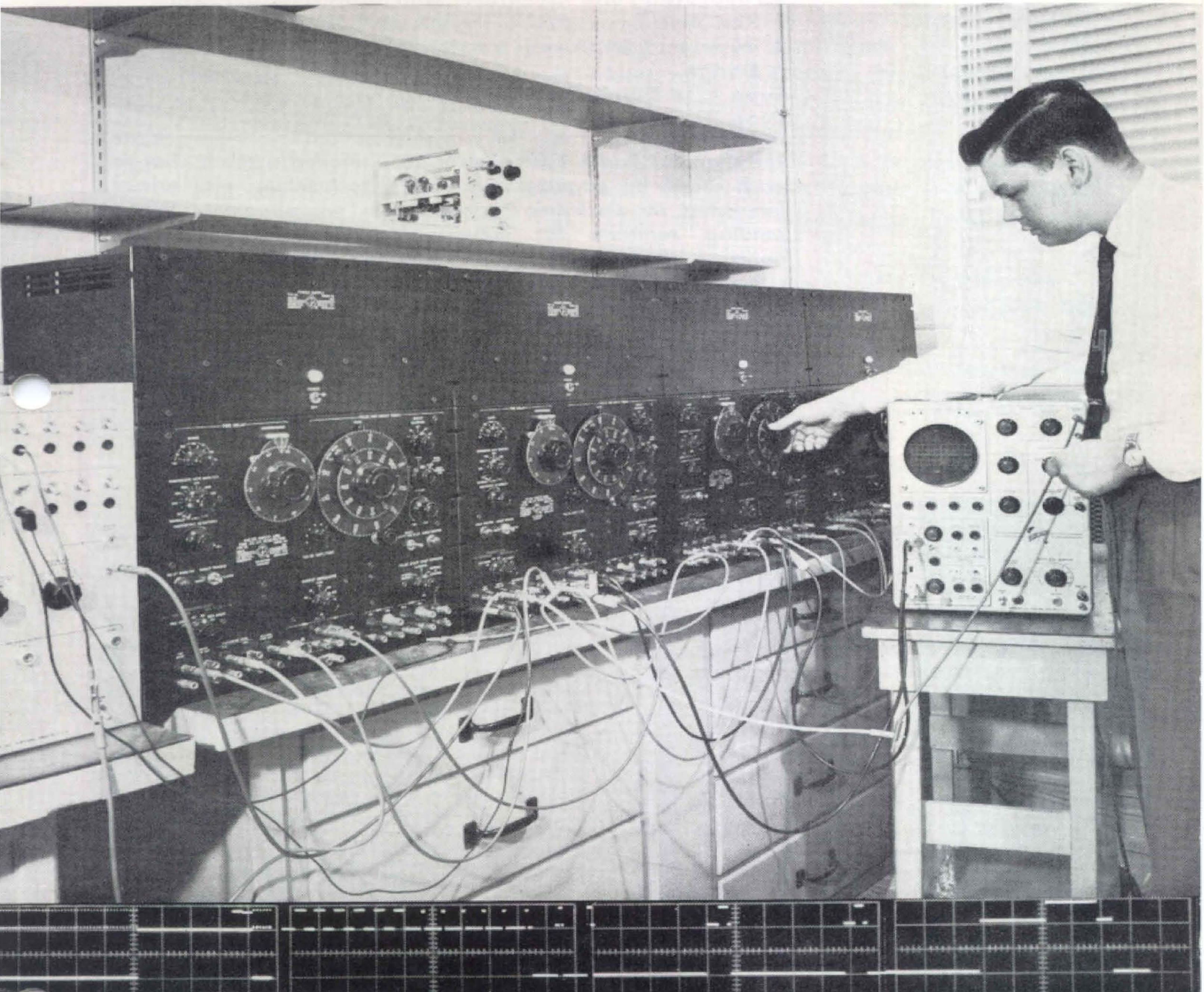
the GENERAL RADIO

Experimenter

Since 1915 – Manufacturers of Electronic Apparatus for Science and Industry

VOLUME 33 No. 2 FEBRUARY, 1959



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Vacuum-Tube Bridge

the GENERAL RADIO **Experimenter**

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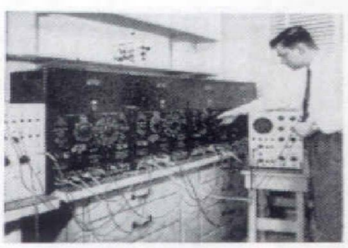
COVER



The output currents from several Type 1391-B Pulse, Sweep, and Time-Delay Generators can be added to produce very complex waveforms. This photograph shows four generators whose outputs are combined to synthesize across the load resistor of one generator the waveforms shown at the base of the photograph.

AN IMPROVED PULSE GENERATOR WITH 15-MILLIMICROSECOND RISE TIME

The Type 1391-B Pulse, Sweep, and Time-Delay Generator is a general-purpose laboratory tool for the synthesis of pulse waveforms and for controlling the occurrence of those waveforms in time. The Type 1391-A model, originally described in 1953, was the result of an effort to extend the signal generator concept to the field of pulse measurements. Before this time, pulse generators had usually been either cranky "breadboards" or highly specialized (and still cranky) commercial devices. This new model reflects both field experience and an advance in technology which brings it nearer to the status of the standard-signal generator as an accurate, stable, and dependable laboratory tool.

An outstanding feature of the new generator is its improved pulse generating circuit with faster rise time, better pulse shape, and improved reliability. Other outstanding characteristics of the predecessor, Type 1391-A, are retained[1, 2]. In particular, the following retained features have been improved:

1. The instrument produces an output signal of 0.15 ampere into any impedance level up to 600 ohms, thus permitting a wide choice of generator source impedance and pulse amplitude.

2. It produces this output signal direct coupled, so that pulses of *any* duration at *any* impedance level do not exhibit ramp-off effects.

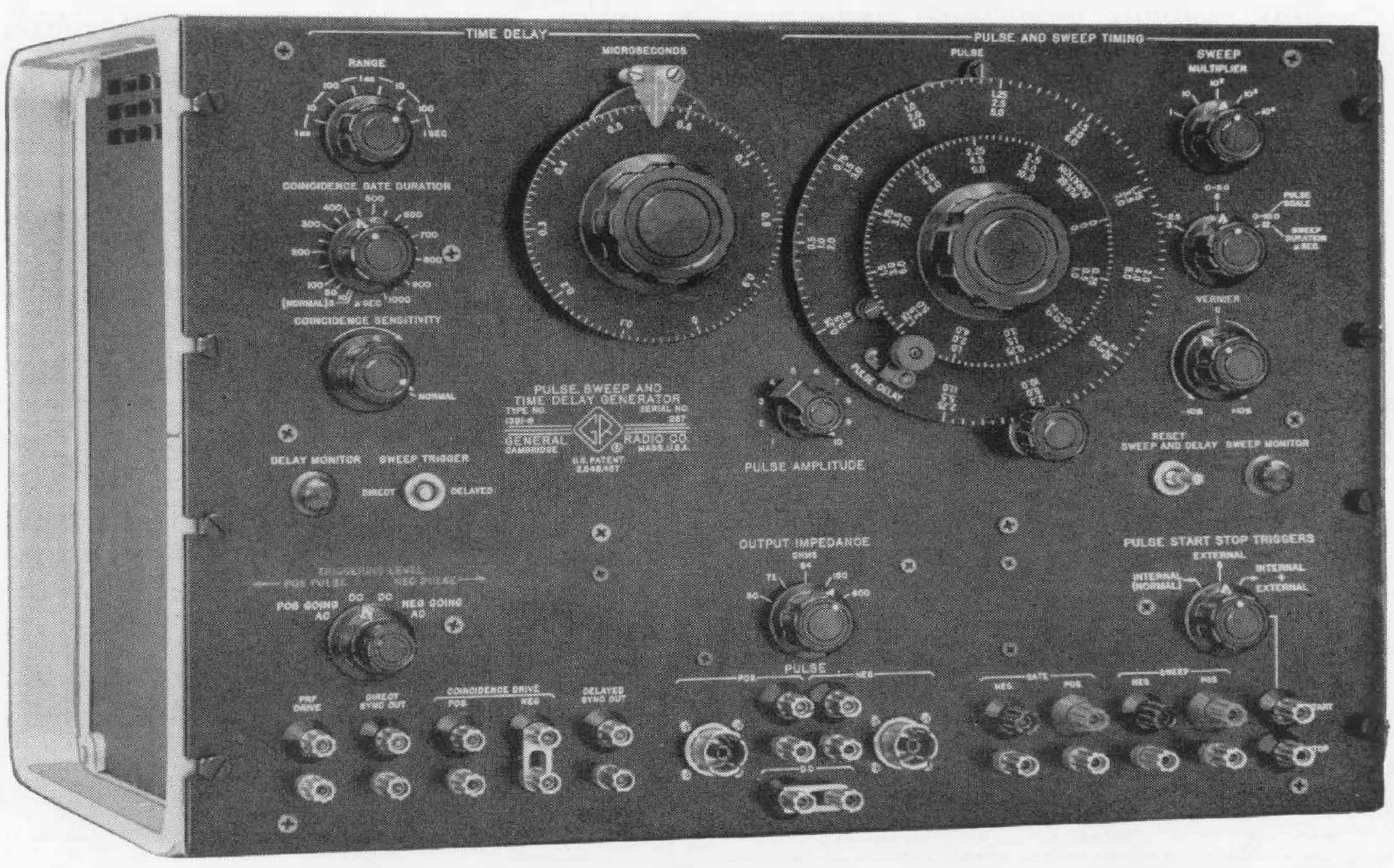
3. It has no duty-ratio restrictions.

