INSTRUCTION MANUAL

Serial Number ____________

type P6016 current probe

type 131 current probe amplifier

passive termination

Tektronix, Inc.
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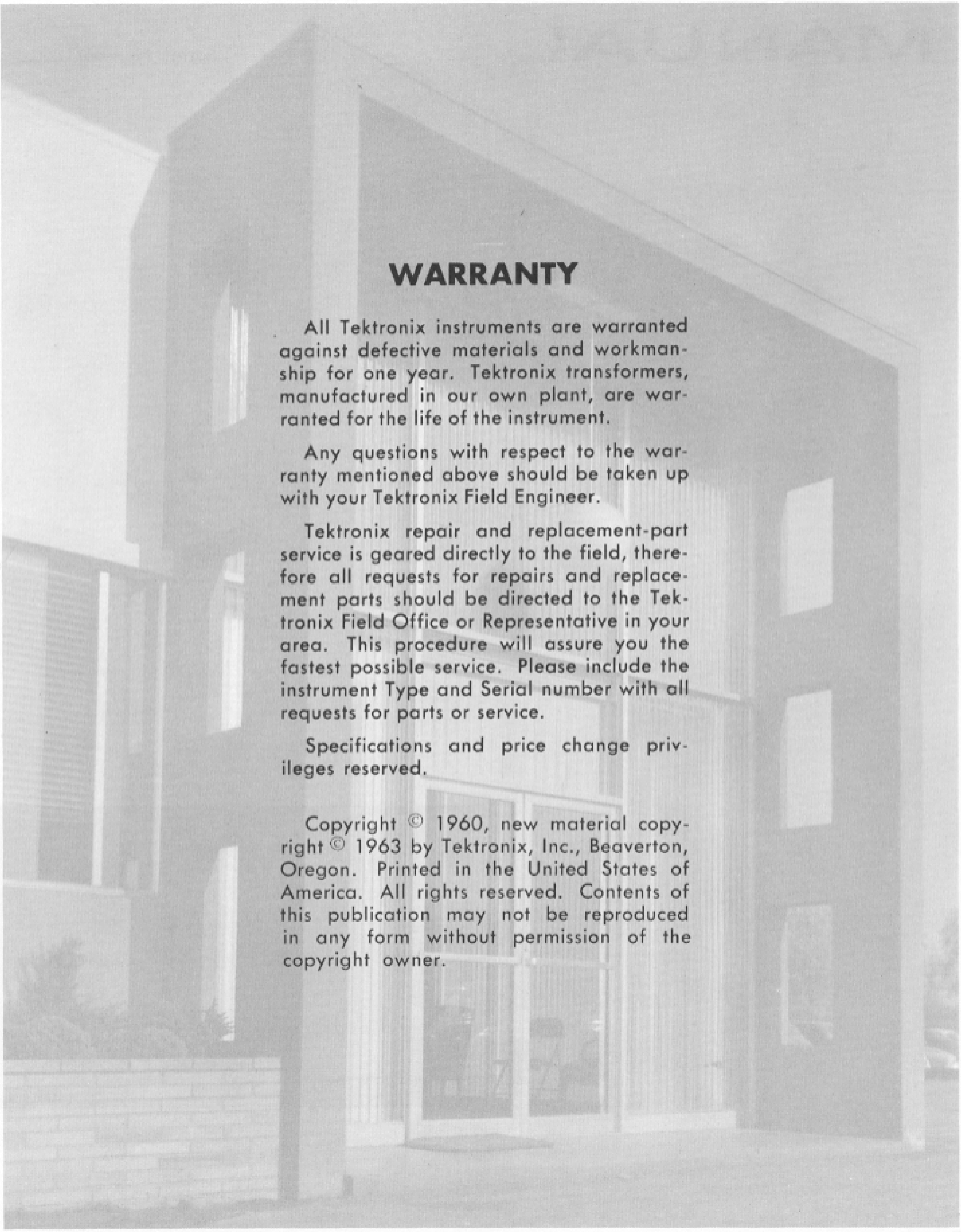
070-237



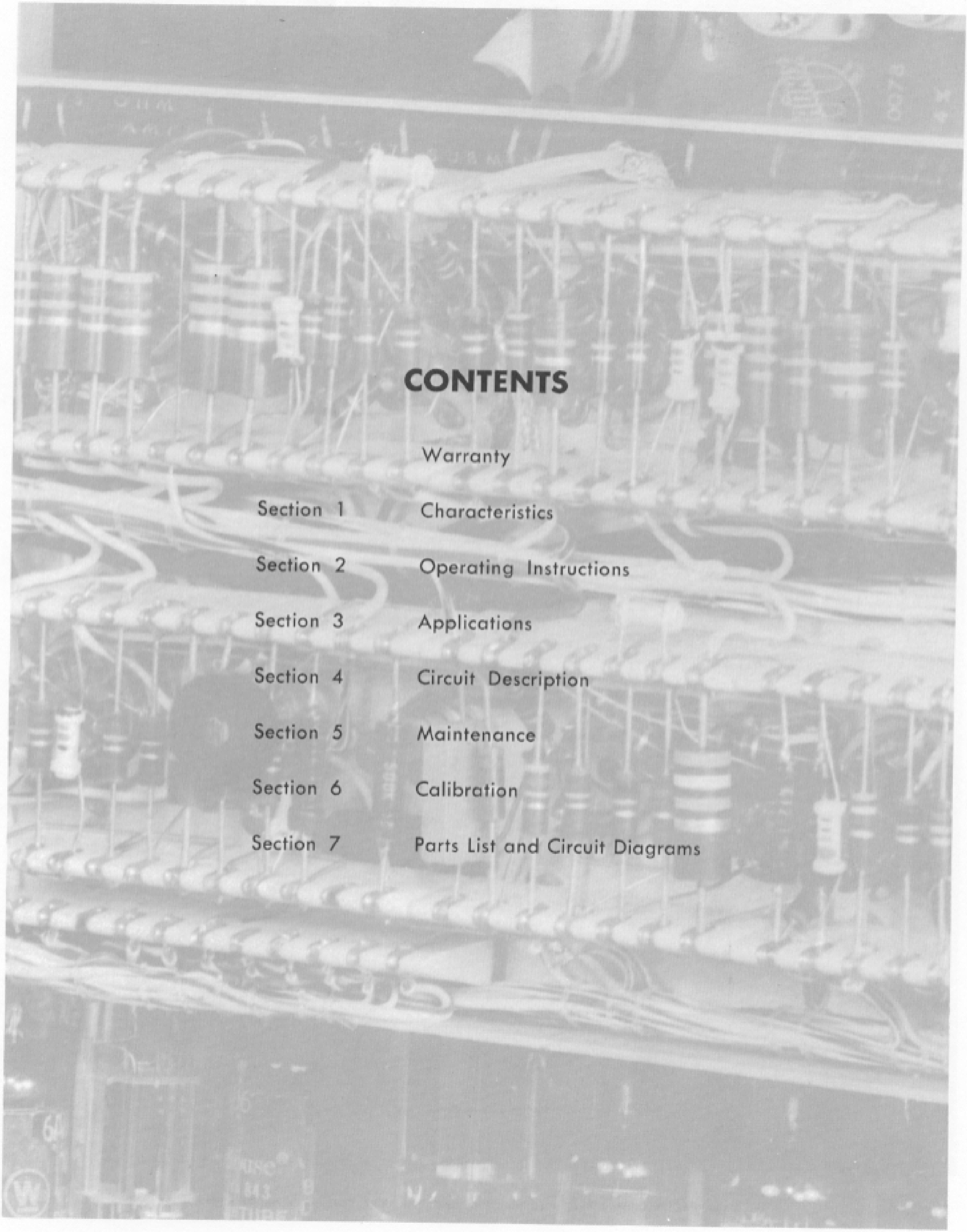
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

Specifications and price change privileges reserved.



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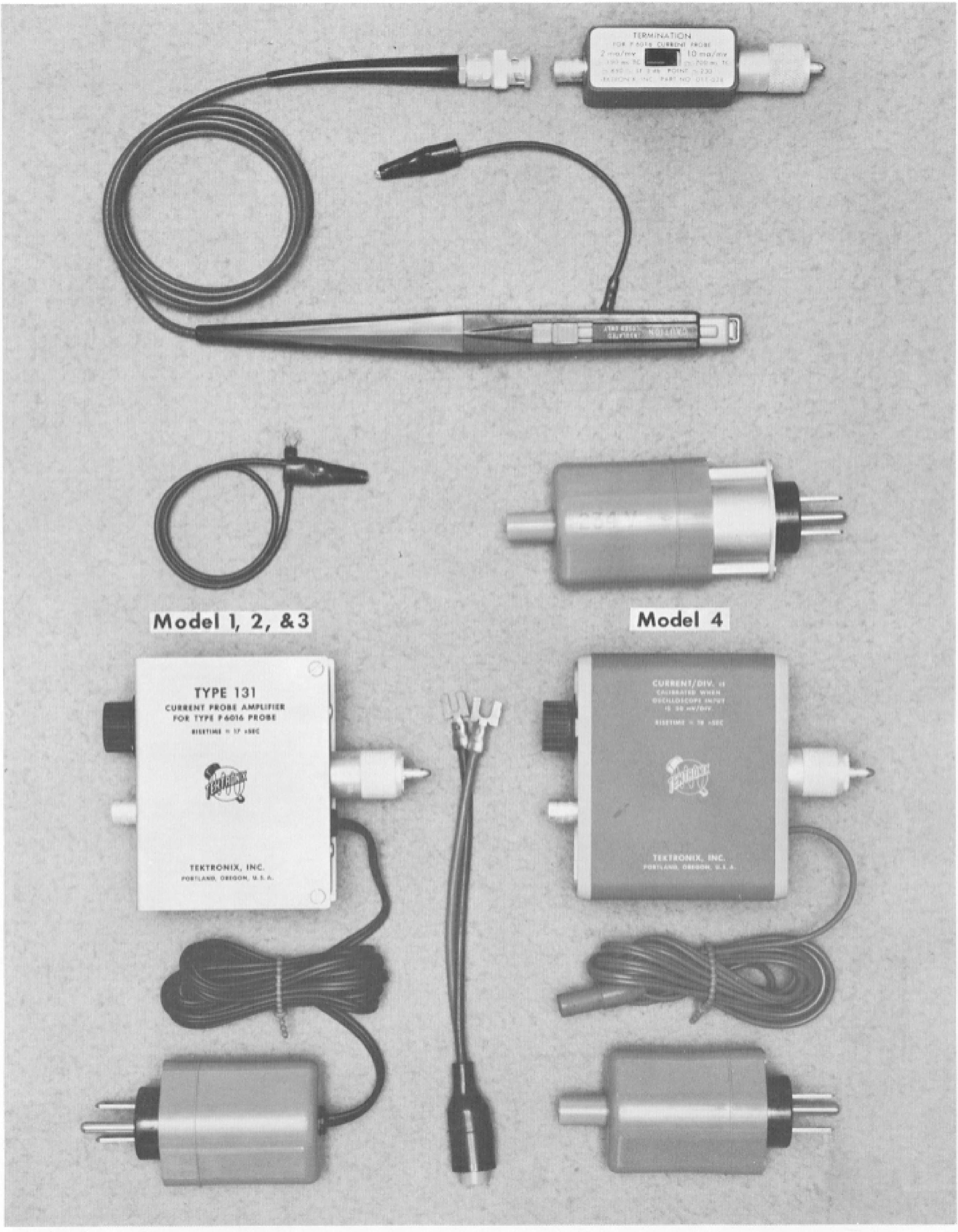
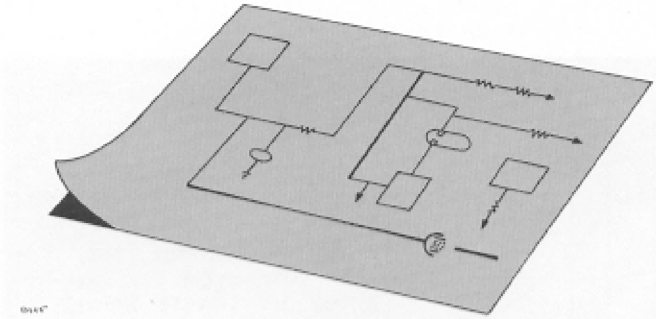


Type P6016 Current Probe, Termination, and Type 131 Current Probe Amplifier.



SECTION 1

CHARACTERISTICS

Introduction

The Type P6016 Current Probe is designed to extend the usefulness of Tektronix oscilloscopes. The probe, used with either a passive Termination or a Type 131 Current Probe Amplifier, permits a current waveform to be viewed and measured on the oscilloscope. No direct electrical connection to the circuit under test is required because the probe clamps around the current-carrying wire. Impedance change and loading of the circuit under test can be considered to be negligible.

Type P6016 Current Probe with Passive Termination

Sensitivity:

2 ma/mv or 10 ma/mv; accuracy within 3%.

(With Type L Plug-In Unit, maximum sensitivity is 10 ma/cm).

Risetime (with Type K or L Plug-In Unit in Type 540-Series Oscilloscope):

18 nanoseconds (approx. 20 mc at 3 db down).

Low-Frequency Response:

At 2 ma/mv—approx. 850 cps at 3 db down (5% tilt of 10-μsec square pulse).

At 10 ma/mv—approx. 230 cps at 3 db down (5% tilt of 35-μsec square pulse).

Maximum Current Rating:

15 amps, peak-to-peak.

Maximum Direct Current Saturation Threshold:

0.5 amp.

Maximum Breakdown Voltage:

600 volts with probe slide closed.

Insertion Impedance:

Refer to Table 1-1 where insertion impedance is listed as a function of time following the start of a fast-rise step current function. Also see Fig. 4-1 in the Circuit Description section.

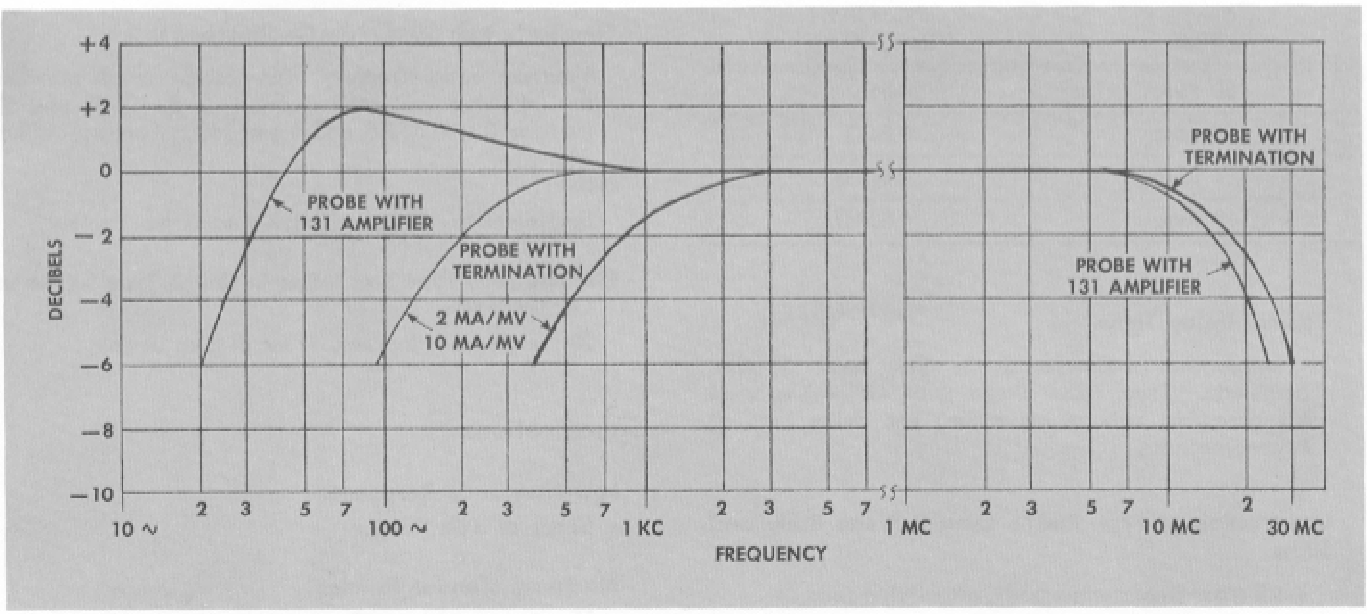


Fig. 1-1. Typical frequency response characteristics of the Type P6016 Current Probe with both the Type 131 Amplifier and the passive Termination, when used with a Type 545A Oscilloscope and a Type K Plug-In Unit. The low-frequency end of the "Probe With 131 Amplifier" curve will vary considerably with adjustment of the LOW FREQ. ADJ. control.

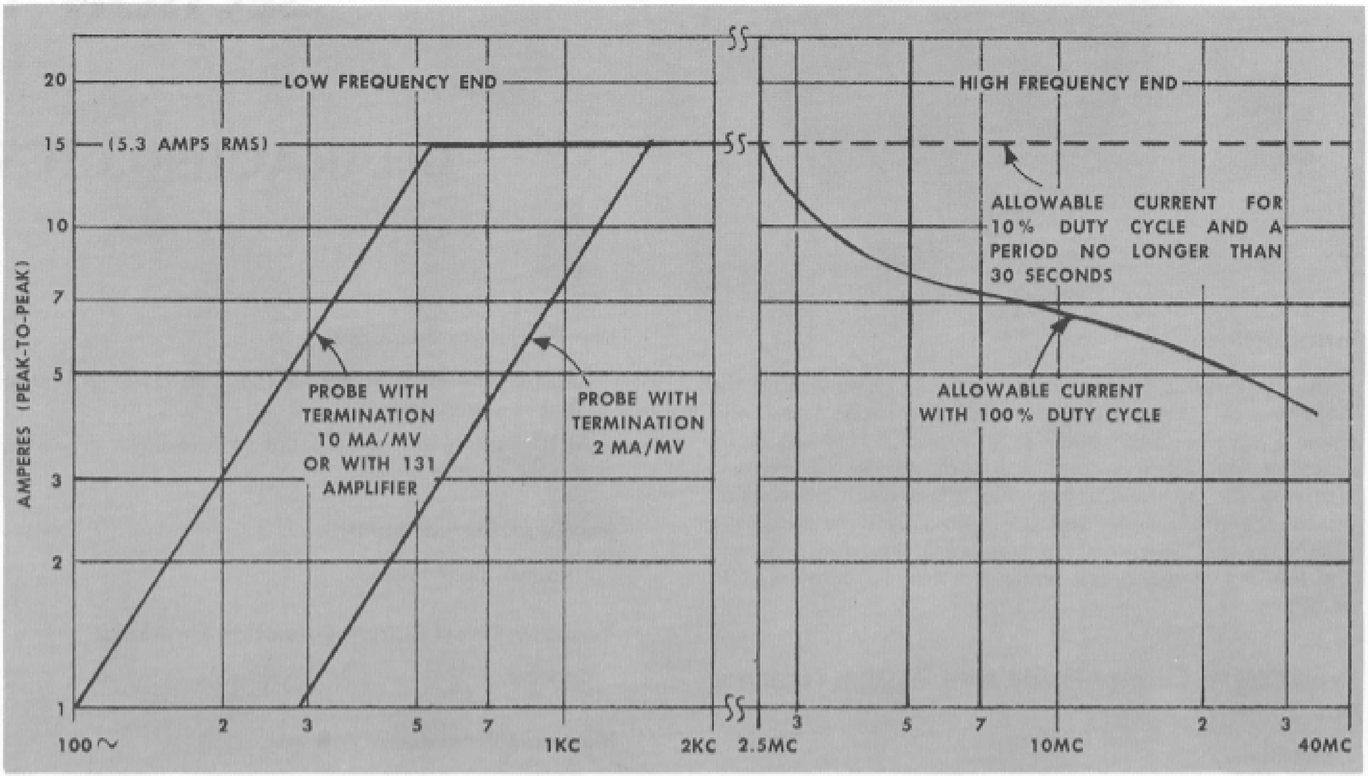


Fig. 1-2. Typical current versus frequency curve. At the low-frequency end detectable sine-wave distortion occurs as a result of core saturation. Although the probe distorts low-frequency current waveforms when the core starts to saturate, any high-frequency waveforms or short-duration microsecond pulses present at the same time are unaffected. At the high-frequency end, current rating may be exceeded under conditions indicated on the graph.

