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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

IMPROVEMENTS IN THE COUNTING-RATE METER

Also IN THIS ISSUE

● **SINCE ITS INTRODUCTION** three years ago, the TYPE 1500-A Counting-Rate Meter[1] has found considerable application in laboratories engaged in nuclear physics research. Basically, a laboratory measurement device, rather than a survey instrument, this meter is particularly useful where it is desirable to have a permanent graphical record of changes in rate over a considerable period of time, since a pen recorder, such as the Esterline Angus 5-milliampere model, can be operated directly from the counting-rate-meter output. A continuous visual indication of rate is also provided on a panel meter so that the instrument can be adapted to a great many measurement problems. The advantage of the counting-rate meter over the scaling-circuit method of rate determination lies in its ability to indicate *directly* not only the rate, but changes in the rate as well.

[1] *General Radio Experimenter*, July-August, 1947.

Figure 1. Panel view of Type 1500-B Counting-Rate Meter with counter tube and probe stand.

Experience with this instrument has indicated that its utility would be increased if the response speed were made adjustable and if the counter-tube probe and preamplifier were redesigned to fit the hand and to permit its use with commercially available sample-changers, lead shields, and other accessories.

These two major changes, therefore, have been incorporated in a new model, the TYPE 1500-B.

Response Control

The Geiger-counter tube transforms each burst of radio-active energy into an electrical pulse. In the counting-rate meter, the pulses are standardized in shape and magnitude, and impressed on a resistance-capacitance tank circuit. The voltage across the tank circuit is a function of the rate of arrival of the pulses, and a voltmeter at the tank circuit is calibrated in counts per minute.

If the capacitance of the R-C tank circuit is decreased, the calibration will not be affected, but the time required for the meter to indicate the average or equilibrium value will be reduced, so that the standard deviation and, hence, the probable error and the meter fluctuations due to the random character of the radio-active disintegrations will be increased.

In the improved TYPE 1500 Meter, the tank capacitance can now be varied by setting a four-position switch. The equilibrium time range is from about one second to the 2 or 3 minutes of the original design. A pair of terminals to which an external capacitor can be connected permits the equilibrium time to be extended to values greater than 3 minutes, if desired.

Another circuit improvement added at this time reduces the charging time. When the response switch is in one of the FAST positions, the capacitors that are used in the adjacent SLOW position are charged up rapidly by a cathode follower circuit. When the switch is thrown to the SLOW position, on the average the capacitor has already received its equilibrium charge and the net equilibrium time is reduced.

With this wide response range, the Counting-Rate Meter is now well adapted to meet the requirements of many new specific applications. The slow response speed assures, even for a single meter observation, the low probable error so desirable in routine disintegration rate measurements. With the high response speed, a change in counting rate that occurs in a fraction of a second can now be indicated and recorded. The change in rate to be measured may be due to a change in the position of the sample or of the counter tube. A change in the position of the sample is exemplified by the hydraulics application[1] where a radio-active "slug," more or less dissolved, moves past a Geiger counter; a change in the position of the counter tube is illustrated in the crystal diffraction spectrometer. When the half-life of the sample is comparable to the measurement time, the change is in the disintegration rate of the sample itself. Whatever causes the change in rate, the speed with which the rate changes depends considerably on the particular application. The response control permits a choice of the optimum response consistent with acceptable probable error.

The recorder trace of Figure 2 illustrates the response range in recording the background (160 counts per minute in this case) and in indicating a sudden pulse from a radio-active sample that

[1] R. S. Archibald, "Radioactive Tracers in Flow Tests." *Journal of the Boston Society of Civil Engineers*, vol. 37, pp. 49-116, 1950.

was allowed to fall past the counter tube. The slowest response speed (No. 4) smoothed out the fluctuations and indicated the background value to a high degree of accuracy, but the falling radio-active sample didn't even cause a ripple. At the fastest speed, the fluctuations were quite large, but the falling sample caused the recorder to go beyond half scale.

