OPERATING INSTRUCTIONS

Type 1398-A

PULSE GENERATOR

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GENERAL RADIO COMPANY

A

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PULSE GENERATOR

Form 1398-0100A
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GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS, USA

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SPECIFICATIONS

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 c/s to 1.2 Mc/s, with calibrated points in a 1–3 sequence from 10 c/s to 300 kc/s, and 1.2 Mc/s, all ±5%. Continuous coverage with an uncalibrated control.

Externally Controlled: Aperiodic, dc to 2.4 Mc/s with 1-V, rms, input (0.5 V at 1 Mc/s and lower); input impedance at 0.5 V, rms, approximately 100 kΩ shunted by 50 pF. Output pulse is started by negative-going input transition.

OUTPUT-PULSE CHARACTERISTICS

Duration: 100 ns to 1 s in 7 decade ranges, ±5% of reading or ±2% of full scale or ±35 ns, whichever is greater.

Rise and Fall Times: Less than 5 ns into 50 or 100 Ω; typically 60 ns + 2 ns/pF external load capacitance into 1 kΩ (60 V).

Voltage: Positive and negative 60-mA current pulses available simultaneously. Dc coupled, dc component negative with respect to ground. 60 V, peak, into 1-kΩ internal load impedance for both negative and positive pulses. Output control has 10 steps plus continuous adjustment.

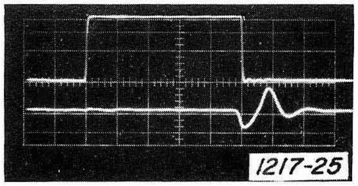
Overshoot: Overshoot and noise in pulse, less than 10% of amplitude with correct termination.

Ramp-off: Less than 1%.

Synchronizing Pulses:

Prepulse: Positive and negative 8-V, approx, pulses of 150-ns duration. If positive sync terminals are shorted, negative pulse can be increased to approximately 50 V.

Sync-pulse source impedance:
positive — approx 300 Ω;
negative — approx 1 kΩ.



1-μs pulse into 50 ohms with delayed sync pulse.

Delay-Sync Pulse: Consists of a negative-going transition of approximately 5 V and 100-ns duration, coincident with the late edge of the main pulse. Duration control reads time between prepulse and delayed sync pulse. This negative transition is immediately followed by a positive transition of approximately 5 V and 150 ns to reset the input circuits of a following pulse generator. (See oscillogram.)

Stability: With external-drive terminals short-circuited, prf jitter and pulse-duration jitter are each 0.04%. (Jitter figures may vary somewhat with range switch settings, magnetic fields, etc.)

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 c/s, 90 W.

Accessories Available: Type 1217-P2 Single-Pulse Trigger, rack-adaptor panel.

MECHANICAL DATA Convertible-Bench Cabinet.

Width		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
12	305	5¼	135	8¼	210	14½	7.0	18	8.5

SECTION 1

INTRODUCTION

1.1 PURPOSE.

The Type 1398-A Pulse Generator is a general-purpose pulse source intended primarily for laboratory use. The repetition rates of the pulses may be either internally controlled, at frequencies from 2.5 c/s to 1.2 Mc/s, or externally controlled at frequencies up to 2.4 Mc/s.

In addition to the main positive and negative output pulses, the instrument also supplies synchronizing pulses that correspond to the beginning and end of the main pulse. The early sync pulse (prepulse) is intended chiefly for synchronizing an oscilloscope while the late pulse (delay pulse) is intended to make the instrument an accurate time-delay generator.

1.2 GENERAL DESCRIPTION.

The Type 1398-A comprises three main circuit groups:

(1) A combination input circuit and oscillator that establishes the repetition rate of the main pulse.

(2) A combination pulse-timing and output circuit that establishes the duration and amplitude of the main pulse.

(3) A power supply that provides regulated voltage for the other two circuit groups.

The repetition frequency, duration, and amplitude of the main output pulse are adjustable by front-panel controls. The instrument, which is housed in a convertible-bench cabinet, may be used as supplied as a bench instrument or may be quickly and easily adapted for use in a relay-rack. (Refer to paragraph 2.3.)

1.3 CONTROLS AND CONNECTORS.

See Figure 1-1 and Table 1-1 for the location and the description of the controls and connectors used on the Type 1398-A.

1.4 ACCESSORIES SUPPLIED.

One instruction book, form number 1398-0100.

One power cord, part number 4200-9622.

1.5 ACCESSORIES AVAILABLE.

Type 1217-P2 Single-Pulse Trigger, catalog number 1217-9602. Used to generate single pulses. See Figure 1-2 and paragraph 3.11.4 for further details.

Type 480-P312 Relay-Rack Adaptor Set, catalog number 0480-9632. Used to rack-mount the Type 1398-A. Refer to paragraph 2.3 for further details.

TABLE 1–1

CONTROLS AND CONNECTORS

Reference (Figure 1-1)	*Name*	*Type*	*Function*
1	PRF	12-position rotary switch	Sets PRF range. In EXT DRIVE, it changes prf oscillator to an aperiodic input circuit.
2	ΔF	Continuous rotary control	Adjusts prf continuously between calibrated switch positions. When set fully clockwise, PRF switch is calibrated. When PRF switch is set to EXT DRIVE, ΔF control sets triggering level of pulse generating circuits.
3	PULSE DURATION	Continuous rotary dial (no stop)	Sets pulse duration.
4	PULSE DURATION RANGE	7-position rotary switch	Sets pulse duration range in decade steps.
5	POWER OFF	Toggle switch	Turns instrument on and off.
6	OUTPUT PULSE −	Jack-top binding post pair	For negative main output pulse.
7	OUTPUT PULSE +	Jack-top binding post pair	For positive main output pulse.
8	AMPLITUDE		
	Inner Control	Continuous rotary control	Adjusts amplitude continuously between switch positions.
	Outer Switch	10-position rotary switch	Sets pulse amplitude in ten steps from zero to maximum.
9	EXT OFFSET	Jack-top binding post pair (note shorting link)	For connection to an external power supply used to change dc level of of output.
10	SYNC DELAYED	Jack-top binding post pair	For delayed sync pulse. Amount of delay is controlled by PULSE DURATION controls.
11	SYNC −	Jack-top binding post pair	For negative prepulse.
12	SYNC +	Jack-top binding post pair	For positive prepulse.
13	EXT DRIVE	Jack-top binding post pair	For external drive signal.
14	– –	12-terminal female connector	For use with forthcoming Type 1398-P1 DC Component Control Unit.

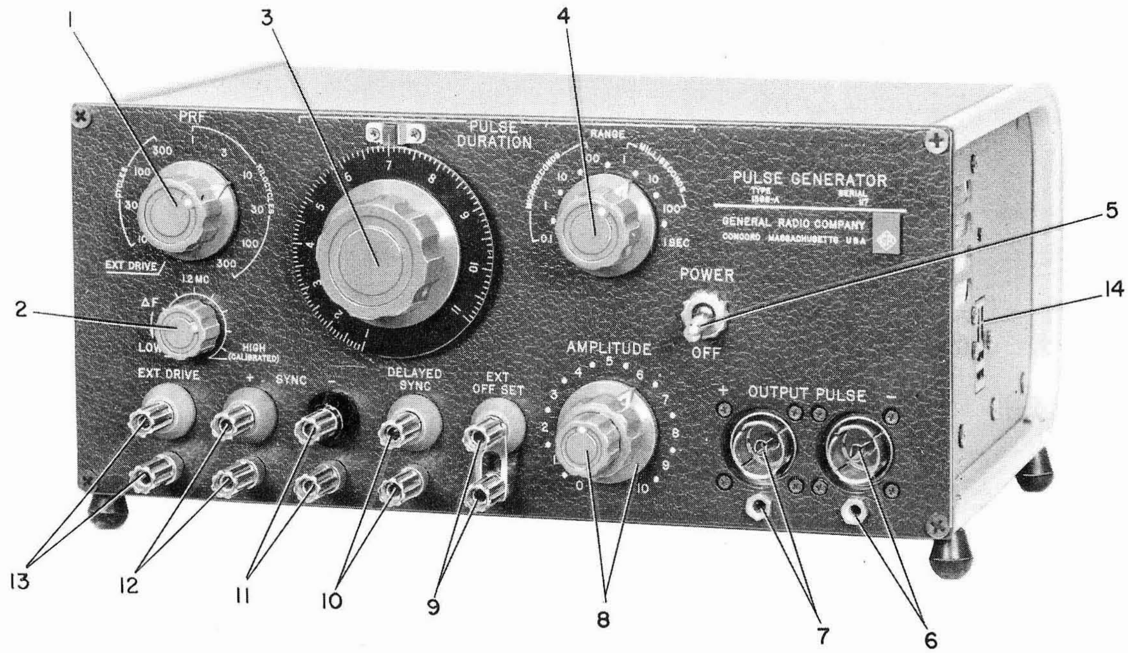


Figure 1-1. Type 1398-A Pulse Generator.

Figure 1-2. Type 1217-P2
Single-Pulse Trigger.

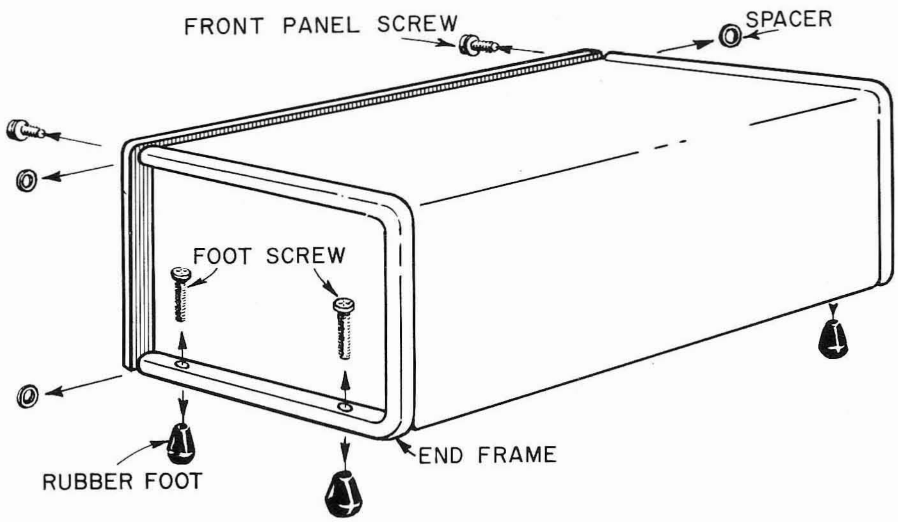


Figure 2-1. Rack Mounting: Preparation of instrument for attachment of wings.

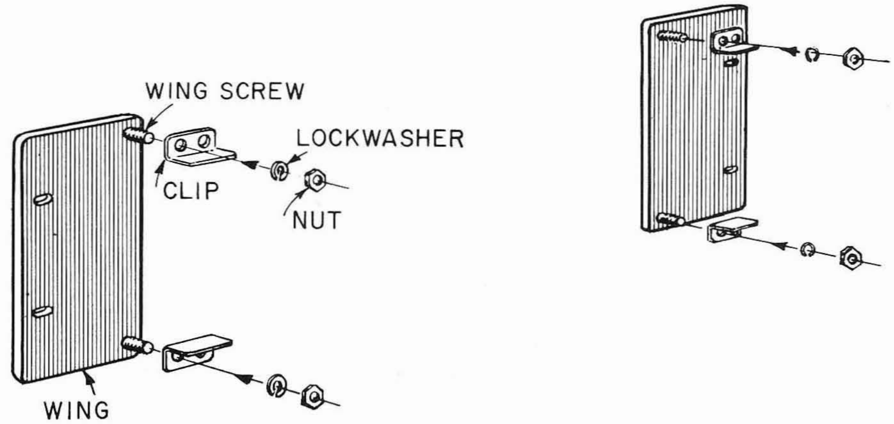


Figure 2-2. Rack Mounting: Wing assembly.

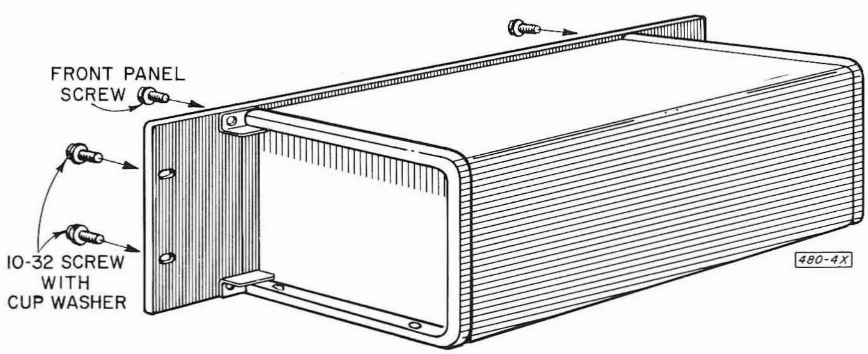


Figure 2-3. Rack Mounting: Attachment of wings to instrument.

SECTION 2

INSTALLATION

2.1 COOLING.

It is important that the interior of the instrument be adequately ventilated; therefore make sure the air holes in the cover, especially those on the right side, are not blocked.

2.2 POWER SUPPLY.

Connect the pulse generator to a source of power as indicated by the legend at the input socket at the rear of the instrument, using the power cord provided. While normally connected for 115-volt operation, the transformer input circuit is so arranged that one can make the conversion from 115-volt to 215-volt operation simply by throwing a switch located directly below the input socket. To do this, unscrew the two clamp fastners on the back of the instrument and slide off the dust cover. Flip the switch over so that the white indicator is on the 195- 235-volt side. The circuit can also be adapted to accommodate a 230-volt line. To do this, set the line voltage switch to the 195- to 235-volt position, and remove the two wires from terminal 2L, which is on the same panel as the line voltage switch, and connect them to terminal 2. For instruments changed to 215-volt or 230-volt operation, nameplates (Type LAP166E5 for 215-volt operation, Type LAP166E2 for 230-volt operation) may be ordered from General Radio.

2.3 RACK MOUNTING.

The pulse generator can be rack-mounted by means of a Type 480-P312 Relay-Rack Adaptor Panel Set (catalog number 0480-9632). The adaptor panels are finished in charcoal gray crackle paint to match the front panel of the instrument and come complete with the necessary hardware to mount the instrument in the rack. To make the installation, proceed as follows:

(a.) Remove the rubber feet. Retain the screws.
(b.) Remove and retain the screws that secure the front panel to the aluminum end frames (see Figure 2-1).
(c.) Remove the spacers between the front panel and the end frames.
(d.) Install two clips on each wing using lock washers and nuts provided (see Figure 2-2).
(e.) Attach the wings to the instrument with the front panel screws removed in step b (see Figure 2-3).
(f.) The assembly is now ready to be rack-mounted in a standard 19-inch relay rack.

SECTION 3

OPERATING PROCEDURE

3.1 DEFINITION OF TERMS.

main pulse .... The principal output of the instrument; available at the OUTPUT PULSE binding posts.

prepulse .... The positive or negative sync pulse supplied just before the start of the main pulse; available at the SYNC + and SYNC − binding posts.

delayed pulse .... The pulse coincident with the end of the main pulse; available at the DELAYED SYNC binding posts.

internal operation .... The mode where pulse repetition frequency is determined by the pulse generator itself and controlled by the PRF controls on the front panel.

external operation .... The mode where pulse repetition frequency is determined by an external signal source; the pulse generator generates pulses only when triggered by signals applied to the EXT DRIVE binding posts.

duty ratio .... The ratio of pulse "on" time to the total time of the period established by the prf setting; duty ratio, in percent = prf × duration × 100.

3.2 NORMAL INTERNAL OPERATION.

3.2.1 PRF ADJUSTMENT.

Pulse repetition frequency is adjusted by the PRF controls (1 and 2, Figure 1-1), over a range of 2.5 c/s to 1.2 Mc/s. The PRF switch is calibrated to indicate prf correctly only when the ΔF control is fully clockwise. When the ΔF control is fully counterclockwise, the prf is lowered well below the next lower PRF switch setting. The range of adjustment of the ΔF control is more than enough to span any one of the ranges set by the PRF switch and thus affords continuous coverage of the prf range of 2.5 c/s to 1.2 Mc/s. It is important to remember, however, that the only calibrated frequencies are those indicated by the PRF switch positions, and that these are accurate only when the ΔF control is fully clockwise.