4. It permits the user to inject his own dc component.

[1] *Proceedings of the National Electronics Conference*. 1953.

[2] R. W. Frank, "A Versatile Generator for Time-Domain Measurements," *General Radio Experimenter*, Vol. 30, No. 12, May, 1956, pp. 1-13.

Figure 1. Panel view of the Pulse, Sweep, and Time-Delay Generator.



Improvements

A completely new principle was used in the design of the dc coupled stages of the pulse generator and output system to increase their bandwidths with a consequent reduction in rise time. The improved rise time makes this pulse generator compatible with the fastest standard oscilloscopes.

A future article is planned in which the theoretical increase in bandwidth for these dc-coupled pulse circuits will be derived. The decrease in rise time is better than two-to-one. In this instrument we chose not to press for the full theoretical increase in bandwidth, but instead to design circuits of increased stability and reliability. Negative-feedback principles and reduced plate dissipation (most of the pulse-amplifier tubes run at less than half their maximum plate dissipation) make the characteristics of the pulse essentially independent of tube aging and line-voltage variations.

In addition to the extensive modification of the pulse generating and output system, important changes have been made in the input circuits, and improvements have been made in the switching system for starting and stopping the main pulse.

The changes in the input circuit now permit (1) either ac or dc connection from the external systems to the trigger circuit and (2) an adjustment of the triggering threshold voltage. This increases the adaptability of the instrument in laboratory systems, since the sensitivity for brief pulses can be optimized, the input circuits can be gated, and some range of phasing for slowly varying waveforms can be had. These possibilities are explored further under *Input Circuits*, below.

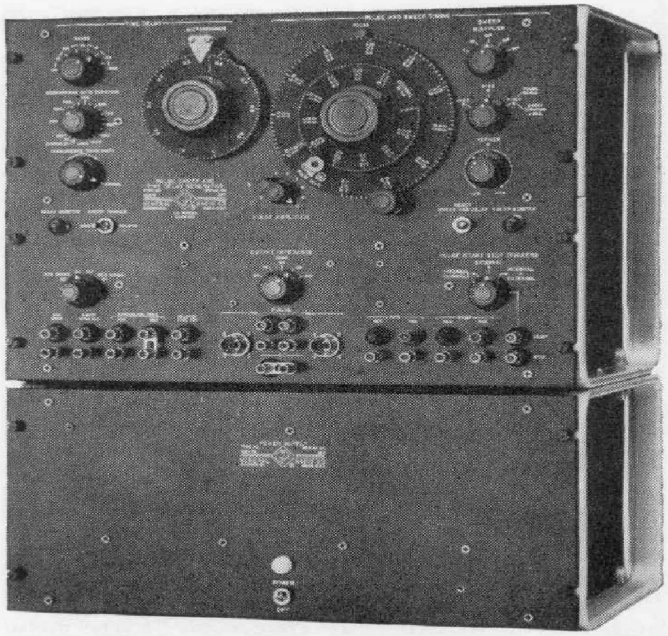


Figure 2. View of generator and power supply.

A change in the switch which routes the "start" and "stop" triggering pulses determining the duration of the main pulse has been made. With this new arrangement it is possible to mix internally produced pulses with pulses generated by outside systems or with pulses produced by the input and delay circuits of the TYPE 1391 itself. With the pulse timed by both the normal system and the delay circuits, the user can produce an accurately timed double pulse. If externally generated pulses are mixed with those produced internally, multiple pulses or even pulses having different repetition rates will be produced by the pulse-generating circuits.

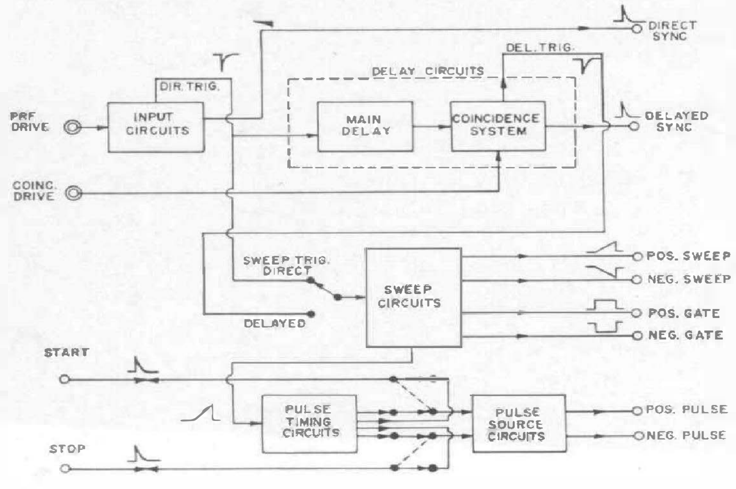


Figure 3A. System block diagram showing major circuit groups and their interconnections.

The newly designed pulse-generating circuits permit some simplification of the power-supply circuitry. Along with the changes necessary for the new circuitry, the selenium rectifiers used in the power supply have been replaced with silicon types, resulting in a reduction of volume required for components and permitting a reduction in the height of the power supply panel.

System

The TYPE 1391-B Pulse, Sweep, and Time-Delay Generator (Figures 1 and 2), as its lengthy name implies, is a combination of three instruments in one. It consists (Figure 3) of a precision delay generator, a saw-tooth sweep generator, and a pulse generator. A versatile input circuit is included, which is capable of driving the three corresponding generating circuits at any recurrence rate from zero to their maximum capabilities. The timing waveform to set the PRF can be sine waves, square waves, or pulses, and it can be provided either by a periodic signal source such as the General Radio TYPE 1210-C Unit R-C Oscillator, or by a one-shot, or random, change in voltage. Alternatively, an output signal from the generator can be fed back into the input terminal to provide a timing period set by the internal circuits themselves. Used in this way, the instrument is a self-contained timing generator of good accuracy and stability.

To provide for the utmost in applicability, many input and output terminals and switches permit interconnection of the major units among themselves and to and from external circuitry. These connections and switching are shown in Figure 3 and will be discussed in connection with the individual circuit groups below.

Input Circuits

The input circuits (Figure 4) provide a triggering pulse to initiate the action of the various circuit systems comprising the generator. They also provide a master synchronizing pulse to synchronize other equipment with the generator. These triggering signals are nearly invariant in slope and duration, irrespective of the slope and amplitude of the driving signal.

