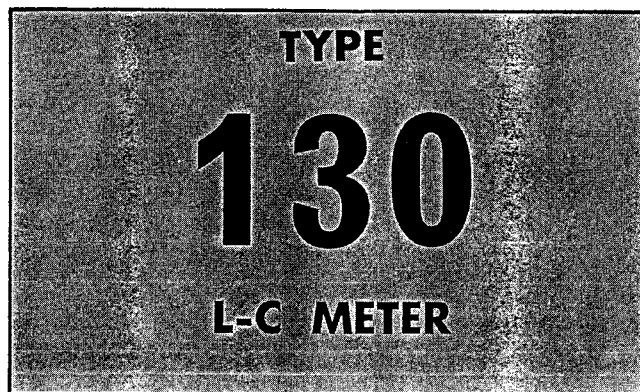


# INSTRUCTION MANUAL

Serial Number \_\_\_\_\_



*Tektronix, Inc.*

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070-0231-01



## 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.

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Abbreviations and symbols used in this manual are based on, or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

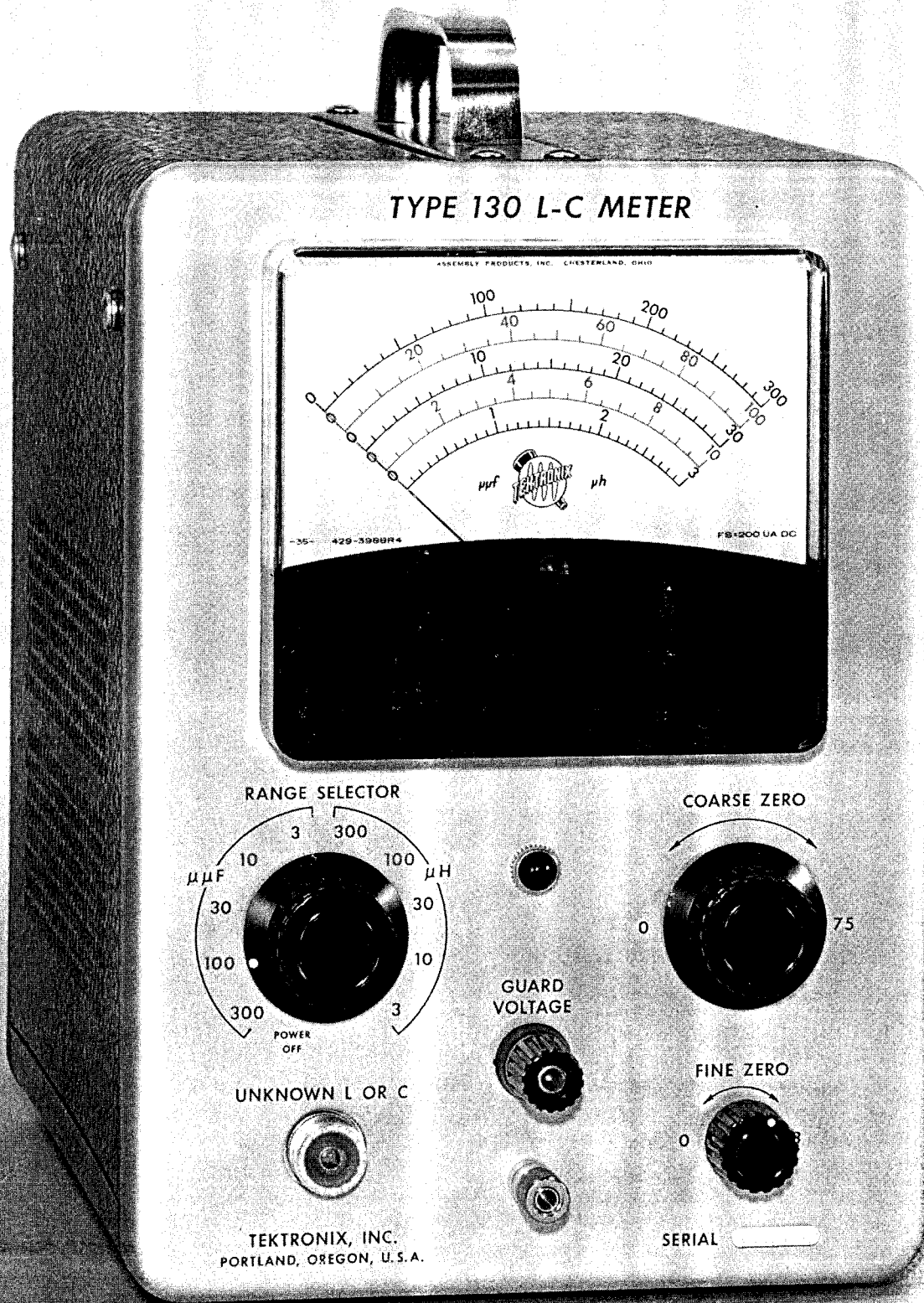


Fig. 1-1. Type 130 L-C Meter.

