

THE *General Radio* EXPERIMENTER

VOLUME XIII NO. 8

JANUARY, 1939

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

Also
IN THIS ISSUE

	Page
TYPE 663 RESISTOR — A STANDARD FOR USE AT HIGH FRE- QUENCIES.	6

A BEAT-FREQUENCY OSCIL- LATOR FOR WIDE-BAND MEASUREMENTS

• FOR MEASUREMENTS and testing in the audio-frequency range, many specialized instruments have been developed which are designed primarily to give the desired results quickly and in the most convenient

form. A particularly good example is the beat-frequency oscillator as a general source of power. The rapidity and ease with which the frequency can be set at any point in the spectrum, and the relatively large and uniform power output which can be obtained with low harmonic content, render this oscillator of great use as a basic tool.

Intensive development work on broad-band devices, notably television amplifiers, has led to a demand for similar specialized tools for a broader frequency span. Since the so-called video spectrum is simply an extension of the older audio spectrum, it follows that, in many cases,

FIGURE 1. Panel view of the TYPE 700-A Wide-Range Beat-Frequency Oscillator.



IET LABS, INC in the GenRad tradition

534 Main Street, Westbury, NY 11590

www.ietlabs.com

TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988

the new testing and measuring instruments are of the same type as the old and differ from them only in degree. This is true, in particular, of the beat-frequency oscillator, which, by an extension of its frequency range, can be made satisfactory for use at video frequencies. The characteristics which make this type of oscillator so serviceable for audio-frequency testing are equally desirable for video-frequency work.

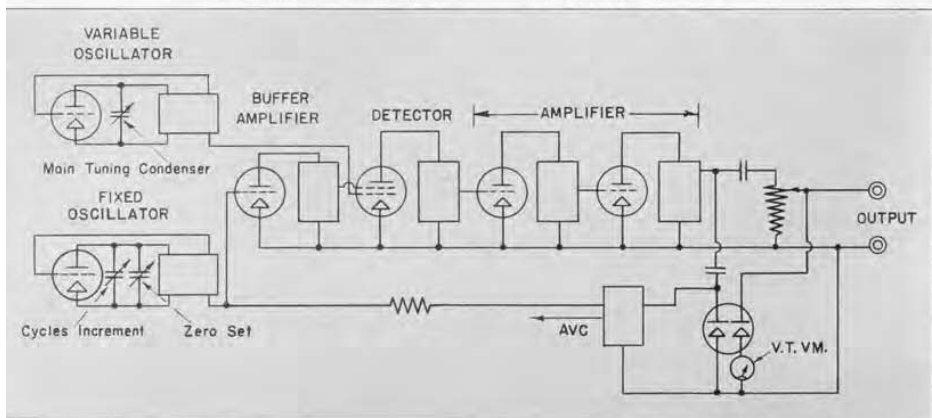
The TYPE 700-A Wide-Range Beat-Frequency Oscillator is intended to satisfy the requirements for a flexible power source at frequencies from 50 cycles to 5 Mc. Because the frequency range is greatly extended in comparison with that covered by the conventional audio-frequency instrument, some of the design problems are markedly different and are of interest as determining factors in general construction and performance.

With an established upper frequency limit of 5 Mc, the frequency of the fixed oscillator is more or less determined at a value of approximately 20 Mc. Lower values will result in excessive spurious beats or "birdies" and higher values in lessened frequency stability. At such a high beating frequency the tendency of the fixed and variable oscillators to lock

together near zero beat is accentuated because of residual capacitive and mutual inductive coupling between them. The behavior of the oscillator near zero beat is consequently not quite as good on a percentage frequency basis as a similar low-frequency oscillator. In terms of absolute frequency, the comparison is still less favorable since a given frequency percentage corresponds to approximately a hundred times the number of cycles. The problem of obtaining satisfactory performance through the ordinary audio range and, at the same time, obtaining good performance in the video range has been solved in the TYPE 700-A Wide-Range Beat-Frequency Oscillator by supplying two separate ranges, which can be selected by a switch, one covering the span from 50 cycles to 40 kilocycles and the other 10 kilocycles to 5 megacycles.

The amplifier for an instrument of this type must follow closely the pattern evolved for television purposes. It is particularly interesting in this case to trace through the interlocking requirements and their effects on design. The limiting feature in high frequency performance is the shunting effect of capacitance of the tubes and circuit wiring. In order to raise the frequency at which the shunting effect becomes serious to a value of approximately 5 Mc, it is

FIGURE 2. Functional schematic diagram of the TYPE 700-A Wide-Range Beat-Frequency Oscillator. The automatic-volume-control circuit tends to maintain a constant output voltage as a function of line voltage as well as of frequency and load.



