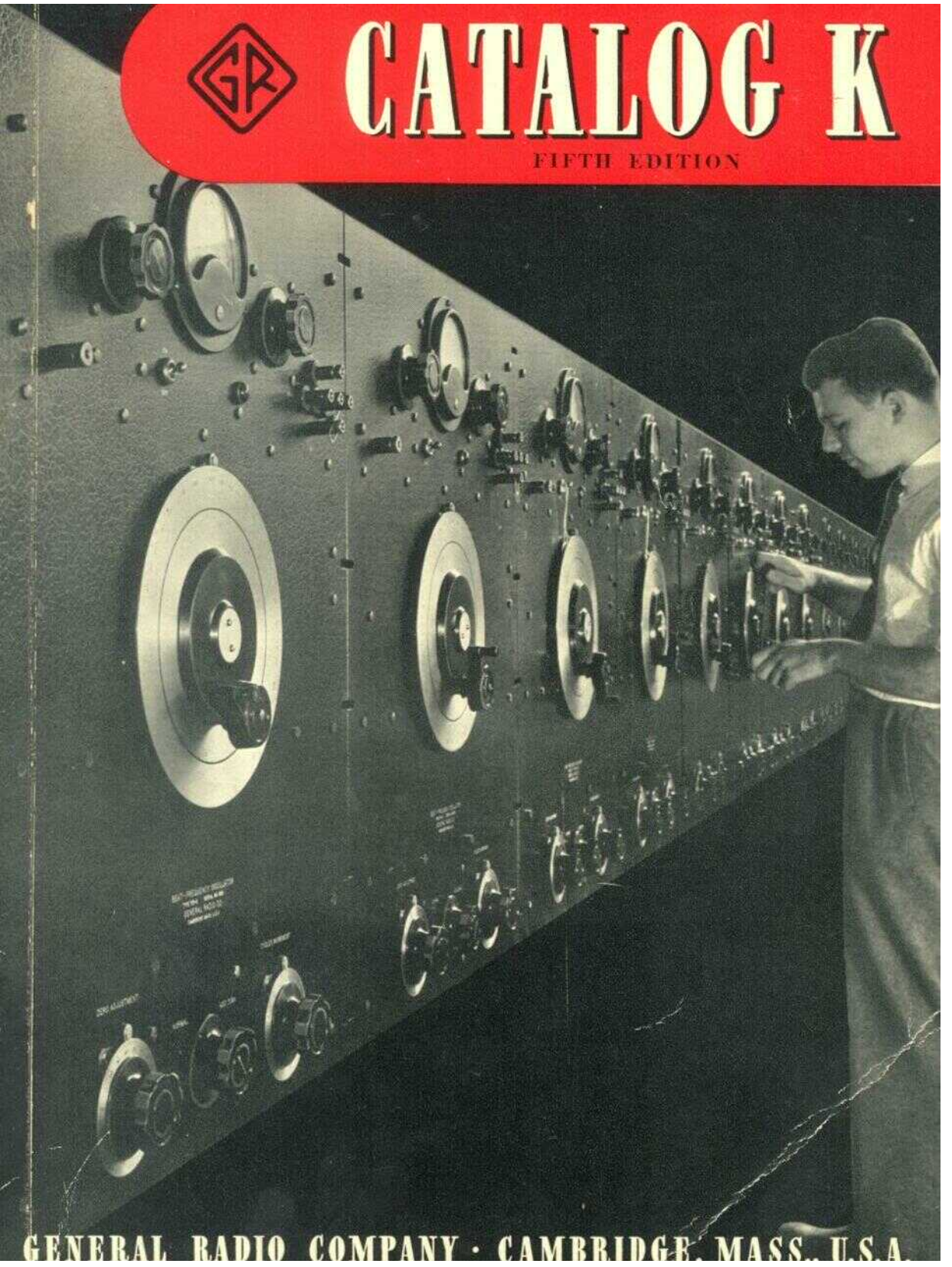
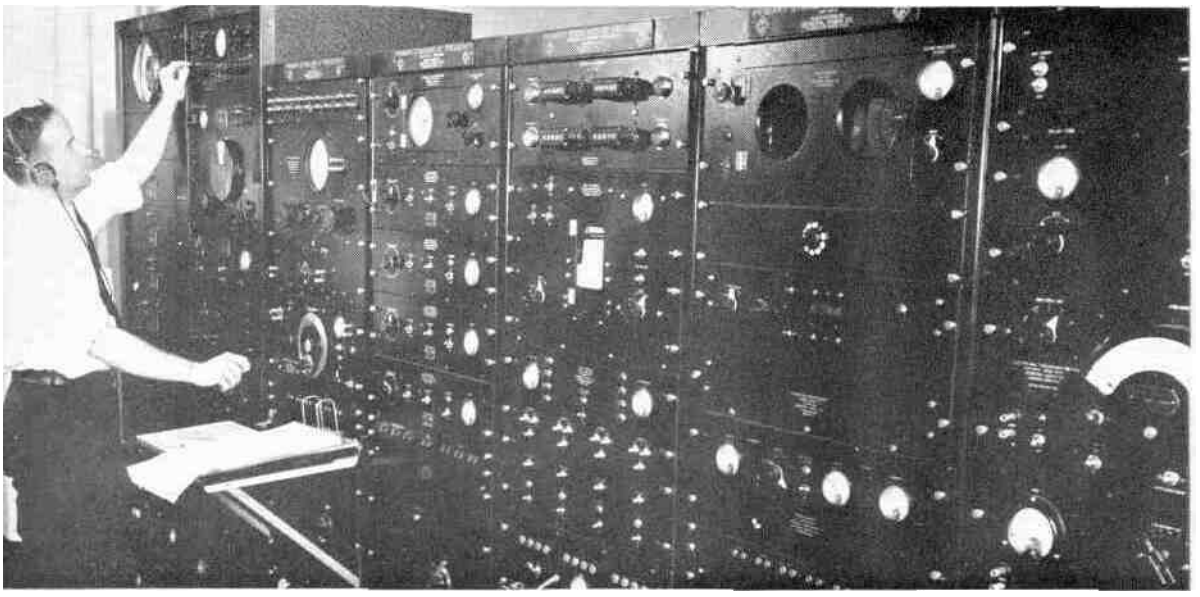
CATALOG K

FIFTH EDITION

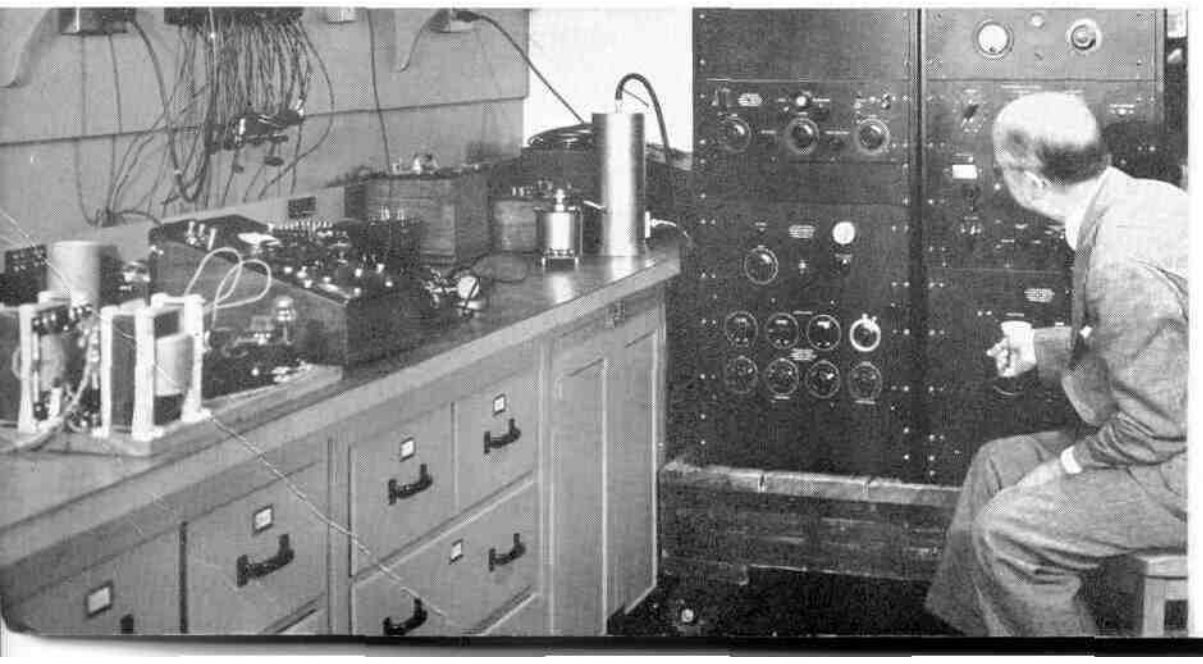


GENERAL RADIO COMPANY · CAMBRIDGE, MASS., U.S.A.

Above—Tests on on experimental model of Type 732-B Distortion and Noise Meter.



Above—Measuring frequencies with the General Radio Primary Standard of Frequency.
Below—Engineering tests on a high-voltage, 60-cycle Schering Bridge.



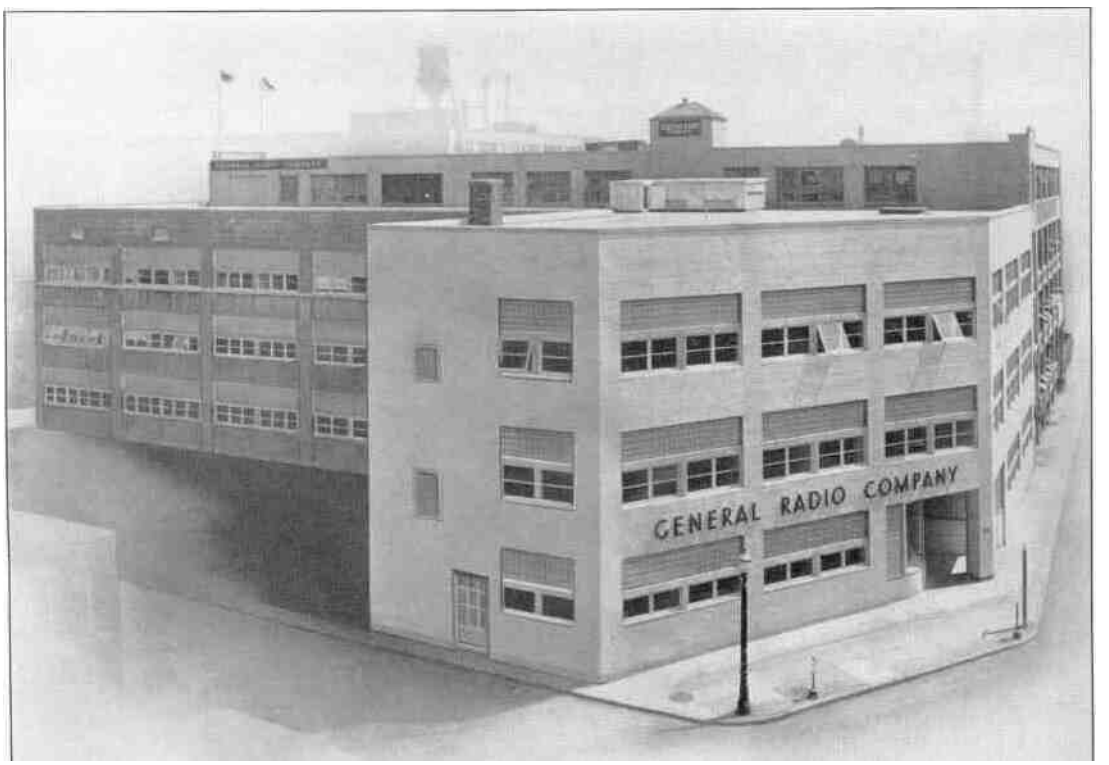
WE SELL DIRECT

To develop the type of product manufactured by the General Radio Company requires a large staff of engineers, each a specialist in one or more phases of the work involved. One of the functions of this staff is to assist the customer in the selection of instruments in order that the correct equipment may be purchased with a minimum expenditure.

There has always been an intimate contact between our engineers and our customers. The technical nature and the manifold uses of our product make the maintenance of this contact essential. For this reason, the General Radio Company maintains no sales agencies in the United States, but distributes its products directly to the consumer on a net, no discount, basis.

In order that customers outside the United States may receive equivalent technical service, exclusive distributors have been appointed in many foreign countries, each capable of giving technical information regarding General Radio products. In all matters regarding General Radio apparatus the customer should communicate with the distributor from whom this catalog was received. Prices listed in the catalog are for domestic use only. Costs in foreign countries, where import duty and freight must be added, can be obtained from the distributors in those countries.

GENERAL RADIO COMPANY



CATALOG K

FIFTH EDITION

1 9 4 6

NOTICE OF PRICE CHANGE

Because of rapidly rising costs, all prices listed in this catalog (except for batteries) are increased by 10% effective October 1, 1946, for shipments to be made after December 31, 1946.

We regret the necessity of this price change, which we have resisted as long as possible, but we know that our customers will understand the conditions that have made it necessary.

We also regret that, contrary to our long-established practice of quoting firm delivered prices, it is now necessary to limit to six months the period for which we will guarantee a price. For shipments which cannot he made within six months from our receipt of the order, customers will be advised prior to shipment if any price changes have been made, at which time the order may be canceled without obligation.

GENERAL RADIO COMPANY
CAMBRIDGE. MASS., U.S.A.

SUGGESTIONS FOR ORDERING

ORDER BY TYPE NUMBER

Always order by catalog type number, and whenever possible mention ranges or other significant specifications as protection against misunderstanding.

Be sure to include orders for any accessories desired or for calibrations which must be made before shipment.

TELEGRAPH AND CABLE ORDERS

We have direct telegraph printer connections with Western Union for the prompt handling of messages.

Use Bentley's code and the code words accompanying each catalog description. Our cable address is GENRADCO BOSTON.

SHIPPING INSTRUCTIONS

Unless specific instructions accompany the order, we shall use our best judgment as to the method of shipment. Repair parts or other items needed quickly can be shipped Air Express if requested. The following table shows approximate costs of this service, in contuiental United States,

Air Miles	2lbs.	5 *lbs.*	25 *lbs.*	*40 lbs.*	*Over 40 lbs. Cents per lb.*
149	$1.00	$1.00	$1.00	$1.23	3.07
349	1.02	1.18	2.30	3.68	9.21
549	1.07	1.42	3.84	6.14	15.35
1049	1.17	1.98	7.68	12.28	30.70
2349	1.45	3.53	17.65	28.24	70.61
Over 2350	1.47	3.68	18.42	29.47	73.68

PACKING

There is no charge for our regular domestic or export packing and no charge for shipping containers or cases. Cases are not returnable.

TERMS

Net 30 days. All prices are F.O.B. Cambridge, Massachusetts. Unless credit has already been established, shipments are made C.O.D.

When full payment accompanies an order for new equipment, we pay transportation charges to any point in the continental United States, except Alaska.

REMITTANCES

Should be made payable at par in Boston or New York funds.

SALES AGENCIES

Because of the Company's direct sales policy no general sales agencies are appointed. Complete stocks are carried only at the factory warehouse. A partial stock is maintained at Los Angeles.

PRICE CHANGES

All prices are subject to change without notice. Billed prices will be in accordance with applicable Federal Regulations at time of shipment. Formal price quotations remain open for 30 days.

SPECIFICATION CHANGES

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

TAXES

Prices shown will be increased by the amount of any applicable sales, use, excise, or similar taxes that are now in effect or that may hereafter be imposed by Federal State, or local governments.

SUGGESTIONS FOR ORDERING

NO TRADE OR EDUCATIONAL DISCOUNTS

Our prices are made on a direct-to-consumer basis which permits of no special discounts.

QUANTITY DISCOUNTS

When 10 or more identical items are ordered at the same time for a single shipment, the following quantity discounts are allowed:

10-19..... 5 per cent
20-99..... 10 per cent
100 or more.....20 per cent

The above discounts also apply to quantities of packages where the unit of sale is a package of small parts.

BRANCH ENGINEERING OFFICES

Engineering offices are maintained in the following cities:

New York 690 West Street
Telephone WOrth 2-5837

Chicago 5: 920 South Michigan Avenue
Telephone WABash 3820

Los Angeles 38: 950 North Highland Avenue
Telephone Hollywood 6201

Customers in or near these cities can quickly and conveniently obtain information about our products from these offices. In charge at each office is a competent, factory-trained engineer who will have all available technical and commercial data.

Although our domestic sales are made on a direct-to-the-consumer basis, we have arranged with numerous foreign distributors for the sale and servicing of our products outside of the United States.

WARRANTY

We warrant each new instrument manufactured and/or sold by us to be free from defects in material and workmanship; our obligation under this warranty being limited to repairing or replacing any instrument or part thereof, except tubes and batteries, which shall, within one year after delivery to the original purchaser, prove upon our examination to be thus defective.

REPAIR PARTS

When ordering repair parts, be sure to describe carefully the parts required and to give the type number and serial number from the panel of the instrument.

SHIPMENTS TO GENERAL RADIO

When returning instruments for repair, recalibration, or for any other reason, please ask our Service Department for shipping instructions. Please state type number and serial number of instrument and date of purchase.

OTHER GENERAL RADIO PUBLICATIONS

In addition to this catalog we publish a monthly magazine, the *General Radio Experimenter, for* free distribution among interested persons. It contains technical and semi-technical engineering articles which are contributed, for the most part, by our engineering staff. To be placed on the mailing list, simply address a request to us containing your name, mailing address, and business affiliation.