3.2.2 PULSE-DURATION ADJUSTMENT.

Duration of the main pulse is adjusted by the PULSE DURATION controls (3 and 4, Figure 1-1). The RANGE switch (4) selects one of seven decade ranges and the range selected is covered by the PULSE DURATION dial (3). This control consists of a knob linked by a slow-motion drive to a dial that is calibrated from 1 to 11 in tenths of a unit. The overlap beyond the decade span ensures continuous coverage of all durations.

3.2.3 AMPLITUDE ADJUSTMENT.

Amplitude of the main pulse is adjusted by the large AMPLITUDE switch, which varies the amplitude from zero to maximum in ten steps, and by the small amplitude control (concentric with the switch) which facilitates continuous adjustment between steps. The positions of the larger switch corresponds to changes in in output impedance in 100-ohm steps. Thus a setting of five indicates that the output impedance is about 500 ohms. When both controls are fully clockwise, the amplitude is 60 volts and the output impedance is one kilohm.

3.2.4 FAMILIARIZATION PROCEDURE.

The best way to become familiar with the pulse generator is to connect it to an oscilloscope and watch the pulses themselves. The procedure is as follows:

a. Connect the OUTPUT PULSE + binding post to the oscilloscope vertical input by means of open leads or a probe.

b. Connect the SYNC + binding post to the oscilloscope sync or trigger input.

c. Connect any of the ground binding posts to the oscilloscope ground.

d. Be sure that the link across the EXT OFFSET binding post is firmly connected to both posts.

e. Adjust the oscilloscope trigger controls to trigger on the 8-volt, 100-ns, positive prepulse of the Type 1398-A.

f. Set the oscilloscope sweep rate controls for a 2-ms/div sweep rate.

g. Set the oscilloscope vertical gain controls for about 40 volts/cm sensitivity.

h. Set the PRF switch to 1 kc/s.

i. Set the ΔF control fully clockwise.

j. Set the PULSE DURATION dial to 5.

k. Set the PULSE DURATION RANGE switch to 100 μs-1 ms.

l. Set the AMPLITUDE control fully clockwise.

The oscilloscope should now display a 1-kc square-wave from the pulse generator. Use the PULSE DURATION dial to shorten and to lengthen the pulse and then set the PULSE DURATION RANGE switch to the next lower range Decrease the prf first by turning the ΔF control counterclockwise and then by setting the PRF switch to the next lower position. Adjust the oscilloscope sweep rate control to keep both the pulse duration and frequency under observation. To decrease pulse amplitude, turn the AMPLITUDE control counterclockwise.

If the oscilloscope has a dc-coupled vertical amplifier, set it for dc, disconnect the pulse, and establish the ground reference trace. Now reconnect the positive main pulse and vary its amplitude. Then move the connector from the + OUTPUT PULSE to the - OUTPUT PULSE binding post and vary the amplitude again. Note that the pulse contains a dc component that is negative with respect to ground. The positive pulse starts from -60 volts and rises to ground during its active interval. The negative pulse starts from ground and falls to -60 volts during its active interval.

If, during any of the above procedures, the pulse is defective or the pattern becomes confused, check to make sure that the pulse duration has not been made too long for the pulse repetition frequency and that an oscilloscope with a dc-coupled vertical amplifier is used to observe pulses of very long duration.

3.3 NORMAL EXTERNAL OPERATION.

3.3.1 DRIVING-SIGNAL REQUIREMENTS.

The Type 1398-A will produce externally triggered pulses at frequencies from dc to 2.4 Mc/s. The driving signal should be applied to the EXT DRIVE terminals, and should be at least 0.5 volt, rms, up to 500 kc/s and at least 1 volt, rms, from 500 kc/s to 2.4 Mc/s. Excessive driving voltages at frequencies above 1.5 Mc/s may overload the triggering circuits. If the unit fails to trigger, reduce the driving voltage. With optimum driving voltage the unit will trigger to frequencies typically as high as 2.5 Mc/s.

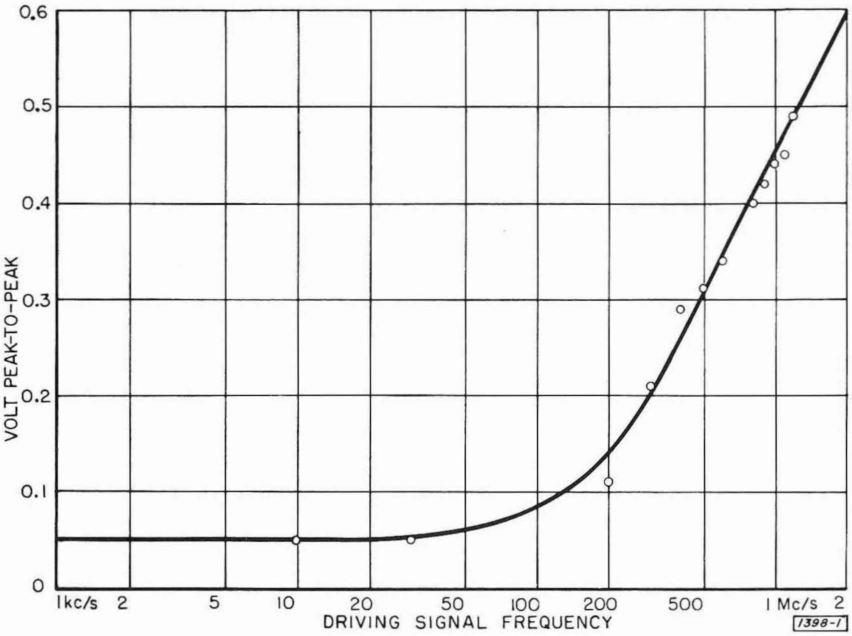


Figure 3-1.
Typical sensitivity-vs-frequency characteristics.

3.3.2 EXTERNAL DRIVE PROCEDURE.

For external operation, set the PRF switch to EXT DRIVE and apply the external driving signal to the EXT DRIVE binding posts. The △F control now becomes a triggering level adjustment; the input circuits are set for maximum sensitivity when this control is centered.

The input circuit is dc-coupled, and the pulse generator will operate from pulses at any low frequency desired. The input signal must therefore either be at a dc potential close to ground or be ac-coupled, with an external blocking capacitor.

3.3.3 OPERATION WITH OSCILLOSCOPE.

To observe external operation on an oscilloscope proceed as follows:

a. Set up the equipment to display a 1-kc square wave, as described in paragraph 3.2.4, a to l.

b. Set the PRF switch to EXT DRIVE.

c. Connect an adjustable audio-frequency generator to the EXT DRIVE binding posts and set the generator to produce a 1-kc signal of at least 1 volt, rms.

d. Center the △F control (now used as a triggering level control). The oscilloscope should display a square wave as described in paragraph 3.2.4.

e. Decrease the frequency of the audio-frequency generator. Note that the external generator controls the prf of the Type 1398-A.

f. Reset the audio-frequency generator to 1 kc/s and reduce its amplitude. When the Type 1398-A fails to trigger, adjust the △F control until triggering is re-established. When no further adjustment of the △F control will re-establish triggering, the triggering threshold has been reached (this should be at about 0.3 volt, p-to-p, to 1 kc/s). A plot of typical sensitivity is given in Figure 3.1.

g. Reset the generator amplitude to 1 volt, rms. If possible, display its output waveform and the Type 1398-A output pulse simultaneously on the oscilloscope.

h. Adjust the △F control and observe the starting point of the pulse. Note that the △F control adjusts the phase at which the pulse is formed, and that the pulse always starts during the negative-going input transition.

TABLE 3–1
DURATION ACCURACY VS DUTY RATIO

Duty Ratio	*Accuracy*
0 to 20%	±2% of full scale with with DURATION dial at 1 to 4. ±5% of reading with DURATION dial at 5 to 10. ±35 ns with durations of 0.1 to 0.7 μs.
20 to 50%	±10% of reading.
Over 50%	Inaccurate.

3.4 PRF VS PULSE DURATION.

3.4.1 DUTY RATIO LIMITS DURATION ACCURACY.

There is no restriction on the duty ratio of the Type 1398-A. (Duty ratio is the ratio of the pulse "on" time to the total time of the period established by the prf setting; duty ratio in percent = prf × duration × 100.) Therefore, the PULSE DURATION controls may be mistakenly set for a duration longer than the total period (period is the reciprocal of prf). The instrument cannot be damaged by such settings, but the user may be confused by the resulting oscilloscope display. Refer to Table 3-1 for duration accuracy versus duty-ratio specifications.

3.4.2 DURATION LESS THAN 50% OF PERIOD.

The accuracy of the DURATION control settings is preserved if the duty ratio is 50% or less (pulse duration is 50% or less of total time of period). Table 3-2 lists the 50%-of-period figures for each PRF control setting.

3.4.3 DURATION GREATER THAN 50% OF PERIOD.

When the pulse occupies more than 50 percent of the total period, the dial reading of duration is erroneous. This effect is due to insufficient recovery time for the pulse-forming circuits but can be circumvented by the reversal of the OUTPUT PULSE polarity.

For example: A 1-kc, 600 μs positive pulse is desired. From Table 3-2 it can be seen that 600 μs exceed the 500 μs maximum duration given for a PRF control setting of 1 kc/s (actual duty ratio = $10^3 \times 6 \times 10^{-4} \times 10^2 = 60\%$). But, from Figure 3-2, it also can be seen that a positive duration of 600 μs can be obtained if connection is made to the −OUTPUT PULSE binding post rather than to the + OUTPUT PULSE binding post and if the DURATION controls are set to 400 μs pulse (total period minus 600 μs). The duty ratio for a 1-kc, 400-μs pulse is 40%; therefore the DURATION control accuracy is preserved.

TABLE 3-2

50%-OF-PERIOD FIGURES

PRF Control Setting (ΔF control fully clockwise)	*50% of Period (Durations inaccurate for DURATION control settings longer than those listed)*
10 c/s	50 ms
30 c/s	17 ms
100 c/s	5 ms
300 c/s	1.7 ms
1 kc/s	500 μs
3 kc/s	170 μs
10 kc/s	50 μs
30 kc/s	17 μs
100 kc/s	5 μs
300 kc/s	1.7 μs
1.2 Mc/s	0.42 μs

3.4.4 DURATION EQUAL TO PERIOD.

When the DURATION controls call for a pulse exactly equal to the pulse period, the instrument fails completely, and both duration and prf are indeterminate.

3.4.5 DURATION GREATER THAN PERIOD.

When the duration is set longer than the pulse period, the pulse timing circuits will "count down", producing one pulse for each 2, 3, 4, ... n input periods. In general, the pulse duration will not be precisely controllable due to lack of recovery time. However, such frequency division may be useful in some applications and it should be remembered that the Type 1398-A can be used as a frequency divider of arbitrary scale by such operation.

3.5 PRECAUTIONS FOR VERY LONG OR VERY SHORT PULSES.

3.5.1 GENERAL.

When pulses of very long or very short duration are to be produced and observed, special attention must

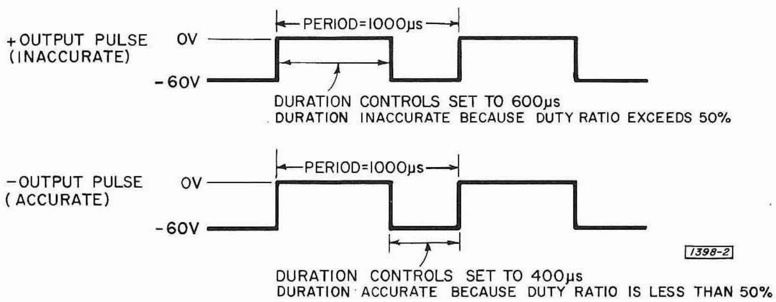


Figure 3-2.
Circumvention of 50% duty-ratio limitation at 1 kc/s by reversal of OUTPUT PULSE polarity.

be given to the equipment setup and interconnections. Bandwidth considerations are fundamental and oscilloscopes with the desired frequency response must be chosen as indicators.

3.5.2 LONG PULSES–LOW-FREQUENCY RESPONSE.

An oscilloscope with a frequency response to dc is necessary to observe very long pulses. The low-frequency cutoff of most oscilloscopes that do not have dc amplifiers is about 5 or 10 c/s, and these oscilloscopes will exhibit "ramp-off" effects with pulse durations over 10 milliseconds. (Ramp-off is the slope on the flat top and bottom.) Almost any indicator has adequate high-frequency response for long-duration pulses becuase the "flats" are usually of more interest than are the rapid rise and fall voltage transitions. The Type 1398-A uses a direct-coupled output system and will not cause ramp-off at any duration.

3.5.3 SHORT PULSES–HIGH-FREQUENCY RESPONSE.

Faithful reproduction of very short pulses or of the rapidly changing voltage of the leading or trailing edge of such a pulse requires wide-bandwidth amplifier and indicator systems. For example, when a pulse with a rise time of 0.05 μs is displayed on an oscilloscope whose amplifier has a rise time of 0.05 μs, the indicated rise time will be 0.07 μs. For a system with n individual components of specified rise time, the equation for over-all rise time[1] is

$$T_r = \sqrt{T_1^2 + T_2^2 + \ldots T_r^2} \qquad (1)$$

The rise time of an amplifier system, T_r, is related to the 3-dB bandwidth, B, by the equation (2), where the factor of 0.35 should be used if the overshoot is less than 10 percent.[2]

$$T_r = \frac{0.35 \text{ to } 0.45}{B} \qquad (2)$$

With very short pulses, it is necessary to take care in the wiring of system components. Short, direct wires should be used for both signal and ground paths if open wiring is used, and coaxial cables should be terminated properly. A common sign of an improperly connected ground or of an inductive loop in the wiring is the presence of high-frequency ringing (damped oscillation) on the pulse transitions.

[1] Valley, G. E., and Wallman, Henry, "Vacuum Tube Amplifiers," *Radiation Laboratory Series,* Vol 18, McGraw-Hill, 1948, p 77.

[2] *Ibid,* p 80.

3.6 RISE AND FALL TIMES.

The Type 1398-A has very short rise and fall times (typically 5 ns) of output current into the internal 1-kilohm loads and their associated stray capacitances. The internal stray capacitances are about 40 pF, which results in open-circuit rise and fall times of about 90 ns across the internal 1-kilohm load. The rise and fall times increase linearly with external capacitance and and decrease linearly with external resistance – the final transition time is about 2.2 RC. The intrinsic rise time can therefore be observed only if a resistance of 100 ohms or less is connected across the output binding posts. With an open-circuit connection, the Type 1398-A output circuit is capacitance-limited, the voltage transition varies exponentially with time, and no overshoot is possible. Because of this important feature, the Type 1398-A can be used to check almost any amplifier system for overshoot – including any oscilloscope whose input impedance is over 1 kilohm.

For further information on rise and fall times, refer to paragraph 3.7, below.

3.7 EXTERNAL LOAD CONSIDERATIONS.

The output circuits of the pulse generator are as stable as possible for an instrument of such simplicity. Some important points to remember are:

(1) The output tubes act as current sources that produce 60-mA pulses into a parallel combination of the AMPLITUDE control resistors and whatever external load is connected to the instrument.

(2) The pulses are direct-coupled to the OUTPUT PULSE binding posts and therefore contain a negative dc component of 60 mA.

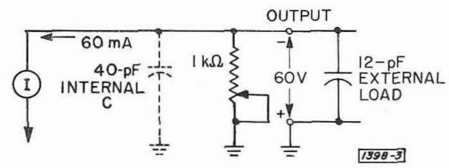
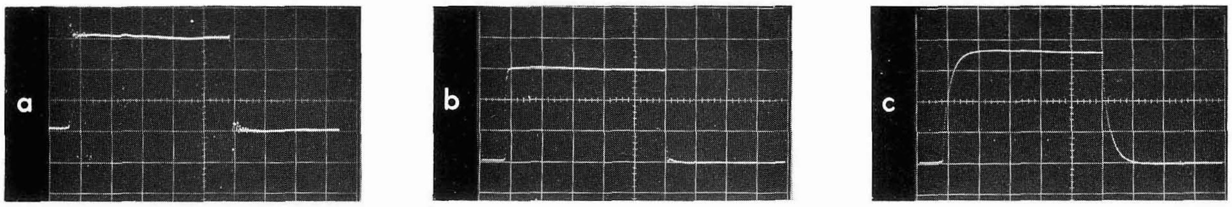


Figure 3-3. Equivalent circuit for Type 1398-A output system feeding high load impedance.

Figure 3-3 shows an equivalent circuit for the Type 1398-A output system as it appears when feeding a high external load impedance (e.g., a 12-pF, 10-megohm oscilloscope probe). The pulses from this circuit will be capacitance-limited by the 50-ns RC time constant, and a rise time of about 100 ns results (Figure 3-4c). The appearance of a brief pulse at output settings of 0.6 volt and 6 volts is shown in Figure 3-4 a and b, respectively.



