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GENERAL RADIO COMPANY

West Concord, Massachusetts*, 01781

Telephone: (Concord) 369–4400; (Boston) 646-7400
Area Code Number: 617

METROPOLITAN NEW YORK:* Broad Avenue at Linden, Ridgefield, N. J., 07657
Telephone—N. Y., 212 964-2722
N. J., 201 943-3140

SYRACUSE: Pickard Building, East Molloy Road, Syracuse, N. Y., 13211
Telephone—315 454-9323

PHILADELPHIA: 1150 York Road, Abington, Pa., 19001
Telephone—Phila., 215 424-7419
Abington, 215 887-8486

WASHINGTON* and BALTIMORE: Rockville Pike at Wall Lane, Rockville, Md., 20852
Telephone—301 946-1600

ORLANDO: 113 East Colonial Drive, Orlando, Florida, 32801
Telephone—305 425-4671

CHICAGO:* 6605 West North Avenue, Oak Park, Illinois, 60302
Telephone—312 848-9400

CLEVELAND: 5579 Pearl, Cleveland, Ohio, 44129
Telephone—216 886-0150

DALLAS: 2501-A West Mockingbird Lane, Dallas, Texas, 75235
Telephone—214 Fleetwood 7-4031

LOS ANGELES:* 1000 North Seward St., Los Angeles 8, Cal., 90038
Telephone—213 469-6201

SAN FRANCISCO: 1186 Los Altos Ave., Los Altos, Cal., 94022
Telephone—415 948-8233

TORONTO:* 99 Floral Parkway, Toronto 15, Ontario
Telephone—416 247-2171

MONTREAL: Office 395 1255 Laird Blvd., Town of Mount Royal, Quebec
Telephone—514 737-3673, -3674

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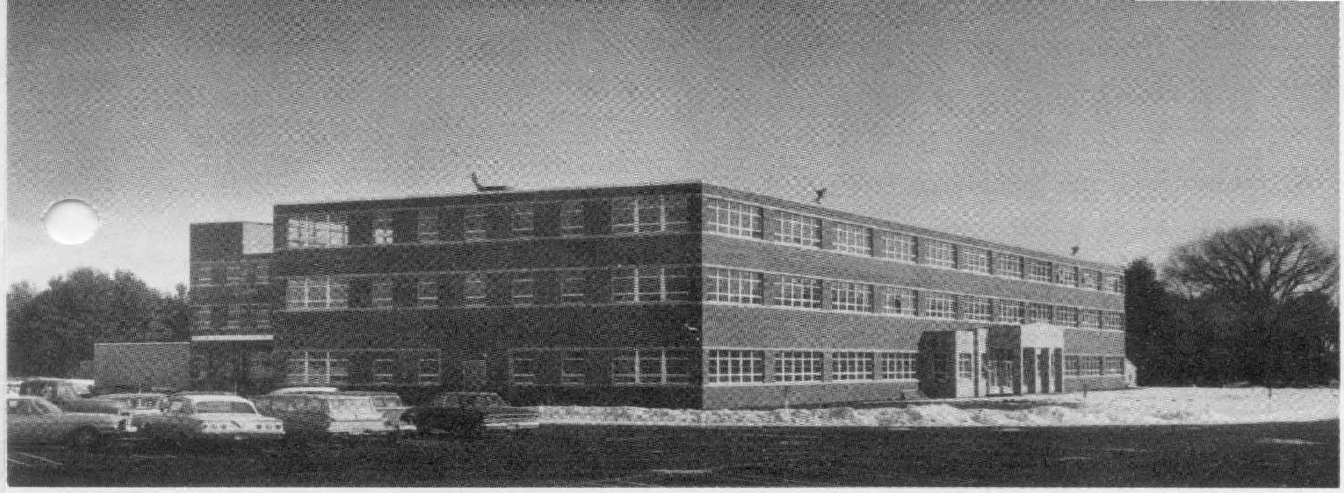
COVER

The inner conductors of Type 900 Precision Coaxial Connectors are measured to one millionth of an inch by the Type 1615-A Capacitance Bridge. See page 4.



