TYPE 105 SQUARE-WAVE GENERATOR

INSTRUCTION MANUAL

TEKTRONIX, INC.

MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

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070-049

TYPE 105 SERIAL NUMBER 4958


TYPE 105 SQUARE-WAVE GENERATOR
SERIAL
OUTPUT
TEKTRONIX
FREQUENCY
OUTPUT AMPLITUDE
RANGE
2.5 KC
10 KC
25 KC
1 KC
100 KC
250 ∿
250 KC
100 ∿
1 MC
FREQUENCY
SYMMETRY
AC
ON
OFF
DC
ON
OFF
SYNC. INPUT
SYNC. INPUT AMPLITUDE
SYNC. OUTPUT
GND
GND
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.

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GENERAL DESCRIPTION

The Tektronix Type 105 Square-Wave Generator is a compact, versatile instrument providing precision square waves at any desired frequency from 25 cycles to 1 megacycle. Short rise time, excellent waveform, variable amplitude control, accurate indication of frequency and many other features are combined to make the Type 105 an ideal instrument for development and production testing of amplifiers and other electronic equipment. Wide range and flexibility of operation qualify the Type 105 for highly specialized laboratory and research applications as well as general purpose uses.

CHARACTERISTICS

Frequency Range

25 cycles to 1 mc continuously variable.

Rise and Fall Time (10% to 90%)

0.02 microseconds with 93-ohm output load.

Output Amplitude

10 to 100 volts peak to peak across internal 600-ohm load.

1.5 to 15 volts peak to peak with 93-ohm external termination load.

Output Current Available for External Load

16 to 160 ma.

Accuracy of Frequency Indication

±3% of full scale.

Sync. Output Amplitude

5 volts.

Sync. Input Requirement

Sine waves of 3 v to 45 v peak to peak. Pulses or square waves of 1 v to 10 v peak amplitude.

Power Requirement

105-125 or 210-250 volts, 50-60 cycles, 250 watts.

Dimensions

10" wide, 16½" high, 14" deep.

Weight

35 lbs.

Finish

Panel, photo-etched aluminum with black letters.

Cabinet, blue wrinkle.

Accessories Included

Power Cord.
Output cable and terminating resistor.
Clip lead adapter.
Binding post adapter.

OPERATING DESCRIPTIONS OF CONTROLS AND CONNECTORS

OUTPUT	Connector from the output stage plates. Internal load resistance, 600 ohms.
OUTPUT AMPL	Control to permit adjustment of output amplitude by varying the supply voltage of the output stage.
RANGE	Nine position switch which inserts suitable time-constant networks into the multivibrator and frequency-meter circuits, thus selecting the desired frequency range.

FREQUENCY	Potentiometer which varies the multivibrator grid return potential, allowing continuously variable adjustment of frequency between steps of the RANGE switch.
SYMMETRY	Dual potentiometer in the multivibrator screen circuit connected so that the screen voltage of V1 may be increased while that of V2 is decreased and vice versa thus varying the duration of the positive portion of the square-wave cycle with respect to the negative.
AC	On-off toggle switch in series with the ac supply line.
DC	On-off toggle switch in the dc supply circuits.
SYNC INPUT AMPL	Variable bias control in the sync amplifier to permit adjusting the amplitude of the sync signal applied to the multivibrator.
SYNC INPUT	Binding post connection to the input of the sync amplifier, V13. Allows the Type 105 to be synchronized with other equipment.
SYNC OUTPUT	Binding post connection from sync output cathode follower V15. Permits an oscilloscope or other instrument to be synchronized with the Type 105.
GND	Binding post connection to chassis.

OPERATING INSTRUCTIONS

ADJUSTING THE CONTROLS

General

You can operate the Type 105 in any normal indoor location, or in the open if the instrument is protected from moisture. If the instrument has been exposed to dampness, you should leave it in a warm room until it is thoroughly dry before you operate it.

CAUTION—It is important that you allow adequate ventilation of the instrument, in order to prevent excessive interior temperatures. Provide a clearance of at least one inch on the left-hand side of the instrument for air intake to the fan. Whenever you operate the Type 105 in its case, you must have the four mounting feet in place on the bottom of the instrument to provide spacing for air exhaust. Be sure to allow adequate spacing around the bottom of the instrument.

If you use the Type 105 for a single application, with only one set of control settings, check the instrument periodically at all control settings to be sure that it is in normal operating condition. When you operate the controls you also help prevent accumulation of dirt and tarnish on their contacts.

The components of the Type 105 are well-supported and the adjustments are stable, so that the instrument is suitable for portable operation. However, don't subject the Type 105 to excessive vibration or rough handling.

Power Switches

A main power switch marked AC ON-OFF applies or removes power for the entire instrument. In addition, a separate switch marked DC ON-OFF is provided to control the internal dc supply circuits when the AC switch is turned ON.

When you first operate the instrument, have both the AC switch and the DC switch turned OFF. Turn on the AC switch first; after a 30-second warm-up period, turn on the DC switch. In this way, you assure maximum tube life.

CAUTION-The output waveform from the Type 105 can produce a painful shock. It is best to turn the DC switch OFF before you make or change connections to the OUTPUT connector.

Frequency Adjustment

You can set the repetition frequency of the output waveform of the Type 105 by means of the RANGE switch and the continuously variable FREQUENCY control. The repetition frequency is indicated by a meter that provides two scales per decade. Read the meter scale whose upper limit corresponds to the setting of the RANGE switch. For the most accurate meter reading, use settings of the RANGE and FREQUENCY controls such that the meter reading is in the upper 75 percent of the scale.

Symmetry

You can use the SYMMETRY control to adjust the time duration of the positive portion of the output square wave with respect to the duration of the negative portion, with only a small change in repetition frequency. In other words, you

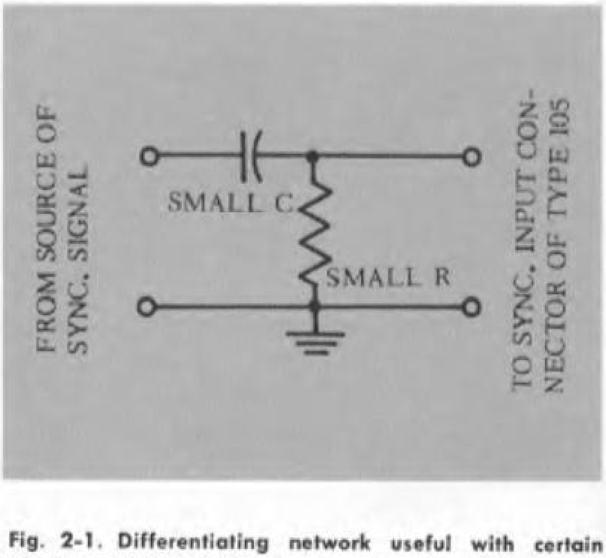


Fig. 2-1. Differentiating network useful with certain nonsinusoidal synchronizing waveforms.

can use the SYMMETRY control to adjust the duty factor of the output waveform.

Sync. Input Connector

You can synchronize the output waveform of the Type 105 with the output waveform from a frequency standard or other equipment by applying the synchronizing waveform to the SYNC. INPUT connector of the Type 105.

Although the Type 105 will synchronize well with a wide variety of waveforms, you might sometimes need to connect a differentiating network (Fig. 2-1) between the source of a non-sinusoidal synchronizing signal and the SYNC. INPUT connector to convert certain synchronizing waveforms into short pulses.

A positive-going synchronizing signal in the range from 3 to 45 volts is suitable. If the synchronizing signal is greater than about 45 volts, connect a suitable voltage divider between the source of the synchronizing signal and the SYNC. INPUT connector. In this way you can reduce the signal applied to the SYNC. INPUT connector to a value between 3 and 45 volts.

After you have connected the source of synchronizing signal to the SYNC. INPUT connector, you can effect synchronization as follows:

Start with the SYNC. INPUT AMPLITUDE control full left (counterclockwise). Then turn this control slowly to the right until synchronization occurs. It is usually best to leave the SYNC. INPUT AMPLITUDE control as far left as is consistent with stable synchronization.

Sync. Output Connector

You can use the output from the SYNC. OUTPUT connector of the Type 105 to synchronize other equipment with the output waveform of the Type 105. The synchronizing signal from the SYNC. OUTPUT connector has a peak-to-peak value of about 5 volts.

Output Amplitude Control

You can use the OUTPUT AMPLITUDE control to effect continuously variable control of the amplitude of the square-wave output of the Type 105.

The range of output voltages that you can get depends upon the amount of external load resistance you connect across the output connector. Block diagrams of some typical combinations of attenuator pads, terminating resistors, and cables are shown in Fig. 2-2, along with typical resulting

TABLE 2-1

TEKTRONIX ACCESSORIES FOR THE TYPE 105

PART NUMBER	TYPE	ITEM DESCRIPTION
011-001	B52-R	52-ohm terminating resistor, 1.5 watts.
011-002	B52-L5	52-ohm 'L' pad, 5-to-1 voltage ratio into high impedance, 1.5 watts.
011-003	B52-L10	52-ohm 'L' pad, 10-to-1 voltage ratio into high impedance, 1.5 watts.
011-006	B52-T10	52-ohm 'T' pad, 10-to-1 voltage ratio into 52 ohms, 1.5 watts.
011-011	B93-R	93-ohm terminating resistor, 1.5 watts.
011-012	B93-L5	93-ohm 'L' pad, 5-to-1 voltage ratio into high impedance, 1.5 watts.
011-013	B93-L10	93-ohm 'L' pad, 10-to-1 voltage ratio into high impedance, 1.5 watts.
011-014	B93-52L	Minimum-loss pad, 93 ohms to 52 ohms, 1.5 watts.
011-015	B93-T10	93-ohm 'T' pad, 10-to-1 voltage ratio into 93 ohms, 1.5 watts.
012-001	P52	Coaxial cable, 52-ohms nominal impedance, 42-inches long.
012-003	P93	Coaxial cable, 93-ohms nominal impedance, 42-inches long.

ranges of peak-to-peak output voltages. For the best output waveform, you should use a combination such that, for the output voltage you want, the OUTPUT AMPLITUDE control is in the right-hand portion of its range.

Certain terminating resistors, attenuator pads and cables suitable for use with the Type 105 are listed in Table 2-1. See also the Accessories section of this Instruction Manual.

Initial Operation

To place the Type 105 in operation for the first time, the following procedure is suggested.

1. Turn the AC and DC switches OFF. Set the SYMMETRY control to midrange. Set the RANGE switch to 1 KC.

2. Connect the power-input cable to the Type 105 and to a source of 117-volt 50-to-60 cycle

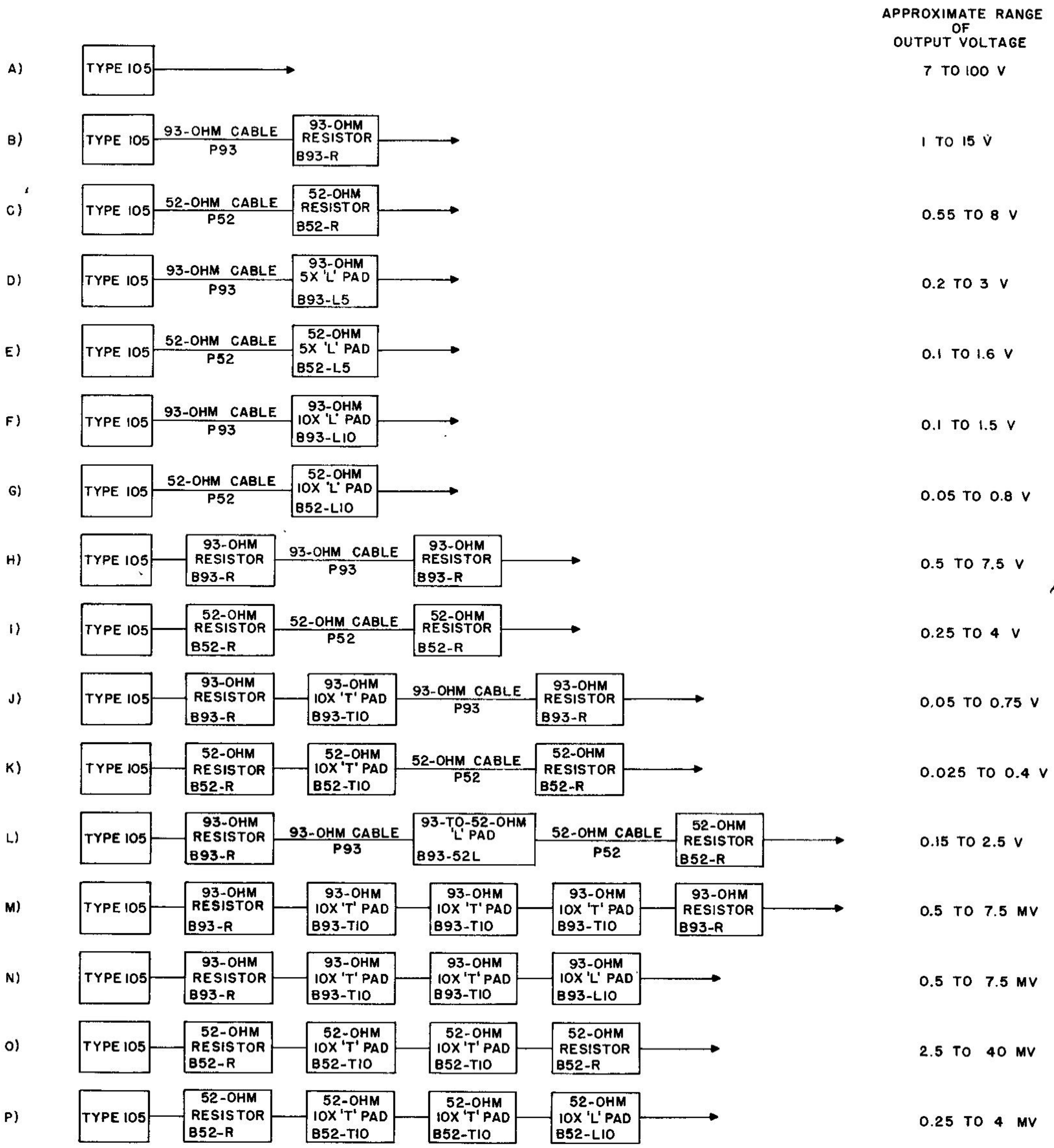


Fig. 2-2. Certain combinations of terminating resistors, attenuator pads and cables.

power (or to a source of 234-volt 50-to-60 cycle power if the power transformer is connected for 234-volt operation). Turn the AC switch ON. This will cause the fan to operate and the tubes to heat.