0.6 volt, peak-to-peak, into 10 ohms; 0.1 μs/cm.

6 volts, peak-to-peak, into 100 ohms; 0.1 μs/cm.

36 volts, peak-to-peak, into 1 kilohm, 0.1 μs/cm.

Figure 3-4. Pulses from circuit of Figure 3-3.

Two important features should be noted from the above: (1) the rise time can be controlled with no termination and maximum output, by the addition of fixed external capacitance according to the equation

$$T_r\,(ns) = 2.2\,(40\text{ pF} + C_{ext}) \qquad (3)$$

and (2) the ultimate rise time can be realized only by termination of the instrument either externally by placing a 50-Ω resistor across the output terminals, or internally by setting the output impedance to 50 Ω (AMPLITUDE switch at 0.1, AMPLITUDE control centered), or both, as shown in Figure 3-5. Here the time constant of the output circuit is about 1.5 ns, and the fast rise and fall of the current pulse can be observed.

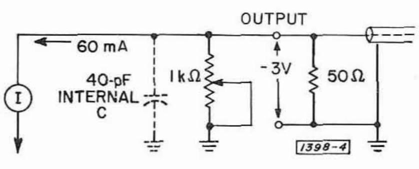


Figure 3-5. Equivalent circuit for achieving ultimate rise time.

In this connection, the transitions will typically be less than 5 ns. See Figure 3-6 for the typical appearance of waveforms under terminated conditions.

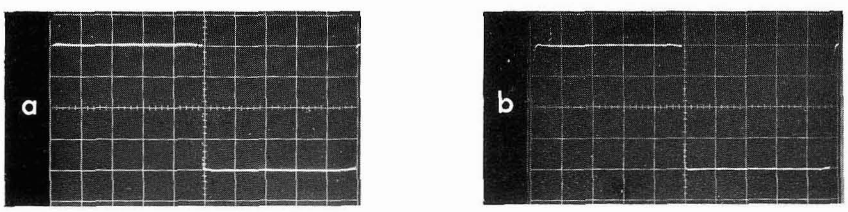
3.8 OUTPUT DC COMPONENT—DC TRANSLATION.

In certain applications it may be desirable to remove or to change the dc component of the main output pulse. If it is necessary only to remove the dc component, and if the pulses are fairly short and the circuit impedances high, the desired result may be obtained simply by addition of an external coupling capacitor large enough to prevent ramp-off for the desired pulse duration. If the above conditions do not hold, or if it is necessary to introduce dc offset, an external power supply can be connected to the OFFSET terminal. Such a connection will allow the dc component level to be shifted by as much as 20 volts in either the positive or the negative direction since the voltage of power supply is then applied to the plate load resistors of the output tubes, thus changing their quiescent – voltage levels.

The AMPLITUDE control is adjusted until a 20-volt swing is attained as measured on an oscilloscope. Then an adjustable positive power supply is connected to the EXT OFFSET terminal and its voltage is adjusted until the dc output of the pulse generator is zero as measured on a dc voltmeter. Alternatively, the voltages needed for the desired offset may be precalculated and set accordingly. For instance, if the duty ratio (refer to paragraph 3.4.1) is 50%, the required offset voltage is + 10 volts for a twenty-volt pulse. A + 10-volt power supply is connected to the EXT OFFSET terminal and, using only a dc voltmeter, the AMPLITUDE control adjusted so that the dc level is zero.

NOTE

Do not apply more than ± 20 volts to the EXT OFFSET terminal, as voltages exceeding this level may damage the output tubes.



3-volt, 5-μs pulse; 50-ohm termination.

As in (a), but with open-circuit termination, 60-volt pulse.

Figure 3-6. Typical waveforms under terminated conditions.

3.9 LOCKING ON HIGH FREQUENCY SIGNALS.

3.9.1 FREQUENCY DIVIDER ACTION.

If an external signal is applied to the EXT DRIVE binding posts and the PRF switch is set to one of the numbered positions, the internal oscillator of the Type 1398-A will lock on the external signal. For instance, if a 50-kc signal is applied at the EXT DRIVE terminals and the PRF is set to nearly 10 kc/s the main pulse of the Type 1398-A can be locked at $\frac{1}{5}$ the external frequency of 50 kc/s. In other words, the pulse generator is operating as a 5-to-1 frequency divider and supplies one output pulse for every five input pulses. The pulse generator can be phase-locked in this manner to frequencies well above the maximum prf of the internal oscillator.

3.9.2 OBSERVATION WITH OSCILLOSCOPE.

To observe the above action, connect an oscilloscope and an audio-frequency generator to the Type 1398-A as described in paragraph 3.3.3. If possible, observe the waveform of the external generator on the oscilloscope, together with the Type 1398-A output. Then proceed as follows

a. Set the PRF switch to 1 kc/s.

b. Set the ΔF control fully clockwise.

c. Set the external generator to 1 kc/s.

d. Set the output amplitude of the external generator to minimum and then increase it until the Type 1398-A locks.

e. Set the frequency of the external generator to 2 kc/s, 3 kc/s, 4 kc/s, etc., and each time advance the signal amplitude to lock the pulse generator. In this way the pulse generator can be locked at very high ratios.

3.10 COUNT-DOWN OPERATION.

When the duration is set longer than the pulse period, the pulse timing circuits will "count down", producing one pulse for each 2, 3, 4, ... n input periods. In general, the pulse duration will not be precisely controllable, owing to lack of recovery time.

3.11 SINGLE-PULSE OPERATION.

3.11.1 METHODS.

There are three ways by which one can produce a single pulse:

(1.) By rotating the ΔF control with the PRF switch set to EXT DRIVE.

(2.) By touching the EXT DRIVE binding post.

(3.) By using the Type 1217-P2 Single-Pulse Trigger.

The following three paragraphs explain each method in detail.

3.11.2 ROTATION OF ΔF CONTROL.

Set the PRF switch to EXT DRIVE and rotate the ΔF control about 20 or 30 degrees clockwise from its center position and then reverse the direction of rotation. An output pulse will be produced as the ΔF control is moved counterclockwise past the center position. Very little rotation is necessary to reset and to start the input circuits. Be careful not to touch the EXT DRIVE binding post because a pulse burst may be produced by the injected hum.

3.11.3 TOUCHING EXT DRIVE BINDING POST.

Set the PRF switch to EXT DRIVE and set the ΔF control near the center of its range. A single pulse will be produced when the EXT DRIVE binding post is touched. This method is useful only for very long pulses because the driving signal is a burst of noise or hum.

3.11.4 TYPE 1217-P2 SINGLE-PULSE TRIGGER.

The most convenient way to produce single pulses is to use a pushbutton actuating-circuit such as the Type 1217-P2 Single-Pulse Trigger, shown pictorially in Figure 1-2 and schematically in Figure 3-7. To use it, set the PRF switch to EXT DRIVE and set the ΔF control between three-quarters clockwise and fully clockwise.

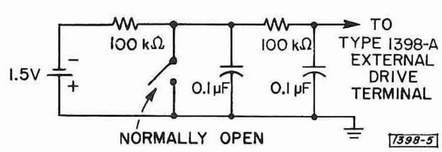


Figure 3-7. Schematic diagram of the Type 1217-P2 Single-Pulse Trigger.

To produce a main pulse when the switch opens, connect the negative banana plug of the Type 1217-P2 (arrowhead terminal in Figure 3-7) to the EXT DRIVE binding post of the Type 1398-A.

To produce a main pulse when the switch closes, reverse the double banana plug of the Type 1217-P2 so the positive banana plug (ground symbol in Figure 3-7) is connected to the EXT DRIVE binding post of the Type 1398-A.

3.12 USE AS A DELAY GENERATOR.

The delayed sync pulse from the Type 1398-A can be used to operate the input circuits of a second Type 1398-A with a minimum of adjustment. The delayed pulse consists of a negative-going transition of about 5 volts and 100-ns duration, followed immediately by a positive transition of about 5 volts and 150-ns duration. The initial negative-going transition will trigger the input circuits and start the main pulse of a following Type 1398-A. The positive-going transition will then reset the input circuits of the second Type 1398-A to prepare it for the next delayed pulse. Figure 3-8 shows connections and timing waveforms of such a system.

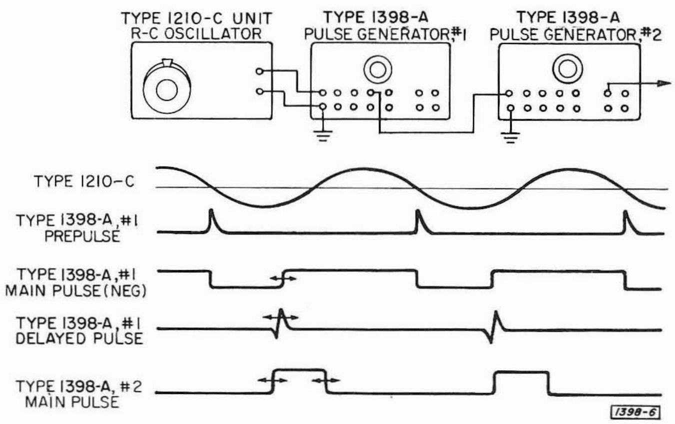


Figure 3-8. Connection of two Type 1398-A's as a delay generator.

3.13 USE FOR COMPLEX WAVEFORMS.

Since the output circuit of the Type 1398-A is essentially a current source feeding a resistive load, the outputs of two or more pulse generators can be directly paralleled to produce complex additive waveforms. The output impedance of n pulse generators so paralleled is 1000/n ohms and the peak voltage is still 60 volts. A complex waveform and the system to produce it are shown in Figure 3-9.

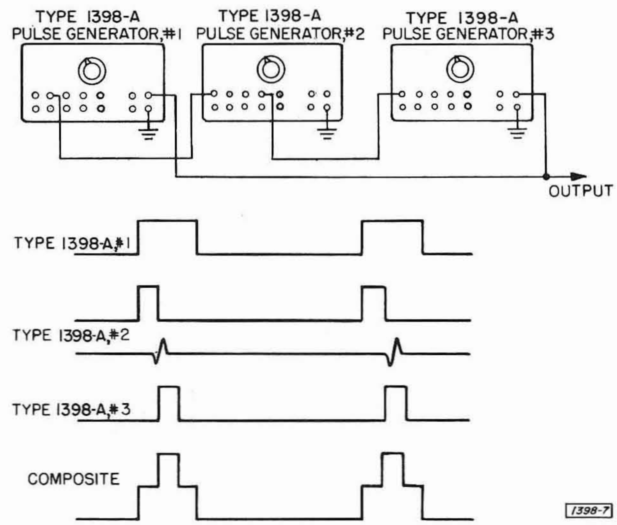


Figure 3-9. System for producing the complex waveform shown.

SECTION 4

PRINCIPLES OF OPERATION

4.1 GENERAL. (See Figure 4-1.)

The Type 1398-A is composed of three basic sections: (1) the input and prf oscillator circuit, (2) the output pulse circuit, and (3) the power supply. The first two sections are shown in block diagram form in Figure 4-1.

Externally or internally generated positive pulses from the input and prf oscillator circuit trigger the output pulse circuit. The output pulse circuit, in turn, produces positive and negative pulses that appear at the OUTPUT PULSE binding posts. A detailed analysis of each circuit is contained in the following paragraphs.

4.2 INPUT AND PRF OSCILLATOR CIRCUIT – EXTERNAL OPERATION.

4.2.1 GENERAL.

Let us first consider the circuit as an aperiodic input circuit, i.e., with the PRF switch set to EXT DRIVE, as shown in Figure 4-2. In this mode, the circuit converts an external signal, applied to the EXT DRIVE binding posts, to a positive pulse, which appears at the output, pin 6 of V102.

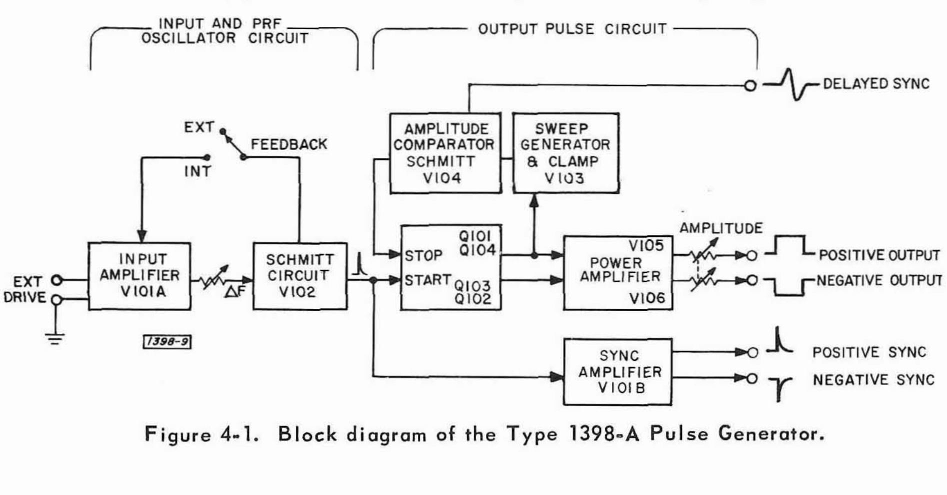


Figure 4-1. Block diagram of the Type 1398-A Pulse Generator.

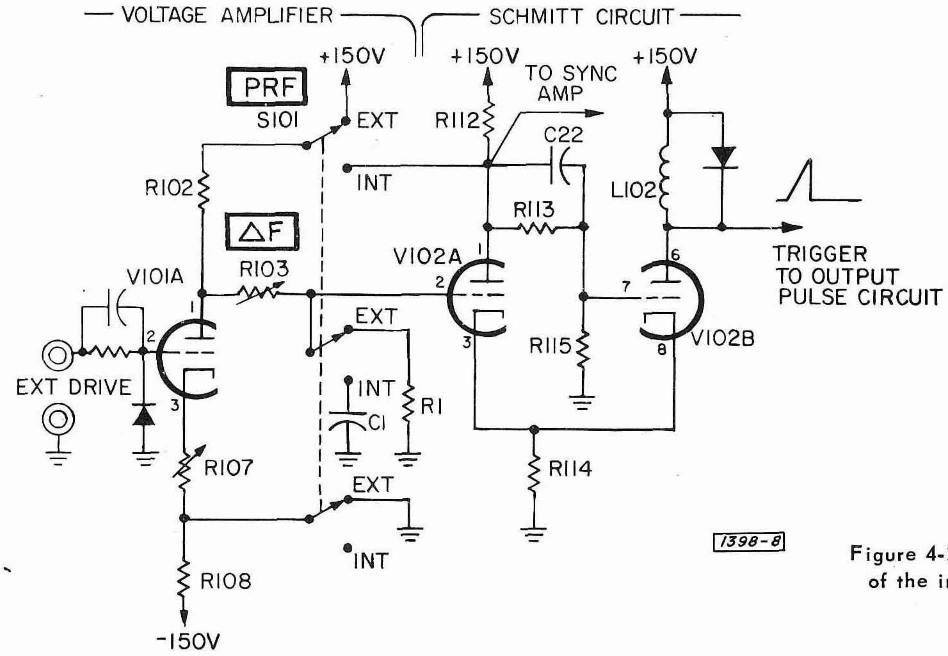


Figure 4-2. Simplified schematic diagram of the input and prf oscillator circuit.

4.2.2 SCHMITT CIRCUIT.

V102A and B form a Schmitt trigger circuit. Whether or not V102B is on (conducting) depends on the voltage at the grid of V102A. When V102A's grid voltage is considerably less then +50 volts, V102B will be on. V102B's grid voltage is set at about +50 volts by R113 and R115. If the grid voltage of V102A is raised toward +50 volts, it will begin to turn on. As V102A goes on, its plate voltage will begin to fall, lowering the grid voltage on V102B and lowering the common cathode voltage. As the cathode voltage falls, the plate current of V102A increases. This regenerative action will terminate only when V102B is completely off and V102A completely on.

To turn V102B back on, the grid voltage of V102A must be lowered to a level below that at which the switching first took place. This voltage hysteresis effect is shown in Figure 4.3. When V102B switches off, its rapidly falling plate current produces the triggering pulse, which is used to initiate the main pulse and which serves as the pre-pulse for the SYNC terminals after amplification by V101B. This pulse is produced when V102A is turned on by a positive voltage applied to its grid. The pre-pulse is therefore produced when a negative transition occurs at the grid of V101A.