# SECTION 1

## CHARACTERISTICS

### General Information

The Tektronix Type 130 L-C Meter is a direct reading reactance meter that measures small reactances at a frequency between 125 kHz (Hz = Hertz; one cycle per second) and 140 kHz. The meter indicates inductance up to 300  $\mu\text{H}$  and capacitance up to 300  $\mu\mu\text{F}$ . The unknown inductor or capacitor is part of a resonant circuit whose frequency is compared to a 140 kHz reference oscillator. The meter actually indicates the frequency difference between the two oscillators, but is calibrated directly in  $\mu\text{H}$  and  $\mu\mu\text{F}$ . The Type 130 is designed for making measurements where possible errors of up to 5% of indicated value are permissible.

The Type 130 is particularly useful for measuring small capacitances in the presence of environmental strays. A front-panel Guard Voltage output provides in-phase drive to the environmental capacitance terminal to eliminate strays from a measurement. Thus it is possible to measure vacuum tube interelectrode capacitances.

Measurement of very small reactances is possible if special measuring procedures described in the Operating Instructions of this manual are followed.

### ELECTRICAL CHARACTERISTICS

Ranges—From zero to 3, 10, 30, 100 and 300  $\mu\text{H}$  or  $\mu\mu\text{F}$  full scale. Minimum scale divisions are 0-3: 0.1; 0-10: 0.5; 0-30: 1.0; 0-100: 5.0 and 0-300: 10.

Accuracy (Not using the Guard Voltage)— $\pm 3\%$  of full scale, with minimum of 0.2  $\mu\text{H}$  or 0.2  $\mu\mu\text{F}$  readable on 0-3 scale when meter set at zero before the unknown is connected. Use of suppressed zero technique described in Operating Instructions permits greater resolution of very small reactances. Accuracy of small reactance measurements can be valid only when the circuit resistance at 140 kHz is known. Full scale accuracy of any one range can be improved by special calibration at the time of measurement.

Absolute measurement accuracy will be affected by resistance in series or parallel with the unknown as stated below.

### Circuit Resistance Loading Limits

The Type 130 resistance loading compensation is optimized for operation at or near a line voltage of 117 volts RMS. When operated at or near 117 volts, resistance in series or parallel with the unknown (including the effects of dielectric and core losses) may be tolerated within the following limits.

**Capacitance Measurements.** Resistance as low as 100  $\text{k}\Omega$  in parallel with the unknown will have negligible effect upon the measurement accuracy. Correction tables in the Operating Instructions indicate corrections needed for values

as low as 30  $\text{k}\Omega$ . Resistance in series with the unknown will affect accuracy in proportion to the capacitive reactance at the measuring frequency (excepting the actual lead and body capacitance of discrete resistances involved).

**Inductance Measurements.** Effective resistance components up to 10  $\Omega$  in series with the unknown (core losses appear as series resistance) or as low as 20  $\text{k}\Omega$  parallel resistance will have negligible effect upon the measurement accuracy. Correction tables in the Operating Instructions indicate corrections needed for series values as high as 35  $\Omega$ . Resistance in parallel with the unknown will affect accuracy in proportion to the inductive reactance at the measuring frequency.

### Guard Voltage

The Guard Voltage can be used to neutralize the effect of up to 300  $\mu\mu\text{F}$  environmental capacitance around an unknown capacitor if the guard terminal loading is not excessive. Loading limits must be determined for each instrument. Nominal limits for guard circuit use in three terminal capacitance measurements are:

Capacitance between Guard Voltage terminal and Unknown terminal is 300  $\mu\mu\text{F}$  maximum.

Capacitance between Guard Voltage terminal and chassis ground is 100  $\mu\mu\text{F}$  maximum when its parallel resistance is  $\geq 50 \text{ k}\Omega$ , and 200  $\mu\mu\text{F}$  maximum when its parallel resistance is  $\geq 100 \text{ k}\Omega$ .