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. Vacuum-tube amplifier devices, electric wave filters, and vacuum-tube oscillators 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. Patent 1,871,886.
3. Patent 2,294,941.
4. Patent applied for.
5. Patent 1,901,343.
6. Patent 1,901,344.
7. Patent 1,944,315.
8. Patent 1,967,185.
9. Patent 2,173,427.
10. Patent 2,367,681.
11. Patent 2,009,013.
12. Licensed under all patents and patent applications of Dr. G. W. Pierce pertaining to piezo-electric crystals and their associated circuits.
13. Patent 2,069,934.
14. Patent 1,943,302.
15. Licensed under designs, patents and patent applications of Edgerton, Germeshausen and Grier, including Patents Nos.

2,185,189 2,302,690
2.201.166 2,331,317
2.201.167

16. Patent 2,376,394.
17. Patent 1,744,675.
18. Patent 1,983,447.
19. Patent 1,967,184.
20. Patent 2,012,497.
21. Patent 2,012,291.
22. Patent 1,999,869.
23. Patent 1,790,153 and other patents, covering electrical discharge devices and circuits with which said devices may be used, owned by the General Electric Company or under which it may grant licenses.
24. Patent 2,173,426.
25. Patent 2,298,177.
26. Patent 2,362,503.
27. Patent 2,029,358.
28. Patent 2,354,718.
29. Patent 2,025,775.
30. Patent 2,374,248.

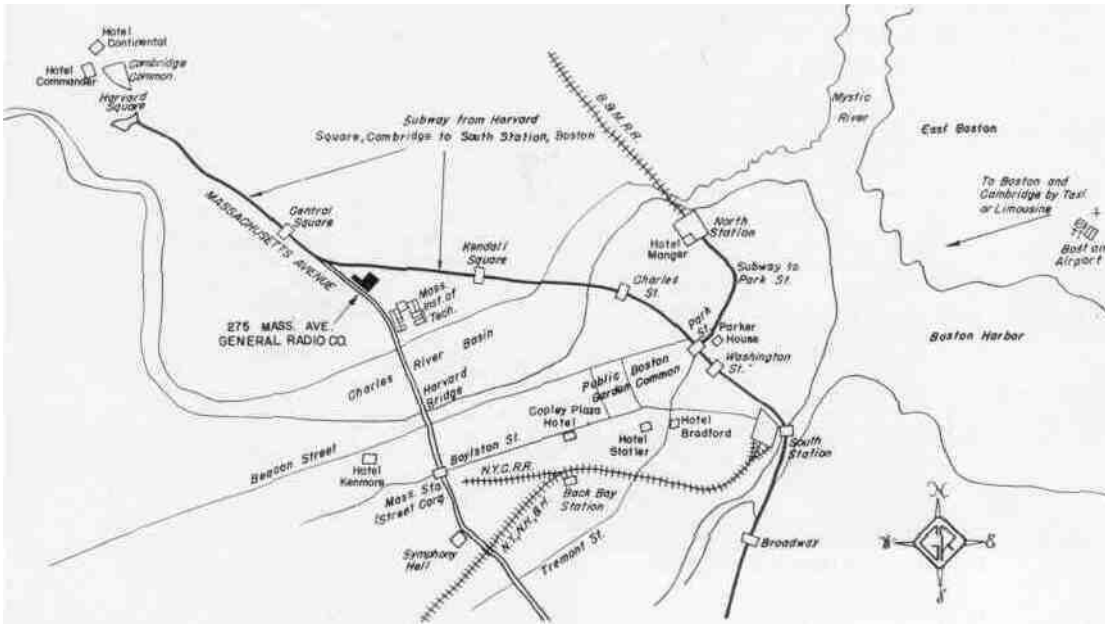
VISIT OUR LABORATORIES AND FACTORY

We cordially invite you to visit our engineering laboratories and factory the next time that you are in the vicinity of Cambridge.

Our plant is located in Cambridge (across the Charles River from Boston) at 275 Massachusetts Avenue. This is half way between the Massachusetts Institute of Technology and Central Square, Cambridge.

The accompanying map and the directions below give details for reaching the plant by public transportation or automobile.

HOURS FOR VISITORS: 10:00 A.M. to 4:00 P.M. every day except Saturdays, Sundays, and holidays.



HOW TO REACH GENERAL RADIO COMPANY

By PUBLIC TRANSPORTATION

From Central Square, Cambridge: Walk down Massachusetts Avenue about six blocks to "275" or take any Boston-bound surface car or bus on Massachusetts Avenue and get off at Windsor Street.

From South Station, Boston: Take a subway train for Cambridge and get off at the fifth stop, which is Central Square. Then follow preceding directions to 275 Massachusetts Avenue.

From North Station, Boston: Take a street car to the Park Street Subway Station and change there to a Cambridge subway train on the lower level. Get off at Central Square, which is the third stop. See above.

From Massachusetts Station, Boston (Massachusetts Avenue and Boylston Street): Take a street car or bus marked "Harvard." After crossing the Charles River into Cambridge, get off at Windsor Street almost directly in front of General Radio.

BY AUTOMOBILE

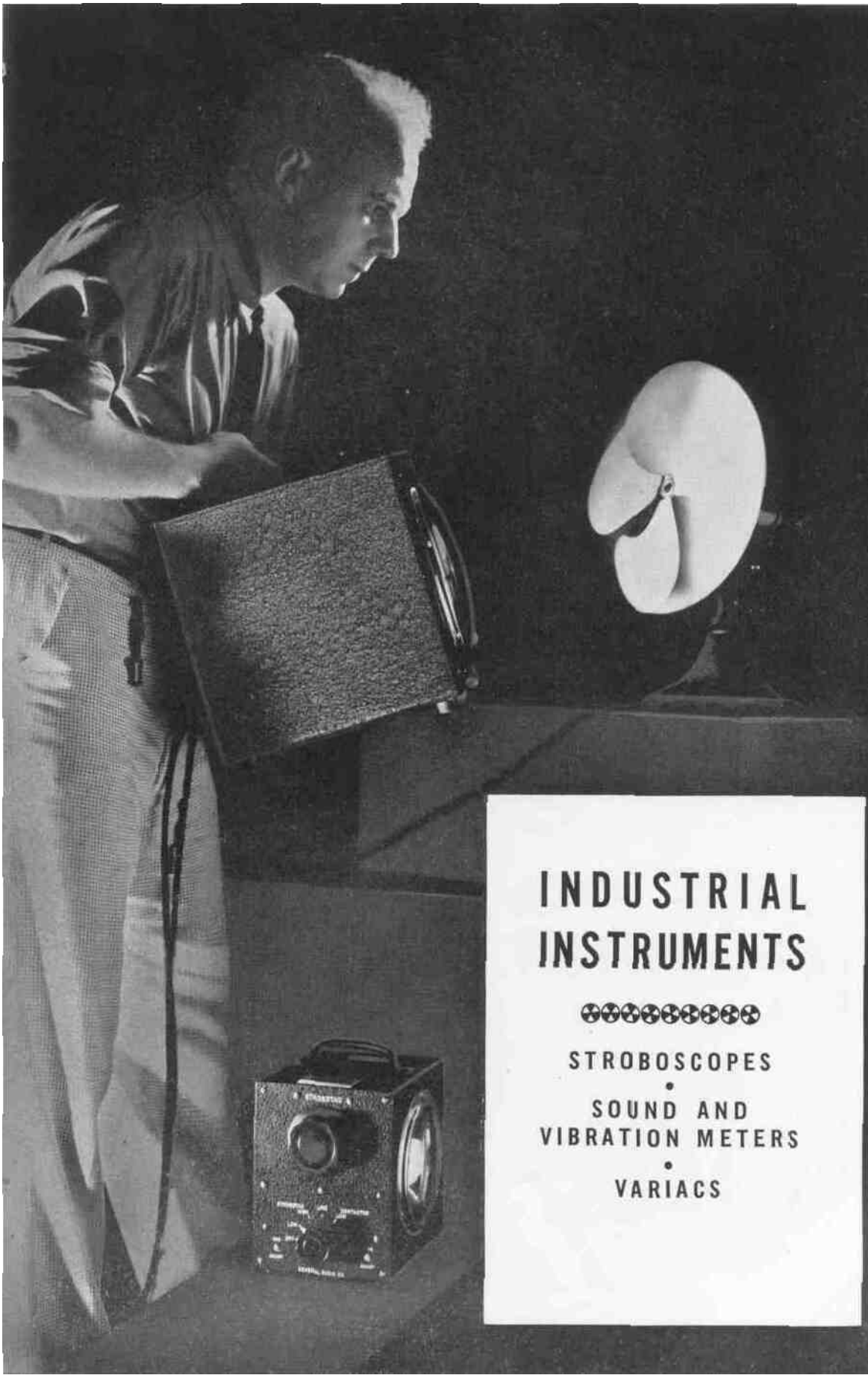
Memorial Drive in Cambridge (Highway Routes U. S. 1 and Mass. 2, 28, and 38) runs along the Charles River and intersects Massachusetts Avenue (underpass) at the Massachusetts Institute of Technology. General

Radio is on Massachusetts Avenue one-third of a mile from this intersection.

Harvard Bridge crosses the Charles River and connects Massachusetts Avenue in Boston and in Cambridge. From the Boston side of the river, turn into Massachusetts Avenue (from Highway Routes U. S. 20 and Mass. 16, 138) and proceed over Harvard Bridge into Cambridge.

WHEN TELEPHONING you may find the following list of departments and individuals of value in eliminating unnecessary delays before obtaining the information you desire. Our office telephone number is TROwbridge 4400.

Delivery Information on Orders Already Placed (catalog items only)	Commercial Dept. H. P. HOKANSON
Price and Delivery Information on Equipment Not Yet Ordered; Technical Information on Uses of Equipment	Sales Engineering Dept. M. T. SMITH W. R. SAYLOR F. D. LEWIS S. W. DEBLOIS M. A. GILMAN
Service and Maintenance Information	Service Dept. R. G. ALEXANDER H. H.DAWES
Repair and Return of Equipment	Service Dept. F.W. SELLER
Price and Delivery Information (new orders and orders already placed for uncataloged replacement parts)	Service Dept. P. G. RICHMOND
Credit Arrangements	Commercial Dept. C. E. Hills, JR.



INDUSTRIAL INSTRUMENTS

STROBOSCOPES

•

SOUND AND VIBRATION METERS

•

VARIACS

STROBOSCOPES

THE STROBOSCOPE is a device that permits rotating or reciprocating objects to be viewed intermittently and thus produces the optical effect of slowing down or stopping motion. If, for example, an electric fan revolving at 1800 rpm is viewed under a light which flashes 1800 times per minute, the fan will apparently be standing still. A slight decrease in the flashing rate will make the fan appear to revolve slowly in the direction of its actual rotation, and an increase will produce a similar motion in the reverse direction. Because the eye retains images for an appreciable fraction of a second (so-called persistence of vision), no flicker is seen except at very low speeds.

Stroboscopes with mechanically operated shutters for interrupting vision have been in use for many years but are subject to the limitations of slow speed and insufficient illumination. General Radio stroboscopes use the flashing lamp principle as developed by Edgerton, Germeshausen, and Grier of the Massachusetts Institute of Technology. Short, brilliant, light flashes are produced by a lamp filled with rare gases, and the speed of the flash is controlled by an electronic switch or a motor-driven contactor. Flashing speeds up to 14,000 per minute, for visual investigation, are obtained by this method with the STROBOTAC, and up to 90,000 per minute for high-speed photography with the Power Stroboscope.

When mechanisms operating at high speeds are viewed by stroboscopic light, in slow motion, all irregularities of the motion present in the original motion are made visible, thus making it possible to observe high-speed mechanisms under actual operating conditions. When the speed of flash coincides with the speed of rotation, motion is apparently stopped. The stroboscope thus becomes an excellent means of measuring speed, and for this purpose the dial which controls the flashing rate of the STROBOTAC is calibrated directly in rpm. Speed measurement by the stroboscopic method absorbs no power from the mechanism under measurement, since no mechanical contact is required.

For the photography of objects moving at high speeds, stroboscopic light provides a means of taking both still and motion pictures. High-speed single-flash photographs can be made with the MICROFLASH. For photographing large areas, and for taking ultra-high-speed motion pictures, the TYPE 621 Power Stroboscope should be used.

TYPE 631-B STROBOTAC*

USES: The Strobotac is used for measuring the speed of rotating, reciprocating, or vibrating mechanisms and for observing their operation in slow motion. In the design and testing of machines and high-speed mechanisms, the Strobotac is invaluable. The operation of motors, fans, pulleys, gears, cams, and other machine elements can be examined in slow motion. Speed measurements for overload and underload tests can be made. It is ideally suited for rapidly adjusting the speeds of a number of machines intended to operate at the same speed, as, for instance, textile spindles. In production testing, it provides a means of rapidly aligning mechanisms that operate under close tolerances. It is approved for use in checking the calibration of aircraft tachometers.

DESCRIPTION: The Strobotac is a small, portable stroboscope calibrated to read speed directly in revolutions per minute. The light source is a Strobotron neon lamp mounted in a parabolic reflector. The frequency of a self-contained electronic pulse generator determines the flashing speed, which can be adjusted, by means of a direct-reading dial, to any value between 600 rpm and 14,400 rpm. If desired, the flashing speed can be controlled by an external contactor, by the a-c line frequency, or by a vacuum-tube oscillator.

The Strobotron is designed to give an extremely short flash, and hence sharp images are obtained even at speeds up to several times the scale values.

Speeds outside the scale range of the instrument can be measured by using multiples of the flashing speed. The upper limit is not

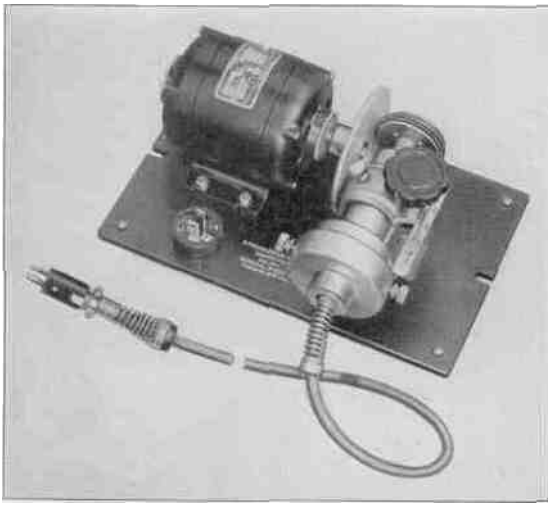
TYPE 549-C SYNCHRONOUS-MOTOR CONTACTOR
TYPE 549-P2 HAND CONTACTOR

USES: These contactors are intended for use with TYPE 631 Strobotac and TYPE 648 Strobolux as sources of accurately timed impulses for flashing. A plug-in cable is provided for connections between the contactor head and the Strobotac.

DESCRIPTION: The synchronous-motor contactor, TYPE 549-C, when driven from a 115-volt, 60-cycle line, is capable of flashing a TYPE 631-B Strobotac at any rate between 150 and 3600 flashes per minute. The contactor is driven by an 1800-rpm self-starting synchronous motor. Flashing rate adjustment is made by turning the fluted knob, which changes the ratio of the friction-drive mechanism. A calibrated scale gives the flashing rate in flashes per minute. Phase can be adjusted independently at the contactor head. Two ranges are provided, one covering speeds from 150 to 1300 rpm, the other from 700 to 3600 rpm. These are fundamental ranges; speeds which are multiples of them can, of course, be measured. Two discs and two scales are provided, and the change from one range to the other can be accomplished in a few minutes.

The contactor head can be removed and used independently as a hand contactor. A rubber driving tip is provided for this purpose.

The uncalibrated head, fitted with rubber tip so that it can be driven from a rotating shaft, is available separately as the TYPE 549-P2 Hand Contactor.



TYPE 549-C Synchronous-Motor-Driven Contactor.

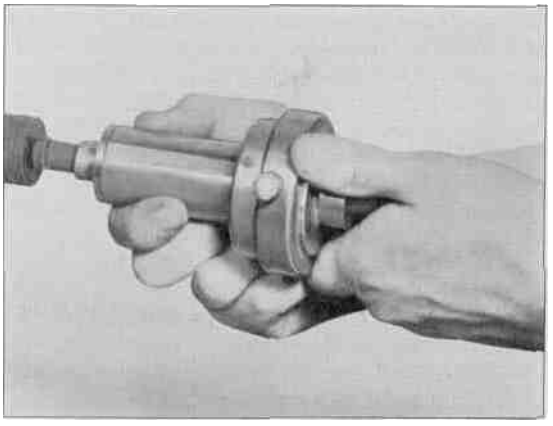
FEATURES: Accurately timed flashing rates as low as 150 per minute can be obtained. The phase of the flash, i.e., its time in the flashing cycle, can be adjusted. This makes it possible to arrest the motion of a mechanism at any point in its cycle of operation. In many stroboscopic investigations this feature is valuable.

SPECIFICATIONS

TYPE 549-C

Range of Flashing Speeds: 150 to 3600 flashes per minute, in two ranges.

Controls: One knob for adjusting speed and the movable contactor head for adjusting phase. Each is provided with a locking arrangement for holding it firmly in the desired position.



TYPE 549-P2 Hand Contactor.