Probe Redesign

The probe, at the end of a 6-foot connecting cable, consists of a quenching preamplifier and a 4-pin socket for plugging in the Geiger-counter tube.

For greatest flexibility and convenience, the preamplifier-probe unit must be small yet capable of sturdy mounting. The new TYPE 1500-P10 Preamplifier was designed for adaptability to the varied types of applications demanded by radio-activity measurements. The preamplifier is small and cylindrical for use as a hand probe. Its case is of anodized aluminum for easy decontamination. It is fitted with a ¼-inch x 20 thread insert for mounting on a camera tripod or on the TYPE 1500-P11 Bench-Top Mount with its universal joint and its heavy base. The preamplifier dimensions permit its use with commercially available sample-changers, lead shields, and other probe accessories. The preamplifier is fitted with a 4-pin socket for plugging in 4-pin based counter tubes such as the TYPE 1500-P4 and 1500-P5 Beta-Gamma Mica Window Counter Tubes. It is supplied with a 4-pin adaptor to permit the use of any other counter-tube type. The quenching circuit works equally well with self-quenching or non-self-quenching counter tubes. The quenching tube is a triode-connected 6AU6 type miniature which may, if desired, be pentode connected. The mechanical design permits very easy access to the components for servicing, or for adapting the probe to specific needs.

Another useful circuit improvement is an increase in the sensitivity of the instrument. A negative pulse of about ¼ volt is now sufficient to operate the instrument. As a consequence, the cable from the instrument to the preamplifier can now be extended by 40 or 50 feet without introducing serious losses.

Features

The new TYPE 1500-B Counting-Rate Meter now includes these several desirable features:

The panel meter is direct reading in counts per minute for *all* ranges.

Counting accuracy not affected by

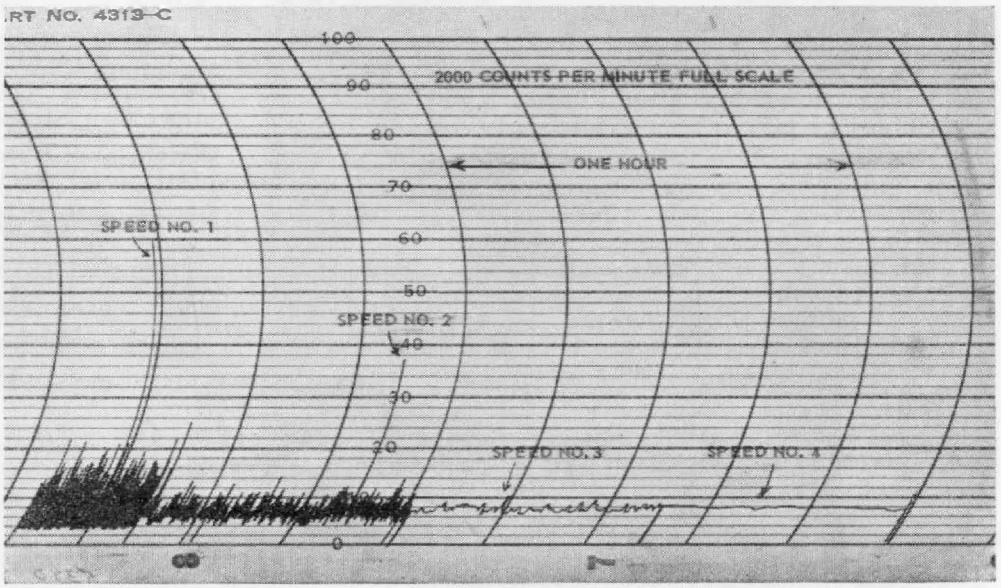


Figure 2. Graphical record of response range of Type 1500-B Counting-Rate Meter to background and to a radio-active sample passing the counter tube. Speed No. 4 gives the most accurate background indication, while Speed No. 1 gives the most pronounced response to the sudden pulse from the sample.

20 per cent line voltage changes.

There are four response speeds for much greater flexibility in application.

The output is adequate for operating a 5 ma pen recorder such as the Esterline Angus Model AW Recorder.