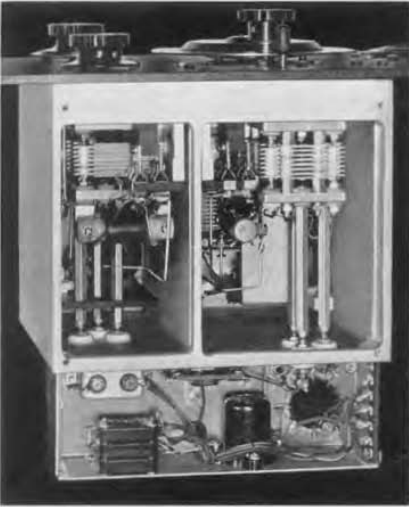


FIGURE 3. View of the heavy aluminum casting which houses the two high-frequency oscillators. Note that the oscillators are of similar construction in order that they may have equal temperature coefficients.

necessary to use low-resistance plate loads and, as a consequence, tubes having a high value of grid-plate transconductance. Because of low load resistances, it is also necessary to use tubes having relatively high plate currents in order to develop appreciable voltages.

Two results immediately follow from these considerations: First, a voltage amplifier requires vacuum tubes of the so-called "power" variety and consequently demands high power input which must be dissipated in the form of heat. Second, at low frequencies the common impedance of the plate supply filter becomes comparable with the plate load impedances, and regenerative and degenerative coupling through the power supply becomes of great importance. The output impedance of the power supply filter must therefore be kept low, either by using very large capacitors or by using an electronic type of voltage regulator.

In the case of the TYPE 700-A Wide-Range Beat-Frequency Oscillator, it was felt that physical smallness was a desirable feature. Because of the large amount of heat generated by the amplifier tubes it was impossible to prevent the temperature of a small instrument from rising appreciably. The effect of this temperature rise on frequency, however, was largely eliminated by designing both oscillator circuits with low temperature coefficients, as nearly equal as possible, and by mounting them in two compartments of a rugged cast aluminum box. The box serves to distribute the heat uniformly between them and to minimize any temperature differential between the compartments, as well as to furnish excellent electromagnetic shielding.

In order to maintain a high degree of electrical isolation between the two oscillators, the detector chosen for use with the TYPE 700-A Wide-Range Beat-Frequency Oscillator was the Type 6L7 Pentagrid Mixer. The capacitive coupling through this tube is small and, since two separate grids are used, both oscillator circuits can be fed in single-ended, with one side grounded. It is interesting to note that, at high frequencies, the greatest coupling between

FIGURE 4. Rear view of the oscillator, showing details of construction. The wooden end pieces can be removed when the instrument is to be mounted in a relay rack.





FIGURE 5. The CYCLES INCREMENT dial, shown here, carries two scales, one for each output frequency range of the oscillator. The range is ± 10 kc for the high-frequency range and ± 100 cycles for the low range.

the two oscillators appears to come from the small capacitance variations caused by modulation of the space current in the detector tube.

In order to maintain as high a degree of constancy in output level as possible, an automatic volume control has been incorporated in the TYPE 700-A Wide-Range Beat-Frequency Oscillator. The a-v-c action is obtained by rectifying the output voltage and using the derived dc to control the gain of a buffer amplifier

SPECIFICATIONS

Frequency Range: Two ranges are provided: 50 cycles to 40 kilocycles, and 10 kilocycles to 5 megacycles.

Frequency Control: The main dial is direct reading in frequency and carries two approximately logarithmic frequency scales covering the ranges specified above. A frequency range switch is provided for rapidly changing from one range to the other. There is also an incremental frequency control which is calibrated between -100 and $+100$ cycles on the low range and -10 and $+10$ kilocycles on the high range. Any frequency change made with this control adds algebraically to the frequency of the main control.

between one of the oscillators and the mixer. The a-v-c circuit reduces any irregularities in the frequency characteristic and also makes the output voltage less dependent upon average line voltage. The control with respect to line voltage is not an inherent property of a-v-c circuits but is obtained in this instrument by deriving the delay voltage from the voltage drop across a neon tube, which is essentially constant as a function of line voltage. Other design features in the amplifier which contribute to over-all uniformity of output are degenerative feedback and both series and shunt inductance compensation.