TABLE 1-1

TIME	INSERTION IMPEDANCE
50 nsec	0.06 Ω
100 nsec	0.04 Ω
1 μsec	0.015 Ω
10 μsec	0.006 Ω

Typical Delay Time:

12 nanoseconds measured at the 50% level of pulse amplitude. (Type P6000 Probe with 42" cable, used for observing voltage waveform, has delay time of 8 nanoseconds.)

Construction of Type P6016 Current Probe Body and Slide:

Black glass-filled styrene body, gray Delrin slide.

Construction of Passive Termination:

Zamac #5 die casting.

Type P6016 Current Probe with Type 131 Current Probe Amplifier

Sensitivity with 50 mv/div Oscilloscope Input:

1 ma/div basic sensitivity. Ten-position switch provides the following calibrated steps: 1, 2, 5, 10, 20 and 50 ma/div; 0.1, 0.2, 0.5 and 1 amp/div. Accuracy within 3%.

Noise:

Equivalent to 100-μamp, peak-to-peak input signal.

Risetime (with Type K or L Plug-In Unit in Type 540-Series Oscilloscope):

20 nanoseconds (approx. 17 mc at 3 db down).

Specifications

Low-Frequency Response:

50 cps at 3 db down.

Maximum Current Rating:

15 amps, peak-to-peak.

Maximum Direct Current Saturation Threshold:

0.5 amp.

Maximum Breakdown Voltage:

600 volts with probe slide closed.

Insertion Impedance:

Refer to Table 1-1. Also refer to Fig. 4-1 in the Circuit Description section.

Typical Delay Time:

32 nanoseconds measured at the 50% level of pulse amplitude. (Type P6000 Probe with 42" cable, used for observing voltage waveform, has delay time of 8 nanoseconds.)

Power Requirements: (Model 1, 2 and 3)

Line voltage and frequency—105 to 125 volts rms, or 210 to 250 volts rms using two 18 k, 1 watt, 10% resistors connected in series with line;* 50-60 cycles

Power—approx. 0.5 watt at 117 vac; approx. 1 watt at 234 vac.

*To obtain a ready-made 234 volt adapter, consult your local Tektronix Field Engineer or overseas Representative.

Power Requirements (Model 4-up)

Line voltage and frequency—105 to 125 volts rms, or 210 to 250 volts rms depending upon which transformer housing is used with the Type 131. The line frequency in either case must be 50-60 cycles.

AC Power—approx. 0.5 watt at 117 vac; approx. 1 watt at 234 vac. Battery voltage—the Type 131 requires a battery that will furnish 22½ volts at 10 ma of current.

Battery power—approx. 0.2 watt at 22½ volts.

Type 131 Mechanical Specifications: (Models 1, 2 and 3)

Construction—Aluminum-alloy cover and etched circuit board chassis. Extruded aluminum frame.

Finish—Photo-etched anodized cover.

Dimensions—3½" high, 1½" wide, 4½" deep (includes connectors).

Type 131 Mechanical Specifications: (Model 4-up)

Construction—Aluminum-alloy wrap-around cover and etched circuit board chassis.

Die cast end plates.

Finish—Blue Vinyl finished cover.

Dimensions—3 11/16" high, 1 15/16" wide, 4 13/16" deep (includes connectors).

Weights:

Type P6016 Current Probe—4 oz.

Passive Termination—5 oz.

Type 131 Model 1, 2, 3 Current Probe and Amplifier—approx. 15 oz.

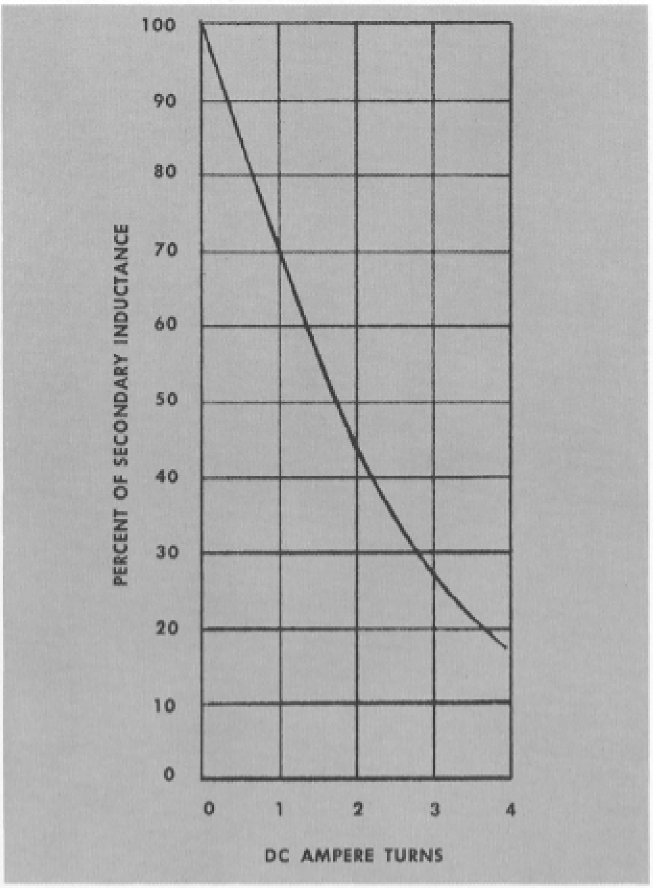


Fig. 1-3. Typical curve showing percent of secondary inductance versus primary dc-ampere turns. The curve shows that the secondary inductance of the current probe transfer decreases as the dc-ampere turns are increased, which impairs the low-frequency response. However, high-frequency response is not impaired.

Type 131 Model 4 Current Probe and Amplifier—approx. 16 oz.

AC Power Supplies add approximately 5 oz. to the total weight.

Accessories

1—Instruction manual

Ordering Information

The Type 131 and associated equipment is available in various combinations. See below for the proper stock number of the combination wanted.

P6016 Probe	010-037
Passive Termination	011-028
P6016 Probe and Passive Termination	011-044
Type 131 with 117 vac Transformer Housing	015-011
Type 131 with 234 vac Transformer Housing	015-024
P6016 Probe and Amplifier (Type 131)	015-030
Type 131 with Battery Adapter	015-026

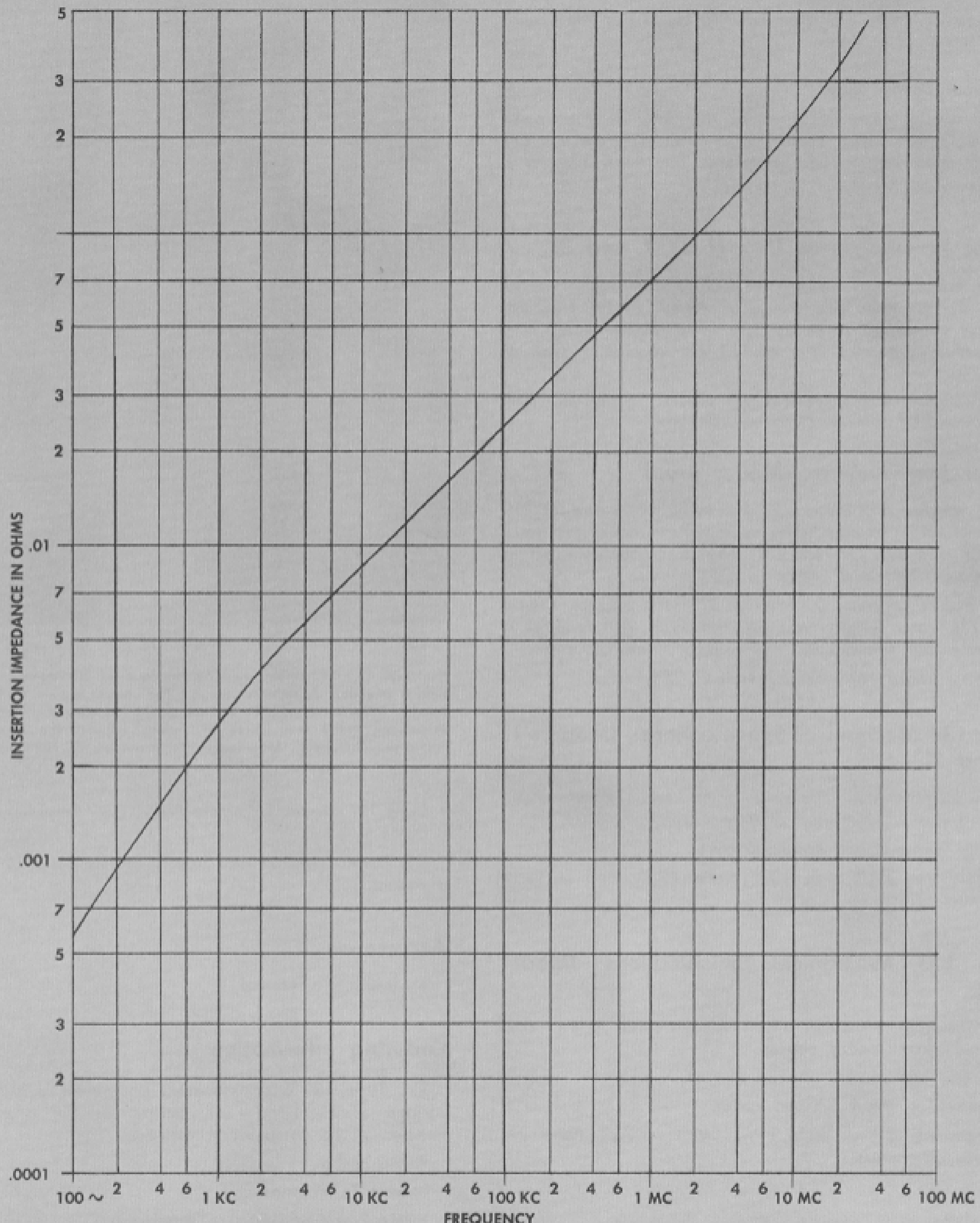
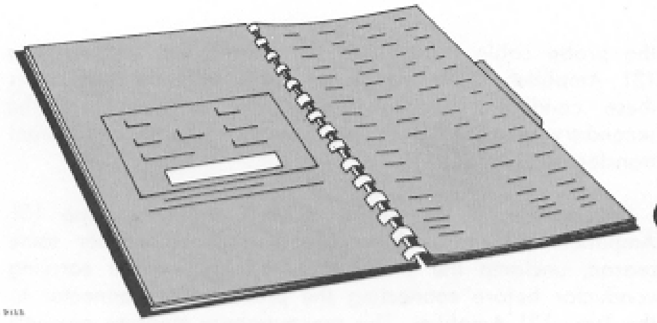


Fig. 1-4. Typical impedance inserted in a circuit by the Type P6016 Current Probe when properly terminated.



SECTION 2

OPERATING INSTRUCTIONS

Operation With Passive Termination

To use the Type P6016 Current Probe with a passive Termination unit and oscilloscope, connect the Termination between the probe cable and the input to the oscilloscope (see Fig. 2-1). Set the slide switch on the Termination to the desired sensitivity. Rotate the variable vertical sensitivity control on the oscilloscope to the detent position for calibrated sensitivity. Set the oscilloscope vertical sensitivity switch to suit the amplitude of the waveform to be observed and measured.

Clamp the current probe around the conductor under test. Make certain the thumb-controlled slide is moved fully forward. Set the remainder of the oscilloscope front-panel controls for a stable display. To measure the peak-to-peak current of the displayed waveform, the example to follow is given as a guide.

If the current probe sensitivity is set for 2 ma/mv and the oscilloscope is set for 50 mv/div (or 50 mv/cm) sensitivity, the overall sensitivity is:

$$2\ \text{ma/mv} \times 50\ \text{mv/div} = 100\ \text{ma/div}.$$

If the current waveform is 3 divisions (centimeters) peak-to-peak in amplitude, the current is:

$$3\ \text{div} \times 100\ \text{ma/div} = 300\ \text{ma, peak-to-peak.}$$

Frequency, phase, and time measurements of current waveforms are determined in the same manner as for voltage waveforms.

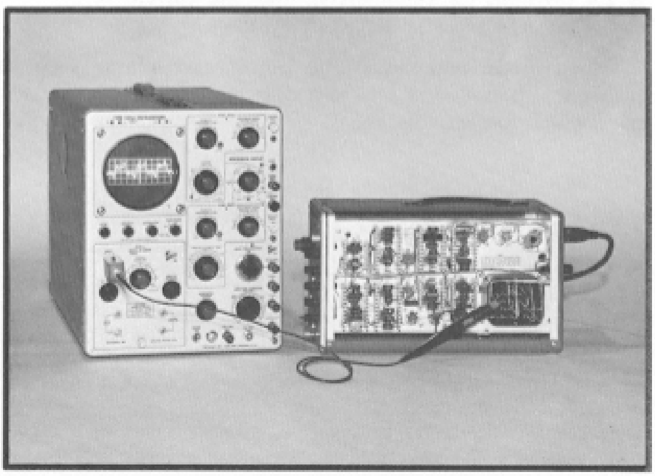


Fig. 2-1. The Type P6016 Current probe in operation when used with the Termination and an oscilloscope.

Direction of Current Flow

Direction of conventional current flow (plus to minus) in the conductor, as opposed to electron flow, is indicated by the arrows located on the top and bottom of the probe. Current flowing in the direction of the arrows produces an upward or positive deflection of the waveform on the crt.

Precautionary Notes

(a) Ground Clip Lead

A ground clip lead is furnished with the probe to ground the shielding at the probe end when desired. Normally, for most applications, the ground lead is unclipped from the probe and not used. Because of the three-wire power cord used on the Type 131 Amplifier, use of the ground clip lead may cause circulation of undesirable chassis currents.

(b) Clamping the Probe around a Bare Wire

Care must be used in clamping the probe around a bare wire lead when the device under test is operating. While the probe is being attached around the wire, the edges of the grounded, metallic shield in the stationary part of the probe, and the shield in the sliding portion, are exposed. Therefore, the probe must be attached without permitting the exposed edges of the shields to come into contact with the bare wire until the slide can be closed over the wire.

To prevent an accidental short circuit to ground through the shield, a piece of spaghetti insulation can be slit down one side and slipped over the bare wire. Then the probe can be safely clamped over the insulation. Or, if preferred, the device under test can be turned off before attaching the probe. Conductors up to 0.150 inch, or the size of a ½-watt composition resistor, can be accepted by the probe.

(c) Performance Limitations

When making current measurements and analyzing the waveform, take into consideration the combined bandwidth of the oscilloscope and the Type P6016 Current Probe (with either the Termination or Type 131). For optimum wideband performance with minimum distortion, the probe should be used with Type 540- and 550-Series Oscilloscopes with a Type K or Type L Plug-In Unit.

To preserve the low-frequency response of the probe, use care in clamping the probe around a conductor to prevent scratching the current transformer ferrite core.

(d) Minimizing Loading Effect

To minimize any loading effect of critical circuits, wherever possible clamp the probe at the low or ground end of a component lead.

(e) High Currents

When measuring high currents, do not leave the current probe clamped around the conductor while disconnecting the probe cable from either the Termination or the Type 131 Amplifier. With the probe cable unterminated under these conditions, a high voltage is developed in the secondary winding which may damage the probe current transformer.

In addition, if the probe is used with the Type 131 Amplifier and the probe cable is disconnected for some reason, unclamp the probe from the high-current carrying conductor before connecting the probe cable connector to the Type 131 Amplifier. This precautionary measure prevents high surge currents from damaging transistors in the amplifier.

Current Probe Amplifier Operation with a Type 131

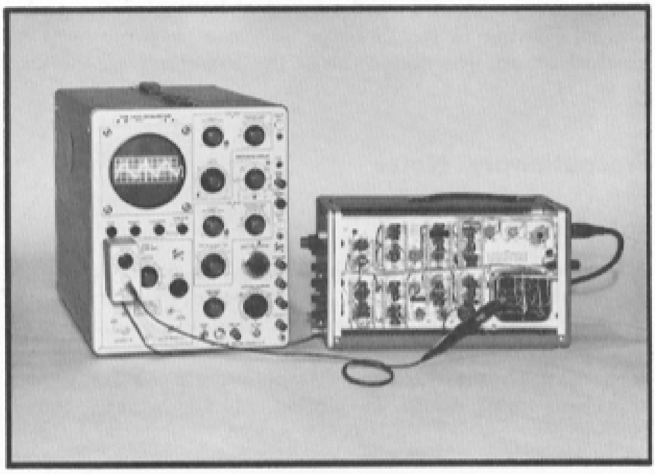


Fig. 2-2. The Type P6016 Current Probe and the Type 131 Current Probe Amplifier connected to the oscilloscope.

To use the P6016 Current Probe with the Type 131 Current Probe Amplifier, connect the Type 131 Amplifier between the probe cable and the input to the oscilloscope (see Fig. 2-2). Set the CURRENT/DIV. switch to the sensitivity you desire. Set the vertical sensitivity of the oscilloscope to 50 mv/div (or 50 mv/cm). Rotate the variable vertical sensitivity control to the detent position. Connect the Type 131 to the proper line voltage or battery.

Power is applied directly to the Type 131. Since power consumption is low and the unit has a long useful life, no power switch is provided.

NOTE

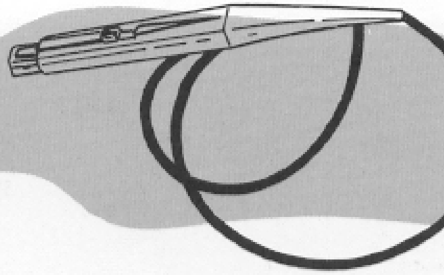
The probe shipped with the Type 131 is not necessarily the probe used in the factory calibration. Before using the Type 131 and probe, refer to the first four steps of the Calibration section. The first time the Type 131 is used on an oscilloscope, the Gain and Low-Frequency Compensation adjustments must be checked. Refer to steps 3 and 4 of the Calibration section for these adjustments.