4.2.3 QUIESCENT CONDITIONS.

In the absence of an input signal, the grid of V101A will be at ground potential, and its plate voltage will be around +60 volts. Whether or not V102A will be on will depend upon the setting of R103, the ΔF and trigger-threshold control. When this control is adjusted for maximum trigger sensitivity(centered), the quiescent voltage at the grid of V102A will lie in the center of the hysteresis region. Input signals applied to the EXT DRIVE terminals are amplified by V101A and cause V102 to switch. The exact phase at which the output trigger will be formed is determined by the setting of R103. Maximum sensitivity will be obtained when the amplified signal is centered in the hysteresis region.

A single pulse can be produced (paragraph 3.4.2) by rotation of the ΔF control through its centered position. This rotation simply sets and resets the Schmitt trigger.

4.3 INPUT AND PRF OSCILLATOR CIRCUIT – INTERNAL OPERATION.

4.3.1 GENERAL.

In Figure 4-2, the PRF switch is shown in the EXT DRIVE position. When this switch is set to any of the other positions, the voltage amplifier and Schmitt circuits are converted to a prf oscillator.

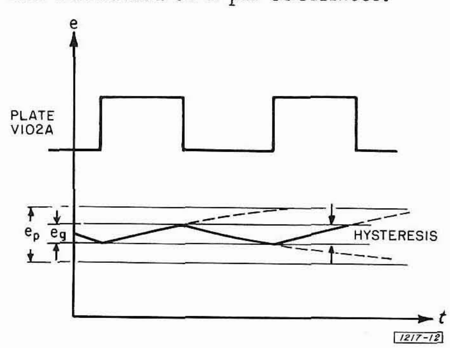


Figure 4-3. Diagram showing operation of internal oscillator.

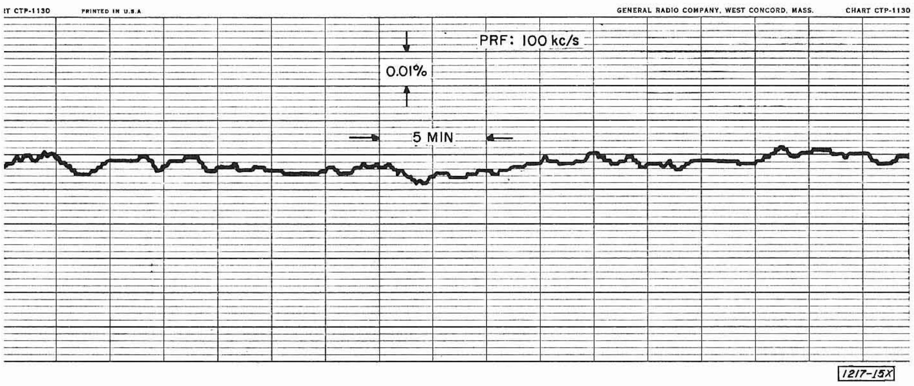


Figure 4-4a. Typical drift characteristics of prf oscillator.

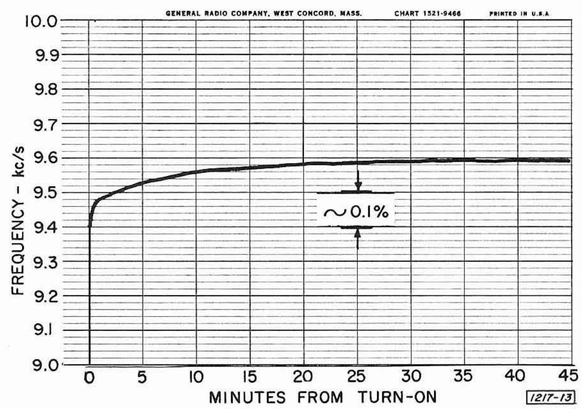


Figure 4-4b. Typical warmup characteristics of prf oscillator.

4.3.2 OSCILLATOR ACTION.

The PRF switch, S101, converts the input amplifier to a current source that translates the plate swing of V102A so that it is symmetrical around its own grid voltage. The switch ungrounds the junction of R107 and R108 and switches R102 from the plate supply voltage to the plate of V102A. The ΔF control (R103) and R102 form the resistance part of the frequency determining network and the PRF switch forms the capacitance part by adding capacitance from the grid of V102A to ground. The mechanism of oscillation is shown in Figure 4.3. Suppose that V102A is off; its plate voltage is high and C1 charges through R103 and R102 until V102A turns on. When V102A turns on, its plate voltage falls and C1 begins to discharge. C1 continues to discharge until V102A again turns off. The Schmitt circuit thus oscillates with V102A's grid voltage trapped within the hysteresis region. The prf is changed by adjustment of capacitance with the PRF switch and resistance with the ΔF control.

4.3.3 OSCILLATOR STABILITY.

The output frequency of this oscillator is quite stable. Parameters important in controlling frequency are R, C, and the magnitude of the hysteresis is established by the Schmitt circuit design, where both sections of V102 operate far from zero bias so that R114 provides current feedback, and stabilizes the circuit against the effects of changing tube characteristics. Typical warm-up and drift characteristics are shown in Figure 4-4.

4.4 OUTPUT PULSE AND TIMING CIRCUITS.

4.4.1 GENERAL.

A balanced-output amplifier pair is driven by a transistor flip-flop circuit to produce the output pulses. The same transistor circuit activates the pulse timing circuit comprising a ramp generator (V103) and a Schmitt circuit (V104) used as an amplitude comparator.

4.4.2 START AND STOP SIGNAL PATHS.

The output-pulse circuit requires a positive pulse to start its action but, once started, will turn itself off. Therefore, there are two signal paths in the circuit; one to start the action and one to stop it. Both paths are shown in Figure 4-5.

4.4.3 POWER AMPLIFIERS, AMPLITUDE CONTROL.

The output power amplifiers are V105 and V106. Nine 100-ohm resistors and one 120-ohm rheostat connected in series make up the plate-load resistance of each amplifier. A single switch determines for both amplifiers the output voltage by switching, in rheostat fashion, the appropriate number of 100-ohm resistors into the output circuit. The two 120-ohm rheostats are ganged together to provide continuous amplitude control, so that a common front panel AMPLITUDE control sets the output amplitude and impedance of both amplifiers.

4.4.4 +OUTPUT AMPLIFIER.

Quiescent: V105 ON

With the AMPLITUDE control set for the maximum output, the positive output pulse starts from −60 volts and rises to 0 volts. Therefore, in the quiescent state (before the trigger pulse from the input and prf oscillator circuit is applied) V105 is on (conducting) and about 60 mA flows through the output resistors.

4.4.5 -OUTPUT AMPLIFIER.
Quiescent: V106 OFF

The negative output pulse starts from 0 volts and falls to -60volts, Therefore, in the quiescent state, V106 is off (not conducting), no current flows through, its plate load resistors and the -OUTPUT point rests at ground potential (0 volts).

4.4.6 MULTIVIBRATOR DRIVER, OUTPUT AMPLIFIER BIAS.
Quiescent: Q101 OFF, Q102 ON

The plate voltages of the output amplifiers are controlled by their grid voltages, which, in turn, are controlled by the bistable driver, which consists of two npn transistors, Q101 and Q102.

As noted before, V105 is on in the quiescent state, which means its grid bias must be low enough to allow conduction. V105 and V106 are self-biased by their common cathode resistor R156, through which about 70 milliamperes flow for a 2-volt bias. If Q101 were on (conducting), current would flow through R154, and the voltage drop across R154 and R156 (V105 bias) would be sufficiently large to turn off V105. Since V105 is on, Q101 must be off. When Q101 is off, Q102 is on because the two transistors form a bistable multivibrator. With Q102 on, current flows through R157 to bias V106 off – the quiescent condition described above in paragraph 4.4.5.

4.4.7 TRIGGER AMPLIFIERS.
Start-Signal Action

Q103 and Q104 are the trigger amplifiers. Both are biased off. Since both are npn transistors, a positive pulse applied to their bases will turn them on for the duration of the pulse. When a start signal (positive pulse) arrives from the input and prf circuit, it is applied to the base of Q103. Q103 conducts and produces a negative pulse at its collector.

4.4.8 MULTIVIBRATOR DRIVER SWITCHING.
Start-Signal Action

The negative pulse at the collector of Q103 is coupled to the base of Q102 and causes Q102 to start to turn off. Q102 is one half of a multivibrator that consists of Q102 and Q101; as Q102 starts to turn off, Q101 starts to turn on. This is the normal regenerative action of any multivibrator and the discussion that follows describes the switching action and the regenerative paths of Q101 and Q102.

The negative pulse at the base of Q102 appears as a positive pulse at the collector of Q102. This positive pulse is coupled through C134 to the base of Q101 and causes Q101 to start to turn on. The positive pulse at the base of Q101 appears as a negative pulse at the collector. This negative pulse is coupled through C133 and R139 back to the base of Q102, aids the negative pulse already present from the collector of Q103, and thus completes the regenerative loop. Upon completion of the switching action, Q101 is on and Q102 is off.

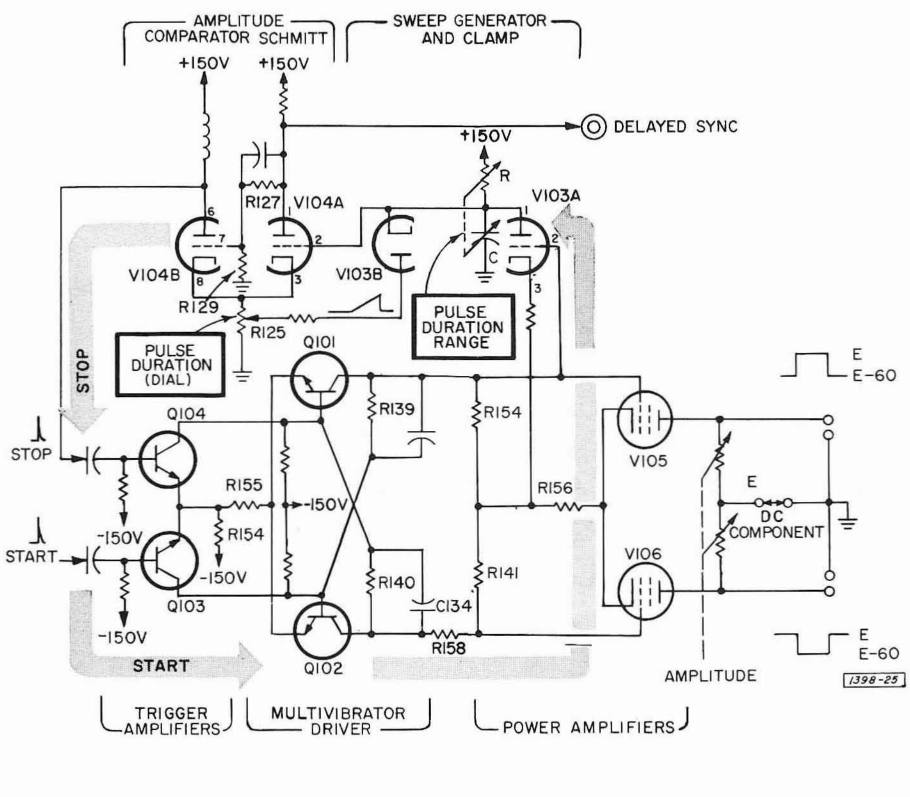


Figure 4-5. Simplified schematic diagram of the output-pulse circuit.

4.4.9 OUTPUT AMPLIFIERS.
Start-Signal Action

Since the multivibrator driver has reversed its state, the output amplifiers have also reversed their states. V105 is now off and the +OUTPUT PULSE voltage is 0 volts, and V106 is now on and the -OUTPUT PULSE voltage is -60 volts instead of 0 volts. All that remains to convert these dc-voltage steps to pulses is to return the circuits to their quiescent levels.

4.4.10 SWEEP GENERATOR AND CLAMP, DURATION CONTROL.
Quiescent: V103A ON, V103B ON

The stop-signal path returns the circuits to their quiescent levels. The time required to do this is the output pulse duration; therefore the PULSE DURATION controls are located in the stop signal path.

The duration is actually controlled by a sweep generator whose sweep rate can be adjusted by the DURATION controls. Before the arrival of a start pulse all circuits are in their quiescent states. V105 is on, and since the grid bias of V105 is also the grid bias of V103A, V103A is also on in the quiescent state.

The diode V103B is connected between C and a tap on the cathode resistor R125 (the PULSE DURATION control) of the Schmitt circuit comprised of V104A and B. This resistor carries a constant current (about 15 milliamperes) so that the voltage V at the tap is constant. This positive voltage forms the base from which the ramp pulse of the sweep generator rises.

As long as V103A is on, C will not charge, and V103B will be on, holding C's voltage to V.

4.4.11 AMPLITUDE COMPARATOR SCHMITT.
Quiescent: V104A OFF, V104B ON

Since the voltage V on its grid is held equal to or lower than its cathode voltage, V104A is biased off. Since V104A and B are a Schmitt circuit, V104B must be on if V104A is off. V104A will not turn on until the voltage on its grid exceeds the voltage on the grid of V104B set by R127 and R129.

4.4.12 SWEEP GENERATOR AND CLAMP.
Stop-Signal Action

When V105 reverts from its quiescent state, it turns off. V103A also turns off because both tubes share a common bias. When V103A turns off, capacitor C begins to charge to +150 volts. As it charges, it draws current through the plate load resistor, R, of V103A and thus keeps the plate of V103A from returning immediately to +150 volts.

Therefore, the voltage at the plate of V103A goes positive at a rate determined by the values of C and R. When this voltage goes more positive than V, V103B turns off. When the voltage reaches the switching voltage of the Schmitt trigger-circuit, V104A turns on and V104B turns off. The length of time it takes the voltage on C to reach this level depends on the base voltage V: if V is tapped from the top of R125, the time is short; if V is zero (tapped from the bottom), time is long. When V104B turns off, a positive pulse is applied to the stop-trigger amplifier.

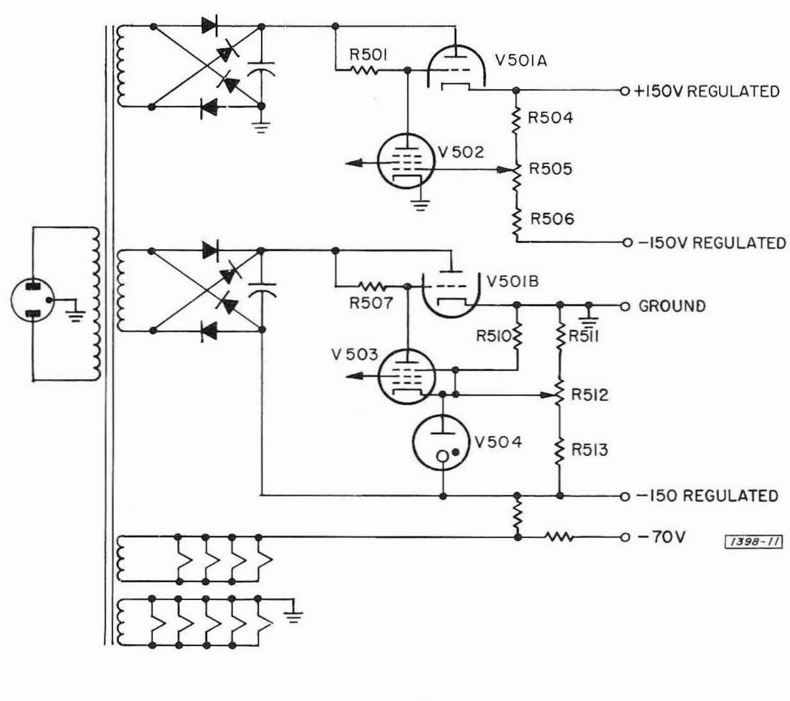


Figure 4-6. Simplified schematic diagram of the power-supply circuit.

4.4.13 STOP-TRIGGER AMPLIFIER.

Stop-Signal Action

The stop-trigger amplifier behaves in the same fashion as the start trigger amplifier when it receives a positive pulse, i.e., it reverses the state of the multivibrator, which, in turn, reverses the state of the output amplifiers. Thus V105 is turned back on, V106 is turned off, all circuits have returned to their quiescent levels, and the output pulse is terminated.

4.5 POWER SUPPLY. (Figure 4-6).

4.5.1 GENERAL.

Both the positive and negative 150-volt supplies are highly regulated with conventional amplifier, series-tube, voltage regulators. The negative supply contains the reference tube and is therefore the primary regulated voltage source. The positive supply obtains its reference from the negative. The raw dc source for each supply is a full-wave bridge rectifier with a capacitor input filter. CR501, CR502, CR503, and CR504 provide + 225 volts with respect to ground to the first half of V501, the positive series tube. In similar fashion CR505, CR506, CR507, and CR508 provide an equal dc voltage which divides across the second section of V501 and the load to provide −150 volts regulated with respect to ground.