The new input switch and dc threshold control make it possible to select either positive-going or negative-going portions

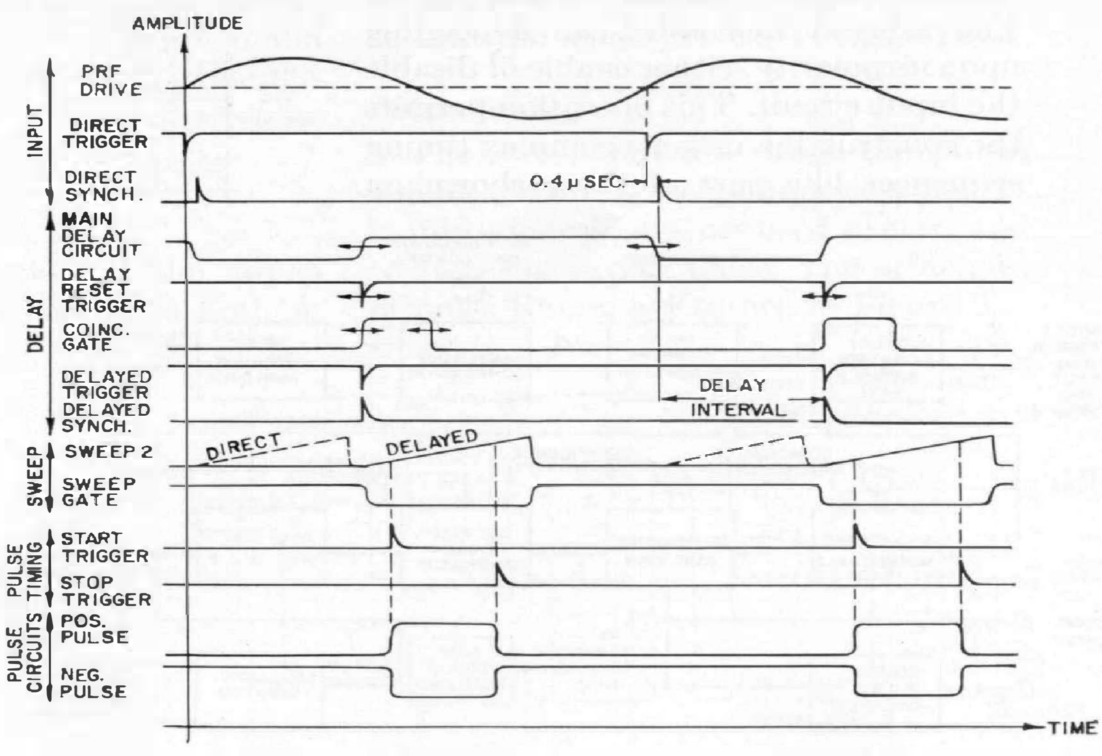


Figure 3B. Timing diagram for the complete system.

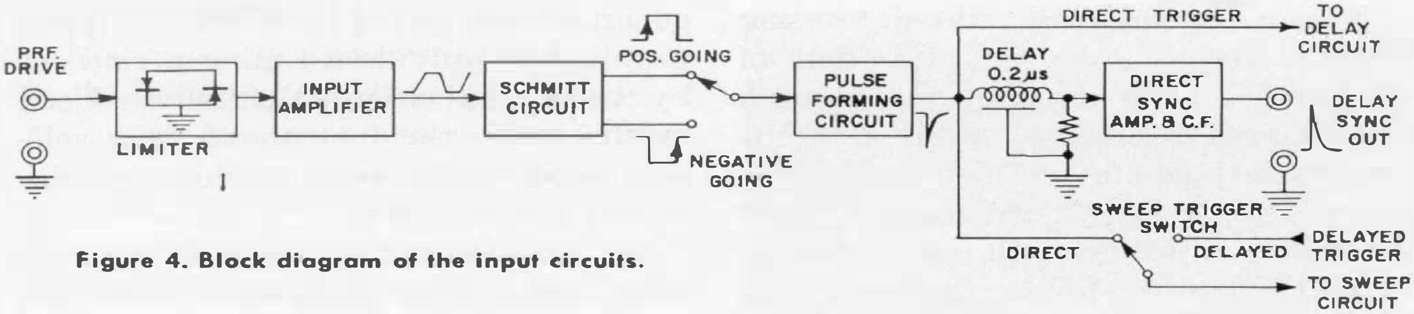


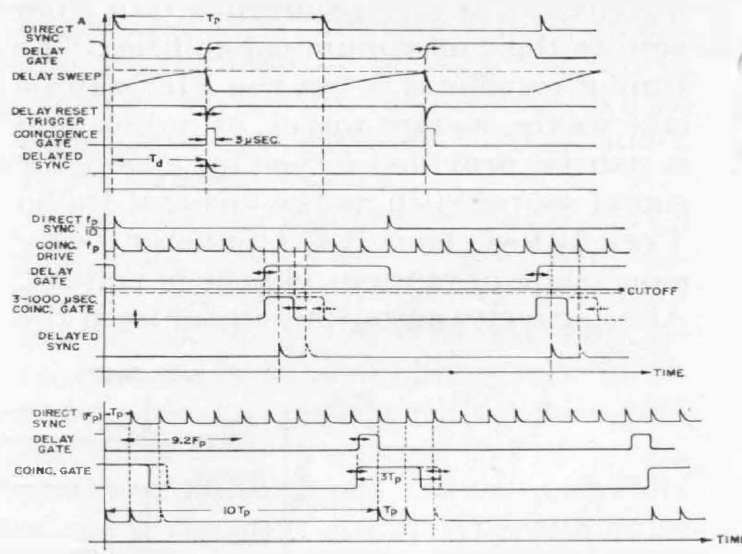
Figure 4. Block diagram of the input circuits.

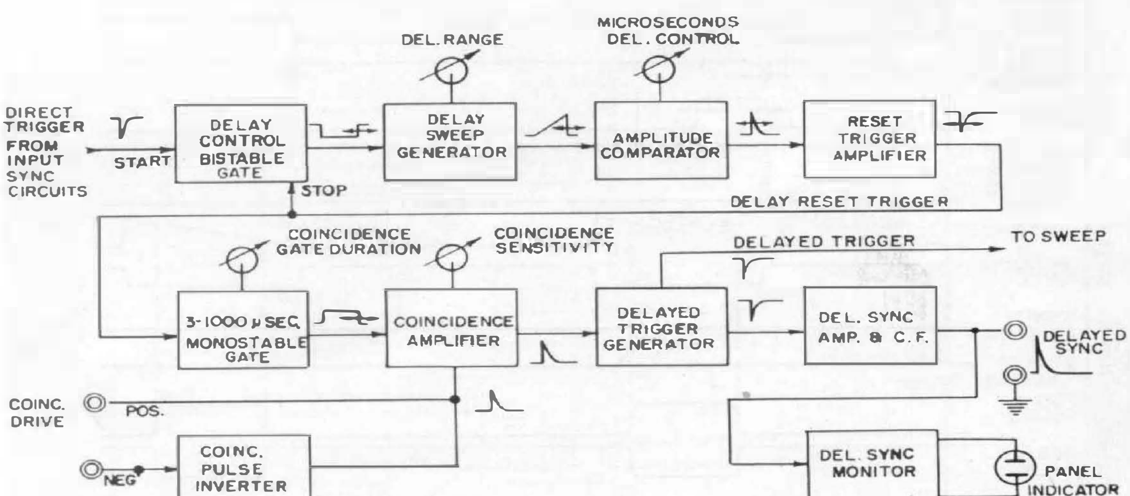
of the input signal to trigger the synchronizing circuits. The switch couples the input signal either directly or capacitively to the trigger circuits, and the threshold control selects, over a limited range, the actual voltage at which the trigger circuits will fire. This control enables the user to optimize the sensitivity to input pulses of either polarity and to initiate the trigger at voltages corresponding precisely to the zero crossings of any waveform.

The cover photograph illustrates a unique and important feature of the new input circuits. The input circuits themselves serve as a very efficient "and" gating circuit, which can, for instance, be used to produce pulse bursts. Another Type 1391 Generator (or any other dc coupled source of pulses, for that matter) is connected to the input terminals in addition to the normal driving signal. The pedestal thus added can, depending upon its polarity, either enable or disable the input circuit. This operation permits the construction of very complex timing sequences like part of those shown on the cover, in which, for example, a "vertical" blanking pedestal will automatically inhibit the formation of "horizontal" synchronizing pulses.

