the GENERAL RADIO Experimenter

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MOTOR DRIVES FOR W-SERIES VARIACS®

Also IN THIS ISSUE

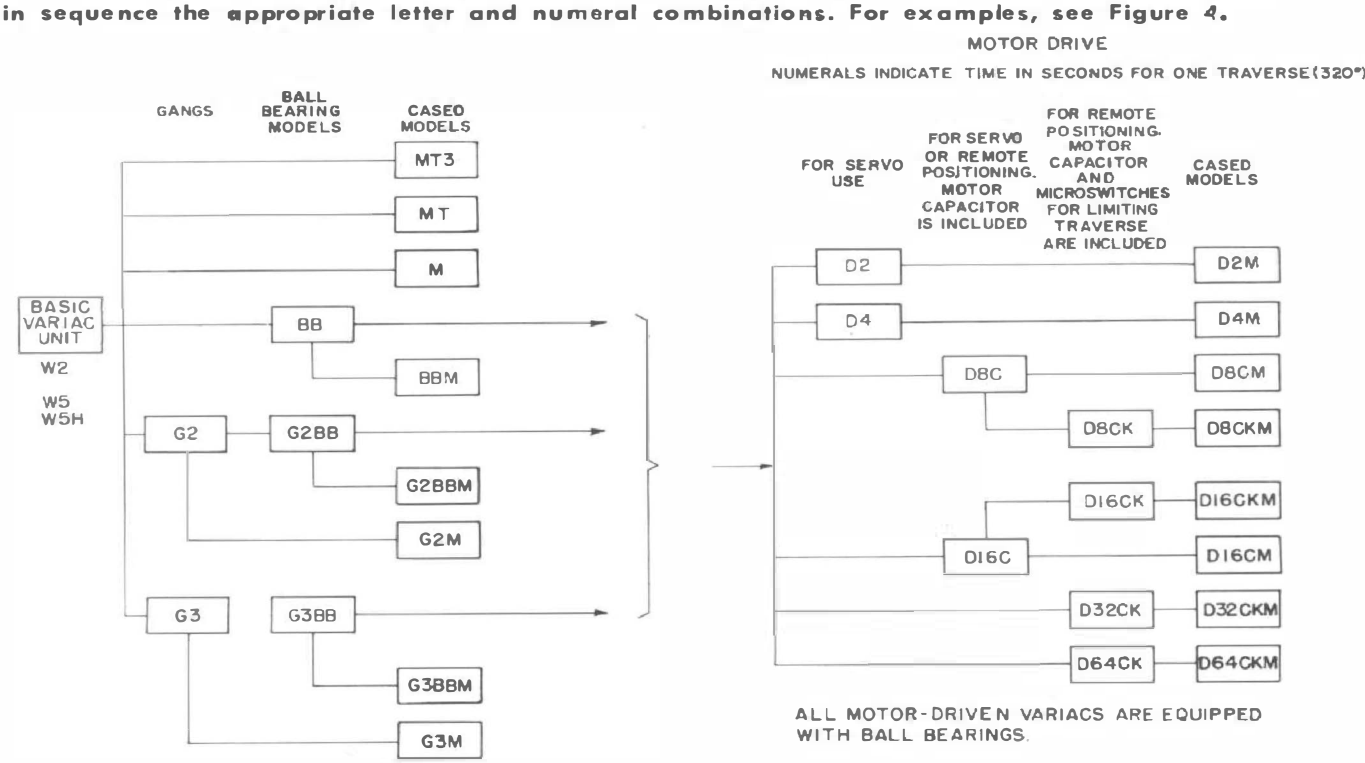
Motor drives in a wide variety of speeds, suitable for servo work as well for remote positioning applications, are now offered for the recently announced Types W5 and W2 Variacs. These drives, together with the several models and ganged assemblies previously announced,[1,2] make the W-series Variacs an extremely flexible and versatile product line. The completeness of the line is best illustrated by the "genealogy" shown in Figure 1. Careful design planning and extensive production tooling make it possible to assemble the many variations shown from a limited number of stocked parts and subassemblies. The prices are consequently determined on a production basis, rather than on the "special-order" basis that might ordinarily be expected.

[1] "Type W5 Variac®, *General Radio Experimenter*, 30, 7; December, 1955; pp 1–11.
[2] "More New Variacs®", *General Radio Experimenter*, 30, 12; May, 1956; pp 13–15.

Mechanical Design

An extremely simple and straightforward design has been adopted to

Figure 1. "Family tree" of W-model Variac® Autotransformers. Type numbers are formed by adding in sequence the appropriate letter and numeral combinations. For examples, see Figure 4.



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provide motor drive. The gear reducer motor, with a suitable mounting plate, is "ganged" to the unit to be driven, much as another Variac would be. The construction is shown in Figure 2. Drive is from the base end of the Variac, making possible a rigid mechanical assembly and minimizing insulation problems. Ball bearings are used on all motor-driven Variacs.

Gear coupling between motor shaft and Variac shaft was chosen for a number of reasons.