3. Connect the 42-inch output cable to the OUTPUT connector. Connect the terminating resistor to the free end of the cable. Connect the output end of the terminating resistor to the vertical-input connector of the oscilloscope. Connect the SYNC. OUTPUT connector to the TRIGGER INPUT connector of the oscilloscope. Turn on the oscilloscope and adjust it for external triggering and for a sweep rate of 200 μSEC/CM (or 200 μSEC/DIV.).

4. Turn the DC switch ON. Adjust the FREQUENCY control for full-scale deflection of the FREQUENCY meter.

5. Adjust the OUTPUT control of the Type 105 and the VOLTS/CM (or VOLTS/DIV.) control of the oscilloscope for a convenient amount of vertical deflection on the cathode-ray-tube screen. You should now observe several cycles of the square-wave output of the Type 105 on the cathode-ray-tube screen.

6. Adjust the SYMMETRY control for equal positive- and negative-going portion of the displayed waveform.

The repetition frequency of the displayed square wave is close to 1 kilocycle. You can observe square waves of other repetition frequencies by adjusting the RANGE and FREQUENCY controls on the Type 105.

APPLICATION INFORMATION

IMPORTANT

To avoid misleading observations or measurements when you are using your Type 105 Square-Wave Generator, be sure that the instrument is properly maintained and operated. Carefully observe the operating instructions given here. Your attention is particularly called to the section titled "Possible distortion of waveform."

One of the applications of a square-wave generator is in the testing and adjustment of the vertical amplifier and delay line of an oscilloscope. The Type 105 is suited to this use with many types of oscilloscopes. However, the risetime of the Type 105, although short, is not short enough for satisfactory results when you are testing or adjusting the vertical amplifier or delay line in an oscilloscope whose vertical-deflection-system bandwidth greatly exceeds 10 megacycle. Your Tektronix Field Engineer or Engineering Representative will be glad to make specific recommendations.

Risetime and Falltime

The risetime of the square-wave output of the generator is taken as the time required for the output voltage to rise from 10 percent of its maximum value to 90 percent of its maximum value (Fig. 2-3). The falltime of the output waveform is taken as the time required for the output voltage to fall from 90 percent of its maximum value to 10 percent of its maximum value. The risetime of the waveform, under given conditions, will not necessarily be equal to the falltime .

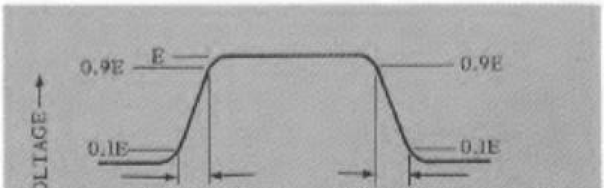


Fig. 2-3. Illustrating risetime and falltime of a square wave of voltage.

The risetime of the output waveform from the Type 105 depends upon various factors, including the values of external resistance and shunt capacitance you connect across the OUTPUT connector. The risetime of the output square wave is nominally 0.02 microsecond (20 millimicroseconds), and the actual risetime will not be greater than this value when the shunt capacitance is small.

Risetime Measurements

One of the applications of the Type 105 is its use, in conjunction with a suitable oscilloscope, to observe and measure the transient responses of amplifiers and other signal-transmitting devices.

An important feature of the transient response of a device is its risetime. To measure the risetime of a device, you would theoretically feed into its input terminals a perfect square wave (one that "jumped" instantly from its most negative voltage to its most positive voltage). Then you would observe with your oscilloscope the time interval required for the output voltage of the device to rise from 10 percent of its maximum value to 90 percent of its maximum value. This time interval would be called the risetime of the device.

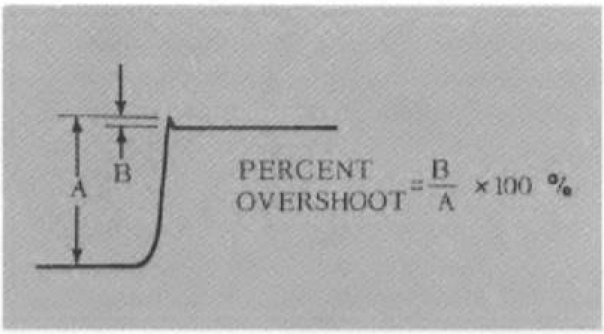


Fig. 2-5. Illustrating overshoot on the leading edge of a square wave.

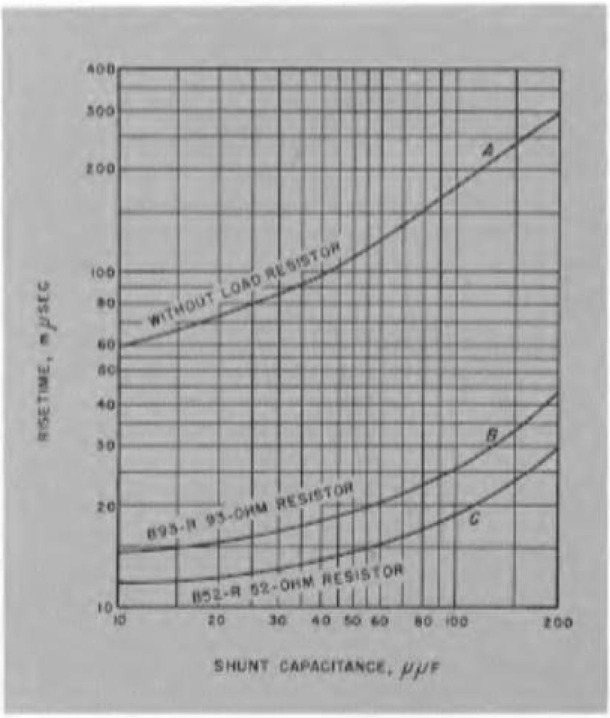


Fig. 2-4. Illustrating the effects upon the risetime of the output waveform of the Type 105 when you connect various values of load resistance and shunt capacitance to the OUTPUT connector.

These measured results are representative only, and are intended to convey the general effect of resistance and capacitance changes in typical cases.

It is impossible, however, to generate an input square wave that jumps instantly from its initial value to its final value (that is, we cannot generate an input square wave whose risetime is zero). Furthermore, the risetime of the oscilloscope itself is greater than zero, and this risetime of the oscilloscope must be taken into account. We will now describe a risetime-measurement technique that permits the use of square-wave generators (such as the Type 105) having risetimes greater than zero and that takes into account the risetime of the oscilloscope.

For best results, use a generator and an oscilloscope whose individual risetimes are appreciably shorter than the riseime of the device under test. You should use a square-wave generator whose output waveform is essentially free from overshoot (Fig. 2-5). The Type 105 is satisfactory in this respect. Furthermore, the accuracy of the method to be described will be affected if the square-wave response of either the oscilloscope or the device under test has appreciable overshoot, say, more than 2 or possibly 3 percent.

It is not usually convenient to determine the actual operating risetimes of the square-wave generator and of the oscilloscope separately. The method given here takes into account the composite effects of these separate risetimes.

The risetime-measurement method is as follows:

1. Observe the risetime of the square-wave output of the generator directly on the oscilloscope[2]. For this measurement, you should terminate the generator with a load resistance and shunt capacitance (including the input capacitance of the oscilloscope) equal to the load resistance and shunt capacitance provided by the input circuit of the device you are going to test. We call this equivalent risetime of the generator and oscilloscope together T_{RE}.

2. Drive the device under test with the output of the square-wave generator. Use the oscilloscope to observe the risetime of the output waveform of the device under test. For the measurement, you should terminate the device under test with a load (including the input resistance and capacitance of the oscilloscope) whose characteristics are similar to those of the load into which the device normally operates. We shall call this observed risetime T_{RO}.

3. Compute the actual risetime T_R of the device under test from the relation[3]

$$T_R=(T_{RO}^2-T_{RE}^2)^{1/2}$$

In the above measurements, use sweep rates such that the leading edge of the displayed waveform rises at an angle appropriate for accurate observations...roughly 45 degrees. In many risetime measurements, you might use horizontal sweep rates of the order of 0.02 μSEC/CM. When you are using these faster sweeps, it becomes important to set the TRIGGERING LEVEL control on your oscilloscope as far left as possible consistent with stable triggering. In this way you display as much of the lower flat portion of the square wave as possible, so that the rising portion does not occur in the first one or two horizontal divisions of the display where a major part of any sweep nonlinearity ordinarily appears.

You can reduce errors due to parallax by placing your eye so that the reflection of its iris, seen in the cathode-ray tube face, is directly behind the point you are observing.

In making risetime measurements, you might want to use a special graticule having the minor divisions scribed completely across the graticule (or at least extended in the areas where you observe the 10-percent and 90-percent points). The larger number of lines might render the graticule somewhat unsuitable for general use, but it permits close observations for risetime measurements.

Possible Distortion of Waveform

This information is included to help you avoid certain conditions that might give you misleading results in the use of your square-wave generator.

1. Proper use of probes

a. Before using a passive probe, always check the adjustment of the probe. An adjustable capacitor in the probe body compensates for variations in input capacitance from one oscilloscope to another, so that your pulse and transient measurements will be accurate. Touch the probe tip to the oscilloscope calibrator output connector and adjust the oscilloscope controls to display several cycles of the waveform. Adjust the probe capacitor for a flat top on the calibrator square wave, as shown in the right-hand picture of Fig. 2-6.

b. Use a probe of a type specified for the oscilloscope. For example, if you are using an oscilloscope whose vertical-deflection-system bandwidth greatly exceeds 10 megacycles, and if you use a probe intended for oscilloscopes having a smaller vertical-deflection-system bandwidth, you might observe a spurious "ringing" or damped oscillation along the top of the displayed square wave (Fig. 2-7). This spurious ringing might lead you to suspect a fault in the square-wave generator, in the oscilloscope, or in the equipment you are testing, whereas the actual difficulty lies in the use of an improper probe.

c. In using a cathode-follower probe, be careful not to use an input amplitude to the probe that exceeds the rated signal-handling capability of the probe. If you thus overdrive the probe, a clipping action can result that might mask certain signal variations or give an incorrect indication of signal amplitude. In particular, you should not use an attenuator between the cathode-follower probe and the vertical-input connector on the oscilloscope.

2. Compensation of voltage dividers on the VOLTS/CM (or VOLTS/DIV) switch.

You might observe overshoot or rolloff at the corners of displayed square waves if the internal capacitors, used to compensate the voltage dividers on the VOLTS/CM or VOLTS/DIV switch in the oscilloscope, are not correctly adjusted. Depending upon the repetition rate of the squarewave the nature of the voltage-divider misadjustment, the waveform distortions might resemble those occurring when the probe is

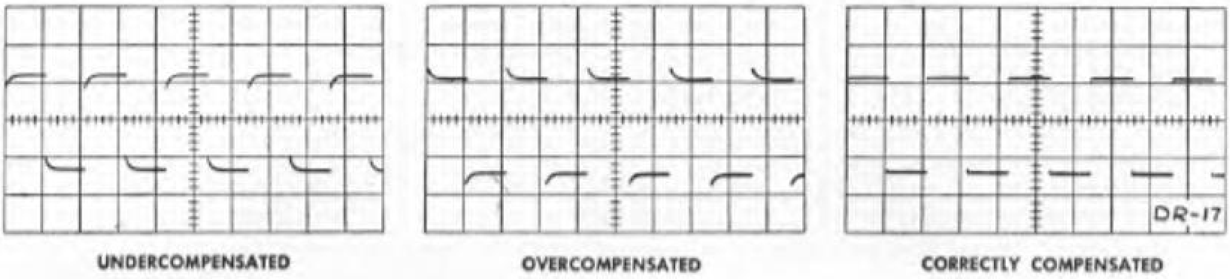


Fig. 2-6. Probe adjustments. Adjust the variable capacitor in the probe body so that the display of the calibrator waveform has a flat top as shown in the right-hand picture.

incorrectly compensated (see Fig. 2-6). This trouble, of course, calls for a maintenance adjustment of these capacitors.

3. Ringing of LC circuits

The risetime of the square-wave output of the Type 105 is short enough to cause "ringing" (damped oscillations) in an LC circuit whose resonant frequency is less than about 30 megacycles. These oscillations appear along the flat top of a square wave displayed on the oscilloscope. Precautions you can take to avoid this trouble include (1) use of short leads to connect the generator or its output cable or termination to the lead, and (2) use of proper terminating resistors or pads at both ends of the generator output cable (see diagrams H through P, Fig. 2-2).

4. Cathode-interface impedance

When the output electron tubes in the Type 105 have been used for a long time, they might develop a fault known as cathode-interface impedance. This condition produces a jagged appearance along the early part of the lower or negative flat portion of the waveform (Fig. 2-8). If you are using only the rising edge and the flat top of the square wave in your tests and measurements, you can neglect this waveform distortion. But if you need to observe the trailing edge and the flat bottom of the waveform, you should replace V6, V7 and V8 (6AG7's) in your Type 105, as required, to correct the waveform distortion. (Incidentally, there might normally be a slight negative-going overshoot at the corner preceding the lower flat portion of the square wave.)

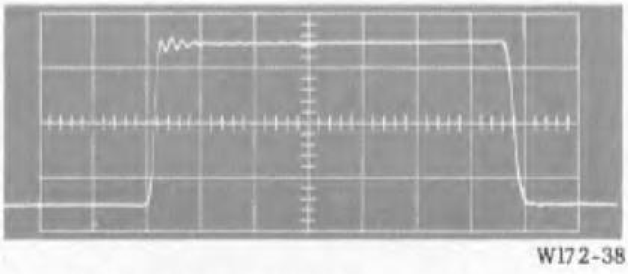


Fig. 2-7. Illustrating spurious ringing (damped oscillation) that might occur as a result of the use of a probe that is unsuited to the oscilloscope.