Delay Circuits

The direct trigger initiates the operation of the delay circuits (Figure 5), which normally produce the delayed synchronizing pulse at an accurately controlled time after the direct sync pulse. This time interval can be varied





(*Left*) Figure 5A. Block diagram of the delay circuits.

(*Above*) Figure 5B. Delay-circuit timing. (*Top*) Coincidence circuit set for normal operation. (*Center*) Multiple-pulse timing. (*Bottom*) Delay circuit used as a prf divider.

from 1 microsecond to 1 second by the 10-turn delay control and the 6-decade range switch, with an absolute accuracy of delay relative to the direct sync pulse of better than ±3% over the entire range. The usefulness of the 1-μsec-to-1-second delay circuit is increased by the 3- to 1000-μsec coincidence gate system (Figure 5B). Through the use of this circuit, multiple pulses, precision delays, and accurate delay-circuit calibration can be accomplished. The similar circuits

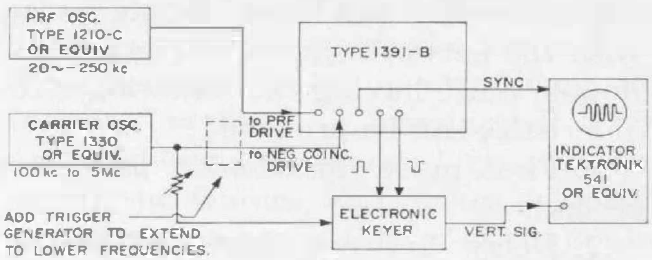


Figure 7. Block diagram of system for generating tone bursts.

of the 1392-A Time-Delay Generator were discussed both in theory and in application in the December, 1958, *Experimenter*. The system, shown in Figure 5, breaks down the various functions of gating, sweep generation, amplitude comparison, and reset of the gating circuits in such a way that accuracy, stability, and resolution are all assured.

One example of the versatility of the delay system is shown in Figures 6 and 7. The output pulse is made coherent with a high frequency to produce tone bursts.

Sweep Circuits

The primary function of the sweep generator is to time the pulse both in

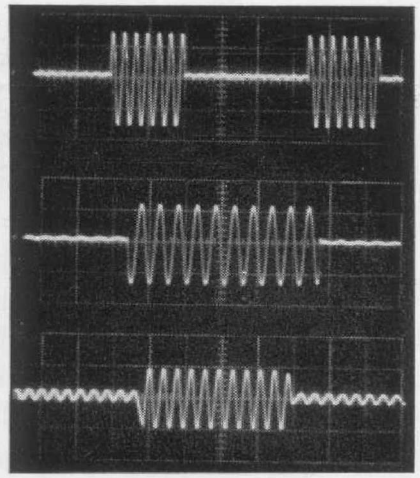


Figure 6. Coherent tone bursts.

(a) 200-kc signal 10-kc burst rate.

(b) 1-Mc signal 10-kc rate.

(c) 5-Mc signal: note increased crosstalk in keyer; note also absence of switching transients.

duration and delay relative to the direct synchronizing pulse or the delayed synchronizing pulse, either of which can be used to start the sweep circuits. The sweep-generating circuits as shown in Figure 8 consist of a bistable gate, "bootstrap," linear sweep circuit, amplitude comparator, and resetting circuits. The push-pull, linear, saw tooth produced by this group of circuits is fed at 135-volt amplitude through isolating cathode followers to output terminals for use with external systems. Positive and negative gate pulses corresponding in time to the start and the stop times of the sweep are also provided at output terminals. The duration of the sweep is nominally 3, 6, or 12 μsecs with a five-decade multiplier so that the longest sweep is 0.12 second.

Pulse Timing

The sweep circuits drive the pulse-timing circuits which comprise a pair of amplitude comparators used to start and to stop the output pulse. The principles of pulse timing are shown in Figure 9.

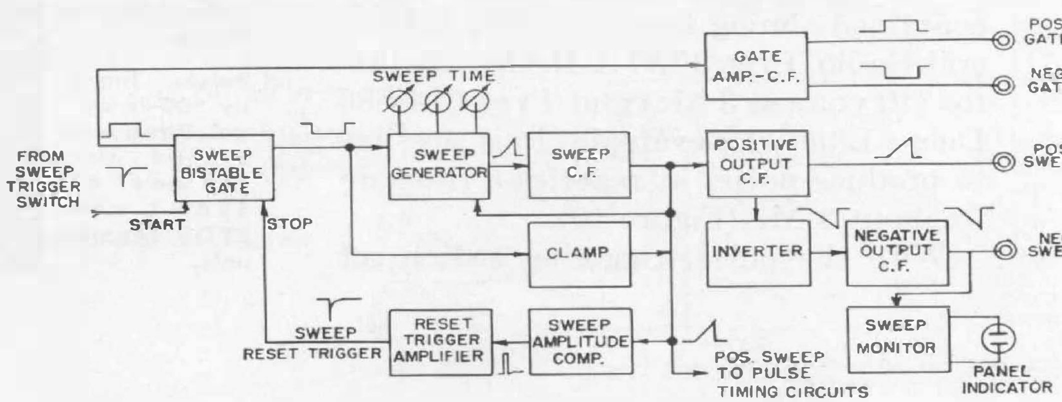


Figure 8. Block diagram of sweep circuits.

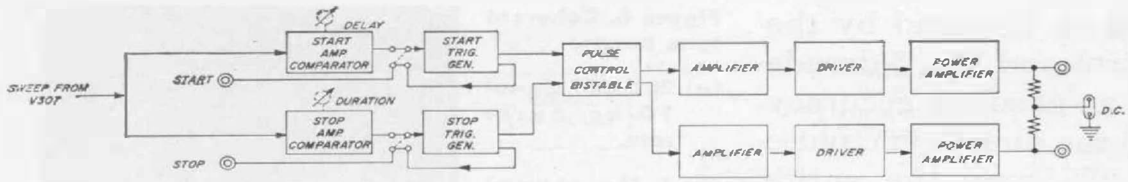


Figure 9. Block diagram of pulse timing and output circuits.

The pulse-timing amplitude-comparison circuits are followed by trigger-forming circuits which produce high-speed pulses to start and stop the pulse generator. Between the amplitude-comparison circuits and the trigger-forming circuits switching is inserted to provide:

(1) Normal operation, in which the amplitude comparators delay the pulse and time its duration relative to the sweep as described above. In this position the trigger pulses, which correspond to "start" and "stop" time, are fed to front-panel binding posts labeled "start" and "stop," respectively.

(2) Means to start and stop the pulse generator using externally generated and timed signals.

(3) For the addition of both internally produced and externally generated timing signals to start and stop the pulse.

These three possible methods of driving the pulse generating circuits contribute to the versatility of the instrument. In normal operation, the start-and-stop triggering pulses available at the trigger-pulse output terminals can be used for making time measurements in external systems, for checking flip-flop resolution, etc. In (2) above, the application of an external signal will permit the pulse generator to be operated at rates far in excess of the 250-kc maximum repetition rate set by the 3-μsec sweep in the self-contained timing system. Using a General Radio TYPE 1330-A Bridge Oscillator (10 volts at 3 Mc) and TYPE 314-S86 Delay Line,[3] for example, it is possible to produce pulses at repetition rates up to about 3 Mc (Figure 10).

With the pulse triggering switch set as in (3) above, any number of start-and-stop pulses can be superimposed upon those generated internally. As a particular example of this application, the generator becomes a useful tool for generating pulse pairs.[3] By addition of the direct and delayed synchronizing pulses to the internally produced timing pulses with the network shown in Figure 11, a double pulse having the following characteristics can be produced:

1. First pulse duration, 1 μsec to 1 second.

2. Delay between first and second pulse, 0.25 μsec to 0.1 second.

3. Duration of second pulse, 0.025 μsec to 0.1 second.

Pairs of pulses produced by this method are shown in Figure 12.

