

THE GENERAL RADIO

EXPERIMENTER



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JANUARY-FEBRUARY, 1962

IN THIS ISSUE

New Products: Microwave Oscillator
Unit Pulse Generator
Output Power Meter
Stereophonic Frequency Test Record
Meter Ballistics Testing

EXPERIMENTER



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CONTENTS

	Page
A Test Oscillator for S-Band Measurements	3
More and Better Pulses from the Unit Pulse Generator	8
Automatic Measurement of Phonograph Reproducers	15
More Talents, New Dress, for the Output Power Meter	21
The Measurement of the Ballistics of Indicating Instruments	23
Quantity Discounts for Coaxial Connectors and Adaptors	24

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COVER



CBS Laboratories' new Stereophonic Test Record, STR-100, is designed for use with the GR Type 1521-A Graphic Level Recorder. See page 15.

GENERAL RADIO COMPANY (OVERSEAS), ZURICH, SWITZERLAND
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A TEST OSCILLATOR FOR S-BAND MEASUREMENTS

With the TYPE 1360-A Microwave Oscillator, the frequency range of General Radio continuously tunable oscillators is extended to 4 Gc. Although not itself one of the Unit Instruments, it supplements this popular line of test equipment that provides the user with versatility and quality at a reasonable price.

Every effort has been made to give this new oscillator, within the design limitations dictated by tube choice and price, maximum usefulness as a driver for slotted lines, as the local oscillator in a heterodyne detector, and as a general-purpose power source for measurements on components and systems at microwave frequencies.

The frequency range of the oscillator is 1.7 to 4.1 Gc. Output power is 100 milliwatts or more over most of the frequency range. Internal 1-ke square-wave modulation is provided, as is also a narrow-band sweep at both 1-ke and the power-line frequency. Modulation

from external sources can be fm, square-wave, or pulse.

RF CIRCUIT

The microwave oscillator in the TYPE 1360-A is a TYPE 5836 Reflex Klystron in a coaxial cavity with a noncontacting tuning plunger. The frequency range is split in order to obtain a maximum range of interference-free operation and, at the same time, to provide maximum output power. For the higher frequency range (2.6-4.1 Gc), the cavity length is $\frac{3}{4}$ wavelength and the klystron is operating in its $2\frac{3}{4}$ repeller mode. In the lower frequency range (1.7-2.8 Gc), the numbers are $\frac{1}{4}$ and $1\frac{1}{4}$ respectively. The range switching is controlled automatically by the main frequency dial (center of panel, Figure 1), and, since the higher frequency range requires the longest cavity, the lower frequency range starts at the top end of the higher one. The two ranges are separated on the dial by different colored scales, and a

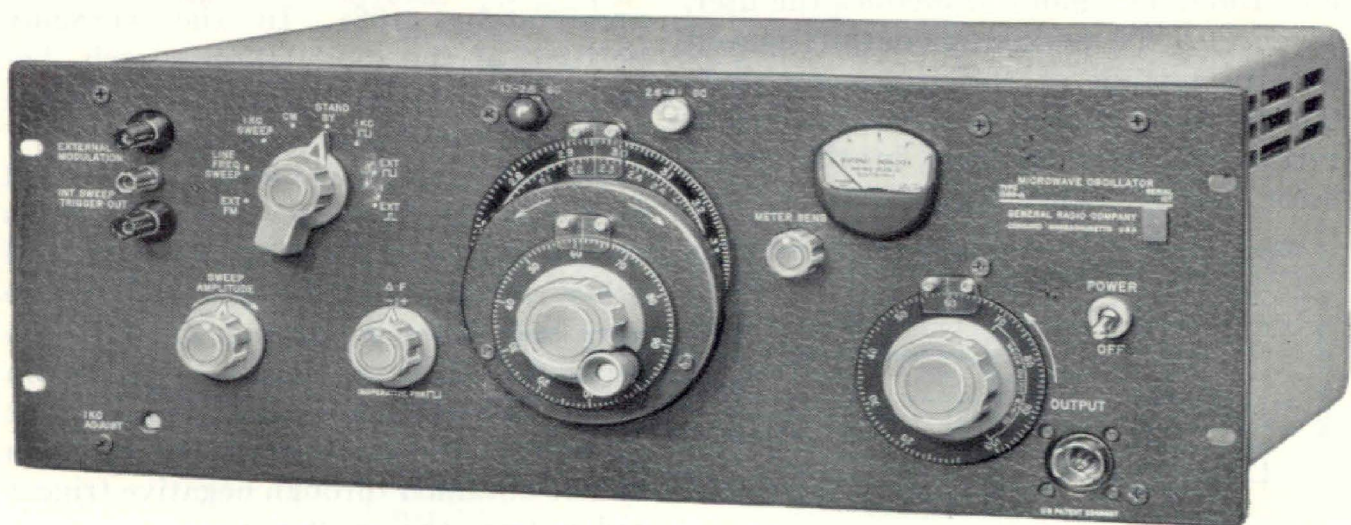


Figure 1. Panel view of the Microwave Oscillator.

pilot lamp indicates which scale is to be read. The tuning law of the repeller is matched to that of the cavity by a specially shaped, high-resolution potentiometer, and the final adjustment is made by trimmer rheostats. In series with the repeller potentiometer is also a small rheostat for fine frequency adjustment (ΔF knob), with a range of approximately 1 Mc. However, since adjustment of this rheostat may seriously harm the tracking of repeller voltage and cavity tuning when the oscillator is square-wave modulated, the ΔF control is disabled under that condition.

OUTPUT CIRCUIT

The output control is at the lower right of the panel. The output power is a function of frequency, as shown in Figure 2, and is more than 100 milliwatts over most of the frequency range. At the very low-frequency end of the range, it may be as low as 20 milliwatts, which corresponds to 1 v into a 50-ohm load. At the upper end of each frequency range, it is possible to overload the klystron oscillator, and an output monitor is provided to warn against this condition. The monitor enables the user to extract the maximum output power at any setting of the frequency dial. The output power is controlled by a retractable pick-up loop in the oscillator cavity. The dial plate on the

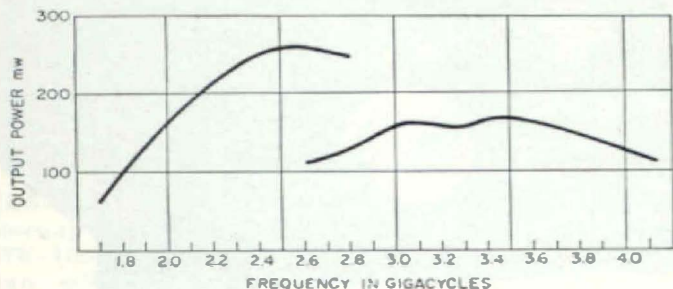


Figure 2. Typical variation in output with frequency.

attenuator (pick-up loop) knob is calibrated in arbitrary units (maximum coupling is 100), but the divisions are equivalent to decibels except in the non-linear range of the attenuator where the output power is greatest. The area where over-coupling is possible at some frequencies, even with a 50-ohm load, is indicated on the attenuator dial by the legend WATCH OUTPUT MONITOR. The output monitor is fed from a directional coupler in such a manner that it is quite insensitive to load changes. A variable resistor in series with the meter serves as a sensitivity control.

The output connector is a 50-ohm TYPE 874 Locking Connector which will permit a semipermanent attachment of a cable or an adaptor to some other type of coaxial connector.

MODULATION

Since the most-used type of operation (other than CW) for a test oscillator at these frequencies is 1-kc square-wave modulation, this is provided internally. To facilitate matching the frequency to the filter in the detector system, a screwdriver adjustment on the front panel can vary the modulation frequency approximately $\pm 5\%$. In the STANDBY position of the modulation switch, between the cw and 1-kc square-wave positions, the rf energy is shut off.

Narrow-band, linear sweep is provided at power-line frequency and 1 kc. This can be used for checking receivers and other narrow-band devices, and is also very useful for realigning the klystron oscillator after a change of klystron tube. When the klystron is being swept internally, oscilloscope synchronization can be obtained through negative trigger pulses from the oscillator.

Square waves for modulation at other



frequencies can be applied by an external source. Recommended sources are the TYPE 1210-C Unit RC Oscillator and the TYPE 1217-B Unit Pulse Generator. The latter is also recommended for pulse modulation. For external frequency modulation, the modulating signal is applied across a series resistor in the repeller lead.

illustrate how modulation is accomplished, and it should be noted that different methods are used for pulse modulation and square-wave modulation. For pulse modulation (Figure 3b), the klystron beam current is interrupted by application of a negative voltage to the normally positive biased grid. During the first couple of hundreds of milliseconds after the current is turned on

The three block diagrams in Figure 3

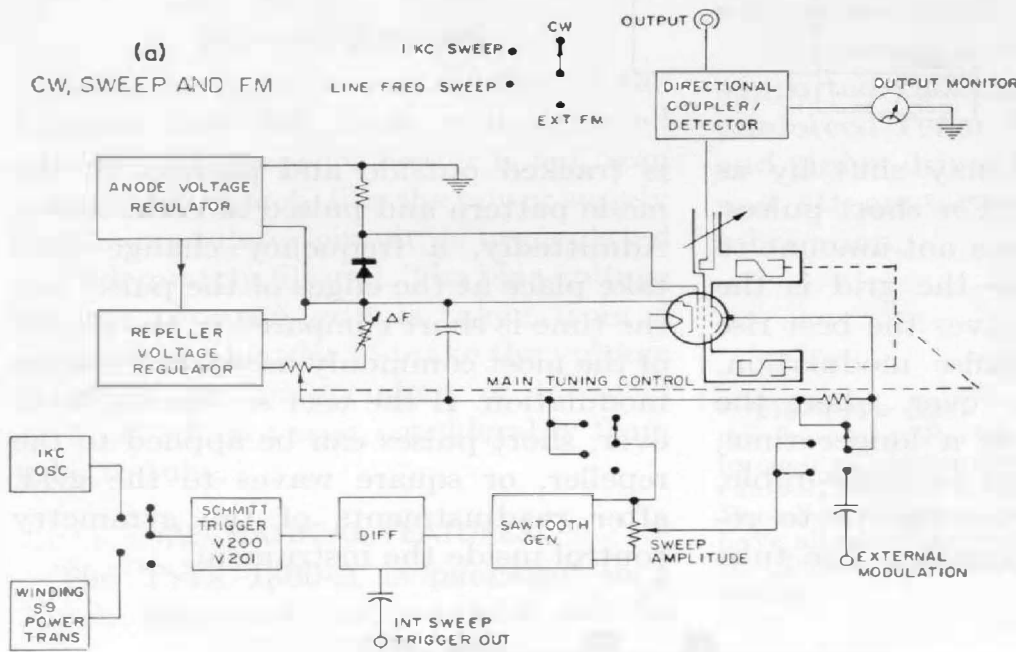


Figure 3a. Schematic for CW, sweep, and frequency modulation.