When a current waveform is displayed on the oscilloscope, peak-to-peak measurements are made according to the following example.

If the CURRENT/DIV. switch is at the 5 mAMP. position and the peak-to-peak amplitude of the current waveform is 2.4 divisions (or centimeters), then the current is:

2.4 div × 5 mAMP./DIV. = 12 ma.

Other measurements of the current waveform such as frequency, phase, and time are determined in the same way as for voltage waveforms.



SECTION 3

APPLICATIONS

General

Information in this section of the manual has been selected to help you use the Type P6016 Current Probe. The probe, used in conjunction with the Termination or the Type 131 Current Probe Amplifier, will increase the usefulness of your oscilloscope. To lay the groundwork for many of the applications that may be encountered, some basic applications are illustrated and explained here.

Undesirable Magnetic Fields

The current probe is shielded to minimize the effect of external magnetic fields. However, strong fields may interfere with a current signal to be measured. If you suspect that an external field is interfering with your measurement, remove the probe from the conductor, slide the core closed, and hold the probe near the conductor in the vicinity of the original measurement. If you obtain appreciable deflection, attempt to measure the conductor current at another point, away from the magnetic field source.

If current measurements must be made in the presence of a strong, external field, the external field interference may be minimized by the use of two current probes and a differential-input oscilloscope. The second probe must be used in conjunction with a similar Termination or Type 131 Amplifier as the one being used for the current measurement.

With both probes connected to a differential-input oscilloscope, clamp one probe around the conductor in which the current is to be measured, and place the other probe near the first but do not clamp it around the conductor. By setting the oscilloscope controls for common-mode rejection, the undesirable current signal induced in the first probe can be minimized by the second. Complete cancellation of the undesirable signal may be difficult to obtain due to probe characteristics and time differences between the two probes and the Terminations or Amplifiers.

Tracing Magnetic Fields

The Type P6016 Current Probe can be used to trace magnetic fields, such as those produced by chassis currents, to their source. This is most easily accomplished by leaving the probe clamp open. The increased sensitivity of the unshielded transformer permits the maximum field current to be induced in the probe.

Increasing the Sensitivity

The sensitivity of the current probe can be increased by increasing the number of turns passing through the core of the probe. For example, if the conductor is looped twice through the probe, a two-turn primary winding is formed and the sensitivity of the probe is doubled. (The sensitivity of the probe is directly proportional to the number of turns.) If, for example, the probe sensitivity is set for 1 ma/div for normal single-turn measurements, the sensitivity using a two-turn loop would actually be 0.5 ma/div.

Remember, however, that the impedance reflected into the primary (circuit being measured) from the secondary (probe winding) varies as the square of the primary turns. When observing high-frequency current waveforms or fast-rise current pulses, additional turns add inductance to the primary circuit.

Balancing Currents

The Type P6016 Current Probe can be used to balance currents in a push-pull circuit. This can be accomplished by clamping the probe around both cathode or emitter leads in the push-pull stage. Algebraic addition of the two currents can then be displayed on the oscilloscope. Adjustments can be made in the device under test until the two currents produce a null display.

Simultaneous Current and Voltage Measurements

Simultaneous current and voltage measurements can be obtained using a Type P6016 Current Probe, a standard Attenuator Probe, and a dual-trace oscilloscope.

1. Connect the current probe through either the Termination or the Type 131 Amplifier to one of the vertical-input connectors on the oscilloscope, and connect the attenuator probe to the other vertical-input connector.

2. Connect the current probe around the conductor at the point where the current is to be measured.

3. Connect the attenuator probe tip and ground lead between the two points at which the voltage is to be measured (the conductor and the chassis, the two ends of a resistor, etc.).

4. Adjust the oscilloscope controls, and the CURRENT/DIV. switch on the Type 131 or the Termination switch, for suitable displays. Obtain the current and voltage readings from the respective displays on the crt.

Voltage Amplifier

A secondary application for the Type 131 is voltage amplification. Although not primarily intended for this purpose, the unit can be converted to operate as a miniature, low-level, wide-band, voltage preamplifier. Or, another unit can be purchased and converted specifically for this use to avoid changing one unit back and forth.

To make the conversion, a few simple changes need to be made at easily accessible locations within the unit. These changes, plus a choice of suggested conversion methods, are described here. Some typical performance figures are given first, since this information applies regardless of the method used. This and other information (except for noise level) was based on the unit operating with a Type 540- or a 550-Series Oscilloscope and a Type K or L Plug-In Unit.

Passband—Approx. 5 cps to 17 mc, within 3 db.

Risetime—Approx. 18 nanoseconds.

Max. DC Input Level—±1 volt at junction of input series resistor (R401) and input to attenuator switch (SW410, wafer 1R).

Max. Output Signal Amplitude—0.5 volt, peak-to-peak.

Max. Noise Level—100 μvolts, peak-to-peak, with input grounded.

To describe the main differences between methods (see Fig. 3-1), the first method uses a 10%-tolerance resistor in the input circuit because it is available locally. When this change is made, the input impedance is 50 ohms and voltage gain of the amplifier is 100. The second method uses closer tolerance input resistors to make the gain and attenuator tolerance of the unit more accurate. The third method changes the input impedance to 125 ohms and the gain to 50. The step-by-step method of conversion is as follows:

Method 1

1. Carefully unsolder and remove inductor L401. Care should be used because the inductor lead ends are wrapped around the leads of R401.

2. Solder a 220Ω, 10%, ½w resistor (with leads cut short) between the center conductor of the input connector and a convenient ground (chassis).

3. Disconnect resistor R482 (15k) where it connects to one terminal of control R481 (LOW FREQ. ADJ.) and solder a short-lead 470k, 10%, ½w resistor in series at this location.

Method 2

1. Carefully unsolder and remove inductor L401 and resistor R401 without separating the two parts. Solder a 52.5 Ω, 1% ½ w resistor in the place of the removed parts.

2. Add a short-lead 240Ω, 5%, ½w resistor between the input center connector and ground.

3. Same as step 3, Method 1.

Method 3

1. Carefully unsolder and remove inductor L401 and resistor R401 without separating the two parts. Solder a 115 Ω, 1%, ½w resistor in the place of the removed parts.

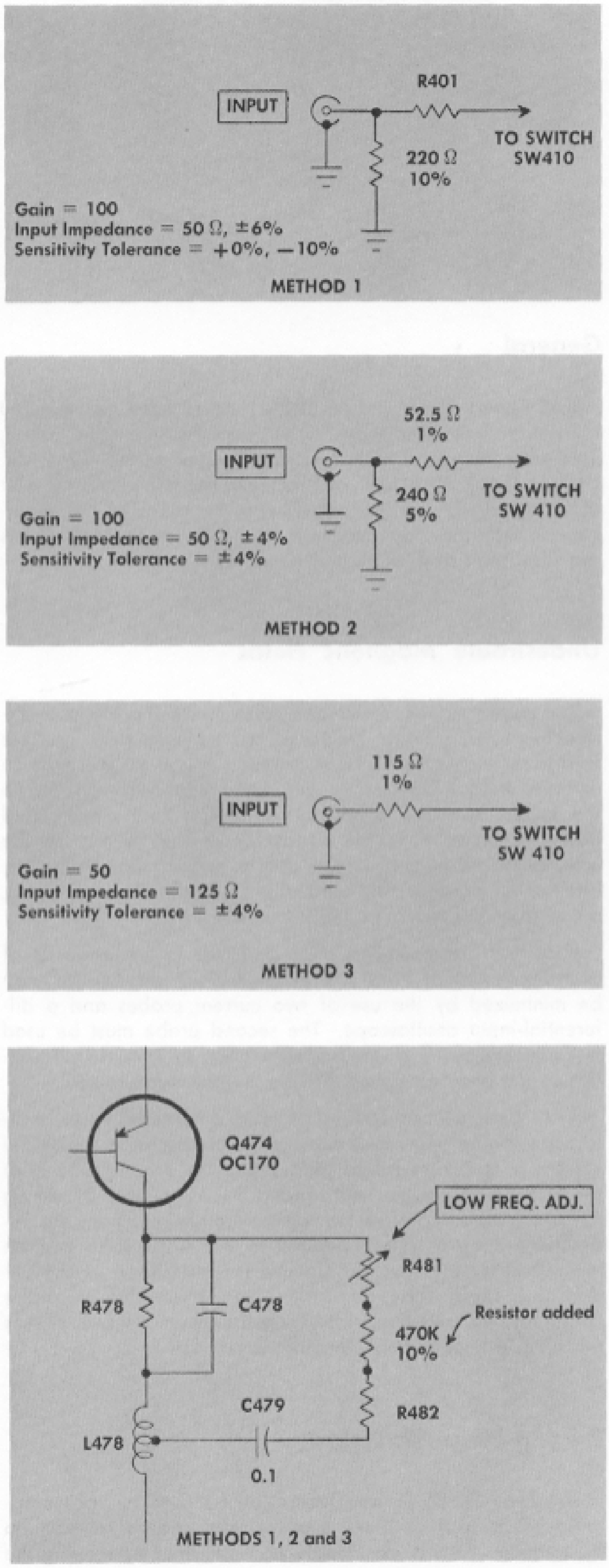


Fig. 3-1. Partial schematic diagrams of the Type 131 Amplifier showing changes to the circuitry using methods 1, 2 and 3.

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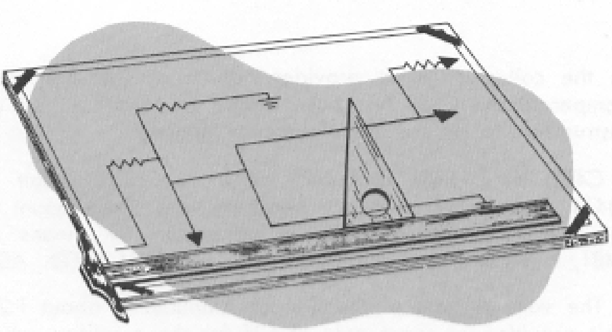
2. Same as step 3, Method 1.

After completing the conversion, the high-frequency compensation should be readjusted for optimum operation if it is going to be used specifically for this purpose from now on. Refer to the Calibration procedure for information about the square-wave generator to use. The unit should then be labeled accordingly, so that it is not inadvertently used as a current amplifier with the current probe.

NOTES



SECTION 4

CIRCUIT DESCRIPTION

Introduction

The circuits to be described in this section are divided into three parts: The Type P6016 Current Probe, the Termination, and the Type 131 Current Probe Amplifier. Schematic diagrams for these circuits are included in Section 7.

Type P6016 Current Probe

The Type P6016 Current Probe consists of a wide-range current transformer mounted in the nose of the case. The transformer contains a two-section, U-shape, ferrite core. One section is stationary; the other is mechanically movable to permit closing the core around the conductor being measured for current. The conductor forms a one-turn primary winding for the transformer; the windings around one end of the stationary core form the secondary winding.

Negligible loading of the circuit under test occurs when the probe is clamped around the conductor. Loading, which is the series impedance reflected into the primary circuit, is approximately equivalent to the circuit diagram shown in Fig. 4-1. The typical values given in the transformer shield section of the equivalent circuit apply the instant a step current waveform is present in the conductor.

The current waveform induced in the secondary winding of the current transformer is coupled through the 62.5-ohm probe cable to either the passive Termination or the Type 131 Amplifier.

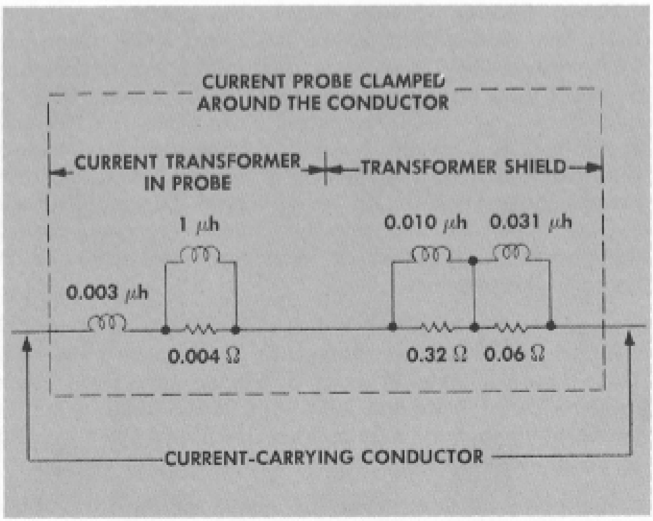


Fig. 4-1. Equivalent circuit of impedance reflected into a conductor when probe is attached.

Passive Termination

Two simplified passive Termination circuits are shown in Fig. 4-2. These schematics show the circuit configuration for both settings of the sensitivity switch. (For simplification, the circuits are shown are shown without the switch.)

At a sensitivity of 2 ma/mv, the signal from the probe is coupled virtually "straight through" to the input of the oscilloscope. When the sensitivity is 10 ma/mv, the signal is attenuated five times before being applied to the oscilloscope input.

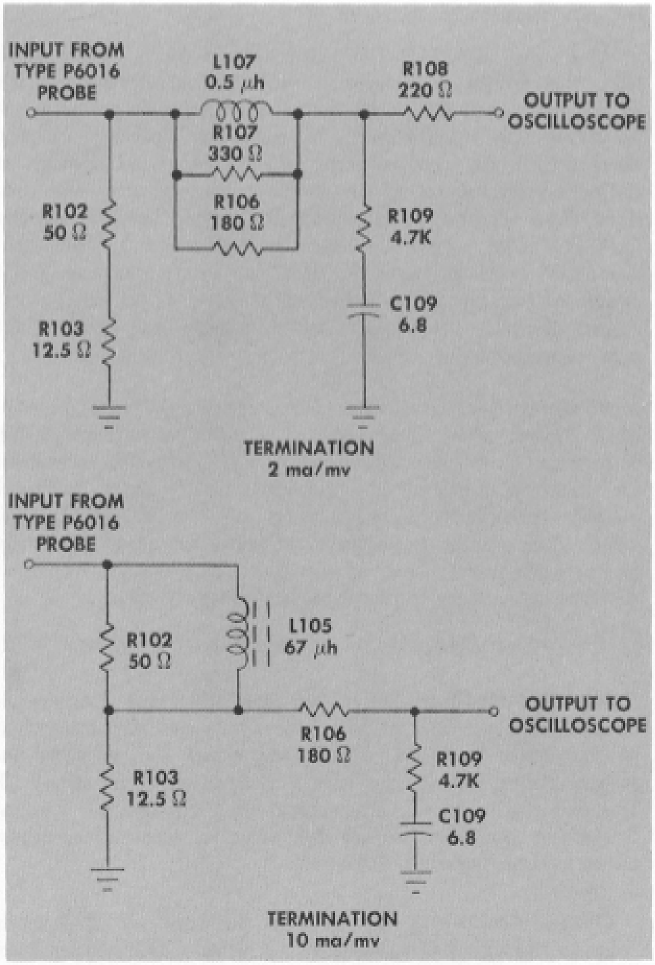


Fig. 4-2. Simplified circuits of the passive Termination unit when switch is omitted.

Resistors R102 and R103, at the INPUT connector, terminate the probe cable. Other components in the circuit provide the necessary compensation to optimize the transient response of the probe-termination combination.

Type 131 Current Probe Amplifier

The Type 131 Current Probe Amplifier consists of five circuits: the Attenuator, Input Amplifier, Second Amplifier, Output Amplifier, and Power Supply. These circuits are discussed separately in the following paragraphs.

Attenuator. When the Type P6016 Probe is connected to the Type 131 Amplifier, the current signal is coupled through a parallel LR network (L401-R401) to the CURRENT/DIV. switch (SW410). For higher frequencies, where it is important to terminate the probe cable, the impedance of the LR network is essentially the 56 ohms of resistance. This impedance, added to the 10-ohm input impedance of the amplifier, provides the proper cable termination for high-frequency signals.

For low-frequency signals, where the cable impedance is essentially zero, the impedance of the LR network is also essentially zero. This permits the probe to work into the 10-ohm input impedance of the amplifier, which extends the low-frequency response.

When the CURRENT/DIV. switch is in the 1 mAMP position, the signal is coupled, unattenuated, through C454 to the emitter of Q454. With the oscilloscope sensitivity set for 50 mv/div (calibrated), a conductor (probe primary) current of 1 ma, peak-to-peak, will produce one division of deflection on the crt. (1 ma in the probe primary will produce 8 μa in the probe secondary). For settings of the CURRENT/DIV. switch between 2 mAMP. and 1 AMP., precision attenuation networks are switched into the input circuit of the amplifier. These networks provide the correct current-dividing attenuation while maintaining a constant input impedance.

Input Amplifier. Transistor, Q454, connected in a common-base configuration, provides a low input impedance. R452, a screwdriver-adjust potentiometer (Z_{in}), provides a means for adjusting the emitter impedance to 10 ohms. In the 1 mAMP. (straight-through) position of the CURRENT/DIV. switch, the emitter impedance of Q454 becomes a portion of each attenuator. The resistance values are such, however, that the attenuator impedance is always 10 ohms.

The voltage gain of the Input Amplifier is about 50.

Second Amplifier. The signal from the Input Amplifier is coupled through half of L457, then through L456 and C457 to the base of Q464. Q464, connected in the common-emitter configuration, provides a voltage gain of about 10. The exact gain of this stage, and thus the overall gain of the entire amplifier, is set by R464, a screwdriver-adjust potentiometer labeled GAIN ADJ.

Output Amplifier. The signal at the collector of Q464 is coupled through C468 (Models 1, 2, 3) or C470 (Model 4-up) to the base of Q474, the Output Amplifier. C475 and the HF COMP. adjustment R475, located in the emitter circuit of Q474, compensate the stage for high frequencies. L478 in the collector circuit provides additional high-frequency compensation. C468 has been added to Model 4 and up instruments to reduce high frequency ringing.

C478, R478, R481 and R482, in the collector circuit of Q474, form a low-frequency boost network. The amount of low-frequency compensation is adjustable by means of R481, a screwdriver adjustment labeled LOW FREQ. ADJ.

The voltage gain of the Output Amplifier is about 1.25. This provides an exact gain of 625 for the amplifier, when the GAIN ADJ., R464, is correctly set. Thus, 8 μa at the emitter of Q454 will produce 50 mv at the OUTPUT TO OSCILLOSCOPE connector.

Power Supply (Model 1, 2, 3). The power transformer T601, two diodes D601 and D602, and capacitor C601 are enclosed in a plastic case as an integral part of the power plug. This arrangement permits the ac field to be isolated from the amplifier and reduces the size of the amplifier chassis. The remainder of the power supply is located on the etched-circuit board in the amplifier.