An interesting side light on the unusual design problems encountered is the fact that extremely good filtering is required on the low range. For this range, which extends from 50 cycles to 40 kilocycles, the beating frequencies are in the neighborhood of 150 to 200 kilocycles. Ordinarily the amplifier in a beat-frequency oscillator of this range does not respond to these frequencies, and the filtering necessary is relatively slight. In the TYPE 700-A Wide-Range Beat-Frequency Oscillator, however, the amplifier is perfectly flat, not only for the difference frequency and beating frequencies but also for the sum frequency, and consequently a good low-pass filter is switched into circuit when operating on the low-frequency range.

— D. B. SINCLAIR

Frequency Calibration: The calibration may be standardized at any time by setting the instrument to zero beat with the zero adjustment control. This adjustment can be made within 5 cycles on the low range or 500 cycles on the high range.

After the oscillator has been correctly set to zero beat, the calibration of the main frequency-control dial can be relied upon within $\pm 2\% \pm 5$ cycles on the low range and $\pm 2\% \pm 500$ cycles on the high range. The calibration of the incremental frequency dial is within ± 5 cycles or ± 500 cycles on the low and high ranges, respectively.

Frequency Stability: Through careful de-



sign adequate thermal distribution and ventilation are provided for minimizing frequency drifts. The oscillator can be accurately reset to zero beat at any time, thereby eliminating errors caused by any small remaining frequency drifting.

Output Impedance: The output is taken from a 1500-ohm Ayrton-Perry-wound potentiometer. One output terminal is grounded.

Output Voltage: The maximum open-circuit output voltage of the oscillator is between 10 and 15 volts. Because of the automatic volume control circuit, this voltage remains constant within ± 1.5 decibels over each entire frequency range.

Waveform: The total harmonic content of the open-circuit voltage is less than 3% for frequencies above 200 cycles on the low range and above 20 kilocycles on the high range.

A-C Hum: When the oscillator is operated from a 60-cycle line the power-supply ripple is less than 2% of the output voltage on either range.

Voltmeter: A vacuum-tube voltmeter circuit is used in the oscillator for measuring the output voltage. The indicating meter on the panel is calibrated directly in volts at the output terminals.

Controls: In addition to the main frequency-control dial and the incremental frequency dial, there is a frequency range switch, and a zero beat adjustment. The output voltage is varied

by a potentiometer control provided near the output terminals.

Terminals: The output terminals are jack-top binding posts with standard $\frac{3}{4}$ -inch spacing. The lower terminal is grounded to the panel and shields.

Mounting: The instrument is normally supplied for table mounting, but can be easily adapted for relay-rack mounting by removing two walnut brackets at the ends of the panel.

Power Supply: A-C power supply, 110 to 120 volts, 40 to 60 cycles, is used. A simple change in the connections to the power transformer allows the instrument to be used on 220 to 240 volts.

The total power consumption is approximately 85 watts.

Tubes: The following tubes are used:

2 — Type 6C5	2 — Type 25L6
1 — Type 6J7	1 — Type 6H6
1 — Type 6L7	1 — Type 5T4

All tubes are supplied.

Accessories: A 7-foot power cord, spare fuses, and a TYPE 274-ND Plug are supplied.

Dimensions: Panel, (width) 19 x (height) 10 $\frac{1}{2}$ inches, over-all; depth behind panel, 11 inches.

Screw holes in the panel are the standard spacing for mounting the instrument in a standard 19-inch relay rack.

Net Weight: 55 pounds.

Type	Code Word	Price
700-A	ORGAN	\$555.00

This instrument is manufactured under the following U. S. Patents and license agreements:
 Patents of the American Telephone and Telegraph Company solely for utilization in research, investigation, measurement, testing, instruction and development work in pure and applied science.
 Patent No. 1,525,178.

GANGED VARIACS FOR THREE-PHASE OPERATION

● **VARIACS** mounted in tandem for operation by a single control were described in the March, 1937, issue of the *Experimenter**. In three-phase circuits, two- and three-gang Variac assemblies can be used in the same manner that single Variacs are used in single-phase

*L. E. Packard, "Three-Phase Voltage Control with the VARIAC."

circuits. The most common methods of connection are the wye and open delta. A complete table of ratings and characteristics will be found in the article referred to above. Economies in manufacturing have made it possible to reduce appreciably the prices previously listed. New prices are as follows:

Type	Description	Code Word	Price
100-KG2	2-gang 100-K	BEAMYGANDU	\$85.00
100-KG3	3-gang 100-K	BEAMYGANTY	130.00
100-LG2	2-gang 100-L	BEARDGANDU	85.00
100-LG3	3-gang 100-L	BEARDGANTY	130.00
200-CUG2	2-gang 200-CU	BAKERGANDU	36.50
200-CUG3	3-gang 200-CU	BAKERGANTY	56.00
200-CUHG2	2-gang 200-CUH	BAGUEGANDU	44.50
200-CUHG3	3-gang 200-CUH	BAGUEGANTY	68.00



THE TYPE 663 RESISTOR—A STANDARD FOR USE AT HIGH FREQUENCIES

● **IMPEDANCE MEASUREMENTS** at high frequencies, as at low frequencies, are usually carried out by comparing unknown impedances with standard impedances, the properties of which are accurately known at the particular frequency used. In order to specify an unknown impedance completely, it is necessary to measure its vector components, either as magnitude and angle in polar co-ordinates, or as resistance and reactance in Cartesian co-ordinates.