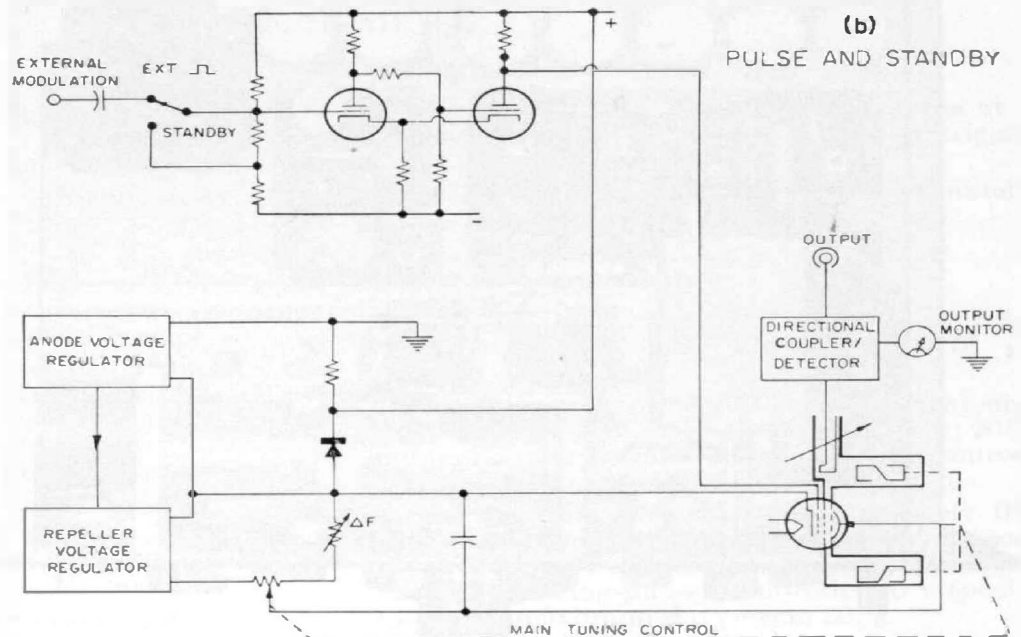


Figure 3b. Schematic for pulse modulation and standby operation.

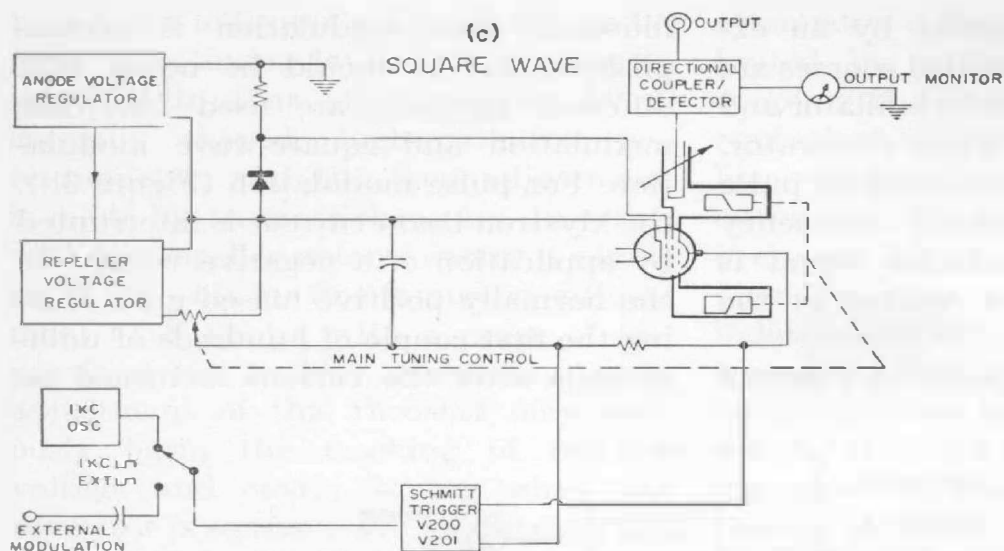


Figure 3c. Schematic for square-wave modulation.

again, the frequency may shift by as much as a megacycle. For short pulses, the frequency shift does not amount to very much, and, since the grid is the pulsing member that gives the best rise time, it is used for pulse modulation. For square waves, however, where the on-period may last for a longer time, the frequency shift may be undesirable, and it was found advantageous to repeller-modulate the klystron. The tube

is tracked outside and parallel to the mode pattern and pulsed into the mode. Admittedly, a frequency change does take place at the edges of the pulse, but the time is short compared to the period of the most commonly used square-wave modulation. If the user so desires, however, short pulses can be applied to the repeller, or square waves to the grid, after readjustments of the symmetry control inside the instrument.

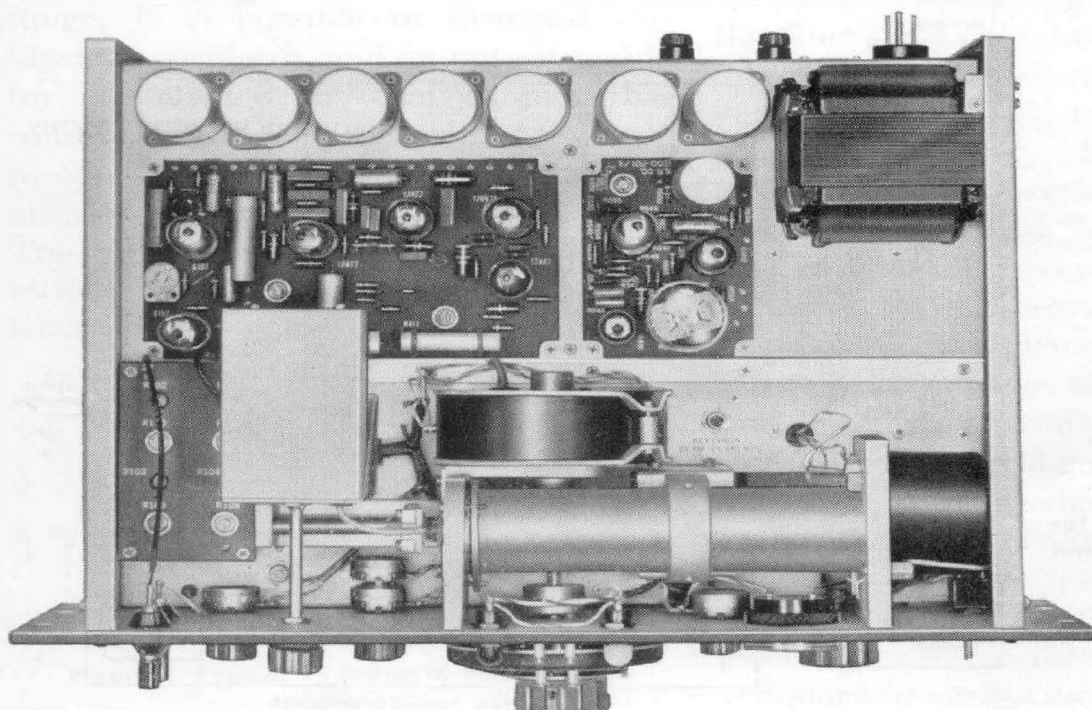


Figure 4. Interior view.



The internal narrow-band sweep at line-frequency or 1-ke rates is produced by application of an internally generated sawtooth voltage to the repeller. Owing to the inherent characteristics of the klystron, the sweep is practically linear in frequency.

External modulation voltage for fm is applied to the repeller through a 0.047- μ f capacitor. The input impedance is 400 kilohms shunted with 70 pf.

POWER SUPPLIES

Both the cathode and repeller of the klystron are fed from well-regulated supplies. The repeller heater is fed from a dc supply, which, like the power supply for the modulator circuit, is unregulated but adequately filtered. The bias voltage for the klystron grid is taken from a Zener diode in order to make the voltage constant and independent of the grid current, which varies considerably from tube to tube.

MECHANICAL FEATURES

The TYPE 1360-A is packaged in a 7-inch relay-rack cabinet and can be

obtained either with end frames for bench use or with support fittings for rack mount. Figure 4 shows the instrument with the cabinet removed. Almost all the electronic components are mounted on etched boards which are easily accessible from both sides. Tube replacements, including the klystron, do not require any tools, and precautions have been taken to prevent service personnel from accidentally touching high-voltage terminals.

The noncontacting tuning plunger is supported by a carriage with long-life reinforced Teflon bearings, and the rack and pinion drives for the tuning plunger and attenuator require a minimum of lubrication.

—PER A. BERGSTAD

CREDITS

The TYPE 1360-A Microwave Oscillator was developed by Per A. Bergstad, author of the foregoing descriptive article. William G. Cooper, Eduard Karplus, Charles S. Kennedy, Benedict O'Brien and Robert A. Soderman have all contributed to the final design. George A. Clemow was responsible for the mechanical design.

— EDITOR

SPECIFICATIONS

FREQUENCY

Range: 1.7 to 4.1 Gc in two ranges, 1.7 to 2.8 Gc and 2.6 to 4.1 Gc.

Fine Frequency Control (ΔF): Order of 1 Mc, but not functioning for square-wave modulation.

Accuracy: $\pm 1\%$.

Stability: Warm-up drift is approximately 0.15% during the first hour, total drift approximately 0.25%. After warm-up, frequency is stable within approximately 5 ppm.

Residual FM: Approximately 0.5 ppm in the lower frequency range and 0.2 ppm in the higher. Dominant frequencies are 60 and 120 cps (with 60-cycle line frequency).

OUTPUT POWER

Typically more than 100 mw above 2 Gc. Total variation in maximum output with frequency is 20 to approximately 300 mw.

Attenuator: Relative calibration only.

INTERNAL MODULATION

Narrow-Band Sweep: 1 to 3 Mc maximum at 1 ke and power-line frequency. Negative trigger pulse supplied.

Square-Wave: 1 ke, adjustable approximately $\pm 5\%$.