Total series resistance between Unknown terminal and chassis ground must be  $\geq 100 \text{ k}\Omega$ . (See Fig. 2-9.)

### Voltage Across Unknown

The sine wave voltage at the unknown reactance is not greater than 1 volt peak to peak across capacitors, nor greater than  $\frac{1}{4}$  volt peak to peak across inductors. Capacitors above 100  $\mu\mu\text{F}$  decrease the voltage slightly. Very small inductors have much less voltage across them.

### Power Requirements

105 to 125 or 210 to 250 volt AC RMS, 50 to 60 cycles. Do not use saturable reactor line voltage stabilizers that distort the waveform more than 5%. Power consumption at 117 or 234 volts, 40 watts.

### PHYSICAL CHARACTERISTICS

The chassis is made of light weight aluminum alloy, with blue vinyl finished cabinet and anodized front panel. Dimensions—7" wide, by 10 $\frac{1}{2}$ " high and 10 $\frac{3}{4}$ " deep. Weight—Approximately 9 pounds.



# SECTION 2

## OPERATING INSTRUCTIONS

### General

Two general types of reactance measurements can be made using the Tektronix Type 130 L-C Meter; individual inductors or capacitors, or in-circuit capacitors. Measurement procedures are included in this section of the manual.

The Type 130 will withstand the usual amount of shock and vibration that a meter movement can withstand, and any ambient temperature the operator is likely to tolerate.

Measurements are most easily made using either the P93C probe, Fig. 2-1, or the Production Test Fixture shown in Fig. 2-2. The P93C Probe is a piece of shielded lead slightly longer than two feet. The probe has a UHF connector on one end and the copperweld center conductor is exposed at the other end.

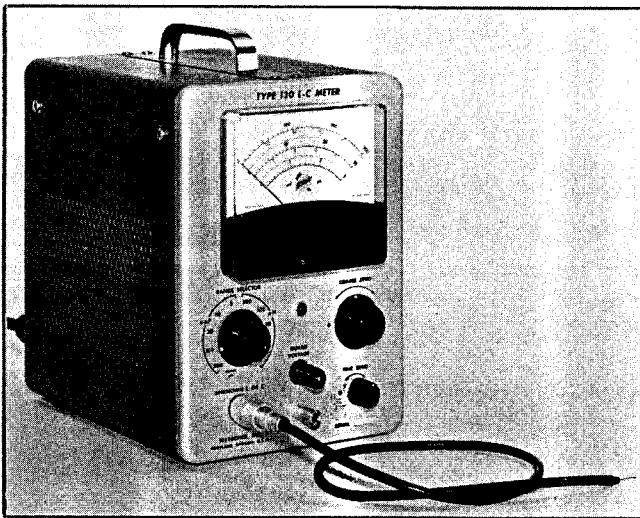


Fig. 2-1. Type 130 with P93C Probe.

The Type 130 measures the series inductance of inductors. Its sensitivity to distributed capacitance is low, but it is sensitive to either series or shunt resistance. Measurements of small inductors are made at a frequency of 140 kHz, with measurement frequency down to 125 kHz for 300  $\mu$ H inductors.

The L-C Meter measures the series capacitance of capacitors, and is sensitive to either series or shunt resistance. Measurement is made at a frequency of 140 kHz for small capacitors. For 300  $\mu$ F capacitors, the measurement frequency is 125 kHz.

The unknown reactance is part of a resonant circuit. The frequency of the unknown circuit is compared to a stable reference oscillator. Both capacitive and inductive unknowns are only a small part of the total reactance of the oscillator circuit.