GR'S NEW BOLTON PLANT

Early in February, about 150 General Radio employees will shift their daily operations about 10 miles west of Concord, to our new plant in Bolton, Mass. Thus begins a new and significant phase in the growth of General Radio.

Less than six years have passed since GR "went suburban," moving from Cambridge to its new 300,000-square-foot headquarters in West Concord. Only a few years after this move, a 100-acre tract in nearby Bolton was purchased in preparation for the next major Company expansion.

The decision to divert expansion to a new site rather than to continue building on our 88-acre Concord property was based on several factors. Maintaining the "small company" familiarity long enjoyed by our employees would become more difficult as the Concord plant population grew. Traffic, too, would become a problem. It was therefore decided that the working force at Concord should be limited to 1000. As the number of employees at Concord passed 900 a year ago, construction began on a building in Bolton.

The new plant will be set up autonomously on a product basis, designing and manufacturing microwave and signal-generating equipment. Therefore, in the future, all GR coaxial connectors and components, slotted lines, coaxial bridges, Unit Oscillators, and signal generators will be made at the Bolton plant, which is specially equipped with the high-precision production machinery required in the manufacture of such items.

The long-term plans for Bolton include a plant about the same size as our present plant at Concord and in the same multiple-tee configuration. The building just completed is the first tee, and the design of this 80,000-square-foot unit provides for the eventual expansion to over three times its present size.

The Bolton site is on State Route 117, less than two miles east of the intersection with Interstate Route 495, now under construction. The plant site is partly wooded, with a stream dammed to form a small pond. Bolton is a small, rural community of 1200, on the eastern edge of Worcester county, and about 20 miles west of Route 128.

Engineering Manager of the Bolton plant is Robert A. Soderman, well known in the electronics industry for his work on standards and on coaxial measuring devices. Philip W. Powers, formerly Assistant to the Vice President for Manufacturing, becomes Manufacturing Manager at Bolton.

THE PRECISE MEASUREMENT OF SMALL DIMENSIONS BY A CAPACITANCE BRIDGE

One of the advantages of being a manufacturer of precision measuring instruments is the chance to apply one precision device to the design and production of another. An example is the use of our TYPE 1615-A Precision (0.01%) Capacitance Bridge to measure dimensions of parts of our TYPE 900 Precision Coaxial Connector to within a few millionths of an inch.

The principle of measuring distance by measuring capacitance is based on the relation between the capacitance of an air capacitor and the spacing between its electrodes. In the application described here, a rod is positioned in a hollow cylinder with a fixed spacing between the rod and the inside wall of the cylinder. The rod and the cylinder form the electrodes of a capacitor. Since the hollow cylinder is a special jig whose dimensions are accurately known, the spacing is governed essentially by the diameter of the rod.

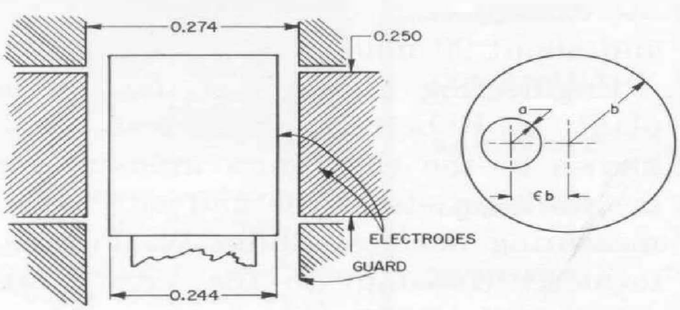


Figure 1.