Accuracy; The accuracy is determined by the frequency stability of the power line and the amount of wear of the rubber rim on the driven wheels. When the wheels and scales are set correctly, the error will increase as either scale end is approached, and may be considered to be not greater than ±50 rpm on the low, and ±100 rpm on the high scales.

Power Supply: 105 to 125 volts, 60 cycles.

Power Input: 35 watts.

Mounting; Motor and contactor are mounted on an aluminum base. Changing from the high to the low speed range, and vice versa, necessitates changing the size and position of the driven disc. Two sets of mounting holes, two discs, and two scales are provided for this purpose.

Dimensions: (Length) 9 3/4 x (width) 6 3/4 x (height) 4 3/8 inches, over-all.

Net Weight: 10 1/2 pounds.

TYPE 549-P2

Dimensions: (Length) 7 x (diameter) 3 1/4 inches, over-all.

Cord: Connecting cord is furnished.

Net Weisht: 25/8 pounds.

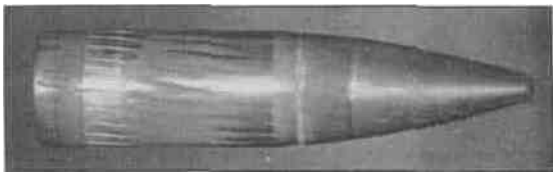
Type		*Code Word*	***Price***
549-C	Synchronous-Motor Contactor	MACAW	$90.00
549-P2	Hand Contactor	MADAM	35.00
549-373	Replacement Disc (150-1300 rpm)	HYDBA	7.00
549-371	Replacement Disc (700-3600 rpm)	HYMBN	4.00

PATENT NOTICE. See® Note 15, page vi.

TYPE 1530-A MICROFLASH

USES: The Microflash is a light source for single-flash photography. It provides a high-intensity light flash whose duration is approximately 2 millionths of a second. Consequently, it is capable of arresting extremely rapid motion. Conventional camera equipment is quite satisfactory for use with the Microflash.

Photographs of bodies moving at extremely high speeds are possible with the Microflash, and it finds many applications in engineering and the physical sciences, particularly in such fields as ballistics, hydraulics, kinematics, and industrial chemistry.



The Microflash was used as a light source in taking this photograph of a projectile in flight.

DESCRIPTION: The elements of the Microflash are a power supply, a gas-filled lamp, and a trigger circuit. The high-voltage transformer and rectifier, operating from the a-c power line, charge a condenser across the lamp terminals. An electrical impulse, which may be derived in any one of several ways from the phenomenon to be photographed, ionizes the gas in the lamp, and the energy stored in the condenser is dissipated in a discharge through the lamp, producing a short brilliant flash. A minimum of 10 seconds is required between flashes for the condenser to become fully charged.

The trigger circuit includes an amplifier, so that the flash can be tripped with a conventional crystal microphone, if desired. The flash can also be triggered by a make or break contact.

FEATURES: The outstanding feature of the Microflash is its high intensity and very short flash. During the flash, an object moving at 1000 feet per second would be displaced only one or two hundredths of an inch. Consequently, sharp records can be obtained of bullets and other projectiles in flight.

SPECIFICATIONS

Duration of Flash: Approximately 2 microseconds.

Guide Number: Product of lamp to subject distance and/stop on camera should be about 45 with moderately fast film.

Temperature and Humidity Effects: Temperature and humidity variations (32 to 100° F, 0 to 95% R.H.) have no appreciable effect upon the operation of the instrument.

Power Supply: 105 to 125, 210 to 250 volts, 50 to 60 cycles.

Power Input: 70 watts.

Tubes:

1 — 5T4 (RCA) I — FG-17 (GE)
1 — 2V3G(RCA) 1 — 6AC7 (1852) RCA
One 1530-P1 (General Radio)

Accessories Supplied: Microphone with cable; tripod; all tubes; spare pilot lamps and fuses; 2 spare flash lamps TYPE 1530-P1; plug for connection to contactor-trip jack.

Mounting: The power supply and trigger circuits are assembled in one metal case, the lamp in another. The two cases lock together for transportation, completely protecting the lamp and controls.

Dimensions: 24 1/8 x 13 1/4 x 11 3/4 inches, over-all.

Net Weight: 72 pounds.

(Right) View of the Microflash assembled for transportation.

Type		*Code Word*	*Price*
1530-A	**Microflash .....**	**TAFFY**	**$550.00***
1530-P1	**Replacement Flash Lamp .**	**TONIC**	20.00*

*Plus current Federal tax on photographic equipment.
PATENT NOTICE. See Notes 15, 23, page vi.

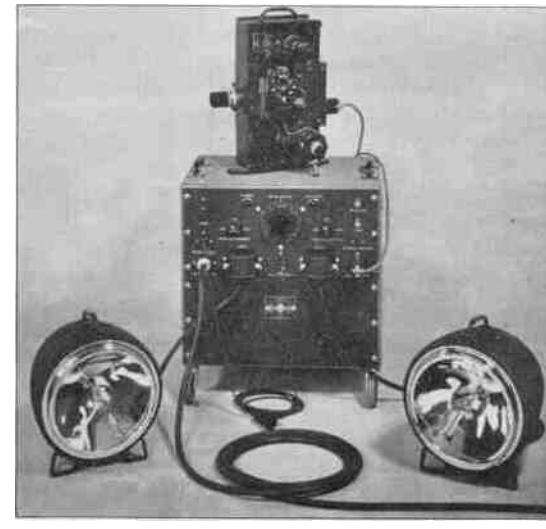
TYPE 621 POWER STROBOSCOPE*

The TYPE 621 Power Stroboscope supplies even greater light intensity per flash than does the TYPE 648-A Strobolux and is capable of being flashed at much higher speeds. It is particularly designed as a light source for the TYPE 651-AG Camera.* With this combination, motion pictures can be taken at speeds up to 1500 exposures per second, permitting the study of high-speed transient or non-repetitive motion. turbulence and cavitation in fluid flow, and other industrial and research problems.

When the Power Stroboscope is used in ultra-high-speed photography, the flashing rate is commonly controlled by a commutator on the camera. In this way the individual exposures are accurately framed for projection at normal speeds.

When stroboscopic lighting of high intensity at a high flashing rate is desired, considerable power is required, since the power that must be supplied to the light is directly proportional to the desired intensity, as well as to the frequency of flashing. Thus, although the TYPE 648-A Strobolux furnishes a light intensity adequate for illuminating small areas or for single-flash photography, the maximum useful flashing rate is limited by the power supply to about 100 per second. For applications involving very high flashing rates or for taking high-speed motion pictures, a Stroboscope of considerable power capacity is required.

The power Stroboscope is built to order only.
** Prices on request.*
PATENT NOTICE. See Notes 15, 23, page vi.



TYPE 759-B

SOUND-LEVEL

METER

USES: The TYPE 759-B Sound-Level Meter is suitable for all types of commercial and industrial noise measurement. Manufacturers of machinery and appliances use it for measuring product noise both in the research laboratory and in production. Sound transmission and absorption and the acoustical properties of materials can also be measured with it. It meets equally well the requirements for noise measurement in surveys of the psychological and physiological effects of noise.

For the industrial plant, it provides a means of measuring product noise, setting up noise standards, accepting or rejecting products on the basis of noise tests, and, finally, analyzing and correcting trouble in the rejected units.

In this last use, as in many others, a frequency analysis of the noise is usually valuable. For this purpose, the TYPE 760-A Sound Analyzer (see page 11) has been designed.

The usefulness of the sound-level meter may be extended to include vibration measurements by substituting a vibration pickup (see page 10) for the microphone. The low-frequency response of the sound-level meter is sufficiently good to permit vibration measurements at frequencies down to 20 cycles. Such measurements include the fundamental and harmonic frequency vibrations of machines rotating at 1200 rpm or higher, as well as many structural resonances.

For vibration measurements below 20 cycles, however, the TYPE 761-A Vibration Meter is recommended (see page 13).

DESCRIPTION: TYPE 759-B Sound-Level Meter is an accurate, portable, low priced meter for reading, in terms of a standard reference level, the sound level at its microphone.

The sound-level meter consists of a non-directional microphone, an amplifier, a calibrated attenuator, and an indicating meter. It is battery operated and completely self-contained.

An a-c power supply unit is also available (see page 92).

This sound-level meter complies with all the tentative standards for sound-level meters specified by the American Standards Association, the American Institute of Electrical Engineers, and the Acoustical Society of America.

All three frequency response characteristics recommended by the A.S.A. are included. In addition to the standard meter characteristic, a heavily damped movement, for reading rapidly fluctuating sounds, is provided.

FEATURES: The outstanding features of this instrument are its portability and ease of operation. Weighing a little over 20 pounds, and being completely self-contained (including the batteries or a-c power supply), the instrument is completely portable. It is so simple in operation that, it can be used by non-technical personnel.

SPECIFICATIONS

Sound-Level Range: Calibrated in decibels from +24 db to 140 db above the standard reference level of 10^{-16} watts (a pressure of 0.0002 dynes) per square centimeter in a free, progressive wave at 1000 cycles.

Frequency Characteristics: The frequency characteristic of the sound-level meter is adjustable to follow three different curves. The first and second of these are, respectively, the 40 and 70 db equal-loudness contours in accordance with the tentative standard proposed by the American Standards Association. The third frequency response characteristic gives a substantially equal response to all frequencies within the range of the instrument. This characteristic is used when measuring extremely high sound levels or when using the instrument with TYPE 760-A Sound Analyzer.

Microphone: The microphone mounts on a folding bracket on top of the instrument and folds down into a recess in the panel when not in use. It can be removed from its mounting bracket for use with an extension cable and tripod (see price list).

The microphone is of the crystal, diaphragm, type with an essentially non-directional response characteristic. It is rugged and stable, and its sensitivity is substantially unaffected by ordinary changes in temperature and humidity.

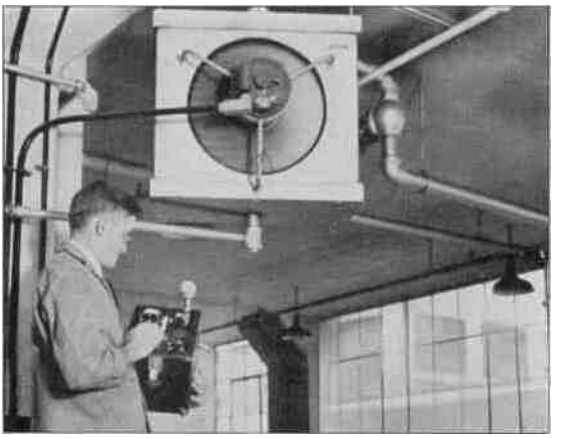
The response of the microphone is essentially flat below 4000 cycles, and the absolute level (of the sound-level meter) is corrected in accordance with the ASA tentative standards to cancel out any minor microphone irregularities when sounds of average frequency distribution are being measured.

The absolute level of all microphones is checked at several frequencies against a standard microphone, whose calibration is periodically checked by the U. S. Bureau of Standards. In addition the impedance of the microphone is held to close tolerances.

Vibration Pickup: The TYPE 759-P35 Vibration Pickup with the TYPE 759-P36 Control Box can be used in place of the microphone (see next page).

Meter plus Attenuator: The sound level is read as the sum of the meter reading and the reading of a stepped attenuator. A single knob controls two attenuators furnishing a total of 100 db attenuation in steps of 10 db. The indicating meter is approximately linear in decibels, and its scale is open and easily read. It covers a 16 db range, thus providing a satisfactory overlap between the steps of the attenuator. A SLOW-FAST switch makes available two meter speeds. With the control switch in the FAST position the ballistic characteristics of the meter closely match those of the human ear and agree with tentative standards of the American Standards Association. In the SLOW position the meter is shunted by a large condenser. The resulting heavily damped movement is convenient for observing the average level of rapidly fluctuating sounds.

Calibration; A means is provided for standardizing the sensitivity of the instrument. Any a-c power line of approximately 115 volts can be used as a source of standardizing voltage. A seven-foot line-connector cord is furnished for this purpose and is stored in the cover of the carrying case.



Measuring the noise from a ventilating fan with the sound-level meter.

Accuracy: The frequency response curves of the TYPE 759-B Sound-Level Meter fall within the tolerances specified by the ASA tentative standards. When the amplifier sensitivity is standardized the absolute accuracy of sound-level measurements is within ±1 decibel for average machinery noises in accordance with the ASA standards.

Temperature and Humidity Effects: Readings are independent (within I db) of temperature and humidity over the ranges of room conditions normally encountered.

Extension Cable and Tripod: An extension cable and tripod (TYPE 759-P21) can be supplied for using the microphone at a distance from the sound-level meter. A correction curve is supplied, giving the cable correction as a function of temperature. This temperature correction is of importance only above 85° Fahrenheit.

Batteries: A single block battery (Burgess type 6TA60) is used and one is supplied with the instrument. The TYPE 1261-A Power Supply is available if a-c operation is desired (see page 92).

Tubes: Three type 1N5-GT and one type 1D8-GT are required. A complete set is supplied with the instrument.

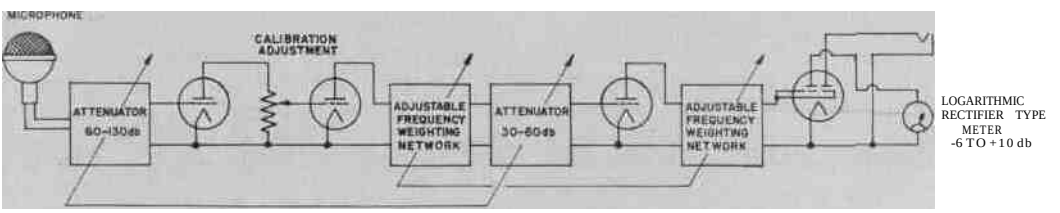
Case: The sound-level meter is mounted in a shielded carrying case of durable airplane-luggage construction.

Dimensions: The over-all dimensions are approximately: (height) 11 1/2 x (length) 13 1/2 x (width) 9 1/2 inches.

Net Weight: 22 1/4 pounds, with battery; 17 1/4 pounds, without battery.

Type		*Code Word*	*Price*
759-B	Sound-Level Meter	NOMAD	$260.00
	Replacement Battery for above	NOMADNUBAT	3.78
759-P21	Extension Cable (25 ft.) and Tripod	KIMBO	25.00

PATENT NOTICE. See Notes 1, 2. page vi.



Functional block diagram of the TYPE 759-B Sound-Level Meter.

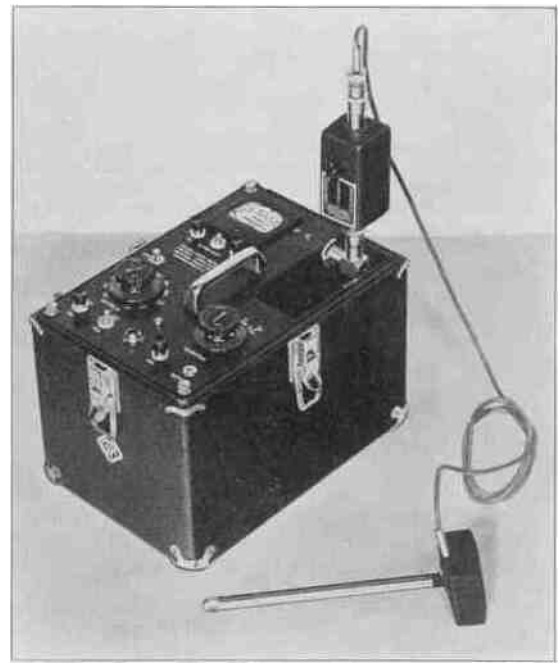
VIBRATION MEASUREMENTS WITH THE SOUND-LEVEL METER

By substituting a vibration pickup for the microphone, vibration measurements can be made with the TYPE 759-B Sound-Level Meter, provided the frequencies of components to be measured are above about 20 cycles per second. For this purpose, the use of the vibration pickup and control box described below is recommended.

VIBRATION PICKUP AND CONTROL BOX

The TYPE 759-P35 Pickup and TYPE 759-P36 Control Box have been designed for use with the TYPE 759-B Sound-Level Meter. To make vibration measurements with the sound-level meter it is merely necessary to replace the microphone by the control box and pickup.

The TYPE 759-P35 Vibration Pickup is an inertia-operated crystal 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-point switch on the control box.



The vibration pickup and control box plug into the sound-level meter in place of the microphone, as shown here.

SPECIFICATIONS

Calibration: The db readings of the sound-level meter can be converted into absolute values of displacement, velocity, or acceleration by means of calibration figures supplied with each pickup and control box.

Range: The range of measurement of the pickup and control box when used with the TYPE 759-B Sound-Level Meter is approximately as follows:

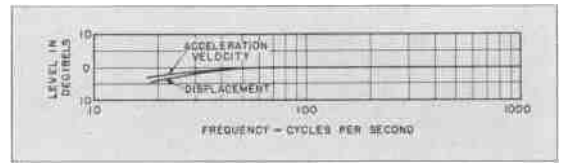
R-m-s Double Amplitude—30 micro-inches (minimum).

R-m-s Velocity—1000 micro-inches per second (minimum). The upper limit of velocity and displacement measurements is dependent on the frequency and is determined by the maximum acceleration permissible before non-linearity occurs (10 g).

R-m-s Acceleration—1000 micro-g to 10 g

g = 32.2 ft./sec./sec.

Frequency Characteristic: The over-all response is approximately flat up to 1000 cycles. A typical response curve is shown at the right.



Over-all frequency response characteristic of the vibration pickup, control box, and sound-level meter.