Power to the amplifier is furnished from a nominal 117-volt ac power source through a step-down transformer T601. The secondary winding is center-tapped so that full-wave rectification is obtained by employing two diodes. About 14 volts rms is obtained from each half of the secondary winding. Approximately 22 volts dc is obtained at the output of the two diodes.

The unfiltered dc at the output of the rectifier is coupled through a two-conductor cable to the amplifier unit. Most of the 120 cycle ripple is filtered by capacitor C610. Any fast-time constant fluctuations, coming in from the power line source, are by-passed through capacitor C601 (located in the power plug case) and C611 (in the amplifier unit).

Zener diode D612 sets the dc level at the base of the series regulator, Q617. This stage maintains a steady dc supply voltage of approximately —15 volts. The collector to emitter impedance ratio of Q617 greatly decreases the ripple. Additional filtering by C612 and C617 reduces the ripple to less than 5 mv.

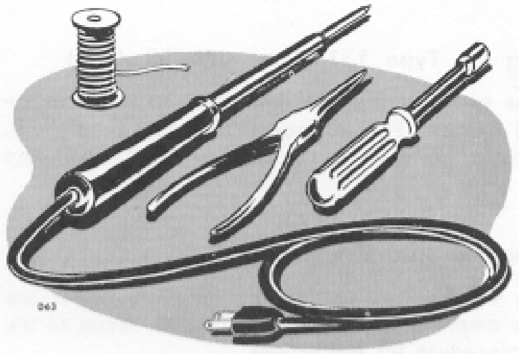
Power Supply (Model 4-up). The power transformer T601, four diodes D601, D602, D603 and D604, Capacitor C601, resistor R606 and Zener diode D606 are enclosed in a plastic case as an integral part of the power plug. In addition to the above mentioned components the 234 volt transformer housing also has two voltage dropping resistors R600 and R601. The arrangement of parts in a separate case permits the ac field to be isolated from the amplifier and reduces the size of the amplifier chassis. The remainder of the power supply circuit is located on the etched-circuit board in the amplifier.

Power to the amplifier is furnished from a nominal 117 volt ac power source through a step-down transformer T601. Approximately 21 volts is applied across the series combination of R606 and D606. The Zener diode will then establish the output voltage from the transformer housing at about —20 volts and partly filter the output voltage.

The partly filtered dc at the output of the transformer housing is coupled through a two-conductor cord to the amplifier unit. D611 in the amplifier unit will again filter the partly filtered 120 cycle ripple. Any fast-time constant fluctuations, coming in from the power line source, are by-passed through capacitor C601 (located in the power plug case) and C611 (in the amplifier unit).

Zener diode D612 sets the dc level at the base of the series regulator, Q617. This stage maintains a steady dc supply voltage of approximately —15 volts. The collector to emitter impedance ratio of Q617 greatly decreases the ripple. Additional filtering by C612 and C617 reduces the ripple to less than 5 mv.

NOTES



SECTION 5
MAINTENANCE

REMOVAL AND REPLACEMENT OF PARTS

General Information

Procedures required for removal and replacement of small component parts are similar to those found in any etched-circuit board work. Detailed instructions for their removal are therefore not required. Other parts, however, can best be removed if a definite procedure is followed. Instructions for the removal of some of these parts are contained in the following paragraphs.

When certain parts are replaced in the Type 131 Current Probe Amplifier, it will be necessary to check the amplifier gain and performance to find out if some recalibration is necessary. Refer to the Calibration section of this manual for test equipment required to make the necessary checks and to calibrate the unit.

Soldering Precautions

In the production of the current-probe Termination and the Type 131 Amplifier, a special silver-bearing solder is used to establish a bond to the etched circuit boards. If it is necessary to service these units, it is advisable to use solder containing about 3% silver. This type of solder is used frequently in printed circuit work and is generally available. It may also be purchased from Tektronix in one-pound rolls (part number 251-514).

A 60-watt soldering iron should be used when servicing these units. Excessive heat, and repeated use of ordinary tin-lead solder, will deteriorate the bond between the etched wiring and the base material. Ordinary solder may be used in an emergency, but excessive heat must be avoided at all times.

To preserve the wide-band characteristics of the Termination and the Type 131 Amplifier, mount new replacement parts in the same physical location as the old parts. Use short leads, and solder each part carefully into place. Use care in handling component leads to keep them from being weakened or broken.

In general, the proper technique for soldering short-lead components requires the use of a hot (60-watt) soldering iron for a short time at the connection to be soldered. The tinned tip of the iron should come in contact with both the component lead and the etched surface for fast transfer of heat as the solder is being applied. Use long-nosed pliers to grip the lead near the component to maneuver it, and to serve as a heat sink.

Cleaning the Type P6016 Current Probe

The Type P6016 Current Probe should be taken apart and cleaned periodically, depending upon local conditions. Take the probe apart as follows:

1. Hold probe in a horizontal position upside down (with the slide at the bottom). Remove the ground lead.

2. Remove four screws which hold the probe halves together.

3. Separate the probe halves about 1" apart at the nose end of the probe.

4. Remove the slide intact with parts and move the strain-relief boot back over the cable.

5. Remove the half of the probe body containing the slide. The probe is shown disassembled in Fig. 5-1.

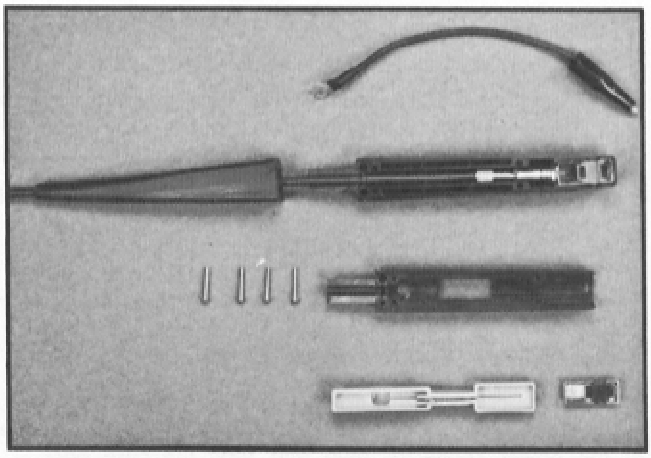


Fig. 5-1. Type P6016 Current Probe shown disassembled.

NOTE

Do not use any organic solvents to clean the probe.

Use a soft bristle brush to dislodge the dust and wipe clean with a soft cloth. If a persistant coating of dirt remains, it can be removed by washing the probe parts in warm water with some liquid detergent added. Allow the parts to air dry thoroughly, or wipe dry with a lint-free cloth. Apply a coating of Lubriplate or other similar lubricant to the contact areas of the spring.

During the time the probe is being cleaned, make a visual check of the probe parts. Look for any excessive wear of the slide parts which may cause improper operation later on. When reassembling the probe, the square holes inside the boot must match up with the raised squares on the base of the probe halves to be brought together. When replacing the four screws, be careful not to get them cross-threaded.

Repairing the Type P6016 Current Probe

To replace the current transformer or to make other repairs inside the probe body, take the probe apart as described previously. To remove the current transformer, the cable must be disconnected from the transformer at the solderless connector. The transformer can then be lifted out. When replacing the current transformer, replace the entire transformer, including the core mounted in the slide. The complete transformer is matched at the factory before it is released for shipment.

Repairing the Termination

A. Replacement of Connectors

To replace the BNC connector, remove the back cover held in place by two truss-head screws. Unsolder the leads from the connector inside the block, loosen the 0.050″ socket-head set screw, apply a soldering iron to the tip of the connector, and slide the connector out of the block.

B. Replacement of Slide Switch

1. Remove the back cover plate from the Termination.
2. Unsolder the leads to the connectors.
3. Loosen the 0.050″ socket-head set screw holding the BNC connector and slide the connector out.
4. Remove the two nuts which hold the switch.
5. Remove the switch complete with components, and transfer the components to the replacement switch.

Repairing the Type 131 Current Probe Amplifier

A. Replacement of Parts in Power Plug Case

To gain access to the parts inside the power plug case, remove the two truss-head screws located on each side of the power connector plug and slide the case back.

CAUTION

Use care and minimum heat when soldering to the power transformer terminals. Over-heating can cause the fine wire used for the transformer winding to break loose from the terminals.

B. Removing the Type 131 Cover (Models 1, 2, 3)

Remove the CURRENT/DIV. knob with a 1/16″ allen wrench. The four screws which hold the cover on the instrument should be removed at this time. After removing the cover the knob may be reinstalled.

C. Removing the Type 131 Cover (Model 4-up)

Remove the two screws which hold the rear panel to the circuit board frame. The rear panel may now be slid off. The wrap around cover is now pulled toward the rear and off.

D. Replacing Transistors

When any of the transistors in the amplifier stages are replaced, the amplifier will require calibration. Refer to the Calibration procedure for instructions.

For optimum performance, checked transistors may be ordered from Tektronix.

E. Replacement of CURRENT/DIV. Switch (Models 1, 2, 3)

1. Unsolder component leads which connect the BNC connector and etched-circuit board to the switch.
2. Remove the knob with a 1/16″ socket wrench and loosen the nut which holds the switch in the slot.
3. Lift the switch out in the direction of the slot opening. Single wafers are normally not replaced on the CURRENT/DIV. switch. If one wafer is defective, the entire switch should be replaced. The switch may be ordered from Tektronix either with the parts wired in place or unwired, as desired. It is suggested that you order the wired switch because the attenuator resistors are held to close tolerances and the switch is tested for accuracy before it is shipped.

F. Replacement of CURRENT/DIV. Switch (Model 4-up)

1. Unsolder component leads which connect the etched circuit board to the switch.
2. Remove the CURRENT/DIV. knob with a 1/16″ allen wrench and the switch nut. Remove the front panel and two flat-head screws which hold the etched circuit board frame to the front subpanel. The front subpanel may now be removed with the BNC Connector and CURRENT/DIV. Switch still attached to it.
3. Unsolder the component leads which connect the BNC connector to the switch.

Single wafers are normally not replaced on the CURRENT/DIV. Switch. If one wafer is defective, the entire switch should be replaced. The switch may be ordered from Tektronix either with the parts wired in place or unwired, as desired. It is suggested that you order the wired switch because the attenuator resistors are held to close tolerances and the switch is tested for accuracy before it is shipped.

G. Removal of Etched-Circuit Board (Models 1, 2, 3)

1. Unsolder all leads which connect the board to the switch and the UHF connector bus.
2. Pull the cable fastener out of the frame and free the cord.
3. Remove the screw and nut which hold the ground lug for the power cord.

4. Remove the two screws which hold the potentiometer bracket and etched-circuit board in place. The screws are located at the UHF connector side of the frame.
5. Remove the etched-circuit board complete with potentiometer bracket.

H. Removal of Etched-circuit Board (Model 4-up)

1. Unsolder all leads which connect the etched-circuit board to the switch.
2. Remove the CURRENT/DIV. knob and the nut holding the switch and remove the front panel. Remove the two flat-head screws holding the etched-circuit board frame to the front subpanel and remove the front subpanel, switch and BNC connector.
3. Remove the two binder-head screws that hold the rear subpanel to the etched circuit board frame and remove the rear subpanel from the unit.
4. Remove the etched-circuit board complete with potentiometer bracket (etched-circuit board frame).

I. Replacing a Potentiometer

1. After removing the etched-circuit board as outlined in parts G and H, unsolder all leads to the potentiometers.

1A. (Applies to Model 4-up only.) Remove the screw and nut which hold the ground lug for the cord. Also remove the cable fastener from the etched circuit board frame and free the cord.

2. Remove the two screws which hold the potentiometer bracket and replace the defective control.

TROUBLESHOOTING

This section is included to provide you with information to aid you in isolating a trouble to a particular circuit in a unit more efficiently. During troubleshooting work, you should correlate information contained in this section with information obtained from the other sections in this manual. We have not attempted to give detailed step-by-step procedures for finding the cause of specific troubles. We have, instead, attempted to outline a general troubleshooting guide which can be used to locate any trouble which may occur in one of the units.

In general, this troubleshooting procedure can be thought of as consisting of two parts, unit isolation and unit troubleshooting. The first step involves isolating a trouble to the unit. The second step involves making detailed checks of the circuits in the unit to determine which part or parts are causing the trouble. This method of troubleshooting is explained in more detail in the Unit and Circuit Isolation procedure contained in this section.

When following the procedure, it is assumed that the oscilloscope used with these accessory units is operating correctly. If you are in doubt, you should check the operation of the oscilloscope before attempting to do any troubleshooting.

Circuit diagrams are contained in Section 7 of this manual. Important voltages and waveforms are shown on the Type 131 Amplifier circuit diagram. These voltages and waveforms should be used as troubleshooting aids.

Switch wafers shown on the Type 131 Amplifier Circuit diagram are coded to indicate the position of the wafer on the actual switch. The number portion of the code refers to the wafer number on the switch assembly, wafers being numbered from the front of the switch to the rear. The letters F. and R. indicate whether the front or the rear of the wafer is used to perform the particular switching function.

UNIT AND CIRCUIT ISOLATION

Type P6016 Current Probe

A good procedure to follow, as a first step in isolating a trouble to one unit, is to check the Type P6016 Current Probe. This can be done easily by making a resistance check. Connect the ohmmeter between the center conductor of the probe cable at the BNC connector and ground (shield). The resistance reading should be approximately 6 ohms. If you do not obtain this reading, remove the four screws as described in the instructions for cleaning and repairing the probe. Disconnect the cable from the current transformer at the solderless connector and make additional resistance checks to determine whether the cable or the transformer is at fault. The resistance of the transformer winding is approximately 6 ohms to ground.

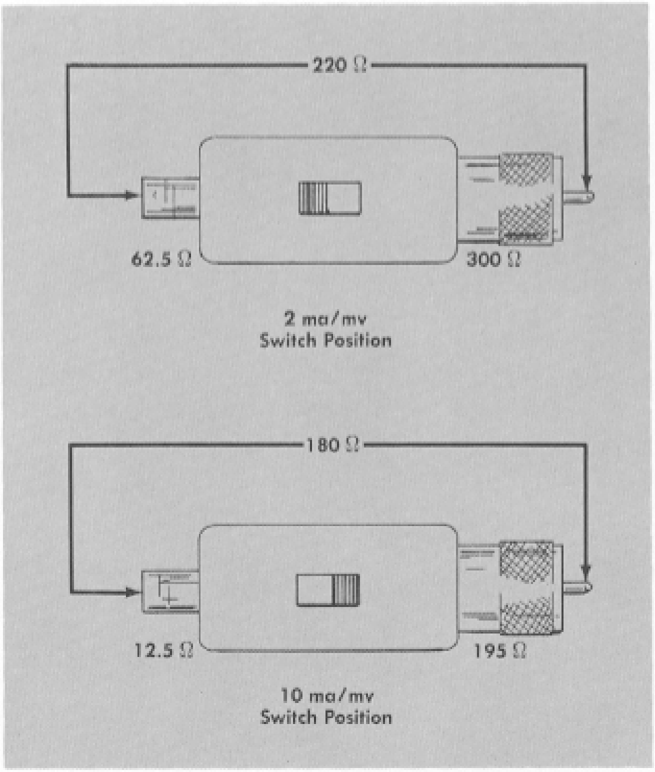


Fig. 5-2. Approximate resistance readings obtained for each position of the Termination slide switch.

Termination Unit

If you are using the Termination unit with the Type P6016 Probe and you have found that the resistance-to-ground measurement of the probe is normal, then the Termination must be checked to find the source of trouble. Refer to Fig. 5-2 where approximate resistance readings are given for each of the two positions of the slide switch. If you find readings which do not correspond to those in the illustrations, detailed resistance measurements can be made by following the circuit diagrams shown in Fig. 4-2.

Type 131 Current Probe Amplifier

To isolate trouble to the Type 131 Amplifier when you are using this unit with the Type P6016 Current Probe, first check the resistance of the probe as directed in the earlier paragraph concerning the probe. If you find the resistance reading to be normal, it is reasonable to expect that amplitude or distortion troubles are being caused by the Type 131 Amplifier. The usual method for finding the cause of such troubles is summarized in the four steps to follow.

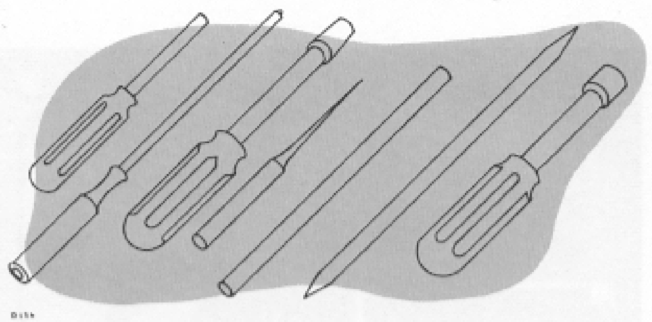
(1) Check the Power Supply. Measure the voltage at the emitter of Q617. If the voltage reading is —15 volts (±1.5 volts), go on to step (2). If not, trace back toward the ac power source to find the cause of the trouble.

(2) Check the voltage at both ends and at the center tap of inductances L457 and L478. This check is made to determine if any of the coil windings are open. If normal voltage readings are obtained, continue on to step (3). If not, make a detailed resistance check where the normal reading was not obtained.

(3) Check for signal at the collector of each transistor used in the amplifier stages, moving from the output back to the input. This check is made to isolate any amplitude trouble to one of the transistor stages. (The Type 131 can be disconnected from the oscilloscope for this step; the oscilloscope, with a low-attenuation probe, can then be used for signal tracing the amplifier.)

If no output is obtained from the last stage, the transistor should be substituted or checked. If the transistor is not at fault, then make voltage and resistance checks until the cause of the trouble is found. The first two stages can be checked in the same manner.

(4) If the signal amplitudes and voltages are normal for all the circuits, but the signal is distorted, determine which stage is at fault by using the signal-tracing method. When the faulty stage is isolated, make further circuit checks within the stage to find the exact cause of the trouble.



SECTION 6

CALIBRATION

Introduction

This section of the manual contains information for calibrating and checking the operation of the Type 131 Current Probe Amplifier when it is used with the Type P6016 Current Probe. In addition, this section may be used as an aid in isolating troubles occuring within the amplifier unit. Abnormal indications occuring during calibration checks will often aid in narrowing the trouble to a definite circuit or stage within the unit.

In the instructions that follow, the steps are arranged in proper sequence for a complete calibration of the unit. However, if the unit is being used with an oscilloscope having a bandpass of less than 30 mc, or if a 30-mc oscilloscope is not available, only the first four steps of the procedure need be performed. The last four steps should not be attempted unless adequate equipment is available to make the high-frequency adjustments.

Equipment Required

The first five listed items of equipment required are the minimum necessary to perform steps 1 through 4 in the calibration procedure.

(1) Oscilloscope, having a bandpass of 3 cps to 100 kc or higher, and a vertical sensitivity of 0.05 to 0.1 volt per division. If the oscilloscope is not equipped with a 1-kc calibrator square-wave generator, capable of supplying a current of 4 ma or more, then a separate 1-kc square-wave generator must be obtained.