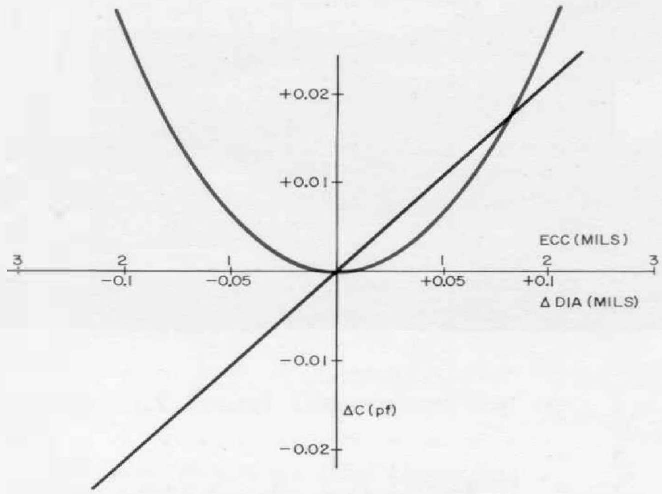


Figure 2. Capacitance deviation vs eccentricity of rod.

The capacitance, C, per unit length of a coaxial air capacitor is as follows:

$$C = \frac{1.4140}{\cosh^{-1}\left[1 + \frac{(b\text{-}a)^2 - (\epsilon b)^2}{2ab}\right]} \text{pf/inch}$$

where the dimensions a, b, and ϵ are as defined in Figure 1.

The resolution of the capacitance-distance measurement technique is increased at least a hundredfold if the bridge is used to compare two capacitances rather than to measure the unknown capacitance directly in terms of an internal standard. Therefore, in the actual measurement, a standard rod is first inserted as a reference, the unknown is then substituted, and the difference between the capacitances is measured. The bridge null detector, calibrated to indicate the deviation of unknown from standard directly, can readily indicate deviations as small as one millionth of an inch.

Of course, a deviation in capacitance could be due to eccentricity of the "unknown" rod as well as to a difference in its average diameter. Therefore, in the graph (Figure 2) showing the relation between capacitance deviation and distance deviation, a curve is added to show the equivalent effect of eccentricity. As the curve shows, one can center the rod in the jig by adjusting the rod for minimum capacitance.

For the high precision required, it is necessary to eliminate the effects of the leads from the bridge to the unknown. Thus the jig is connected as a three-terminal capacitor, and is measured as such by the TYPE 1615-A Bridge.

The absolute accuracy of this measurement depends on the accuracy of the standard rod. Rods with tolerances as small as ±10 microinches are commercially available. The sensitivity of capacitance to changes in distance is inversely proportional to the spacing between rod and jig. Decreasing this spacing will add leverage to the relation, in the direction of increased precision. As the spacing is reduced, however, the linearity of the capacitance-distance relation is sacrificed. The optimum spacing therefore represents a compromise between sensitivity and linearity.

— A. E. SANDERSON
— F. VAN VEEN

NEW, MEGOHM, WIRE-WOUND RESISTORS AND DECADES

Figure 1. Type 1432-Z Decade Resistor *(rear)*. Type 510-H Decade Resistance Unit *(left foreground)*. Type 500-Y Resistor *(right foreground)*.

The development of a new, fine-wire 1-megohm resistor has made it possible to extend to higher resistances the range of our series of separately boxed, fixed resistors (TYPE 500), our decade-resistance units (TYPE 510), and our multiple-decade-resistance boxes (TYPE 1432).

Separate 2-megohm, 5-megohm, and 10-megohm fixed units are now available that use the appropriate number of the new resistors in series. The decades use ten units to give a total of 10 megohms in 1-megohm steps.

Like other GR resistors of 500 ohms and higher, these new units are singlelayer wound on a thin, card-type form. This type of resistor has lower inductance and capacitance than does a spool-wound resistor and, therefore, has much better ac properties. High-valued resistors of this type must use very fine wire if they are to be wound on a form of reasonable size. Recently developed winding techniques have made practical the use of 0.5-mil Evanohm wire, which makes possible one-megohm units that are only slightly larger in size than those of lower resistance values. It is easy to imagine the difficulties of winding wire of this size when one realizes that it is about ¼ the diameter of human hair!