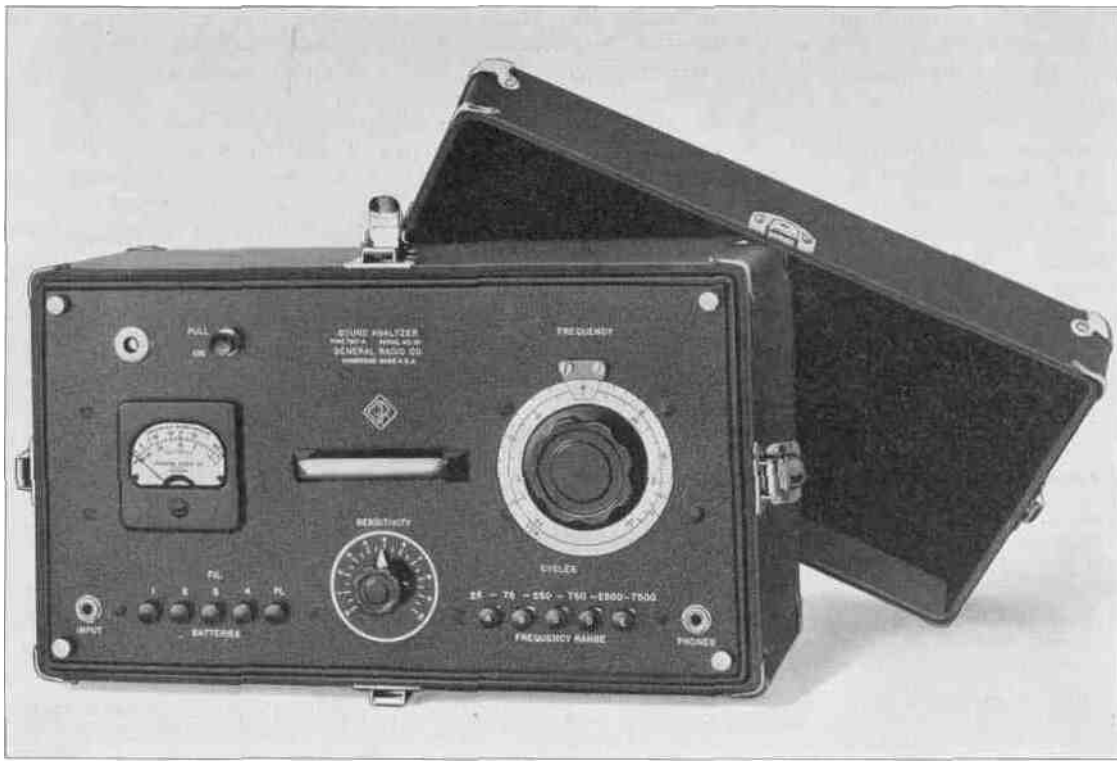
Mounting: Both control box and pickup are housed in metal containers, finished in black lacquer. The control box plugs into the sound-level meter, and the pickup in turn plugs into the control box. A flexible cable 7 feet long is supplied.

Net Weight: TYPE 759-P33 Vibration Pickup, 8 ounces (pickup only); pickup plus cable and tips. 1 pound; TYPE 759-P36 Control Box, 1 pound, 6 ounces.

Type		*Code Word*	*Price*
759-P35	**Vibration Pickup....**	NOSEY	**$40.00**
759-P36	**Control Box.....**	NANNY	**45.00**

A-C POWER SUPPLY FOR THE TYPE 759-B SOUND-LEVEL METER

The TYPE 759-P50 Power Supply formerly available has been discontinued and is superseded by the TYPE 1261-A Power Supply described on page 92.



TYPE 760-A SOUND ANALYZER

USES: The TYPE 760-A Sound Analyzer has been designed particularly for analyzing machinery noises or noise levels caused mainly by electrical or mechanical equipment. The fact that the selectivity curve widens proportionally as the frequency is increased makes it suitable for measuring noises caused by machines that do not run at absolutely constant speed. The instrument is particularly well adapted for analyzing the sound made by automobile and airplane motors and industrial or household equipment.

Although designed for use with the TYPE 759 Sound-Level Meter, the analyzer is not necessarily restricted to this application. It may be used in conjunction with any microphone and amplifier combination that provides sufficient output voltage.

As a general laboratory instrument the TYPE 760-A Sound Analyzer can be used as a harmonic analyzer to measure components down to 1% of the fundamental. It is very useful as a bridge-balancing indicator, since it can be tuned to the bridge frequency, thus eliminating errors caused by harmonics. The logarithmic indicating meter is of particular advantage in this application.

Another important use is the analysis of vibrations in conjunction with the TYPE 759-B Sound-Level Meter and vibration pickup.

DESCRIPTION: The TYPE 760-A Sound Analyzer consists of a selective amplifier, operating on the degeneration principle and having a constant percentage band width, combined with a vacuum-tube voltmeter having approximately logarithmic characteristics over a wide range.

The principles on which the analyzer operates are shown in the functional diagram on the next page.

The instrument was designed particularly for use with the TYPE 759 Sound-Level Meter, and this combination provides an accurate and convenient means for measuring not only the actual level of sound, but also the relative amplitudes of the component frequencies.

FEATURES: In the development of this analyzer, simplicity and convenience of operation were considered of primary importance. The frequency calibration is read directly on a large dial, which can be rotated continuously to cover the entire frequency range of the instrument with a minimum of effort. A push-button switch operates the multipliers, so that it is a simple matter to scan quickly the entire frequency range of the analyzer or to change the tuning

between two remote points in the range. A stabilized circuit eliminates the need of any battery adjustments, and a neon ballast lamp provides satisfactory accuracy of the logarithmic voltmeter circuit, regardless of the condition of the batteries.

A volume control is included to adjust the instrument for use at various input levels, but, in actual operation, no meter multipliers or volume controls are used since the complete range may be read on the single logarithmic meter scale.

The selective circuits used in this analyzer contain only resistors and capacitors; no inductors are used. Because of this, external magnetic fields have no appreciable effect on the operation.

Since the instrument was designed as a companion to the TYPE 759 Sound-Level Meter, small size and low weight were considered extremely important, and the instrument is smaller and lighter than most of the analyzers which have been used for noise work in the past. The complete instrument is mounted in an airplane-luggage type of case matching that of the sound-level meter in appearance.

SPECIFICATIONS

Frequency Range; Calibrated directly in cycles per second from 25 to 7500. This total range is covered in five complete turns of the tuning knob, the ranges on the various dial rotations being 25 to 75, 75 to 250, 250 to 750, 750 to 2500, and 2500 to 7500 cycles. A push-button switch allows immediate change of the main control to any of these ranges.

Frequency Calibration: The accuracy of frequency calibration is ±1 1/2% of the frequency to which the dial *is set* or ±1 1/2 cycles per second, whichever is the larger.

Voltage Range: The analyzer will give usable indications on input voltages ranging from 1 millivolt to 10 volts. The meter scale is calibrated for reading directly component tones down to 1 % of the sound pressure (or voltage) of the fundamental or loudest component. Accordingly, to make full use of this feature, the input voltage at the loudest component or fundamental should be 0.1 volt or higher.

Input Impedance: The input impedance is between 20,000 and 30,000 ohms, depending upon the setting of the sensitivity control. A 3-uf blocking condenser is in series with the input.

Frequency Response: The response is flat within ±2 db over the entire range. At points where two ranges overlap, the sensitivity is the same on either range, within ±1 db.

Band Width; The average selectivity is such that the relative attenuation is 3 db at 1 % off the peak to which the analyzer is tuned.

Temperature and Humidity Effects: Under very severe conditions of temperature and humidity only slight, and generally negligible, shifts **in** calibration, sensitivity, and band width will occur.

Circuit: The circuit consists of a three-stage amplifier made selective by the use of degeneration, and an approximately logarithmic vacuum-tube voltmeter circuit, which allows a range slightly in excess of 40 decibels, or 100 to 1, to be read on the meter scale.

Meter: The indicating meter is calibrated down to 1 % of the fundamental or loudest component of the sound. A decibel scale is also included, extending to 40 decibels below the fundamental or loudest component.

Telephones: A jack is provided on the panel for plugging in a pair of head telephones, in order to listen to the actual component of the sound to which the instrument is tuned. This is also useful when using the analyzer as a bridge-balance indicator.

Tubes: Three 1L4 and one 1S5 tubes are required. A neon regulator tube (type 2LAG-949) is also used. A complete set of tubes is supplied with the instrument.

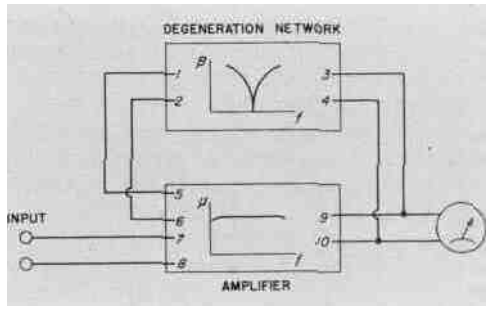
Batteries: The batteries required are four Burgess No. 2FBP 3-volt batteries, or the equivalent, and three Burgess No. Z30N 45-volt batteries, or the equivalent. A compartment **is** provided in the case of the analyzer for holding all batteries, and connections are automatically made to the batteries when the cover of this compartment is closed. A set of batteries is included in the price of the instrument.

Accessories Supplied: A shielded cable-and-plug assembly for connecting the analyzer to the sound-level meter.

Case: The analyzer is built into a shielded carrying case of airplane-luggage construction. In addition to the handle on the carrying case, a handle is provided on the panel of the instrument for convenience in moving the instrument about while it is in operation.

Dimensions: (Length) 18 x (width) 10 x (height) 11 1/2 inches, over-all.

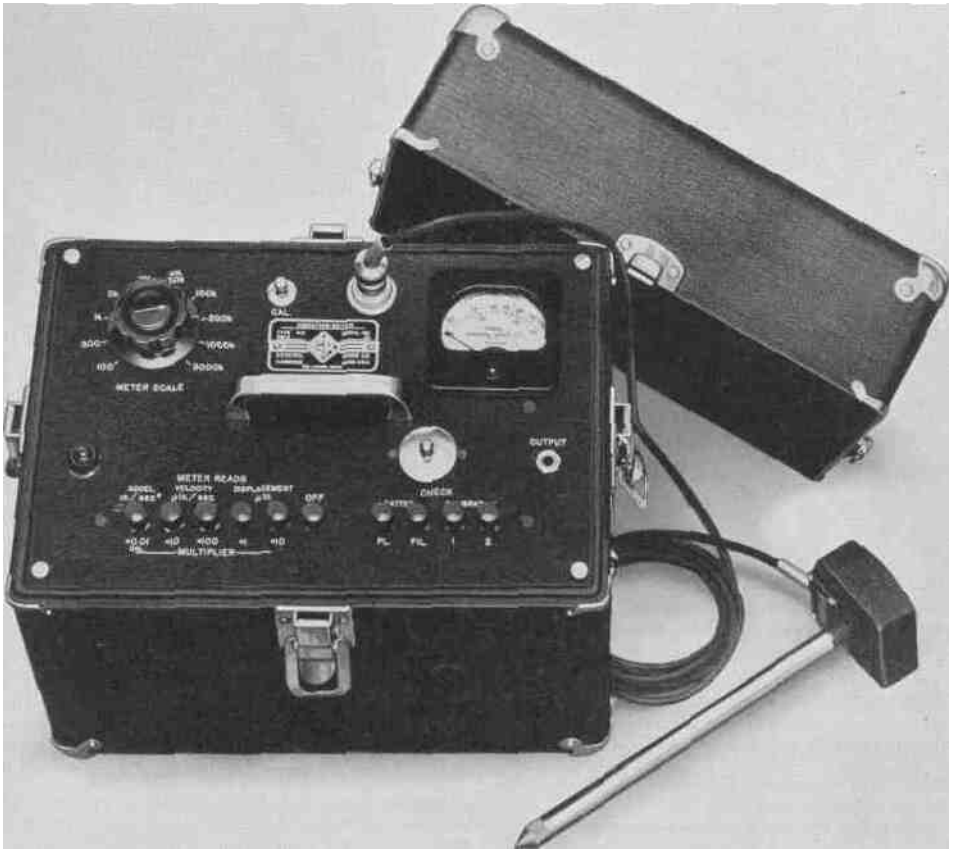
Net Weight: 34 pounds, with batteries; 27% pounds, without batteries.



A functional diagram of the general type of circuit used in TYPE 760-A Sound Analyzer. The system consists of an amplifier with a propagation constant *u* and a feedback network with a propagation constant (3 having the frequency characteristics shown above. The degeneration network is highly selective, and at its null point the normal gain of the amplifier is obtained. At lower and higher frequencies, degeneration occurs, and the gain of the amplifier is greatly reduced.

Type		*Code Word*	*Price*
760-A	Sound Analyzer	ATTAR	$330.00
Set of Replacement Batteries for Above		ATTARADBAT	9.30

PATENT NOTICE. See Note 24, page vi.



TYPE 761-A VIBRATION METER

USES: With the TYPE 761-A Vibration Meter measurements of the vibratory characteristics of machines and structures can be made quickly and easily. The excellent low-frequency response of this instrument makes possible the measurements of vibrations at frequencies as low as two cycles per second. This permits the study of the operation of belt drives and of the effectiveness of mountings designed to reduce vibrations in adjacent structures.

For the manufacturer of machinery and equipment, the TYPE 761-A Vibration Meter is extremely useful in research, design, and production testing. Maintenance engineers will find the instrument useful for checking the operating condition of bearings, gear trains, and other mechanisms. With this instrument excessive vibrations due to improper adjustment or design and to structural resonances may be located and measured.

When an analysis of the frequency spectrum of the vibration is desired, the TYPE 762-B Vibration Analyzer (see page 15) should be used, in conjunction with the vibration meter.

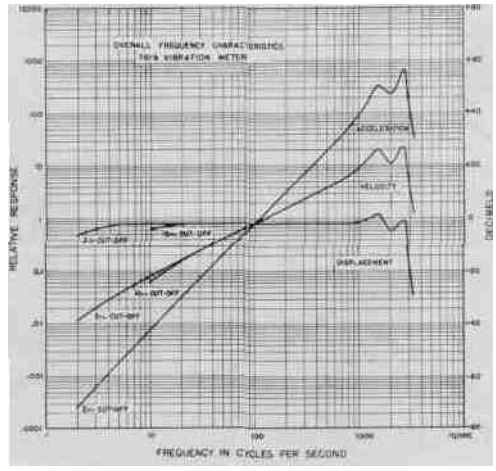
DESCRIPTION: The TYPE 761-A Vibration Meter consists essentially of a vibration pickup, an adjustable attenuator, an amplifier, and a direct-reading indicating meter. The pickup is of the inertia-operated crystal type which delivers a voltage proportional to the acceleration of the vibratory motion. An integrating network converts this output, when desired, to a voltage proportional to velocity or displacement. The type of response is selected by push-button switches. Thus the acceleration, velocity, and displacement of a vibrating body may be measured independently.

Calibrations are made in terms of r-m-s values. The basic units in which the instrument is calibrated, inches and seconds, are the simplest and least confusing of those commonly used. Acceleration is read directly in terms of inches per second per second, velocity in micro-inches per second, and displacement in micro-

inches. Calibrations are made on a motor-driven precision vibrator, which produces essentially sinusoidal vibrations.

FEATURES: Like the sound-level meter and sound analyzer this new vibration meter is small, portable, self-contained, and extremely simple in operation. The instrument reads directly the absolute value of the quantity under measurement so that no reference to calibration figures is necessary.

The inclusion of three response characteristics—namely, acceleration, velocity, and displacement—and the extension of the range down to 2 cycles per second with substantially flat response characteristics provide a degree of flexibility hitherto unapproached in commercially available vibration-measuring apparatus.



(Right) Over-all frequency characteristics of the vibration meter, including the vibration pickup.

SPECIFICATIONS

RANGES:

Vibration Displacement: Calibrated directly **in r-m-s micro-**inches from 16 micro-inches to 30 inches.

Vibration Velocity: Calibrated directly in r-m-s micro-inches per second from 160 micro-inches per second to 300 inches per second.

Vibration Acceleration: Calibrated directly in r-m-s inches per second per second from .160 inch per second per second to 3900 inches per second per second.

PICKUP UNIT: The vibration pickup is of the inertia-operated crystal type, housed in a cast aluminum container. The maximum vibration acceleration which can be impressed upon the pickup before non-linearity occurs is 10 g or 3900 inches per second per second. Point and ball tips and an 8-inch extension rod are supplied.

RESPONSE CHARACTERISTICS:

Acceleration Characteristic: The over-all response of the vibration pickup and vibration meter for acceleration measurements follows a theoretical curve of acceleration vs. frequency within ±10% from 4 to 500 cycles per second. Below 4 cycles per second the sensitivity drops gradually, so that at 2 cycles per second it is down approximately 25%.

Velocity Characteristic: The over-all response of the vibration pickup and vibration meter for velocity measurements between 1600 micro-inches per second and 300 inches per second follows a theoretical curve of velocity vs. frequency within ±10% from 5 to 500 cycles per second. Below 5 cycles per second the sensitivity drops gradually, so that at 2 cycles per second it is down approximately 40%. For velocity measurements below 1600 micro-inches per second the response is within ±15% from 20 to 500 cycles per second, and drops off approximately 25% at 10 cycles per second.