Both the high- and low-voltage power supplies are stabilized.

An internal calibration check and adjustment are provided on the panel.

A loudspeaker on the panel, with volume control, operates as an aural monitor.

A tank circuit shunt aids in speeding up meter changes.

A quenching preamplifier, designed for great adaptability, is supplied.

Increased input sensitivity permits the use of a long cable to the counter tube. — A. G. BOUSQUET

SPECIFICATIONS

Range: Full-scale values of 200, 600, 2000, 6000, and 20,000 counts per minute are provided. The minimum rate that can be read on the meter scale is 5 counts per minute.

Accuracy: The instrument has been calibrated with a generator of equally spaced pulses to yield an accuracy of ±3% of full scale on all ranges.

The resolving time of the instrument is adequate for random counts up to 20,000 per minute.

Preamplifier: The TYPE 1500-P10 Preamplifier is a hand-probe design at the end of a 6-foot cable. It is fitted with a ¼-20 thread for mounting on a camera tripod or on the TYPE 1500-P11 Mount. The preamplifier circuit permits the use of either self-quenched or externally quenched counter tubes. The preamplifier is designed primarily for use with 4-pin based counter tubes; however, an adaptor is supplied to permit the use of any counter-tube design.

Response: There are four response speeds available, starting at about one second at all rates and covering a speed spectrum of over 100 to one. The actual values are also a function of the counting rate.

Counter Circuit Voltage: The voltage applied to the counter circuit is continuously adjustable from 400 to 2000 volts. The value of the voltage is read from an eight-position switch and a calibrated dial which covers the 200-volt interval between switch points. A means is provided for standardizing the voltage so that the accuracy of the voltage readings is within ±5% of the actual value. The power supply is well regulated so that line-voltage fluctuations do not cause changes in the high-voltage supply.

Counter Tube: No counter tube is supplied with the instrument but self-quenching beta- and gamma-ray Geiger-Mueller counter tubes are available as shown in the price list below. The counter tube is mounted in the probe, which is supplied with the instrument, and replacement is simple.

Output: The output of the trigger circuit is available at terminals at the rear of the instrument. The 400- to 2000-volt variable high-voltage supply is also available at the rear of the instrum nt.

Recorder: A panel jack is provided for connecting a 5-ma recorder into the meter circuit.

Aural Monitor: A small loudspeaker is mounted on the panel for use as an aural monitor. A control, with an off position, is provided for adjusting the volume.

Power Supply: 105 to 125 volts, 50 to 60 cycles. By a simple change in connections on the power transformer, a 210- to 250-volt line can be used.

Power Input: 60 watts.

Accessories Supplied: Plug for connecting recorder, counter-tube adaptor, and line connector cord.

Accessories Required: A counter tube must be obtained separately (see price list below).

Other Accessories Available: Probe Mounting Stand (see photo).

Vacuum Tubes:

3—6SJ7	2—6J5
1—6AG7	1—6C6
1—6X5-GT/G	2—991
1—2X2/879	2—0C3/VR105
1—6SH7	1—6AU6
	1—NE2

All are supplied.

Mounting: The instrument is shipped with end frames for table mounting. For relay-rack mounting, simply remove the end frames.

Dimensions: Panel, 19 x 8¾ inches; depth behind panel, 13 inches.

Net Weight: 38½ pounds.

Type		*Code Word*	*Price*
*1500-B	Counting-Rate Meter	WORRY	$495.00
1500-P4	Beta-Gamma-Ray Counter Tube	WORRYLOBBY	40.00
1500-P5	Beta-Gamma-Ray Counter Tube	WORRYLOCAL	50.00
1500-P11	Probe Mounting Stand	WORRYSTAND	12.50

*Without counter tubes.

Manufactured and sold under United States Letters Patent 2,374,248.

Licensed under patents of the Radio Corporation of America.