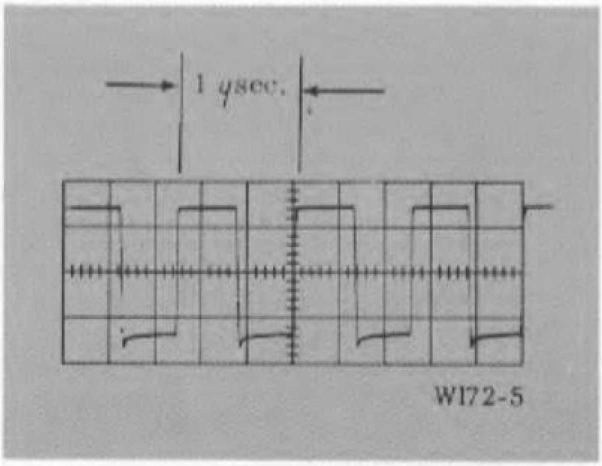


Fig. 2-8. Distortion in output waveform of the Type 105 resulting from cathode-interface impedance in aging tubes in the Type 105.

FOOTNOTES

[1] The square-wave output voltage of the Type 105 starts at a negative value and rises to zero (or ground) voltage, then drops again to the negative value.

[2]It is not usually convenient to determine the actual operating risetimes of the square-wave generator and of the oscilloscope separately. The method given here takes into account the composite effects of these separate risetimes.

[3] It should be noted in passing that the formula given here is actually an approximation. But the results are sufficiently accurate for most purposes. (See G.E. Valley and H. Wallman, "Vacuum Tube Amplifiers," pages 77-79, McGraw-Hill Book Company, Inc., New York, 1948).

CIRCUIT DESCRIPTION

GENERATOR CIRCUITS

The generator circuits of the Type 105 consist essentially of a conventional multivibrator signal source followed by two limiter-amplifier stages which, in turn, drive the output stage. The unconventional circuitry by which the Type 105 attains the rise time of less than .02 microseconds with no overshoot on the flat-top portion of the square wave, includes: direct coupling between stages, high-frequency compensation, the use of high-transconductance low-capacitance tubes, and an inverted output amplifier having the plate connected to ground through the load resistor.

Multivibrator

V1 and V2 are connected in a symmetrical plate-to-grid-coupled multivibrator circuit, with various time-constant networks inserted in the grid circuit by the RANGE Switch, SW1. These networks consist of combinations of capacitors C3 through C12 with resistors R7 through R24. Resistors R4, R5, R27 and R28 are parasitic suppressors. Variation of the frequency generated by the multivibrator in each position of SW1 is accomplished by returning the lower ends of the grid resistors to the FREQUENCY potentiometer, R6, which applies a voltage varying from zero to plus 150 V.

Symmetrical output of the multivibrator is attained by varying the cross-connected dual potentiometer, R25, which changes the screen potential of V1 with reference to the screen potential of V2. These relative (and opposite) changes in screen potential cause corresponding changes in the plate current of V1 and V2, therefore changing the duration of the positive portion of the multivibrator waveform with respect to the negative. This provides compensation for variation in tubes and other components, so that the two parts of the square wave can be set equal to each other in time duration.

> **CAUTION—Do not attempt to convert the Type 105 into a pulse generator by increasing the range of the symmetry control. Tubes and other components might be damaged.**

R25.4 is a variable resistor which simultaneously increases or decreases the screen voltage on both multivibrator tubes, thus setting a limit on the maximum frequency of each range step for the particular pair of multivibrator tubes in use. This adjustment is made only when changing multivibrator tubes. See Maintenance and Adjustment section.

At the higher frequencies, C1 and C13 compensate for degeneration across R1 and R30. C1.1 and C11.1 also provide compensation and improvement in the rise-time characteristics of the multivibrator on the four higher-frequency ranges. Output from the multivibrator is taken across R29, in the cathode of V2, and this signal is fed to the grid of the shaping amplifier.

Shaping Amplifier

The shaping amplifier, V3, is directly coupled from the cathode of V2. A cathode resistor, R32, bypassed by C14, provides self bias in case of multivibrator failure. A shunt-compensating inductance, L1, is placed in series with R31, the plate-load resistor, to increase the rate of rise of the amplified multivibrator waveform. The plate of the shaping amplifier is coupled, by C15, to the grids of the driver amplifier.

Driver Amplifier

The driver amplifier consists of two tubes, V4 and V5, connected in parallel with appropriate parasitic suppressors, R35, R36, R37, R38, R39, and R40. The grid-bias network does not prevent V4 and V5 from drawing plate current. This steady plate current will then bias the grids of the output amplifier stage to cutoff and prevent excessive dissipation therein. The dissipation in V4 and V5 is well with recommended limits during this condition.

The screen-grid potential for V4 and V5 is provided by a series screen-resistor network consisting of R42 and R43, with R43 bypassed to ground by C16 and C17A. The unbypassed portion of the series screen resistor, R42, feeds a sample of the square wave, via a coupling capacitor, C20, into the grid of the meter amplifier, V9.

The shaping amplifier drives the grids of V4 and V5 alternately between zero and cutoff, thus clipping a portion of the waveform in the grid circuit of the driver amplifier. A shunt-compensating inductance, L2, in series with load resistor R41 compensates for the effects of stray circuit capacitances, increasing the rate of rise of the output voltage. The signal from the plates of V4 and V5 is directly connected to the grids of the output amplifier.

Output Amplifier

The output amplifier employs three tubes, V6 V7 and V8, connected in parallel. R44, R45, R46, R47, R48, R49, R50 and R51 are parasitic suppressors. The cathodes are bypassed to ground by C18 and C19. The three grids are directly connected to the plates of V4 and V5 and are driven between zero and cutoff potential by that stage. The plate load resistor consists of an internal resistor, R54, paralleled with desired internal terminating resistor, pad, or combination. See Operating Instructions section.

The amplitude of the output waveform is controlled by varying the screen-grid potential of V6, V7 and V8 by varying the dc negative voltage applied to the cathodes of these three tubes. This is accomplished by the OUTPUT AMPL control R98, located in the variable power supply circuit.

FREQUENCY-METER CIRCUITS

The meter circuit of the Type 105 Square Wave Generator provides a direct indication of the output repetition rate of square waves generated. A sample of the square wave being generated is taken across R42, in the screen circuit of the driver tubes V4 and V5, and is coupled to V9 by capaitor C20 and resistor R59 which form a grid-leak bias network. This signal is amplified by V9. L3 is used to improve rise time.

One section of V10 constitutes a clamp diode (pins 2 and 5) which prevents the plate of V9 from rising above the supply voltage. The plate will attempt to do this because of the collapsing field of L3. The plate of V9 is "caught" by the plate-catcher diode (pins 1 and 7 of V10). V11 is a cathode-follower voltage-regulator tube which determines the potential at which the plate of V9 will be caught by V10. The METER ADJ. potentiometer R63, in conjunction with limit resistors R62 and R64, permits adjustment of the potential on the cahode of V11 so that V9 generates a square wave of constant 65-volt amplitude.

A capacitor, selected from C23 to C31 by RANGE switch sections SW1-G and SW1-H, is charged on each positive excursion of the square wave because the meter diode V12 (pins 2 and 5) clamps switch arm SW1-H at "common ground" potential (actually to the —160- to —320-volt bus plus a small voltage drop across R66). The negative excursion of the square-wave cycle then discharges the selected capacitor through meter M1 (resistance approximately 5,000 ohms). M1 has a special temperature-compensated movement of 200-microampere basic sensitivity. A shunt resistor is connected in parallel with the meter movement by the RANGE selector switch section SW1-1. Either the resistor or the capacitor is made variable for each range to provide calibration adjustment.

The charge on a capacitor represents a certain quantity of electrons (coulombs). Since each cycle of the square wave drives one charge through the meter, the meter (reading current) will indicate the number of charges per second, or the number of cycles per second. Resistors R65 and R66 provide a bias on the meter diode tube (pin 5) which "bucks out" the effect of diode current.

SYNC CIRCUITS

Sync Input

Sync signals fed to the SYNC INPUT binding post are coupled through capacitor C32 to the grid of sync amplifier tube V13. Variable grid bias for this tube is provided for by the SYNC AMPL control, R80 in the cathode circuit. Resistor R79 provides a fixed minimum bias to protect the tube. Bias voltages greater than cut off can be provided because of the current through R81, so that large sync signals can be accommodated. C33 bypasses the cathode bias resistors for high frequencies. The amplified sync signal at the plate of V13 is coupled to the plate of multivibrator tube V1 through diode V14. This diode disconnects the multivibrator from the sync amplifier while V1 is in conduction. This feature prevents another sync impulse from reaching V1 until the multivibrator has completed its cycle.

Sync Output

Output synchronizing signals are available from a front-panel binding post and are developed by a cathode follower, V15, driven from the signal across the cathode resistor of V1, the first multivibrator tube.

To protect the operator from electrical shock, a blocking capacitor, C34, is provided to isolate the SYNC OUTPUT binding post from the —160 v- to —320 v-bus. R83 serves to differentiate low-frequency square-wave signals.

POWER SUPPLY CIRCUITS

150-Volt Fixed Power Supply

The fixed power supply of the Type 105 employs tubes V21 and V22 in a full-wave rectifier circuit. This is followed by a conventional voltage regulator circuit in which a portion of the output voltage is compared with a fixed dc potential derived from a voltage reference tube, V26. The difference between these two voltages is then amplified in V25 and applied to the grids of the series regulator tubes, V23 and V24, in such a way as to oppose the original change which unbalanced the regulator circuit. Potentiometer R109 (ADJ 150V) with limit resistors R110 and R112 selects the portion of the output voltage which is coupled directly to the grid of the comparator-amplifier tube V25 by R109. The cathode of V25 is held constant by the voltage reference tube V26. Suitable screen voltage for V25 and ionizing voltage for V26 is supplied by the divider R107 and R108. The plate of V25 is coupled to the grids of the series regulator tubes V23 and V24 through parasitic suppressors R105 and R106, with R104 serving as the plate load for the tube. Suppressor resistors R102 and R103 tie the screen grids of V23 and V24 to their respective plates for operation as triodes. C43 and C44 provide low-impedance paths for transients, so that the regulator will accommodate the rapid load changes of the generator circuits. A large by-pass capacitor, C45, further stabilizes the regulator output.

The fixed power supply floats below chassis ground at a potential determined by the output voltage of the variable power supply.

Variable Power Supply

Rectified current is supplied by V16 and V17 to a regulator circuit employing V18, V19 and V20.

The operation of this regulator circuit is similar to the fixed power supply regulator. Regulated 150 volts dc obtained from the fixed power supply is applied across resistor network R91, R92 and R95 and serves as a reference voltage for V20 cathode. The front-panel OUTPUT control, R98, in conjunction with R97 and potentiometer R99 marked ADJ 175V from a network which applies a sample of the output voltage to the grid of V20. Any change in the grid voltage is amplified and applied to the grids of V18 and V19, thus stabilizing the output voltage at a value determined by the setting of R98. R99 permits compensation for variation of tubes and other components. See Maintenance and Adjustment section.

D. C. Power Switch

The DC switch, SW3A and SW3B, opens both the fixed and variable power supplies. This feature permits changing output terminations, tube replacement, etc., without shock hazard, when it would be undersirable to open the AC power switch, SW2.

MAINTENANCE

PREVENTIVE MAINTENANCE

Cleaning

At regular intervals all accumulated dust should be cleaned from the instrument. The use of dry air under moderate pressure in conjunction with a brush having long, soft bristles is recommended. Solvents should not be used to clean the instrument. However, the case, panel and fan may be cleaned with mild soap and water.

> CAUTION—Remove the powercord and allow sufficient time for the bleeders to discharge the filter capacitors before cleaning is undertaken.

Fan Motor

To protect the fan motor bearings, they should be lubricated every three or four months with a few drops of light machine oil.

Visual Inspection

You should visually inspect the entire generator every few months for possible circuit defects. These defects may include loose or broken connections, damaged binding posts, improperly seated tubes, scorched wires or resistors, missing tube shields, or broken terminal strips as well as many others. For most of these troubles, the remedy is apparent, but particular care must be taken when scorched components are detected. Scorched parts are often the result of other, less apparent, defects in the circuit. Therefore, it is essential that you determine the cause of overheating before replacing scorched parts in order to prevent damage to the new components.

Recalibration

The Type 105 Square Wave Generator is a stable instrument, and will provide many hours of trouble-free operation. To insure the reliability of measurements obtained with the Type 105 we suggest that you recalibrate the instrument after each 500 hours of operation. (or every six months if used intermittently). A complete step-by-step procedure for recalibrating the instrument is presented in the Recalibration Procedure section of this manual.

REMOVING AND REPLACING PARTS

Removal of the Case

Set the generator face downward on a padded flat surface, remove the four screws holding the rubber feet, then lift off the case. On models with the fan mounted on the case, reach inside and unplug the fan motor before completely removing the case from the instrument.

> CAUTION — After replacing the case, be sure the fan is operating, otherwise some components may be subject to destructive temperatures.

Replacement of Components

Most of the components used in the construction of TEKTRONIX instruments are standard parts obtainable from any well-equipped parts distributor. Some of the components carrying 1% and 2% tolerances may not be so readily obtainable but may be purchased from the manufacturer at these tolerances. The remainder of the low-tolerance components are standard 10%- and 20%-tolerance parts that are checked at the factory for proper value or performance. Replacement parts are available on order from the factory at current net prices but in the case of standard parts it is probably more economical of time to purchase them locally. It is not feasible to attempt to check out low-tolerance parts or matched pairs without a reasonably large stock to choose from as the rejection percentage is quite high in many cases.

IMPORTANT: It is imperative that you get parts-ordering information from the instruction book prepared specifically for the instrument involved. The serial number of the instruction book must agree with the serial number of the instrument.

A TEKTRONIX instruction manual will usually contain hand-made changes of diagrams, parts lists, and text, appropriate only to the instrument it was prepared for. There are good reasons why this is true.

First, TEKTRONIX engineers are continually working to improve TEKTRONIX instruments. When the improved circuitry is developed or when better components become available they are put into TEKTRONIX instruments as soon as possible. As a result of constant improvement TEKTRONIX instruments are always built as good as we can build them, but the changes caused by these improvements must frequently be entered by hand into the manual.