4.5.2 THE NEGATIVE VOLTAGE SUPPLY.

R510 and V503 draw about 10 milliamperes of current in V504, the voltage reference tube. The drop across V504 is a very constant 80 volts. R511, R512, and R513 form a voltage divider establishing the grid potential of amplifier tube V503 at a level very slightly more negative than the cathode. The plate current of V503 in R507 controls the drop across V501. V501 and V503 are therefore an amplifier with high gain and any attempt by V503's grid voltage to change with respect to its cathode voltage results in a compensating change in the voltage drop across V501. The drop across R513 and to the top of R512 is therefore held very constant and is near 80 volts.

4.5.3 THE POSITIVE VOLTAGE SUPPLY.

The constant −150-volt source established with V501B, V503, and V504 is used as a reference for the positive supply. The plate current of V502, the cathode of which is grounded, in R501 controls the drop across V501A. Thus V501A and V502 comprise an amplifier with high gain. The grid voltage of V502, only slightly negative (one volt) with respect to its cathode, is established by the voltage divider consisting of R504, R505, and R506. This divider is set so that the portion of resistance above the tap is equal to that below. For the grid voltage of V501 to be near zero volts the output voltage at pin 3 of V501 *must* be 150 volts.

4.5.4 THE HEATER VOLTAGE SUPPLY.

Two heater busses are used in the Type 1398-A. The 6.3-volt dc heaters of V101, V102, V104, V501, and V502 are fed from a common buss at ground potential. The heater supply for V103, V105, V106, and V501 is biased to − 70 volts dc by a divider from − 150 volts comprised of R514, R515, and R518.

SECTION 5

SERVICE AND MAINTENANCE

5.1 WARRANTY.

We warrant that each new instrument sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, sales engineering office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

5.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type number of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest sales engineering office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 REMOVAL OF COVER.

To open the instrument for access to components, loosen the large fluted screw at the rear of the right-hand side of the cabinet. Then grasp the panel by the top and bottom edges with one hand, and with the other hand slide the aluminum dust cover away from the panel and off the rear.

All components are easily accessible. See Figures 5-3, 5-4, and 5-6 for location of components.

5.4 ROUTINE MAINTENANCE.

5.4.1 LUBRICATING THE FAN MOTOR.

For long, trouble-free operation, lubricate the fan motor at least once a year with SAE 20 or 30 premium-quality oil. There are two lubricating holes, one in each of the brass brackets on either side of the motor laminations.

5.4.2 CLEANING THE AIR FILTER.

To maintain proper cooling efficiency, the air filter should be cleaned periodically. Local air conditions determine how often this is necessary. To clean, release the air filter from its holder, rap gently to remove excess dirt, flush from the dirty side with hot soapy water, rinse, and let dry. Commercially available preparations to increase the filtering efficiency may be applied but are not necessary.

5.5 TROUBLE-SHOOTING NOTES.

5.5.1 GENERAL.

If the pulse generator is inoperative, make the following simple checks before proceeding further:

a. Check the power line voltage and frequency to make sure they are as required by the power supply.

b. Check line cord, fuses, and power supply voltage. If the voltage from pin 3 of V501 to ground is not 150 volts or if the voltage from pin 2 of V504 is not -150 volts, refer to paragraph 5.5.2.

c. See if the prepulse is present at the SYNC binding posts. If this pulse is present and the main pulse is defective, refer to paragraph 5.5.2. If the prepulse is present and there is no main pulse, refer to paragraph 5.5.3. If neither prepulse nor main pulse is present, refer to paragraph 5.5.4. If prepulse is absent and the main pulse is present, refer to paragraph 5.5.7.

5.5.2 INOPERATIVE POWER SUPPLY.

Incorrect voltage. If the positive supply voltage at pin 3 of V501 is regulated but not +150 volts with respect to ground, first see if the negative supply voltage at pin 4 of V504 is -150 volts. If this voltage is regulated but not correct, adjust R512 so that an accurate voltmeter indicates +150 volts from pin 3 of V501 to ground. If the positive supply voltage adjustment drifts, but the negative supply voltage does not, replace either R504, R506, or R505. If the negative supply voltage adjustment drifts, replace R511, R513, R510, R512, or V504.

If the voltage drops only at full load, replace V501, and check the voltage at pins 2 and 5 of V501. If either of these voltages is less than 210 volts, check the corresponding capacitors and diodes.

Unregulated voltage. The most probable cause of this trouble is a defective tube. Remove V502 and V503 test them, and replace any defective tube. Measure the voltage at pin 2 of V503 with respect to ground. If this is not within 5% of -66 volts, regardless of the output load, replace V504. Measure the resistances to ground from pin 2, pin 3, pin 5, and pin 6 of V501 and compare the results with the values in Table 5-1. Replace any defective resistors or capacitors thus found.

No output supply voltage. Check V501. Measure the regulator input voltage across C501 and C502. If either of these voltages is zero, check for a shorted rectifier diode, C501, C502, and a blown fuse in the primary of T501. If the input voltage is normal, check V502 and V503 for an internal short. Check V504 for a short. Measure the voltages at key points with a vacuum tube voltmeter, comparing them with those given in Table 5-1.

Incorrect heater voltage. If the dc voltage at pin 4 of V103, V105, or V106 or pin 3 of V503 is not within 10% of -70 volts, check for a cathode-heater short in one of those tubes. Check the resistance to ground from pin 2 of V504 against the value in Table 5-1. Replace any defective resistors. Check for a short in C504 or C505.

5.5.3 DEFECTIVE MAIN PULSE.

Overshoot. Under normal conditions, with a high impedance load, overshoot is not possible on any transition. Therefore, check the oscilloscope for overshoot first. If overshoot occurs with a low-impedance terminated system, check the system for proper grounding and make sure that all wiring is as short as possible. Note that some overshoot may be present on negative pulse transitions as shown in Figure 3.6.

Large imbalance in pulse amplitudes or slowly falling negative-going edge of positive pulse. These defects can be caused by weakening of one of the output tubes.

Output pulse occasionally fails, and starts only when RANGE switch setting is changed. There are two possible causes of this difficulty: (1) The ionization voltage of V107 has drifted sufficiently so that the automatic restarting circuit no longer functions, or (2) a tube has developed heater-to-cathode leakage. First check the voltage from the negative side of V107 to ground, using an electronic voltmeter of at least 100 megohms input impedance. The proper voltage is -65 ± 5 volts behind 5 megohms. If this voltage is correct, the trouble is a defective V107, and a new NE-96 should be installed. If the voltage measured is not correct, check all tubes for heater-to-cathode leakage.

Pulse-duration errors. An error indication on only, one setting of the RANGE switch is an indication that a time-determining component for that range has drifted or failed.

5.7 VOLTAGES AND RESISTANCES.

TABLE 5–1
VOLTAGES AND RESISTANCES

Tube	*Pin*	** *Dc Volts to Ground*	*** *Ohms to Ground*
V101	1	34	33k
(6DJ8)	2	– 0.1	1M or 10k*
	3	0.8	60k
	6	145	1k
	7	0	22k
	8	4.5	1k
V102	1	125	3.2k
(6DJ8)	2	34	100k
	3	40	3.3k
	6	150	2.5k
	7	33	70k
	8	40	3.3k
V103	1	46	60k
(6DJ8)	2	– 125	4.6k
	3	– 120	4.8k
	6	47	5.5k
	7	47	5.5k
	8	46	60k

Tube	*Pin*	** *Dc Volts to Ground*	*** *Ohms to Ground*
V104	1	150	1.6k
(6922)	2	46	63k
	3	54	5k
	6	150	1.2k
	7	52	65k
	8	54	5k
V105	1	– 70	1k
(8233)	2	– 122	50k
	3	0	0
	8	– 125	49k
V106	1	0	1k
(8233)	2	– 122	50k
	3	0	0
	8	– 130	49k
V107	+	46	63k
(NE-96)	–	– 65	5M

Tube	*Pin*	** *Dc Volts to Ground*	*** *Ohms to Ground*
V501	1	130	1M
(6080)	2	225	—
	3	150	0
	4	– 12	1M
	5	70	—
	6	0	0
V502	1	– 4.8	80k
(6AG5)	2	0	0
	5	130	1M
	6	165	10k
V503	1	– 68	15k
(6AH6)	2	– 66	27k
	5	– 12	1M
	6	9.2	8.5k
	7	– 66	27k
V504	1	– 66	27k
(5651)	2	- 150	0

Transistor (Type)	*Lead*	*Dc Volts to Supply*	*** *Ohms to Ground*
Q101	E	1.9	24
(2N2369)	B	2.1	50k
	C	24.5	50k
Q102	E	1.9	24
(2N2369)	B	2.9	50k
	C	2.2	50k

Transistor (Type)	*Lead*	*Dc Volts to Supply*	*** *Ohms to Ground*
Q103	E	0.96	12
(2N2369)	B	0	5.6k
	C	2.9	50k
Q104	E	0.96	12
(2N2369)	B	0	5.6k
	C	2.1	50k

* Depends on ohmmeter polarity and resistance range.

** All heater voltages = 6.2 volts ac.

*** Power supply disconnected, terminals #117 and #118 (near AMPLITUDE control) grounded, all transistors removed.

TEST CONDITIONS

This table lists important voltages and resistances in the Type 1398-A. These voltages, measured by a Type 1806-A Electronic Voltmeter (input resistances = 100 MΩ), are accurate to within ±5%. R505 and R512 were set for normal power supply output = 150 volts dc. Power line = 115 volts, power = 82 watts. The Type 1398-A controls were set as follows:

PRF . . . . 1 kc/s
ΔF . . . . centered
PULSE DURATION
dial 1
RANGE . . . . 0.1 to 1 μs
AMPLITUDE. 10 (fully cw)

A uniform error on all ranges is an indication that the amplitude comparison circuit (V104 and associated components) is defective. For instance, a decrease in resistance of R127 would make all pulses too long at all settings of the PULSE DURATION controls, while an increase in this resistance would reverse the effect.

If the output pulse is of fixed, long duration, independent of the PULSE DURATION controls, V103B is not functioning and a new tube should be inserted.

Another difficulty traceable to a defective V103 would be excessive duration at the high end of each range, especially at longer duration ranges. It is probable that V103 is not remaining off, and it should be replaced.

5.5.4 NO MAIN OUTPUT PULSE, SYNC PULSES PRESENT.

If no output pulses are present and V107 flashes continually, check V103 and V104 and replace if necessary.

If V107 is not flashing, measure the voltage at the + OUTPUT PULSE binding post. If it is - 60 volts with respect to ground, the trouble is either a defective transistor Q102 or Q104 or failure of the start triggering circuits. Check for the presence of a 15-volt, 0.15-μs positive trigger pulse at pin 6 of V102. Check L103 for a short or open circuit.

5.5.5 MAIN AND SYNC PULSES BOTH ABSENT.

This indicates trouble in the input circuits. First check V101 and V102. (After replacing V101, center the ΔF control and adjust R107 for optimum sensitivity with an external signal.) If this fails to pinpoint the problem, check voltages against those given in Table5 1.

5.5.6 INCORRECT FREQUENCIES.

If the frequency error occurs at only one setting of the PRF switch, the fault is one of the timing capacitors, C108 through C117. Replace the appropriate capacitor.

If all frequencies are in error by about the same amount with the ΔF control fully clockwise, check R102, R104, R105, and R108.

5.5.7 FAILS TO SYNC ON EXTERNAL SIGNAL.

If the instrument operates normally on internal operation but will not synchronize on external signals, check the input network. An extremely high transient voltage may have caused CR101 to short-circuit.

5.5.8 MAIN PULSES PRESENT, NO SYNC PULSES.

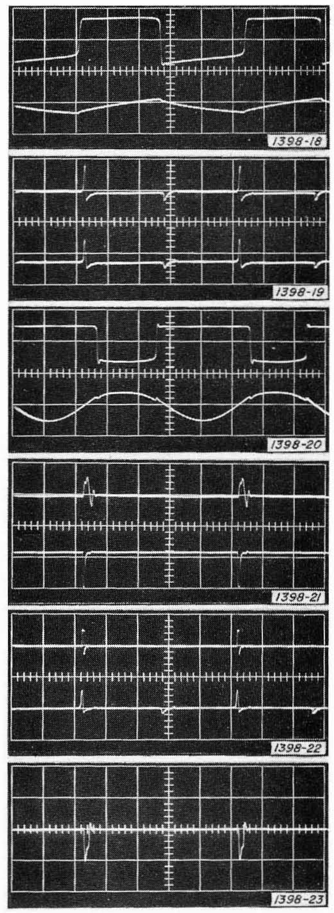
Check V101 and the components associated with V101B.

5.6 WAVEFORMS.

5.6.1 TEST CONDITIONS.

Figure 5-1 depicts important waveforms in the Type 1398-A. They were taken with a 10-megohm, 12-pF probe; the vertical sensitivity listed beside each oscillogram includes the 10X attenuation of the probe. The Type 1398-A controls were set as follows (except where noted):

PRF . . . . 100 kc/s
ΔF . . . . centered
PULSE DURATION dial 1
PULSE DURATION RANGE . . . . . . 0.1 to 1 μs
AMPLITUDE . . . . 10 (fully clockwise)



V102, pin 1, 20 V/cm, 2 μs/cm.
V102, pin 2, 20 V/cm, 2 μs/cm.

V101, pin 7, 10 V/cm, 2 μs/cm.
V101, pin 8, 10 V/cm, 2 μs/cm.

V102, pin 1, 20 V/cm, 2 μs/cm.
V102, pin 2, 20 V/cm, 2 μs/cm.

V104, pin 2, 10 V/cm, 2 μs/cm.
V103, pin 2, 20 V/cm, 2 μs/cm.

V106, pin 8, 10 V/cm, 2 μs/cm.
V102, pin 1, 20 V/cm, 2 μs/cm.

V104, pin 1, 20 V/cm, 2 μs/cm.

Figure 5-1. Waveforms.

5.7 VOLTAGES AND RESISTANCES (See Table 5-1).

5.8 CALIBRATION PROCEDURE.

5.8.1 TEST SETUP AND EQUIPMENT REQUIRED.

General. A description of the equipment required for a complete calibration of the Type 1398-A Pulse Generator is given in the paragraphs that follow. The interconnections necessary are shown in Figure 5-2.

(1) Sine-wave generator. Capable of 10 kc/s, 0.1 V into 1 MΩ and 2.2 Mc/s, 0.5 V into 1 MΩ. Accuracy ±10% or better. The Type 1330 Bridge Oscillator or the Type 1001 Standard-Signal Generator may be used.

(2) Time-mark generator. Capable of 100-ms to 0.1-μs marks in 5 decade ranges. Accuracy ±0.1% or better. The use of a time-mark generator is optional. When it is used, time-measurement accuracy is dependent upon the accuracy of the time-mark generator (typically 0.001%) rather than upon the accuracy of the oscilloscope time-base (typically 3%).

(3) Terminated 50-ohm coaxial patch cord. A coaxial cable with coaxial fittings on both ends with a 50-ohm noninductive resistor on one end. An assembly that consists of a Type 874-R20A Coaxial Patch Cord, a Type 874-W50 50-ohm Termination, and an adaptor to fit the 50-ohm termination to the oscilloscope may be used. A Type 874-QUP Adaptor fits uhf connectors and a Type 874-QBPA Adaptor fits BNC connectors. A Table of GR874 Connectors is included at the end of this book.

(4) Oscilloscope. Capable of measuring 5-ns rise times and durations of 1.05 s to 75 ns. Accuracy ±1% or better. Must have sweep delaying provision if time jitter is to be measured (paragraph 5.8.4).

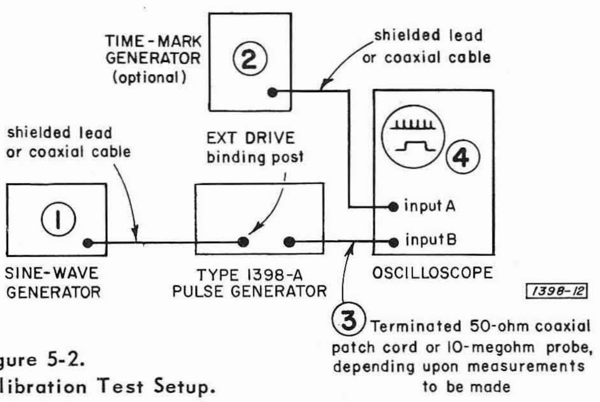


Figure 5-2. Calibration Test Setup.