Displacement Characteristic: The over-all response of the vibration pickup and vibration meter for displacement measurements between 160 micro-inches and 30 inches is flat within ±10% from 10 to 500 cycles per second. Below 5 cycles per second the sensitivity drops off, so that at 2 cycles per second it is down approximately 50%. For measurements below 160 micro-inches the response is flat within ±10% to 20 cycles per second and drops off approximately 25% at 10 cycles per second.

Higher Frequencies: Above 500 cycles the error increases and may possibly reach ±30% at 1000 cycles. This is caused by the differences in response of individual pickups near resonance.

Meter: The indicating meter has a scale which reads directly in the quantity being measured—r-m-s micro-inches for displacement, r-m-s micro-inches per second for velocity, and r-m-s inches per second per second for acceleration.

Attenuators: A 10-step attenuator is provided which changes the meter scale calibration over a range of 30,000 to 1. Additional multipliers are provided which indicate the correct units of measurement and multiplying factors for each response characteristic.

Calibration: A calibrating circuit is provided in the instrument which, by connection to any a-c power line, makes it possible to check the over-all calibration of the vibration meter, excluding the vibration pickup. A seven-foot line connector cord is provided for this purpose.

Telephones: A jack is provided on the panel for plugging in a pair of head telephones in order to listen to the vibrations being measured, tor connecting the TYPE 760-A Sound Analyzer, or for connecting a cathode-ray oscillograph. Practically any load impedance can be impressed across this output telephone jack without affecting the reading of the meter.

Tubes: Three 1N5-GT tubes and one 1D8-GT tube are required. A complete set of tubes is supplied.

Batteries: A single battery unit. Burgess type 6TA60, which supplies the necessary plate and filament voltages, is included.

Case: The unit is built into a shielded carrying case of airplane-luggage construction, covered with durable black waterproof material, and equipped with chromium-plated corners, clasps, etc.

Dimensions: The over-all dimensions are approximately: (height) 12 1/2 inches x (length) 13 1/2 inches x (width) 9 1/2 inches.

Net Weight: Approximately 21 pounds with battery.

Type		*Code Word*	*Price*
761-A	**Vibration Meter**	**VIRUS**	**$320.00**
Replacement Battery for Above		**VIBUSADBAT**	**3.78**

TYPE 762-B VIBRATION ANALYZER

USES: The TYPE 762-B Vibration Analyzer makes possible the analysis of vibration phenomena having fundamental frequencies as low as 2.5 cycles per second. It is intended primarily for use with the TYPE 761-A Vibration Meter but can also be used with other pickup and amplifier combinations that provide sufficient voltage to give useful deflections. It can also be used for general harmonic analysis of low audio- and sub-audible-frequency voltages in the laboratory.

The frequency range covered (2.5 cycles to 750 cycles) includes practically all frequencies normally encountered in vibration studies, from the fundamental vibrations of ships and other large structures to the unbalance vibrations of high-speed centrifuges.

DESCRIPTION: This analyzer is similar in all essential characteristics of performance, construction, operation, and appearance to the TYPE 760-A Sound Analyzer except that the frequency has been lowered by a factor of 10 and provision has been made for operation with broad selectivity if desired. The latter arrangement is particularly useful in identifying components in the two lowest frequency ranges (2.5 to 25 cycles per second) and in making analyses involving components that vary slightly about a mean frequency.

SPECIFICATIONS

Frequency Range: 2.5 to 750 cycles, covered in five ranges as follows: 2.5 to 7.5.7.5 to 25,25 to 75,75 to 250,250 to 750. Band Width; For the sharp selectivity position, the relative attenuation is approximately 30% (3 db) at a frequency differing by 1% from that to which the analyzer is tuned. For the broad selectivity position, the attenuation is 30% for a frequency difference of 5%. At one octave from the peak, the relative attenuations are 98% (35 db) and 90% (20 db), respectively.

Frequency Calibration: The accuracy of frequency calibration of the sharp selectivity network is ±1 1/2% or ±1 1/2 cycles, whichever is the larger, over the three highest ranges (25 to 750 cycles); on the two lower ranges (2.5 to 25 cycles), the accuracy is ±5% or ±0.2 cycle, whichever is the larger. The frequency as determined with the broad selectivity network deviates on the average by less than ±2% from that determined with the sharp selectivity network.

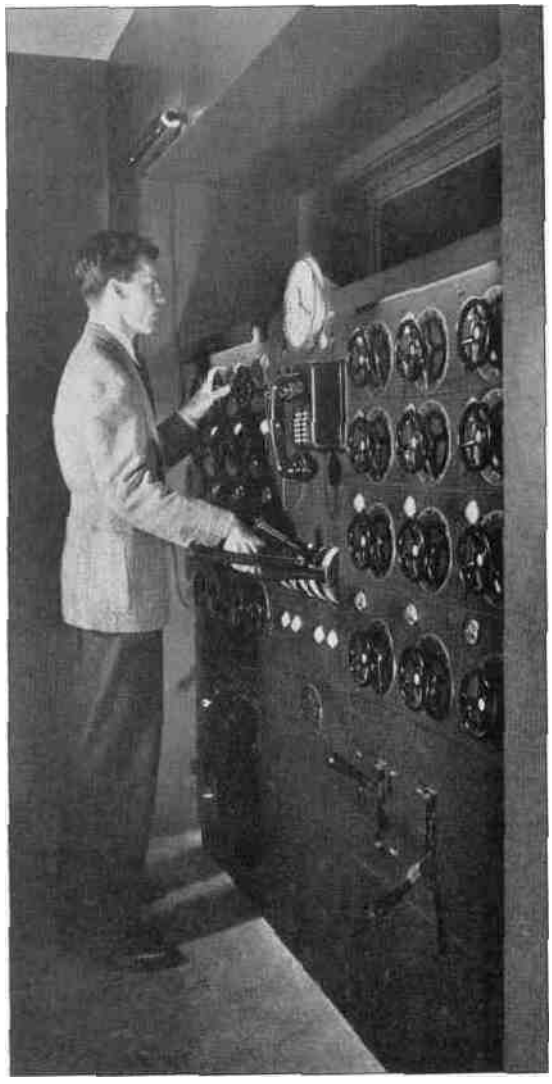
Frequency Response: The response of the sharp selectivity network is flat within ±2 db over the enlire range. At points where two ranges overlap, the sensitivity is the same on either range within ±1 db. The sensitivity of the broad selectivity network is the same as that of the sharp selectivity network to within ±2 db.

For other specifications see TYPE 760-A, page 12.

Type		*Code Word*	***Price***
762-B	**Vibration Analyzer.**		**$375.00**

PATENT NOTICE: See Note 24, page vi.

VARIAC*



VARIACS in a theater lighting control panel at Allegheny College.

USES: The VARIAC is a voltage control that finds applications in shop and laboratory wherever a-c voltage must be adjusted smoothly and continuously. Thousands are in use for motor speed control; for heat control on electric ovens and furnaces; for illumination control in auditoriums, photographic studios, and darkrooms ; as voltage controls in laboratory testing and research; and as output voltage controls in transformer-rectifier systems.

Although designed primarily for use at ordinary power frequencies, VARIACS are equally useful as voltage controls in power circuits operating at higher frequencies.

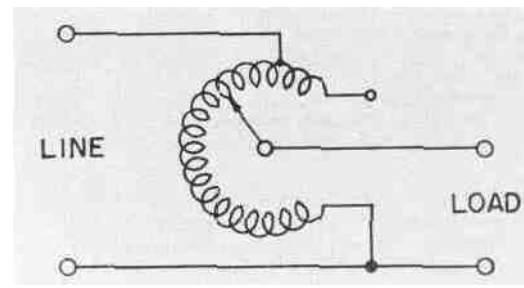
In the testing and calibration of voltmeters, ammeters, wattmeters, and power-factor meters, the VARIAC is a convenient source of adjustable voltage, and, by using combinations of VARIACS, the phase of the test voltage can be varied, as well as the amplitude.

Two and three-gang assemblies of VARIACS are available for use on three-phase systems. With the largest units, volt-ampere loads up to 17.5 kva can be controlled in this way. Although VARIACS are built for 115 and 230-volt service, they can be used on circuits of higher or lower voltage in conjunction with fixed-ratio auxiliary transformers and autotransformers.

DESCRIPTION: The VARIAC is a continuously variable autotransformer supplying an output voltage from zero to *above* line voltage. It consists of a single-layer winding on a toroidal iron core. As the dial is rotated a carbon-brush contact traverses the winding, "tapping off" a portion of the total voltage across the winding. The brush is always in contact with the winding, and the voltage between turns is always less than 1 volt, even in the largest models, while in the smallest model it is only about 0.2 volt. The actual increments of voltage obtained as the dial is turned are always less than the voltage between turns, the action of the carbon brush being such that the change in voltage is practically continuous. The resistance of the brush is so chosen that no excessive heating can occur in the short-circuited turn.

FEATURES: Compared to resistive methods of voltage control, the VARIAC has the advantages of high efficiency, smooth control, good voltage regulation, and comparatively small size. Because the output voltage is essentially independent of load, a linear variation of voltage is obtained. VARIACS also furnish output voltages above line voltage, making it possible to compensate for under-voltage lines.

Functional diagram of the VARIAC.



*Reg. U. S. Pat. Office.

Today's VARIACS, the new V-models, are more useful, more reliable, and more efficient than ever before. Among their outstanding features are:

Greatly increased ratio of output to weight.

New unit brush — easily changed in a few seconds.

Unaffected by vibration — constant pressure — brush holder cannot contact winding surface.

Shaft reversal to convert from panel to table mounting is accomplished by loosening and tightening a single screw — does not affect brush adjustment.

Rubber feet prevent damage.

Extra terminals for mid-winding taps facilitate the use of auxiliary transformers.

Case easily and quickly removed — tabs automatically register the model number for all combinations.

Direct-reading voltage scale has large, easily read numbers.

Brush travel limited by resilient stop.

Terminals have both screw and solder connections, easily accessible and logically arranged.

Heavy duty switch in mounted small models breaks both sides of line.

Attractive case — rounded contours — no sharp edges.

Grain-oriented steel cores yield high KVA rating per pound.

Aluminum structural parts mean lighter weight and minimum corrosion.

Durable black lacquer baked finish — wear and abrasion resistant.

Uniform windings on newly designed machine.

"Hyprolapped" commutator surface — plane oriented for uniform brush pressure and contact, with resultant minimum wear.

GENERAL SPECIFICATIONS

Models ranging in capacity from 170 va to 7 kva are listed on the next page. Specifications are for 50 to 60-cycle service.

Rated Current can be drawn from the VARIAC at any dial position. It is limited by heat loss in the winding.

Maximum Current can be drawn at low voltages or at voltages near the input voltage. It is limited by losses in the carbon brush. Currents up to 150% of this value can be drawn for brief periods without damage to the VARIAC.

Input Voltage is the voltage that should be applied to the input terminals to make the dial calibration correct. All 230-volt VARIACS have center-taps for use on 115-volt lines. When so used, the rated current is reduced by a factor of 2, and the regulation is not quite as good as with a 230-volt input.

Output Voltage is the range of voltage available at the output terminals, with rated voltage applied to the input terminals.

Load Rating is the maximum output current multiplied by input voltage. A VARIAC can handle, at any lower setting, a constant impedance load which draws at input voltage a current no greater than the "maximum current."

Temperature Rise: The ratings of VARIACS are based on a temperature rise of 50° Centigrade, or less, at 60 cycles. At 30 cycles the temperature rise may exceed the above value slightly but the VARJAC can be safely operated at full voltage and current ratings, except for the TYPE 200-B which should not be run at overvoltage.

Operation at 25 Cycles: On 25-cycle supply, VARIACS should be operated at one-half rated voltage or excessive healing will result. Thus 230-volt models can be used on 115-volt, 25-cycle lines.

Higher Frequencies: At frequencies above 60 cycles all VARIACS can be used at full rated current and voltage. No-load losses will be reduced compared to the 60-cycle values, but regulation will be poorer, owing to increased leakage reactance.

No Load Loss is measured at 60 cycles with rated input voltage. The values quoted in the table are the guaranteed maxima.

Driving Torque is the torque required to turn the VARIAC shaft.

Terminals (see also Mounting below): TYPE 200-B is furnished with threaded terminal studs and soldering lugs. TYPES V-5, V-10, and V-20 have combined soldering and screw-type terminals. TYPE 50 models have self-locking terminals and provision for attaching BX cable.

Panel Thickness is the maximum thickness of panel on which the VARIAC can be mounted, with the shaft supplied.

Dial: A reversible dial, reading in output voltage for the overvoltage connection, is provided on all models. One side is used for table mounting with rotating dial, the other for panel mounting, with fixed dial and rotating pointer. Dials can be supplied on special order engraved for maximum voltage equal to line voltage, if the overvoltage connection is not to be used. The total angle of rotation is 320°.

Mounting: TYPE 200-B is supplied without case, for panel mounting. TYPE V-20 models are always supplied with case. TYPES V-5 and V-10 can be ordered cither with or without terminal box cover and cord and plug. The accompanying photographs show stock combinations. On special order, they can also be supplied without case, but with terminal box and line cord.

Dimensions; Over-all height tor table mounting and depth behind panel for panel mounting are given in the table on page 18. Complete dimensional sketches can be furnished on request.

Net Weight: See table on page 18.

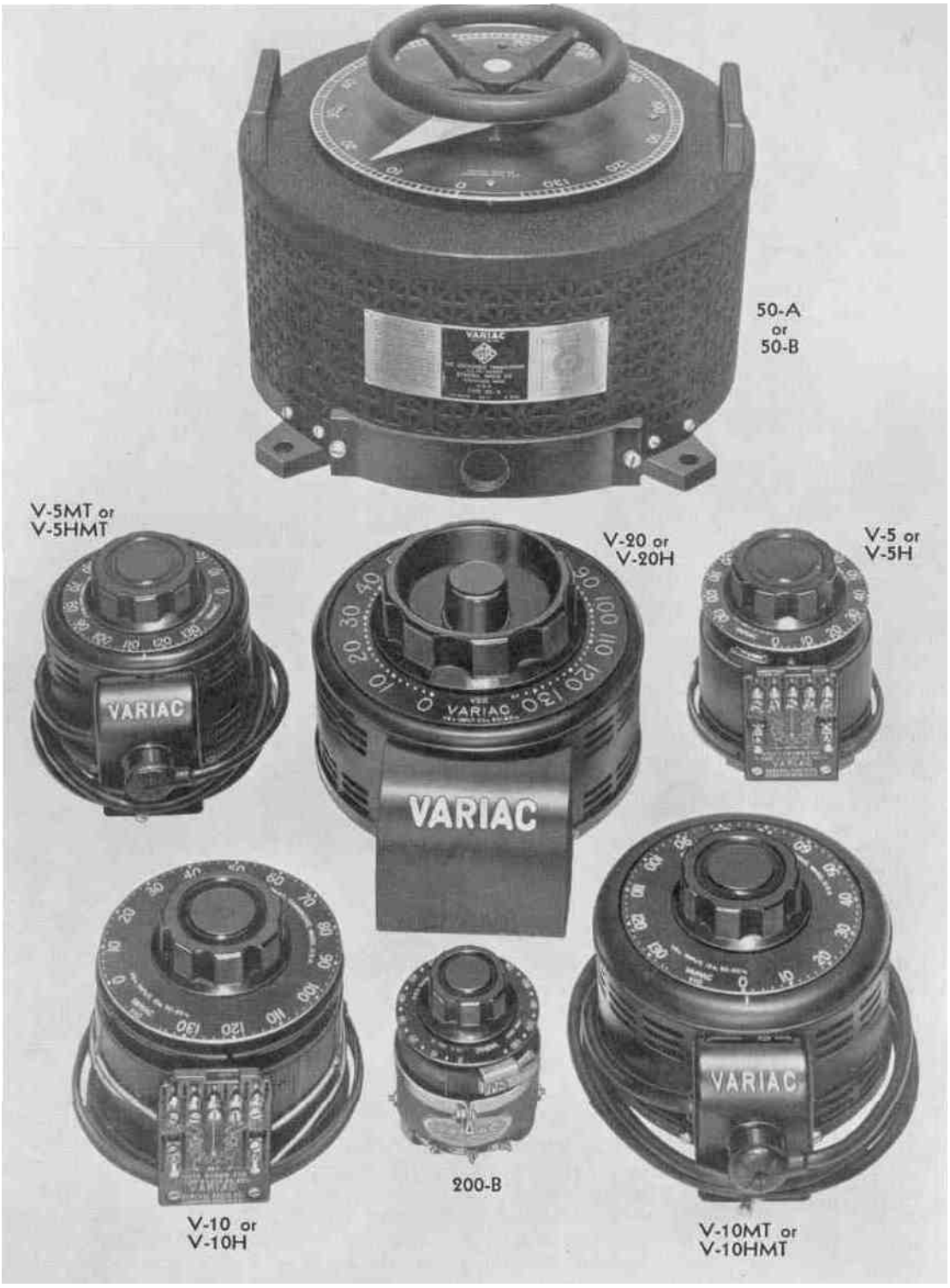
DETAILED SPECIFICATIONS

Type	Load Rating (KVA)	Input Voltage	Output Voltage (Zero to—)	Rated Current (Amperes)	Maximum Current (Amperes)	60 ~ No-Load Loss (Watts)	Driving Torque (Inch — Ounces)	Overall Height for Table Mounting (Inches)	Maximum Panel Thickness (Inches)	Depth behind Panel (Inches)	Diameter of Variac Cylinder (Inches)	Add for Terminals (Inches)	Net Weight (Pounds)	Code Word	Price
200-B	.170	115	135 115	1	1.5	3	20-40	4	1/4	3	35/8	1/4	27/8	BALSA	$11.50
V-5	.862	115	135 115	5	7.5	9	20-40	5	3/8	321/32	413/16	1/32	63/4	COBRA	16.50
V-5M	.862	115	135 115	5	7.5	9	20-40	5	3/8	4	4	9/32	7	COPAL	17.50
V-5MT	.862	115	135 115	5	7.5	9	20-40	5	3/8	4	415/16	121/32	8	CORAL	20.00
V-5H	.575	230 or 115	270 230	2 I*	2.5	9	20-40	5	3/8	321/32	413/16	1/32	61/2	CULPA	21.50
V-5HM	.575	230 or 115	270 230	2 I*	2.5	9	20-40	5	3/8	4	415/16	1/8	63/4	CUMIN	22.50
V-5HMT	.575	230 or 115	270 230	2 I*	2.5	9	20-40	5	%	4	415/16	121/32	73/8	CUPID	25.00
V-10	1.725	115	135 115	10	15	17	—	51/8	3/8	313/16	49/64	3/8	111/4	HAZEL	27.50
V-10M	1.725	115	135 115	10	15	17	—	51/8	3/8	45/32	617/64	5/16	115/8	HEAVY	29.00
V-10MT	1.725	115	135 115	10	15	17	—	51/8	3/8	45/32	617/64	11/16	121/8	HELOT	31.50
V.IOH	1.15	230 or 115	270 230	4 2*	5	17	—	51/8	3/8	313/16	49/64	3/8	105/8	HINNY	31.50
V-10HM	1.15	230 or 115	270 230	4 2*	5	17	—	51/8	3/8	45/32	617/64	5/16	11	HOARY	33.00
V-10HMT	1.15	230 or 115	270 230	4 2*	5	17	—	51/8	3/8	45/32	617/64	11/16	111/2	HOBBY	35.50
V-20	3.45	115	135 115	20	30	27	—	51/2	3/8	41/8	77/8	113/32	123/4	JEWEL	+
V-20H	2.30	230 or 115	270 230	8 4*	10	27	—	51/2	3/8	41/8	77/8	113/32	111/2	JIMMY	*
50-A	5.00	115	135 115	40	45	60	250-500	101/8	11/2	21/8	16	—	85	TOKEN	116.00
50-B	7.00	230 or 115	270 230	20 10*	31	75	250-500	10^	11/2	21/8	163/16	—	81	TOPAZ	116.00