Pulse Generating and Output Circuits

A simplified schematic diagram of the newly designed pulse generating and output circuit is shown in Figure 13. The circuits comprise a bistable multivibra-

[3] F. D. Lewis, R. M. Frazier, "A New Type of Variable Delay Line," *General Radio Experimenter*, Vol. 31, No. 5, October, 1956, pp. 1-8.

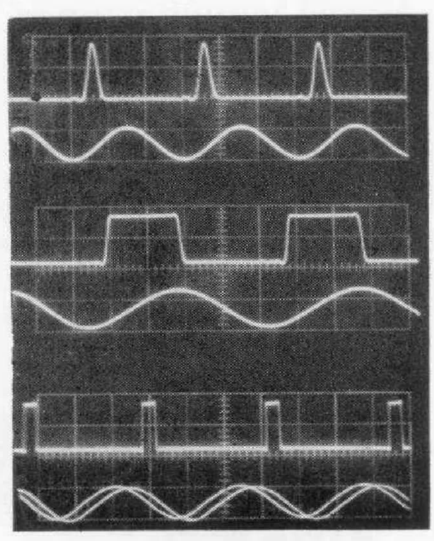


Figure 10. Pulses at high repetition rates; external timing.

(a) 0.03 μsec pulse. 3.3-Mc timing signal.

(b) 0.4 μsec pulse. 1-Mc timing signal.

(c) Pulses timed by 500-kc signal. Direct and delayed sine waves at START and STOP terminals.

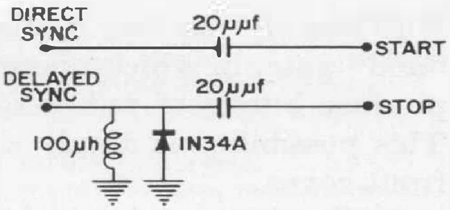


Figure 11. Adding network for producing pulses.

tor, started and stopped by timing pulses, a pair of pulse amplifiers, and an output stage. The output stage consists of a pair of push-pull 6550 beam tubes driven by a pair of 6AV5's. The circuits from the bistable multivibrator onward are push-pull and direct-coupled by a unique method in which the loss in gain characteristic of the conventional dc coupling methods is eliminated. This new coupling system uses high-μ triodes as current sources, and makes practical an increase in bandwidth of about 3:1 in a circuit like that in Figure 13. This circuit can be viewed as a video amplifier flat from dc to about 25 Mc.

All stages, including the output tubes, work well below their maximum cathode-current and plate-dissipation ratings, and all stages in the "on" state operate well into the negative grid region, under self-biased conditions, permitting the stabilization of plate current during the life of the tube. The 6550 output tubes supply about 150 ma to the variable source resistors across which the pulse is produced. The common transmission-line impedances of 50, 72, 94, 150, and 600 ohms are provided internally, and any impedance lower than 600 ohms can be obtained by the connection of an appropriate resistor in parallel with the internal resistors. Examination of Figure 13 shows that the pulse of voltage developed across these resistors contains a dc component which is negative with respect to ground at the output terminals. Only by preservation of the dc component can pulses of long durations at low-impedance levels be delivered to the outside world without deterioration of waveform. The dc component can be changed over about a ± 50-volt range by the addition at the dc-insertion binding post of either a resistor for negative translation or a dc voltage for positive translation.

Pulse amplitude can be changed over a decade range by use of the built-in step-amplitude control switch. This switch reduces pulse amplitude in ten steps. Pulse amplitude is stabilized against variations or transients in line voltage. A 20% change in line voltage will produce no visible transient in either pulse shape or duration, and only a very small long-

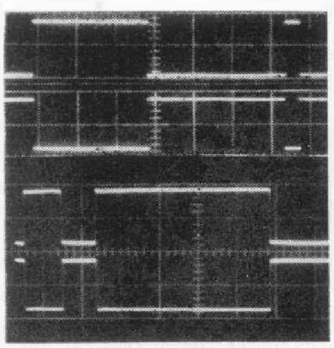


Figure 12. Double pulses.
(a) First pulse, 30 μsec; 30-μsec delay; second pulse, 5 μsec. Generator self-timed at 10 kc.
(b) First pulse, 1 μsec; 1-μsec delay; second pulse, 5 μsec.

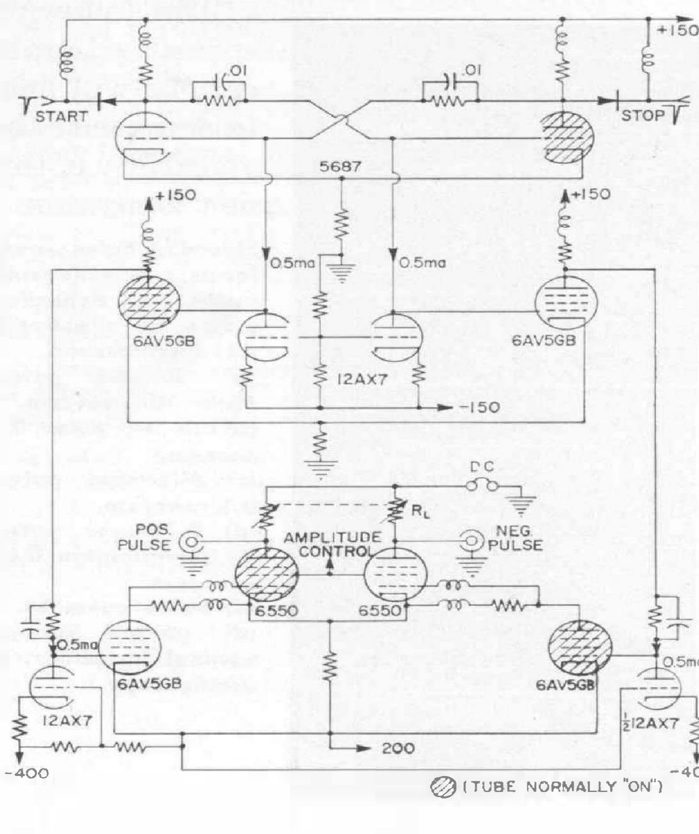


Figure 13. Simplified schematic of the pulse generating circuits.

term variation in pulse amplitude, which is due entirely to cathode temperature variation with heater-supply voltage.

Figure 14 consists of unretouched photographs of output pulses under various conditions. Careful examination of these pictures for the characteristics of rise time, overshoot, and flatness will convey a better feeling for the over-all quality of the pulses produced by this generator than can the words used to describe them or their specifications. The reader should note particularly Figure 14 (C and D) which shows the pulse applied directly on the deflecting plates of a Tektronix 541 Oscilloscope and the same pulse passed through the 53/54-C plug-in unit and oscilloscope amplifiers. With the 53/54-C plug-in unit this oscilloscope has a rated rise time of 14 mμ seconds.

Summary and Applications

Since the Type 1391-B is such a general-purpose device, it is very difficult to make a complete listing of applications. To the reader the applications to his work will probably be obvious.

The following specialized applications will help to emphasize the versatility of this new generator:

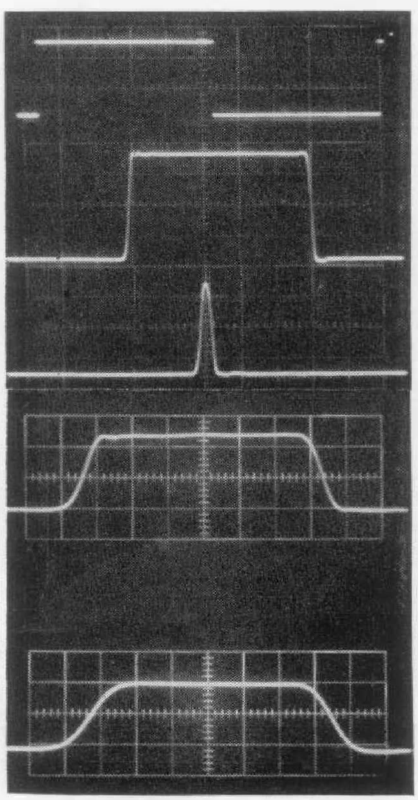


Figure 14. Pulse waveforms; connections directly to deflection plates of Tektronix 541 Oscilloscope.
(a) 50-μsec pulse; scale 10 μsec/cm.
(b) 0.5-μsec pulse; 0.1 μsec/cm.
(c) Minimum pulse; 0.1 μsec/cm.
(d) 0.12-μsec pulse, 94 Ω termination, 0.02 μsec/cm.
(e) Same pulse as in (d), passed through vertical amplifier of oscilloscope.