Second, when TEKTRONIX instruments go through our exhaustive test procedure, TEKTRONIX technicians adjust them individually to obtain optimum operation. This kind of hand tailoring occasionally requires substitution of components differing from the nominal values printed in the manuals.

Third, because of procurement difficulties, equivalent but different parts are sometimes used. Usually such parts are directly interchangeable with those originally specified. No alternate parts have been used which adversely affected the instrument, and you were able to receive your instrument much earlier than you might have otherwise.

To assure that you will receive the correct replacement parts with the minimum of delay it is therefore important that you include the instrument serial number with your order, along with the instrument type and part numbers, of course. And as a further precaution, get ordering information from the instruction manual whose serial number agrees with the instrument.

Equivalent parts, supplied by the factory when the exact replacement parts ordered are not available, will be accompanied by an explanation and will be directly interchangeable in most cases.

OPERATIONAL CHECKS

1. Frequency Coverage

The FREQUENCY control of the Type 105 should have enough range to allow the operator to adjust the output over the ranges marked on the RANGE switch. To check the operation of this control set the front-panel controls of the instruments to the positions described at the beginning of Step 5 of the Recalibration Procedure. This will provide a display of the 100 cycle square wave.

Turn the FREQUENCY control full left. When the control is in this position the meter needle should drop below 2.5 on the upper scale. Next, turn the FREQUENCY control full right. The meter needle should move to a position above the upper end of the meter scale. Repeat this procedure for all output ranges.

If the frequency range is inadequate it will be necessary to carry out Steps 3, 4 and 5 of the Recalibration Procedure.

2. Sync Output Amplitude

The amplitude of the pulse available at the SYNC. OUTPUT connector is approximately 5 volts—a convenient trigger amplitude for synchronizing another circuit with the Type 105.

To measure the amplitude of the sync. output pulse use the connections and front-panel control settings described in Step 5 of the Recalibration Procedure for obtaining a 10 kc square wave. Switch the MODE switch of the Type CA to B ONLY, and disconnect the "T" connector from the input of this channel. Set the VOLTS/CM switch of CHANNEL B to 2. Adjust the FREQUENCY control of the Type 105 to give a full scale meter reading. Using an 18 inch test lead, connect the SYNC OUTPUT connector of the Type 105 to the input of CHANNEL B on the Type CA. The amplitude of the positive portion of the pulse should be at least five volts.

Insufficient amplitude at the SYNC. OUTPUT connector may be caused by low screen voltage on the multivibrator tubes, V1 and V2—see Step 4 of the Recalibration Procedure. If it is necessary to change the screen voltage it will also be necessary to perform Step 5 of the Recalibration Procedure, since a change in the multivibrator screen voltage will be reflected as a change in the output frequency.

3. Output Amplitude

To provide sufficient amplitude for use with a large variety of terminating resistors, the Type 105 has a minimum output amplitude of 15 volts, peak-to-peak. The output amplitude can be measured as follows:

Display a 1 megacycle square wave in the test oscilloscope as described in Step 5 of the Recalibration Procedure. Remove one of the Type B93-R Terminating Resistors from the Type P93 Coaxial Cable connected to the Type CA, and reconnect the cable directly to the input of CHANNEL A. Switch the MODE switch of the Type CA to A ONLY. Turn the OUTPUT AMPLITUDE control of the Type 105 full right. Carefully measure the peak-to-peak amplitude of the square wave. The minimum allowable amplitude is 15 volts; however, the peak-to-peak value obtained with most instruments will exceed this by several volts and does not indicate faulty operation of any circuit.

RECALIBRATION PROCEDURE

Normally, it will not be necessary to make all of the adjustments described in these instructions at any one time. However, any adjustments you make should be made in the indicated sequence.

EQUIPMENT REQUIRED

The following equipment or its equivalent, is necessary for a full recalibration of the Type 105.

1. Test oscilloscope, Tektronix Type 541 Oscilloscope and Type CA Plug-In Unit.

The use of the Tektronix Type 541 is recommended, since its operating specifications will permit all of the measurements described in this procedure. If a Tektronix Type 541 is not available, an oscilloscope having the following characteristics may be substituted:

Calibrated vertical-deflection factors from 5 millivolts per centimeter to 5 volts per centimeter.

Calibrated sweep rates from 20 millimicroseconds to 2 milliseconds per centimeter.

Bandpass of 24 megacycles.

Dual-trace operation.

2. Time-Mark Generator, Tektronix Type 180.

If a Type 180 is not available, a time-mark generator which has the following characteristics may be substituted: 1-, 5-, 10-, 50-, 100-, and 500-microseconds and 1-, and 5-millisecond time marker outputs having an amplitude of at least one volt.

3. DC voltmeter of at least 20,000 ohms per volt, calibrated for an accuracy of ±1% at 150 and 175 volts. Be sure your meter is accurate. Few meters have the required accuracy after long periods of use.

4. Accurate rms-reading ac voltmeter, 0-150 volts, calibrated for an accuracy of ±1% at 105, 117, and 125 volts.

5. Autotransformer (Powerstat, Variac, etc.) capable of varying the line voltage to the instrument being calibrated from 105 to 125 volts, and rated at three amperes.

6. Miscellaneous interconnecting cables and terminating resistors.

If you are using the equipment recommended in this list, you will need two Type P93 Coaxial Cables, two Type B93-R Terminating Resistors, a test lead about 18 to 24 inches long terminated in banana plug connectors, a coaxial "T" connector and a Type A-100 clip-lead adapter.

7. Low-capacitance, insulated alignment screwdrivers.

RECALIBRATION PROCEDURE

1. Power Supply Output Voltages

There are two voltage adjustments in the Type 105; the first, the A-150-volt supply, is used as a reference voltage, and the second, the —175-volt supply, determines the amplitude of the square-wave output. In the instructions that follow, we describe a method of adjusting the output voltage of these supplies.

To prepare the Type 105 for recalibration, remove the instrument from the cabinet. It will be easier to make some of the adjustments if you also remove the fan blade at this time. If the instrument is not enclosed in the cabinet it

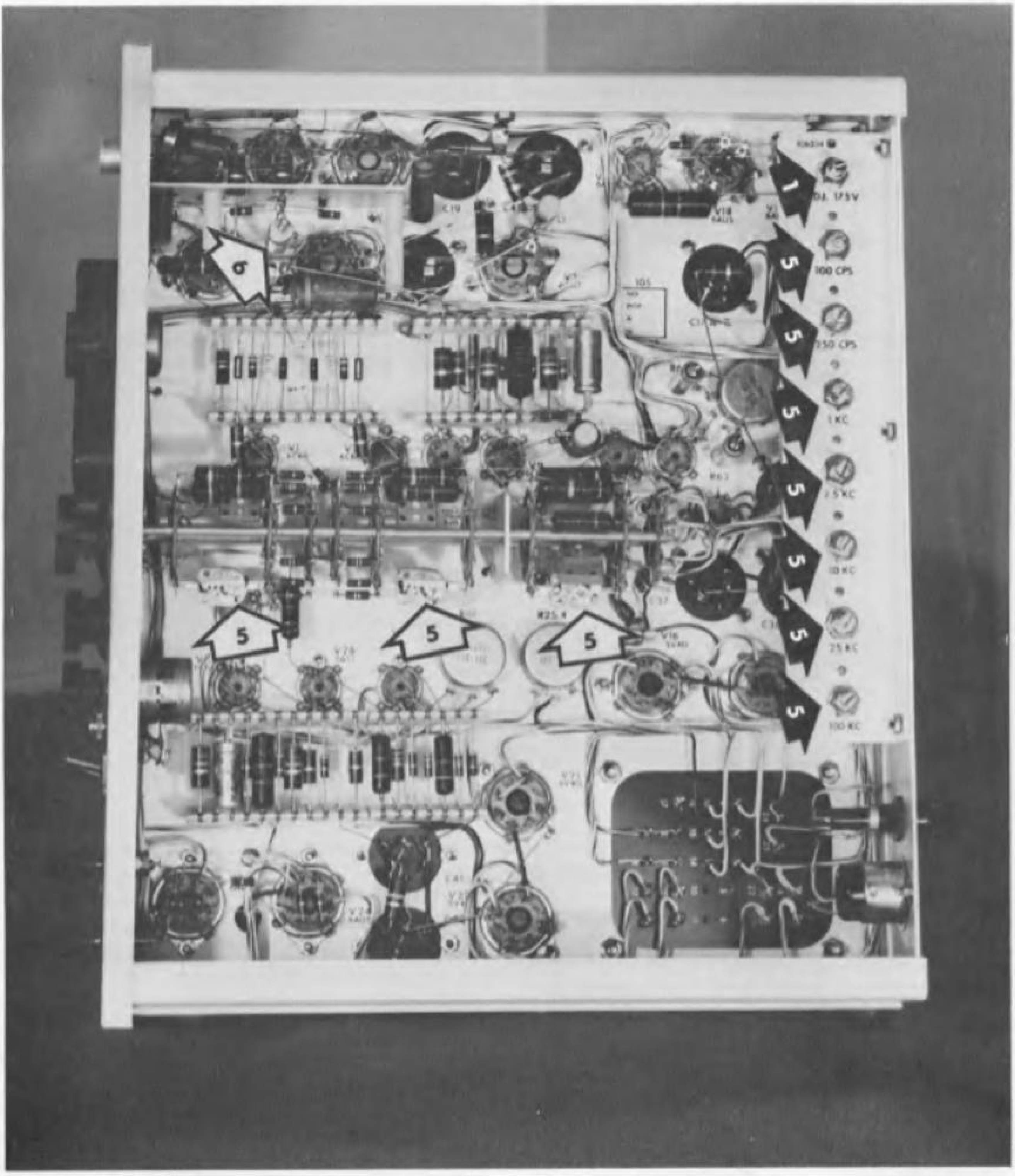


Fig. 5-1. The right-hand side of the Type 105. (Controls adjustable from the right-hand side during the Recalibration Procedure are marked.)

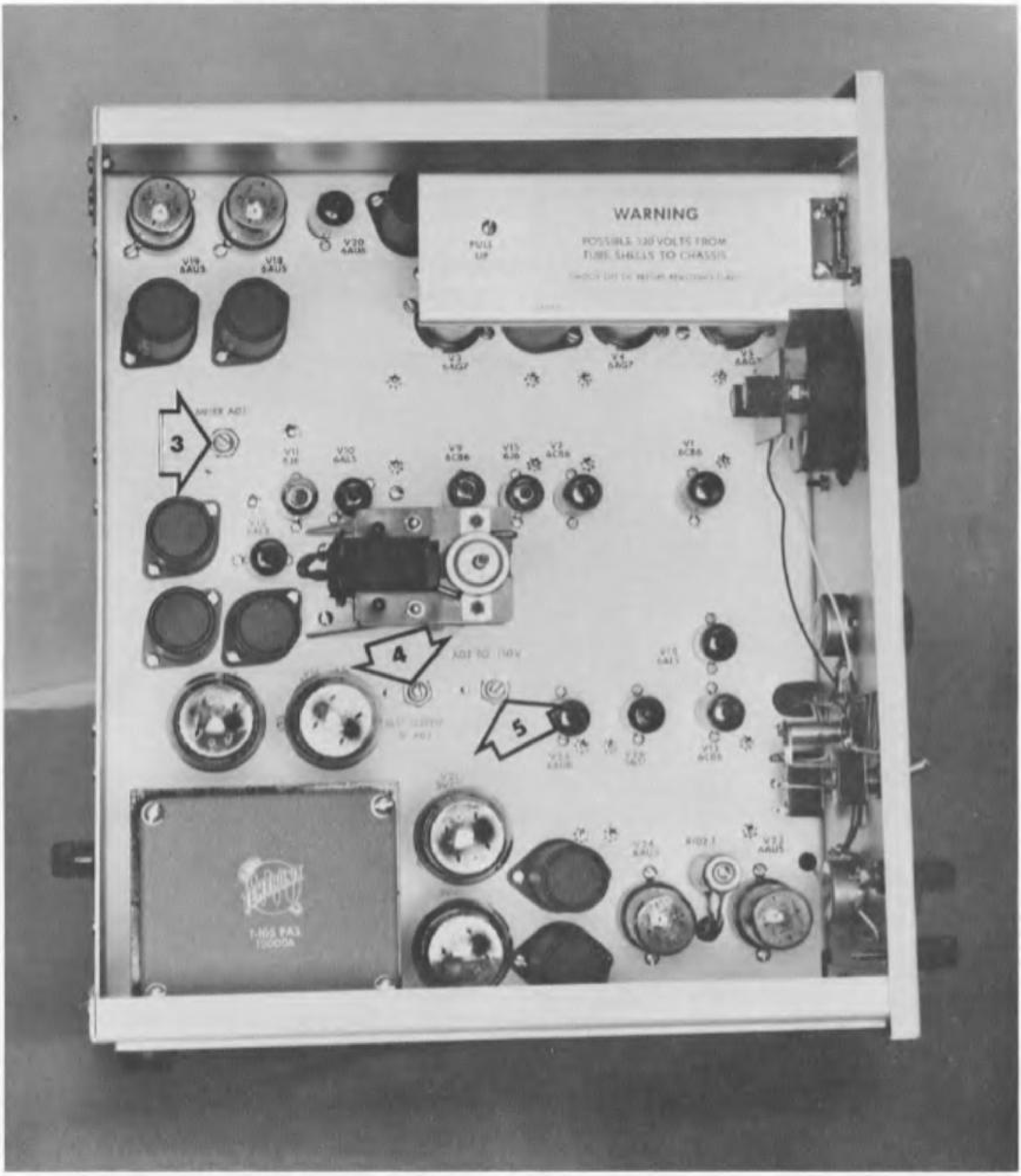


Fig. 5-2. The left-hand side of the Type 105. (Controls adjustable from the left-hand side of the Type 105 during the Recalibration Procedure are marked. Note that the fan blade has been removed to facilitate access to the controls.)

may be operated safely for short periods of time without the fan blade.

