# TYPE 1420 VARIABLE AIR CAPACITOR

## A NEW, HIGH-QUALITY COMPONENT FOR INSTRUMENT USE

The concept of machining a parallel-plate type of variable air capacitor from solid metal, although not a new one, is unique among contemporary manufacturers. The main features of the new TYPE 1420 Capacitors (Fig. 1) are derived from this technique, which offers advantages, both mechanical and electrical, over more conventional methods.

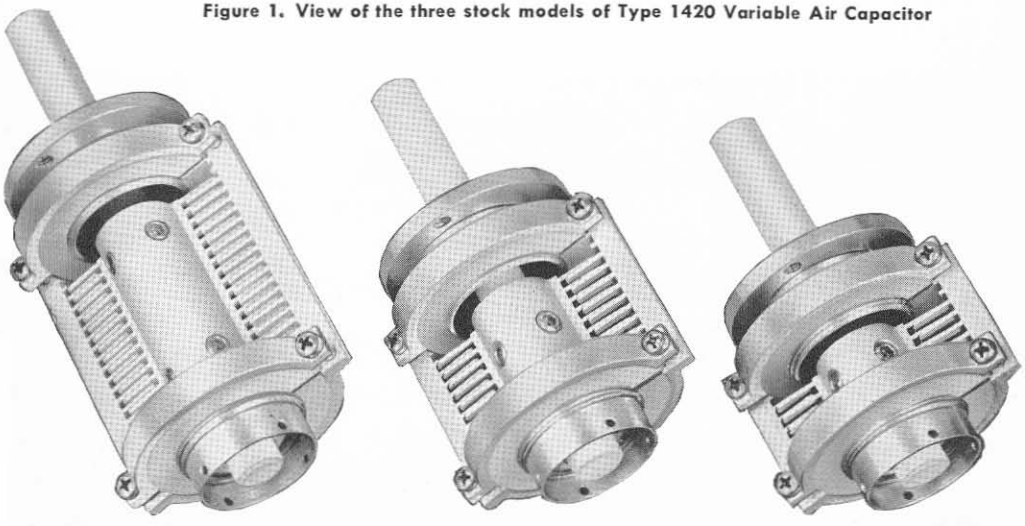
Certain mechanical advantages are obvious. Machining is inherently a more precise operation than rolling, so that plates can be better controlled in thickness and straightness. Gang milling eliminates the cumulative spacing errors imposed by piece tolerances on a stacked structure, and turning and boring on a single piece insures better concentricity than can be obtained in a composite assembly. The integral-plate construction makes a sturdy structure with high mechanical stability.

Electrical performance gains are equally apparent. The precise machining produces inherently good linearity and control of capacitance magnitude. The homogeneous nature of the conductors yields lower metallic resistance and inductance than even a soldered stack and provides low thermal drift. The ruggedness of the plates minimizes microphonic tendencies.

The General Radio Company, in the light of the advanced state of the arts of aluminum extrusion alloys and cutting tools, undertook the development of a practical capacitor incorporating the foregoing advantages. Although the improved performance for this construction in an instrument-grade capacitor would warrant a cost premium, it was discovered that the proper combination of free-machining aluminum alloy with tungsten-carbide tools in a special machine (Fig. 3) produced superior one-piece plate assemblies at less cost than the conventional punching, stacking and soldering methods.

The design of the TYPE 1420 Variable Air Capacitor, delineated in Fig. 2, takes further advantage of the machining process to provide a number of extra features. Because the stator (1) is plunge cut, the resulting plates are completely joined on their outer pe-

**Figure 1. View of the three stock models of Type 1420 Variable Air Capacitor**



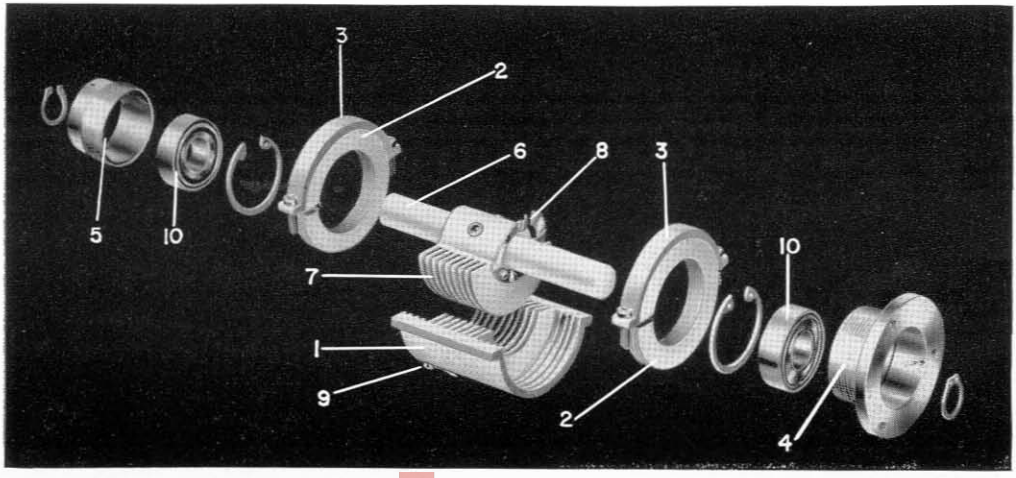
ripheries. This eliminates irregularities in the capacitance-vs.-rotation curve which might otherwise be caused when the rotor passes the vicinity of a stator supporting post or strut, helps to minimize resistance and inductance, and makes the part rigid enough to serve as the supporting frame for the whole capacitor. Use of the stator as a frame is accomplished by concentrically boring out all but $\frac{1}{32}$ in. of the four plates on each end of the piece. Precisely fitted polystyrene insulators (2) are matched to these bored ends and held by clamps (3). The vestigial plates in both stator and clamps lock the insulators axially.