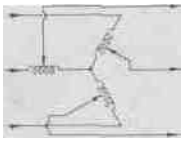
-With **115-volt input** applied across **half** the winding. Load **rating** is **reduced to one-half** the **value** shown.

PATENT NOTICE. See Note **11,** page **vi.**

+Prices on request.


50-A
or
50-B
V-5MT or
V-5HMT
V-20 or
V-20H
V-5 or
V-5H
VARIAC
200-B
V-10 or
V-10H
V-10MT or
V-10HMT

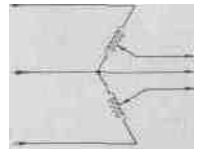
MULTIPLE OPERATION OF VARIACS



A Wye-connected three-phase arrangement of VARIACS.

Two and three-gang VARIAC assemblies are available for controlling several circuits from a single dial, or for controlling 3-phase circuits in the same manner that one VARIAC controls a single-phase circuit.

In polyphase circuits a large variety of input and output voltage combinations is possible. The Wye and open-delta connections listed are most frequently used, although the closed-delta finds occasional application.



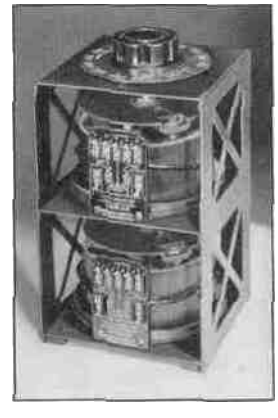
A three-phase arrangement **of** VARIACS in the open-delta circuit,

Input —KVA— Km			Output —				
Three-Phase Line Voltage	*At Input Voltage*	*At Maximum Voltage*	*Line Current in Amperes Rated*	*Maximum*	*Three-Phase Line Voltage*	*Type of Assembly*	*Circuit*
230	1.15	1.08	2.0	2.5	0-270	V-5H-G2	Open-Delta
230	2.30	2.16	4.0	5.0	0-270	V-10H-G2	Open-Delta
230	3.00	3.00	5.0	7.5	0-230	V-5-G3	Wye
230	4.60	4.32	8.0	10.0	0-270	V-20H-G2	Open-Delta
230	6.00	6.00	10.0	15.0	0-230	V-10-G3	Wye
230	12.0	12.0	20.0	30.0	0-230	V-20-G3	Wye
230	18.0	17.5	37.5	45.0	0-270	50-A-G3	Wye
230	12.5	9.40	20.0	31.0	0-270	50-BG2	Open-Delta
460	2.00	2.00	2.0	.2.5	0-460	V-5H-G3	Wye
460	4.00	4.00	4.0	5.0	0-460	V-10H-G3	Wye
460	8.00	8.00	8.0	10.0	0-460	V-20H-G3	Wye
460	25.0	25.0	20.0	31.0	0-460	50-BG3	Wye

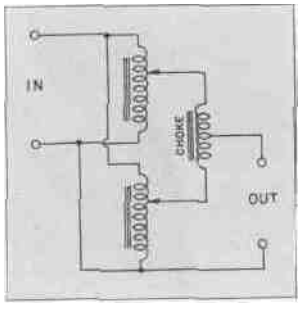
VARIAC ASSEMBLIES

Type	*Description*	*Net Weight in Pounds*	*Code Word*	*Price*
V-5-G2	2-Gang V-5	161/2	COBRAGANDU	$41.00
V-5-G3	3-Gang V-5	231/2	COBRAGANTY	61.50
V-5H-G2	2-Gang V-5H. ...	16	CULPAGANDU	51.00
V-5H-G3	3-Gang V-5H. ...	223/4	CULPAGANTY	76.50
V-10-G2	2-Gang V-10	27	HAZELGANDU	63.00
V-10-G3	3-Gang V-10	385/8	HAZELGANTY	96.00
V-10H-G2	2-Gang V-10H ...	253/4	HINNYGANDU	71.00
V-10H-G3	3-Gang V-10H...	363/4	HINNYGANTY	108.00
V-20-G2	2-Gang V-20	53	JEWELGANDU	*
V-20-G3	3-Gang V-20	753/4	JEWELGANTY	*
V-20H-G2	2-Gang V-20H ...	501/2	JIMMYGANDU	*
V-20H-G3	3-Gang V-20H...	72	JIMMYGANTY	*
50-AG2	2-Gang 50-A.	180	TOKENGANDU	260.00
50-AG3	3-Gang 50-A.....	265	TOKENGANTY	388.00
50-BG2	2-Gang 50-B	175	TOPAZGANDU	260.00
50-BG3	3-Gang 50-B	256	TOPAZGANTY	388.00
50-P1	Choke.....	11/4	PARALLCHOK	8.50

•Prices on request.

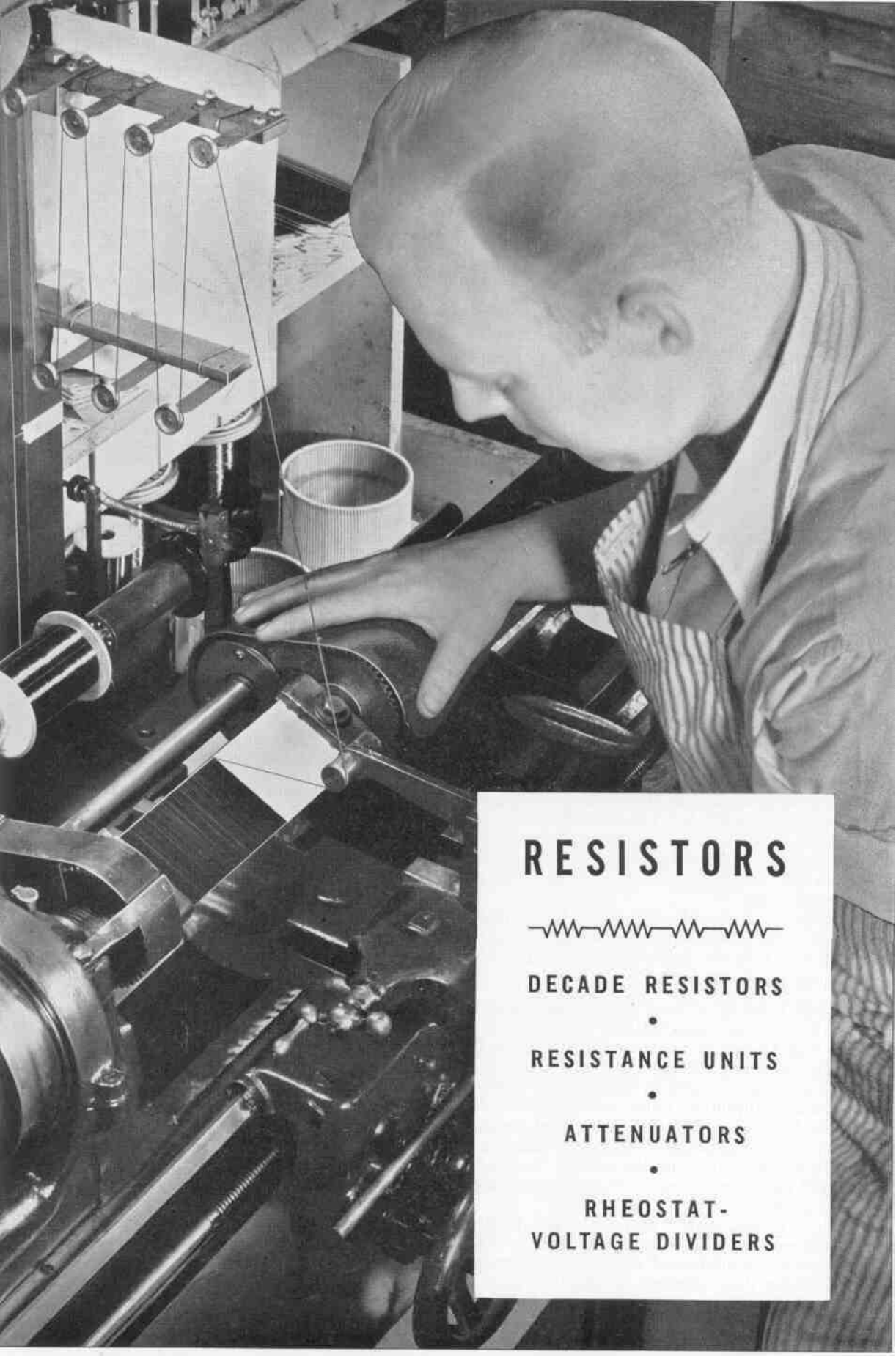


View of TYPE V-10-G2 Variac Assembly.



PARALLEL OPERATION

The TYPE 50-P1 Choke is available for parallel operation of two TYPE 50 VARIACS. Connections for this choke are shown in the sketch. The choke serves to equalize the currents from the two VARIACS and also to limit the flow of circulating currents. The use of a choke with smaller sizes of VARIACS is not recommended, because better results can be obtained by using a single larger unit.



RESISTORS

DECADE RESISTORS

•

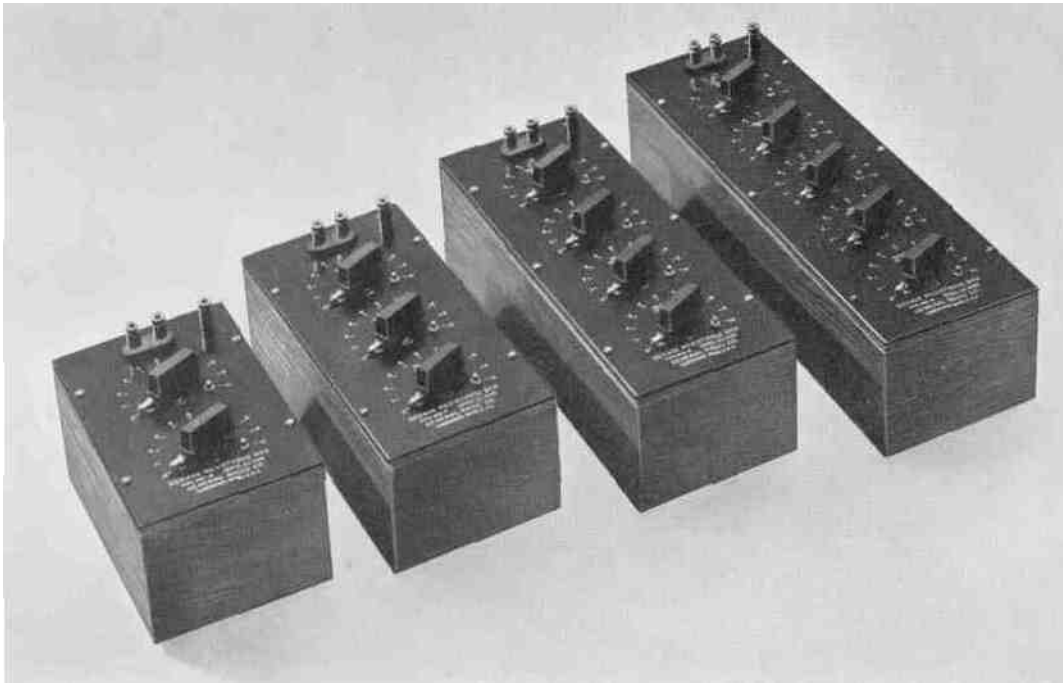
RESISTANCE UNITS

•

ATTENUATORS

•

RHEOSTAT-
VOLTAGE DIVIDERS



TYPE 602 DECADE-RESISTANCE BOX

USES: Accurate resistance boxes are extremely valuable wherever electrical measurements are made. Such boxes are constantly used in circuits where a wide range of resistance values is required or where variable dummy generator and load resistances are needed. The accuracy of TYPE 602 Decade-Resistance Boxes also permits them to be used as laboratory standards and as ratio arms for direct- and alternating-current bridges.

Although designed primarily for direct-current and audio-frequency work, they are useful well into the radio-frequency range for many applications.

DESCRIPTION: The TYPE 602 Decade-Resistance Box is an assembly of two or more TYPE 510 Decade-Resistance Units in a single cabinet. Mechanical and electrical protection of the units is provided by the shielded walnut cabinet and aluminum panel, which completely enclose both the resistance units and switch contacts. The resistance elements have no electrical connection to the shield, which is brought out to a separate terminal connected to the panel.

Two-, three-, four-, and five-dial decade assemblies are available. Each decade has eleven contact studs and ten resistance units, so that the dials overlap. A positive detent mechanism assists in setting squarely on the contacts and so permits adjustments to be made without looking at the dials.

FEATURES: By careful mechanical design the zero resistance of the TYPE 602 Decade-Resistance Boxes has been kept below 0.003 ohm per decade. In applications where a minimum zero resistance is desired, this feature is very valuable. On the other hand, there are many types of measurement, such as substitution measurements, in which the difference between two settings of a resistance box is the significant value. This difference is given correctly only when the individual resistors have been adjusted independently of switch and wiring resistance. Accordingly, the resistance units in the TYPE 602 Decade-Resistance Boxes are adjusted to have their specified values at their own terminals, rather than at the terminals of the box.

All resistors are wound with a special alloy wire which has a very low temperature coefficient. Furthermore, the characteristics of this wire eliminate all difficulties caused by thermal emf in direct-current measurements.

At radio frequencies, the residual inductances and capacitances cause the effective series resistance at the terminals to depart from the

low-frequency value.* In addition, the reactance component, which is negligible at audio frequencies, may become significant. The 100-, 10-, and 1-ohm-per-step decades of the TYPE 602 Decade-Resistance Boxes are the most satisfactory for use at high frequencies. In no case, however, is the frequency error serious below 50 kc. The magnitudes of the residual impedances are given in the specifications below.

The maximum allowable current for each decade, based on a 40° Centigrade temperature rise, is engraved just above each decade switch knob.

•See "Radio Frequency Characteristics of **Decade Resistors,**" General Radio *Experimenter,* Vol. XV, No. 6.

SPECIFICATIONS

Frequency Characteristics:* A TYPE 602 Decade-Resistance Box can be represented quite closely by the equivalent circuit below, which represents one decade of a box, with the remaining decades set to zero. Ro and Lo are the zero resistance and inductance of the box, due to the wiring and switches. These values are proportional to the number of decades in the box. AL is the inductance associated with each increment of resistance, AR. The effective capacitance C depends, in general, upon the dial setting, the variation being approximately linear with setting (the higher value is for the lowest setting). The values of the constants are tabulated below:

Lo = 0.10 uh per dial
Ro (d-c) = .002 to .003 ohm per dial
$_{R»}$ (1 Mc) = 0.04 ohm per dial; proportional to the square root of frequency at all frequencies above 100 kc.