The output voltage of the —175-volt supply is variable and changes with the setting of the front-panel controls. The measurements and adjustments required in this step are based upon the following front-panel control settings:

OUTPUT AMPLITUDE	full left (counterclockwise)
RANGE	10 KC
FREQUENCY	mid-range
SYMMETRY	mid-range
AC	OFF
DC	OFF
SYNC. INPUT AMPLITUDE	full left

Connect the Type 105 to the autotransformer output, switch the AC switch to ON, and adjust the autotransformer output voltage to 117 volts. Allow the instrument about one minute to warm up and then switch the DC switch to ON.

The output voltage of the A-150-volt supply is measured with respect to the A Supply. The points for making this measurement are shown in Fig. 5-3. Set this voltage to exactly —150 volts by means of the ADJ TO —150V control. Take care in making this adjustment, since the remainder of the calibration will not be accurate unless this voltage is correct.

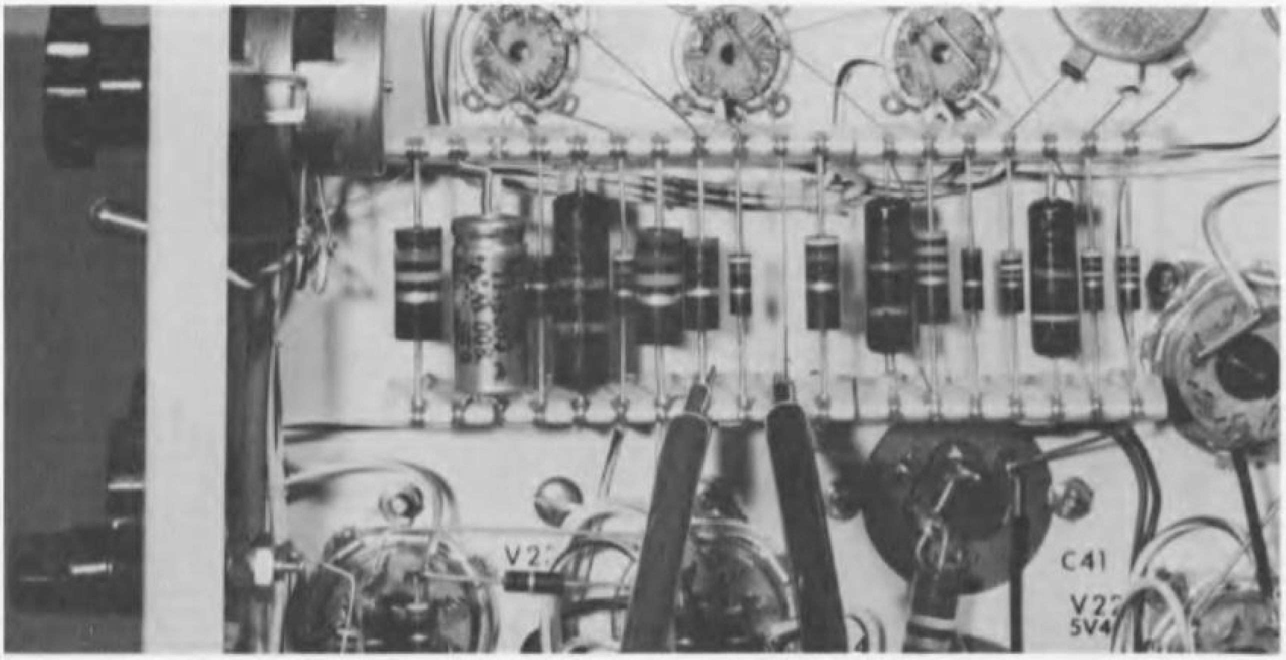


Fig. 5-3. Measuring the output voltage of the A-150-volt supply. The meter leads are shown connected to the correct points for measuring the output voltage of the A-150-volt supply.

Fig. 5-4. Measuring the output voltage of the A supply The meter leads are shown connected to the correct points for measuring the output voltage of the A supply.

The output voltage of the A supply (—5 to —175 volt supply) is measured with respect to ground. The test point is shown in Fig. 5-4. With a voltmeter connected as shown, turn the ADJ. 175V control slowly to the left. The output voltage of the supply will decrease, and may even become positive. Set the control for an output voltage between five- and seven-volts negative.

Next, turn the OUTPUT AMPLITUDE control full right. The supply should now be at its maximum output voltage of —175 volts. If the output voltage of the supply is not —175 volts, it will be necessary to change resistor R98.1 (location shown in Fig. 5-5.) To lower the output voltage lower the value of R98.1. To raise the output voltage, raise the value of R98.1. Changing R98.1 should be done in steps of one RMA value until the output voltage is exactly —175 volts.

For example, if R98.1 in your instrument is a 1.2 megohm resistor and you wish to raise the voltage, replace it with a 1.5 megohm resistor (the next higher RMA value). If this does not raise the voltage high enough, increase the resistance one more RMA step (to 1.8 megohms), and continue in this manner until the output voltage is —175 volts.

2. Power Supply Regulation

It is important that the operation of the Type 105 be unaffected by normal line-voltage variations. The regulating circuits in the power supply should hold the output voltages constant for all line voltages within the range from 105 to 125 volts. A convenient way to check for proper operation of the regulator circuits is to measure the ripple amplitude on the two supplies. Ripple in excess of 80 millivolts, peak-to-peak, on the A-150-volt supply and in excess of 60 millivolts, peak-to-peak, on the A supply is an indication of faulty operation.

To measure the ripple amplitude accurately, it is necessary to connect the ripple signal to the test-oscilloscope input connector without introducing attenuation or extraneous signals. A shielded lead is the simplest means of doing this. A Type P93 Coaxial Cable and a Type A-100 clip-lead Adapter are convenient for this purpose.

With the Type CA Plug-In installed in the test oscilloscope, and while it is warming up, set the front-panel controls as follows:

Type 541:

- STABILITY — *PRESET
- TRIGGERING LEVEL — not used in AUTOMATIC mode
- TRIGGERING MODE — AUTOMATIC
- TRIGGER SLOPE — +LINE
- TIME/CM — 5 MILLISEC
- 5X MAGNIFIER — OFF
- HORIZONTAL DISPLAY — INTERNAL SWEEP
- SQUARE-WAVE CALIBRATOR (red knob) — VOLTS
- SQUARE-WAVE CALIBRATOR (black knob) — .5
- HORIZONTAL POSITIONING — centered
- POWER — ON

Type CA:

- MODE — B ONLY
- AC-DC (Channel B) — AC
- POLARITY (Channel B) — NORMAL
- VERTICAL POSITION (Channel B) — centered
- VOLTS C/M (black knob—Channel B) — .05
- VARIABLE (red knob—Channel B) — CALIBRATED

*If your oscilloscope STABILITY control does not have a PRESET position, adjust the control for a stable display.

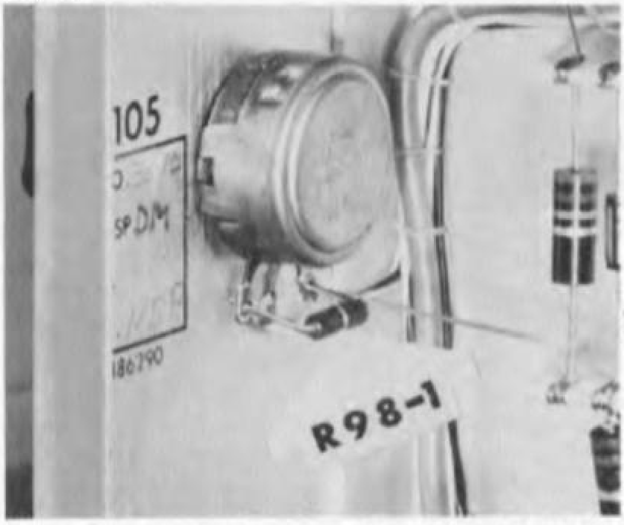


Fig. 5-5. R98.1 is located on the OUTPUT AMPLITUDE control and determines the range of the control.

The controls for the A Channel of the Type CA may be left in any position, since the A channel will not be used in this step.

At low square-wave frequencies, the multivibrator waveform is evident on the power supply output. Set the front-panel controls of the Type 105 to the positions described in Step 1.

Connect the shielded test lead to the test-oscilloscope CHANNEL B input connector. To measure the ripple on the A-150-volt supply, connect the test-lead ground connection to ground (be sure the Type 105 OUTPUT AMPLITUDE control is turned full left), and connect the center conductor to the A-150 supply. The 120-cycle ripple displayed on the test oscilloscope (approximately six cycles on the graticule) should not exceed 50 millivolts, peak-to-peak, as the autotransformer output is varied from 105 to 125 volts.

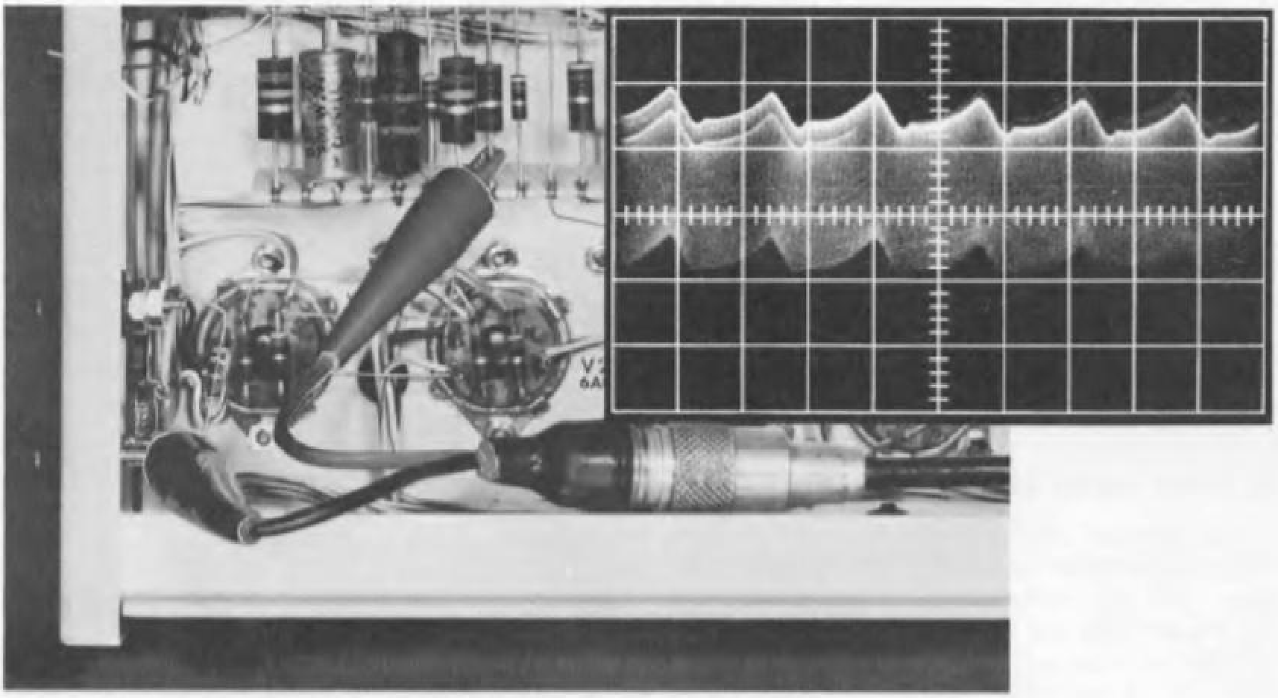
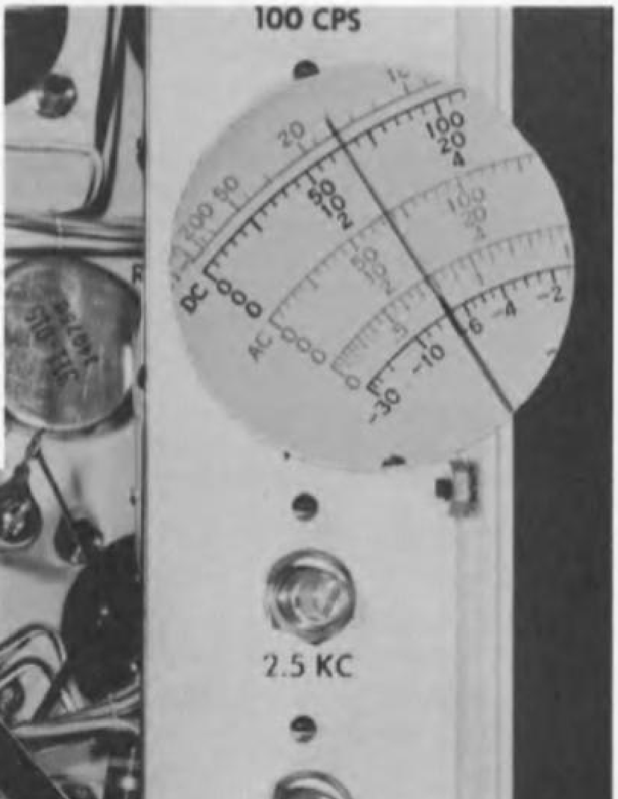


Fig. 5-6. Measuring the ripple present on the A supply.

The inset waveform photograph is typical of the ripple present on the supply. Vertical calibration is .05 v/cm.

To measure the ripple on the A Supply, connect the test-lead outer connector to the chassis, and connect the center conductor to the A Supply as shown in Fig. 5-6. The ripple observed at this point should not exceed 60 millivolts, peak-to-peak, as the autotransformer output is varied from 105 to 125 volts.

Return the Autotransformer Output to 117 volts.



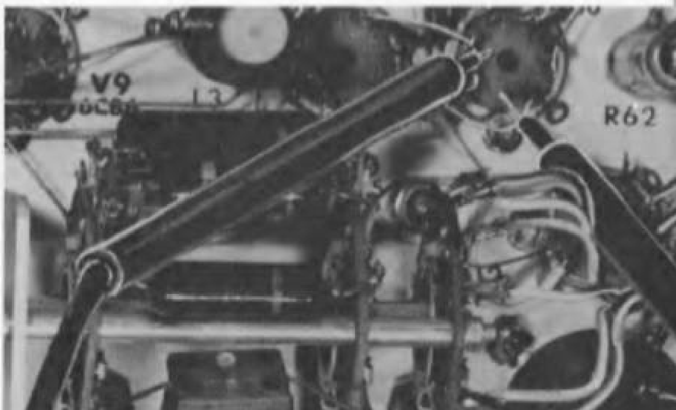


Fig. 5-7. Measuring the voltage across the metering diode.