1. The problem of alignment between shafts is reduced as compared to a rigid direct coupling.

2. The problem of phase shift in a flexible coupling is eliminated, simplifying the servo-drive problem.

3. With a choice of gear ratios several drive speeds can be provided from a given motor.

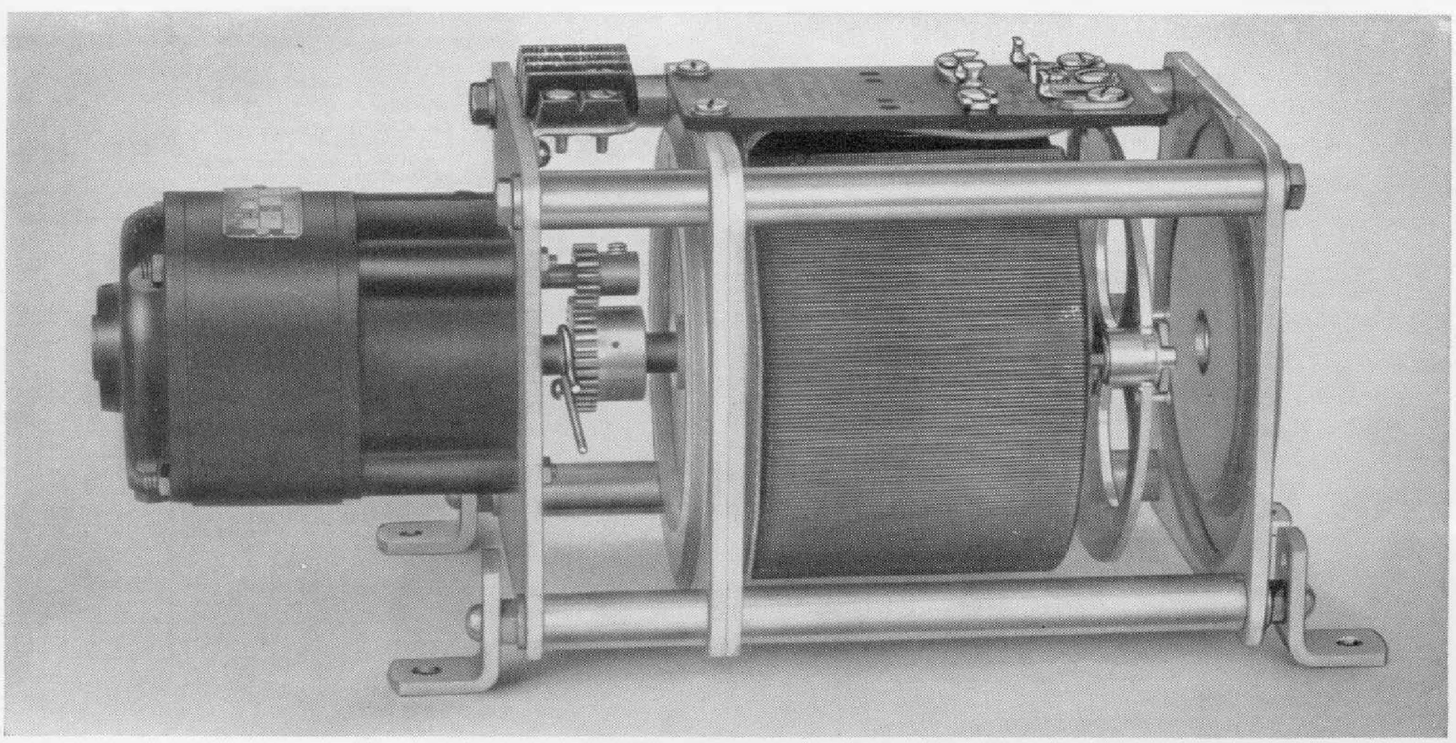
Mounting slots in all motor plates permit proper motor location for the selected gear and close adjustment of the gear and pinion mating. Motor leads are brought out to a terminal strip attached to the motor plate.

Motor

To make available a wide range of drive speeds, three different motor speeds will be stocked. Gear reducers assembled to the basic motors produce output shaft rates of approximately one second, four seconds, and sixteen seconds per revolution. These speeds, in conjunction with the additional choice of reduction available in the coupling gears, provide Variac traverse rates of 2, 4, 8, 16, 32, or 64 seconds, full scale.

The two fastest drives (2 and 4 seconds) are intended for servo operation, as in the GR Type 1570-A Automatic Voltage Regulator. For such applications the motor chosen has low moment of inertia and high angular acceleration. The low angular momentum eliminates any need for limit switches, ordinarily used to de-energize the motor. A simple mechanical stop is used, arranged so that stalled torques are not transmitted to the Variac. Enough elastic deformation is provided by the Variac shaft to prevent impact damage to the gear train. Both motor and gear train will withstand stalled

Figure 2. View of a motor driven Type W5 Variac.



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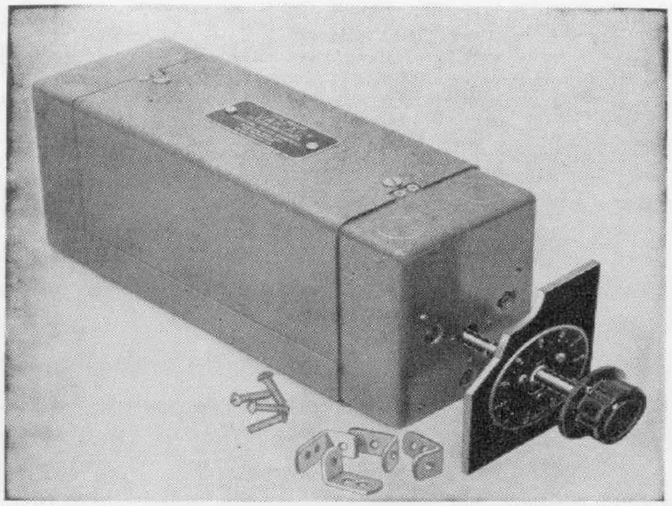

Figure 3. View of cased model of motor-driven Variac. Appearance is identical with that of a ganged model with case.

conditions indefinitely and will take, without damage, thousands of full-impact stops. Since, for servo-operation, it is assumed that the proper motor capacitor will be included in the servo amplifier, no capacitor is furnished.

The same type of low-inertia motor is used also for the medium-speed drives (8 and 16 seconds), in whose applications fast starting is not ordinarily essential, but fast stopping with minimum overshoot is desirable. With the motors selected, stopping is fast enough so that for most applications no dynamic braking is required.

This motor can be used for either servo or remote positioning applications, and so a motor capacitor is furnished. Microswitches for limiting traverse are optional.

The third motor, for 32- and 64-second traverse and remote-positioning applications, has a higher torque, exceeding the capabilities of the mechanical stop, so that microswitches are mandatory. Motor capacitor is furnished.

Table I summarizes the mechanical specifications for the three motors.

Enclosures

Motor-driven assemblies are available open or completely enclosed. The structural similarity to a ganged Variac is extended to the method of enclosure. Neat, economical enclosure is provided by making use of already available cases and methods. Figure 3 shows a typical enclosed assembly.

TABLE I

		STANDARD EXTERNAL GEARING					
STANDARD MOTOR	A	2:1	4:1				
	B			2:1	4:1		
	C					2:1	4:1
SECONDS FOR 320°		2	4	8	16	32	64
OUNCE-INCHES TORQUE		30	60	120	240	240	480
VARIAC	2	x	x	xo	xo	xo	xo
W — or M — * Model 115 or 230 volts	2G2	x	x	xo	xo	xo	xo
	2G3		x	xo	xo	xo	xo
	5	x	x	xo	xo	xo	xo
	5G2		x	xo	xo	xo	xo
	5G3		x	xo	xo	xo	xo
STOP		MECHANICAL		OPTIONAL		MICROSWITCH	
CAPACITOR		NO		YES		YES	

x Servo applications only xo Either servo or remote positioning * 60-cycle motor, 400-cycle Variac

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Although the many possible assemblies and variations as shown in Figure 1 are not stocked assembled for immediate shipment, inventory will be carried of basic ball-bearing Variacs, as well as motor drive, micro-switch assembly and enclosure parts. Under normal conditions, therefore, any of the combinations shown can be shipped, in moderate quantities, within a few weeks of order.