TYPE 941-A TOROIDAL TRANSFORMER

This transformer is designed for use as an impedance-matching or bridging transformer in low level 600-ohm communication systems. It employs a toroidal, "doughnut-shaped" core, which is preferable to the familiar shell-type core in two respects.* (1) The toroidal core is much more astatic and thus less susceptible to external magnetic fields while, conversely, it produces smaller external magnetic fields. (2) A tighter degree of coupling between primary and secondary windings can be obtained than with a shell core. The resulting lower leakage reactance extends the high frequency flat characteristic about a decade higher than that of a conventional shell-core transformer, while the high permeability core used is beneficial in the low-frequency range.

This TYPE 941-A Transformer, therefore, is especially useful where either a high degree of astaticism or an ultra-wide frequency range is desired.

The core carries two identical semi-circumferential inner windings, 1-2, 3-4, which are used either in series or in parallel combinations. Over these are wound two identical semi-circumferential outer windings, 5-6, 7-8, which are likewise used either in series or in parallel combinations. These four windings terminate in eight individual terminals on the panel. We have designated such an arrangement as a "duplex" transformer.

Performance Characteristics

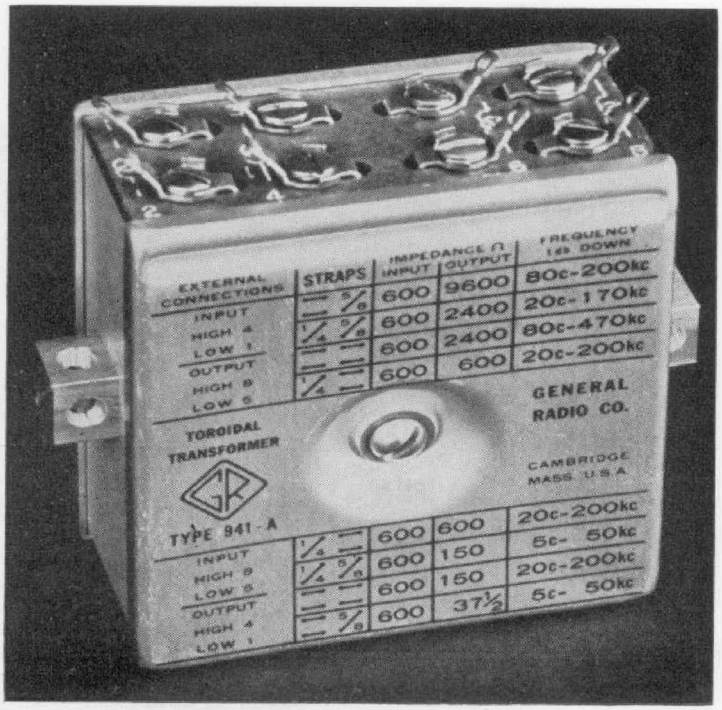
Each outer winding has twice the number of turns of each inner winding. This permits the impedance-matching ratios 1:1, 4:1, and 16:1 in either direction. All four windings are employed simultaneously in each case, which is decidedly beneficial. When working either into or out of the design value of 600 ohms, the characteristics shown in the table on page 6 are obtained.

The 941-A may be used as a matching transformer with other terminating impedances. When both terminating impedances are 600 ohms or less (as in Circuits 4, 5, 6, and 7), a frequency span ratio of 10^4 for a 1 db drop from the flat characteristic is obtained. For a conventional shell-core transformer, this ratio is about 10^3. The low-frequency limit of this range is determined by the ratio of the generator impedance, Z, to the primary inductance, L_p. For a 1 db drop:

$$f = \frac{0.156\ Z}{L_p}$$

As either terminating impedance increases appreciably above 600 ohms (as in Circuits 1, 2, and 3), the frequency span ratio will be reduced, since the high-frequency extent is ultimately limited by resonance between leakage

Figure 1. View of the Type 941-A Transformer.



*Horatio W. Lamson, "Some Advantages of the Toroidal Transformer in Communication Engineering," *Tele-Tech*, May, 1950. Reprints are available on request.