Polystyrene is an ideal dielectric material for the insulators of an air capacitor, because of its low dielectric constant and extremely low losses. Although it is thermally and mechanically unsuitable in most structures, the insulators in the TYPE 1420 are machined from a cast bar of cross-linked polystyrene for thermal adequacy and are stressed entirely in compression over a wide area to eliminate crazing or other structural failure.

These insulators have tapped center holes and are slit, to mate with and to clamp on to, threaded bearing cages (4) and (5), thereby permitting micrometer adjustment and subsequent locking of the ball bearings (10), which support the shaft (6). The shaft is of glass-reinforced polyester, filled with long axial fibers, similar to a modern fishing rod, and is of exceptional strength and stability as well as being good electrically. The use of an insulating shaft isolates the rotor for three-terminal connections and takes the ball bearings out of any electrical path. It is well known that the erratic conductivity of ball bearings produces electrical noise even when well shunted by parallel sliding contacts.

The rotor (7) is simply and firmly attached to the shaft by setscrews transverse to a closely fitted through hole. The concentricity of the rotor is insured, because the plates are milled and turned on a centered arbor held by the setscrews exactly as the shaft is secured in assembly. The front end bearing cage (4) has a flange by which the capacitor is mounted, and the rear cage (5) has a thin-walled, perforated extension to which a rotor connection may be soldered. Electrical connection to the stator is normally made by a solder lug (9) which is affixed adjacent to the rotor terminal to aid in providing short leads to associated circuitry.

**Figure 2. Exploded view of a Type 1420 Variable Air Capacitor with elements identified. In order to show the split-spring ring contact, the rotor is reversed in this view.**



A coin-silver, split-spring ring (8) is attached permanently to the rotor with drive pins and has two independent sliding contacts brushing the rear bearing cage. In the General Radio TYPE 1606-A R-F Bridge, a special reversed version is used, in which the rotor brush makes contact with the front bearing housing to provide a grounded rotor.

The rotor, stator, and clamp blanks are cut off from shaped extruded rods (Fig. 4). The aluminum alloy is identical in these parts to eliminate differential expansions and consequent thermal capacitance drift. The bearing cages are of brass, bright-alloy plated, and the full size (standard inch series 3/8") ball bearings are double shielded, packed with wide-temperature-range lubricant and are suitable for continuous motor drive. In the TYPE 1606-A R-F Bridge these capacitors have passed all the environmental tests of MIL-T-945-A.

An interesting application of the TYPE 1420 Capacitor is shown in Fig. 5. This small, plug-in, general-purpose variable capacitor is shielded and equipped with a coaxial connector. The design takes advantage of the good high-frequency characteristics of the TYPE 1420, as well as its compactness, ruggedness and reliability.

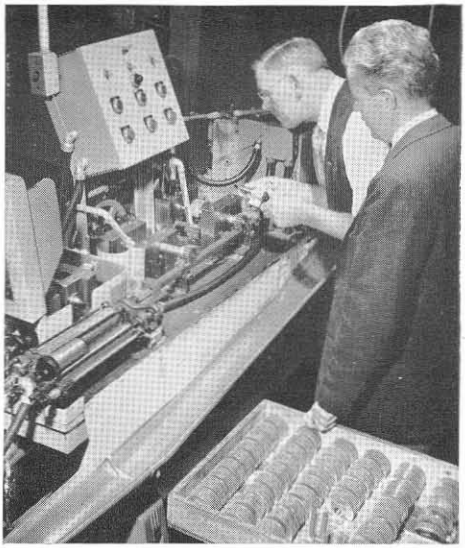
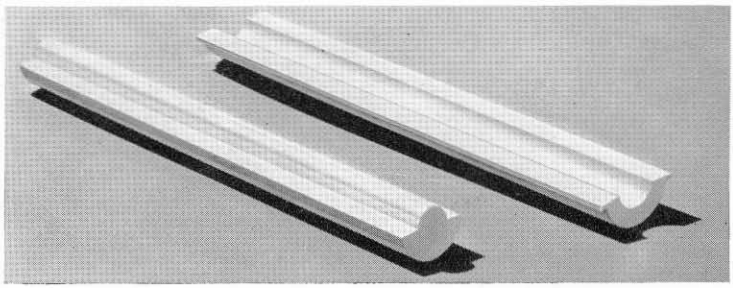