**Inductors.** The current of the Type 130 unknown oscillator tank flows through the unknown inductor, causing only

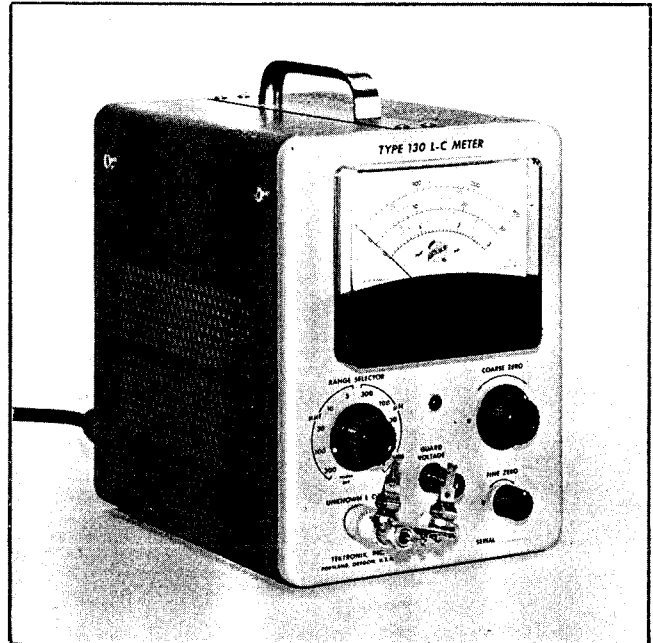


Fig. 2-2. Type 130 with Production Test Fixture.

a few millivolts of signal to appear across it. See Fig. 2-3. The Type 130 indicates the inductance of the unknown as if measured in a series mode by other bridge devices at the

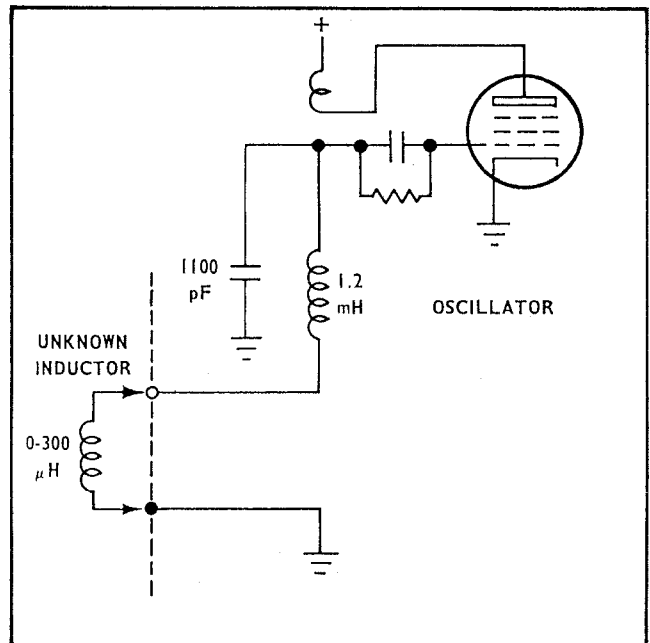


Fig. 2-3. Inductance measurement. Oscillator DC grid return is completed through the Unknown.

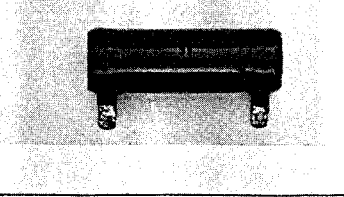
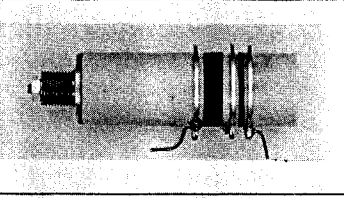
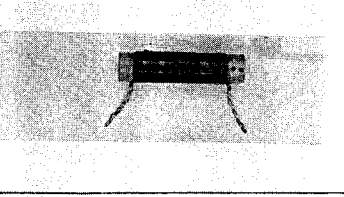
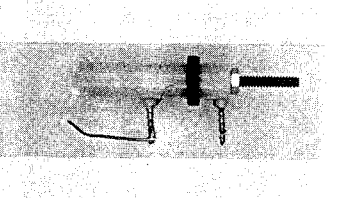
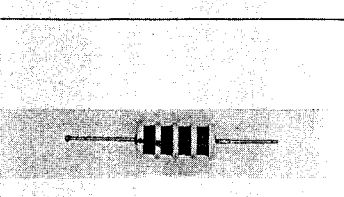
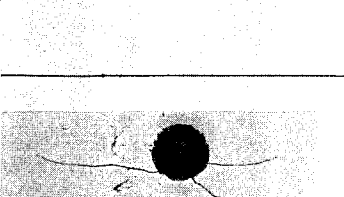
frequency of 125 to 140 kHz. Since it is the normal characteristic of inductors to reduce their inductance with increasing frequency, inductors with less than 10 Ω series losses (including any core losses) will have a slightly higher value of inductance when measured at lower frequencies. Inductors with magnetic cores are normally operated at the initial permeability of the core by the Type 130, so comparison

measurement by any other method must also excite the unknown very lightly.