Type of Decade	*.1-Ohm Step*	*1-Ohm Step*	*10-Ohm Step*	*WO-Ohm Step*	*1000-Ohm Step*	*10,000-Ohm Step*
AR in ohms	0.1	1.0	10	100	1000	10,000
AL (uh)	.014	.05	0.11	0.29	3.3	9.5
C+ (uuf)	—	27	26-23	21-13	—	—

Zero Resistance: The direct-current zero resistance of the various boxes depends on the number of dials, as follows:

No. of Dials	*Zero Resistance*
2	0.004-0.006 ohm
3	0.006-0.009 ohm
4	0.003-0.012 ohm
5	0.010-0.015 ohm

Temperature Coefficient: Less than ±0.002% per degree Centigrade at room temperatures, except for the 0.1^ decade, where the box wiring will affect **the over-all** temperature coefficient.

*See "Radio Frequency Characteristics of **Decade Resistors,**" General Radio *Experimenter,* Vol. XV, No. 6.

+The value of the capacitance shunting a single decade in a box depends upon the location of the decade in the box, as well as on the resistance of the decade. The values given here are for a TYPE 602-G and may be taken as representative.

If several decades of a box are in circuit at the same time, the incremental inductances of the several decades may be added directly, and the capacitance may be taken to be approximately that of the highest decade in use.

Type of Winding: See specifications for TYPE 510 Decade-Resistance Units, page 24.

Accuracy of Adjustment: All cards are adjusted within 0.1% of the stated value between card terminals, except the 1-ohm cards which are adjusted within 0.25% and the 0.1-ohm units which are adjusted within 1%.

Maximum Current: See specifications for TYPE 510 Decade-Resistance Units, page 24. Values for 40° Centigrade rise are engraved on panels directly above switch knobs.

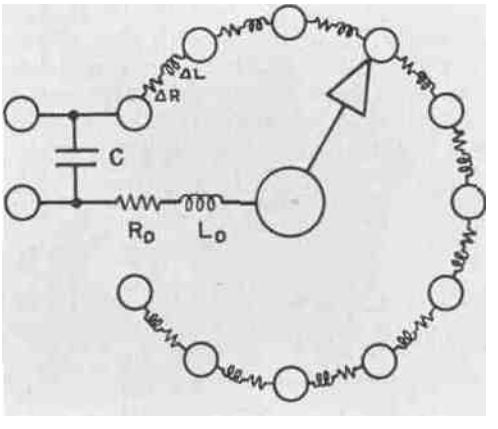
Switches: Quadruple-leaf, phosphor-bronze switches bear on contact studs 3/8 inch in diameter. Switch brushes are bent so as not to be tangent to the arc of travel, thus avoiding cutting. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive).

Terminals: Jack-top binding posts set on General Radio standard 3/4-inch spacing for resistance connections. There is an extra post at the corner of the panel for connections to the shield.

Mounting: A copper-lined walnut cabinet, with aluminum panel, completely encloses switches and resistance units. The panel finish is black crackle lacquer.

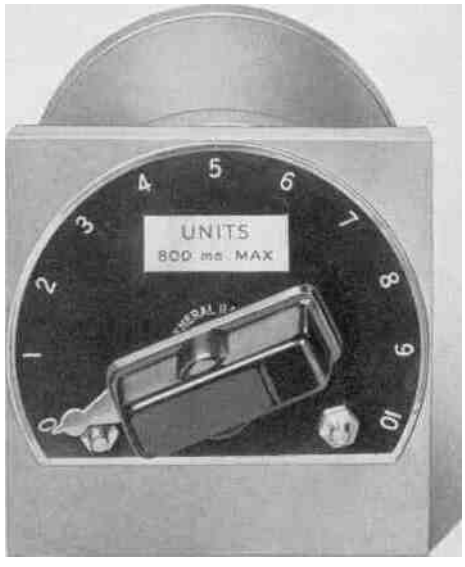
Dimensions: Panel length depends on the number of dials (see price list), being *7 3/4,* for 2-dial, *10 3/8* for 3-dial, 13 for 4-dial, and 15 5/8 inches for 5-dial boxes. **Panel width,** 5 inches. Over-all height, 5 inches.

Net Weight: 3 *3/4* for 2-dial, 4 1/4 for 3-dial, 5 for 4-dial, and 6 1/4 pounds for 5-dial boxes.



Type	*Resistance*	*No. of Dials*	*Type 510 Decades Used*	*Code Word*	*Price*
602-D	**11 ohms, total, in steps of 0.1 ohm**	2	**A, B**	**DECOY**	**$30.00**
602-F	**111 ohms, total, in steps of 0.1 ohm**	**3**	**A, B, C**	**DELTA**	**45.00**
602-G	**1110 ohms, total, in steps of 1 ohm**	**3**	**B, C, D**	**DIGIT**	**45.00**
602-K	**1111 ohms, total, in steps of 0.1 ohm**	4	**A, B, C, D**	**DEFER**	**55.00**
602-J	**11,110 ohms, total, in steps of 1 ohm**	4	**B,** C, **D, E**	**DEBIT**	**60.00**
602-N	**11,111 ohms, total, in steps of 0.1 ohm**	**5**	A, B. C, **D,**	DEMON	**75.00**
602-M	**111,110 ohms, total, in steps of 1 ohm**	**5**	**B,** C, **D, E,**	**DEMIT**	**80.00**
602-L	**111,100 ohms, total, in steps of 10 ohms**	4	**C, D, E, F**	DECAY	**70.00**

TYPE 510 DECADE-RESISTANCE UNIT



DESCRIPTION: The 1-, 10-, and 100-ohm steps are Ayrton-Perry wound on molded phenolic forms especially shaped and heat treated to minimize aging effects. The 0.1-ohm steps are bifilar wound of ribbon, while the 1000 and 10,000-ohm steps are unifilar wound on thin mica cards. The 100,000-ohm steps are wound in pies *on* ceramic forms.

The resistors are mounted on an eleven-contact switch similar to the one shown on page 27. The highest resistance unit (1,000,000 ohms maximum) uses a low-loss phenolic material for the switch form.

Each decade is enclosed in an aluminum shield, and a knob and etched-metal dial plate are supplied. The mechanical assembly is also available complete with shield, blank dial plate, switch stops, and knob, but without resistors, as the TYPE 510-P3 Switch.

USES: Because of their precision, compactness, and sturdy construction the TYPE 510 Decade-Resistance Units are ideal for assembly into special test equipment, bridges, and other experimental or permanent equipment. They are particularly useful in applications where only a single decade is desired, or where a TYPE 602 Decade Box cannot be mounted conveniently. In many cases the use of these units will make available for general laboratory work relatively more expensive decade-resistance boxes, otherwise tied up for long periods of time in experimental equipment.

FEATURES: Each resistor is aged at a temperature of 135° Centigrade before being assembled into the units. The construction is such that frequency errors are negligible below 50 kilocycles. Complete information is given in the specifications under "Frequency Characteristics."

All resistors have a temperature coefficient of resistance of less than ±0.002% per degree Centigrade at room temperatures.

Special alloy wire is used in all resistors, except the 100,000-ohm units, thus eliminating difficulties due to thermal emf in direct-current measurements. The TYPE 510-G Decades are wound with Advance wire and care should be taken in low-voltage direct-current work to see that temperature differences are kept at a minimum.

SPECIFICATIONS

Accuracy of Adjustment: Resistors are adjusted to be accurate at card terminals within the tolerances given in Table I on next page.

Maximum Current: See Table I on next page.

Type of Winding: See Table I on next page.

Frequency Characteristics: In Table II is listed the **maximum** percentage change in effective series resistance of each decade as a function of frequency. For the TYPES 510-A and 510-B the error is due almost entirely to skin effect and is independent of switch setting. For the TYPE 510-C the error changes slowly with dial setting and is a maximum at maximum resistance setting. For the TYPE 510-D (100-ohm step decade) a broad maximum occurs at the 600-ohm setting, while for all the higher resistance units, the position of maximum frequency error is at the maximum resistance setting. For these latter decades (TYPES 510-E and -F) the error is due almost entirely to shunt capacitance and is approximately proportional **to** the square of the resistance setting.

The reactance at any frequency and setting may be determined quite accurately from the equivalent circuit shown on page 23 for the TYPE 602 Decade-Resistance Box. The values of the constants, as determined by high-frequency bridge measurements, are listed in Table III.

The high-resistance decades (TYPES 510-F and 510-G) are very commonly used as parallel resistance elements **in** measurement circuits, and so the error due to the shunt capacitance of the decades can frequently be eliminated. The remaining parallel resistance changes by only a fraction of the amount indicated in Table II as the series resistance change. This fact is particularly important with reference to the TYPE 510-G which has 100,000-ohm steps. At maximum setting this unit has a —1% change in series resistance at 1 kilocycle, but its parallel resistance is changed by only —1% at 10 kilocycles.

TABLE I

Type	Resistance per Step	Accuracy	Type of Winding	Maximum Current 20° C. Rise	Maximum Current 40° C. Rise	Maximum Power per Step 40 C. Rise
510-A	0.1W	±1.0%	Bifilar	1 a	1.6 a	0.25 watt
510-B	1 W	±0.25%	Ayrton-Perry	550 ma	800 ma	0.6 watt
510-C	10 W	±0.1%	Ayrton-Perry	170 ma	250 ma	0.6 watt
510-D	100W	±0.1%	Ayrton-Perry	55 ma	80 ma	0.6 watt
510-E	1000 W	±0.1%	Unifilar on Mica	16 ma	23 ma	0.5 watt
510-F	10,000 W	±0.1%	Unifilar on Mica	5 ma	7 ma	0.5 watt
510-G	100,000 W	±0.1%	Pies	1.5 ma	2.5 ma	0.6 watt

TABLE II

Maximum Percentage Changge in Series Resistance as a Function of Freequency

Decade	50 kc	100 kc	Frequency Junction 200 kc	500 kc	1000 kc	2000 kc	5000 kc
0.1-ohm steps					0.1%	0.8%	5%
1.0-ohm steps	—	—	—	0.1%	0.5%	1.5%	9%
10-ohm steps	—	—	—	—	0.1%	0.2%	1.5%
100-ohm steps	—	—	—	—	0.1%	0.2%	0.9%
1000-ohm steps	—	-0.1%	-0.3%	-1.5%	-6.5%		
10,000-ohm steps	-2%	-8%	—	—	—	—	—

TABLE III

Value of Constants for the Equivalent Circuit of a TYPE 510 Decade-Resistance Unit
(See diagram on page 23)

Type of Decade	AR Ohms	AL Mh	La uh	C* uuf
510-A	0.1	0.014	0023	7.7-4.5
510-B	1.0	0.056	0.023	7.7-4.5
510-C	10.0	0.11	0.023	7.7-4.5
510-D	100	0.29	0.023	7.7-4.5
510-E	1000	3.3	0.023	7.7-4.5
510-F	10,000	9.5	0.023	7.7-4.5
510-G	100,000		0.023	7.7-4.5

*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 uuf greater than indicated here. depending on whether the shield is tied to the switch or to the zero end of the decade.

Switches: Quadruple-leaf, phosphor-bronze switches bear on contact studs % inch in diameter. Switch brushes are bent so as not to be tangent to the arc of travel, thus avoiding cutting. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive). The switch resistance is between 0.002 and 0.003 ohm, and the effective capacitance of the switch is of the order of 5 uuf, with a dissipation factor of 6% at 1 kilocycle. A molded bakelite switch form is used. The form for TYPE 510-G is molded from low-loss bakelite.

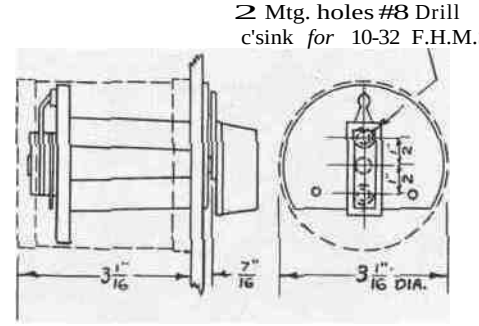
Temperature Coefficient: The temperature coefficient of resistance is less than ±0.002% per degree Centigrade at room temperatures.

Terminals: Soldering lugs are provided.

Mounting: Each decade is complete with dial plate and knob and can be mounted on any panel between 1/4 inch and 3/8 inch in thickness.

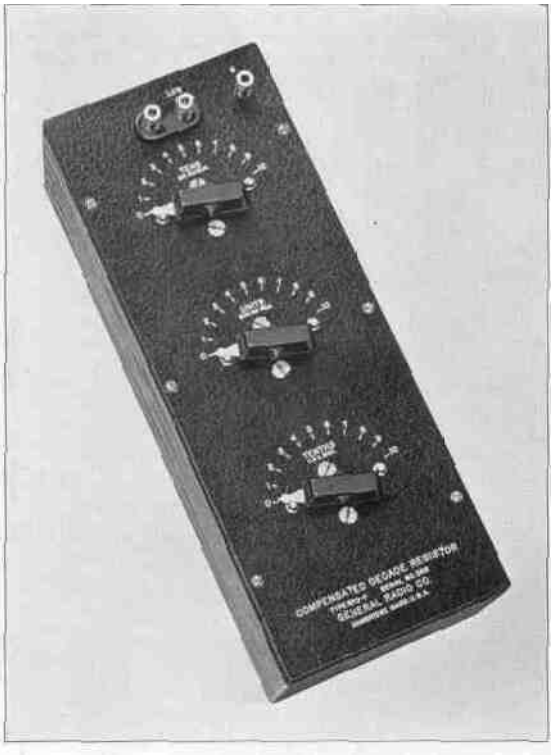
Dimensions: See sketch; shaft diameter is % inch.

Net Weight: TYPE 510 Units, 11 ounces; TYPE 510-P3 9 1/2 ounces.



Type	Resistance Total	Resistance Per Step	Code Word	Price
510-A	1 ohm	0.1 ohm	ELATE	$10.00
510-B	10 ohms	1 ohm	ELDER	10.00
510-C	100 ohms	10 ohms	ELEGY	10.00
510-D	1000 ohms	100 ohms	ELBOW	12.50
510.E	10,000 ohms	1000 ohms	ELECT	15.00
510-F	100,000 ohms	10,000 ohms	ELVAN	17.50
510-G	1,000,000 ohms	100,000 ohms	ENTER	40.00
510-P3 Switch			ENVOY	6.00

TYPE 670 COMPENSATED DECADE RESISTOR



USES: The TYPE 670 Compensated Decade Resistor is intended for use in a-c impedance measurements where non-reactive increments of resistance are desired. This type of decade resistor made possible the development of the first precision radio-frequency bridge. It is also used in the TYPE 667-A Inductance Bridge and is an important factor in determining the accuracy and convenience of operation of this bridge. Compensated decade resistors are useful in tuned-circuit substitution measurements, as variable resistance elements in antenna measuring circuits, and, in general, for bridge measurements wherever the variation in inductance of the conventional type of decade resistor cannot be tolerated.

DESCRIPTION: The TYPE 670-F Compensated Decade Resistor is an assembly of TYPE 668 Compensated Decade-Resistance Units.

The decade-resistance units use a double card system, as shown on page 28, and the switch is so arranged that a copper coil is substituted when a resistance coil is switched out of circuit. The inductance of the copper coil is equal to the inductance of the resistance coil but its resistance is very small. Consequently, as the position of the switch is changed, the inductance of the decade is kept constant and only the resistance is varied.

The decade units are mounted on a black crackle-finished aluminum panel and encased in a walnut cabinet, lined with sheet copper. The copper lining, together with the aluminum panel, forms a complete shield for the resistors. A separate terminal is provided so that independent connection to this shield may be made.

FEATURES: The greatest advantage of the TYPE 670 Compensated Decade Resistor is that its inductance is constant within 0.1 microhenry regardless of the resistance setting of the box. Furthermore, the total inductance of the box is but one microhenry, and so little difficulty is encountered in balancing out this amount in preliminary adjustments.

High accuracy and low temperature coefficient of resistance are maintained in the TYPE 670 Boxes. The current ratings for all decades, based on a 40° Centigrade temperature rise, are engraved on the panel.

SPECIFICATIONS

Type *of* Winding: The 10-ohm and 1-ohm steps are Ayrton-Perry resistance cards, while the O.1-ohm steps are bifilar ribbon units.

All decades are compensated by copper coils as shown in the diagram on page 28.

Accuracy of Adjustment: Resistance increments are correct within ±0.1% for the 10-ohm steps, ±0.25% for the 1-ohm steps, and ±1% for the O.1-ohm steps.

Zero Resistance: The direct-current zero resistance is about 0.04 ohm. The zero resistance at 1 Mc is about 0.3 ohm and at frequencies above 100 kc is proportional to the square root of the frequency.

Inductance: The zero inductance is 1.05 microhenry. This value remains constant **regardless** of resistance setting within 0.1 microhenry.

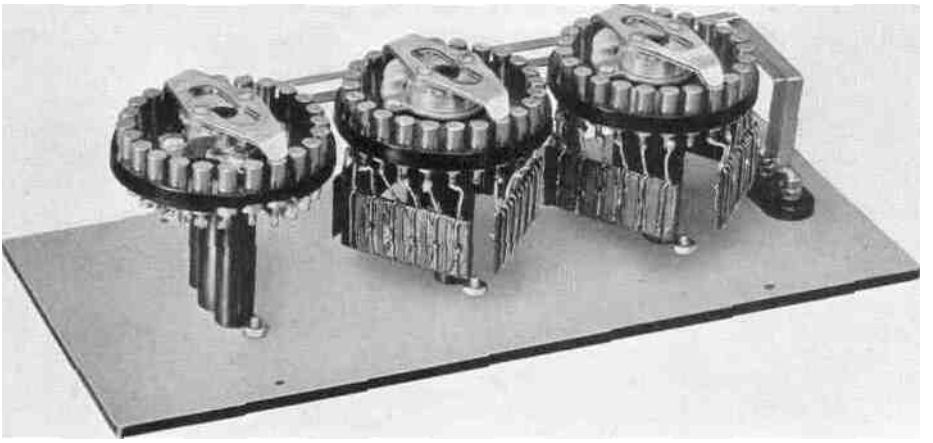
Switches: Double-leaf, phosphor-bronze switches bear on contact studs % inch in diameter. Switch brushes are bent so as not to be tangent to the arc of travel, thus avoiding cutting. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive).