Circuit	Terminating Impedances Ω	Ω	Connect: Inner Windings	Connect: Outer Windings	Frequency for 1 db drop	Flat Insertion Loss Less than
1	600	9600	Parallel	Series	80 c — 200 Kc	0.3 db
2	600	2400	Series	Series	20 c — 170 Kc	0.2 db
3	600	2400	Parallel	Parallel	80 c — 470 Kc	0.2 db
4	600	600	Series	Parallel	20 c — 200 Kc	0.1 db
5	150	600	Series	Series	5 c — 50 Kc	0.7 db
6	150	600	Parallel	Parallel	20 c — 200 Kc	0.2 db
7	37.5	600	Parallel	Series	5 c — 50 Kc	0.8 db

inductance and transformer capacitance. It will be noted that for matching impedances 1:4 or 4:1, a choice of connections is available. Circuits 2 and 5 extend the lower range while Circuits 3 and 6 extend the higher range of the flat characteristic. When the ratio is 1:1, Circuit 4, the leakage inductance is only about 360 microhenries.

A concept of the feasible operating level for this transformer may be gained from the following 60-cycle rms distortion values:

At 31 VU level (1.26 watts), less than 1.0%.
At 30 VU level (1 watt), less than 0.5%.
At 27 VU level (0.5 watt), less than 0.2%.
At 15 VU level (0.032 watt), less than 0.1%.

When the transformer is used in an unbalanced system, it is important that the input or output terminals marked "low" (Nos. 1 and 5) be either directly strapped (if permissible) or be at essentially the same dynamic potential. Otherwise, the extent of the high-frequency range will be shortened appreciably.

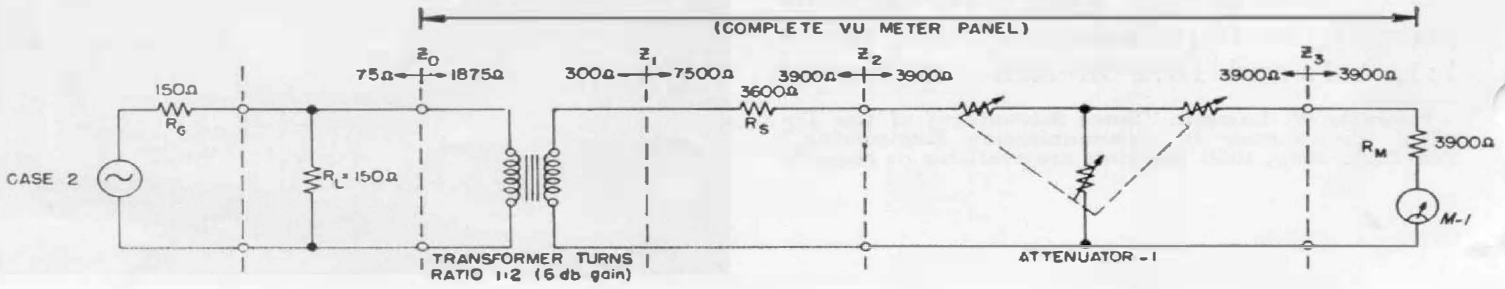
In a typical application, the TYPE 941-A can be used as a bridging transformer, Circuit 5, for applying a 600-ohm VU meter to a 150-ohm audio system, as shown in Figure 2.

Physical Characteristics

The transformer is housed in a rectangular aluminum case. A centricore of spirally-wound, 3-mil tape, specially insulated and annealed, is used. Multilayer progressive windings are applied by a toroidal winding machine developed for this purpose. The impregnated toroid is clamped between felt washers by a central screw which is insulated from the case. All circuits are insulated for 500 volts from the case. The performance data given above, together with appropriate diagrams for strapping the terminals and making external connections, are printed on one large face of the case. One small face consists of a phenolic panel carrying eight combination screw-clamp and solder terminals. These terminals are numerically identified and the internal connections are indicated. Two double-drilled mounting blocks permit the transformer to be mounted: (1) on its large face, (2) on its small face opposite the terminal panel, or (3) projecting through a hole 3⅛" x 1⅝" in an assembly chassis.