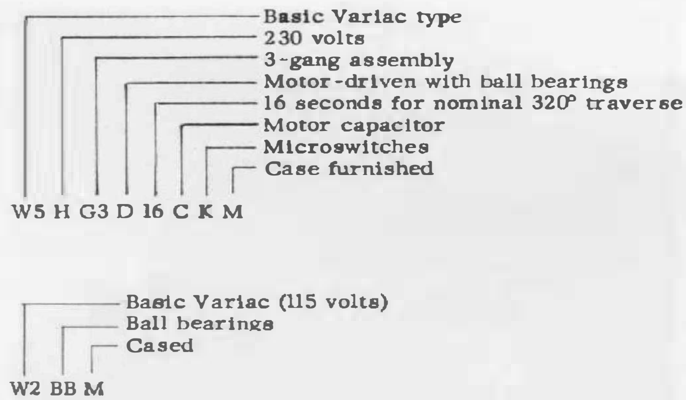

Figure 4. Two examples of how Variac type numbers are formed.

SPECIFICATIONS

Motor: 2-phase, 115 volts, 60 cycles
Winding Impedance: at 60c, 1300 + j2200 ohms, each winding; d-c resistance, 575 ohms, each winding.
Capacitor: 0.8 to 0.9 μf, oil-filled, 300 v wkg.
Normal speed, rotor: 1350 rpm

Moment of Inertia, rotor: 0.1 ounce-in.^{2}
Stalled rotor torque: 2 ounce-inches
Theoretical acceleration: 7680 radians/sec.^{2}
Variac Moment of Inertia: Type W2, 0.95 ounce-in.^{2}
Type W5, 3.08 ounce-in.^{2}

PRICES

Refer to Table I for available models
Refer to Figure 3 for type numbering system

Variac or Variac Assembly with ball bearings		Price
W2	BB*	$18.50
W2G2	BB*	39.00
W2G3	BB*	57.00
W5	BB*	23.00
W5G2	BB*	49.00
W5G3	BB*	71.00
W5H	BB*	25.00
W5HG2	BB*	53.00
W5HG3	BB*	77.00

MOTOR-DRIVEN ATTACHMENTS

		Unit Price
Motor Drive Only	(D)	$75.00†
Capacitor	(C)	n/c
Microswitches	(K)	7.00
Case	(M)	8.00

* Motor-driven Variacs need not include the BB designation in the type number, since all motor-driven models are equipped with ball bearings.

† In lots of 5 or more. For quantities less than 5, an additional set-up charge of $6.00 is added and is prorated over the quantity ordered.

NATIONAL ELECTRONICS CONFERENCE

Hotel Sherman — Chicago

October 1–3, 1956

Visit the General Radio exhibit in booths 142 and 143 to see the latest in electronic test equipment. The motor-driven Variacs® and the X-Y dial drives described in this issue will be on display, as will the new Type 1230-A D-C Amplifier and Electrometer, the Type 1605-A Impedance Comparator, the Type 1213-C Time/Frequency Calibrator, the Type 1391-A Pulse, Sweep and Time-Delay Generator, and other important new instruments.

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SYNCHRONOUS DIAL DRIVES FOR AUTOMATIC X-Y PLOTTING

Automatic sweeping techniques continue to increase in importance in electronic measurement systems. The improved reliability of data and the conservation of man-hours, together with the design of new recorders and sweeping devices, have stimulated greater use of this test method. Basically, the independent variable, whether it be frequency, voltage or other quantity, is varied at a controlled rate over a fixed range while the output characteristic of the device under test is observed or recorded. In particular, the measurement of the frequency response of a device or system lends itself readily to this technique.

The output amplitude as a function of frequency can be displayed on a cathode-ray oscilloscope by use of the methods previously described for General Radio's Type 1750-A Sweep Drive[1] and Type 908-P1 and P2 Synchronous Dial Drives.[2] When permanent and more precise recordings of the data are required, however, the use of a two axis plotter is desirable. A d-c voltage proportional to the independent variable is fed in to drive the X axis, while the output characteristic as a d-c signal is used to drive the Y axis of the recording pen. For most plots a single trace is sufficient, and it is desirable to use sweeping rates considerably slower than those used in CRO presentation. A synchronous sweeping rate is not always required but is often valuable because it furnishes a standard, reproducible, common time base.

[1] Eduard Karplus, "A New System for Automatic Data Display", *General Radio Experimenter*, 29, 11, April, 1955.
[2] H. C. Littlejohn, "Motor Drives for Precision Dials and Beat-Frequency Oscillators," *General Radio Experimenter*, 29, 6, November, 1954.

The new General Radio X-Y Dial Drives are designed to sweep standard GR 4-inch (Type 907-WA) and 6-inch (Type 908-WA) Gear Driven Precision Dials for front-of-panel mounting. The 4-inch model is shown in Figure 1 and the 6-inch model in Figure 6. The synchronous motor in the drive rotates the dial at a uniform rate, which, in turn, rotates a potentiometer providing an output voltage proportional to the dial position. The motor can be switched off and disengaged from the dial to permit manual operation of the instrument by means of a knob mounted on the potentiometer shaft. The potentiometer remains engaged with the dial regardless of the method of operation, thus facilitating adjustments of zero position before the recording is made.

These drives are readily mounted in place of the existing manual gear drive on the GR oscillators listed on the next page.

The drives may be used with other equipment when the Type 907-WA or Type 908-WA Dial is installed.[3]

[3] See latest General Radio Catalog.

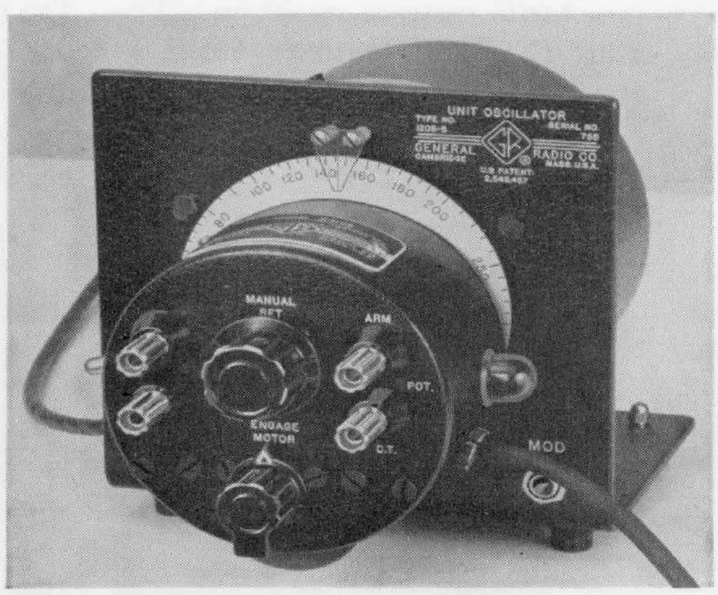

Figure 1. View of the Type 908-R144 X-Y Dial Drive installed on a Type 1208-B Unit Oscillator.