The meter leads are connected to pins 1 and 7 of V11. The METER ADJ. control is adjusted for a meter reading of 65 volts (see inset).

3. Frequency-Meter DC Adjustment

Dc voltages in the meter circuit are controlled by V11, a cathode-follower voltage regulartor, and the METER ADJ. control determines the operating voltage on this regulator tube. To provide the proper meter-circuit voltages, the METER ADJ. control must be adjusted for a voltage drop across the regulator tube of exactly 65 volts (see Fig. 5-7).

4. Multivibrator Screen-Voltage Adjustment

Current flowing through the multivibrator tubes V1 and V2 determines the output amplitude of the synchronizing voltage, and partially determines the output frequency range of the Type 105. The M.V. SCREEN V. ADJ. control enables us to set this current for optimum performance of the multivibrator and associated circuits.

To make this adjustment, short together the screens of V1 and V2 (pins 6 of the 6CB6), and measure from this point to the A-150-volt supply (pin 7 of V26). Adjust the M.V. SCREEN V. ADJ. control for a difference voltage of exactly 80 volts.

5. Frequency-Meter Calibration

The meter circuits are calibrated to indicate the actual output frequency of the square-wave generator. A separate meter adjustment is provided for each frequency range. The following procedure describes a means of calibrating the meter circuits. To perform this step set the front-panel controls of the instruments as follows:

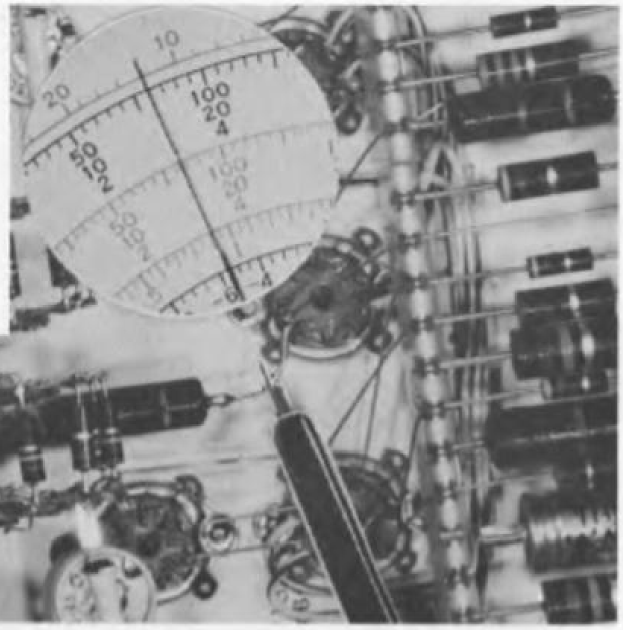
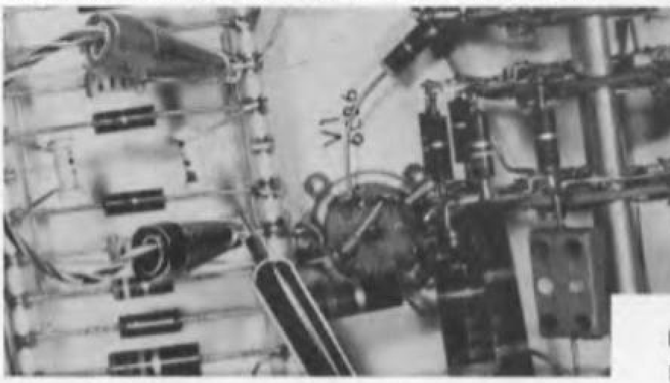



Fig. 5-8. Measuring the multivibrator screen voltage. Pins 6 of V1 are shorted together with a shorting strap. The meter leads are connected between the multivibrator screens and the A-150-volt supply. The M.V. SCREEN ADJ. control is adjusted for a meter reading of 80 volts (see inset).

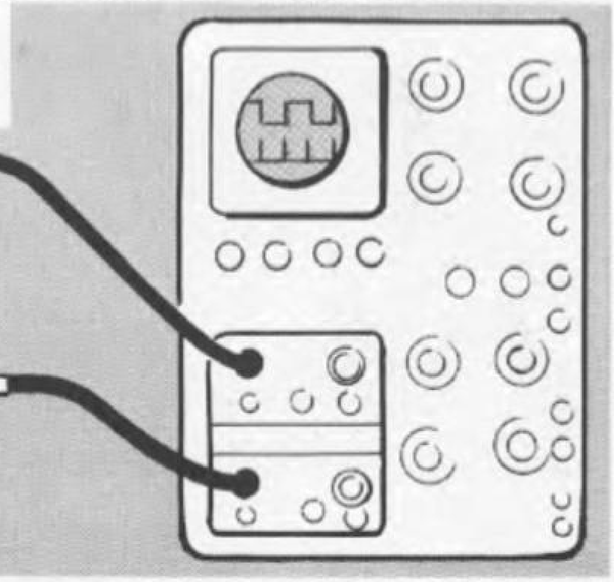
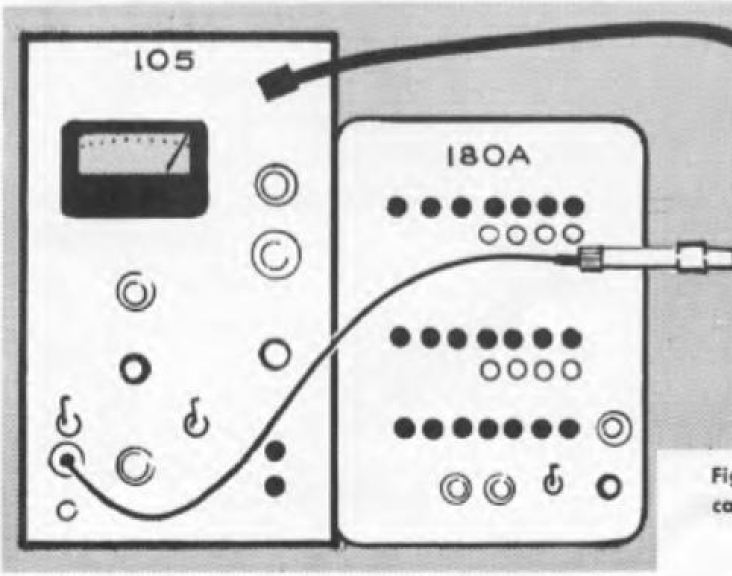



Fig. 5-9. Interconnection of equipment necessary for calibrating meter circuits.

Type 180:

Control	Setting
SIGNAL SELECTOR	MARKERS
MILLISECOND MARKERS	5, ON
POWER	ON
TRIGGER RATE SELECTOR	10 KC
POWER	ON

Type 105:

Control	Setting
OUTPUT AMPLITUDE	full left
RANGE	100
FREQUENCY	mid range
SYMMETRY	mid range
AC	ON
DC	OFF
SYNC. INPUT AMPLITUDE	full left

Type 541:

Control	Setting
STABILITY	full right
TRIGGERING LEVEL	full right
TRIGGER MODE	AC SLOW
TRIGGER SLOPE	+INT.
TIME/CM	1 MILLISEC
5X MAGNIFIER	OFF
HORIZONTAL DISPLAY	+INTERNAL SWEEP
SQUARE-WAVE CALIBRATOR (red knob)	VOLTS
SQUARE-WAVE CALIBRATOR (black knob)	.5
HORIZONTAL POSITIONING	centered
POWER	ON
MODE	ALTERNATE
Set controls in the CHANNEL A block as follows:	
AC-DC	AC
POLARITY	NORMAL
VERTICAL POSITION	centered
VOLTS/CM (black knob)	10
VARIABLE (red knob)	CALIBRATED
Set controls in the CHANNEL B block as follows:	
AC-DC	AC
POLARITY	NORMAL
VERTICAL POSITION	centered
VOLTS/CM (black knob)	1
VARIABLE (red knob)	CALIBRATED

Terminate the Type P93 Coaial Cable at both ends with a Type B93-R Terminating Resistor and connect it between the OUTPUT connector of the Type 105 and the CHANNEL A input connector on the Type CA Plug-In. Connect the coaxial "T" connector to the CHANNEL B input connector, connect the SIGNAL OUTPUT connector of the Type 180 to the "T" connector with a coaxial cable, and connect the other side of the "T" connector to the Type 105 SYNC. INPUT connector with an 18-inch lead. (See Fig. 5-9.)

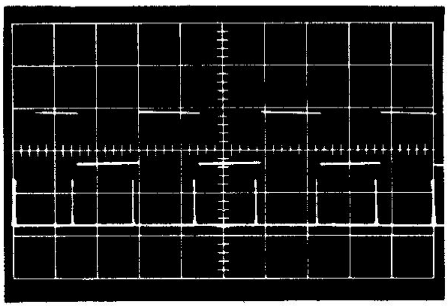


Fig.5-10. Display of square waves and time marks preliminary to synchronizing the Type 105 with the Type 180.

Note that the square wave frequency is lower than the frequency of the time marks.

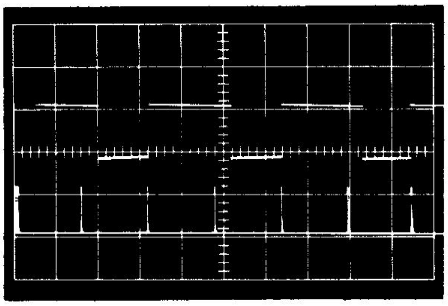


Fig. 5-11. Display of square waves and time marks after synchronizing the Type 105 with the Type 180.

Although the square wave is not symmetrical its frequency is identical with the time mark frequency.

Turn the DC switch on the Type 105 to ON.

Table 1 gives the control setting changes for each instrument used in a check of the meter calibration. The general procedure to follow in making the adjustments is outlined below.

With the controls set as indicated get a stable display on the oscilloscope. Adjust the FREQUENCY control on the Type 105 for a display on the oscilloscope similar to the one shown in Fig. 5-10. This display indicates that the Type 105 output frequency is slightly below the Type 180 output frequency. Turn the SYNC. INPUT AMPLITUDE control slowly to the right. As this control is turned, the square wave will synchronize with the time marks. This synchronization will be indicated by a pronounced movement of the square wave. When the frequency of the square wave is synchronized with that of the time marks a slight change in symmetry will be noticed. Figure 5-11 shows this condition. A large change in symmetry as shown in Fig. 5-12 indicates that the SYNC. INPUT AMPLITUDE control has been turned too far. If this occurs, turn the control back to the left to achieve correct synchronization as shown in Fig. 5-10.

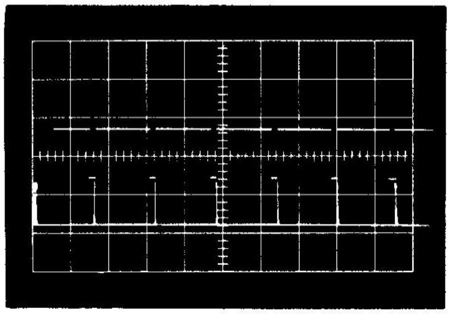


Fig. 5-12. Display of square waves and time markers resulting from excessive synchronizing voltage.

As an example of how to use Table 1, the 100 cycle range of the Type 105 is set up as follows.

Adjust the Type 105 OUTPUT AMPLITUDE control for a square-wave display of about two-centimeters vertical deflection. Position the square wave near the top of the graticule. Position the time-marks directly below the square-wave display. Turn the STABILITY control slowly to the left until the display disappears. Then, turn the TRIGGERING LEVEL control slowly to the left until the display reappears. This should result in a stable display similar to Fig. 5-9.

With a stable display of the square wave and the time marks on your test oscilloscope, adjust the Type 105 FREQUENCY control for a display similar to Fig. 5-10. When this is done the Type 105 output frequency is slightly below 100 cycles. Adjust the SYNC. INPUT AMPLITUDE control until the frequency of the square wave is synchronized with the frequency of the time marks as described above. When this is done you will see exactly 3 time marks for each complete cycle of the square wave. Now adjust the control marked 100 CPS (on the row of controls at the rear of the instrument) for a meter reading of exactly 10.

Symmetry and frequency of the 1 megacycle square wave output are controlled by C11 and C12, a pair of variable capacitors mounted on the forward sections of the RANGE switch (see Fig. 5-1). Since this adjustment, once made, is extremely stable, it is not likely that they will require much attention. Lack of sufficient frequency coverage, or poor symmtery, indicates the need for adjustment.

TABLE I

TEST OSCILLOSCOPE		TYPE 180	TYPE 105		MARKER/ cycle on crt
TIME/CM	MULTIPLIER	MARKERS	RANGE	INTERNAL CONTROL	
1 MILLISEC	2	5 MILLISEC	100 cycles	100 CPS	3
1 MILLISEC	1	1 MILLISEC	250 cycles	250 cps	5
100 MICROSEC	2	500 MICROSEC	1 KC	1 KC	3
100 MICROSEC	1	100 MICROSEC	2.5 KC	2.5 KC	5
10 MICROSEC	2	50 MICROSEC	10 KC	10 KC	3
10 MICROSEC	1	10 MICROSEC	25 KC	25 KC	5
1 MICROSEC	2	5 MICROSEC	100 KC	100 KC	3
1 MICROSEC	1	1 MICROSEC	250 KC	C30	5
1 MICROSEC (Turn 5X MAGNIFIER ON)	1	1 MICROSEC	1 MC	C31	2

Adjustment of C11 and C12 should be made after adjusting the meter calibration on the 1 megacycle range of the Type 105. Set the frequency indication as described above, and then check the symmetry of the square wave displayed on the test oscilloscope to be sure that it is satisfactory. Satisfactory symmetry has been attained when the positive and negative portions of the square wave are equal, with the SYMMETRY control between the nine and three o' clock positions. If the symmetry of the one megacycle wave is not satisfactory adjust C11 and C12 until the positive and negative portions of the square wave are equal.

C11 and C12 affect the frequency coverage of the one megacycle range as well as its symmetry of the square wave.