EXTERNAL MODULATION

FM: Sensitivity approximately 0.2 Mc per volt, input impedance, 400 kilohms and 70 pf (ac only).

Square-Wave: 50 cps to 200 ke, 12-v (rms) sine wave or 20-v (peak-to-peak) square wave; 20% minimum duty cycle from external source. Input impedance greater than 100 kilohms.

Pulse: Rise and fall times approximately 0.2 μ sec, minimum length approximately 0.5 μ sec, jitter may be 0.2 μ sec. Input impedance 100 kilohms; driving-pulse amplitude, 20 v (peak-to-peak); maximum duty cycle 20%.



SPECIFICATIONS (Cont.)

GENERAL

Terminals: RF output, TYPE 874 Locking Connector. Modulation, binding posts.

Mounting: Bench or relay rack.

Power Input: 105 to 125 (or 210 to 250) volts, 50 to 60 cps, 85 watts. Instrument will operate satisfactorily (except for line-frequency sweep) at power-line frequencies up to 400 c.

Tube Complement: Two each 6197 and 12AT7,

one each 6AN8, 6AV5GA, 12AX7, 12BH7A, 5651, 5836 (Reflex Klystron), 5965.

Accessories Supplied: TYPE 874-R22 Patch Cord, TYPE 874-C58 Cable Connector, TYPE CAP-22 Power Cord, and spare fuses.

Dimensions: Width 19, height 7 1/2, depth 15 1/2 inches (485 by 195 by 395 mm), over-all; panel, 19 by 7 inches (485 by 180 mm).

Net Weight: 38 pounds (17.5 kg).

Type		Code Word	Price
1360-AM	Microwave Oscillator, Bench Mount.....	BURLY	\$1100.00
1360-AR	Microwave Oscillator, Rack Mount.....	BASSO	1100.00

U.S. Patent No. 2,548,457

MORE AND BETTER PULSES FROM THE UNIT PULSE GENERATOR

The TYPE 1217-A Unit Pulser¹ was, like its companion instruments in the unit line, designed for maximum utility, minimum complexity, and low cost. The thousands of these compact, high performance devices that are now in use have shown that the design was indeed

a successful blend of these often conflicting factors. Time has made available new circuits and components, and experience has shown where improvements would be both desirable and practical. In the redesign the goals set were simple: to make every possible improvement compatible with the two conditions of no increase in price and no increase in power supply requirements.

¹R. W. Frank, "Pulses in a Small Package — A Pulse Generator for the Unit Line," *General Radio Experimenter*, 28, 10, March, 1954.

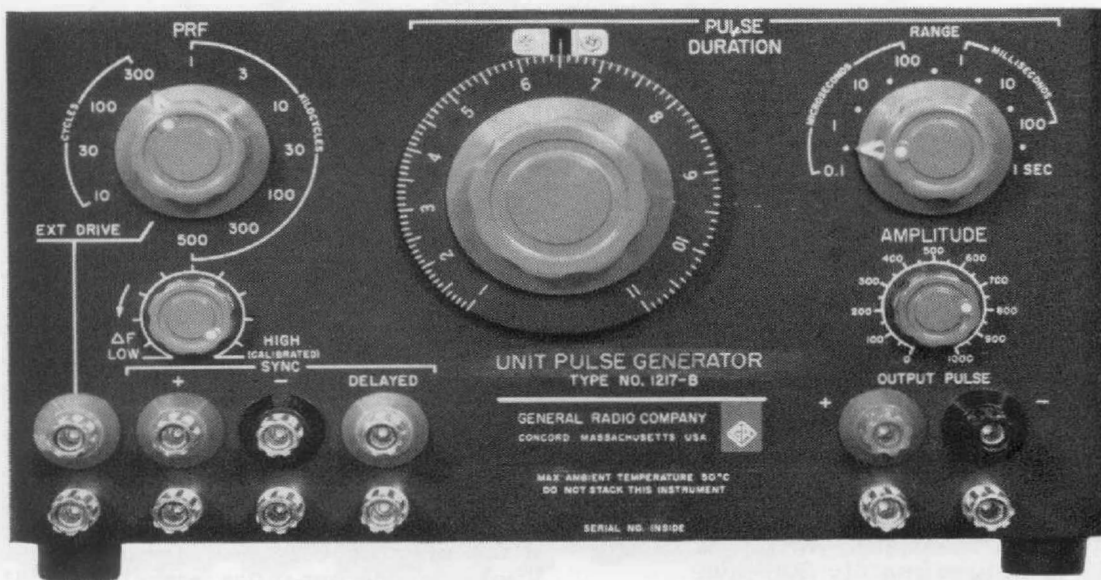


Figure 1. Panel view of the Unit Pulse Generator.



TABLE I
Comparison of Major Characteristics of the Types 1217-A and 1217-B

Characteristic	1217-A	1217-B
Pulse Rise Time	< 50 nsec	< 20 nsec (50 ohms)
Pulse Fall Time	< 150 nsec	< 10 nsec (50 ohms)
Pulse Duration	Continuous 150 nsec — 60 msec	Continuous 100 nsec — 1 sec
PRF (Internal)	Steps 30 cps — 100 kc	Continuous 2.5 cps to 500 kc
PRF (External)	Locked 30 cps — 100 kc	Continuous dc to 1 Mc
Pulse Amplitude (1-kilohm output impedance)	±20 v into 1 kilohm	±40 v into 1 kilohm
Input Sensitivity	30 v at 100 kc	0.3 v at 1 Mc
Accuracy PRF and Duration	±15%	±5%
Delayed Pulse	None	To trigger a second generator

Similarity between the new TYPE 1217-B Unit Pulse Generator and its popular predecessor goes little further than the four digits of its type number. Significant changes have been made in all performance specifications. The most important parameters are listed for comparison in Table I. It can be seen that, in every instance, the performance figures are increased by at least 2:1 and often by more than 10:1.

This performance is achieved in two ways:

- (1) The TYPE 1217-B uses better devices; being neither wholly “transistorized” nor wholly “vacuum tube-ized” it takes full advantage of the best properties of both modern transistors and vacuum tubes.
- (2) The TYPE 1217-B has completely unconventional circuitry for all functions—every component works full time. In fact, through a series arrangement of

timing and output circuits, the 55-ma input current from the power supply is used to provide 40 ma of useful load current.

The new design has other new features, not clearly shown in Table I, which can be better appreciated after some of the new circuit characteristics are more completely explained. These will be discussed in the section on applications, below, after the circuits have been explained in some detail.

CIRCUITS.

Block Diagram

Figure 2 is a block diagram of the circuit. In block form things look quite conventional. The input circuits consist of a Schmitt trigger circuit driven by an amplifier connected to the input terminals so that the pulse generator will be started by a triggering pulse once per cycle of any input waveform at any

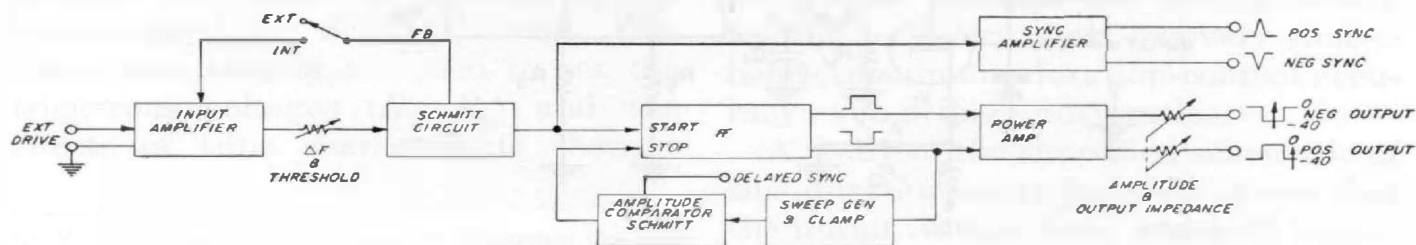


Figure 2. Block diagram of the circuit system.

frequency from dc to over one megacycle per second. Conventional—yes, but every active part of this input-triggering circuit is converted to a stable RC-controlled oscillator when internally produced pulse repetition frequency (prf) is desired. This oscillator will produce any desired recurrence frequency between 2.5 cps and 500 kc.

The trigger pulse from these input circuits: (1) operates a sync-pulse-producing stage to form both positive and negative pre-triggers, and (2) starts the pulse-generating and timing circuits.

A transistor-bistable circuit, set by the trigger from the input circuit, simultaneously operates the pulse output stage and the pulse-timing circuit. The output stages, producing both positive and negative pulses, are a pair of power pentodes acting as 40-ma current sources. The timing circuits are comprised of a switch tube, a high-speed clamp and a Schmitt trigger. When the transistor bistable switches, starting the pulse, the timing switch is turned off. A precision capacitor is charged to the point where the Schmitt trigger operates, producing a reset trigger for the bistable control circuit, thereby terminating the pulse.

The 40-ma current-source output pentodes are directly connected to the output terminals through a 1-kilohm amplitude control.² Forty-volt positive and negative pulses are thereby produced at full amplitude. Since the connection to the output terminals is direct, the dc component of the pulses is present, and ramp-off cannot occur, no matter how great the pulse duration.

Input Circuits

Figure 3 is a simplified schematic diagram of the input circuits and prf oscillator. The switching for the circuit is shown here in proper position for the aperiodic-input-circuit connection.

In this connection V_1 amplifies the input signal, and the voltage divider R_1 and variable resistor R_2 apply the amplified input signal to the Schmitt circuit, V_2 . R_2 in this application permits an adjustment of the dc component of the input signal either to optimize the triggering sensitivity or to adjust the phase of the output pulse with respect to the input signal over a limited range.

When the PRF selector switch is thrown to any one of its other twelve positions

²This output circuit configuration is identical to that of the General Radio TYPE 1391-B Pulse, Sweep, and Time-Delay Generator.