1. Use of the input circuits as an "and" gate, in which one generator can produce bursts of pulses from another. This possibility is amply shown on the front cover.

2. The delay and coincidence circuits can produce pulses capable of timing bursts of high frequency coherent with any frequency within the generator's specified range of PRF's.

3. The linear sweep produced at the sweep output terminals can be used to produce a multiplicity of pulses, all of individually variable duration and delay. Use of the amplitude comparator described in the January, 1959, *Experimenter* is recommended.

4. Since the pulse output circuit consists of a current source and load resistor, the currents from several 1391-B's can be added to produce a very complex waveform without the usual adding circuit; again, note the front cover illustration where the complex waveform developed by four instruments appears across the load resistor of one instrument.

5. Only the resolution of the bistable circuit in the pulse-generator assembly establishes an upper limit on the repetition rate of this unit. By the use of externally timed start and stop pulses, or when the pulse is timed by any other external device, the output pulse generating circuit can be driven at repetition rates above 3 Mc.

6. For the testing of high-speed computer devices, such as flip-flops, even where the clock rate is in the megacycle range, it is usually the pulse-pair resolution which is of interest. The brief start-stop pulses used to time the main pulse can be continuously varied from coincidence to 0.1 second apart and form a useful pair of signals for such resolution testing.

— R. W. Frank

SPECIFICATIONS

Input Synchronizing Signal: Signals of almost any shape will trigger the input timing circuits.

Typical input signal minimum amplitudes are:

(1) Sine wave 0.1 volt, rms.
(2) Square waves 0.3 volt, peak-to-peak.
(3) Brief positive pulse 1.0 volt, peak-to-peak.
(4) Brief negative pulse 1.0 volt, peak-to-peak.

Switch for a-c or d-c input and triggering threshold controls are provided.

Direct Synchronizing Pulse

Polarity-positive amplitude: 75 volts.
Duration: (½ amplitude) 1 μsec.
Output Impedance: 600 ohms.
Repetition Rate: Amplitude constant to 300 kc; down 20% at 500 kc.

Time-Delay Circuit

Range: 1.0 μsec to 1.1 sec in six ranges.
Delay Dial Calibration: 1.00 to 11.00 in 1000 divisions.
Delay Dial Resolution: 1 part in 8800.
Accuracy: Absolute, ±2% of full scale, or ±3% of scale reading + 0.05 μsec, whichever is larger; incremental delay, ±(1% + .05 μsec).
Maximum PRF: 400 kc.
Duty Ratio Effects: Less than 2% error in delay for duty ratios up to 60%, at the low end of each range, and up to 90% at the high end of each range.
Delayed Synchronizing Pulse Characteristics: Positive, 60 v, 1.0-μsec half-amplitude duration, 600-ohm cathode-follower output.
Stability:

	Low End of Dial	*High End of Dial*
Time Jitter	1:10,000	1:50,000
10% Line Change	2:1000	2:10,000
Sudden 10% Line Transient	3:1000	3:10,000

Concidence Circuits

Gate Duration: 3 to 1000 μsec.
Gate Accuracy: ±15% or ±1 μsec, whichever is larger.

Coincidence driving circuit will accept either positive or negative input pulses. Source impedance should be low, have rise time less than 0.2 μsec. Amplitudes between 5 and 20 volts are acceptable for negative pulses, and between 10 and 100 for positive pulses.

Sweep Circuit

Sweep Duration: 3, 6, 12 μsec with 5-decade multiplier.
Sweep Linearity: Determined by the accuracy of pulse timing. On longer ranges, where time delay effects are absent, the linearity is better than 1%.
Sweep Amplitude: Push-pull, each phase, 135 volts, nominal.
Cathode-Follower output, 1-μf blocking capacitors.
Sweep Gate Amplitude: Push-pull, each phase 40 volts nominal.
Positive sweep gate is cathode-follower output circuit with a 1-μf coupling capacitor. Negative gate is amplifier output with 1-uf blocking capacitor.
Duty Ratio and Repetition Rate Effects: Maximum repetition rate, 3-μsec sweep, 250 kc.

Range	*Maximum Frequency for 5% Error in Sweep Slope*		
Sweep Time	3 μsec	6 μsec	12 μsec
× 1	150 kc	100 kc	60 kc
× 10	16 kc	12 kc	7 kc
× 10^2	1.6 kc	1.2 kc	700 c
× 10^3	160 c	120 c	70 c
× 10^4	16 c	12 c	7 c

Pulse Generating Circuit

Pulse Duration: (Timed by sweep) 0.025 to 2.5, 0.05 to 5.0, and 0.05 to 10.0 between half amplitude points, with decade multipliers to a maximum of 100,000 μsec. Pulse can be extended to 1.1 seconds if pulse is timed by delay circuit.
Pulse Duration Accuracy: After sweep calibration, ±1% of dial reading or ±0.02% μsec whichever is the larger.
Pulse Position Accuracy: 0.5 μsec ±1% of dial reading.
Pulse Rise Time: Where the load R_LC_S is negligible with respect to 15 × 10^{-9} sec, the rise time will be faster than 15 mμsec. Higher load impedances or higher shunt C_S will result in increased rise time.
Typical rise times in mμsec are as follows:

Load Impedance	*Positive Pulse* Rise	*Positive Pulse* Decay	*Negative Pulse* Rise	*Negative Pulse* Decay	
50 Ω terminated	15	12	13	15	overshoots
600 Ω with 8 μμf oscilloscope probe	40	40	38	38	approx. 3%

Pulse Shape: Overshoots and other defects are less than 3% of pulse amplitude when the pulse generator is correctly terminated. Pulse ramp-off does not exist, owing to direct coupling of output circuits.
Pulse Duty Ratio: Push-pull circuit with unity duty ratio possible.
Output Impedance: 50, 72, 94, 150, 600 ohms, all ±10%.
Output Pulse Amplitude: 150-ma current source; voltage from each phase of push-pull channel, 0.15 Z_o ±20%.

Typical nominal amplitudes, 50 ohms, 7.5 v; 72 ohms, 10 v; 94 ohms, 14 v; 150 ohms, 22 v; 600 ohms, 90 v.

D-C Component Insertion: Binding posts provided for this purpose. DC can be moved ±25 volts for all output impedance except 600 ohms.

Accessories Supplied: Interconnecting cables, Type CAP-35 Power Cord, 2 Type 874-C58 Cable Connectors, spare fuses.

Other Accessories Available: Type 1219-A Unit Pulse Amplifier for higher power output.

Accessories Required: Trigger source; practically any laboratory oscillator of the appropriate frequency range is adequate; the Type 1210-C Unit R-C Oscillator is recommended.

Tube Complement: Generator:

1-5963	4-6AV5GA	1-6AU8
1-6BQ7A	2-12BH7	
3-6U8	5-5965	Power Supply
8-6485/6AH6WA	2-5687	1-OC3
3-6AN5	1-OA2	1-6AK5
6-12AX7	2-6550	1-6AS7

Power Supply Input: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles, 385 watts.

Power input receptacle will accept either 2-wire (TYPE CAP-35) or 3-wire (TYPE CAP-15) power cord. Two-wire cord is supplied.

Dimensions: Generator, 19 (width) x 14 (height) x 12½ inches (depth) over-all; Power Supply, 19 (width) x 8¾ (height) x 12½ (depth) over-all.

Net Weight: Generator, 30 pounds; power supply, 62 pounds.