Terminals: Standard 3/4-inch spacing is used on the terminals. A ground post connected to shield and panel is also provided.

Maximum Current: See specifications for TYPE 668 Compensated Decade-Resistance Unit on page 28. Values for 40° Centigrade rise are engraved on the panels directly above the switch knob.

Frequency Characteristics: The frequency characteristics of the TYPE 670 Compensated Decade Resistor are similar to those of the TYPE 668 Unit which is used in the boxes. However, the box wiring and cabinet shield affect these characteristics somewhat.

Temperature Coefficient: Less than ±0.002% per degree Centigrade at room tempeatures, except at the lower settings where the temperature coefficient of the copper



Interior of TYPE 670-F Compensated Decade Resistor.

compensating windings may affect the over-all temperature coefficient,

Mounting: The dials are mounted on aluminum panels in copper-lined walnut cabinets.

Dimensions: Panel, (length) 13 x (width) 5 inches. Cabinet, (height) 5 inches, over-all.

Net Weight: 5 1/2 pounds.

Type	*Resistance*	*Type Units Used*	*Code Word*	*Price*
670-F;	**0 to 111 ohms, total, in steps of 0.1 ohm**	**668-A,-B,-C**	ABYSS	**$55.00**

TYPE 668 COMPENSATED DECADE-RESISTANCE UNIT

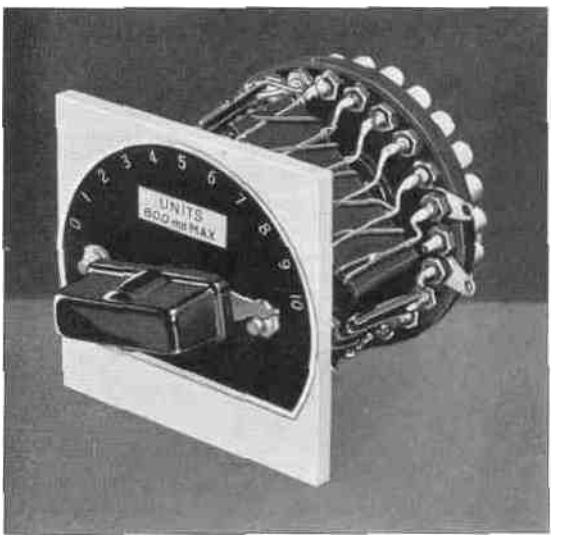
USES: The TYPE 668 Compensated Decade-Resistance Unit is the basic unit for the TYPE 670 Compensated Decade Resistor. In addition, it has found wide application as a component part for building into experimental or permanent measuring equipment for use at radio frequencies. It has been built into antenna measuring equipment as well as into general r-f impedance-measuring circuits. It is useful for any measurements where constancy of inductance is desired.

DESCRIPTION: The TYPE 668 Compensated Decade-Resistance Unit is equipped with a double set of switch contacts, by means of which a copper winding is exchanged, step by step, for the resistance cards, thus keeping the total inductance constant regardless of resistance setting. This arrangement is shown in the diagram on the next page.

The units are mounted with an etched-metal dial plate, knob, and stops, but with no shield.

FEATURES: The TYPE 668 Compensated Decade-Resistance Units are accurately adjusted resistances with a low temperature coefficient of resistance.

Since it is impossible to build a resistance with no inductance, the next best condition is a unit with a low but constant inductance. Accordingly, the TYPE 668 Units have been built to have but a few tenths of a micro-



henry inductance, and this value remains constant to within 0.05 microhenry regardless of resistance setting.

Careful construction has made it possible to keep the frequency errors small, and so all units are useful up to several megacycles.

SPECIFICATIONS

Accuracy of Adjustment: Resistance increments are correct within ±1% for the 0.1-ohm steps, ±0.25% for the 1-ohm steps, and ±0.1% for the 10-ohm steps.

Zero Resistance: The direct-current zero resistance of the different units is given in Table I. The zero resistance at 1 Mc is about 8 times that at dc and at frequencies above 100 kc is proportional to the square root of the frequency.

TABLE I

Type	*Zero Resistance*	*Inductance*
668-A	0.001-0.010 ohm	0.15 microhenry
668-B	0.015-0.025 ohm	0.30 microhenry
668-C	0.010-0.020 ohm	0.50 microhenry

Inductance: The inductance of the different units is given in the table above. The inductance remains constant regardless of resistance setting within 0.05 microhenry.

Temperature Coefficient: The temperature coefficient of resistance is less than ±0.002 % per degree Centigrade at room temperatures, except for the lower settings of TYPES 668-A and 668-B, where the temperature coefficient of the compensating windings may affect the over-all temperature coefficient.

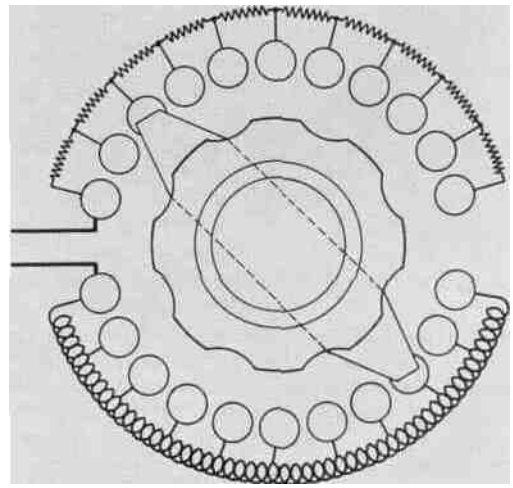
Frequency Characteristics: The frequency characteristics of TYPE 668 Compensated Decade-Resistance Units are similar to those of TYPE 510 Decade-Resistance Unite, page 24. Because 10-ohm cards are the largest used, the effects of shunt capacitance are entirely negligible, and the change in resistance with frequency results almost entirely from skin effect.

Although skin effect produces a positive effect on the total resistance, the skin effect in the compensating winding is greater than that in the resistance cards. Accordingly there is a net negative change in resistance increments. That is, the increment in resistance between one switch point and the next higher one will be less at high frequencies than at low. This "negative skin effect," at one megacycle, is about —0.8% for the units decade and about —0.6% for the tens decade.

Maximum Current: The following table gives the allowable current for the different units. The values of current for a 40° Centigrade temperature rise, based on one-quarter watt dissipation per resistor, are engraved on the dial plate.

TABLE II

Type	*Current for 20° C. Rise*	*Current for 40° C. Rise*
668-A	1.0 a	1.6 a
668-B	300 ma	500 ma
668-C	100 ma	160 ma



The construction of the compensated decade resistance is shown above. Opposite ends of the switch blade make contact with resistance or inductance windings, respectively. As a resistance step is added to the circuit, a compensating inductance step is removed, and vice versa.

Type of Winding: The 10-ohm and 1-ohm cards are Ayrton-Perry wound, while the 0.1-ohm steps are bifilar ribbon. Compensated windings are used on all decades to maintain constant inductance. (See diagram above.)

Switch: A double-leaf, phosphor-bronze switch bears on contact studs 1/4 inch in diameter. Switch brushes are bent so as not to be tangent to the arc of travel, thus avoiding cutting. A cam-type detent is provided and there are eleven contact points (0 to 10 inclusive).

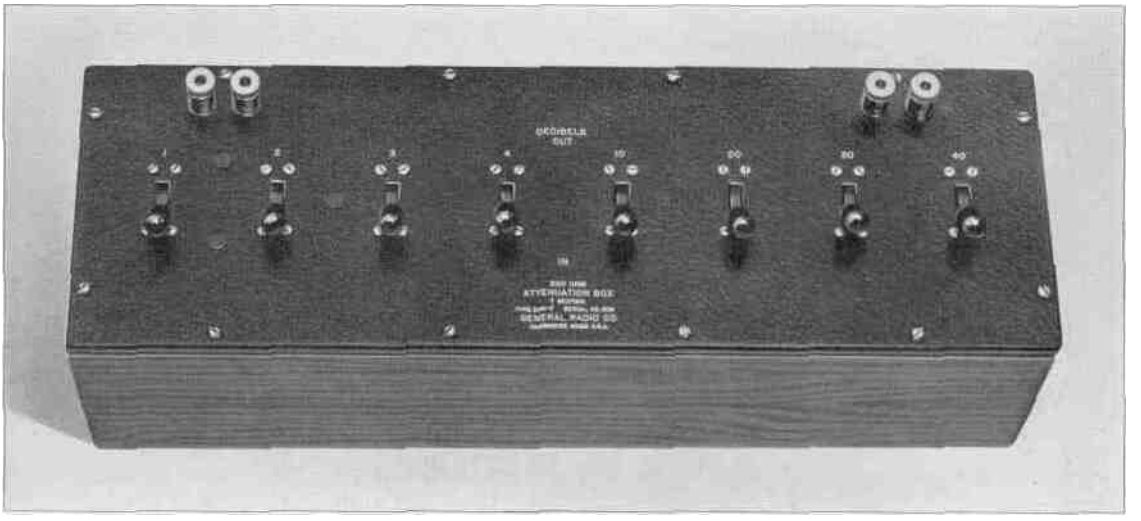
Terminals: Soldering lugs are provided.

Mounting: Interchangeable (except for switch stops) with TYPE 510 (see page 24). A combination dial plate and drilling template is furnished.

Dimensions: Diameter, 3 1/8 inches; depth behind panel, 3 inches, over-all; shaft diameter, % inch.

Net Weight: 7 ounces.

Type	*Resistance Total*	*Resistance Per Step*	*Code Word*	*Price*
668-A	1 ohm	0.1 ohm	GABLE	$12.50
668-B	10 ohms	1 ohm	GAILY	15.00
668-C	100 ohms	10 ohms	GALOP	15.00



TYPE 249 ATTENUATION BOX

USES: The TYPE 249 Attenuation Box is useful in power-level measurements, transmission-efficiency tests, and in gain or loss measurements on transformers, filters, amplifiers, and similar equipment. It is also used as a power-level control in circuits not equipped with other volume controls.

DESCRIPTION: The TYPE 249 Attenuation Box is a constant impedance attenuator which contains a group of resistance elements so arranged that definite and known amounts of power loss can be introduced by operating the key switches, when the box is used between specified values of input and output impedances. The total attenuation is given by adding the decibel values engraved by each of the keys.

FEATURES: The outstanding features of this box are its wide range and high accuracy. It can be used on frequencies as high as fifty kilocycles without introducing any appreciable error. Both the T-type section and the balanced-H section are available.

SPECIFICATIONS

Attenuation Range: 110 decibels in steps of 1.0 decibel. Boxes with other attenuation ranges can be made on special order.

Terminal Impedance: 600 ohms. Boxes for other impedances can be made on special order.

Accuracy: Each individual resistor is adjusted within 0.5% of its correct value. At frequencies below 50 kc the maximum error in attenuation is 0.2 db.

Type of Section; Both the T-section and balanced-H-section models are available. Both types present a constant impedance in both directions, but the balanced-H should be used where both sides of the circuit must be balanced to ground.

Type of Winding: Ayrton-Perry windings are used for the low-resistance elements, while unifilar windings on thin mica cards are used for the high-resistance units.

Maximum Voltage: The maximum permissible voltage varies somewhat with the attenuation, but the power-handling capacity of the boxes will not be exceeded, for any setting, if the voltage applied to the input of the TYPE 249-T is kept below 25 volts and that applied to the TYPE 249-H below 35 volts.

Switches: Eight low-capacity key switches control the eight attenuation sections.

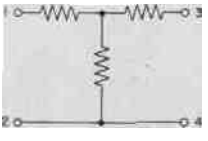
Mounting: The units are mounted in shielded walnut cabinets with aluminum panels. The panel and shield are connected to the terminal marked G.

Terminals: Jack-top binding posts with 3/4-inch spacing.

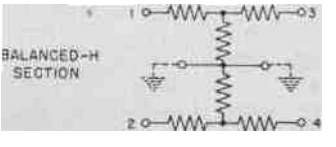
Dimensions: Panel, (length) 16 x (width) 5 1/4 inches. Cabinet, (depth) 5 1/4 inches, over-all.

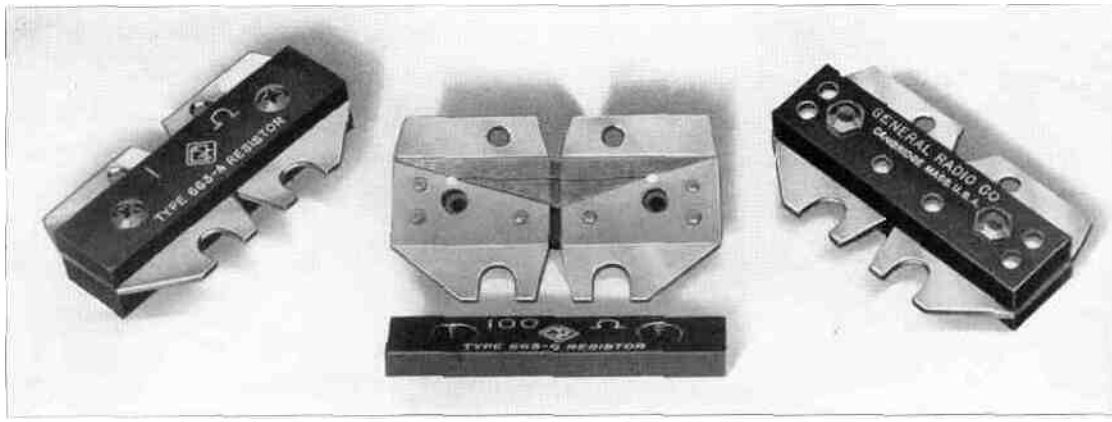
Net Weight: 7 1/8 pounds.

Type	*Range*	*Impedance*	***Type** of Section*	***Code Word***	***Price***
249-H	110 db in steps of 1.0 db	600 ohms	Balanced-H	NETWORKROD	$135.00
249-T	110db in steps of 1.0 db	600 ohms	T	NETWORKTOP	115.00



T-SECTION





TYPE 663 RESISTOR

USES: The TYPE 663 Resistor is designed to have an accurately known impedance at high frequencies. It is particularly useful as a standard resistor for the resistance-variation method of impedance measurement at radio frequencies and as a circuit element in bridges and similar equipment. It is also useful as a terminating resistor for matching radio-frequency transmission lines and, generally, as a low-resistance standard in high-frequency applications where small residual reactance, accurately known resistance, and moderate power-handling capacity are required.

DESCRIPTION: A straight piece of resistance wire is soldered to two flat metal plates, which are mounted close together on a strip of insulating material. A thin piece of mica insulates the wire from the plates, except at the soldered ends. This assembly is rigidly clamped together with a top piece of insulating material. The flat metal plates extend on either side to form slotted terminals.

FEATURES: A resistor for high-frequency use should have an impedance which varies as little as possible with frequency and which is as nearly resistive in nature as possible. These requirements demand that skin effect be kept at a minimum and that residual inductance and capacitance be made very small.

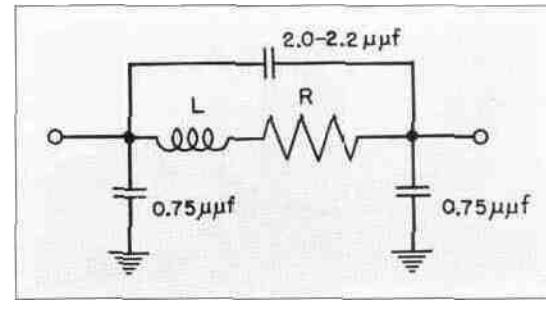
The straight-wire resistor approaches this ideal more closely than any other type through the use of short pieces of fine wire. In the conventional form, however, two disadvantages occur. First, the fine wire has relatively high series inductance compared to its shunt capacitance, and low-resistance units consequently tend to have relatively high inductive reactances. Second, the fine wire cannot dissipate any appreciable power without overheating.

The design of the TYPE 663 Resistor* overcomes these disadvantages. The straight wire is clamped down upon the flat metal fins and, as a result, the inductance is decreased over the free space value by virtue of the shielding effect of the current flow in the plates. By this same construction the power dissipation is greatly increased because the heat is carried away from the wire by the terminal fins.

The equivalent circuit for the TYPE 663 Resistor, when mounted approximately one inch above a metal panel, is given below. Values of the residual inductance, L, for the different units are tabulated in the specifications.

Residual inductance and capacitance cause two effects. First, they cause the resistance component to vary with frequency and, second, they create a residual reactive component. If the resistance, R, is large compared to $L/C^{1/2}$ where L is the effective series inductance and C the effective shunt capacitance, the resistive component decreases with frequency; if the resistance is small compared to $L/C^{1/2}$, the resistance increases with frequency up to a peak beyond which it decreases. For values of R

Equivalent circuit of TYPE 663 Resistor, mounted 7/8 inch above a metal panel.



*See D. B. Sinclair, "The TYPE 663 Resistor," General Radio Experimenter, Vol. XIII, No. 8, page 6. January, 1939.