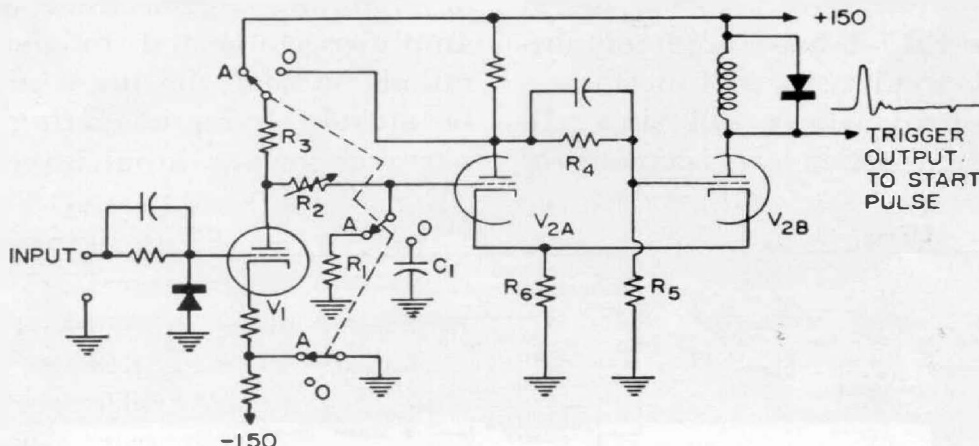


Figure 3. Elementary schematic of the input circuits.

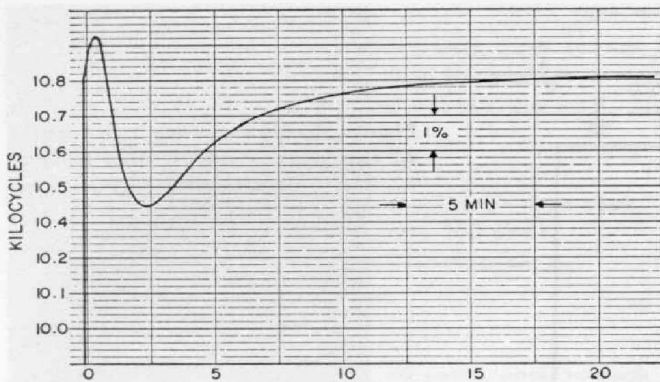


Figure 4. Warm-up frequency drift of prf circuit at 10 kc.

the input circuit is converted to an oscillator. This oscillator configuration is obtained when the switches of Figure 3 are thrown to the "0" position. Note that the Schmitt-circuit structure is not disturbed—except that the plate voltage of the left-hand side is directly coupled to the left-hand grid of V_2 by V_1 which has been converted by the switch into a current source translating device.³ Under ideal conditions nearly the full plate swing of V_{2A} would appear at the grid. R_2 , R_3 and C_1 form a delay circuit so that C_1 must charge to a voltage equivalent to the circuit hysteresis before V_{1A} can switch to its other stable state, whereupon C_1 must discharge by the circuit hysteresis before switching again takes place. Therefore, an oscillator is produced whose natural frequency is determined by: the circuit hysteresis, the resistors R_2 and R_3 , and the capacitor C_1 .

The frequency stability of this oscillator is dependent only on the RC product and upon the stability of the hysteresis of the Schmitt circuit. Precision components are used to set the triggering voltages (R_4 , R_5) and the effects of tube characteristic changes

are minimized by the current feedback produced by the large cathode resistor, R_6 . This form of oscillator is inherently stable. Figure 4 shows the warm-up characteristic. After 15 minutes, the frequency is within 0.1% of its final value and will remain within 0.1% for several hours, under laboratory conditions.

Pulse-Timing Circuits

The pulse-timing circuits are shown in Figure 5. Upon the receipt of a trigger from the input circuits, Q_1 goes off, turning V_3 off, starting the output positive pulse. (At the same time Q_2 goes on, turning V_4 on, starting the negative pulse.) Q_1 going off also turns V_5 off and C_2 starts to charge through R_1 . The resulting positive-going exponential rises from a level set by the clamping diode, D_1 , to the potential at which the Schmitt trigger (V_6) switches. The transition of the trigger circuit turns Q_2 off, Q_1 on, stopping the pulses, turning V_5 back on to discharge C_2 , and the process stops, until a new trigger is received from the input circuit.

This circuit structure meets practically all the conditions for the production of an accurate and stable time interval:

- (1) The timing elements form an integrating circuit. (Best for low jitter.)
- (2) The timing is dependent only on an RC circuit and an easily controlled amplitude comparator.
- (3) The timing capacitor is directly discharged through the timing switch leading to a very short recovery time—hence, maximum duration-control accuracy even at high duty-ratios.

A study of the simplified schematic of this duration-control circuit shows that the initial voltage from which C_2 begins its charge to determine the pulse dura-

³R. W. Frank and H. T. McAleer, "A Frequency Counter with a Memory and with Built-In Reliability," *General Radio Experimenter*, 35, 5, May, 1961, p. 10.

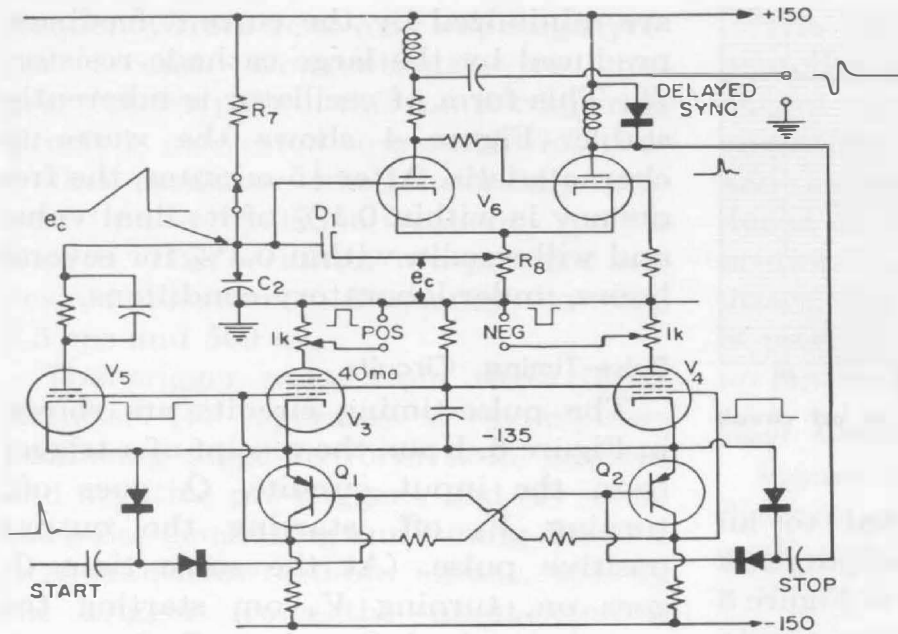


Figure 5. Elementary schematic of the pulse-timing and output circuits.

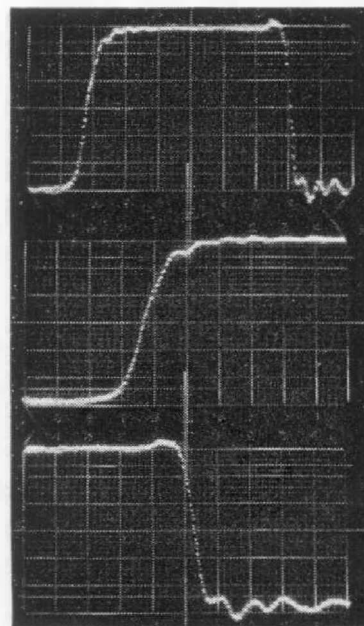
tion is set by the cathode current of the amplitude-comparator Schmitt in R_8 . Any variations in this current will affect both the initial and final voltage values. Again, as in the input circuits, this comparator is stabilized by heavy current feedback and the triggering voltage is determined by precision resistors.

Output Circuits

Figure 5 also shows the output circuits. Before a start trigger pulse is received from the input circuits Q_1 is on and Q_2 off. V_3 is therefore conducting at (nearly) zero-bias and V_4 is off. When a trigger pulse is received Q_2 goes on bringing V_4 on. V_3 and V_4 are a pair of power pentodes which pass 40 ma when on at zero-bias. The interruption of plate current in V_3 produces a 40-volt positive pulse in its load resistor. Simultaneously V_4 turning on produces a 40-volt negative pulse across its load resistor. The extreme speed of Q_1 and Q_2 in the transistor flip-flop switches these plate currents on and off very rapidly. A typical positive current transition is of the order of 15 nanoseconds, while the

negative transitions are typically 8 nsec. (See Figure 6.)

The very rapid current transitions are applied to the 1-kilohm output potentiometers and an internal stray-capacitance of approximately 30 pf. With no external loading the rise time of voltage is approximately 60 nsec. External capacitance will increase this rise time by



0.12- μ sec pulse in 1-nsec rise time sampling system; 20 nsec/cm.

Positive transition, 10 nsec/cm

Negative transition, 10 nsec/cm

Figure 6. Oscilloscope showing typical output transitions in a 50-ohm system.

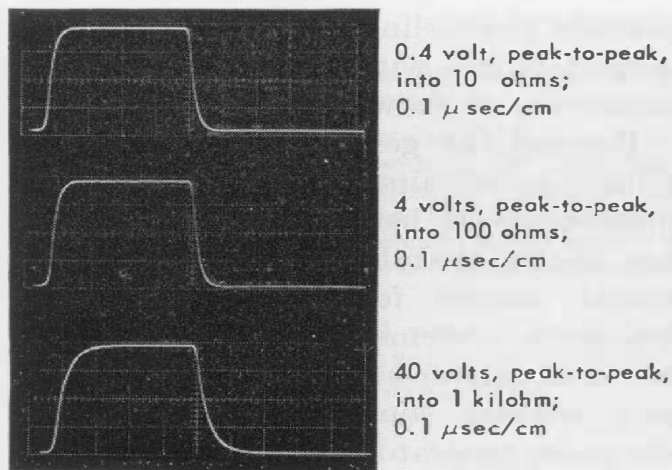


Figure 7. Open-circuit rise-and fall-time oscillograms; 'scope has 12-pf probe.

approximately 2 nsec/pf. With this output circuit form, no overshoot will ever be observed, and the rise and fall of output voltage is purely exponential (see Figure 7 where the output pulse is shown as presented on a Tektronix 543 oscilloscope with 12-pf probe).

When the ultimate current rise times are to be utilized it is necessary to terminate the pulse generator in an impedance appropriate to the coaxial cable (50 or 93 ohms) to be used. Fast 2-volt pulses in a 50-ohm system are shown in Figure 8.

