.420	17.431	17.443	17.455	17.466	17.478	17.490
7.5	17.501	17.513	17.524	17.536	17.547	17.559	17.570	17.582	17.593	17.605
7.6	17.616	17.628	17.639	17.650	17.662	17.673	17.685	17.696	17.707	17.719
7.7	17.730	17.741	17.752	17.764	17.775	17.786	17.797	17.808	17.820	17.831
7.8	17.842	17.853	17.864	17.875	17.886	17.897	17.908	17.919	17.931	17.942
7.9	17.953	17.964	17.975	17.985	17.996	18.007	18.018	18.029	18.040	18.051
8.0	**18.062**	**18.073**	**18.083**	**18.094**	**18.105**	**18.116**	**18.127**	**18.137**	**18.148**	**18.159**
8.1	18.170	18.180	18.191	18.202	18.212	18.223	18.234	18.244	18.255	18.266
8.2	18.276	18.287	18.297	18.308	18.319	18.329	18.340	18.350	18.361	18.371
8.3	18.382	18.392	18.402	18.413	18.423	18.434	18.444	18.455	18.465	18.475
8.4	18.486	18.496	18.506	18.517	18.527	18.537	18.547	18.558	18.568	18.578
8.5	18.588	18.599	18.609	18.619	18.629	18.639	18.649	18.660	18.670	18.680
8.6	18.690	18.700	18.710	18.720	18.730	18.740	18.750	18.760	18.770	18.780
8.7	18.790	18.800	18.810	18.820	18.830	18.840	18.850	18.860	18.870	18.880
8.8	18.890	18.900	18.909	18.919	18.929	18.939	18.949	18.958	18.968	18.978
8.9	18.988	18.998	19.007	19.017	19.027	19.036	19.046	19.056	19.066	19.075
9.0	**19.085**	**19.094**	**19.104**	**19.114**	**19.123**	**19.133**	**19.143**	**19.152**	**19.162**	**19.171**
9.1	19.181	19.190	19.200	19.209	19.219	19.228	19.238	19.247	19.257	19.226
9.2	19.276	19.285	19.295	19.304	19.313	19.323	19.332	19.342	19.351	19.360
9.3	19.370	19.379	19.388	19.398	19.407	19.416	19.426	19.435	19.444	19.453
9.4	19.463	19.472	19.481	19.490	19.499	19.509	19.518	19.527	19.536	19.545
9.5	19.554	19.564	19.573	19.582	19.591	19.600	19.609	19.618	19.627	19.636
9.6	19.645	19.654	19.664	19.673	19.682	19.691	19.700	19.709	19.718	19.726
9.7	19.735	19.744	19.753	19.762	19.771	19.780	19.789	19.798	19.807	19.816
9.8	19.825	19.833	19.842	19.851	19.860	19.869	19.878	19.886	19.895	19.904
9.9	19.913	19.921	19.930	19.939	19.948	19.956	19.965	19.974	19.983	19.991

Voltage Ratio	0	1	2	3	4	5	6	7	8	9
10	**20.000**	**20.828**	**21.584**	**22.279**	**22.923**	**23.522**	**24.082**	**24.609**	**25.105**	**25.575**
20	26.021	26.444	26.848	27.235	27.604	27.959	28.299	28.627	28.943	29.248
30	29.542	29.827	30.103	30.370	30.630	30.881	31.126	31.364	31.596	31.821
40	32.041	32.256	32.465	32.669	32.869	33.064	33.255	33.442	33.625	33.804
50	33.979	34.151	34.320	34.486	34.648	34.807	34.964	35.117	35.269	35.417
60	35.563	35.707	35.848	35.987	36.124	36.258	36.391	36.521	36.650	36.777
70	36.902	37.025	37.147	37.266	37.385	37.501	37.616	37.730	37.842	37.953
80	38.062	38.170	38.276	38.382	38.486	38.588	38.690	38.790	38.890	38.988
90	39.085	39.181	39.276	39.370	39.463	39.554	39.645	39.735	39.825	39.913
100	**40.000**	—	—	—	—	—	—	—	—	—

To find ratios outside the range of this table, see page 262.

INDEX BY TYPE NUMBER

INDEX BY SUBJECT AND TITLE

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