**Figure 3. Designed and built in General Radio's tool department, this machine automatically mills the rotors and stators from the aluminum extrusions shown in Figure 4.**

The General Radio Company has had several years experience in the manufacture and use of these milled plate capacitors in proprietary instruments. They are now being offered for sale as a catalog component in the belief that many customers will have applications ideally suited to their many features.

— H. M. WILSON

**(Below) Figure 4. Extruded aluminum stock from which rotor and stator are milled. (right) Figure 5. View of the Type 874-VC Variable Capacitor, a shielded unit of the 1420-type, used as a tuning element in coaxial circuits.**



## SPECIFICATIONS

**Capacitance Range:**

| | *Nominal* Max. | Min. | *Range for Linear variation* |
|---|---|---|---|
| H | 250 | 16 | 216 ± 5μμf |
| G | 130 | 14 | 108 ± 5μμf |
| F | 70 | 13 | 54 ± 5μμf |

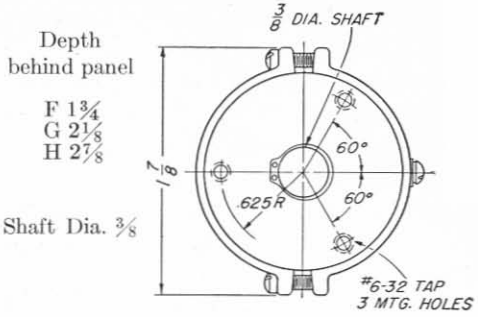
The rotor-to-ground capacitance is about 2μμf, and the stator-to-ground capacitance is about 6μμf, for all sizes. The data in the above table are for the capacitor used as a two-terminal device, with rotor grounded. If stator is grounded, maximum and minimum capacitance values will be decreased by about 4μμf.

**Linearity:** The variation of capacitance with angle of rotation is guaranteed linear within ± 0.2% of full scale. The angular range of linear variations is 160°.

Typical linearity is better than ± 0.1%.

**Dielectric Losses:** For the grounded-rotor connection, the dielectric losses correspond to a $D_oC_o$ product of less than .01 x $10^{-12}$. The rotor-to-ground capacitance has a $D_oC_o$ product of 0.1 x $10^{-12}$. This loss component is in parallel with the main capacitance only for the ground-stator connection.

**Insulation Resistance:** Greater than $10^{11}$ ohms under standard ASTM laboratory conditions (23° C, 50% RH).




**Temperature Coefficient of Capacitance:** Approximately + .003% per degree C.

**Shock and Vibration:** Will pass shock and vibration tests of MIL-T-945-A.

**Maximum Voltage:** 70 volts peak.

**Inductance:** Approximately 0.006 micro-henry.

**Torque:** 2 ounce-inches maximum.

**Net Weight:** TYPE 1420-F, 4 oz; -G, 4½ oz; -H, 5½ oz.

**Dimensions:** See sketch.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1420-F** | **70 μμf, max.....** | MARRY | **$20.00** |
| **1420-G** | **130 μμf, max.....** | MATIN | **21.50** |
| **1420-H** | **250 μμf, max.....** | MAXIM | **22.50** |

# CLOSE-OUT SALE OF TYPE 1702-M MOTOR CONTROL

### ¾-hp, push-button-controlled model

We have on hand a number of our ¾-hp, TYPE 1702-M Variac® Speed Controls, complete with push-button control stations. This model, which originally sold for $350.00, has been discontinued as a result of the introduction of the new TYPE 1702-BW, which can be used with a drum-type controller to accomplish the same purpose at a lower price.

These controls are brand new and carry our standard new-equipment guarantee. To close out our stock, they are now offered at $175.00 each, just one-half the original price. Circuit and characteristics are identical with those currently supplied on newer models, and the unit is an exceptional bargain at this price, which is well below that of current models.

This control will operate a 115-volt, d-c, shunt or compound motor from a 115-volt, 60-cycle, a-c line. Motor speed is continuously adjustable and is controlled by a Variac® autotransformer. A description will be found on page 3 of the *Experimenter* for December, 1953.