APPLICATIONS

The extremely wide ranges of pulse duration and prf produced by this pulse generator fit it for almost any application in which a pulse is needed. There are so many applications that it is difficult to select a sample group to be included here. The new model has demonstrated itself to be far more useful than its predecessor because:

(1) Its duration control, being more accurately calibrated, can be used for quantitative measurement of maximum and minimum durations, for example, over which a flip-flop will function. The

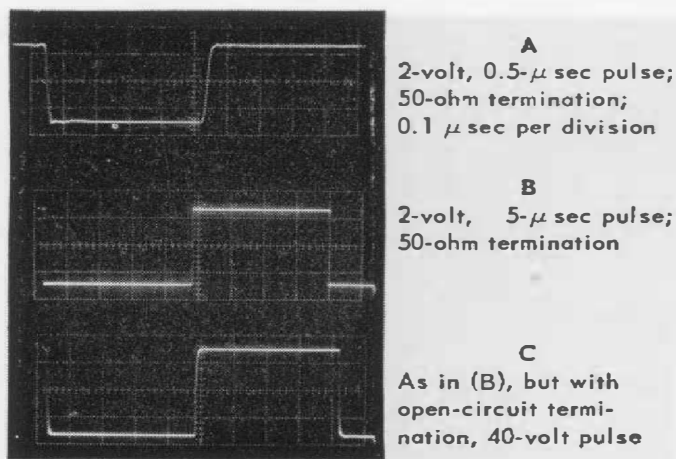


Figure 8. 2-volt pulses into 50 ohms.

pulse duration can be established without the need to read an oscilloscope.

(2) Since the amplitude control varies output impedance, the instrument can be set to produce a correct driving-point impedance for any passive pulse network.

(3) Its linear current-source output system produces a clean pulse of easily adjustable and equal rise-fall time.

(4) Since the prf can be continuously varied it is possible, for example, to establish the resolution failure point of a flip-flop precisely.

(5) The aperiodic synchronizing circuit for external control of the prf makes it possible to drive the instrument from an RC or beat oscillator over the full range of that oscillator with no control adjustments on the pulse generator. Therefore, the prf accuracy and stability is that of the driving oscillator. It is also possible to produce pulses with a random frequency distribution.

(6) The stability of the internal prf oscillator makes it possible to use the TYPE 1217-B in systems as a precise frequency divider of high ratio (Figure 9, A and B).

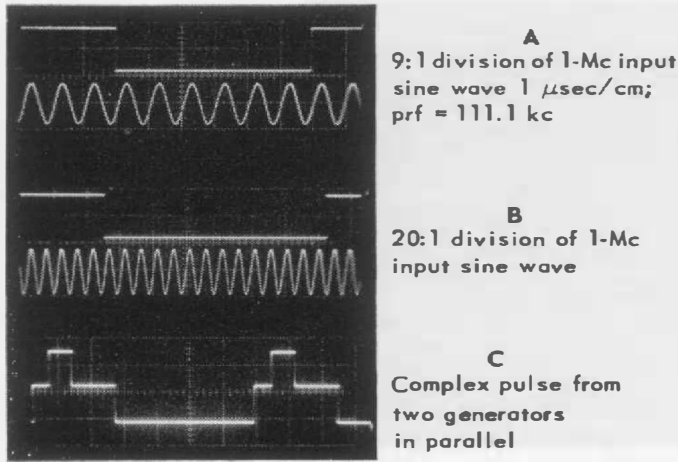


Figure 9.

(7) The presence of a threshold control for the external synchronizing circuit makes it easily possible to produce single pulses. A 1.5-volt cell and Micro Switch can also be used to produce single pulses from a hand-held trigger generator.

(8) The linear, dc coupled output

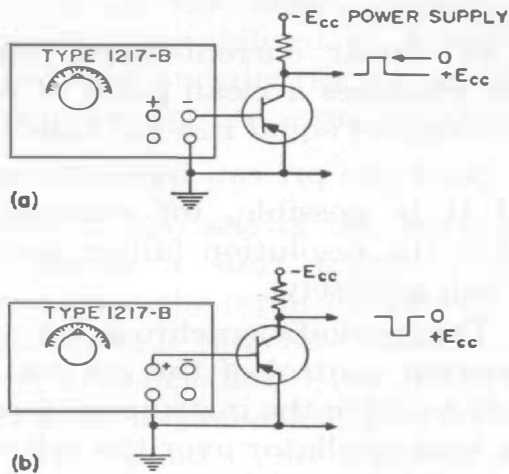


Figure 10. Control of pnp transistor switch.

permits paralleling to provide complex output pulses with no external adding networks, as shown in Figure 9C.

Beyond the general increases in applicability obtained through the design improvements listed above, experience has shown that the TYPE 1217-B is a useful source for measurements on transistor systems. It can operate saturated transistor switches, both *nnp* and *pnp*, without coupling networks. Since the pulse generator is direct-coupled, the solid-state switches can be operated over its full duration-range. Figure 10 shows the connections for driving a *pnp* transistor switch. The low output impedance of the TYPE 1217-B is normally sufficient for hold-back during the pulse off-time. Figure 11 shows the direct connection for switching *nnp* transistors.

— R. W. FRANK

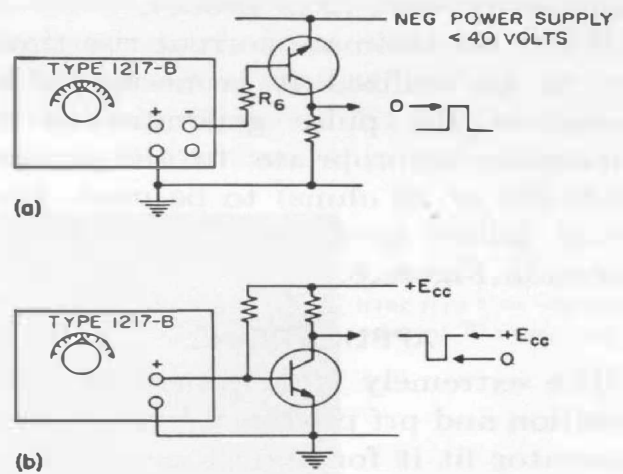


Figure 11. Control of nnp transistor switch.

SPECIFICATIONS

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 cps to 500 kc with calibrated points in a 1-3 sequence from 10 cps to 300 kc, and 500 kc, all $\pm 5\%$. Continuous coverage of the range from 2.5 cps to 500 kc with an uncalibrated control lowering the frequency of the calibrated points.

Externally Controlled: Aperiodic, dc to 1 Mc with 1-v rms input (0.5 v at 500 kc and lower); input impedance, at 0.5 v rms, approximately 100 kilohms shunted by 50 pf.

OUTPUT PULSE CHARACTERISTICS

Duration: 100 nsec to 1 sec in seven decade ranges, $\pm 5\%$ of reading, or $\pm 2\%$ of full scale or ± 25 nsec, whichever is greater.

Rise Time:

a. Into terminated 50- or 100-ohm cables all transitions will have rise times less than 20 nanoseconds (typically 12 nsec).

b. On high-voltage output (40 v at 1 kilohm) rise time will be limited by load capacitance.



SPECIFICATIONS (Cont.)

Rise and fall times typically 60 nsec + 2 nsec /pf external load capacitance.

Voltage: Positive and negative 40-ma current pulses available simultaneously. DC coupled, with dc component negative with respect to ground. 40 volts peak into 1-kilohm internal load impedance for both negative and positive pulses. Output control marked in approximate output impedance.

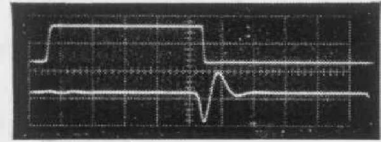
Overshoot: Overshoots and noise in pulse, less than 5% of amplitude with correct termination.
Ramp-off: less than 1% everywhere.

Synchronizing Pulses:

Pre-pulse: Positive and negative 10-volt pulses of 150-nsec duration. If positive sync terminal is shorted, negative pulse can be increased to 50 v. Sync-pulse source impedance:
positive — approx 300 ohms
negative — approx 1 kilohm

Delayed Sync Pulse: The delayed sync pulse consists of a negative-going transition of approximately 5 volts and 100-nsec duration coincident with the late edge of the main pulse. The duration control reads the time between the pre-pulse and the delayed sync pulse. The delayed sync-pulse negative transition is immediately followed by a positive transition of approximately 5 volts amplitude and 150-nsec

1-μ sec pulse into 50 ohms with delayed sync pulse



duration to reset the input circuits of a following pulse generator. (See oscillogram above.)

STABILITY

PRF and pulse-duration jitter are dependent on power-supply ripple and regulation.

- a. With TYPE 1201 Power Supply (recommended), input terminals short-circuited,
 - PRF Jitter 0.01%
 - Pulse-Duration Jitter 0.01%
- b. With TYPE 1203 Power Supply
 - PRF Jitter 0.05%
 - Pulse-Duration Jitter 0.05%

POWER REQUIRED

300 v at 55 ma, 6.3 v at 3 amp. TYPE 1203-B Unit Power Supply or TYPE 1201-B Unit Regulated Power Supply is recommended.

DIMENSIONS

Width 9½, height 5¾, depth 6½ inches (240 by 150 by 165 mm), over-all.

NET WEIGHT

4½ pounds (2.1 kg).

Type		Code Word	Price
1217-B	Unit Pulse Generator	AMASS	\$250.00

AUTOMATIC MEASUREMENT OF PHONOGRAPH REPRODUCERS

By B. B. BAUER, Vice President
CBS Laboratories, Stamford, Connecticut

Among the latest of manual procedures to yield to automation is the measurement of phonograph reproducer characteristics. This is made possible by development of the new CBS Laboratories Type STR 100 Stereophonic Frequency Test Record, which is adapted for use with General Radio TYPE 1521-A Graphic Level Recorder.

A stereophonic record contains two related program channels which are identified with orthogonal modulations of the walls of a single groove. The left channel corresponds to the inner groove wall, the one closest to the center, and the right channel to the outer groove wall (away from the center). The positive directions of these modulations are at

+45° and -45° to the record surface, respectively (Figure 1). The pickup has a single stylus acting on a pair of transducers, arranged in an orthogonal fashion and intended to generate independent voltages when driven by the respective groove-wall modulations (Figure 2). The voltages e_l and e_r generated in the transducers drive two amplifiers and loudspeakers to reproduce the recorded information.

The only feasible way of testing the performance of a phonograph pickup is by use of a frequency-test record, on which tones have been recorded at various frequencies. Stereophonic frequency-test records have separate recordings for the left and the right channels. The response vs frequency of any given pickup channel produced by the corresponding record channel is known as "response-frequency characteristic" or simply "response" of the channel on the particular record. The response from the opposite channel is known as "crosstalk-frequency characteristic" or simply "crosstalk." The customary units for both characteristics are db re 1 volt rms. The difference at any one frequency (or average over a group of frequencies) between response and crosstalk is known as "channel separation," expressed in db.