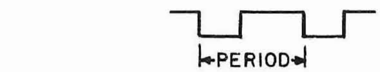
5.8.2 PRF ACCURACY.

Setup. Connect the - OUTPUT PULSE coaxial connectors to the oscilloscope via a terminated 50-ohm coaxial patch cord. Set the Type 1398-A controls as follows:

ΔF . . . . HIGH (fully clockwise)
PULSE DURATION dial 1
PULSE DURATION RANGE . . . . . . 0.1 to 1 μs
AMPLITUDE . . . . 10 (fully clockwise)

PRF switch accuracy. Check or adjust the pulse repetition frequency as outlined in Table 5-2. Note that frequency is measured in terms of period length (1/prf).

TABLE 5-2
PRF ACCURACY



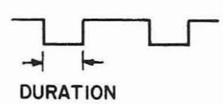
PRF Switch Setting	*Period 1/prf ±5% Tolerance*
100 c/s	Adjust R158 for period of 10 ms.
10 c/s	95 to 105 ms
30 c/s	31.7 to 35 ms
300 c/s	3.17 to 3.5 ms
1 kc/s	950 to 1050 μs
3 kc/s	315 to 350 μs
10 kc/s	95 tp 105 μs
30 kc/s	31.7 to 35 μs
100 kc/s	9.5 to 10.5 μs
300 kc/s	Adjust C117 for period of 3.33 μs. Vary ΔF control over full range; period must change smoothly and be greater than 10 μs when ΔF control is set fully counterclockwise.
1.2 Mc/s	Adjust C140 for period of 850 μs.

5.8.3 PULSE DURATION ACCURACY.

Setup. Connect the - OUTPUT PULSE coaxial connector to the oscilloscope via a terminated 50-ohm coaxial patch cord. Set the Type 1398-A controls as follows:

ΔF . . . . HIGH (fully clockwise)
AMPLITUDE . . . . 10 (fully clockwise)

PULSE DURATION dial accuracy. In each of the following checks, set the PULSE DURATION dial for the indicated duration as measured on the oscilloscope and note the PULSE DURATION dial reading:



PULSE DURATION RANGE Setting	*Maximum PRF*	*Set PULSE DURATION dial for measured duration of*
10 to 100 μs	3 kc/s	50 μs
100 μs to 1 ms	300 c/s	500 μs
1 to 10 μs	30 c/s	5 ms
10 to 100 ms	10 c/s	50 ms

The difference between the lowest and highest PULSE DURATION dial readings is the error span. Mechanically position the PULSE DURATION dial with respect to its associated potentiometer so that a reading of 5 lies on the center of the error span.

For example: If the lowest dial reading was 5.8 and occurred on the 10 to 100 ms RANGE and the highest dial reading was 6.6 and occurred on the 1 to 10 ms RANGE, the error span is 6.6 - 5.8 = 0.8.

Set the RANGE switch to 10 to 100 ms (the range where the lowest dial reading was noted) and set the PULSE DURATION dial for a measured duration of 50 ms. Loosen the hub set-screw (behind the PULSE DURATION potentiometer) and position the dial for a reading of 5 - 0.4 = 4.6. Be careful not to disturb the setting of the potentiometer itself; the measured duration must remain 50 ms. Tighten the setscrew. A dial reading of 5 now lies in the center of the error span (center of error span = error span ÷ 2 or 0.8 ÷ 2 = 0.4).

To be sure a PULSE DURATION dial reading of 5 lies in the center of the error span, set the RANGE switch to 1 to 10 ms (the range where the highest dial reading was noted) and set the PULSE DURATION dial for a measured duration of 5 ms. If the dial has been positioned correctly it will read 5 + 0.4 = 5.4.

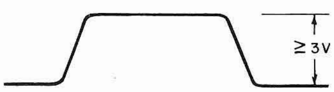
PULSE DURATION RANGE accuracy. Check or adjust the PULSE DURATION RANGE accuracy as outlined in Table 5-3.

5.8.4 OUTPUT-PULSE CHARACTERISTICS.

Setup. The characteristics and specifications for both the + and the – OUTPUT PULSE waveforms are the same except for polarity. Connect the appropriate OUTPUT PULSE binding posts to the oscilloscope via a terminated 50-ohm cable. Set the Type 1398-A controls as follows:

ΔF . . . . HIGH (fully clockwise)
PRF . . . . 1.2 MC
PULSE DURATION dial. 5
PULSE DURATION RANGE. . . . . .0.1 to 1 μs
AMPLITUDE. . . . . 10 (fully clockwise)

Amplitude. Equal to or greater than 3 volts, p-to-p.



Rise time. 5ns or faster as measured between the 10 and 90% points. Be sure any rise-time limitations of the oscilloscope are taken into account (refer to paragraph 3.5.3 for further rise-time details).

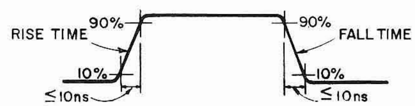
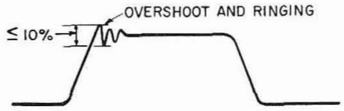


TABLE 5-3

PULSE DURATION RANGE ACCURACY

PULSE DURATION *RANGE*	*Dial*	*Maximum PRF*	*Duration Limits*
100 ms to 1 s	1	10 c/s	95 to 105 ms (±2% of full scale)
10 to 100 ms	1	30 c/s	9.5 to 10.5 ms (±2% of full scale)
1 to 10 ms	1	300 c/s	0.95 to 1.05 ms (±2% of full scale)
100 μs to 1 ms	1	3 kc/s	95 to 105 μs (±2% of full scale)
10 to 100 μs	1	30 kc/s	9.5 to 10.5 μs (±2% of full scale)
1 to 10 μs	1	300 kc/s	0.9 to 1.05 μs (±2% of full scale)
0.1 to 1 μs	1	1.2 Mc/s	65 to 135 ns (±35 ns)
100 ms to 1 s	5	10 d/s	475 to 525 ms (±5% of reading)
10 to 100 ms	5	10 c/s	47.5 to 52.5 ms (±5% of reading)
1 to 10 ms	5	30 c/s	4.75 to 5.25 ms (±5% of reading)
100 μs to 1 ms	5	300 c/s	475 to 525 μs (±5% of reading
10 to 100 μs	5	3 kc/s	47.5 to 52.5 μs (±5% of reading)
1 to 10 μs	5	30 kc/s	4.75 to 5.25 μs (±5% of reading)
0.1 to 1 μs	5	300 kc/s	465 to 535 ns (±35 ns)
100 ms to 1 s	10	10 c/s	0.95 to 1.05 s (±5% of reading)
10 to 100 ms	10	10 c/s	95 to 105 ms (±5% of reading)
1 to 10 ms	10	30 c/s	9.5 to 10.5 ms (±5% of reading)
100 μs to 1 ms	10	300 c/s	0.95 to 1.05 ms (±5% of reading)
10 to 100 μs	10	3 kc/s	95 to 105 μs (±5% of reading)
1 to 10 μs	10	30 kc/s	9.5 to 10.5 μs (±5% of reading)
0.1 to 1 μs	10	300 kc/s	Adjust C141 for duration of 1 μs

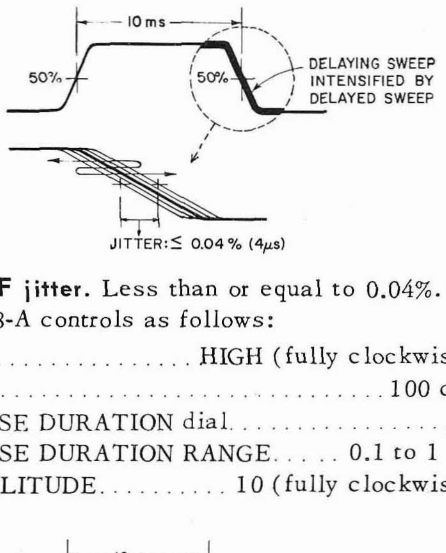
Overshoot and ringing. Not greater than 10% of amplitude.



Jitter-oscilloscope limitation. The amount of jitter present in the oscilloscope must be taken into account when duration and period jitter are measured. Typical jitter for most delaying sweep oscilloscopes is 0.02% of the amount of delay. To determine actual jitter, connect a stable time-mark signal to the oscilloscope, set the oscilloscope for the amount of delay required, and measure any jitter that may be present. If the time-mark signal is stable, any jitter present is due to the oscilloscope.

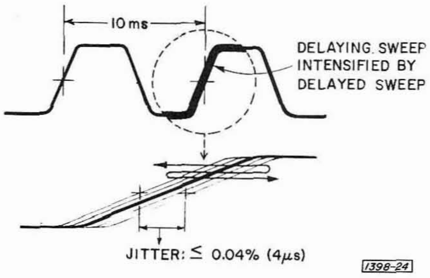
Duration jitter. Less than or equal to 0.04%. Set the Type 1398-A controls as follows:

ΔF	centered
PRF	30 c/s
PULSE DURATION dial	10
PULSE DURATION RANGE	1 to 10 ms
AMPLITUDE	10 (fully clockwise)



PRF jitter. Less than or equal to 0.04%. Set the Type 1398-A controls as follows:

ΔF	HIGH (fully clockwise)
PRF	100 c/s
PULSE DURATION dial	1
PULSE DURATION RANGE	0.1 to 1 μs
AMPLITUDE	10 (fully clockwise)

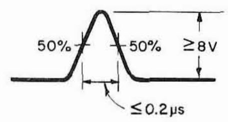


5.8.5 SYNC-OUTPUT CHARACTERISTICS.

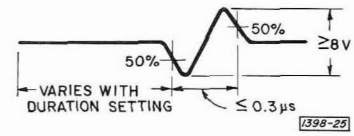
Setup. Connect the OUTPUT PULSE binding posts to the external trigger input of the oscilloscope and connect the appropriate SYNC binding post to the vertical input of the oscilloscope via a 10-megohm, 12-pF probe. Set the Type 1398-A controls as follows:

ΔF	HIGH (fully clockwise)
PRF	1.2 Mc/s
PULSE DURATION dial	.5
PULSE DURATION RANGE	0.1 to 1 μs
AMPLITUDE	10 (fully clockwise)

±SYNC output. The characteristics and specifications for both the + and the − SYNC outputs are the same, except for polarity. Amplitude: Equal to or greater than 8 volts, peak-to-peak. Duration: Equal to or less than 0.2 μs.



DELAYED SYNC output. Amplitude: Equal to or greater than 8 volts, peak-to-peak. Duration: Equal to or less than 0.3 μs.



5.8.6 EXTERNAL DRIVE.

Setup. Connect a sine-wave generator to the EXT DRIVE binding posts. Set the generator for an output of 10 kc/s, 0.1 V, rms. Set the Type 1398-A controls as follows:

ΔF	centered
PRF	EXT DRIVE
PULSE DURATION dial	1
PULSE DURATION RANGE	0.1 to 1 μs
AMPLITUDE	10 (fully clockwise)

R107 adjustment. Connect a 10-megohm probe from the oscilloscope to V102, pin 1. Adjust R107 for a symmetrical square wave.

2.2-Mc sensitivity. Set the generator for an output of 2.2 Mc/s, 0.5 V, rms. Set the ΔF control for a triggered oscilloscope display. After the ΔF control has been set for a triggered display, it must be within 30 degrees of center. To check if the display is actually triggered, disconnect the sine-wave generator; if the display was triggered, the display will disappear. Reconnect the generator.

Trigger pulling. Vary the PULSE DURATION dial from 1 to 6; the pulse repetition frequency must remain 2.2 Mc/s.

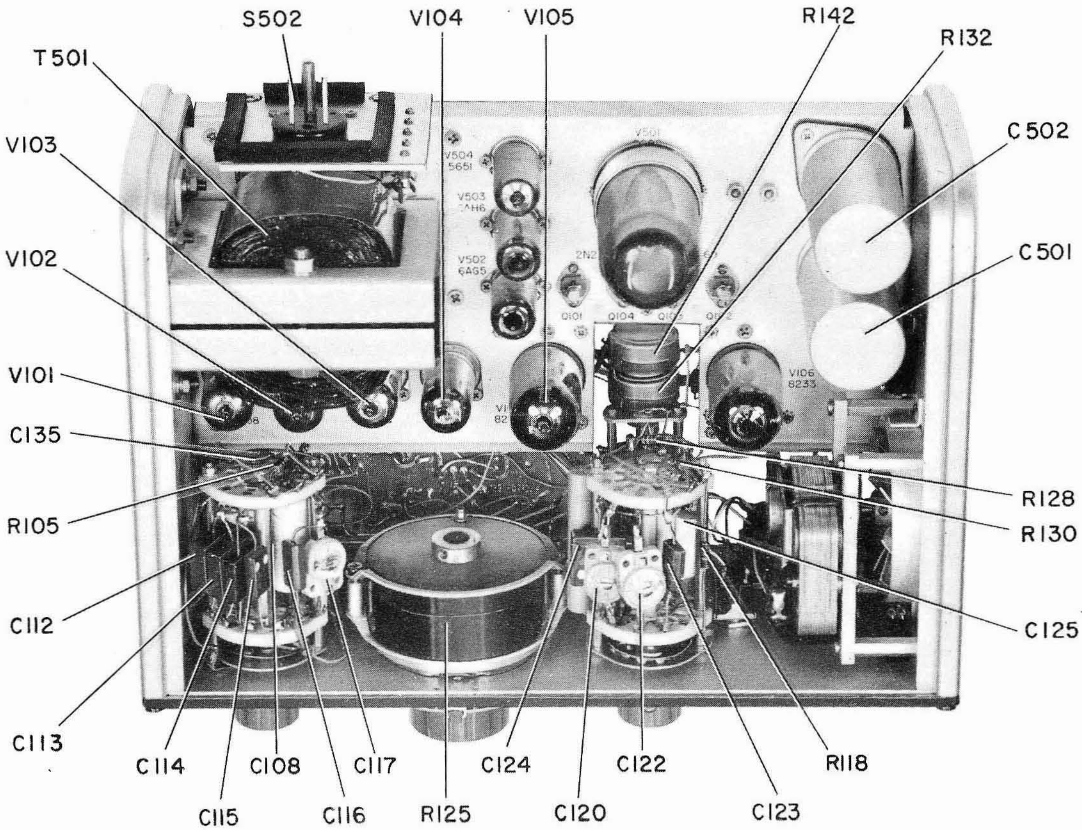


Figure 5-3. Top interior view.

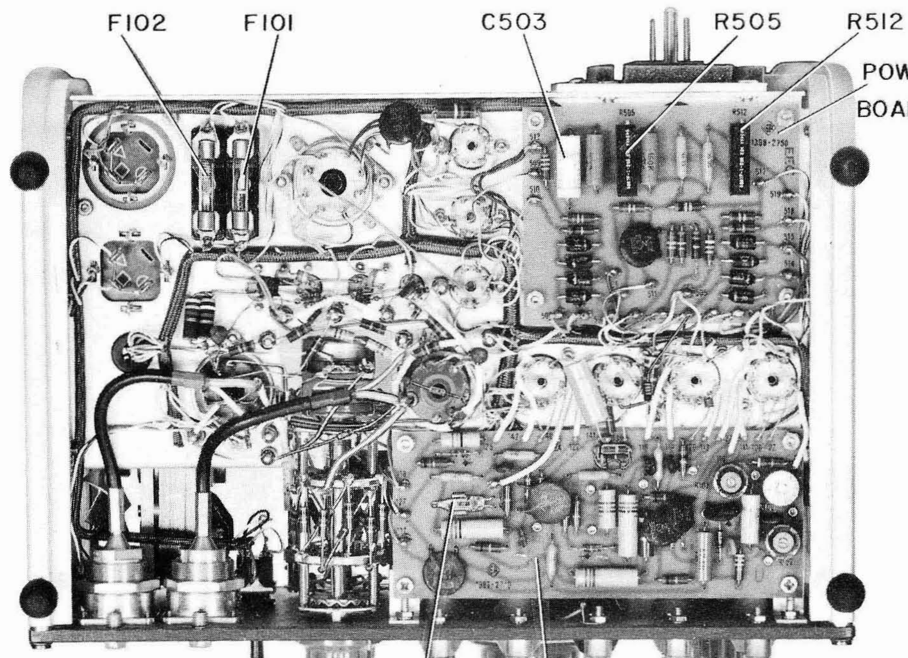


Figure 5-4. Bottom interior view.