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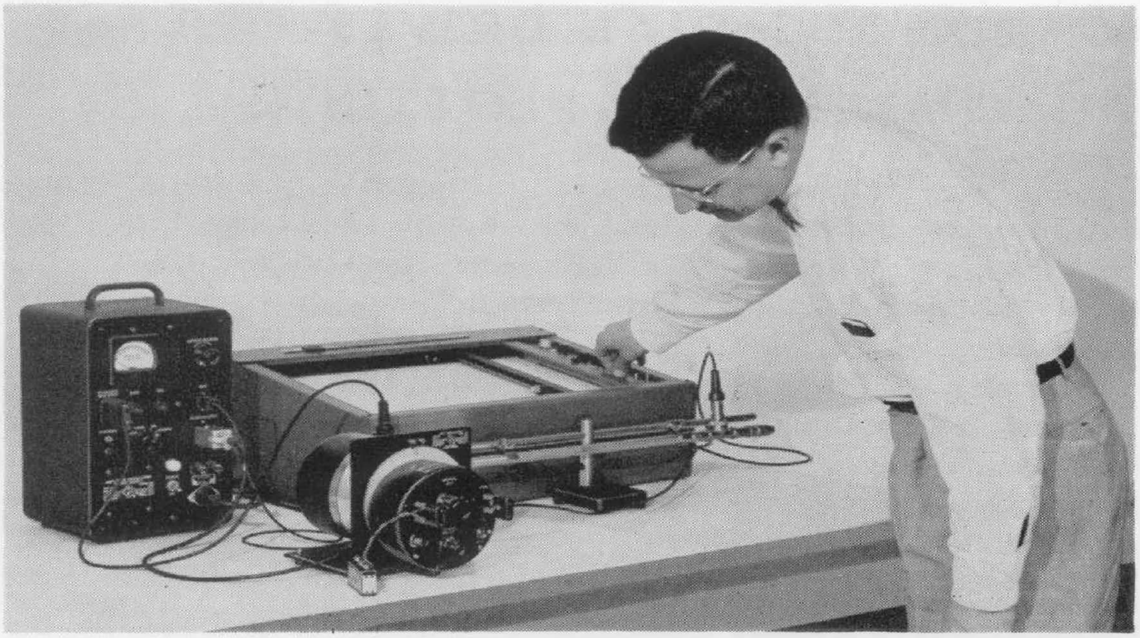


Figure 2. Assembly of equipment for plotting frequency characteristic of a Type 874-F185 Rejection Filter. The Type 1215-A Unit Oscillator is driven by the Type 908-R96 X-Y Dial Drive; oscillator amplitude is held constant by the Type 1263-A Amplitude-Regulating Power Supply. The recorder is a Variplotter, Model 1100-A, manufactured by Electronic Associates.

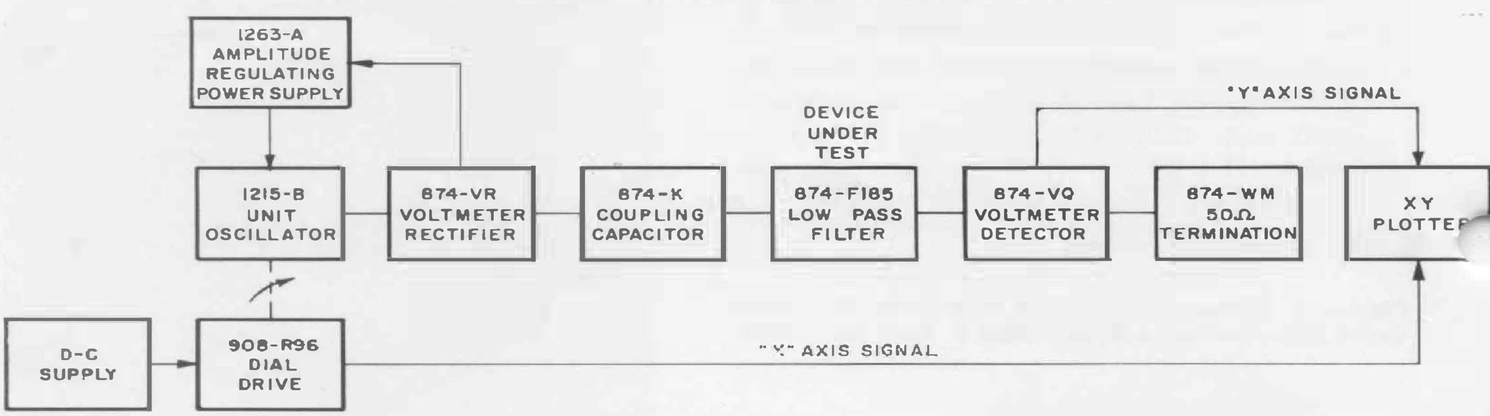
Type No.		*Frequency Range*
1304-B	Beat Frequency Audio Generator	20–40,000 cycles
*1210-B	Unit Oscillator	20–500,000 cycles
1211-B	Unit Oscillator	0.5–50 Mc
1215-B	Unit Oscillator	50–250 Mc
*1208-B	Unit Oscillator	65–500 Mc
*1209-B	Unit Oscillator	250–920 Mc
1218-A	Unit Oscillator	900–2000 Mc

(* Instruments marked require the Type 907-R Drive while those not marked require the Type 908-R Drive.)

The amplitude of the signal from the oscillator must be held constant if the final recording is to be a direct indication of relative response. The General Radio Type 1263-A Amplitude Regulating Power Supply, when used with the Types 1211-B, 1215-B, 1209-B or 1218-A Unit Oscillators, will provide a constant output voltage. The Type 1304-B Beat-Frequency Audio Generator and 1210-B Unit R-C Oscillator contain built-in, automatic-voltage-control circuits. A system response can, of course, be recorded and compared with a recording of a varying input signal if it is impracticable to maintain a constant input signal.

Fig. 2 shows a set-up in which the regulated output of a Type 1215-B oscillator is being swept over the range of 50 to 250 Mc and fed into a Type 874-F185 Low-Pass Filter. The rectified output from the filter and the dial position voltage are plotted by an X-Y recorder with the results shown in Fig. 4. Figure 3 is a block diagram of the system. It may be of interest to note that one can prepare suitable calibrated coordinate paper on the recorder by first manually positioning the dial to a specific frequency and then traversing

Figure 3. Block diagram for equipment shown in Figure 2.