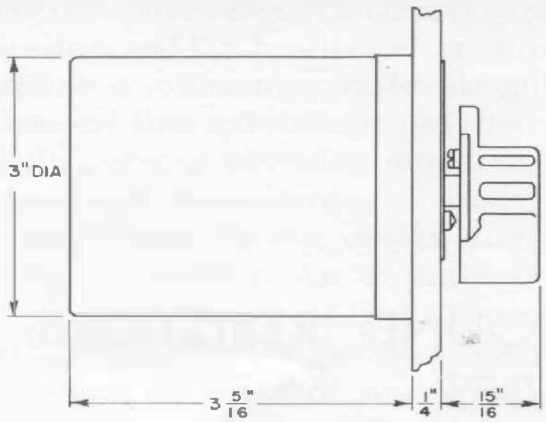


Figure 2. Dimensions of Type 510 Decade-Resistance Unit.

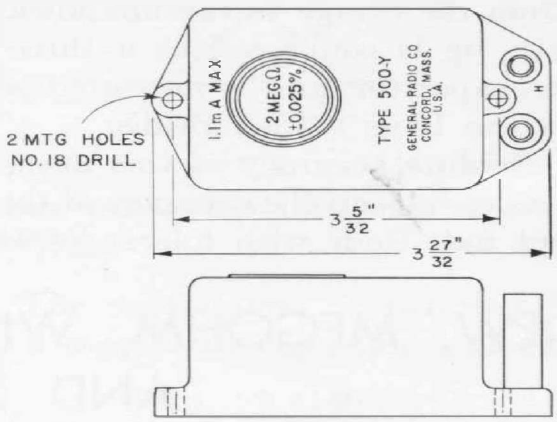


Figure 3. Dimensions of Type 500 Resistor.

SPECIFICATIONS

TYPE 500 RESISTORS

Dimensions: See sketch.
Net Weight: 2 ounces (60 grams).
Shipping Weight: 8 ounces (230 grams).

Type	*DC Resistance*	*Max Current*	*Accuracy*	*Code Number*	*Price*
500-Y	2 megohms	1.1 ma	0.025%	0500-9725	$28.00
500-Z	5 megohms	0.7 ma	0.025%	0500-9726	62.00
500-ZZ	10 megohms	0.5 ma	0.025%	0500-9504	95.00

TYPE 510-H DECADE-RESISTANCE UNIT

Dimensions: See sketch.
Net Weight: 11 ounces (310 grams).
Shipping Weight: 2 pounds (1.0 kg).

DC Resistance Per Step	Total	*Accuracy**	*Max Current*	*Code Number*	*Price*
1 megohm	10 megohms	0.025%	0.7 ma	0510-9708	$98.00

* Each of the 10 resistors in each decade is adjusted to be accurate at its terminals within the tolerance given. Resistance increments are accurate to this same tolerance.

TYPE 1432 DECADE RESISTOR

Dimensions: Width 4 5/16 inches (110 mm), height 4¾ inches (120 mm); length, 15¾ inches (400 mm) for Type 1432-Y and 18¼ inches (470 mm) for Type 1432-Z.

Net Weight: Type 1432-Y — 6 pounds, 5 ounces (2.9 kg); Type 1432-Z — 7 pounds, 8 ounces (3.4 kg).

Shipping Weight: Type 1432-Y — 7 pounds (3.2 kg); Type 1432-Z — 9 pounds (4.1 kg).

Type	*Resistance* Total	Per Step	*No. of Dials*	*Type 510 Decades Used*	*Code Number*	*Price*
1432-Y	11,111,000 ohms	100 ohms	5	D, E, F, G, H	1432-9725	$229.00
1432-Z	11,111,100 ohms	10 ohms	6	C, D, E, F, G, H	1432-9726	262.00

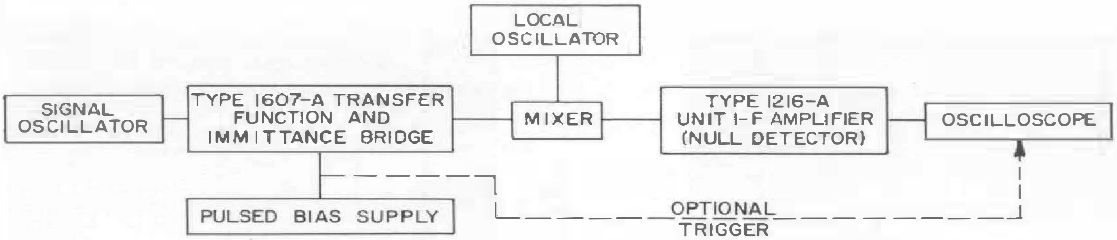


Figure 1. Block diagram of the measurement system, showing bridge, pulsed bias supply, and oscilloscope.