(2) DC voltmeter with a sensitivity of at least 5000 Ω/volt.

(3) Test fixture, Tektronix part number 013-001.

(4) Resistor, 24.5 k, ½-watt, composition, 1%. Obtain this value by connecting a 25 k, 1% resistor in parallel with a 1.2-meg. 10% resistor. Or, use a current probe calibration adapter, Tektronix part number 017-031. These items are for use with Tektronix oscilloscopes having an integral 100-volt amplitude calibrator.

A third method is described following this list of equipment.

(5) Suggested calibration tool. 2″ or 3″ screwdriver.

NOTE

The following equipment, plus the test fixture and screwdriver listed previously, are required to perform steps 5 through 8.

(6) Tektronix Type 540-Series Oscilloscope with a Type K Plug-In Unit or equivalent. The oscilloscope must be properly calibrated for vertical sensitivity and the delay line properly tuned. Required specifications are: vertical sensitivity of 0.05 volt/div, calibrated; risetime of 12 nsec or less; sweep rate of 0.2 μsec/div. to 0.02 μsec/div.

(7) Square-wave Generator, Tektronix Type 107 or equivalent. Required specifications are: output frequency of approximately 500 kc; current capabilities of 10 ma or more (0.5 volt); risetime of 3 nsec or less.

(8) Sine-wave Generator, Tektronix Type 190A/B Constant-Amplitude Signal Generator or equivalent. Required specifications are: output frequencies of 50 kc and approximately 17 mc; current capabilities of 20 ma or more (1 volt); output amplitude must be constant when switching between the above frequency ranges.

(9) Shield cover with holes to make the step 5 adjustments in the procedure; replaces the original cover on the Type 131 Amplifier.

(10) Clip-lead adapter, Tektronix part number 013-003 or equivalent.

(11) Resistor, 51 ohms, ½ watt, composition, 5%.

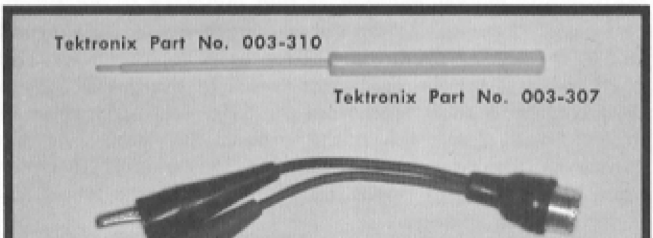


Fig. 6-1. Clip-lead adapter, test fixture and calibration tools are shown above.

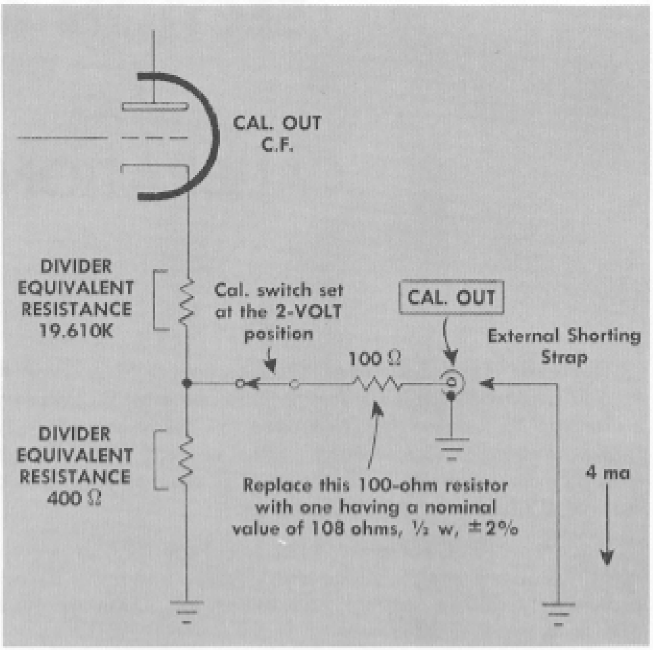


Fig. 6-2. Method used to modify the oscilloscope calibrator. This method provides a simple, accurate, 4-ma current probe source which is readily available for checking the probe.

(12) Suggested calibration tool: two-piece hexagonal alignment tool; Tektronix part numbers are 003-307 for the handle and 003-310 for the hexagonal insert.

Oscilloscope Calibrator Modification

A method that can be used to obtain an accurate 4-ma current source for calibration purposes is shown in Fig. 6-2. This modification can be made to any Tektronix oscilloscope calibrator having the same equivalent resistance in the cathode divider network as that indicated in the simplified circuit drawing. When this change is made, no external 24.5-k resistor or calibration adapter is needed. All you need to do is set the calibrator switch to the 2 VOLT position, connect a short lead from the CAL. OUT connector to ground, and clamp the probe around the lead. The accuracy of the 4-ma current flowing in the lead is better than 1.5%. Normal operation of the calibrator is not affected by this change.

CAUTION

Use care in unsoldering the 100-ohm resistor, and soldering in the 108-ohm resistor. Do not let any solder flow past the rivet in the calibrator switch terminal. Solder flowing beyond this point, toward the switch contact area, will weaken the spring action of the contact.

CALIBRATION PROCEDURE

Preliminary Information

Remove the cover from the Type 131 Current Probe Amplifier. Connect the amplifier power cable to its 117-volt ac, 234-volt ac, or battery power source.

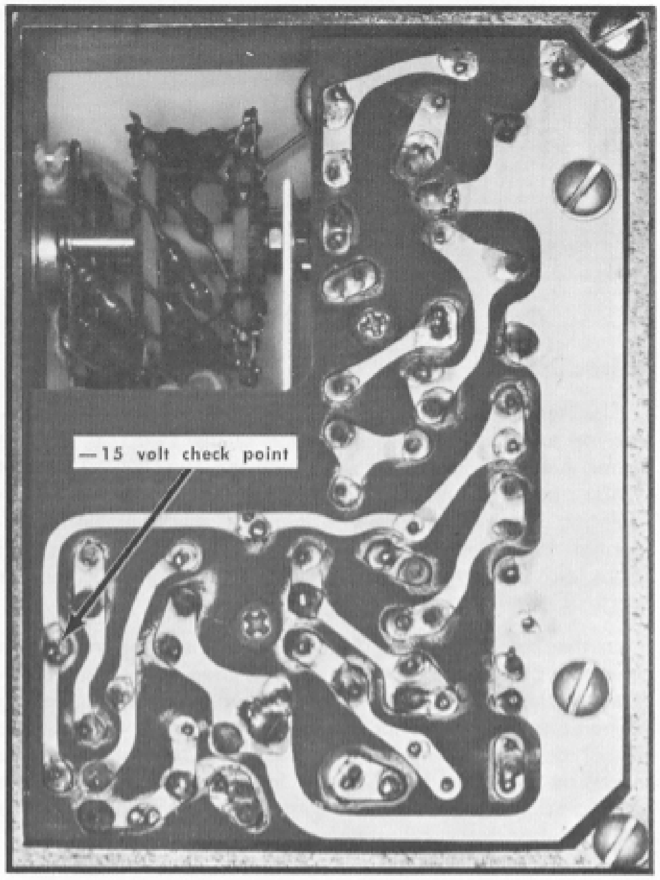


Fig. 6-3. Location of the voltage and ripple test point for Model 1, 2, 3.

1. Check Regulator Circuit

Connect the dc voltmeter between the emitter of Q617 and ground. The voltage reading should be —15 volts, tolerance ±1.5 volts. Disconnect the voltmeter.

Check the ripple at the same test point, using a shielded test lead or 1X probe from the oscilloscope. The ripple should not exceed 4 millivolts. With the oscilloscope set for a maximum vertical sensitivity of 50 mv/div, a normal amount of ripple would not be measurable but any excessive amount could be seen. Disconnect the shielded test lead, or probe.

2. Input Impedance Adjustment

The correct input impedance is obtained by setting R452 (Z_{in} ADJ).

To make the adjustment, connect the Type 131 Amplifier to the input of the oscilloscope. Connect the Type P6016 Current Probe to the input of the amplifier. Connect the part #013-001 test fixture to the oscilloscope calibrator output or other 1-kc square-wave source. Place a ½-inch piece of spaghetti insulation over one lead of the 24.5-k resistor. Insert the resistor in the test fixture clips so that both ends make contact. Set the calibrator (or square-wave generator) for 100 volts output. This will provide 4 ma of current

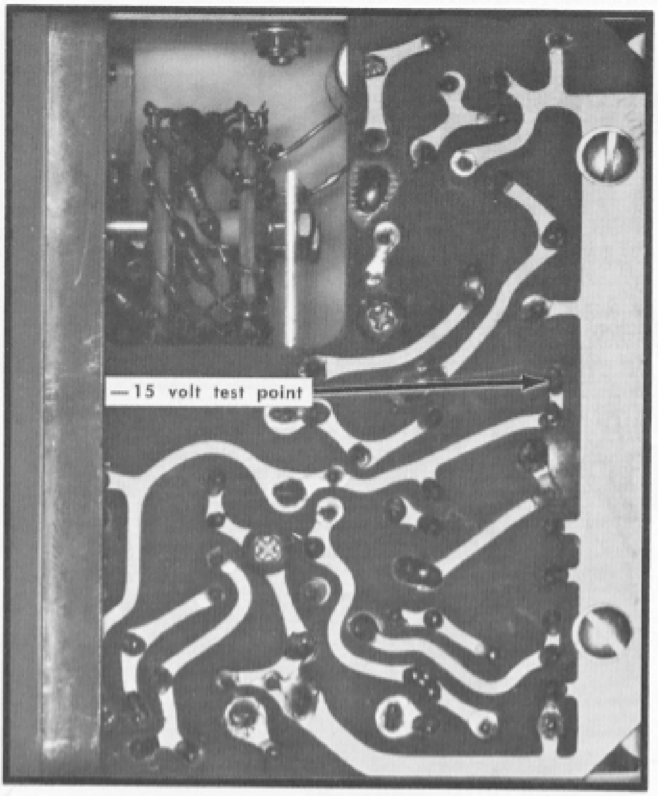


Fig. 6-4. Location of the voltage and ripple test point for Model 4.

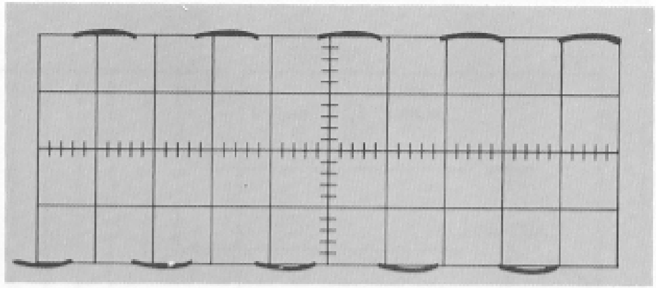


Fig. 6-5. Normal calibrator current waveform obtained when the LOW FREQ. ADJ. and GAIN ADJ. controls are set correctly. Sweep rate is 0.5 millisec/div.

through the 24.5-k resistor. Alternate methods (described previously) for obtaining an accurate 4-ma current may be used if desired.

Clamp the probe around the insulated resistor lead. Make certain the slide on the probe is all the way forward. Place the CURRENT/DIV. switch at 1 mAMP. Set the oscilloscope vertical sensitivity for 0.1 volt/div. Note the amplitude of the waveform. Set the CURRENT/DIV. switch to 2 mAMP. and the oscilloscope sensitivity switch to 0.05 volt/div. Note the amplitude once again. Adjust R452 (Z_{in} ADJ.) to obtain the same amplitude as that noted the first time. Repeat this step to make sure R452 is set correctly to obtain optimum attenuator accuracy.

3. Gain Adjustment

The gain of the Type 131 Amplifier is set to calibrate the 1 mAMP. position of the CURRENT/DIV. switch.

To set the amplifier for proper gain, use the same current waveform source described in step 2. Place the CURRENT/DIV. switch to the 1 mAMP. position. Set the oscilloscope vertical sensitivity switch to 0.05 volt/div. Check to make certain that the variable sensitivity control on the oscilloscope is rotated to the calibrated position. Adjust the GAIN ADJ. (R464) control for a deflection of 4 divisions (centimeters) on the crt at the rising portion of the waveform.

4. Low-Frequency Compensation Adjustment

Compensation for the lower frequencies is made by adjusting the LOW FREQ. ADJ. ((R481) control.

Using the same operating conditions as described in the previous step, adjust the LOW FREQ. ADJ. control to obtain the same amplitude at the rise of the square waveform as obtained at the fall. This adjustment, when properly made, will cause the corners of the square wave to be at equal amplitudes (see Fig. 6-5).

If the waveform is not exactly 4 divisions in amplitude after making the low-frequency adjustment, readjust the GAIN ADJ. control as described in step 3 for correct amplitude. The Z_{in} ADJ. should also be checked at this time.

Unclamp the current probe, turn off the calibrator, remove the 24.5-k resistor and the test fixture.

NOTE

To make high-frequency adjustments in the following steps, use an oscilloscope and other equipment which meet the specifications listed under Equipment Required heading.

5. High-Frequency Compensation Adjustments

Several adjustments are made in this step to obtain optimum high-frequency response. To duplicate the operating conditions with the cover installed, another metal cover with access holes is needed. See Fig. 6-6. Drill ¼-inch diameter holes in the second cover which will align with the location of the adjustments to be made in this procedure. Or, if you prefer, similar holes may be drilled in the original cover, in which case a second cover is not required.

To proceed with this step, connect the test fixture to the output of the Type 107 Square-Wave Generator, or equivalent. Insert the 51-ohm resistor in the clips of the test fixture. Clamp the current probe around the resistor and set the CURRENT/DIV. switch to the 5 mAMP. position. Make certain the vertical sensitivity switch on the oscilloscope is set to 0.05 volts/div. Adjust the square-wave generator to obtain a waveform 2 divisions high, at about 500 kc. Set the oscilloscope sweep rate and triggering controls to display one positive half-cycle of the square wave. Usual sweep rate is 0.2 μsec/div (or 0.2 μsec/cm) with 5X magnifier on. Other sweep rates may be used to observe effects of adjustments on the waveform.

Model 1, 2, 3

To start with, the slug in L457 should be located inside the coil and the slug in L478 should be at the bottom end

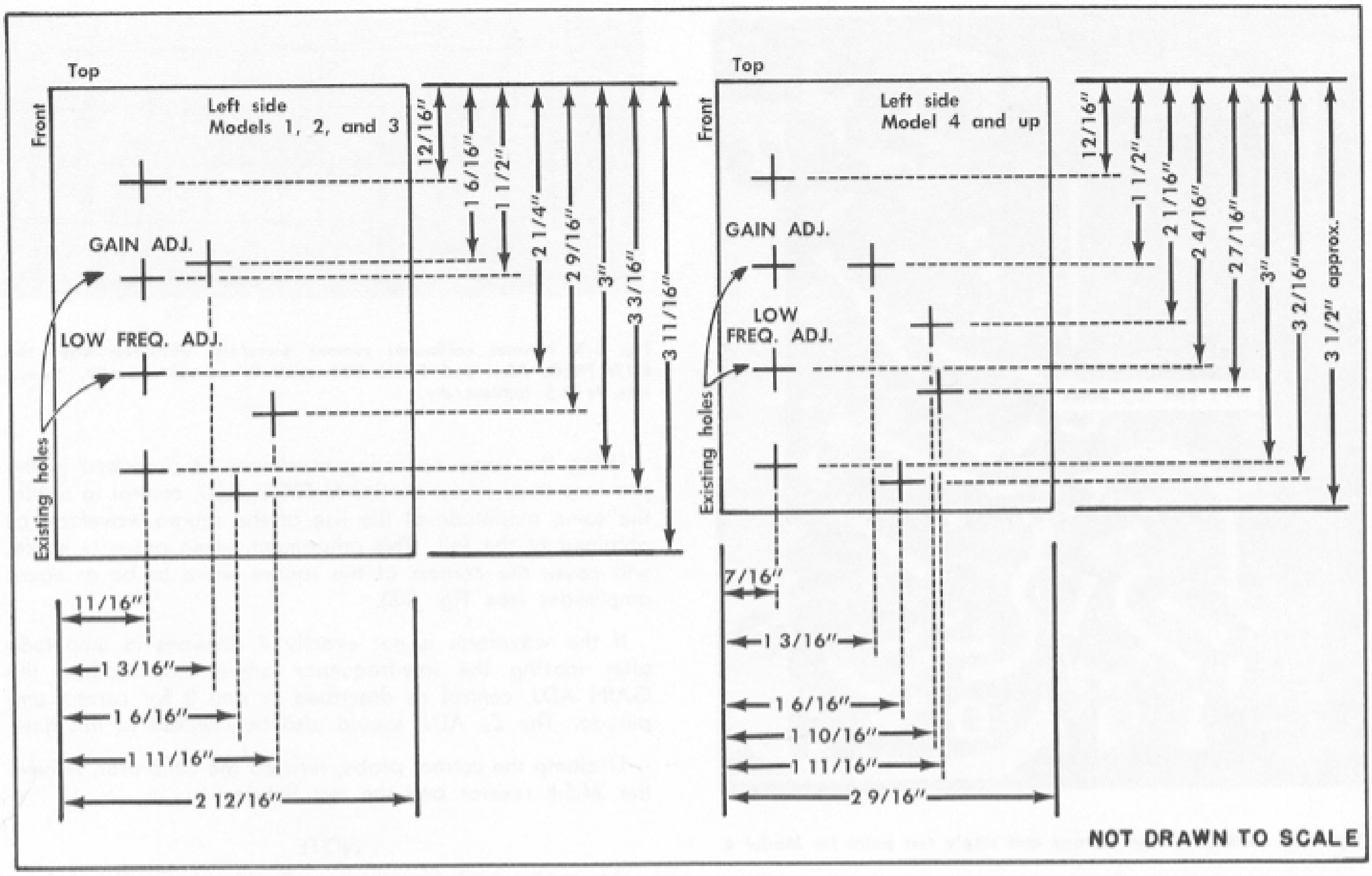


Fig. 6-6. Diagram showing additional holes needed for calibration. The locations are accurate to the nearest 1/16 of an inch. (Do not use as a template.)

of the coil. Adjust R475 (HF COMP.) and C475 for a slight amount of rolloff of the square wave. Then adjust L457 and L478 for a square corner with minimum overshoot or rolloff. L457 affects a wider portion of the front corner, while L478 affects a narrower portion. The few cycles of ringing in the waveform should never exceed 4%. Typical appearance of the waveform, when the adjustments have been properly made, is shown in Fig. 6-7.