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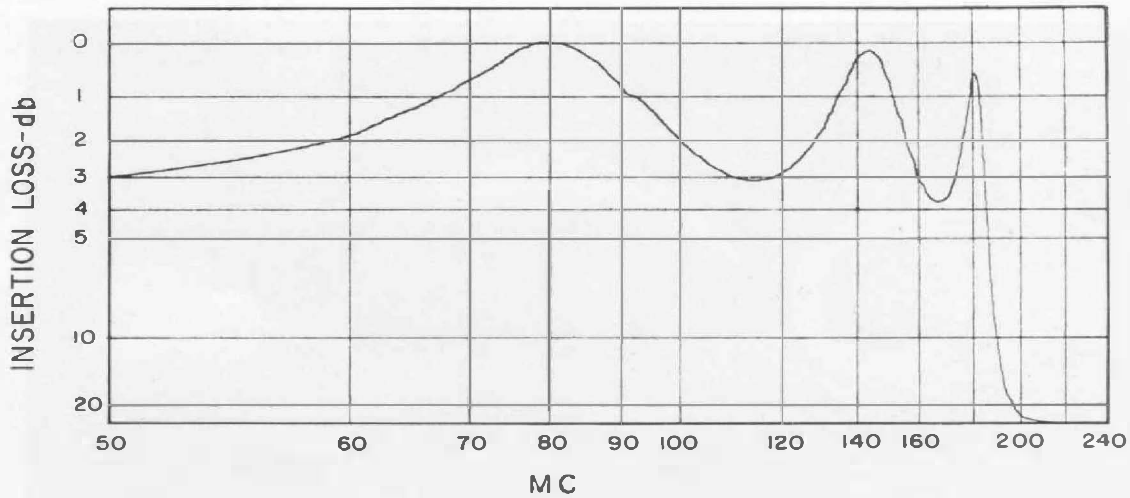


Figure 4. Plot obtained on recorder for the measurement shown in Figure 2 and 3. Horizontal and vertical coordinates were drawn by recorder.

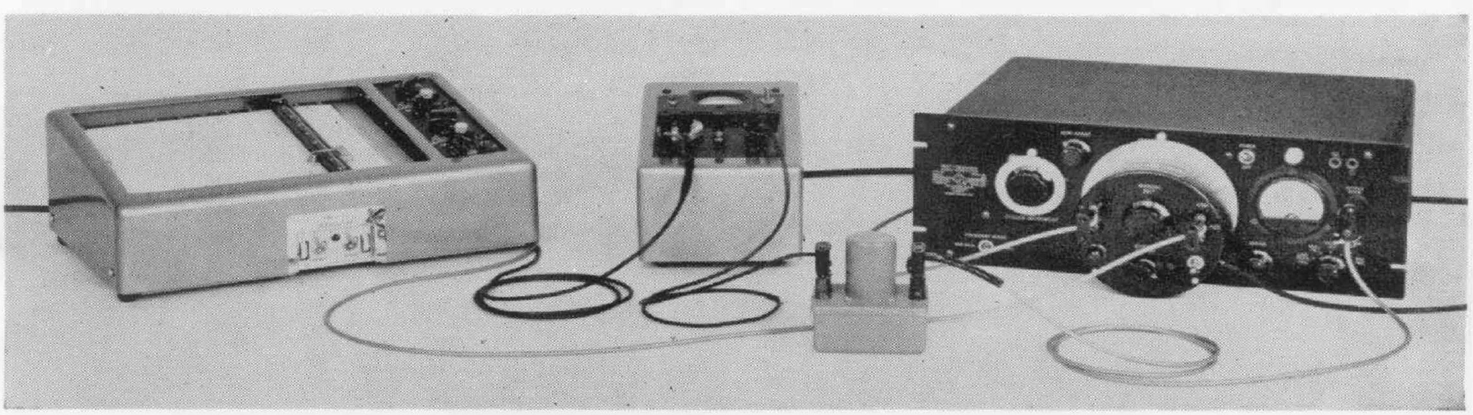
the pen in the Y direction. After this procedure has been completed for principal values of frequency, suitable values of the Y axis voltage are fed in and the pen traversed along the X axis. If this grid is drawn on tracing paper prints can be made to provide specialized plotting paper.

The TYPE 1304-B Beat-Frequency Audio Generator has been designed with a logarithmic dial, thus conveniently permitting the use of commercially available audio-frequency semilog paper. This feature is a great advantage in amplitude frequency tests on lines, amplifiers, loudspeakers, filters, equalizers, transducers and other networks.

An interesting application of the sweep technique in the audio range is shown in Figure 7. While some tape recorders record and play back at the same time, the leakage of the bias signal between the two heads may influence the apparent output response level. To obtain the most reliable results, the input signal should first be recorded and then played back on a subsequent rerun. Since the oscillator is being driven synchronously, it is possible to insert a frequency marker on the original signal fed to the tape recorder, which can be used to key the recorded sweep of the oscillator with the output signal from the tape recorder.

To provide greater versatility in the use of these dial drives, two speeds are offered in each of the two sizes. The higher-speed models operate with a self-reversing synchronous motor while the lower-speed models are driven by counterclockwise (increasing frequency

Figure 5. View of the Type 1304-B Best-Frequency Audio Generator and X-Y Dial Drive, with Moseley Model 60 Logarithmic Amplifier and Model 3 Autograph X-Y Recorder, arranged to measure the audio network shown in the foreground. The logarithmic amplifier, whose d-c output is proportional to the logarithm of the a-c input, permits the use of an amplitude scale linear in db.



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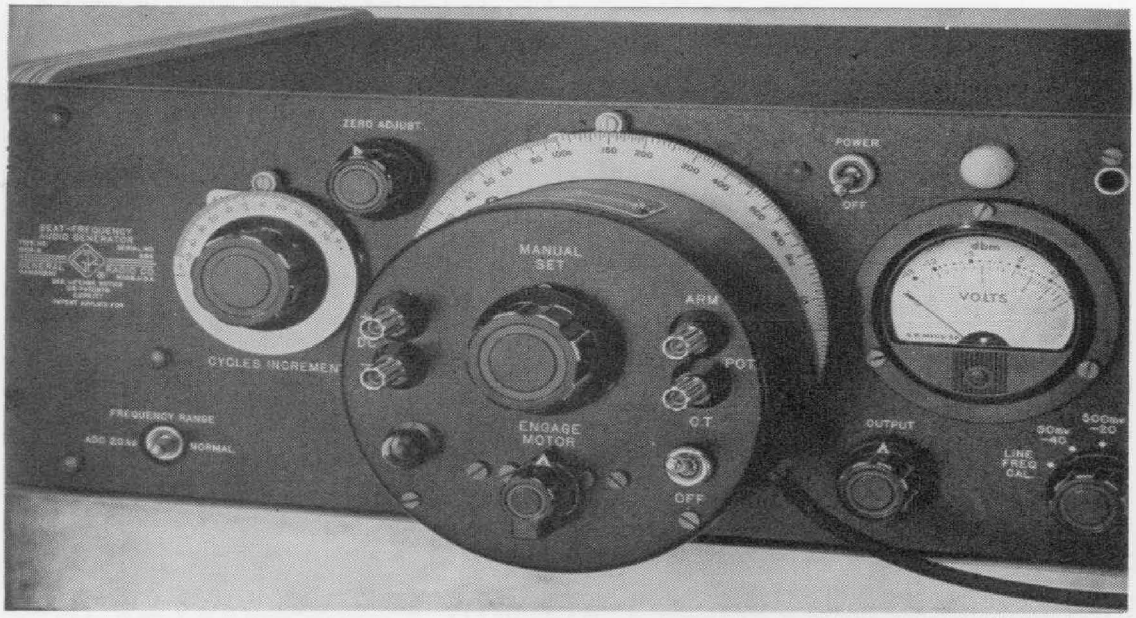

Figure 6. Close-up view of the Type 908-R X-Y Dial Drive installed on the Type 1304-B Beat-Frequency Audio Generator. This generator is ideal for audio-frequency plotting, because it covers the entire audio range in a single sweep of the dial and its output voltage is constant to ± 0.25 db.

on GR oscillators) motors. On these lower-speed units, a friction clutch is supplied to prevent damage if the motor is permitted to run after the dial has reached its stop.