Measurements are most commonly made in terms of resistance and reactance components. For such measurements a comparison method ideally demands both a pure resistance and a pure reactance standard, the one for comparison with the unknown resistance component and the other for comparison with the unknown reactance component. Standards, in practice, are never really pure because a physical realization of any one of the three circuit parameters—inductance, resistance, and capacitance—has, in addition to the main desired parameter, residual amounts of the other two undesired parameters. The existence of these residual parameters causes the impedance of a standard to depart from one of the ideal laws of

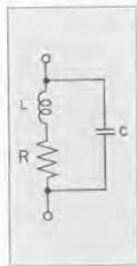


FIGURE 1. Equivalent circuit of fixed resistor. R is the desired resistance, L and C are the undesired residual inductance and capacitance.

variation with frequency $j\omega L$, R , and $\frac{1}{j\omega C}$ in both magnitude and phase. The departure means that not only does the effective inductance, resistance, or capacitance vary with frequency, but that there occurs also a resistive component in reactance standards and a reactive component in resistance standards. Since methods of measurement are most commonly evolved on the assumption of ideally pure standards, it is highly desirable in practice to use actual standards which have as small residual parameters as possible in order to minimize correction terms.

In any given impedance element the effects of residual parameters ordinarily increase as the frequency goes up. They also tend to be greater for continuously adjustable units than for fixed units. As reactance standards, variable air condensers achieve a high degree of purity. They may consequently be used over an extensive frequency range¹. As resistance standards, continuously adjustable resistors have not yet been sufficiently highly developed to meet the exacting requirements of high-frequency operation. Fixed resistance standards, however, can be built with such a degree of freedom from residual parameters that they can be used over a frequency range comparable with that covered by the precision type of variable air condenser.

RESIDUAL PARAMETERS IN RESISTANCE STANDARDS

The effect of residual parameters on the frequency characteristics of a fixed

¹ See, for instance, "A High-Frequency Model of the Precision Condenser," *General Radio Experimenter*, Vol. XIII, Nos. 5 and 6, October-November, 1938, page 1.

resistor can be deduced from the approximate equivalent circuit of Figure 1.

In this figure, R represents the desired main resistance parameter and L and C the undesired residual inductance and capacitance parameters.

The input impedance of the equivalent circuit can be expressed most conveniently in terms of the quantities.

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

and $D_0 = R/\sqrt{\frac{L}{C}} = \frac{R}{\omega_0 L} = \frac{1}{Q_0}$

by means of the equation

$$Z_e = R_e + jX_e = \frac{R}{\left[1 - \left(\frac{\omega}{\omega_0}\right)^2\right]^2 + D_0^2 \left(\frac{\omega}{\omega_0}\right)^2} + j \left(\frac{\omega}{\omega_0}\right) \frac{R}{D_0} \frac{1 - \left(\frac{\omega}{\omega_0}\right)^2 - D_0^2}{\left[1 - \left(\frac{\omega}{\omega_0}\right)^2\right]^2 + D_0^2 \left(\frac{\omega}{\omega_0}\right)^2}$$

This equation is readily normalized by dividing through by R . The nor-

malized resistive and reactive components are plotted in terms of the variable (ω/ω_0) and the parameter D_0 in Figures 2 and 3.

While it is logical to suppose that reducing the residual parameters L and C with respect to the main parameter R will render the effective resistance R_e more nearly constant and the effective reactance more nearly zero over a wider frequency range, a survey of the curves of Figures 2 and 3 raises the further question as to whether there is a specific proportioning of the limiting residuals which will lead to an optimum design.

If the product of the residual inductance L and shunt capacitance C can be kept constant, while the quotient is varied, D_0 can be changed without altering ω_0 . Under these conditions an optimum design will be reached for constancy of resistance if $D_0^2 \approx 1.8$ and for lowness of reactance if $D_0^2 = 1$. However, if L and C are not absolutely inversely related to each other, the proper proportioning is not so easily deduced.

FIGURE 2. General normalized curves of resistance as a function of frequency for fixed resistor.