Model 4-up

To start with C468 is adjusted for overshoot on the leading edge of the waveform. The above adjustment will place

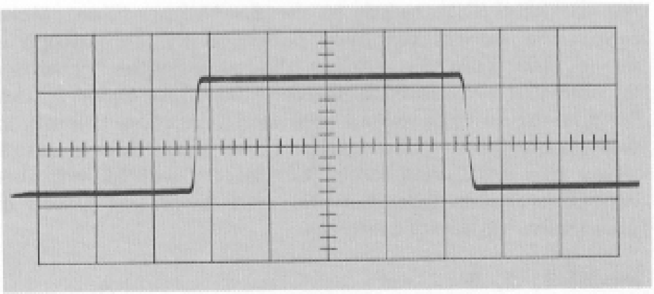


Fig. 6-7. Typical appearance of waveform after completing high-frequency compensation adjustments. Sweep rate is 0.2 μsec/div.

C468 at minimum capacitance. The slug in L457 should be located inside the coil and the slug in L478 should be at the bottom end of the coil. Adjust R475 (HF COMP.) and C475 for a slight amount of rolloff of the square wave. Then adjust L457 and L478 for a square corner with minimum overshoot or rolloff. L457 affects a narrower portion.

The few cycles of ringing near the leading edge of the waveform should never exceed 4%. If the amount of ringing does exceed 4% then C468 should be adjusted away from its minimum capacitance position, thus adding some capacitance to the circuit. Just enough capacitance from C468 should be added to reduce the ringing below 4%.

Every time one of the above controls is adjusted the other controls affecting the High-Frequency Compensations must be rechecked for proper adjustment. Typical appearance of the waveform, when the adjustments have been properly made, is shown in Fig. 6-7.

NOTE

The 4% of ringing on the leading edge of the waveform is measured as a positive 2% and a negative 2% from the nominal top of the square wave.

6. Check Risetime

A risetime measurement will check the accuracy of the adjustments made in step 5.

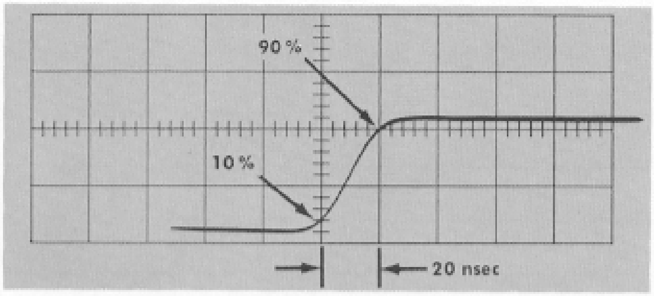


Fig. 6-8. Measuring the risetime when the sweep rate is 20 nsec/div.

Set the oscilloscope for a sweep rate of 0.02 μsec/div (20 nanoseconds/div). Measure the time interval between the 10% and 90% amplitude levels of the rising portion of the square wave. This time interval should not exceed 20 nanoseconds (see Fig. 6-8). To obtain this risetime, the oscilloscope delay line and the Type 131 Amplifier must be properly adjusted. In addition, the oscilloscope TRIGGERING LEVEL control must be set to shift the rising portion of the waveform to the right as far as possible from the start of the trace to obtain a true display for risetime measurements.

7. Selecting C407B

C407B is selected at the factory for optimum high-frequency response of the Type 131 Amplifier when the CURRENT/DIV. switch is set to the 1 mAMP. position. If the first amplifier transistor Q454 has been replaced, continue with this step. If Q454 has not been replaced, omit this step.

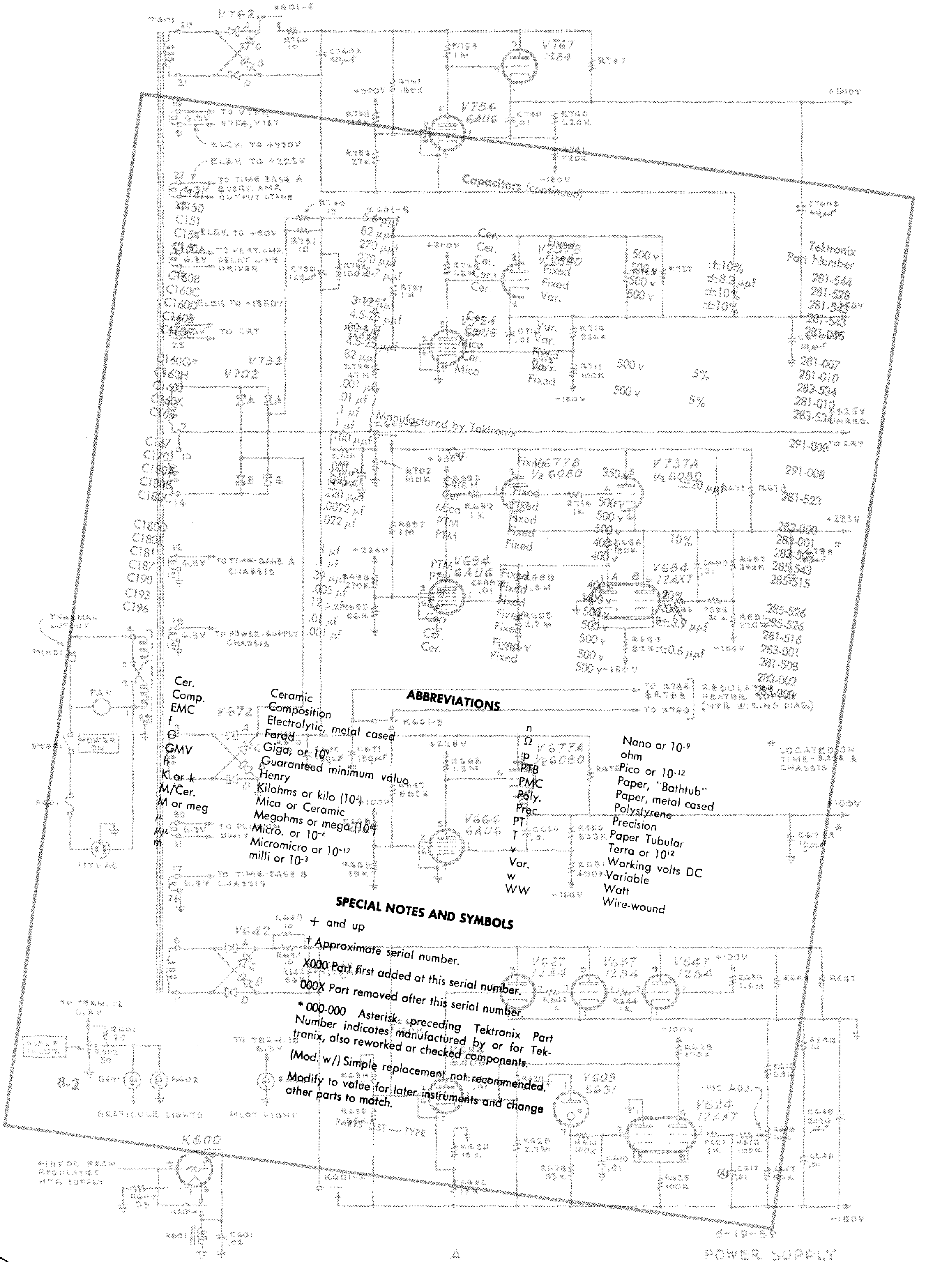
To determine if C407B needs to be changed to a new value, use the same operating information as that given in step 5 to display one positive half-cycle of the waveform. Set the CURRENT/DIV. switch to 1 mAMP. Adjust the amplitude control of the square-wave generator for 4-division signal. If the overshoot exceeds 1.6 minor divisions, then select a new value for C407B which will reduce the height to 1.6 minor divisions or less. Unclamp the probe and remove the 51-ohm resistor.

8. Check Bandpass

To measure the bandpass, connect the clip-lead adapter to the output of the signal generator, at the attenuator box. Connect the 51-ohm resistor between the clip leads. Clamp the current probe around the resistor. Set the CURRENT/DIV. switch to the 5 mAMP. position. Set the oscilloscope sweep rate to 0.5 millisec/div. Set the output frequency of the signal generator to 50 kc and the amplitude control for a deflection of exactly 4 divisions. Let the sweep free-run (not triggered). Then, without adjusting any other controls, increase the frequency of the signal generator to 17 mc. The deflection should now be at least 2.8 divisions. The 2.8-division amplitude is the 3 db point given as a specification for the Type 131 Amplifier when it is used with the current probe and oscilloscope. After completing this step, disconnect the test equipment, the current probe, remove the substitute shield cover and install the original cover.

NOTES

PARTS LIST *and* DIAGRAMS



ABBREVIATIONS

Cer. Ceramic
Comp. Composition
EMC Electrolytic, metal cased
f Farad
G Giga, or 10^9
GMV Guaranteed minimum value
h Henry
K or k Kilohms or kilo (10^3)
M/Cer. Mica or Ceramic
M or meg Megohms or mega (10^6)
μ Micro, or 10^{-6}
μμ Micromicro or 10^{-12}
m milli or 10^{-3}
n Nano or 10^{-9}
Ω ohm
p Pico or 10^{-12}
PTB Paper, "Bathtub"
PMC Paper, metal cased
Poly. Polystyrene
Prec. Precision
PT Paper Tubular
T Terra or 10^{12}
v Working volts DC
Var. Variable
w Watt
WW Wire-wound

SPECIAL NOTES AND SYMBOLS

\+ and up
† Approximate serial number.
X000 Part first added at this serial number.
000X Part removed after this serial number.
* 000-000 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, also reworked or checked components.
(Mod. w/) Simple replacement not recommended. Modify to value for later instruments and change other parts to match.

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

HOW TO ORDER PARTS

Replacement parts are available from or through your local Tektronix Field Office.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Field Office will contact you concerning any change in part number.

PART LIST

Capacitors

Values fixed unless marked variable.
Tolerance ±20% unless otherwise indicated.

							Tektronix Part Number
C407A	Model 1—Model 2	150 μμf	Cer.		500 v		281-524
C407A	Model 3-up	120 μμf	Cer.		500 v	±10%	281-550
C407B		Selected					
C408	Model 1—Model 2	270 μμf	Cer.		500 v		281-543
C408	Model 3-up	150 μμf	Cer.		500 v	±30 μμf	281-524
C452		180 μf	EMT		6 v		290-139
C454		330 μf	EMT		6 v		290-138
C457		22 μf	EMT		15 v		290-134
C458		120 μf	EMT		10 v		290-140
C468	Model 1-2-3	22 μf	EMT		15 v		290-134
C468	Model 4-up	2-8 μμf	Cer.	Var.			281-060
C470	X Model 4-up	22 μf	EMT		15 v	−10+250%	290-134
C473	Model 1—Model 2	47 μμf	Cer.		500 v		281-518
C473	Model 3-up	18 μμf	Cer.		500 v	±10%	281-542
C474		470 μμf	Cer.		500 v	±94 μμf	281-525
C475		8-50 μμf	Cer.	Var.	500 v		281-022
C477	Model 1X	4.7 μμf	Cer.		500 v		281-501
C478		.001 μf	Cer.		500 v		283-000
C479	Model 1-2-3	0.1 μf	Cer.		10 v		283-023
C479	Model 4-up	.1 μf	Cer.		30 v		283-024
C482		0.2 μf	Cer.		25 v		283-026
C601	Model 1-2-3	.01 μf	Cer.		250 v		283-005
C601	Model 4-up	50 μf	EMT		25 v	−15+75%	290-158
C610	Model 1-2-3X	100 μf	EMT		30 v	−15+75%	290-137
C611		.01 μf	Cer.		250 v		283-005
C612		15 μf	EMT		20 v		290-135
C617		2.2 μf	EMT		20 v		290-136

Diodes

D601		T12G	152-008
D602		T12G	152-008
D603	X Model 4-up	T12G	152-008
D604	X Model 4-up	T12G	152-008
D606	X Model 4-up	Zener 20 v-1 w	152-060
D611	X Model 4-up	T12G	152-008
D612		1N718 Zener 15 v	152-031

Inductors

L401		Toroid, TD23			*120-183
L455	X Model 4-up	1.1 μh			*108-215
L456		Ferramic Suppressor			276-507
L457	Model 1—Model 2	9-18.5 μh	Var.	Core 276-506	*114-135
L457	Model 3-up	8.5-17 μh	Var.	Core 276-506	*114-142
L478	Model 1—Model 2	3-6.5 μh	Var.	Core 276-506	*114-134
L478	Model 3-up	3-5.3 μh	Var.	Core 276-506	*114-141

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R401	Model 1—Model 2	56 Ω	½ w		5%	301-560
R401	Model 3-up	51 Ω	½ w		5%	301-510
R406	Model 1—Model 2	10.2 Ω	⅛ w	Prec.	1%	318-051
R406	Model 3-up	11.8 Ω	½ w	Prec.	1%	309-318
R407	Model 1—Model 2	62 Ω	¼ w		5%	315-620
R407	Model 3-up	100 Ω	¼ w		10%	316-101
R408A		19.1 Ω	⅛ w	Prec.	1%	318-075

Resistors *(continued)*

Ckt. No.	Model	Value	Wattage			Tolerance	Tektronix Part Number
R408B		9.09 Ω	1/8 w		Prec.	1%	318-067
R409A		12.5 Ω	1/8 w		Prec.	1%	318-055
R409B		40 Ω	1/8 w		Prec.	1%	318-057
R410A	Model 1—Model2X	11.1 Ω	1/8 w		Prec.	1%	318-054
R410B	Model 1—Model 2	90 Ω	1/8 w		Prec.	1%	318-058
R410B	Model 3-up	96.2 Ω	1/8 w		Prec.	1%	318-068
R411A	Model 1—Model2X	10.5 Ω	1/8 w		Prec.	1%	318-053
R411B	Model 1—Model 2	189 Ω	1/8 w		Prec.	1%	318-059
R411B	Model 3-up	214 Ω	1/8 w		Prec.	1%	318-069
R412	Model 1—Model 2	490 Ω	1/8 w		Prec.	1%	318-060
R412	Model 3-up	568 Ω	1/8 w		Prec.	1%	318-070
R413	Model 1—Model 2	1 k	1/8 w		Prec.	1%	318-049
R413	Model 3-up	1.16 k	1/8 w		Prec.	1%	318-071
R414	Model 1—Model 2	2.02 k	1/8 w		Prec.	1%	318-061
R414	Model 3-up	2.34 k	1/8 w		Prec.	1%	318-072
R415	Model 1—Model 2	5.08 k	1/8 w		Prec.	1%	318-062
R415	Model 3-up	5.88 k	1/8 w		Prec.	1%	318-073
R416	Model 1—Model 2	10.2 k	1/8 w		Prec.	1%	318-063
R416	Model 3-up	11.8 k	1/8 w		Prec.	1%	318-074
R451		750 Ω	1/4 w			5%	315-751
R452		500 Ω	0.1 w	Var.	Comp.	Z-In Adj.	311-056
R453		4.3 k	1/4 w			5%	315-432
R454		330 Ω	1/4 w			5%	315-331
R458	Model 1	680 Ω	1/4 w			5%	315-681
R458	Model 2-up	620 Ω	1/4 w		Comp.	5%	315-621
R461		6.2 k	1/4 w			5%	315-622
R462		62 Ω	1/4 w			5%	Use 315-620
R463	Model 1—Model 2	150 Ω	1/4 w				316-151
R463	Model 3-up	100 Ω	1/4 w		Comp.	10%	316-101
R464		500 Ω	0.1 w	Var.	Comp.	Gain Adj.	311-056
R468		1 k	1/4 w				316-102
R471		1.5 k	1/4 w				316-152
R472		22 k	1/4 w				316-223
R473	Model 1—Model 2	330 Ω	1/4 w			10%	316-331
R473	Model 3-up	330 Ω	1/4 w			5%	315-331
R474		33 k	1/4 w				316-333
R475		2.5 k	0.1 w	Var.	Comp.	H.F. Comp.	311-010
R477	Model 1X	39 k	1/4 w				316-393
R478		2.2 k	1/4 w				316-222
R479		470 Ω	1/4 w			5%	315-471
R481	Model 1-2-3	50 k	0.1 w	Var.	Comp.	L.F. Adj.	311-078
R481	Model 4	100 k	0.1 w	Var.			311-115
R482		15 k	1/4 w				316-153
R606	X Model 4-up	56 Ω	1/4 w				316-560
R610 †		18 k	1 w	Fixed	Comp.	10%	304-183
R611 †		18 k	1 w	Fixed	Comp.	10%	304-183
R612		4.7 k	1/4 w				316-472
R614		2.2 k	1/4 w				316-222

Switch

				Wired	Unwired
SW410	Model 1—Model 2	Rotary	CURRENT/DIV.	*262-403	*260-335
SW410	Model 3-up	Rotary	CURRENT/DIV.	*262-404	*260-380

Transformer

T601	Model 1-2-3	Power	*120-184
T601	Model 4-up	Power	*120-231

† Used in 234V operation.

Transistors

				Tektronix Part Number
Q454		2N1517 or Equivalent		151-031
Q464	Model 1 & 2	2N1517 or Equivalent		use 050-040
Q464†	Model 3-up	2N1517 or Equivalent	Selected	use *153-515
Q474	Model 1 & 2	2N1517 or Equivalent		use 050-040
Q474†	Model 3-up	2N1517 or Equivalent	Selected	use *153-515
Q617		2N1381		151-039

†If the high frequency characteristics of the transistors, Tektronix number 153-515, are extremely high, serious ringing may occur. In such cases, replace one of the transistors with Tektronix part number 153-518.