To accommodate the wide range of d-c voltage ranges that may be desired from the position potentiometer, binding posts are provided for the insertion of a selected d-c supply. Binding posts are also available for the position signal. The direct-coupled, manual-drive knob can be used to center the potentiometer about any dial setting.

These drives find many important applications in both laboratory development and production testing, because they offer advantages of a rapid, reliable, semi-automatic test uncomplicated by the tedious task of reading, logging and plotting point by point values. It can produce an accurate graphic performance record that is easily compared with acceptance standards and one which can be reproduced for record files, certification reports and customer's information.

— G. A. Clemow

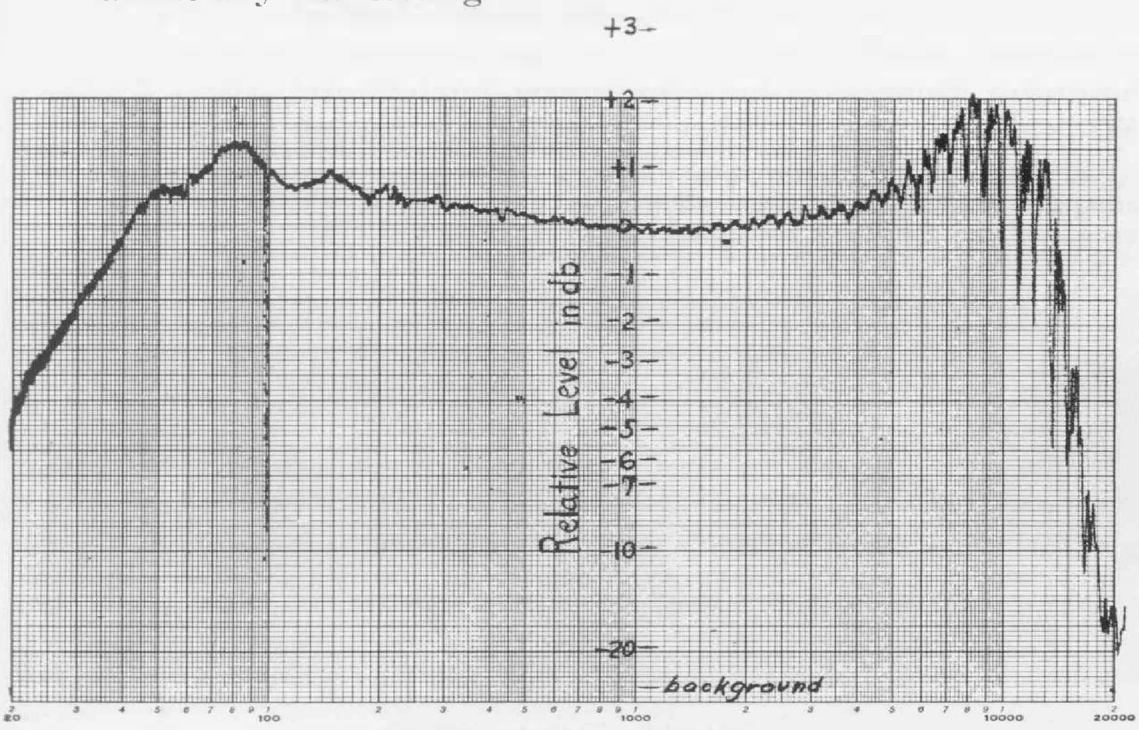

Figure 7. Graphic record of the frequency response of a tape recorder. The test voltage source was the Beat-Frequency Audio Generator shown in Figure 6. The vertical line at 100 cycles is the frequency calibration reference.

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SPECIFICATIONS

Power Supply: Motor: 105–120 volts, 50–60 cycles, 3 watts. Potentiometer, see below.

Dimensions: 907-R, 4 (diameter) x $3\frac{7}{8}$ (deep) inches.
908-R, $5\frac{3}{4}$ (diameter) x $3\frac{7}{8}$ (deep) inches.

Weight: 907-R, one pound, 11 ounces.
908-R, two pounds.

Note: Data are for 60-cycle operation. Multiply speeds by $\frac{5}{6}$ for 50-cycle operation.

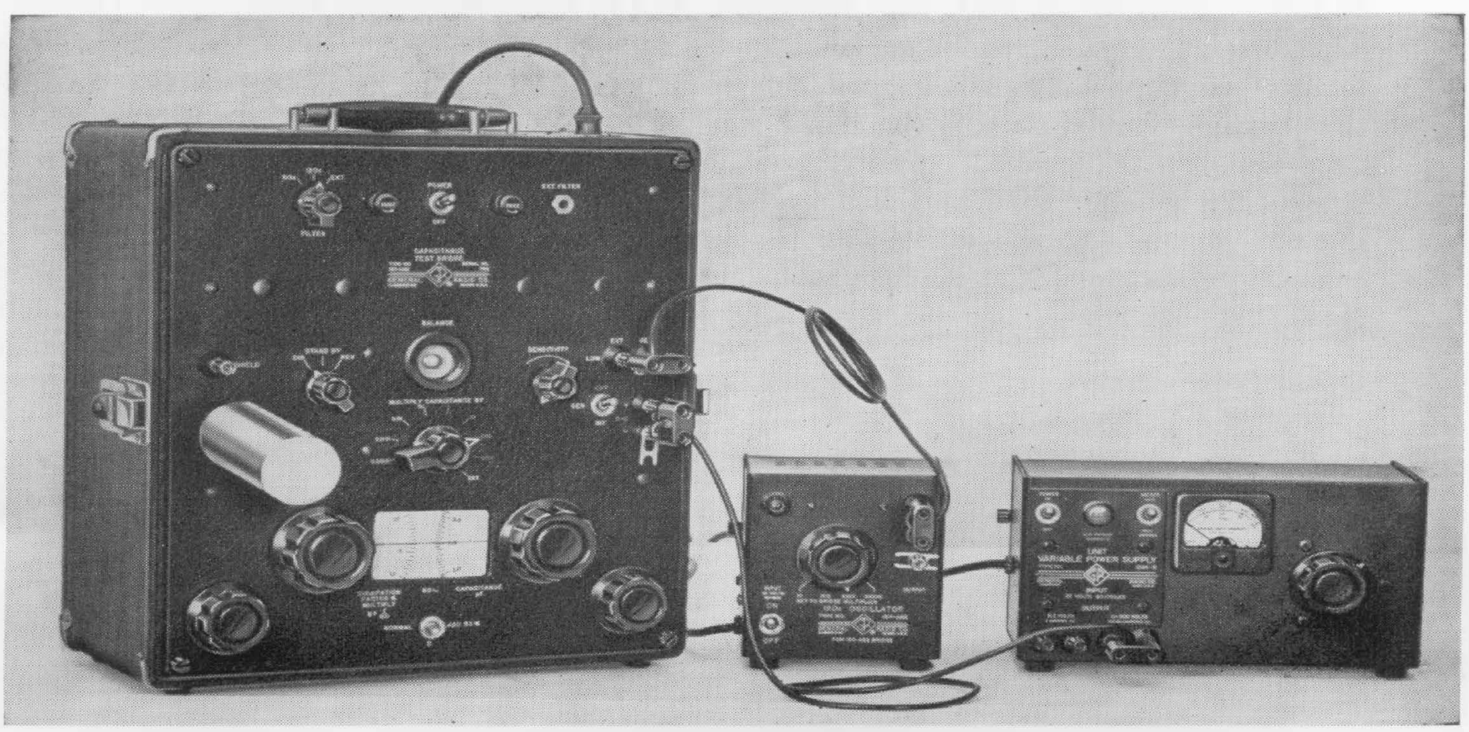
Type	*Dial*	*Pinion Speed*	*Dial Speed*	*Rotation*	*Center-tapped Potentiometer Resistance*	*Max Potentiometer Current*	*Reso-lution*
907-R18	907	½ RPM	18°/min	CCW	20 kΩ	10 ma	0.4°
907-R144	907	4 RPM	144°/min	Self-reversing	20 kΩ	10 ma	0.4°
908-R12	908	½ RPM	12°/min	CCW	50 kΩ	10 ma	0.2°
908-R96	908	4 RPM	96°/min	Self-reversing	50 kΩ	10 ma	0.2°