To check the frequency coverage turn the SYNC. INPUT AMPLITUDE control full left. Rotate the FREQUENCY control from full left to full right. When the FREQUENCY control is positioned full left the meter needle should rest below the 2.5 mark on the upper meter scale. When the FREQUENCY control is full right the meter needle should rest above the upper end of the scale. If the meter needle does not move to these two positions adjust C11 and C12 until it does. When C11 and C12 are correctly adjusted they should both be in approximately the same physical position. Minor adjustments of either C11 or C12 may be made to bring the

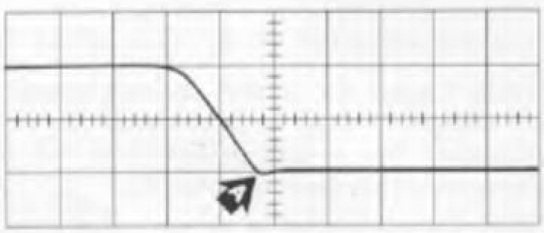


Fig. 5-13. Coil L2 controls the negative overshoot on the high frequency output waveform.

L2 is adjusted while observing the one megacycle output waveform.

symmetry into the desired ratio. (Usually with the half cycles equal when the SYMMETRY control is at mid-range.)

After the adjustment of C11 and C12 is completed repeat the calibration of the one megacycle range of the frequency meter.

6. High Frequency Compensation

L2, a high-frequency compensating coil, controls the amount of overshoot on the negative-going portion of the square wave. To check the adjustment of the high frequency compensation, use the front-panel control settings given in Step 5 of the Recalibration Procedure. Connect the instruments as described in Step 5 with the exception of the Type 180, which will not be needed for this adjustment.

Use the settings given in Table II to display 1 megacycle square wave on the test oscilloscope. Switch the Type CA MODE switch to A ONLY. Adjust the STABILITY and TRIGGERING LEVEL controls for a stable display. Position the display on the crt screen so that the falling edge of the square wave may be observed. Fig. 5-15 shows the desired waveform. If the display you see does not match this, adjust L2 until it does. The display will be observed to change its shape at point A on Fig. 5-15 as L2 is adjusted.

ABBREVIATIONS USED IN OUR PARTS LISTS

Cer.	ceramic	m	milli
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	thousands of ohms	v	working volts dc
meg	megohms	Var.	variable
μ	micro	w	watt
μμ	micromicro	WW	wire wound
GMV	guaranteed minimum value		

ABBREVIATIONS USED IN OUR CIRCUIT DIAGRAMS

Resistance values are in ohms. The symbol k stands for thousands. A resistor marked 2.7 k has a resistance of 2,700 ohms. The symbol M stands for million. For example, a resistor marked 5.6 M has a resistance of 5.6 megohms.

Unless otherwise specified on the circuit diagram, capacitance values marked with the number 1 and numbers greater than 1 are in μμf. For example, a capacitor marked 3.3 would have a capacitance of 3.3 micromicrofarads. Capacitance values marked with a number less than 1 are in μf. For example, a capacitor marked .47 would have a capacitance of .47 microfarads.

Inductance values marked in mh are in millihenrys. Inductance values marked in μh are in microhenrys.

Your instrument WARRANTY appears on the reverse side of this sheet.

PARTS LIST

For an explanation of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Bulbs

		Tektronix Part Number
B1	#47	150-001

Capacitors

						Tektronix Part Number
C1	100 μμf	Cer.	Fixed	350 v	20%	281-523
C1.1	27 μμf	Cer.	Fixed	500 v	20%	281-513
C2	.01 μf	PT	Fixed	400 v	20%	285-510
C3	.047 μf	PT	Fixed	400 v	10%*	Timing Series 290-052
C4	.047 μf	PT	Fixed	400 v	10%*	
C5	.0047 μf	Mica	Fixed	500 v	10%*	
C6	.0047 μf	Mica	Fixed	500 v	10%*	
C7	470 μμf	Mica	Fixed	500 v	10%*	
C8	470 μμf	Mica	Fixed	500 v	10%*	
C9	56 μμf	Mica or Cer.	Fixed	500 v	10%*	
C10	56 μμf	Mica or Cer.	Fixed	400 v	10%*	
C11	7-45 μμf	Cer.	Var.	500 v		281-012
C11.1	47 μμf	Cer.	Fixed	500 v	20%	281-518
C12	7-45 μμf	Cer.	Var.	500 v		281-012
C13	100 μμf	Cer.	Fixed	350 v	20%	281-523
C14	1000 μf	EMC	Fixed	15 v	−20% +50%	290-049
C15	.5 μf	PT	Fixed	400 v	20%	285-537
C16	.01 μf	PT	Fixed	400 v	20%	285-510
C17a,b	2x20 μf	EMC	Fixed	450 v	−20% +50%	290-036
C18	.1 μf	PT	Fixed	600 v	20%	285-527
C18.1	.1 μf	PT	Fixed	600 v	20%	285-527
C19	2x20 μf	EMC	Fixed	450 v	−20% +50%	290-036
C20	.047 μf	PT	Fixed	400 v	20%	285-519
C22	.1 μf	PT	Fixed	600 v	20%	285-527
C23	.1 μf	PT	Fixed	600 v	20%	285-527
C24	.047 μf	PT	Fixed	400 v	20%	285-519
C25	.01 μf	PT	Fixed	400 v	20%	285-510
C26	.0047 μf	PT	Fixed	400 v	20%	285-506
C27	.001 μf	PT	Fixed	600 v	20%	285-501
C28	470 μμf	Mica	Fixed	500 v	10%	283-522
C29	100 μμf	Mica	Fixed	500 v	10%	283-505
C30	7-45 μμf	Cer.	Var.	500 v		281-012
C31	7-45 μμf	Cer.	Var.	500 v		281-012
C32	.01 μf	PT	Fixed	600 v	20%	285-511
C33	6.25 μf	EMC	Fixed	300 v	−20% +50%	290-000
C34	.001 μf	Cer.	Fixed	500 v	GMV	283-000

*Selected with R7 to R22

Capacitors *(continued)*

						Tektronix Part Number
C36	2 x 20 μf	EMC	Fixed	450 v	—20% +50%	290-036
C37	2 x 20 μf	EMC	Fixed	450 v	—20% +50%	290-036
C38	2 x 20 μf	EMC	Fixed	450 v	—20% +50%	290-036
C39	1 μf	PT	Fixed	400 v	20%	285-526
C40	2 x 20 μf	EMC	Fixed	450 v	—20% +50%	290-036
C41	2 x 20 μf	EMC	Fixed	450 v	—20% +50%	290-036
C42	2 x 20 μf	EMC	Fixed	450 v	—20% +50%	290-036
C43	.01 μf	PT	Fixed	400 v	20%	285-510
C44	.01 μf	PT	Fixed	400 v	20%	285-510
C45	2 x 20 μf	EMC	Fixed	450 v	—20% +50%	290-036
C85	6.25 μf	EMC	Fixed	300 v	—20% +50%	290-000

Frequency Meter

M1	Special, temperature compensated, 0-200 micromamperes.	149-014

Fuses

Fuse	3 amp	3AG	Slo-Blo	for 117 v operation	159-005
Fuse	1.6 amp	3AG	Slo-Blo	for 234 v operation	159-003

Inductors

L1	7.5 μh	Fixed	CF752	108-021
L2	.88-1.4 μh	Var.	CV881	114-027
L3	990 μh	Fixed	CF994	108-025
L5	8.8 μh	Fixed	CF882	108-057
L26	8.8 μh	Fixed	CF882	108-057
LR1		#37 wire, 65 turns, on 33 Ω 1 w resistor.		108-118

Resistors

R1	1.8 k	½ w	Fixed	Comp.	10%		302-182
R2	390 Ω	½ w	Fixed	Comp.	10%		302-391
R3	1.6 k	1 w	Fixed	Comp.	5%		303-162
R4	47 Ω	½ w	Fixed	Comp.	10%		302-470
R5	47 Ω	½ w	Fixed	Comp.	10%		302-470
R6	100 k	2 w	Var.	Comp.	20%	FREQUENCY	311-026
R7	1.5 meg	½ w	Fixed	Comp.	10%*		
R8	1.5 meg	½ w	Fixed	Comp.	10%*		
R9	560 k	½ w	Fixed	Comp.	10%*		
R10	560 k	½ w	Fixed	Comp.	10%*		

* Selected with C3 to C10

							Tektronix Part Number
R11	1.5 meg	½ w	Fixed	Comp.	10%*		
R12	1.5 meg	½ w	Fixed	Comp.	10%*		
R13	560 k	½ w	Fixed	Comp.	10%*		
R14	560 k	½ w	Fixed	Comp.	10%*	R7 thru R22—Timing	
R15	1.5 meg	½ w	Fixed	Comp.	10%*	Series	295-052
R16	1.5 meg	½ w	Fixed	Comp.	10%*		
R17	560 k	½ w	Fixed	Comp.	10%*		
R18	560 k	½ w	Fixed	Comp.	10%*		
R19	1.8 meg	½ w	Fixed	Comp.	10%*		
R20	1.8 meg	½ w	Fixed	Comp.	10%*		
R21	680 k	½ w	Fixed	Comp.	10%*		
R22	680 k	½ w	Fixed	Comp.	10%*		
R23	390 k	½ w	Fixed	Comp.	10%		302-394
R24	390 k	½ w	Fixed	Comp.	10%		302-394
R25A,B	2 x 5 k	2 w	Var.	WW	20%	SYMMETRY	311-014
R25.2	27 k	2 w	Fixed	Comp.	10%		306-273
R25.4	10 k	2 w	Var.	WW	20%	MV. SCREEN V. ADJ.	311-015
R25.5	4.7 k	1 w	Fixed	Comp.	10%		304-472
R26	1.6 k	1 w	Fixed	Comp.	5%		303-162
R27	47 Ω	½ w	Fixed	Comp.	10%		302-470
R28	47 Ω	½ w	Fixed	Comp.	10%		302-470
R29	390 Ω	½ w	Fixed	Comp.	10%		302-391
R30	1.8 k	½ w	Fixed	Comp.	10%		302-182
R31	330 Ω	2 w	Fixed	Comp.	10%		306-331
R32	150 Ω	2 w	Fixed	Comp.	10%		306-151
R33	47 Ω	½ w	Fixed	Comp.	10%		302-470
R34	1 meg	½ w	Fixed	Comp.	10%		302-105
R35	47 Ω	½ w	Fixed	Comp.	10%		302-470
R36	47 Ω	½ w	Fixed	Comp.	10%		302-470
R37	10 Ω	½ w	Fixed	Comp.	10%		302-100
R38	47 Ω	½ w	Fixed	Comp.	10%		302-470
R39	47 Ω	½ w	Fixed	Comp.	10%		302-470
R40	10 Ω	½ w	Fixed	Comp.	10%		302-100
R41	180 Ω	2 w	Fixed	Comp.	10%		306-181
R42	560 Ω	½ w	Fixed	Comp.	10%		302-561
R43	2.2 k	2 w	Fixed	Comp.	10%		306-222
R44	27 Ω	½ w	Fixed	Comp.	10%		302-270
R44.5	27 Ω	½ w	Fixed	Comp.	10%		302-270
R45	27 Ω	½ w	Fixed	Comp.	10%		302-270
R46	10 Ω	½ w	Fixed	Comp.	10%		302-100
R47	47 Ω	½ w	Fixed	Comp.	10%		302-470
R48	10 Ω	½ w	Fixed	Comp.	10%		302-100
R49	47 Ω	½ w	Fixed	Comp.	10%		302-470
R50	10 Ω	½ w	Fixed	Comp.	10%		302-100
R51	47 Ω	½ w	Fixed	Comp.	10%		302-470

*Selected with C3 to C10

Resistors *(continued)*

							Tektronix Part Number
R54	600 Ω	10 w	Fixed	WW	5%		308-015
R58	47 Ω	½ w	Fixed	Comp.	10%		302-470
R59	1 meg	½ w	Fixed	Comp.	10%		302-105
R60	4.7 k	1 w	Fixed	Comp.	10%		304-472
R61	5.6 k	2 w	Fixed	Comp.	10%		306-562
R62	4.5 k	10 w	Fixed	WW	10%		308-021
R63	10 k	2 w	Var.	WW	20%	METER ADJ.	311-015
R64	10 k	10 w	Fixed	WW	10%		308-023
R65	27 k	2 w	Fixed	Comp.	10%		306-273
R66	270 Ω	½ w	Fixed	Comp.	10%		302-271
R67	5 k	2 w	Var.	WW	20%	100 CPS	311-012
R68	5 k	2 w	Var.	WW	20%	250 CPS	311-012
R69	5 k	2 w	Var.	WW	20%	1 KC	311-012
R70	5 k	2 w	Var.	WW	20%	2.5 KC	311-012
R71	5 k	2 w	Var.	WW	20%	10 KC	311-012
R72	5 k	2 w	Var.	WW	20%	25 KC	311-012
R73	5 k	2 w	Var.	WW	20%	100 KC	311-012
R74	680 Ω	½ w	Fixed	Comp.	10%		302-681
R76	47 Ω	½ w	Fixed	Comp.	10%		302-470
R77	1 meg	½ w	Fixed	Comp.	10%		302-105
R78	1.5 k	1 w	Fixed	Comp.	10%		304-152
R79	470 Ω	½ w	Fixed	Comp.	10%		302-471
R80	5 k	2 w	Var.	WW	20%	SYNC. AMPL.	311-012
R81	18 k	2 w	Fixed	Comp.	10%		306-183
R82	5.6 k	2 w	Fixed	Comp.	10%		306-562
R83	4.7 k	½ w	Fixed	Comp.	10%		302-472
R85	470 Ω	½ w	Fixed	Comp.	10%		302-471
R87	220 k	2 w	Fixed	Comp.	10%		306-224
R88	47 Ω	½ w	Fixed	Comp.	10%		302-470
R89	47 Ω	½ w	Fixed	Comp.	10%		302-470
R90	1 meg	½ w	Fixed	Comp.	10%		302-105
R91	1 k	½ w	Fixed	Comp.	10%		302-102
R92	12 k	2 w	Fixed	Comp.	10%		306-123
R93	1 k	½ w	Fixed	Comp.	10%		302-102
R94	1 k	½ w	Fixed	Comp.	10%		302-102
R95	5.6 k	1 w	Fixed	Comp.	10%		304-562
R96	56 k	½ w	Fixed	Comp.	10%		302-563
R97	68 k	1 w	Fixed	Comp.	10%		304-683
R98	250 k	2 w	Var.	Comp.	20%	OUTPUT	311-032
R98.1	Selected	½ w	Fixed	Comp.	See text		
R99	100 k	2 w	Var.	Comp.	20%	ADJ. 175 V	311-026
R99.1	Selected	½ w	Fixed	Comp.	See text		
R101	220 k	2 w	Fixed	Comp.	10%		306-224
R102	47 Ω	½ w	Fixed	Comp.	10%		302-470
R102.1	1.5 k	25 w	Fixed	WW	5%		308-040