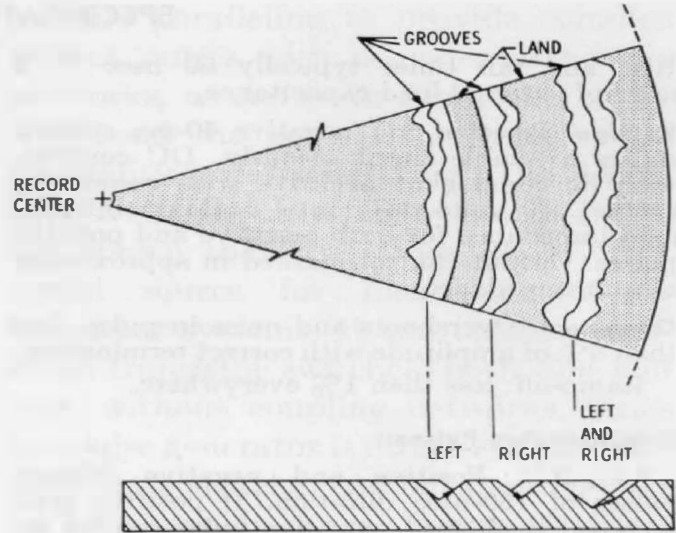


Figure 1. "Pie" representation of a stereophonic record portraying modulation associated with left channel, right channel, and combined left and right channels.

The STR 100 record has a frequency sweep band for each channel, and its frequency varies logarithmically with time, at a rate of 1 decade each 24 seconds. This corresponds to a chart speed on the General Radio TYPE 1521-A Graphic Level Recorder of thirty 1/4-inches per minute. The sweep band starts with a 1000-cycle tone of sufficient duration to permit the recorder pen to be set to the 40 cps ordinate and the recording level to be adjusted to a convenient value. Upon cessation of the 1000-cycle tone the frequency drops immediately to 40 cps and

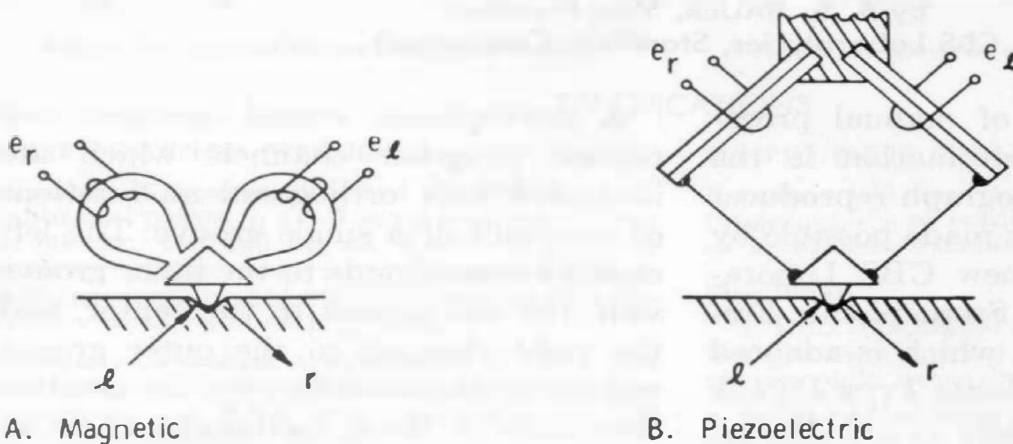


Figure 2. Typical arrangements of stereophonic pickups.

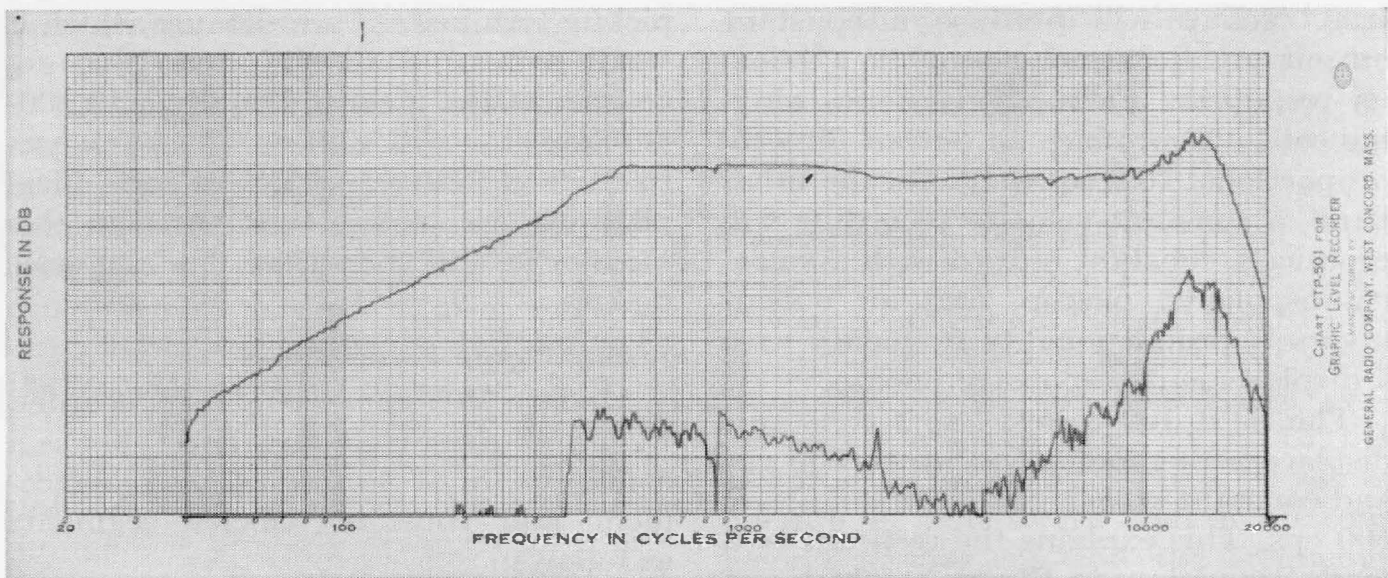


Figure 3. Automatically plotted response of typical high-grade magnetic pickup. Upper curve is direct response of one channel; lower curve is crosstalk from other channel.

then rises continuously to 20,000 cps in $24 \log (20,000/40) = 64.8$ seconds. Next, an interval is allowed for the operator to reset the recorder chart back to the 40 cps ordinate. Then, the right-channel 1-ke tone is heard, being followed by the right-channel sweep. If one channel of a pickup under test is connected to the recorder (through a suitable amplifier), then the response-frequency and the crosstalk-frequency characteristics for the particular channel will be successively recorded. A typical set of curves for a magnetic phonograph pickup is shown in Figure 3. Two such sets, one for each channel, are required to describe the performance of the pickup.

Previously available test records used spot-frequency tones not adapted for automatic recording. The STR 100 record also has such fixed-frequency tones for the left and right channels, but each tone is preceded by a voice announcement of frequency, so that there is no doubt as to which tone is being played. The results of the spot-frequency tests are similar to those obtained with the sweep-frequency bands, but the

process is far more laborious, and the information between the spot-frequency tones is not revealed. A system that appears flat when measured with spot-frequencies often has resonant peaks or dips in between the spot frequencies.

The spot-frequency bands in the STR 100 record above 500 cps were cut with the same recorder setup as were the sweep-tone bands. This permitted an absolute calibration of the sweep-tone bands by measurement of the spot-frequency bands with microscope and by diffraction-of-light patterns.¹

Test Record Characteristics

As indicated above, the reproducing characteristics of a pickup or system under test are referred to the characteristics of a particular test record. These may be defined in terms of displacement or velocity of groove modulation.

For constant-displacement recording, a displacement-responsive (piezo-elec-

¹58-IRE-19-S1, *Standards on Recording and Reproducing: Methods of Calibration of Mechanically Recorded Lateral Frequency Records*, Institute of Radio Engineers, 1 East 79th Street, N.Y. 21, N.Y.

tric) pickup will produce a constant output at all frequencies, while a velocity-responsive pickup (magnetic, moving coil) will produce an output directly proportional to frequency. On the other hand, a constant-velocity recording will produce a constant output with a velocity-responsive pickup, and an output inversely proportional to frequency with a displacement-responsive pickup.

The STR 100 record has a constant-displacement modulation up to 500 cps and constant-velocity modulation above 500 cps. This explains the response of a magnetic pickup in Figure 3, which is a rising straight-line in db vs log frequency at 6 db per octave below 500 cps and constant above 500 cps. The deviation of response from two straight lines denotes the departure of the pickup from ideal performance. The crosstalk curve, which is 20 to 30 db below the principal channel output, is typical of the channel separation that may be expected in present-day high-grade pickups.

Similar measurements can readily be performed on displacement-responsive pickups if the generated voltage is differentiated by connection across the

pickup terminals of a resistance which is small compared to the capacitive reactance of the pickup. Usually a 10,000-ohm resistor will suffice. The response-frequency characteristic of an ideal piezo-electric pickup terminated in this manner is similar to that of a magnetic pickup.

Testing Pickup Preamplifiers

Modern 33 1/3 rpm records are recorded with a frequency characteristic that is a composite of several constant-displacement and constant-velocity segments as follows:

Up to 50 cps — constant velocity.

From 50 to 500 cps — constant displacement.

From 500 to 2120 cps — constant velocity.

Above 2120 cps — constant displacement.

The transitions between these segments are not sharply defined, but instead they are blended together, in a manner defined by the RIAA.² The velocity (db)-vs-frequency character-

²Standard Recording and Reproducing Characteristic, Record Industries Association of America Inc., 1 East 57th Street, N.Y. 22, N.Y.