— HORATIO W. LAMSON

Figure 2. Circuit showing how the transformer can be used to adapt a 600-ohm VU indicator to 150-ohm lines.



SPECIFICATIONS

Initial Inductance: Inner windings, in series, 5 to 6 henrys; outer windings, in series, 20 to 24 henrys.

Resistance: Inner windings, in series, 9 ohms; outer windings, in series, 34 ohms.

Dimensions: Aluminum case, 3⅝ x 3⅛ x 1⅝ inches. Mounting blocks project 9/32 inch beyond case in 3⅛ inch dimension.

Mounting Dimensions: 3⅜ inches on centers. Mounting holes are drilled for clearance with 10-32 machine screws.

Net Weight: 13½ ounces.

Type		*Code Word*	*Price*
941-A	**Toroidal Transformer**	TRANTORCAT	**$35.00**

NEW, SPECIAL TERMINAL BOXES FOR V-5 AND V-10 VARIACS*

Variac users have frequently requested special terminal facilities and features impossible to accommodate in the limited space provided by the standard "T" terminal box regularly supplied on V-5MT, V-5HMT, V-10MT, and V-10HMT Variacs. In response to such requests, we now offer a new, larger, rectangular terminal box with plenty of room for almost any special terminal arrangement that may be required. Unlike the standard "T" box, the new box has a removable cover for easy access to its interior.

Boxes are designated alphabetically, in order of their design. This designation is coordinated with the standard type numbering system already established for "V" line postwar Variacs. Thus a V-5MTC shown in Figure 1 is a 115-volt, 5-ampere Variac with case and terminal box, the latter provided with knockouts. Figure 2 illustrates a V-5MTE Variac, 115-volt, 5-ampere, cased model, with three-wire cord and plug for a safety ground circuit, and a two-pole switch.

These two combinations are carried in stock for both the V-5 and the V-10 sizes. Other combinations are available, including models with fuses, cord, plug, and switch. These can be supplied on special order in quantity lots.

*T.M. Reg. U. S. Pat. Off. U. S. Pat. 2,009,013.

Figure 1. View of the Type V-5MTC Variac with cover to terminal box removed.

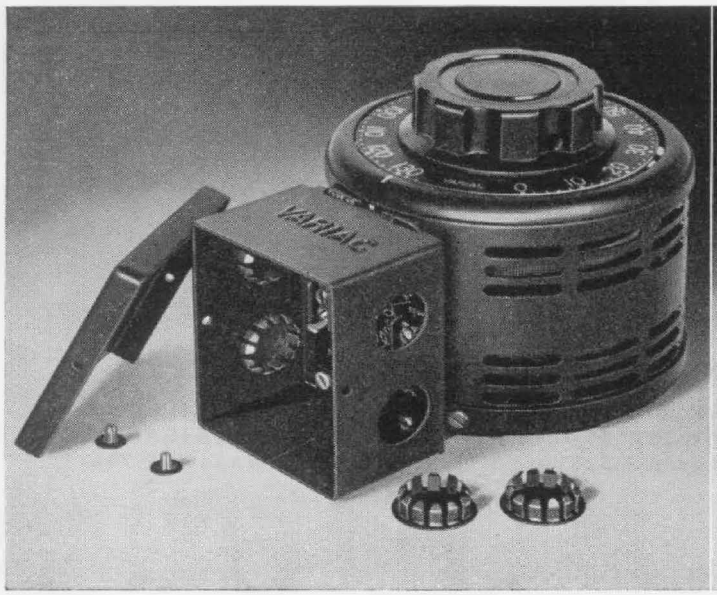
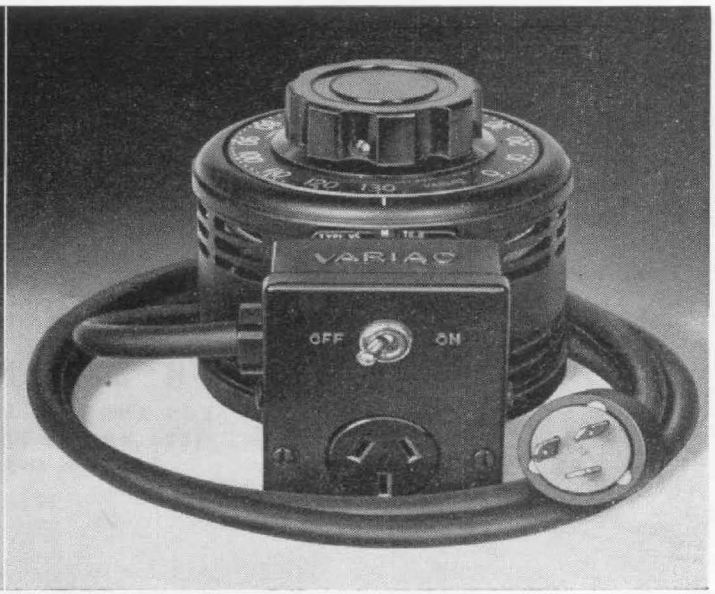