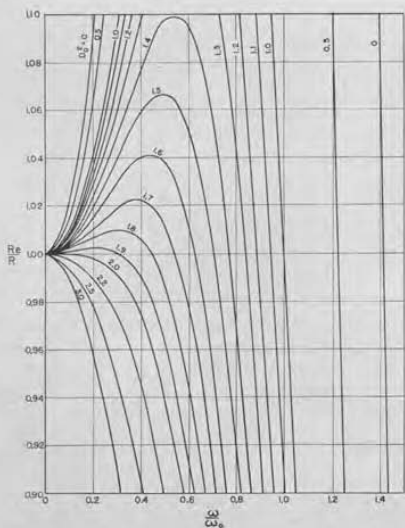
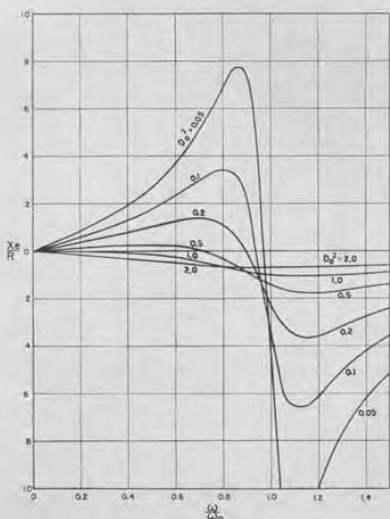


FIGURE 3. General normalized curves of reactance as a function of frequency for fixed resistor.



In particular it is interesting to know whether adding shunt capacitance to a resistor which has a definite fixed inductance will, under any conditions, improve the performance. The question cannot be immediately answered by an inspection of the curves of Figures 2 and 3 because both $\frac{\omega}{\omega_0}$ and D_0 change as the capacitance is added. It can be shown, however, that if the parameter D_0^2 is less than 1 or greater than 2, there is a loss in performance when shunt capacitance is placed across the resistor terminals. If D_0^2 lies between 1 and 2 there may or may not be a gain in performance, depending upon the frequency range and upon the criterion of merit used.

Curves of effective resistance and effective reactance for a typical 10-ohm resistor are illustrated in Figures 4 and

FIGURE 4. Specific curves of normalized resistance as a function of frequency for typical 10 Ω resistor. Residual inductance assumed equal to 0.03 μ h. Residual capacitance taken as parameter.

5 as a function of frequency with total shunt capacitance as parameter. For these curves the residual inductance L is taken as 0.030 μ h and the minimum shunt capacitance as 3 μ mf.

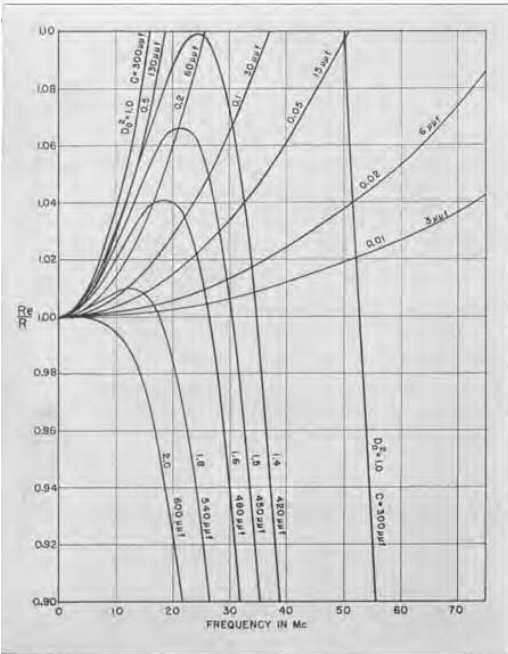
The minimum shunt capacitance is seen to correspond to the best resistance characteristic. For a criterion of goodness, take the maximum frequency for which the resistance remains within $\pm 1\%$ of its d-c value. The addition of shunt capacitance lowers the maximum frequency from 36.5 Mc for $D_0^2 = 0.01$ to 5.3 Mc for $D_0^2 = 1$. Further addition to capacitance, however, improves the resistance characteristic again, until the maximum frequency increases to 19.5 Mc for $D_0^2 = 1.8$. At higher values of D_0^2 the resistance characteristic deteriorates from this figure.

For the reactance characteristic, take as a criterion of goodness the maximum frequency at which the reactance remains within $\pm 25\%$ of the d-c resistance. The addition of shunt capacitance raises the maximum frequency from 13.5 Mc for $D_0^2 = 0.01$ to 58.0 Mc for $D_0^2 = 0.5$. Further addition of capacitance reduces the maximum frequency again.