MEASUREMENTS ON POWER TRANSISTORS WITH THE TRANSFER-FUNCTION BRIDGE

The measurement of the impedances and other characteristics of transistors at very-high and ultra-high frequencies can be carried out under normal operating conditions with the TYPE 1607-A Transfer-Function and Immittance Bridge. With some power transistors, however, the heat to be dissipated creates a problem, because it is not always convenient to provide a heat sink for the transistor while it is being measured.

At our suggestion, a number of users of the bridge solved the problem by pulsing the bias supply to the transistor, permitting higher power levels to be used without excessive heating. (See Figure 1.)

Pulsing prevents the use of the meter indication of null balance on the TYPE 1216-A Unit I-F Amplifier, because of the two different impedance states, bias-off and bias-on. Therefore, an oscilloscope, connected to the video output terminals of the i-f amplifier, is used as the null indicator, and the null is adjusted at the bias-on portion of the pulse.

Figure 2 shows a pulsed bias supply as used by Clark Division, National Semiconductor Corporation. Similar circuits have been used by other manufacturers.

Transistors in the double-ended stud package, TO-3, or TO-8 package, for example, can be measured by use of this pulse technique. We have recommended that a General Radio Type 1607-P201 triode tube mount be modified to accept these larger packages. In the version used by Clark, a Jettron model 74-026 socket was fitted into the tube mount after the tube socket was removed. The emitter lead was grounded

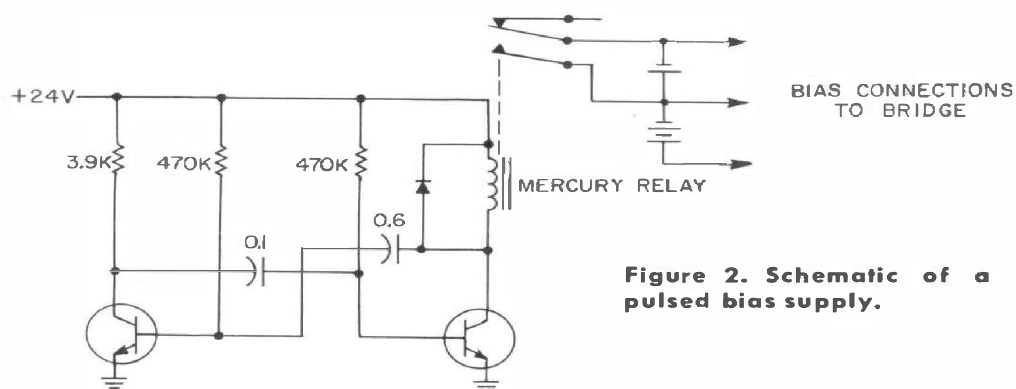


Figure 2. Schematic of a pulsed bias supply.

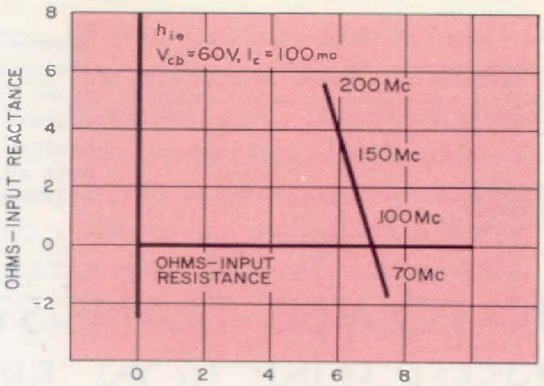


Figure 3.