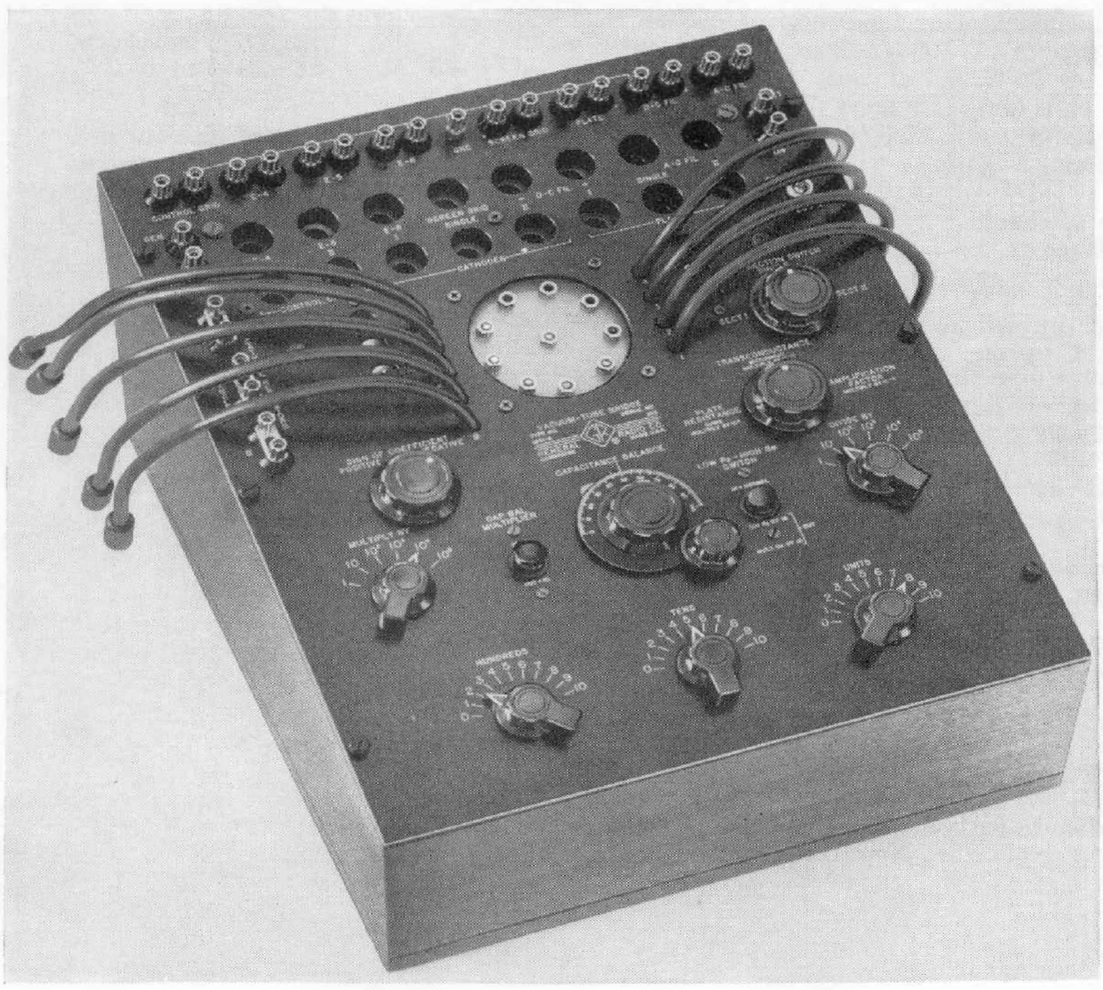
Type		*Code Word*	*Price*
1391-BM*	**Cabinet Model (incl. Power Supply)**	EDIFY	**$1975.00**
1391-BR*	**Relay-Rack Model (incl. Power Supply)**	EBONY	**1975.00**

*U. S. Patent No. 2,548,458.

A NEW AND IMPROVED VERSION OF THE VACUUM-TUBE BRIDGE

The TYPE 561 Vacuum-Tube Bridge has for many years been the industry standard for determining to a high degree of accuracy the low-frequency coefficients of vacuum tubes. It meets the requirements of the IRE Standards on Electron Tubes[1] and has also proved useful for transistor measurements.[2] Its ruggedness is more than adequate for many production-testing applications.

The basic circuitry, devised by Dr. W. N. Tuttle,[3] replaces the usual resistive ratio arms of a bridge by low-impedance voltage sources from transformer secondaries. While phase and amplitude specifications



Panel view of the new Type 1661-A Vacuum-Tube Bridge.

[1]Standards on Electron Tubes: Methods of Testing, 1950.

[2]A. G. Bousquet, "Transistor Measurements with the Vacuum-Tube Bridge," *General Radio Experimenter*, Vol. 27, No. 10, March, 1953.

[3]W. N. Tuttle, "Dynamic Measurement of Electron Tube Coefficients," *Proc. IRE*, No. 21, pp. 844-857, June, 1933.

require close manufacturing tolerances, the novel circuit successfully meets requirements peculiar to tube and transistor measurements. The common electrode of the device under test and the power supplies can all be connected to a common ground, and the voltage drop due to electrode currents is negligible. The bridge indicates directly the real component of the coefficient as plate resistance, transconductance, or amplification factor. The out-of-phase component due to interelectrode capacitance is balanced out without affecting the real component value.

The basic design has not changed in successive models, but the method of connecting the device under test has occasionally been modified to adapt to the growing list of tube-base types and to transistors.

A new and improved version, the TYPE 1661-A Vacuum-Tube Bridge, incorporates many small but significant features.

The general panel layout and the sloping-front cabinet have been retained. The cabinet depth has been reduced somewhat, but other dimensions are left unchanged to permit the new bridge to be mounted in the consoles that many users have found convenient for laboratory use and for production testing with previous models.

Twin Triodes

Perhaps the most welcome new feature is a switching arrangement that permits measurement sequentially of both sections of twin triodes, twin pentodes, etc., without the need for reconnection of the patch cords. This feature will be most appreciated in production testing where formerly two-section tubes had to be run through test twice because the patch-cord connection system was adequate only for one tube section at a time.

Self-Bias

Tests with self-biasing cathode resistors in the circuit are now required for several tube types, and connections for such tests have heretofore been quite difficult to set up. In the new design, the panel switch that selects the tube section also connects the cathodes to a system of three pairs of binding posts that permit the connection of self-biasing resistors to the separate cathodes or to the two cathodes in parallel.

Tube and Transistor Base Adaptors

In spite of the multiplicity of tube and transistor bases, the bridge has been kept up to date relatively simply, because an adaptor plate is provided for each kind of base. With the adaptor plugged into the panel, the tube electrodes can be connected to the appropriate power-supply and bridge terminals by means of the nine doubly shielded coaxial cables. Four grounded connectors have been added to simplify the grounding of any tube terminals. These connectors and two ungrounded connectors provide convenient anchor points to hold the unused patch cords securely out of the way. The patch cords have been lengthened to insure that they will not interfere with the envelope of a large tube.

A new adaptor plate carries three sockets for transistors. One is for JETEC-30 based transistors; a second is for 3- or 4-in-line long-lead transistors (or tubes); the third is for 3- or 4-in-cluster long-lead transistors. There are now a total of thirteen adaptor plates including the "universal" plate to which any unusual socket or tube can be soldered. The adaptor plates and other accessories are supplied in a convenient accessory box.

Voltage and Current Limits

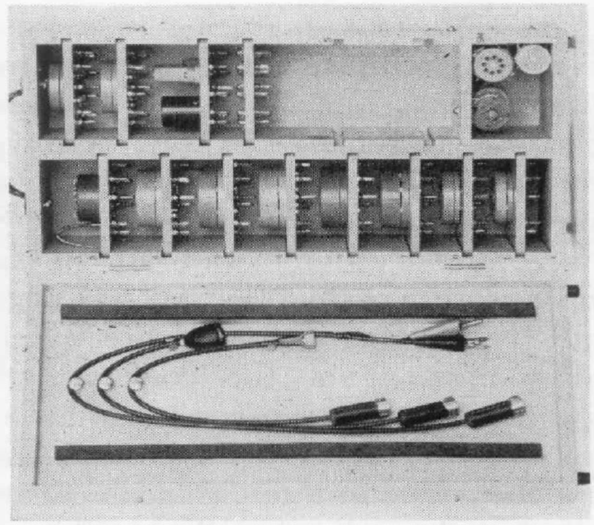
The 1500-volt limit has been retained as the maximum allowable "plate" voltage but, because of the growing list of relatively high-current tubes, the "plate" current limit has been raised from 150 to 400-milliamperes dc. Because some transistors show a frequency effect even at 1000 cycles, the redesign has extended the operating frequency to include the 270 to 400-cycle range in addition to the 1000-cycle point.