The optimum conditions for resistance and reactance are seen to be incompatible. If a different criterion for optimum reactance be used, the disparity is even more marked. At $D_0^2 = 1$, for instance, the reactance is a minimum for low frequencies.² The frequency characteristic of resistance, on the other hand, is the worst for any value of D_0^2 less than 2.

At high frequencies, resistance units are most often used under conditions in which their effective series reactances can be tuned out. The more important

² This case corresponds to the condition $L = CR^2$ which is often approximated at low frequencies for standard resistors of very low-time constant. An excellent treatment of low-frequency resistance design is given on pages 66-82 of B. Hogue's "Alternating Current Bridge Methods," 3rd edition.



characteristic is, therefore, the resistance. On this basis, with the 10-ohm unit, no gain will be made by adding shunt capacitance.

However, a 100-ohm unit with the same residual inductance behaves quite differently. A shunt capacitance of $3 \mu\mu\text{f}$, for this unit, corresponds to $D_0^2 = 1$. In this case, the addition of $2.4 \mu\mu\text{f}$ in shunt raises the maximum frequency at which the resistance remains within $\pm 1\%$ of its d-c value from 53 Mc for $D_0^2 = 1$ to 195 Mc for $D_0^2 = 1.8$, a factor of nearly 4:1. The improvement in behavior of the 100-ohm unit, with D_0^2 in the neighborhood of 1, over that of the 10-ohm unit, with D_0^2 in the neighborhood of 0.01, is marked. It occurs because the higher value of D_0^2 is secured without lowering the natural angular velocity ω_0 .

PRACTICAL DESIGN CONSIDERATIONS

The design of a line of high-frequency resistors must contemplate, in addition to the problem of residual parameters, the problems of skin effect, power-handling capacity, temperature coefficient, and mechanical ruggedness.

The bearing of these various factors on the design of the TYPE 663 Resistor line can best be illustrated by discussing them in the following order:

(1) Minimization of residual parameters.

In order to minimize residual inductance and capacitance the "straight-wire" type of construction was selected. This type of resistor has been popular with experimenters for many years but has not previously been available commercially.³

(2) Skin effect and temperature coefficient.

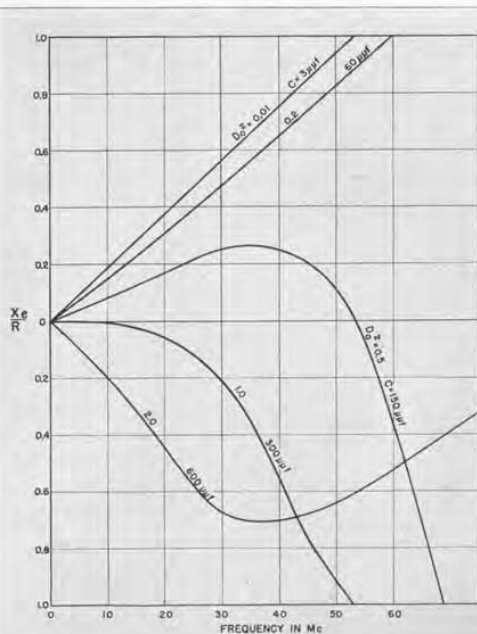
³ See, for instance, "Radio Instruments and Measurements," Circular No. 74 of the Bureau of Standards, pages 175, 176.

In order to minimize skin effect and temperature coefficient, manganin wires of very small diameter were chosen. Through the use of wire diameters as small as 0.0006 inch (No. 54, B. & S. Gauge) resistances up to 100 ohms can be obtained in wire lengths of less than 2 inches.

(3) Proportioning of residual parameters and power-handling capacity.

The analysis of residual parameters shows that, for a given product of residual inductance and capacitance, optimum results will be obtained for a value of the parameter D_0^2 in the neighborhood of unity. In the case of a line of straight-wire resistors in a standardized type of mechanical mounting the best condition can be obtained at only one value of resistance, since the residual inductance and capacitance are more or less fixed. The resistance characteristics deterio-

FIGURE 5. Specific curves of normalized reactance as a function of frequency for typical 10 Ω resistor. Residual inductance assumed equal to 0.03 μh . Residual capacitance taken as parameter.



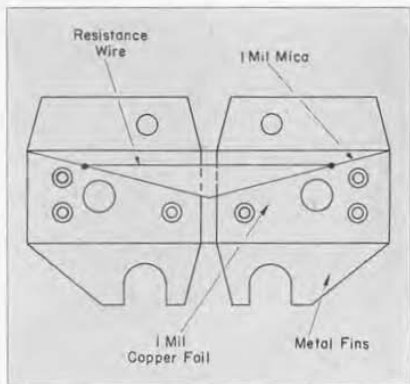


FIGURE 6. Outline sketch of mechanical construction of TYPE 663 Resistors.

rate more rapidly as D_0^2 increases from unity than as it decreases from unity. The design should, therefore, place the $D_0^2 = 1$ point near the high end of the resistance range.