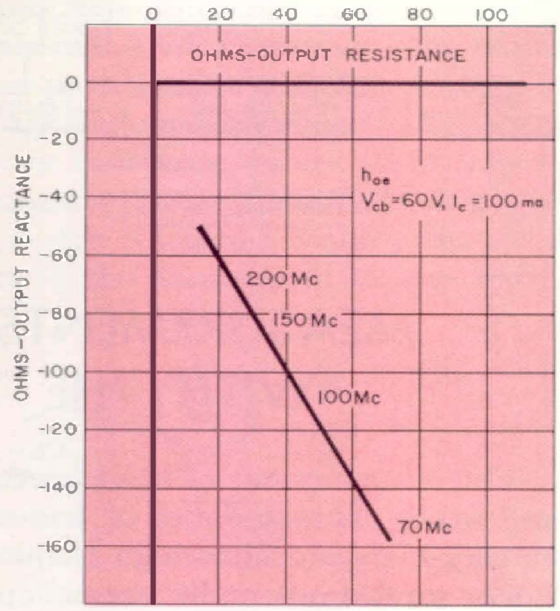
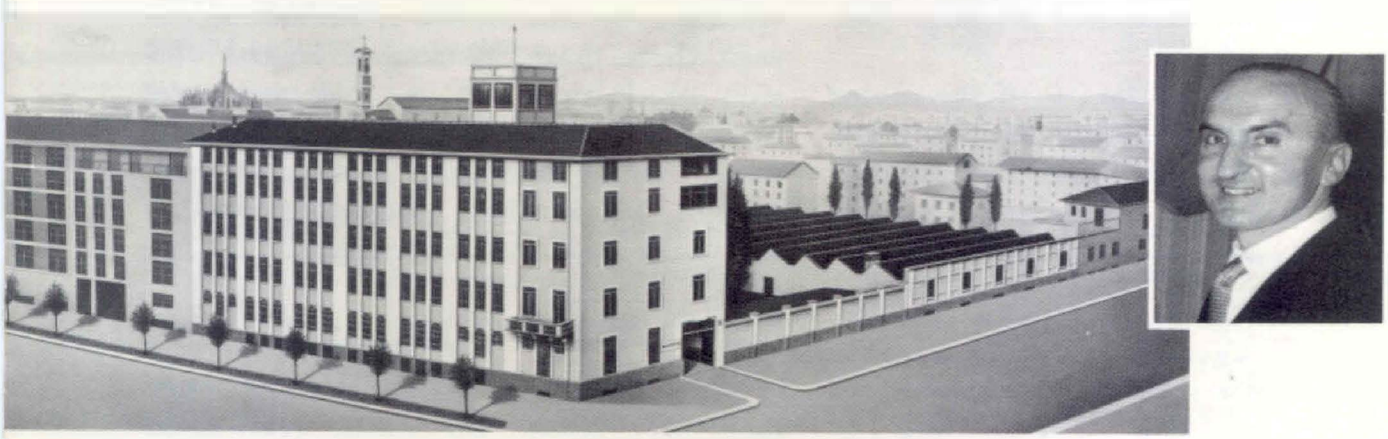


Figure 4.

with a copper strap. The base and collector leads were brought over to the normal connections within the coaxial lines. A Ferroxcube choke coil (#VK 200 10/3B) was also connected between the base lead and the feedthru capacitor supplied in the mount. This allowed the connection of a 0.5-μf capacitor across the external bias connections on the mount to stop low-frequency oscillations, which may occur at certain settings of the bridge. In addition, the leads from the emitter-base supply were kept as short as possible in order to prevent parasitic oscillations.

Typical results for the Clark 100-series transistors are shown in Figures 3 and 4.

NOTE: We are indebted to S. W. Daskam Manager, Applications Division, National Semiconductor Corporation, Clark Division, for much of the information in this article.
— Editor



View of the recently remodeled plant of Ing. S. and Dr. Guido Belotti at Piazza Trento 8, Milan, Italy. The firm of Belotti have been sales representatives for General Radio products in Italy since 1930. Inset shows Dr. Guido Belotti.

General Radio Company

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