Type		*Code Word*	*Price*
907-R18	**X-Y Dial Drive**	EARLY	**$55.00**
907-R144	**X-Y Dial Drive**	EDUCE	**55.00**
908-R12	**X-Y Dial Drive**	EGRET	**55.00**
908-R96	**X-Y Dial Drive**	EJECT	**55.00**

A 120-CYCLE SOURCE FOR ELECTROLYTIC CAPACITOR TESTING WITH THE CAPACITANCE TEST BRIDGE

In most applications of electrolytic capacitors, a significant 120-cycle ripple component is superimposed on the applied unidirectional voltage. For this reason it has become widely accepted standard practice to test such capacitors at that frequency rather than at the more readily available 60 cycles. To meet this requirement, a modification of the 60-cycle TYPE 1611-A Capaci-

Figure 1. View of the Capacitance Test Bridge (left) with 120-cycle oscillator (center) and Unit Variable Power Supply (right) for furnishing the d-c polarizing voltage.



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tance Test Bridge has been available for some time.[1] The modification as shown in the schematic diagram (Figure 2), consists primarily of the addition of terminals for connection of an external generator and of providing 120-cycle tuning for the internal detector. Switching is provided so that either the standard circuit or the special configuration can be used.

Because the input impedance to the bridge varies between 1 ohm and 1000 ohms, most available audio oscillators are not capable of delivering enough voltage directly to the bridge over its entire range for adequate sensitivity of balance. A multiwinding impedance-matching transformer is frequently required to deliver adequate energy to the bridge, particularly for the 1000 multiplier setting, and, in any event, a transformer is required to isolate the a-c source from the d-c polarizing voltage.

A recent modification of the TYPE 1214-A Unit Oscillator, the TYPE 1214-AS2 120-cycle Oscillator, has a power output approaching the maximum that the bridge arms will withstand. This inexpensive oscillator provides the 120-cycle source, the impedance matching, and the isolation. An output transformer is provided, tapped to provide optimum match to the bridge for each of the four applicable multipliers. A panel switch selects the proper tap, and the engraving corresponds to the multiplier markings of the bridge, X1, X10, X100, and X1000.

Other Frequencies

For the measurement of electrolytic

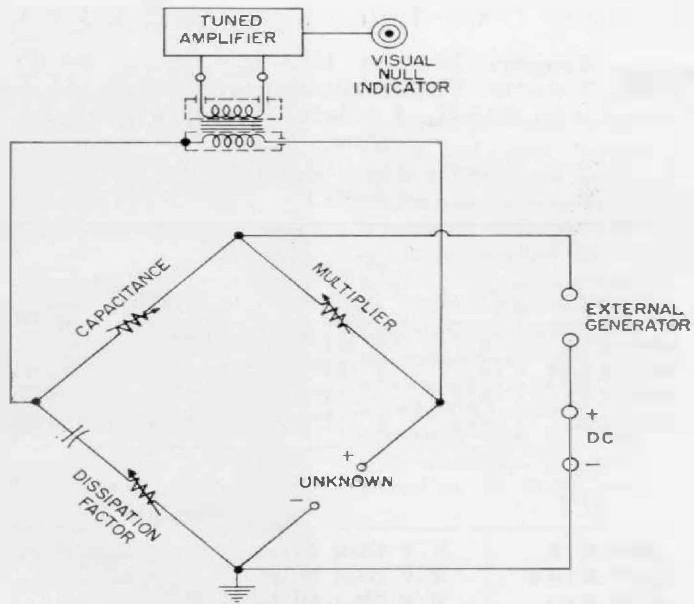

Figure 2. Elementary schematic of the bridge.

capacitors over a range of low audio frequencies, it is convenient to make use of the impedance-matching transformer and switching provided in the new oscillator. Accordingly, a jack is provided on the panel of the oscillator by means of which an external source can be connected.

The bridge circuit is designed for optimum sensitivity at 60 cycles, and substantially the same performance is obtained at 120 cycles. As the measuring frequency is raised, however, the bridge sensitivity factor decreases and above about 400 cycles is inversely protional to frequency. Figure 3 shows the variation of the bridge sensitivity factor[2] S for the different settings of the CAPACITANCE dial. The sensitivity factor is independent of multiplier setting, but the voltage applied to the bridge varies with ratio arm setting, as

[1] "Electrolytic Capacitor Testing at 120 Cycles", *General Radio Experimenter*, Vol. 28, No. 6, November, 1953, p. 8.

[2] Defined as $S = \dfrac{\frac{Za}{Zb}}{1+\frac{Za}{Zb}}\, d$, where d is the precision of setting of the reactive balance

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shown in the following table.

Bridge Multiplier	*Approx. Voltage (rms) Applied to Bridge*
× 1	18
× 10	6
× 100	2
× 1000	0.6

The upper frequency limit for satisfactory operation is thus a function not only of available detector sensitivity and applied voltage but also of the magnitude of the capacitance being measured and of the accuracy of measurement desired. With the internal detector, measurements can be made at 1 kilocycle on even the highest multiplier with a resolution of about 1%. If higher resolution is desired, a more sensitive detector can be connected externally to the external-filter jack of the bridge. For best results the external detector should have a 20-db discrimination to harmonics and noise.