PARTS LIST

REF NO	DESCRIPTION	PART NO
	CAPACITORS	
C100	Trimmer, 8-50 pF	4910-1170
C101	Ceramic, 51 pF ±5% 500 V	4404-0515
C102	Ceramic, 68 pF ±10% 500 V	4404-0688
C103	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C104	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C105	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C106	Ceramic, 100 pF ±10% 500 V	4404-1108
C107	Ceramic, 22 pF ±10% 500 V	4404-0228
C108	Plastic, 0.909 μF ±2% 100 V	4860-7975
C109	Plastic, 0.301 μF ±2% 200 V	4860-7982
C110	Plastic, 0.0909 μF ±2% 100 V	4860-7880
C111	Plastic, 0.0301 μF ±2% 200 V	4860-7602
C112	Mica, 0.00887 μF ±1% 300 V	4780-0088
C113	Mica, 0.00301 μF ±2% 500 V	4780-0030
C114	Mica, 825 pF ±2% 300 V	4690-4070
C115	Mica, 499 pF ±1% 300 V	4690-3999
C116	Mica, 100 pF ±1% 500 V	4650-0200
C117	Trimmer, 3-12 pF 500 V	4910-0600
C118	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C119	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C120	Trimmer, 3-12 pF 500 V	4910-0600
C121	Trimmer, 750 pF ±10% 500 V	4405-1758
C122	Trimmer, 5-20 pF	4910-0400
C123	Mica, 976 pF ±1% 300 V	4690-4095
C124	Mica, 0.01 μF ±2% 300 V	4780-0300
C125	Plastic, 0.1 μF ±2% 200 V	4860-8252
C126	Plastic, 1 μF ±2% 100 V	4860-8002
C127	Ceramic, 82 pF ±5% 500 V	4404-0825
C128	Ceramic, 0.022 μF +80-20% 500 V	4407-3229
C129	Ceramic, 0.022 μF +80-20% 500 V	4407-3229
C130	Mica, 43 pF ±5% 500 V	4640-0297
C132	Ceramic, 4.7 pF ±10% 500 V	4400-0471
C133	Ceramic, 4.7 pF ±10% 500 V	4400-0471
C134	Ceramic, 6.8 pF ±10% 500 V	4400-0800
C135	Ceramic, 0.01 μF +80-20% 500 V	4406-3109
C136	Ceramic, 0.001 μF ±10% 500 V	4410-0158
C137	Ceramic, 15 pF ±10% 500 V	4410-0158
C138	Ceramic, 0.001 μF ±10% 500 V	4405-2108
C139	Ceramic, 100 pF ±10%	4404-1108
C140	Ceramic, 100 pF ±10%	4404-1108
C141	Ceramic, 150 pF ±2% 500 V	4910-0100
C501A	Ceramic, 150 pF ±2% 500 V	4910-0100
C501B	Electrolytic, 50 μF 300 V	4450-2650
C501C	Electrolytic, 50 μF 300 V	4450-2650
C501A	Electrolytic, 60 μF 300 V	4450-2650
C502B	Electrolytic, 50 μF 300 V	4450-2650
C502C	Electrolytic, 50 μF 300 V	4450-2650
C503	Plastic, 0.1 μF ±10% 200 V	4860-8253
C504	Ceramic, 0.022 μF +80-20% 500 V	4407-3229
C505	Plastic, 0.1 μF ±10% 200 V	4860-8253
C506	Ceramic, 0.022 μF +80-20% 500 V	4407-3229
	RESISTORS	
R100	Composition, 1 MΩ ±5% 1/2 W	6100-5105
R101	Composition, 33 kΩ ±5% 1/2 W	6100-3335
R102	Film, 33.2 kΩ ±1% 1/2 W	6450-2332
R103	Potentiometer, composition 250 kΩ ±10% 1/2 W (ΔF)	6048-4260
R104	Film, 32.4 kΩ ±1% 1/4 W	6350-2324
R105	Composition, 3 kΩ ±5% 1/2 W	6100-2305
R106	Composition, 2 MΩ ±5% 1/2 W	6100-5205
R107	Potentiometer, composition 500 Ω ±20%	6040-0300
R108	Film, 57.6 kΩ ±1% 1/2 W	6450-2576
R109	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R110	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R111	Composition, 22 kΩ ±5% 1/2 W	6100-3225

REF NO	DESCRIPTION	PART NO
	RESISTORS (cont)	
R112	Composition, 3 kΩ ±5% 1 W	6110-2305
R113	Film, 100 kΩ ±1% 1/4 W	6350-3100
R114	Composition, 3.3 kΩ ±5% 1 W	6110-2335
R115	Film, 51.1 kΩ ±1% 1/4 W	6350-2511
R116	Film, 150 kΩ ±1% 1/4 W	6350-3150
R117	Composition, 330 Ω ±5% 1/2 W	6100-3565
R118	Composition, 56 kΩ ±5% 1/2 W	6100-3685
R119	Film, 270 kΩ ±1% 1/4 W	6350-3270
*R120	Film, 2.74 MΩ ±1% 2 W	6195-4274
R121	Composition, 56 Ω ±5% 1/2 W	6100-0565
R122	Composition, 1 kΩ ±5% 1/2 W	6100-2105
R123	Composition, 1.2 kΩ ±5% 1/2 W	6100-2125
R124	Composition, 1.2 kΩ ±5% 1/2 W	6100-2105
R125	Potentiometer, wire-wound 5 kΩ ±2% (PULSE DURATION)	0975-4050
R126	Composition, 1.5 kΩ ±5% 1/2 W	6100-2155
R127	Film, 191 kΩ ±1% 1/4 W	6350-3191
R128	Composition, 180 Ω ±5% 1/2 W	6100-1185
R129	Film, 100 kΩ ±1% 1/4 W	6350-3100
R130	Composition, 130 Ω ±5% 1/2 W	6100-1135
R131	Composition, 2 kΩ ±5% 1/2 W	6100-2205
R132	Potentiometer, ganged, wire-wound 120 Ω ±10% (AMPLITUDE)	1398-0400
R133	Composition, 100 Ω ±5% 1/2 W	6100-1105
R134	Composition, 100 Ω ±5% 1/2 W	6100-1105
R135	Composition, 100 Ω ±5% 1/2 W	6100-1105
R136	Composition, 100 Ω ±5% 1/2 W	6100-1105
R137	Composition, 100 Ω ±5% 1/2 W	6100-1105
R138	Composition, 100 Ω ±5% 1/2 W	6100-1105
R139	Composition, 100 Ω ±5% 1/2 W	6100-1105
R140	Composition, 100 Ω ±5% 1/2 W	6100-1105
R141	Composition, 100 Ω ±5% 1/2 W	6100-1105
R142	Potentiometer, ganged, wire-wound 120 Ω ±10% (AMPLITUDE)	1398-0400
R143	Composition, 100 Ω ±5% 1/2 W	6100-1105
R144	Composition, 100 Ω ±5% 1/2 W	6100-1105
R145	Composition, 100 Ω ±5% 1/2 W	6100-1105
R146	Composition, 100 Ω ±5% 1/2 W	6100-1105
R147	Composition, 100 Ω ±5% 1/2 W	6100-1105
R148	Composition, 100 Ω ±5% 1/2 W	6100-1105
R149	Composition, 100 Ω ±5% 1/2 W	6100-1105
R150	Composition, 100 Ω ±5% 1/2 W	6100-1105
R151	Composition, 100 Ω ±5% 1/2 W	6100-1105
R152	Potentiometer, composition 10 kΩ ±20%	6040-0700
R153	Composition, 200 Ω ±5% 1 W	6110-1205
R154	Composition, 100 Ω ±5% 1/2 W	6100-1105
R155	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R156	Composition, 27 Ω ±5% 1/2 W	6100-0275
R157	Composition, 100 Ω ±5% 1/2 W	6100-1105
R158	Composition, 200 Ω ±5% 2 W	6120-1205
R159	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R160	Composition, 12 Ω ±5% 1/4 W	6099-0125
R161	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R162	Composition, 100 kΩ ±5% 1/4 W	6099-4105
R163	Composition, 12 Ω ±5% 1/4 W	6099-0125
R164	Composition, 100 kΩ ±5% 1/4 W	6099-4105
R165	Composition, 5.6 kΩ ±5% 1/4 W	6099-2565
R166	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R167	Composition, 100 kΩ ±5% 1/2 W	6100-4105
R168	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475
R169	Composition, 200 Ω ±5% 1/2 W	6100-1205
R170	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225
R171	Composition, 1 kΩ ±10% 1/2 W	6099-2109
*R172	Composition, 68 Ω ±5% 1/2 W	6100-0685
R173	Composition, 56 kΩ ±5% 1/2 W	6100-3565
R174	Composition, 33 kΩ ±5% 1/2 W	6100-3335

* Selected in laboratory

REF NO	DESCRIPTION	PART NO
	RESISTORS (cont)	
R175	Composition, 51 Ω ±5% 1/4 W	6099-0515
R176	Composition, 51 Ω ±5% 1/4 W	6099-0515
R501	Composition, 1 MΩ ±5% 1/2 W	6100-5105
R502	Composition, 51 kΩ ±5% 1/2 W	6100-3515
R503	Composition, 13 kΩ ±5% 1/2 W	6100-3135
R504	Film, 150 kΩ ±1% 1/2 W	6450-3150
R505	Potentiometer, wire-wound 20 kΩ ±10%	6059-3209
R506	Film, 150 kΩ ±1% 1/2 W	6450-3150
R507	Composition, 1 MΩ ±5% 1/2 W	6100-5105
R508	Composition, 62 kΩ ±5% 1/2 W	6100-3625
R509	Composition, 10 kΩ ±5% 1/2 W	6100-3105
R510	Composition, 27 kΩ ±5% 1/2 W	6100-3275
R511	Film, 13.3 kΩ ±1% 1/2 W	6450-2133
R512	Potentiometer, wire-wound 20 kΩ ±10%	6059-3209
R513	Film, 26.1 kΩ ±1% 1/2 W	6450-2261
R514	Composition, 24 kΩ ±5% 1/2 W	6100-3245
R515	Composition, 27 kΩ ±5% 1/2 W	6100-3275
R516	Composition, 11 Ω ±5% 1/2 W	6100-0115
R517	Composition, 5.1 MΩ ±5% 1/2 W	6100-5515
R518	Composition, 82 kΩ ±5% 1/2 W	6100-3825
R519	Composition, 100 Ω ±10% 1 W	6110-1109
	INDUCTORS	
L101	Choke, Metal, 120 μH ±10%	4300-3600
L102	Choke, Metal, 82 μH ±10%	4300-3400
L103	Choke, Metal, 150 μH ±10%	4300-3810
L104	Choke, Metal, 27 μH ±10%	4300-2800
L105	Choke, Metal, 56 μH ±10%	4300-3200
L106	Choke, Metal, 0.22 μH ±20%	4300-0200
L107	Choke, Metal, 0.1 μH ±10%	4300-0080
	CIRCUIT-BOARD ASSEMBLIES	
Power Supply Board Assembly		1398-2750
Etched Circuit Assembly		1398-2710
	MISCELLANEOUS	
CR101	DIODE, Type 1N625	6082-1012
CR102	DIODE, Type 1N118A	6082-1006
CR103	DIODE, Type 1N118A	6082-1006
CR104	DIODE, Type 1N3604	6082-1001
CR105	DIODE, Type 1N3604	6082-1001
CR501 through CR508	DIODE, Type 1N3254	6081-1002

REF NO	DESCRIPTION	PART NO
	MISCELLANEOUS (cont)	
F501	FUSE, 215 V, 0.5 A, Slo-Blo	5330-1000
F502	FUSE, 115 V, 1 A, Slo-Blo	5330-1400
FC101	FERRITE CORE	5000-1250
FC102	FERRITE CORE	5000-1255
FC103	FERRITE CORE	5000-1255
J101	BINDING POST, (EXT DRIVE)	4060-0100
J102	BINDING POST, (EXT DRIVE ground)	4060-0100
J103	BINDING POST, (SYNC +)	4060-0100
J104	BINDING POST, (SYNC + ground)	4060-1800
J105	BINDING POST, (SYNC -)	4060-0100
J106	BINDING POST, (SYNC - ground)	4060-1800
J107	BINDING POST, (DELAYED SYNC)	4060-0100
J108	BINDING POST, (DELAYED SYNC) ground)	4060-1800
J109	BINDING POST, (EXT OFFSET)	4060-0100
J110	BINDING POST, (EXT OFFSET ground)	4060-1800
J111	CONNECTOR, Coaxial (OUTPUT +)	0874-4552
J112	JACK, (OUTPUT + ground)	0874-6690
J113	CONNECTOR, Coaxial (OUTPUT +)	0874-4552
J114	JACK, (OUTPUT - ground)	0874-6690
M501	MOTOR	5760-1200
P501	PILOT LIGHT, Type 1784	5600-1001
PL501	PLUG, Power	4240-0600
Q101 through Q104	TRANSISTOR, Type 2N2369	8210-1052
S101	SWITCH, Rotary wafer (PRF)	7890-3670
S102	SWITCH, Rotary wafer (PULSE DURATION)	7890-3640
S103	SWITCH, Rotary wafer (AMPLITUDE)	7890-3730
S501	SWITCH, Toggle (POWER)	7910-1300
S502	SWITCH, Slide	7910-0831
SO501	SOCKET	4230-3700
T501	TRANSFORMER, Power	0365-4008
V101	TUBE, Type 6DJ8	8380-4510
V102	TUBE, Type 6DJ8	8380-4510
V103	TUBE, Type 6DJ8	8380-4510
V104	TUBE, Type 6922	8380-6922
V105	TUBE, Type 8233	8380-8233
V106	TUBE, Type 8233	8380-8233
V107	TUBE, Type NE-96	8390-0960
V501	TUBE, Type 6080	8380-6080
V502	TUBE, Type 6AG5	8360-0400
V503	TUBE, Type 6AH6	8360-0600
V504	TUBE, Type 5651	8380-5651

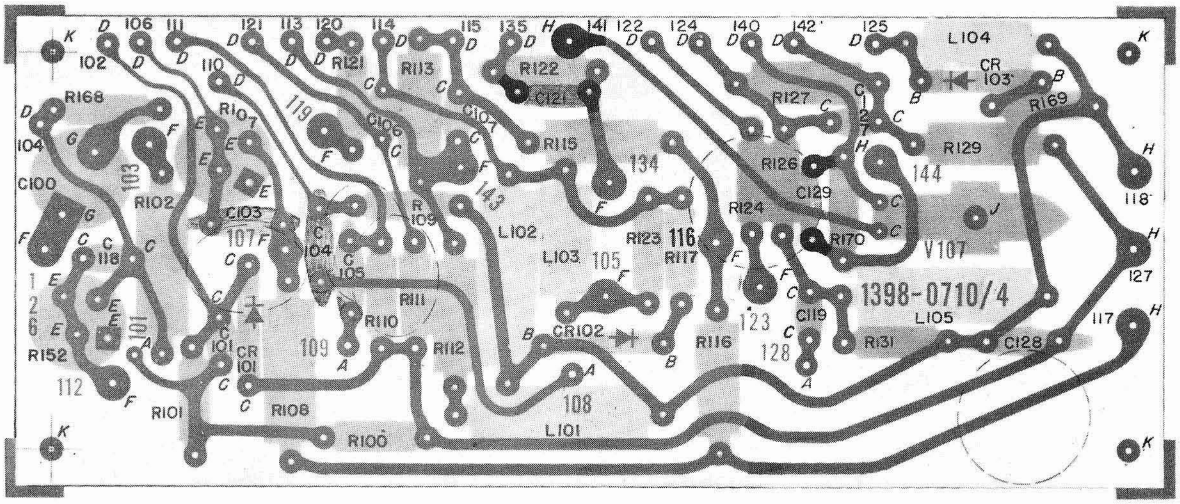


Figure 5-5. Main etched-board layout (P/N 1389-2710).