The usual type of straight-wire resistor has relatively high residual inductance in comparison with the residual capacitance. This results in a value of D_0^2 which is small compared to unity for resistance values of 100 ohms and less. In the TYPE 663 Resistor the inductance was reduced at the expense of an increase in capacitance by clamping the resistance wire down on a thin piece of mica, backed by a metal plate which serves as an eddy-current shield.⁴

⁴ See, for instance, L. B. Argimbeau, "A High-Frequency Voltage Standard," *General Radio Experimenter*, June, 1937.

This construction also serves to increase the power-handling capacity over that obtained with a straight-wire resistor which has the wire suspended in air, because of heat conduction from the wire to the metal plate and subsequent dissipation by convection and radiation.

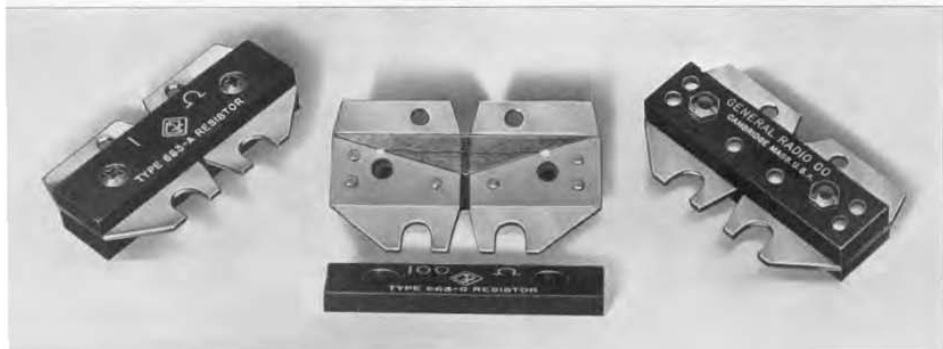
The final design of the TYPE 663 Resistor is illustrated in the drawing of Figure 6 and photograph of Figure 7.

With this construction, D_0^2 is in the neighborhood of unity for the 100-ohm unit and is less for the lower resistances. Approximate frequency characteristics⁵ for TYPE 663 Resistors are illustrated in Figures 8 and 9. The values for residual capacitance and inductance upon which these curves are based are given under Specifications.

The importance of the type of mounting used with these resistors cannot be over-emphasized. Great care has been exercised in reducing the residual parameters to a minimum. The residual parameters associated with the mounting can very easily be comparable to those of the resistor. In the case for which the curves of Figures 8 and 9 are drawn, for instance, more than half of the 6.5 μmf effective shunt capacitance is in the binding posts. For high-frequency measurements, in particular, caution should, therefore, be used to minimize residual parameters inherent in the mounting. Careful attention should also

⁵ When mounted on a pair of TYPE 138-VD Binding Posts with one end grounded to a 1/4 inch metal panel upon which the binding posts are assembled with TYPE 274-Y Mounting Plates. See cut under Specifications.

FIGURE 7. Photograph of TYPE 663 Resistors. The disassembled unit shows the method of construction.



be given to the question of just what change in circuit conditions occurs when one of these resistors is placed in circuit and taken out. The shorting bar used to replace the resistor, when it is out of circuit, should preferably have an induc-

tance less than 0.005 μ h and a capacitance to ground of the same order as that of the resistor.

— D. B. SINCLAIR

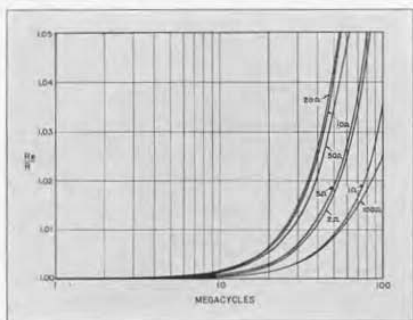


FIGURE 8. Ratio of effective resistance to d-c resistance as a function of frequency for TYPE 663 Resistors mounted on binding posts.

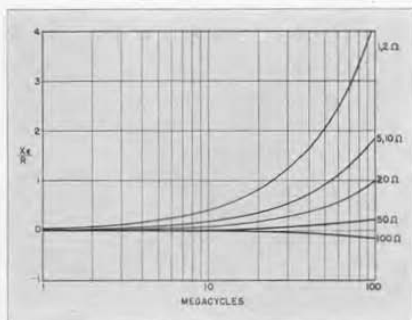


FIGURE 9. Ratio of effective reactance to d-c resistance as a function of frequency for TYPE 663 Resistors mounted on binding posts.