Resistors *(continued)*

							Tektronix Part Number
R103	47 Ω	½ w	Fixed	Comp.	10%		302-470
R104	1 meg	½ w	Fixed	Comp.	10%		302-105
R105	1 k	½ w	Fixed	Comp.	10%		302-102
R106	1 k	½ w	Fixed	Comp.	10%		302-102
R107	1 k	½ w	Fixed	Comp.	10%		302-102
R108	33 k	1 w	Fixed	Comp.	10%		304-333
R109	470 k	½ w	Fixed	Comp.	10%		302-474
R110	39 k	½ w	Fixed	Comp.	10%		302-393
R111	10 k	2 w	Var.	WW	20%	ADJ. TO —150V	311-015
R112	47 k	½ w	Fixed	Comp.	10%		302-473

Switches

SW1	9 wafer 9 position rotary RANGE	260-057
SW2	Single Pole Single Throw Toggle AC ON	260-134
SW3	Double Pole Double Throw Toggle DC ON	260-014

Transformers

T1 — Plate and Heater Circuit — 120-006

Primary: 117/234 volt 50/60 cycle 250 watts

Secondaries:

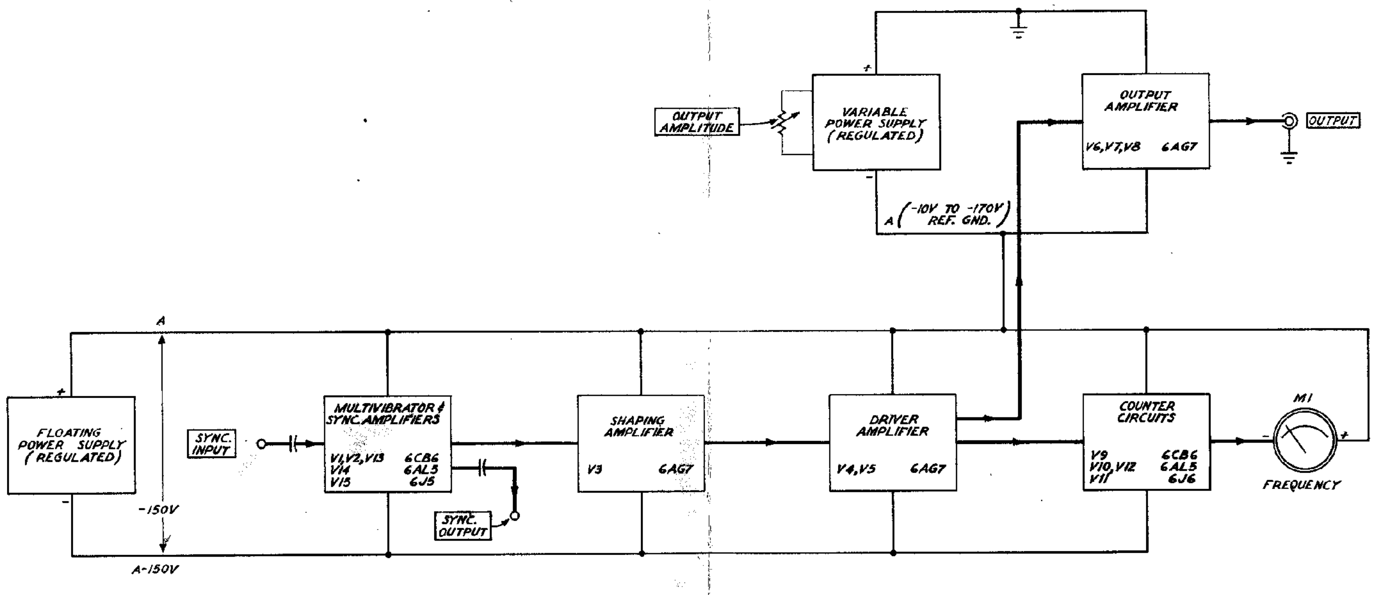
235-0-235 volts	200 ma
265-0-265 volts	150 ma
5.2 volts	4A
5.2 volts	4A
6.5 volts	5.2A
6.5 volts	4.5A
6.5 volts	2.5A

Vacuum Tubes

V1	6CB6	Multivibrator	157-020
V2	6CB6	Multivibrator	157-020
V3	6AG7	Shaping Amplifier	154-012
V4	6AG7	Driver Amplifier	154-012
V5	6AG7	Driver Amplifier	154-012
V6	6AG7	Output Amplifier	154-012
V7	6AG7	Output Amplifier	154-012
V8	6AG7	Output Amplifier	154-012
V9	6CB6	Meter Amplifier	154-030
V10	6AL5	Plate Catcher and Limiter Diode	154-016

Vacuum Tubes *(continued)*

			Tektronix Part Number
V11	6J6	Cathode-Follower Voltage Regulator	154-032
V12	6AL5	Meter Diode	154-016
V13	6CB6	Sync. Amplifier	154-030
V14	6AL5	Sync. Coupling Diode	154-016
V15	6J6	Sync. Output Cathode Follower	154-032
V16	5V4G	Variable Power Supply Rectifier	154-008
V17	5V4G	Variable Power Supply Rectifier	154-008
V18	6AU5	Variable Power Supply Series Regulator	154-021
V19	6AU5	Variable Power Supply Series Regulator	154-021
V20	6AU6	Variable Power Supply Regulator Amplifier	154-022
V21	5V4G	Fixed Power Supply Rectifier	154-008
V22	5V4G	Fixed Power Supply Rectifier	154-008
V23	6AU5	Fixed Power Supply Series Regulator	154-021
V24	6AU5	Fixed Power Supply Series Regulator	154-021
V25	6AU6	Fixed Power Supply Regulator Amplifier	154-022
V26	5651	Voltage Reference	154-052

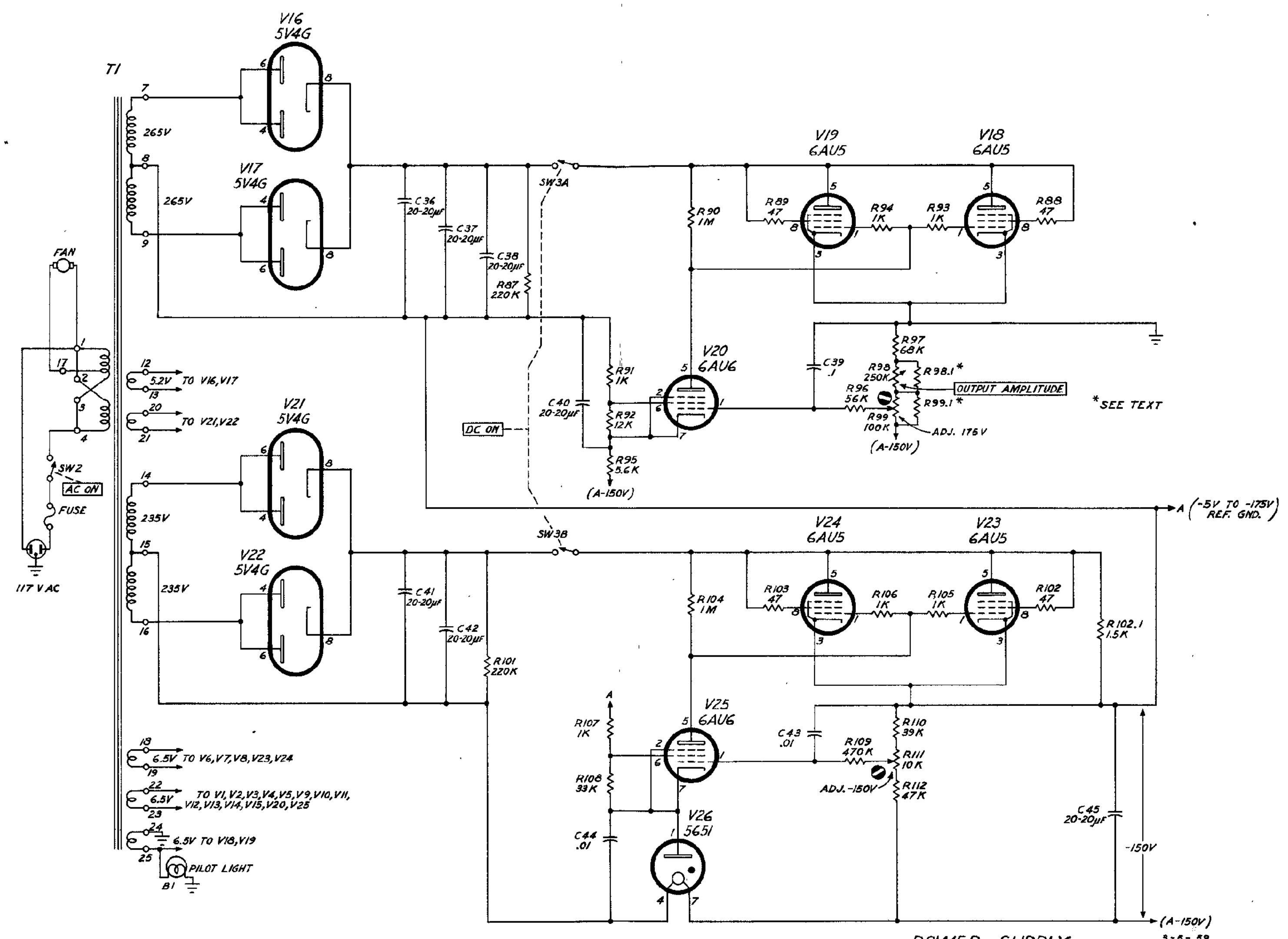


TYPE 105 SQUARE-WAVE GENERATOR

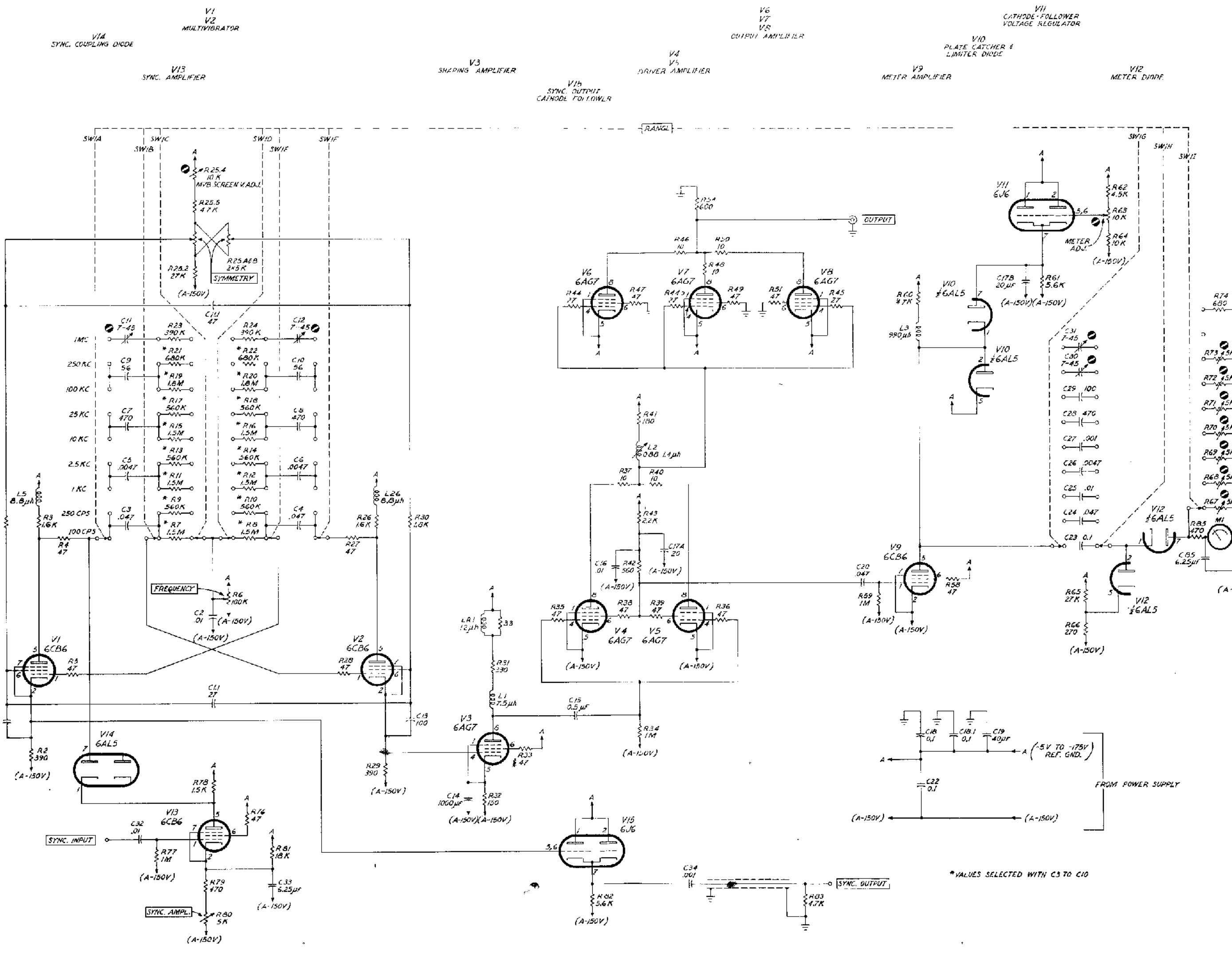
A

BLOCK DIAGRAM

9-23-54
KF



TYPE 105 SQUARE-WAVE GENERATOR D POWER SUPPLY 3-5-59 KF



TYPE 105 SQUARE-WAVE GENERATOR

G

GENERATOR & FREQUENCY METER

7-3-58
KF