Passive Termination

Capacitor

C109	6.8 $\mu\mu$f	Cer.	500 v	±10%	281-541

Inductors

L105		Toroid	*120-183
L107	.5 μh	Coil wound on R107, 330 Ω resistor	*108-212

Resistors

R102	50 Ω	½ w	Prec.	1%	303-128
R103	12.5 Ω	⅛ w	Prec.	1%	318-055
R106	180 Ω	¼ w	Comp.	10%	316-181
R108	220 Ω	¼ w	Comp.	10%	316-221
R109	4.7 k	¼ w	Comp.	10%	316-472

Switch

SW100	Slide Switch, 2-position	260-212

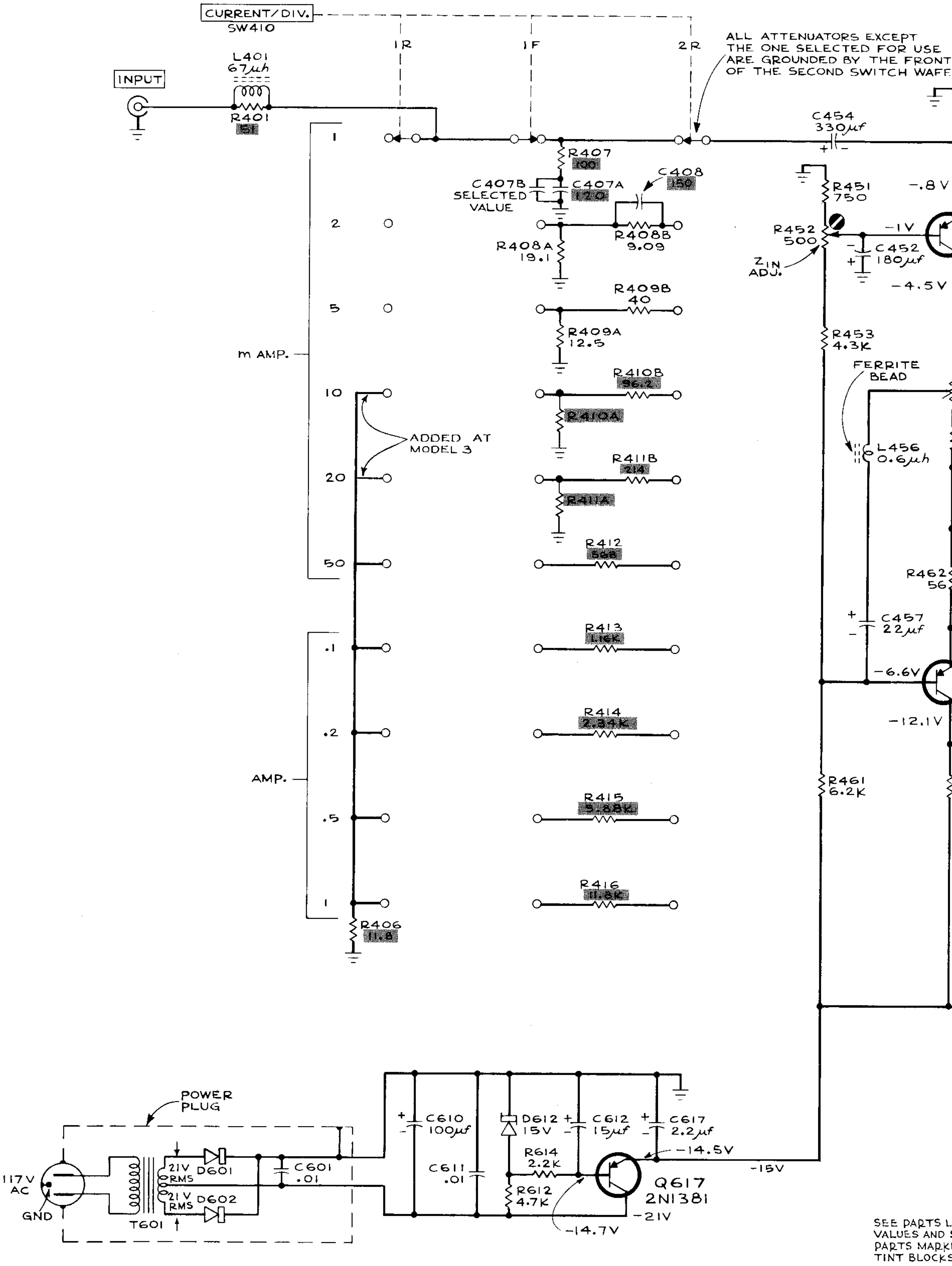
MECHANICAL

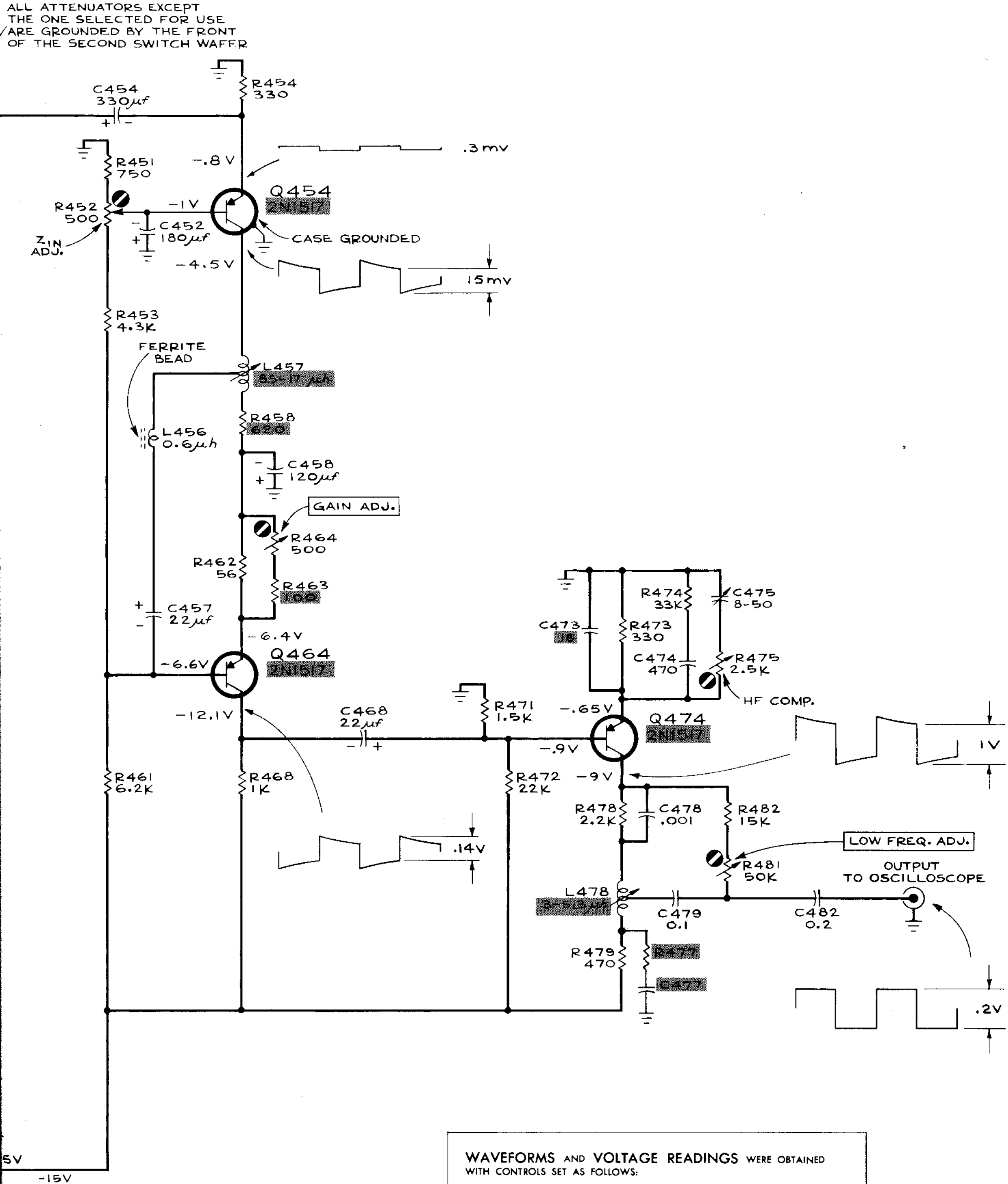
Box, Terminal	202-054
Connector, Cable end (includes coax connector 131-136)	131-058
Connector, female	131-106
Cover, Male Conn.	200-026
Cover, Back	200-252
Tag, Termination Block	334-738

Type 131
Mechanical Parts List

		Tektronix Part Number
BRACKET, TRANSFORMER MOUNTING	MODEL 1-2-3	406-650
BRACKET, TRANSFORMER MOUNTING	MODEL 4-up	406-732
BRACKET, POT MOUNTING	MODEL 1-2-3X	406-595
BUSHING, STRAIN RELIEF		358-103
CLIP, GROUNDING SPRING	X MODEL 4-up	344-062
CONNECTOR, CHAS. MOUNT COAX 1 CONT. FEMALE		131-106
CONNECTOR, CABLE END (COVER REMOVED)		131-168
CONNECTOR, MOLDED PIN ASSY'	X MODEL 4-up	131-190
COVER, COAX UHF MALE CONNECTOR		200-026
COVER, 3 WIRE MOTOR BASE		200-185
COVER, TRANSFORMER (KRALASTIC)		200-246
COVER, TRANSFORMER, HEAT STAMPED 117 V		200-248
COVER, FRONT BOX		200-328
COVER, REAR BOX		200-329
FRAME	X MODEL 4-up	426-136
HOUSING, WRAP-AROUND $2\frac{9}{16} \times 1\frac{25}{32} \times 3\frac{17}{32}$	X MODEL 4-up	380-027
INSERT, MOTOR BASE		377-041
KNOB, BLACK	MODEL 1-2-3	366-108
KNOB, CHARCOAL	MODEL 4-up	366-155
LOCKWASHER, INT. #2		210-001
LOCKWASHER, INT. #4		210-004
LOCKWASHER, POT. INT. $\frac{3}{8} \times \frac{1}{2}$		210-012
LUG, SOLDER SE6 W/2 WIRE HOLES		210-201
LUG, SOLDER DE6		210-204
NUT, HEX 2-56 x $\frac{3}{16}$		210-405
NUT, HEX 4-40 x $\frac{3}{16}$		210-406
NUT, HEX $\frac{3}{8}$-32 x $\frac{1}{2}$		210-413
NUT, HEX 1-72 x $\frac{5}{32}$		210-438
NUT, KEPS, STEEL 4-40 x $\frac{1}{4}$		210-586
PANEL, FRONT	MODEL 1-2-3	333-617
PANEL, FRONT	MODEL 4-up	333-675
PIN, CONNECTING		214-078
PLATE, COVER TRANSFORMER		387-265
PLATE, CRICUIT	MODEL 1-2-3	387-266
PLATE, CIRCUIT BOARD	MODEL 4-up	387-472
POST, GROUND MOTOR BASE		129-060
SCREW, 4-40 x $\frac{3}{16}$ BHS		211-007
SCREW, 4-40 x $\frac{1}{4}$ BHS		211-008
SCREW, 4-40 x $\frac{1}{2}$ RHS		211-015

	Tektronix Part Number
SCREW, 4-40 x $^5/_{16}$ FHS, PHILLIPS	211-038
SCREW, THREAD CUTTING 4-40 x $^1/_4$ PHS, PHILLIPS	213-035
SCREW, THREAD CUTTING 6-32 x $^3/_8$ TRUSS HS, PHILLIPS	213-041
SHIELD, SWITCH MODEL 1-2-3	337-397
SHIELD, SWITCH MODEL 4-up	337-475
SOCKET, 4 PIN TUBE FOR $^1/_8$ ETCHED CIRCUIT	136-062
WASHER, STEEL .390 x $^9/_{16}$ x .020	210-840


CURRENT/DIV.
SW410
1R
1F
2R
ALL ATTENUATORS EXCEPT
THE ONE SELECTED FOR USE
ARE GROUNDED BY THE FRONT
OF THE SECOND SWITCH WAFE
INPUT
L401
67µh
R401
51
C454
330µf
R407
100
C407B
SELECTED
VALUE
C407A
120
C408
150
R408B
9.09
R408A
19.1
R409B
40
R409A
12.5
R410B
96.2
R410A
R411B
214
R411A
R412
568
R413
1.16K
R414
2.34K
R415
5.88K
R416
11.8K
R406
11.8
m AMP.
AMP.
1
2
5
10
20
50
.1
.2
.5
1
ADDED AT
MODEL 3
R451
750
-.8 V
R452
500
-1V
C452
180µf
-4.5V
ZIN
ADJ.
R453
4.3K
FERRITE
BEAD
L456
0.6µh
R462
56
C457
22µf
-6.6V
-12.1V
R461
6.2K
POWER
PLUG
117V
AC
GND
21V
RMS
D601
21V
RMS
D602
T601
C601
.01
C610
100µf
C611
.01
D612
15V
C612
15µf
C617
2.2µf
R614
2.2K
R612
4.7K
-14.5V
-15V
Q617
2N1381
-21V
-14.7V
SEE PARTS L
VALUES AND S
PARTS MARK
TINT BLOCKS



SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH RED TINT BLOCKS

WAVEFORMS AND **VOLTAGE READINGS** WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117V AC 60 CPS
CURRENT/DIV	1 mAMP
INPUT SIGNAL	
FOR VOLTAGE READINGS	NONE
FOR WAVEFORMS	4 mAMP 1 KC SQUARE-WAVE

NOTE:

SET CALIBRATOR OF TEKTRONIX 530-540 SERIES OR EQUIVALENT OSCILLOSCOPE TO 100 VOLTS. CONNECT A 24.5 K RESISTOR FROM CAL. OUT CONNECTED TO GROUND. CLAMP CURRENT PROBE AROUND RESISTOR LEAD. CURRENT FLOW IS 4 mA.

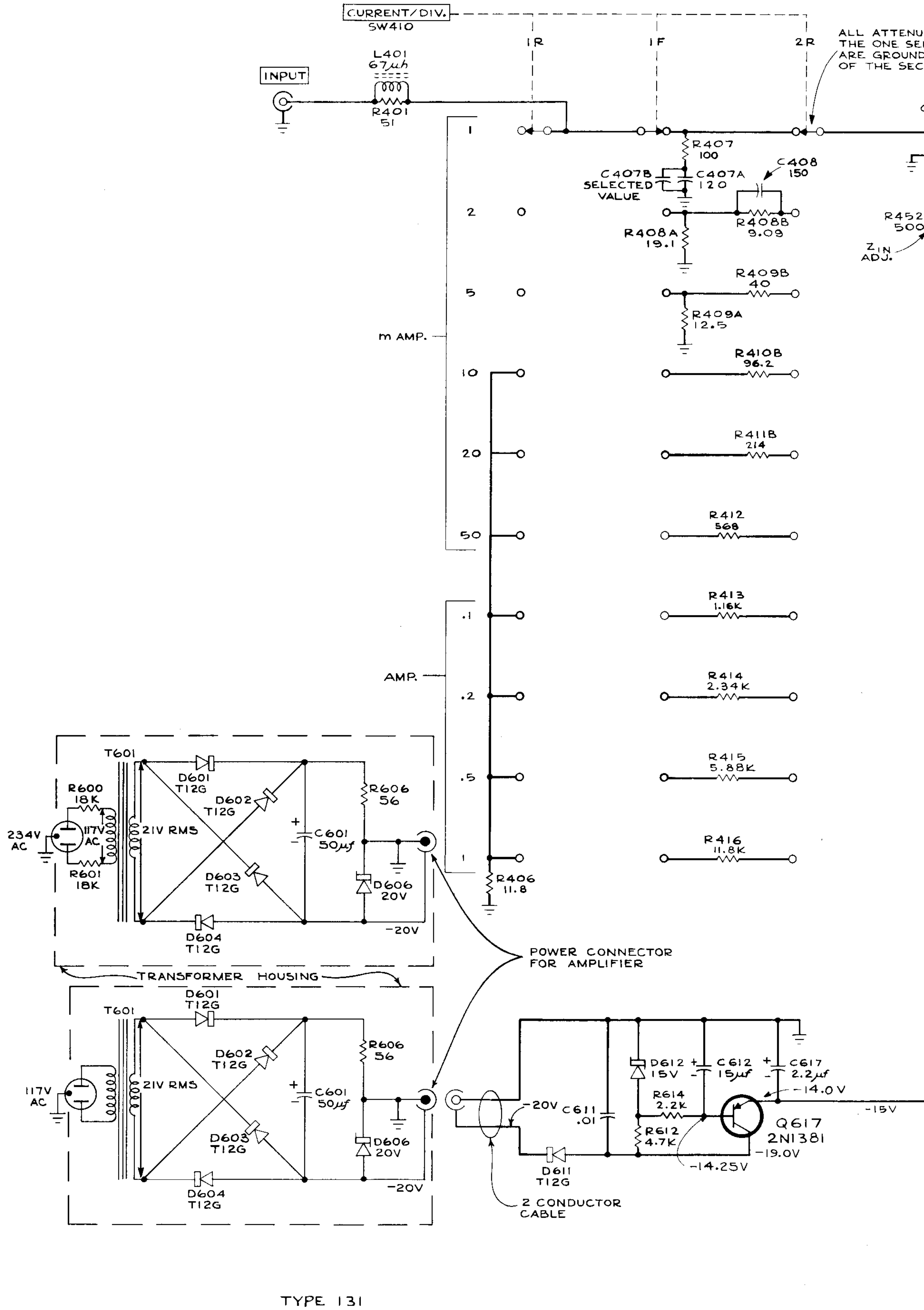
131 2631 CURRENT PROBE

TP

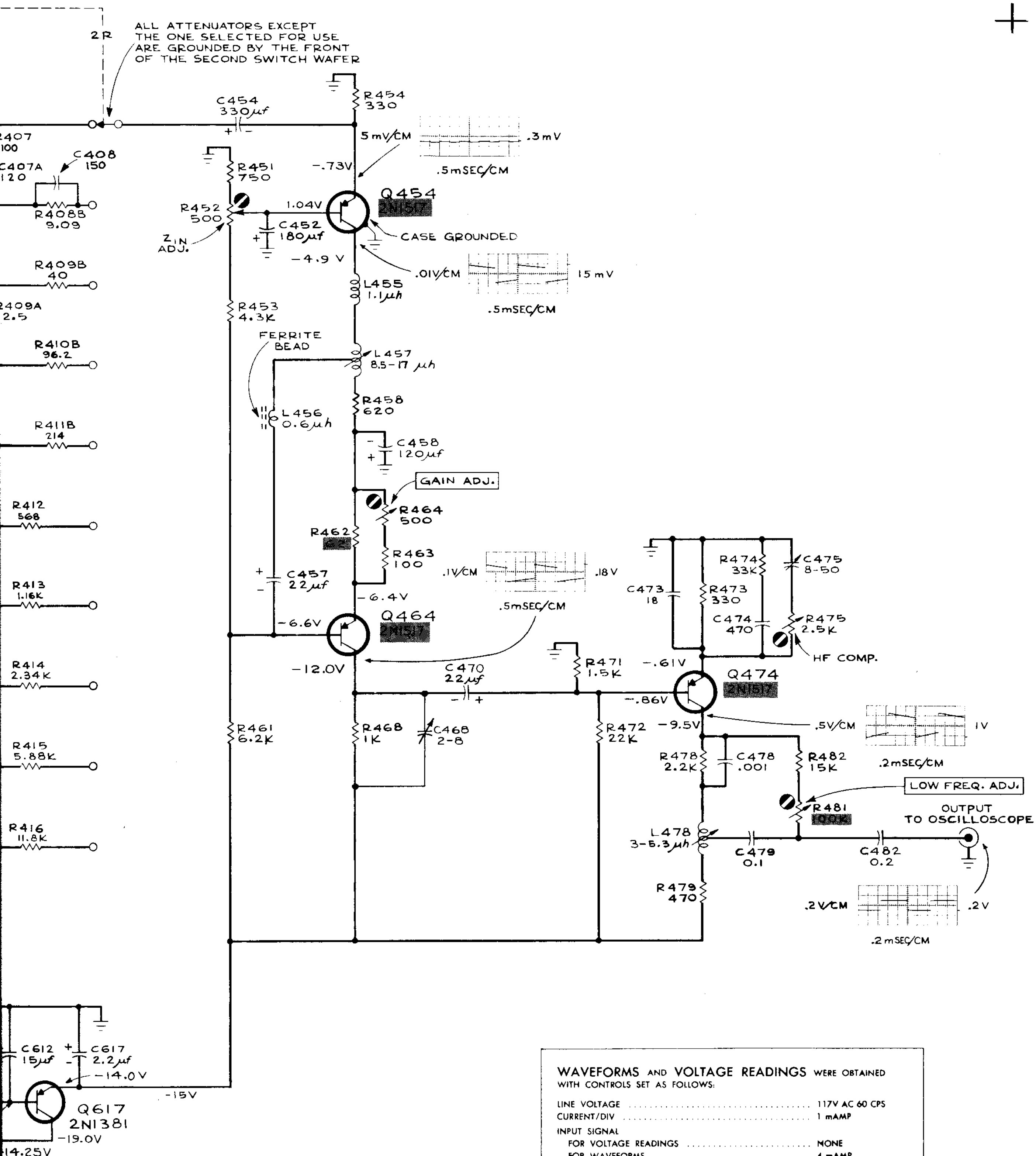
D2

CURRENT PROBE AMPLIFIER

MODELS 1, 2 & 3


CURRENT/DIV.
SW410
INPUT
L401
67µh
R401
51
1R
1F
2R
ALL ATTENU
THE ONE SE
ARE GROUND
OF THE SEC
R407
100
C407B
SELECTED
VALUE
C407A
120
C408
150
R408A
19.1
R408B
9.09
R452
500
Z IN
ADJ.
R409B
40
R409A
12.5
R410B
96.2
R411B
214
R412
568
R413
1.16K
R414
2.34K
R415
5.88K
R416
11.8K
R406
11.8
m AMP.
AMP.
1
2
5
10
20
50
.1
.2
.5
1
T601
R600
18K
R601
18K
234V
AC
117V
AC
21V RMS
D601
T12G
D602
T12G
D603
T12G
D604
T12G
C601
50µf
R606
56
D606
20V
-20V
TRANSFORMER HOUSING
POWER CONNECTOR
FOR AMPLIFIER
117V
AC
-20V
C611
.01
D611
T12G
2 CONDUCTOR
CABLE
D612
15V
C612
15µf
C617
2.2µf
R614
2.2K
R612
4.7K
-14.0V
-14.25V
-19.0V
Q617
2N1381
-15V