Other Changes

Operation at lower frequencies and at higher currents has necessitated a redesign of the transformers. Magnetic shielding has been improved by mounting the transformers in μ-metal shields. The input transformer has been eliminated and the input impedance has been reduced (550-2100 ohms).

A new oscillator and a new filter have been designed (see below) to provide both bridge power and detector selectivity at 270 and 1000 cycles.

For the resistance and transconductance measurements, the resistance standard has been 100,000 ohms. A panel switch now permits a choice between a 10,000-ohm and a 100,000-ohm standard. The use of the lower resistance standard improves the sensitivity of balance and the signal-to-noise ratio by a factor approaching 10 when low "plate resistance" or high "transconductance" devices are measured. By the same token, for a given signal-to-noise ratio the range of resistance or transconductance measurements is extended.



View of storage box, opened to show accessory adaptors and cables.

Many of the new features are the direct result of suggestions from the users of the bridge who, after all, are in a much better position than is the instrument designer to evaluate the virtues and the foibles of the equipment.

– A. G. Bousquet

SPECIFICATIONS

Range: Amplification factor (μ), 0.001 to 10,000.

Dynamic internal plate resistance (r_p), 50 ohms to 20 megohms.

Transconductance (g_m), 0.02 to 50,000 micromhos.

Under proper conditions, the above ranges can be exceeded. The various parameters can also be measured with respect to various elements, such as screen grids, etc. Negative as well as positive values can be measured.

Accuracy: Within $\pm 2\%$ for resistances (r_p switch position) from 1000 to 1,000,000 ohms. At lower and higher values the error increases.

The expression $\mu = r_p g_m$ will check to $\pm 2\%$ when the quantities are all measured by the bridge, and when r_p is between 1000 and 1,000,000 ohms.

Tube and Transistor Mounting: Adaptors are provided for 3- and 4-lead transistors (including JETEC 30) and for tubes of 4-pin, 5-pin, 6-pin, small 7-pin, large 7-pin, octal, loctal, miniature button 7-pin, miniature button 9-pin (noval), acorn (5- and 7-pin), flat-press sub-miniature up to 7 wires, and 8-wire sub-minar. In addition, a universal adaptor, with nine soldering lugs, is provided so that unbased transistors, unmounted tubes, or tubes with non-standard bases can be measured conveniently. For short-lead sub-miniature tubes and for transistors, sockets are supplied which can be mounted on the universal adaptor. Thus all standard commercial receiving tubes and transistors can be measured. The panel jack plate and the adaptors are made of low-loss (natural) phenolic, reducing to a minimum the shunting effect of dielectric losses on the dynamic resistance being measured.

Current and Voltage Ratings: Maximum allowable plate current, 400 ma; maximum plate voltage, 1500 volts.

Electrode Voltage Supply: Batteries or other suitable power supplies are necessary for providing the various voltages required by the device under test.

Bridge Source: TYPE 1214-E Oscillator is recommended.

Null Detector: The TYPE 1212-A Unit Null Detector with the TYPE 1951-E Filter is recommended.

Accessories Supplied: Adaptors as listed above, all necessary plug-in leads, and shielded patch cords for connecting generator and detector.

Mounting: The instrument is mounted in a hardwood cabinet. A wooden storage case is provided for the adaptors and leads. Storage space is provided for a spare Universal adaptor, on which any type of socket can be permanently mounted.

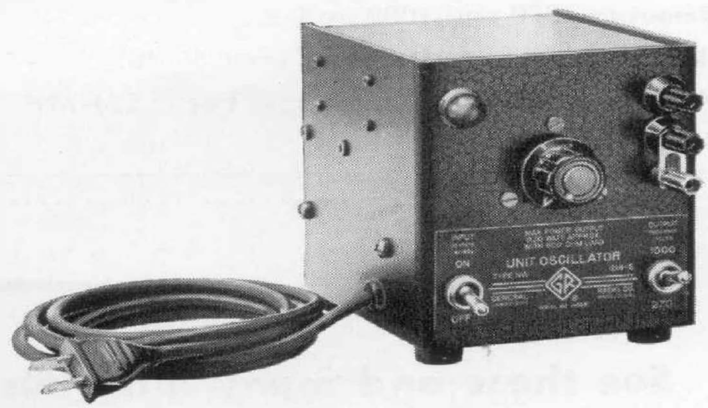
Dimensions: (Length) 18½ x (width) 15¾ x (height) 11 inches.

Net Weight: TYPE 1661-A weighs 40 pounds. The accessories supplied and the accessory box weigh 14 pounds.

Type		Code Word	Price
1661-A	Vacuum-Tube Bridge........................	BEIGE	$975.00

TYPE 1214-E UNIT OSCILLATOR

The TYPE 1214-E Unit Oscillator was designed to meet the bridge-source requirements of the TYPE 1661-A Vacuum-Tube Bridge described above. It is small, self-contained, sufficiently well shielded, adequate in power output, and of appropriate impedance level. Output is available at 1000 cycles and at the low-audio frequency of 270 cycles, which is desirable for tests on some transistors.



Like the other TYPE 1214 Oscillators, this instrument includes a transformerless power supply, and isolation from the power line is obtained by inductively coupling the output circuit to the oscillator tank.

The impedance level presented by the TYPE 1661-A Bridge is in the range of 550 to 2100 ohms, and the power delivered by a typical TYPE 1214-E over this range is at least 300 milliwatts.

SPECIFICATIONS

Frequency: 270 and 1000 cycles per second.

Accuracy: ±2%.

Output: 300 milliwatts into 800 ohms.

Output Impedance: Approximately 200 ohms at 270 cycles; approximately 500 ohms at 1000 cycles; both at maximum setting of output control.

Harmonic Distortion: 3% with 800-ohm load.

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

Power Input: 16 watts at 115 volts.

Accessories Supplied: Spare fuses.

Tube Complement: One 117N7-GT.

Dimensions: Panel, (width) 4¾ x (height) 5¼ inches; depth behind panel, 5⅛ inches.

Net Weight: 4½ pounds.

Type		Code Word	Price
1214-E	Unit Oscillator........................	ASSAY	$75.00

TYPE 1951-E FILTER

The null detector recommended for the TYPE 1661-A Vacuum-Tube Bridge is the TYPE 1212-A Unit Null Detector. It is essentially a three-stage amplifier with the null indicated on a panel meter. The response is quasi-logarithmic. For maximum sensitivity and selectivity, it is suggested that an impedance-matching filter be placed between the bridge and the amplifier. For 400- and 1000-cycle operation, the TYPE 1951-A Filter has proved adequate. Since provision has been made for 270-cycle operation of the vacuum-tube bridge, a new filter has been designed to include the new frequency. The TYPE 1951-E Filter has a panel switch to permit operation at either 270 or 1000 cycles. Like the TYPE 1951-A model, it provides four input connections for optimum impedance matching over the nominal ranges of 0-5 kilohms, 5-50 kilohms, 50-500 kilohms, and 500 kilohms and higher.

The filter is a tuned circuit with a capacitive voltage divider to provide the impedance matching. The inductor is a toroid with permalloy shielding. As a consequence, external coupling is negligible and the filter can be connected to the input of an amplifier of microvolt sensitivity without introducing spurious pickup.

SPECIFICATIONS

Frequency: 270 and 1000 cycles.

Second Harmonic Rejection: At least 30 db.

Accessories Supplied: One each TYPE 274-MB Double Plug, TYPE 274-NK Shielded Plug TYPE 874-Q6 Adaptor.

Dimensions: $3\frac{1}{2}$ x $3\frac{3}{4}$ x $4\frac{3}{8}$ inches, over-all.

Net Weight: $1\frac{3}{4}$ pounds.

Type		*Code Word*	*Price*
1951-E	Filter	FURRY	$80.00