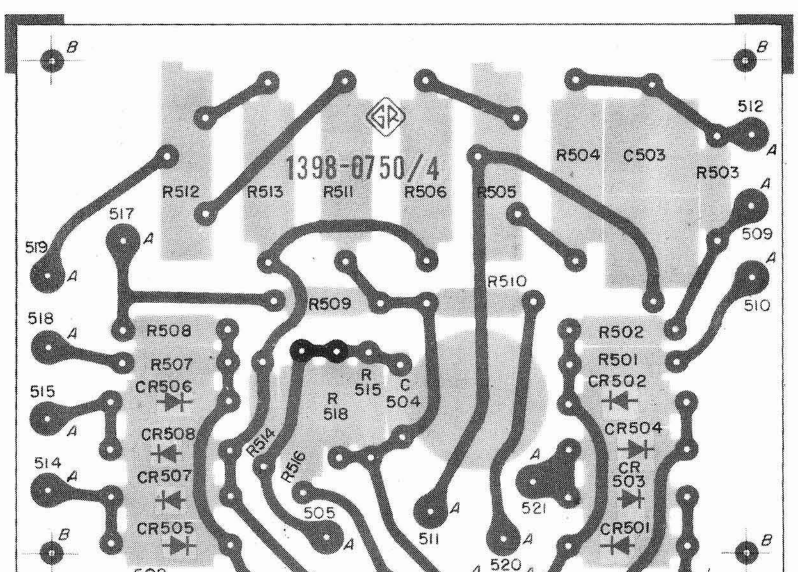
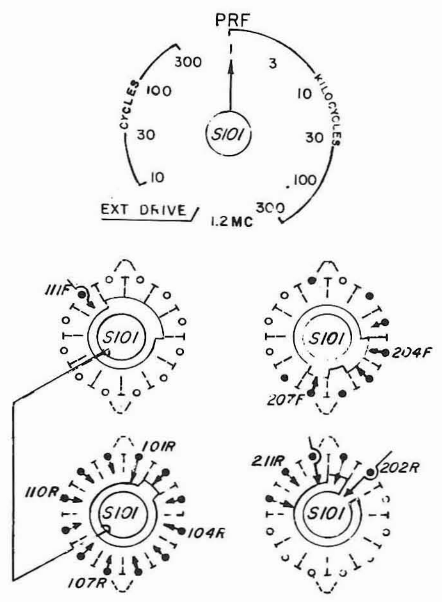
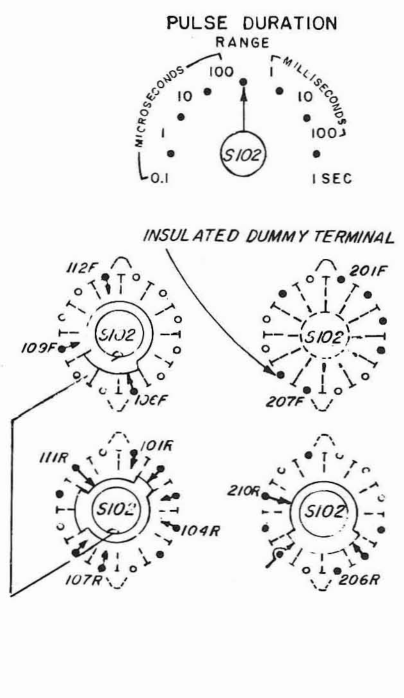


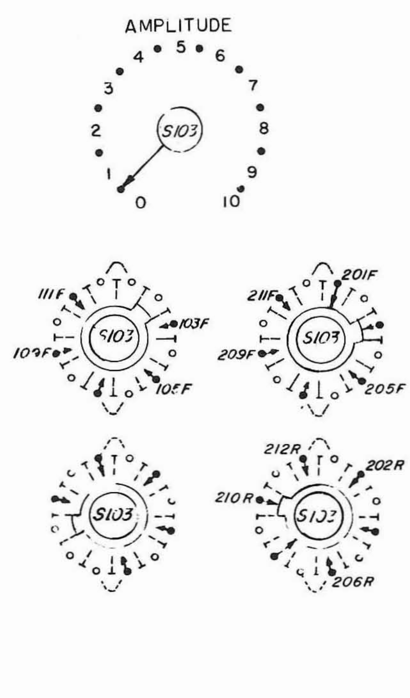
Figure 5-6. Power Supply etched-board layout (P/N 1389-2750).

NOTE: The number on the foil side is not the part number for the complete assembly.

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc.), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.







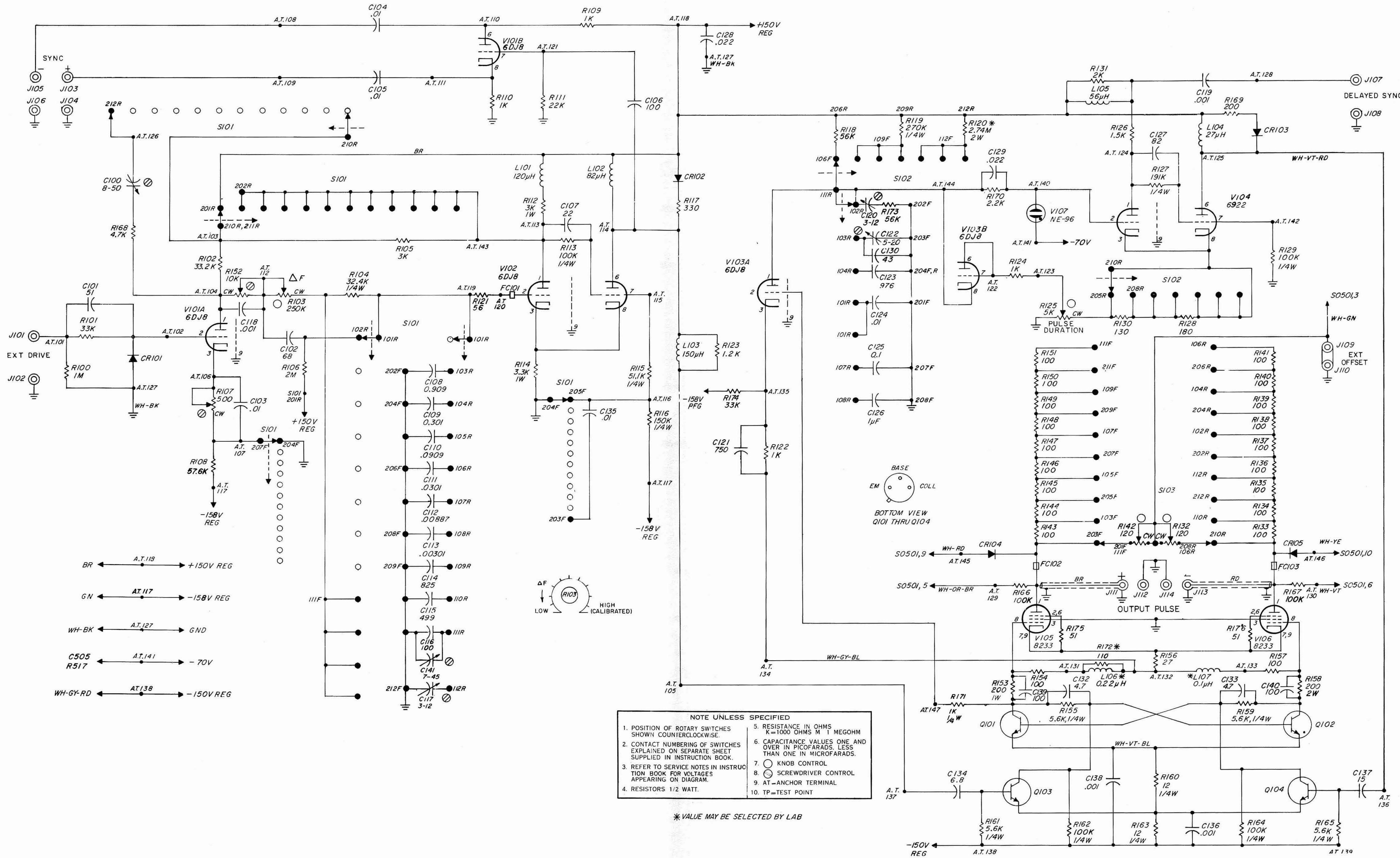


Figure 5-7. Schematic Diagram of the Type 1398-A Pulse Generator.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K=1000 OHMS M=1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT=ANCHOR TERMINAL
10. TP=TEST POINT

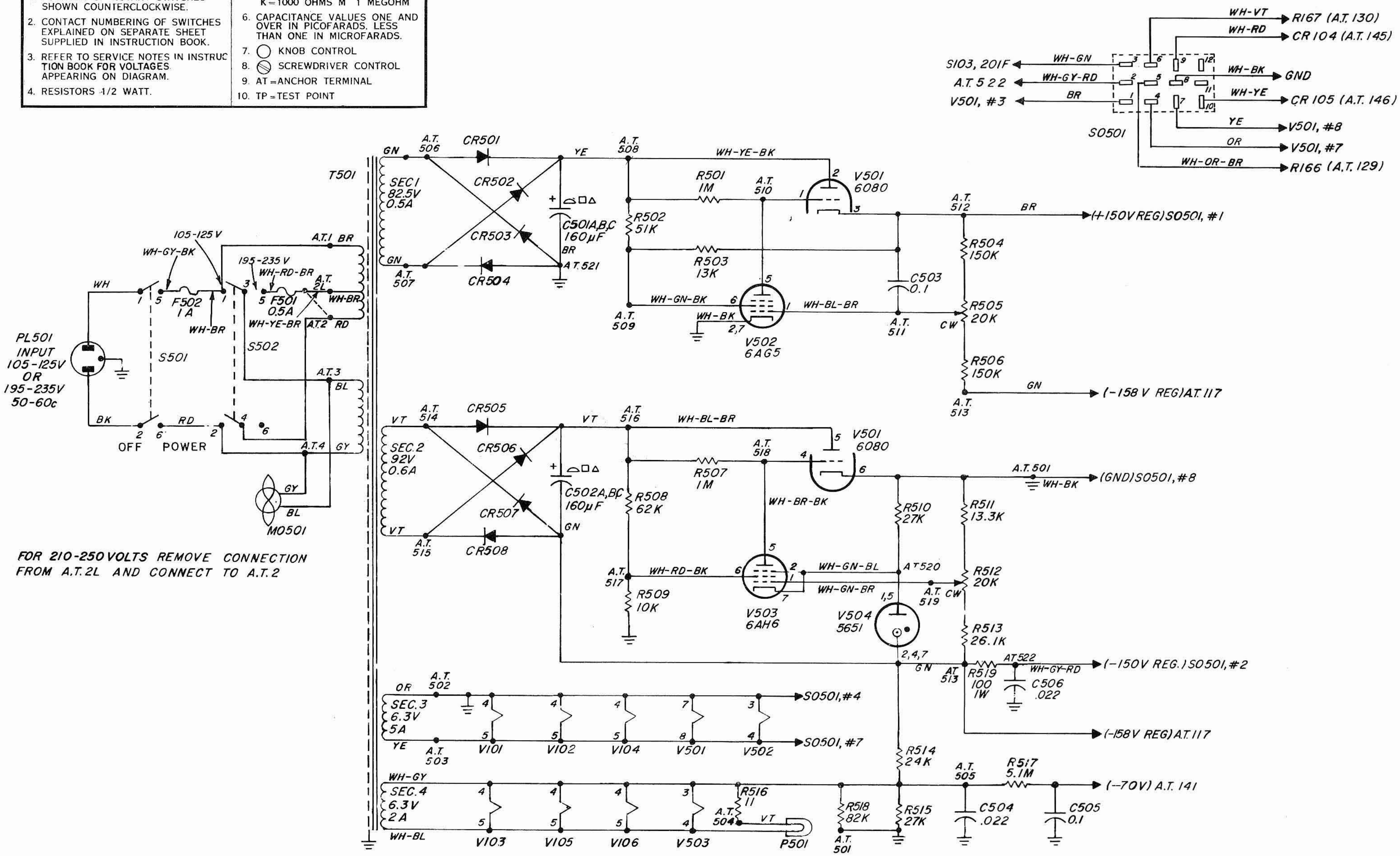


Figure 5-8. Schematic Diagram of the Type 1398-A Pulse Generator Power Supply.

TYPE 874 COAXIAL COMPONENTS

TYPE 874 CABLE CONNECTORS

APPLICABLE CABLE TYPES	CONNECTOR TYPE	CABLE	CABLE LOCKING	PANEL FLANGED	PANEL LOCKING	PANEL LOCKING RECESSED
50-OHM	874-A2	-CA	-CLA	-PBA	-PLA	-PRLA
50-OHM	RG-8A/U RG-9B/U RG-10A/U RG-87A/U RG-116/U RG-156/U RG-165/U RG-166/U RG-213/U RG-214/U RG-215/U RG-225/U RG-227/U	-C8A	-CL8A	-PB8A	-PL8A	-PRL8A
NON-50-OHM	RG-11A/U RG-12A/U RG-13A/U RG-63B/U RG-79B/U RG-89/U RG-144/U RG-146/U RG-149/U RG-216/U					
50-OHM	874-A3 RG-29/U RG-55/U (Series) RG-58/U (Series) RG-141A/U RG-142A/U RG-159/U RG-223/U	-C58A	-CL58A	-PB58A	-PL58A	-PRL58A
NON-50-OHM	RG-59/U RG-62/U (Series) RG-71B/U RG-140/U RG-210/U	-C62A	-CL62A	-PB62A	-PL62A	-PRL62A
50-OHM	RG-174/U RG-188/U RG-316/U	-C174A	-CL174A	-PB174A	-PL174A	-PRL174A
NON 50-OHM	RG-161/U RG-187/U RG-179/U					

Example: For a locking cable connector for RG-8A/U, order Type 874-CL8A.

TYPE 874 ADAPTORS

TO TYPE		874-
BNC	plug	QBJA QBJL*
	jack	QBPA
C	plug	QCJA QCJL*
	jack	QCP
HN	plug	QHJA
	jack	QHPA
LC	plug	QLJA QLPA
LT	plug	QLTJ
	jack	QLPT
Microdot	plug	QMDJ QMDJL*
	jack	QMDP
N	plug	QNJA QNJL*
	jack	QNP QNPL*
OSM/BRM	plug	QMMJ QMMJL*
	jack	QMMP QMMPL*
SC (Sandia)	plug	QSCJ QSCJL*
	jack	QSCP
TNC	plug	QTNJ QTNJL*
	jack	QTNP
UHF	plug	QUJ QUJL*
	jack	QUP
UHF 50-Ω Air Line	7/8-in.	QU1A
	1-5/8-in.	QU2
	3-1/8-in.	QU3A

*Locking Type 874 Connector

Example: To connect Type 874 to a type N jack, order Type 874-QNP.

CONNECTOR ASSEMBLY TOOLS

TYPE 874–	FUNCTION
TOK	Tool Kit
TO58	Crimping Tool
TO8	Crimping Tool

OTHER COAXIAL ELEMENTS

TYPE 874-		TYPE 874-	
A2	50 Ω cable (low loss)	ML	component mount
A3	50 Ω cable	MB	coupling probe
D20L, D50L	20-, 50-cm adjustable stubs	MR, MRL	mixer-rectifier
EL, EL-L	90° ell	R20A, R20LA	patch cord, double shield
F185L	185-Mc/s low-pass filter	R22A, R22LA	patch cord, double shield
F500L	500-Mc/s low-pass filter	R33, R34	patch cord, single shield
F1000L	1000-Mc/s low-pass filter	T, TL	tee
F2000L	2000-Mc/s low-pass filter	TPD, TPDL	power divider
F4000L	4000-Mc/s low-pass filter	U	U-line section
FBL	bias insertion unit	UBL	balun
G3, G3L, G6, G6L G10, G10L G20, G20L	3-, 6-, 10-, and 20-dB attenuators	VCL	variable capacitor
GAL	adjustable attenuator	VI	voltmeter indicator
JR	rotary joint	VQ, VQL	voltmeter detector
K, KL	coupling capacitor	VR, VRL	voltmeter rectifier
L10, L10L L20, L20L L30, L30L	10-, 20-, and 30-cm rigid air lines	W100	100-Ω termination
LAL	33-58 cm adjustable line	W200	200-Ω termination
LK10L, LK20L	constant-Z adjustable lines	W50B, W50BL	50-Ω termination
LR	radiating line	WN, WN3	short-circuit terminations
LTL	trombone constant-Z line	WO, WO3	open-circuit terminations
		X	insertion unit
		XL	series inductor
		Y	cliplock
		Z	stand

MISCELLANEOUS COAXIAL CONNECTORS

CONNECTOR TYPE	TYPE NO.	USED WITH
Basic	874-B	50-ohm Air Line
Basic Locking	874-BBL	50-ohm Air Line
Panel Locking	874-PLT	Wire Lead
Panel Locking Recessed	874-PRLT	Wire Lead
Panel Locking Feedthrough	874-PFL	Type 874 Patch Cords

L suffix indicates locking Type 874 Connector.

FOR COMPLETE DETAILS, REFER TO THE GENERAL RADIO CATALOG.

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General Radio Company (Overseas), 8008 Zurich, Switzerland
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