TYPE 131



SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH RED TINT BLOCKS

WAVEFORMS AND VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117V AC 60 CPS
CURRENT/DIV	1 mAMP
INPUT SIGNAL	
FOR VOLTAGE READINGS	NONE
FOR WAVEFORMS	4 mAMP 1 KC SQUARE-WAVE

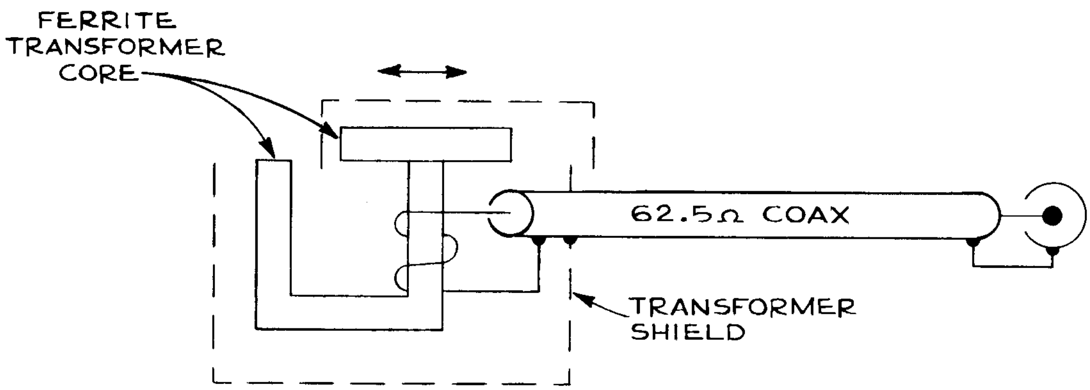
NOTE:

SET CALIBRATOR OF TEKTRONIX 530-540 SERIES OR EQUIVALENT OSCILLOSCOPE TO 100 VOLTS. CONNECT A 24.5 K RESISTOR FROM CAL. OUT CONNECTED TO GROUND. CLAMP CURRENT PROBE AROUND RESISTOR LEAD. CURRENT FLOW IS 4 mA.

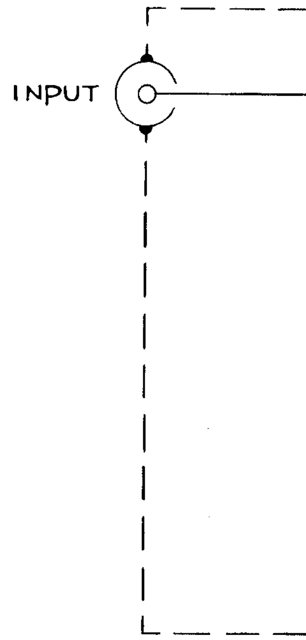
TP

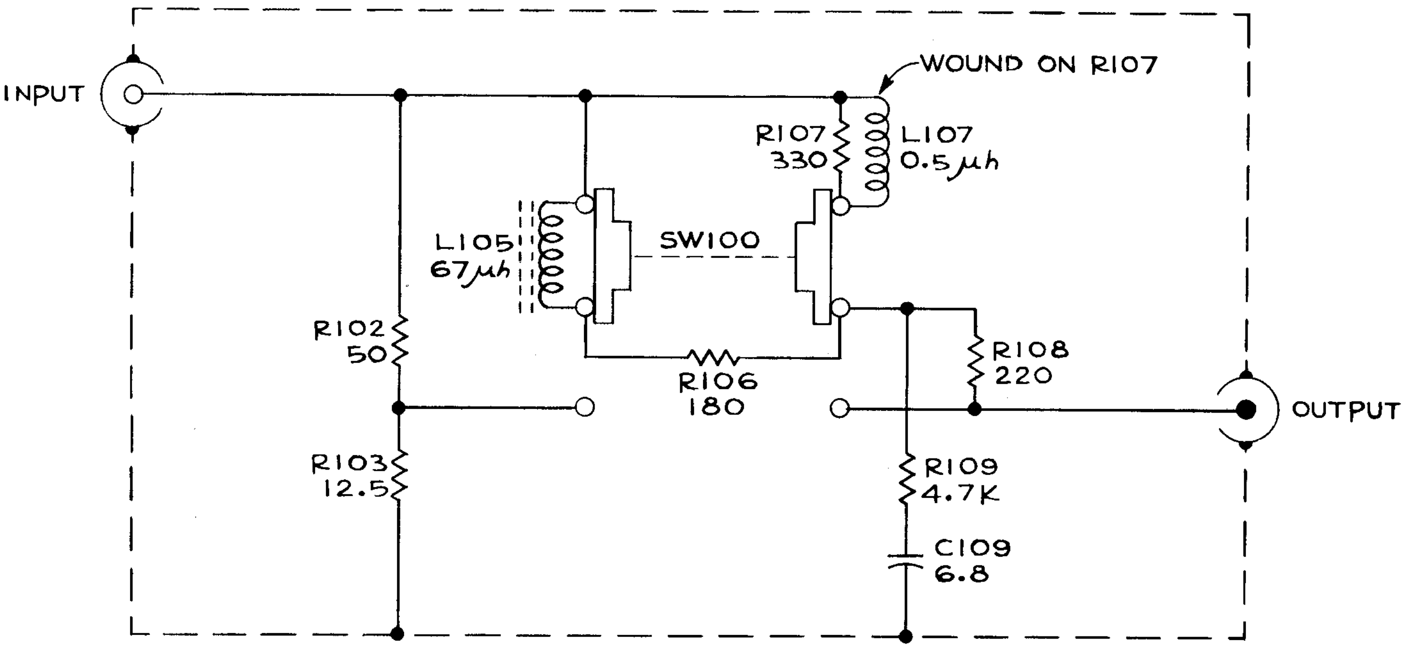
F2

CURRENT PROBE AMPLIFIER
MODEL 4



CURRENT PROBE - P6016





PASSIVE TERMINATION

7-6-60
TR

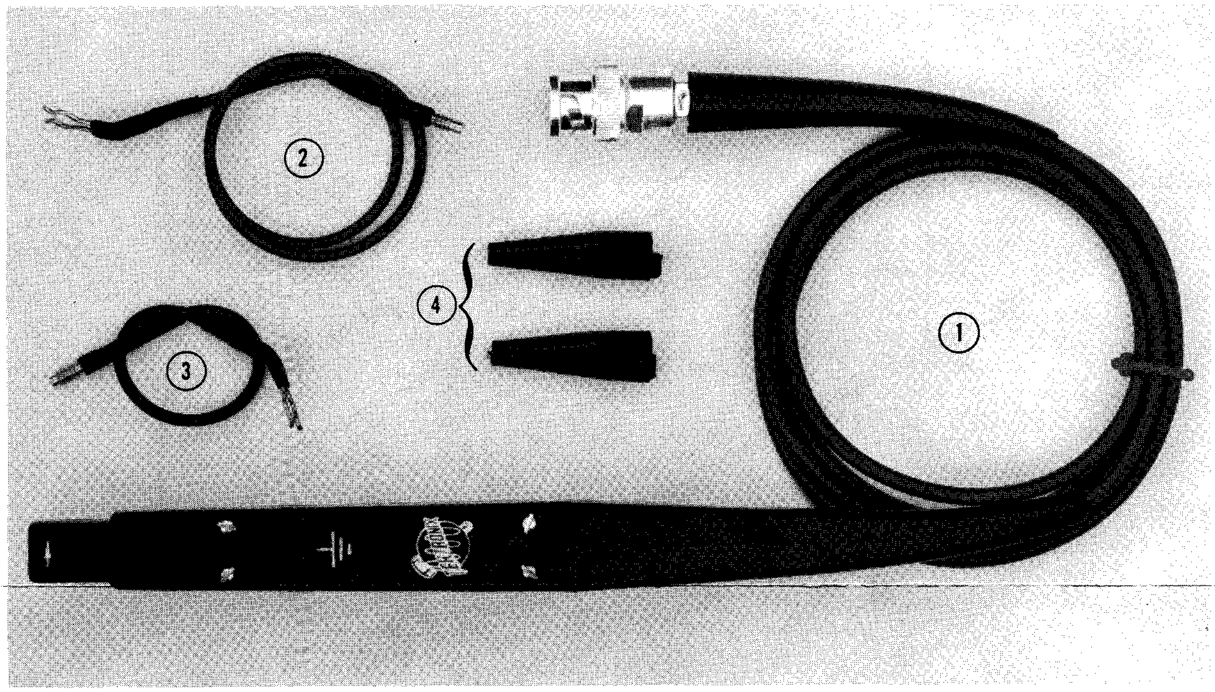
CURRENT PROBE & TERMINATION

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

P6016 PROBE PACKAGE



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
PROBE PACKAGE					
1-4	010-0037-00				P6016 CURRENT PROBE WITH STANDARD ACCESSORIES
PROBE ONLY					
1	010-0169-00				PROBE, current
STANDARD ACCESSORIES					
2	175-0125-00			1	CABLE, ground lead, 12 inch
3	175-0124-00			1	CABLE, ground lead, 5 inch
4	344-0046-00			2	CLIP, probe

PUBLICATION NO.

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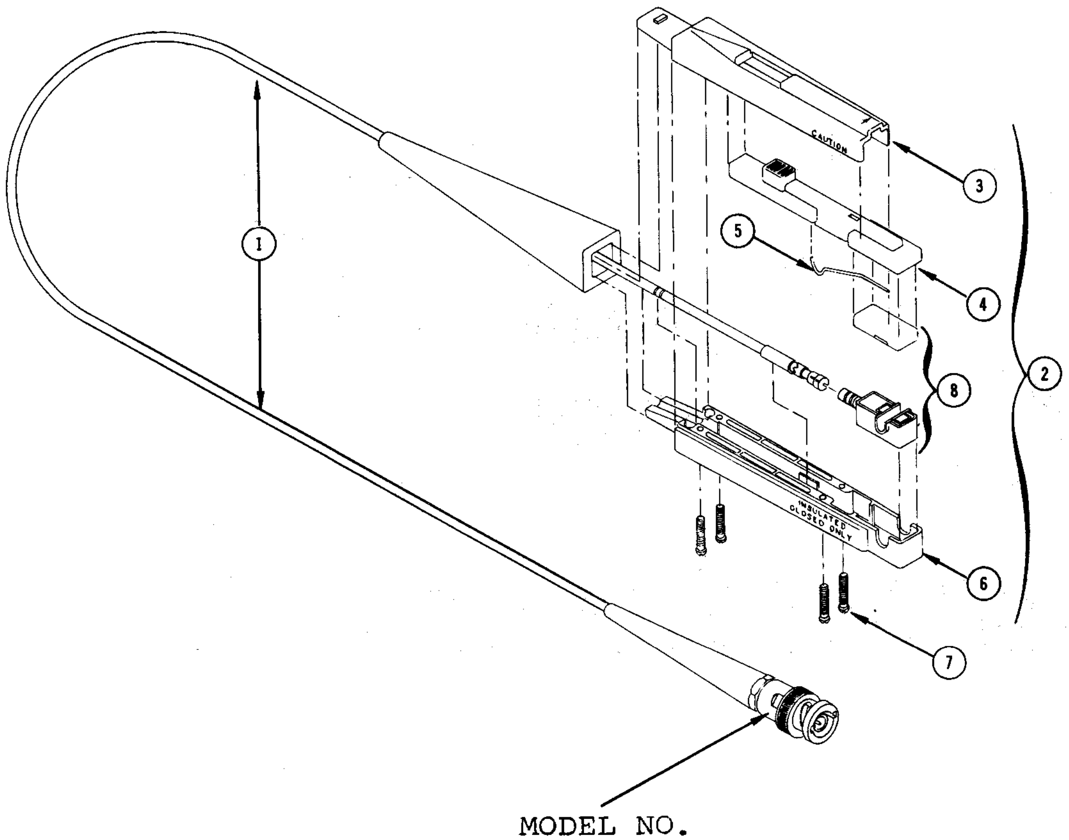
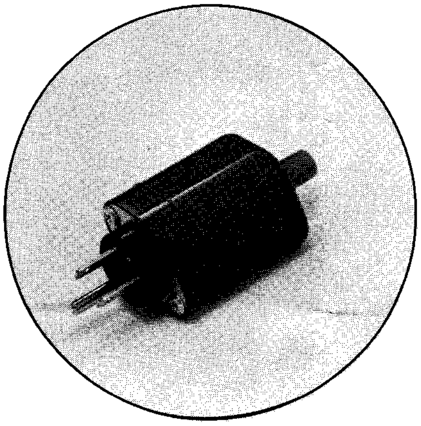
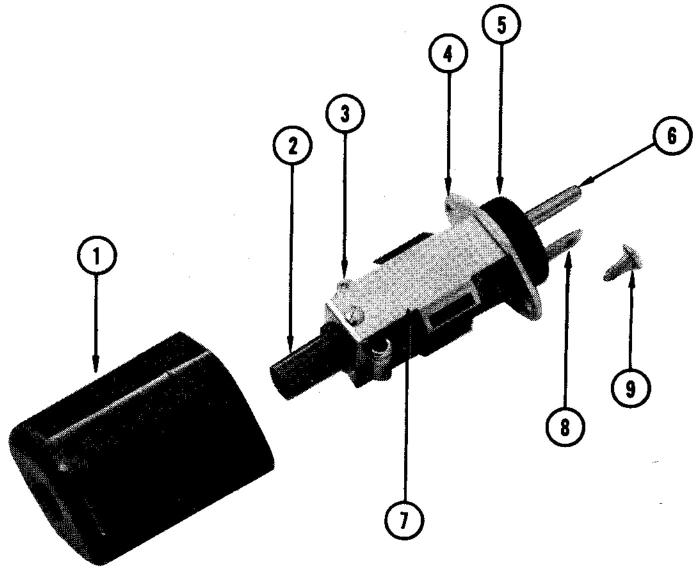
PROBE REPLACEABLE PARTS



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	175-0113-00			1	CABLE ASSEMBLY
2	204-0103-00			1	BODY, probe, assembly
	- - - - - -			-	Assembly Includes:
3	204-0053-00	——	6335	1	BODY, current probe, top half
	204-0217-00	6336		1	BODY, current probe, top half
4	351-0042-00			1	SLIDE, delrin
5	214-0140-00			1	SPRING, ground leaf
6	204-0063-00	——	6335	1	BODY, current probe, bottom half
	204-0218-00	6336		1	BODY, current probe, bottom half
7	211-0034-00			4	SCREW, 2-56 x 1/2 inch RHS
8	120-0207-00			1	TRANSFORMER ASSEMBLY

131 POWER SUPPLY (117 VOLT)
(Part No. 015-027)





REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	200-484			1	COVER, transformer
2	131-190			1	CONNECTOR, molded
3	210-201			1	LUG, solder
					Mounting Hardware: (not included)
	211-007			1	SCREW, 4-40 x 3/16 inch BHS
	210-406			1	NUT, hex, 4-40 x 3/16 inch
4	387-265			1	PLATE, cover
5	200-185			1	COVER, 3 wire motor base
	211-015			1	SCREW, 4-40 x 1/2 inch RHS
	377-041			1	INSERT
6	129-060			1	POST, ground
7	406-732			1	BRACKET, transformer mounting
					Mounting Hardware: (not included)
	210-586			2	NUT, keps, 4-40 x 1/4 inch
8	214-078			2	PIN, connecting
9	213-041			2	SCREW, thread cutting, 6-32 x 3/8 inch Truss HS

FOR REPLACEMENT OF ELECTRICAL COMPONENTS SEE REVERSE SIDE

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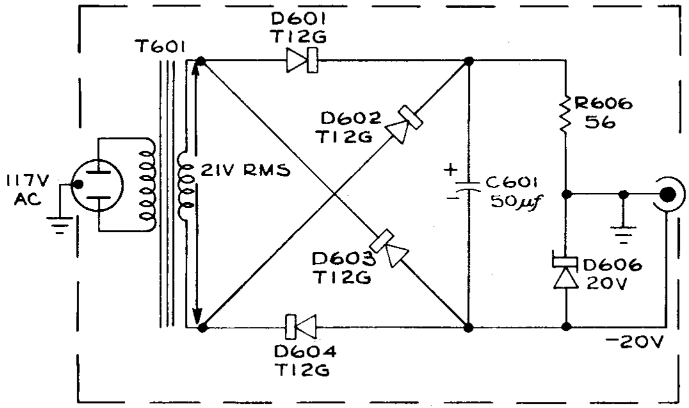
ELECTRICAL COMPONENTS



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
	120-231			1	T601 TRANSFORMER, power
	152-008			4	D601, D602, D603, D604 DIODE, germanium, T12G
	290-158			1	C601 CAPACITOR, 50 μf, EMT, 25 v
	316-560			1	R606 RESISTOR, 56 Ω, 1/4 w, 10%
	152-060			1	D606 DIODE, Zener, 20 v, 1 w, 10%