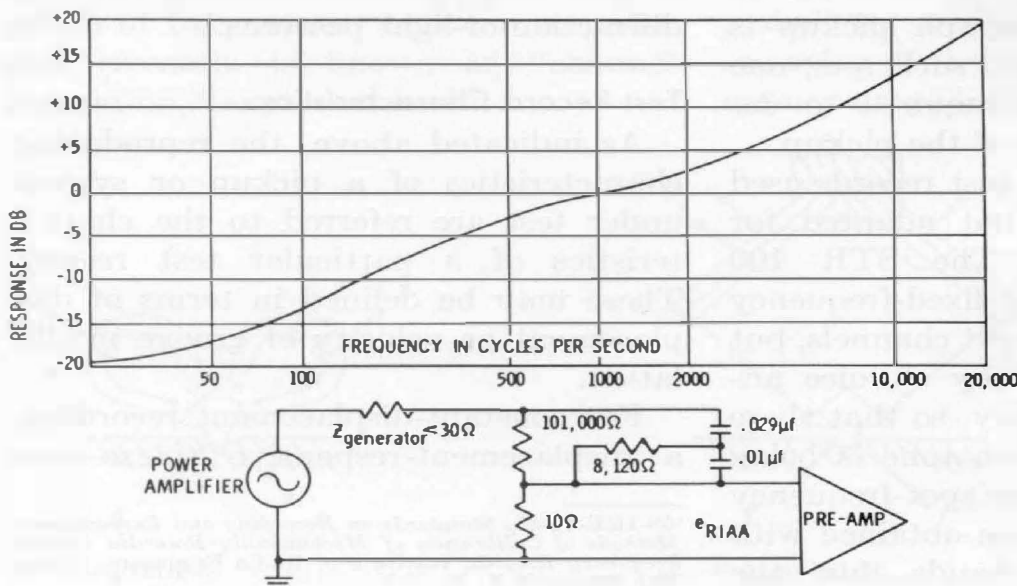


Figure 4. RIAA recording characteristic and R-C RIAA network.



istic which is obtained is shown in Figure 4.

When the pickup is a true velocity-responsive device, it follows that the pickup preamplifier should have an inverse RIAA characteristic. This characteristic of the preamplifier is most conveniently verified by the insertion of an RIAA generator network between the oscillator and the amplifier under test. One such network is shown in Figure 4. If the measured response is uniform with frequency, then the preamplifier is properly designed for reproducing records with a magnetic pickup. A TYPE 1521-A Recorder and TYPE 1304-B Beat-Frequency Audio Generator can be advantageously used in this test.

Over-all Measurements of Response Characteristics

The STR 100 record and the TYPE 1521-A Recorder can also be used to measure the over-all response-frequency characteristics of a playback system regardless of the type of pickup or amplifier employed. The ideal response-frequency characteristic of a properly adjusted reproduction system playing an STR 100 record will be simply the difference between the response-fre-

quency characteristic of the record and the RIAA characteristic shown in Figure 4. Subtracting these two results in the set of values in the accompanying table.

Tone-Arm-Resonance Test

To test resonance of tone arms, loudspeakers, etc., the STR 100 record provides sweep-tone bands, left and right, from 200 to 10 cps. These are synchronized also to the TYPE 1521-A Recorder. The recorder must be set to operate in reverse, as the sweep tone begins at 200 cps and the frequency decreases during the glide.

Automatic-Start Circuit

The 1000-cycle tones at the beginning of each glide serve not only for level adjustment, but also for keying an automatic-start circuit for the recorder. This circuit, developed by Messrs. A. Schwartz and A. Gust of CBS Laboratories, is shown in Figure 5.

The 1000-cycle keying tone preceding the sweep initiates the cycle. All relays are initially de-energized as shown in the schematic diagram. Left and right channel inputs are combined in the cathode of *V1* insuring that the keying tone will be present for either direct or crosstalk measurements. The cathode follower output is fed to the *V2* high gain amplifier through a high-*Q* LC 1000-cycle filter allowing only 1000 cps to feed through. Following this stage is a cathode follower *V3* employed as a power amplifier to drive a sensitive relay *K1* (Elgin Advance) after rectification by the two 1N2482 diodes. A Zener diode and clipping-range control prevent high signal levels from overheating the sensitive relay.

With *K1* energized, relay *K2* is energized and locks itself across the power

Ideal System Response — RIAA Equalized

Frequency	db	Frequency	db
1,000	0	800	+0.7
20,000	-19.5	600	+1.8
18,000	-18.8	500	+2.6
16,000	-17.7	400	+1.9
14,000	-16.6	300	+1.1
12,000	-15.3	200	+0.2
10,000	-13.7	150	-0.6
8,000	-11.9	100	-0.9
6,000	-9.6	80	-1.3
5,000	-8.2	60	-2.3
4,000	-6.6	50	-3.0
3,000	-4.8	40	-4.2
2,000	-2.6	30	-5.8
1,500	-1.5	25	-7.0
1,000	0	20	-8.6

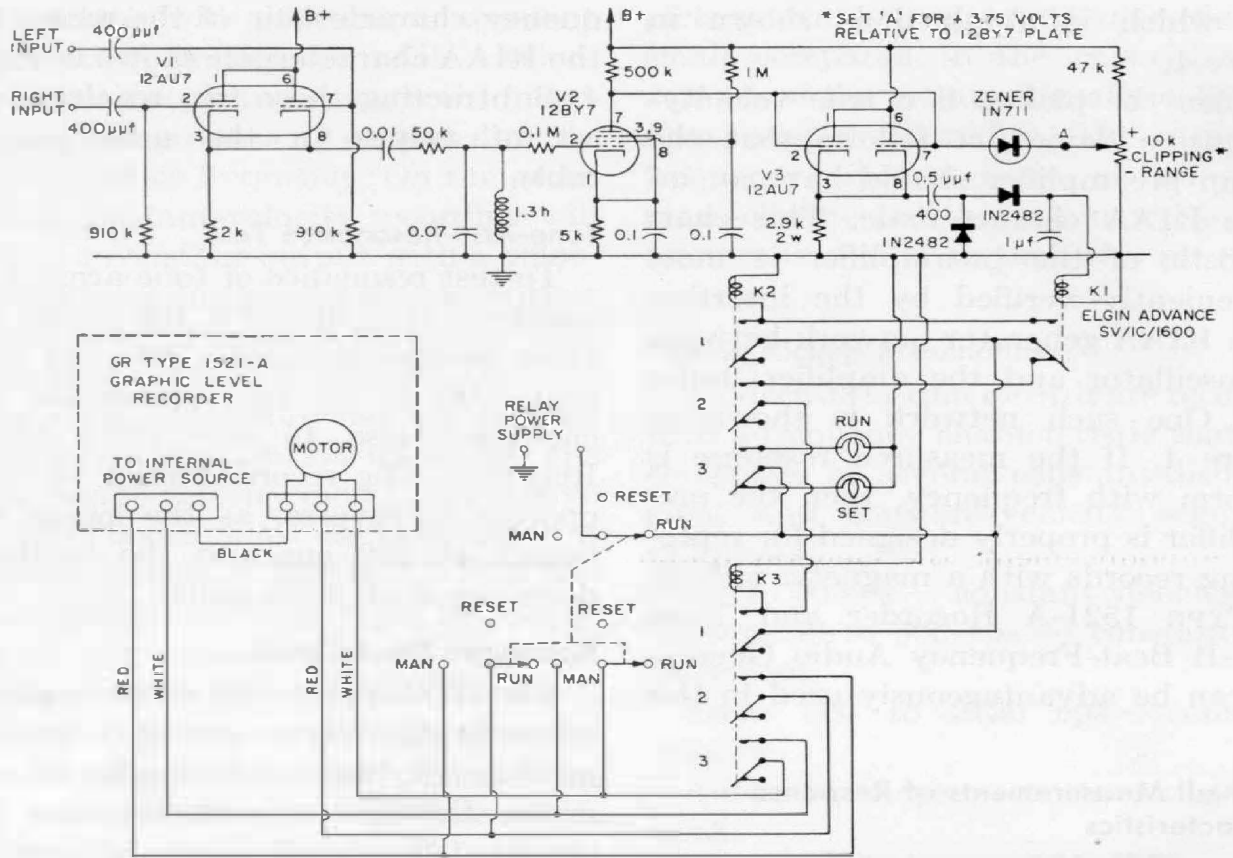


Figure 5. Automatic control circuit for the recorder.

supply through contact 1. At the cessation of the keying tone, *K1* is de-energized — thereby actuating *K3*, which starts the recorder motor at the instant the sweep begins. At the termination of the sweep band, the reset switch is manually set at RESET momentarily to de-energize *K2*, and the circuit is then ready for the next sweep.

Economics of Automation

The economic value of automation in testing phonograph reproducers deserves particular mention. The development of a phonograph pickup or complete player involves considerable experimental work in which the device under test is modified by successive rearrangement or modification of components until the desired performance is obtained. Each modification is followed

by response and separation tests. Spot-frequency tests require the better part of one hour. It has been estimated that one-third to one-half the manpower used in pickup and phonograph development is expended in this tedious endeavor. Delegating these measurements to an automatic device which does not mind tedium and makes no error releases trained manpower for more creative tasks and saves thousands of dollars annually. In one instance, changing from manual to automatic recording has been shown to save the cost of a recorder in a single month, and the cost of the new record in a single test.

Use by Audiophiles

While the STR 100 record has been designed especially for the professional user, the requirements of the audiophiles have also been kept in mind. Complete



instructions are included with each record for testing frequency range of the reproducing system, channel separation, pickup compliance and tracking, tone-arm resonance and stylus wear.

The STR 100 record is priced at \$8.50 and can be obtained from CBS Laboratories, Stamford, Connecticut, or from Columbia Records distributors and dealers.

MORE TALENTS, NEW DRESS, FOR THE OUTPUT POWER METER

In the nearly thirty years since its first announcement, the General Radio TYPE 583-A Output Power Meter has served as a work-horse of the audio-frequency industry. During this time, significant advances in material and techniques have made possible its replacement by a new instrument, based on the same general theory, but improved in all respects.

Both instruments are basically multi-tapped audio-frequency transformers that, by transformation ratio, reflect an essentially fixed secondary load as a variable primary impedance. They differ, however, in several respects, which make possible the new instrument's greater frequency, impedance, and power

ranges and its improved accuracy on complex waveforms.

The TYPE 583-A used a mu-metal core to secure high initial permeability (necessary for impedance accuracy at low power input), but was limited to a 5-watt maximum input by the low saturation level of mu-metal. The TYPE 1840-A secures high initial permeability through the use of grain-oriented silicon steel in a lamination specifically designed to take advantage of grain-orientation, and thereby increases its maximum input to 20 watts with but little increase in core size, since grain-oriented silicon-steel is a true "power" material.