SPECIFICATIONS

Resistance Values: Standard units are available in the following resistances: 1, 2, 5, 10, 20, 50 and 100 ohms.

Accuracy: All units are adjusted within 1%.

Residual Parameters: The following table gives approximate values for *L* for the different units:

Resistance	<i>L</i>	Current for 40° C. Rise
1 ohm	0.0065 μ h	1.4 a
2 ohms	0.013 μ h	1.0 a
5 ohms	0.015 μ h	0.5 a
10 ohms	0.029 μ h	0.35 a
20 ohms	0.032 μ h	0.2 a
50 ohms	0.034 μ h	0.1 a
100 ohms	0.039 μ h	0.06 a

Skin Effect: For all units the skin effect is less than 1% for frequencies below 50 megacycles.

Temperature Coefficient: At normal room temperature the temperature coefficient is less than $\pm 0.002\%$ per degree Centigrade.

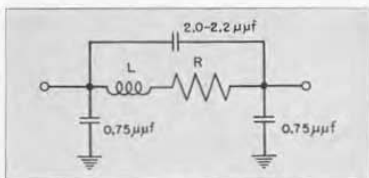
Maximum Power and Current: The allowable power dissipation for a 40° Centigrade

temperature rise varies slightly with resistance, being 2 watts for the 1-ohm unit and 0.4 watt for the 100-ohm unit. The rated current for this temperature rise for the different units is given in the table.

Terminals: The flat metal plates to which the resistance wire is attached are used as terminals, and are both slotted and drilled for convenience in mounting.

Dimensions: (Length) $2\frac{1}{4}$ x (width) $1\frac{1}{4}$ inches. Over-all height, $\frac{5}{8}$ inch.

Net Weight: 2 ounces.



Equivalent circuit of a TYPE 663 Resistor. The 0.75 μ mf ground capacitances correspond to a spacing between resistor and ground of $\frac{3}{8}$ inch.

Type	Resistance	Code Word	Price
663-A	1 ohm	PANIC	\$5.00
663-B	2 ohms	PARTY	5.00
663-C	5 ohms	PATTY	5.00
663-D	10 ohms	PEDAL	5.00
663-E	20 ohms	PENAL	5.00
663-F	50 ohms	PENNY	5.00
663-G	100 ohms	PETTY	5.00



MISCELLANY

• **DR. DONALD B. SINCLAIR**, author of both articles in this issue, will be one of the speakers at the Second Annual Broadcast Engineering Conference at Ohio State University, February 6 to 17, 1939. His subject: "Measurements on Broadcast Antennas."

The value of this Conference to broadcast engineers is attested by the reports of those who attended last year. Of particular interest this year is the Panel Discussion on "Standards of Good Engineering Practice" led by A. D. Ring of the FCC.

• **APPROXIMATELY** 18 tons of paper were used in the new General Radio Catalog K. About 1200 pounds, or 0.6 ton, are used in each issue of the *Experimenter*.

• **A RECENT INVESTIGATION** by the editor shows 79 Variacs in use in the General Radio plant. Of these, 42 are permanently installed and 37 are used as laboratory accessories. The permanent installations are used for motor

speed control on winding machines, lathes, and ventilators; for lighting control in the photographic and drafting departments, in the demonstration room, and in test sets in the testing laboratory. Those in the laboratories are about evenly divided between the standardizing laboratory and the engineering department. The engineering department uses them as a source of variable voltage for development work, the standardizing laboratory to obtain a standard line voltage for testing.

• **THE AIR CONDITIONING BUREAU**, an organization composed of Boston men connected with the air conditioning industry, was addressed on December 14 by H. H. Scott of the General Radio engineering staff. His talk, entitled "Equipment for the Measurement and Analysis of Sound," was accompanied by a demonstration. John A. Chambers of the Boston office of Johns-Manville Corporation was also a speaker on the same program.

THE General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in communication-frequency measurement and control problems. When sending requests for subscriptions and address-change notices, please supply the following information: name, company name, company address, type of business company is engaged in, and title or position of individual.

GENERAL RADIO COMPANY

30 STATE STREET - CAMBRIDGE A, MASSACHUSETTS

BRANCH ENGINEERING OFFICES

90 WEST STREET, NEW YORK CITY

1000 NORTH SEWARD STREET, LOS ANGELES, CALIFORNIA