Figure 2. View of the Type V-5MTE Variac.



SPECIFICATIONS

Identical with those for V-5 and V-10 Variacs, except for terminal box. Dimensions of box only, 2⅞ inches wide x 3⅝ inches high x 2 inches deep.

Type		*Code Word*	*Price*
V-5MTC	V-5 Variac with knockouts in terminal box.....	COAST	$24.00
V-5MTE	V-5 Variac with 3-wire terminal box, cord, plug, and 2-pole switch.....	COMET	33.50
V-10MTC	V-10 Variac with knockouts in terminal box.....	HERON	39.00
V-10MTE	V-10 Variac with 3-wire terminal box, cord, plug, and 2-pole switch.....	HILLY	48.50

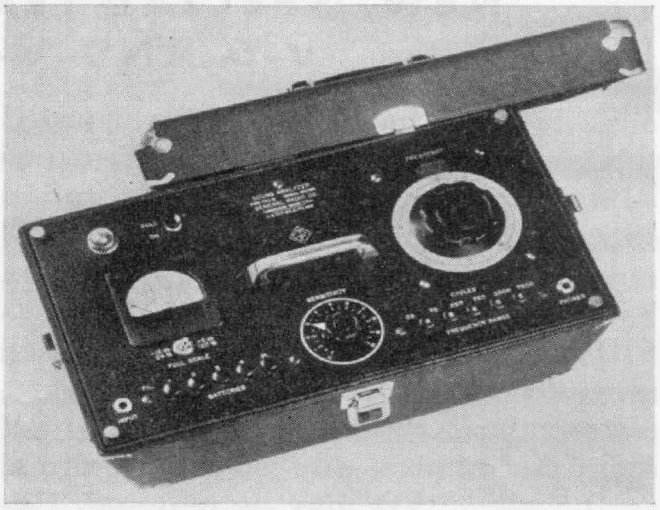
TYPE 760-B SOUND ANALYZER

A new model of the Sound Analyzer, TYPE 760-B, now supersedes the older TYPE 760-A. While general performance specifications are unchanged, two important circuit and operating improvements have been made:

(1) A two-range meter is now used, instead of the single-scale type used on the old model.

(2) The output at the PHONES jack is a voltage of the frequency to which the analyzer is tuned, rather than a rectified voltage.

The two-range meter is easier to read and permits associated circuit changes that eliminate, to a considerable degree, the dependence of the calibration upon individual tube characteristics, thus improving the long-time stability. The meter now reads the average value of the signal component and is better suited for continuous-spectrum indications with unpitched noises.



The new output circuit produces a voltage of the frequency to which the dial is set. Output amplitude is linear with respect to input and, with suitable amplification where necessary, can be used to operate a high-speed recorder.

Other specifications remain unchanged.

Type		*Code Word*	*Price*
760-B	Sound Analyzer.....	ATTAR	$495.00

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