The TYPE 583-A had ten secondary taps to yield ten impedance values

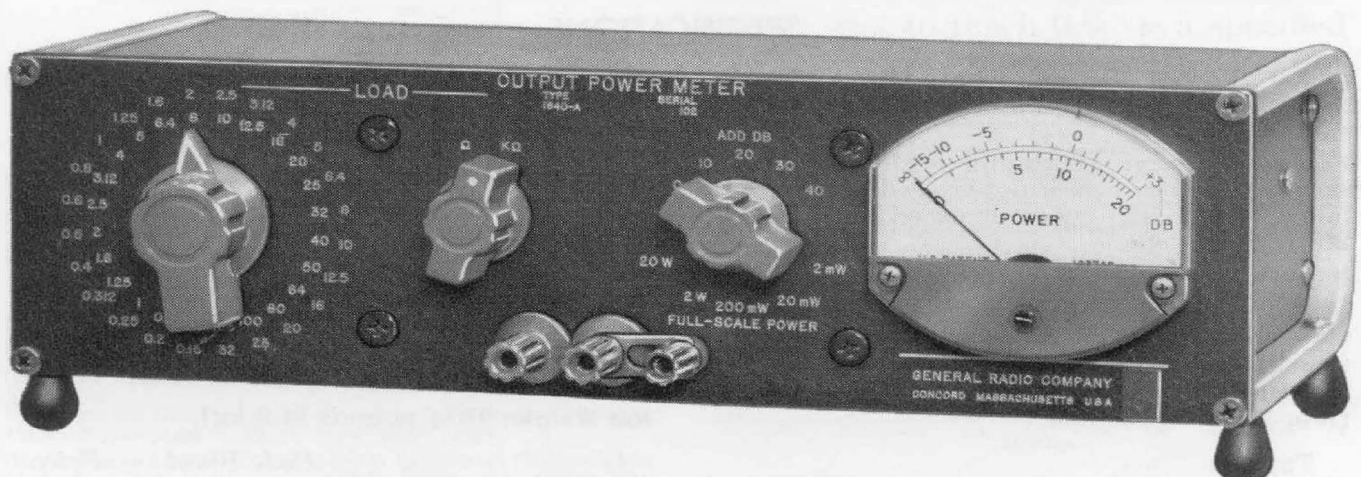


Figure 1. Panel view of the Output Power Meter.



spaced, approximately, at $\sqrt[10]{10}$ (tenth root of 10) intervals and four-primary taps to provide multiplication by powers of 10 (0.1, 1, 10, 100). This yielded forty impedance values between 2.5 and 20,000 ohms. The TYPE 1840-A has six secondary taps to yield six impedance values, spaced, approximately, at $\sqrt[6]{4}$ (sixth root of 4) intervals. Note that the two intervals are comparable

$$\sqrt[10]{10} \cong \sqrt[6]{4} \cong 1.26.$$

The TYPE 1840-A, however, has eight identical primaries, each tapped to provide a multiplier of 250/1, which primaries are switched from all parallel to all series in four configurations, each configuration introducing a multiplier of 4/1. The six secondary taps and four primary connections are all controlled by a single twenty-four position rotary switch yielding six times four, or twenty-four, discrete impedance values. The taps on all eight primaries are switched, simultaneously, by the ohms-kilohms switch. The ohms range lies between 0.6 and 128 ohms. The kilohms range multiplies these values by 250, to yield 0.15 to 32 kilohms. The net result of all these shenanigans is more efficient use of the transformer windings. While, in the

older instrument, up to forty percent of the input power was dissipated in the windings, in the new model it is reduced to less than eight percent. This fivefold decrease in winding dissipation so reduces the winding's contribution to input impedance that all TYPE 1840-A's use the same accurate resistors in contrast to the hand-tailored resistors required for each TYPE 583-A.

A further advantage of primary switching is apparent in the improved frequency response. Since all primaries are always active, and are interleaved with the secondary windings in two pi's, an octave improvement in both high and low frequency response has been achieved.

The quasi-rms meter in the TYPE 1840-A tolerates second and third harmonics up to 20% in the signal without departure from a true rms indication. The new General Radio rack-bench-instrument cabinet provides convenience, access and an adjustable tilt for easy reading.

A T-network attenuator, described in the instruction book, permits extension of the power level to 200 watts for any particular impedance setting.

— GILBERT SMILEY

SPECIFICATIONS

Power Range: 0.1 milliwatt to 20 watts. Auxiliary db scale reads from -15 to +43 db re 1 milliwatt.

Power Accuracy: Maximum error in full-scale power indication does not exceed 0.5 db from 50 to 10,000 cps; does not exceed 1.5 db from 20 to 20,000 cps.

Impedance Range: 0.6 ohm to 32 kilohms in two ranges; yielding 48 individual impedances spaced $\sqrt[6]{4}$ apart.

Impedance Accuracy: Maximum error does not exceed $\pm 5\%$ from 100 to 10,000 cps or $\pm 50\%$ from 20 to 30,000 cps.

Waveform Error: A quasi-rms meter is used which will indicate true rms with as much as 20% second and third harmonics.

Cabinet: Rack-bench instrument cabinet, aluminum panel. Cabinet has extension legs to permit instrument to be used in a tilted position. Panel extensions are available for relay-rack mounting.

Dimensions: Panel, width 12, height 3 1/2 inches (305 by 89 mm); depth behind panel, 6 1/2 inches (170 mm).

Net Weight: 10 3/4 pounds (4.9 kg).

Type		Code Word	Price
1840-A	Output Power Meter.....	BELOW	\$210.00



THE MEASUREMENT OF THE BALLISTICS OF INDICATING INSTRUMENTS

The ballistic characteristics of moving-coil electrical indicating instruments are important in many applications, for example, in VU meters, sound-level meters, and modulation monitors. They can be uniquely defined in terms of (1) dc resistance, (2) time to first rise to a specified point, when energized from a high-impedance source, (3) overshoot, and (4) time to fall from one point to another with the instrument terminals short-circuited.

Stroboscopic light offers a means of determining (2), (3), and (4), while (1) is easily measured by a conventional bridge. One method of measurement previously described¹ used a continuous-film camera in conjunction with a stroboscope.

delays are supplied by two TYPE 1217-B Unit Pulse Generators.

The electrical indicating instrument is energized simultaneously with the triggering of one pulse generator. The pulse generator fires the Strobotac at a time later than the initial event determined by the setting of the pulse-duration dial. The pointer is seen by a single, microsecond flash of light from the stroboscope after the pointer has moved for the length of time that the stroboscope firing impulse was delayed. A series of such observations at different delay times will provide data for plots such as that in Figure 2. The details of the initial acceleration, the rate of rise and the overshoot with its decaying oscillation are readily apparent. The ballistic parameters of the instrument mechanism can be derived by analysis of curves plotted by this method.

Production quality control is an important use of this delay-generator-stroboscope technique. For our own instrument specifications we have defined rise time as "the time, in seconds, for the pointer first to reach 0.9, ± a specified tolerance, of the end scale when constant

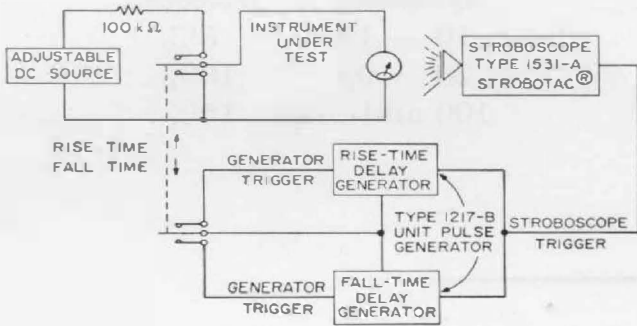


Figure 1. Block diagram of the meter test system.

A new technique of measurement, permitting direct observation,² has been made possible by the short, high-intensity flash of the General Radio TYPE 1531-A Strobotac[®] Electronic Stroboscope. Figure 1 is a block diagram of the test setup. The necessary time

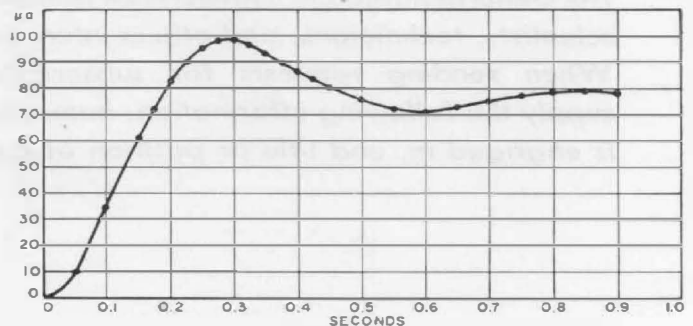


Figure 2. Plot of meter deflection vs time from data taken with the test system of Figure 1.

¹"A Note on the Measurement of Meter Speeds," *General Radio Experimenter*, 10, 6, November, 1935.

²R. G. Fulks and H. C. Littlejohn, "A Direct Observation of Instrument Ballistics," AIEE Paper No. CP62-370, presented at the AIEE Winter General Meeting, N. Y., N. Y., January 28 - February 2, 1962.



electric power is suddenly applied from a high impedance source"; likewise, fall time as "the time, in seconds, for the pointer to reach 0.1, ± a specified tolerance, of end scale from a steady end-scale deflection when the instrument is short circuited."³

For production testing two delay generators are used, one energized when the electrical instrument is energized and the other when the electrical instrument is short circuited. One generator is set to the specified rise time, the other to the specified fall time. An operator then

³Definitions to be incorporated in proposed revision of ASA C39-1 American Standard Requirements for Electrical Measuring Instruments.

simply places the instrument to be tested in a fixture, which makes the connections and indicates the spread allowed in rise-time deflection and fall-time deflection. By the flipping of a switch once for rise time and again for fall time the inspection is completed.

Our system of direct observation of instrument ballistics will serve the research engineer and the quality-control man alike.

— H. C. LITTLEJOHN

CREDITS

This method of test was developed by R. G. Fulks, A. E. Sanderson, and H. C. Littlejohn. — EDITOR

QUANTITY DISCOUNTS FOR COAXIAL CONNECTORS AND ADAPTORS

Prices of TYPE 874 Adaptors listed in the table on page 10 of the October, 1961, *Experimenter* are subject to domestic quantity discounts as listed below.

This schedule also applies to quanti-

ties of 10 to 99 of the connectors listed in the table on page 9 of the same issue.

Quantity	Discount
10 — 19	5%
20 — 99	10%
100 and over	15%

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

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