Dissipation Factor

The dissipation factor range of the bridge is directly proportional to frequency. At 60 cycles the range is 0.6 (60%), at 120 cycles 1.2 (120%) and at 400 cycles 4.0 (400%). This variation is compatible with the normal tendency of high-value electrolytic capacitors to show dissipation factors rising with frequency as a result of fixed series resistance.

The effective accuracy of dissipation factor measurement decreases at the high frequencies. In addition to the problem of residual phase-angle errors within the bridge, the problem of making a satisfactorily low resistance connection to the capacitor under measurement is a serious one. For example, at 10,000 μf and 1000 cycles a series resistance of 0.001 ohm in lead or connection produces a dissipation factor of 0.6 (60%). For such an extreme case the limitation on accuracy is external to the bridge; for less extreme combinations of frequency and capacitance the accuracy of dissipation factor is ±2% of dial reading ±.0005 (f/60).

Applied Voltage

The a-c voltage applied to the capacitor under test is always somewhat lower than the voltage applied to the bridge, shown in the table above, since the ratio arm is in series with the unknown. The d-c polarizing voltage should normally be greater than the peak value of a-c test voltage. The voltages applied by the Type 1214-AS2 Oscillators are safely below ordinary voltage ratings for any given range. If, however, reduced test voltage is desired for capacitors of very low d-c rating or for any other reason, an adjustable resistor may be connected (in series or shunt) between the oscillator and the bridge to set to an arbitrarily specified level.

— I. G. Easton

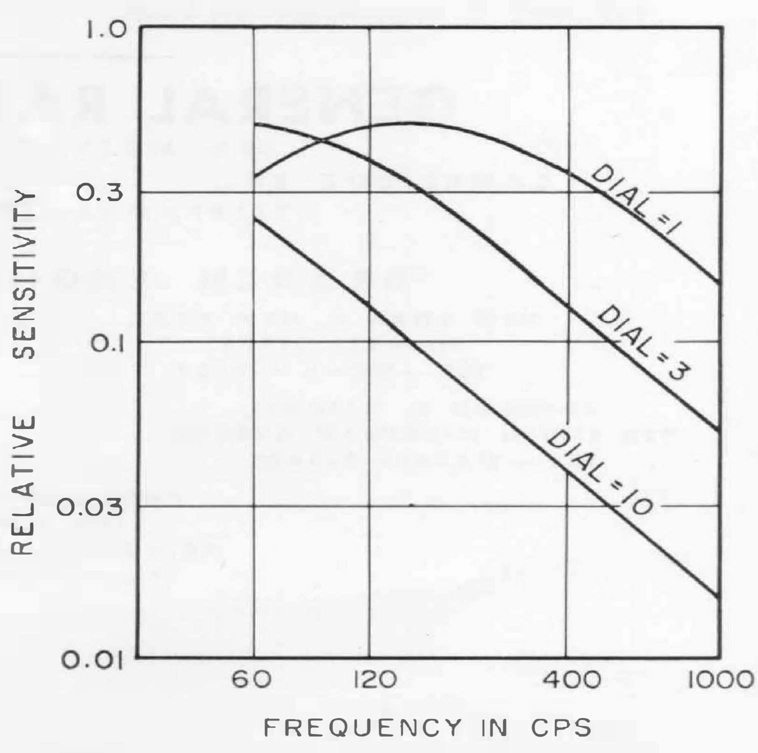

Figure 3. Variation of bridge sensitivity with frequency for different settings of the CAPACITANCE dial.

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SPECIFICATIONS FOR TYPE 1214-AS2 UNIT OSCILLATOR

Frequency: 120 cycles ±2%.
Output Impedance: Four impedances to match the impedance of the TYPE 1611-AS2 Capacitance Test Bridge at four multiplier positions.
Output: At least 200 milliwatts into matched load.
Controls: Output impedance switch and power switch.
Distortion: Less than 3% into a matched load.
Terminals: The output terminals are jack-top binding posts with standard ¾-inch spacing; a ground terminal is provided, adjacent to one of the output terminals. Jack is provided for connecting external oscillator.
Power Supply: Unlike most instruments of the Unit line, the power supply is built into the instrument; 115 volts, 40–60 cycles; power consumption is about 16 watts.
Accessories Supplied: Spare fuses; the power cord is integral with the unit.
Tube: One 117N7-GT, which is supplied with the instrument.
Mounting: Aluminum panel and sides finished in black-crackle lacquer. Aluminum dust cover finished in clear lacquer. Relay-rack adaptor panel available.
Dimensions: (Height) 5¾ x (width) 5 x (depth) 6¼ inches, over-all, not including power-line connector cord.
Net Weight: 4½ pounds.

SPECIFICATIONS FOR TYPE 1611-AS2 CAPACITANCE TEST BRIDGE

Capacitance Range: 0 to 11,000 μf at 60 cycles. 1 μf to 11,000 μf at 120 cycles or other external frequency.
Dissipation-Factor Range: 0 to 60% at 60 cycles. Range proportional to frequency. (0 to 120% at 120 cycles.) Dial readings must be multiplied by the ratio $\frac{f}{60}$ for frequencies other than 60 cycles.
Accuracy: Capacitance ±1%. Dissipation factor ±(2% of dial reading +0.05% x $\frac{f}{60}$ dissipation factor).
Detector Filter: Tuned to 60 or 120 cycles, selected by switch. Jack provided for use of an external filter for other frequencies.
External Generator: Required for frequencies other than 60 cycles. TYPE 1214-AS2 Oscillator described below is recommended for 120-cycle measurements.
Polarizing Voltage: Terminals are provided for connecting an external d-c polarizing voltage. The maximum voltage that should be impressed is 500 volts.

One of the terminals is grounded so that any a-c operated power supply with grounded output can be used. The terminal capacitances of the power supply do not affect the bridge circuit.
Power Supply Voltage: 105 to 125 (or 210 to 250) volts, 60 cycles. **Power Input:** 15 watts.
Accessories Supplied: TYPE CAP-35 Power Cord and spare fuses.
Mounting: Portable carrying case of luggage-type construction. Case is completely shielded to insure freedom from electrostatic pickup.
Tube Complement: One each 6X5-GT/G, 6SJ7, and 6U5.
Net Weight: 30½ pounds.
Dimensions: (Width) 14½ x (depth) 16 x (height) 10 inches, over-all, including cover and handles.

Type		*Code Word*	*Price*
1214-AS2	Unit Oscillator (including power supply)........	ABBOT	$95.00
1611-AS2	Capacitance Test Bridge......................	FAVOR	$545.00

GENERAL RADIO COMPANY

275 MASSACHUSETTS AVENUE
CAMBRIDGE 39 MASSACHUSETTS
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