Table 2-1 shows the series inductance values of six different inductors, measured by three different methods at five different frequencies. Note the effect of large series resistance in the Type 130 measurement of inductors number 4 and 5.

TABLE 2-1

Series inductance values of test inductors at five frequencies.

	Inductor	Test Method	Value
	1. 6 Ω, 25 W, Wire Wound Res. DC. Res. 5.982 Ω	Maxwell Bridge  Type 130  Schering Bridge	1 kHz 7.2 μH, Q = 0.008, R = 5.75 Ω 10 kHz 7.0 μH, Q = 0.078, R = 5.77 Ω  140 kHz 5.15 μH  0.55 MHz 4.01 μH, R = 8 Ω 1.0 MHz 3.43 μH, R = 12 Ω
	2. 3/4" Single Layer Powered Core DC. Res. 0.7466 Ω	Maxwell Bridge  Type 130  Schering Bridge	1 kHz 18.7 μH, Q = 0.230, R = 0.514 Ω 10 kHz 18.6 μH, Q = 2.37, R = 0.506 Ω  138 kHz 18.0 μH  0.55 MHz 17.10 μH, R = 8 Ω 1.0 MHz 17.29 μH, R = 20 Ω
	3. 5/16" Single Layer Air Core DC. Res. 0.9644 Ω	Maxwell Bridge  Type 130  Schering Bridge	1 kHz 17.8 μH, Q = 0.112, R = 1.08 Ω 10 kHz 17.7 μH, Q = 1.15, R = 0.976 Ω  138 kHz 17.45 μH  0.55 MHz 16.76 μH, R = 6 Ω 1.0 MHz 16.87 μH, R = 18 Ω
	4. 3/8" Single Pi Powered Core DC. Res. 6.823 Ω	Maxwell Bridge  Type 130  Schering Bridge	1 kHz 310.4 μH, Q = 0.287, R = 6.7 Ω 10 kHz 309.5 μH, Q = 2.97, R = 6.7 Ω  125 kHz 300 μH (error due to large effective AC resistance)  0.55 MHz 380 μH, R = 660 Ω 1.0 MHz 1620 μH, R = 4.84 kΩ
	5. 1/4" Four Section Multilayer, Air Core DC. Res. 16.40 Ω	Maxwell Bridge  Type 130  Schering Bridge	1 kHz 265.6 μH, Q = 0.103, R = 15.7 Ω 10 kHz 264.0 μH, Q = 1.04, R = 16.15 Ω  130 kHz 249.5 μH (error due to large effective AC resistance)  0.55 MHz 285.8 μH, R = 460 Ω 1.0 MHz 1273.5 μH, R = 3.3 kΩ
	6. Toroid on 455 kHz Xfmr Core DC. Res. 1.024 Ω	Maxwell Bridge  Type 130  Schering Bridge	1 kHz 41.1 μH, Q = 0.25, R = 1.04 Ω 10 kHz 40.65 μH, Q = 2.52, R = 1.05 Ω  135 kHz 40.0 μH  0.55 MHz 36.25 μH, R = 57 Ω 1.0 MHz 32.65 μH, R = 144 Ω

**Capacitors.** The Type 130 unknown oscillator tank voltage appears across the unknown capacitor at less than 1 volt peak to peak. The capacitance of the unknown is measured in a series mode at a frequency of 125 to 140 kHz. Capacitance within the Type 130 unknown resonant circuit is a little more than 0.001 μF, so that the external unknown

is less than 30% of the total tank circuit capacitance. See Fig. 2-4. It is this relationship that permits resistance in series with the unknown to alter the reading in direct proportion to the capacitive reactance at the measuring frequency. Resistance of 100 kΩ or greater can be in parallel with the unknown capacitor, and not significantly change the reading



## FIRST TIME OPERATION

Turn on the Type 130 by setting the RANGE SELECTOR switch to  $300 \mu\mu\text{F}$ .

Attach the measuring device, either the P93C Probe or the Production Test Fixture.

## Capacitance Measurement

Set the electrical zero. Set the FINE ZERO control with the white dot at top midrange.

Check that nothing is near the probe or test fixture hot terminal. If using the probe, do not lay the tip on the bench surface.

Adjust the COARSE ZERO control for minimum meter reading.

Change the RANGE SELECTOR switch to the desired range. Adjust the FINE ZERO control for zero meter reading.

## NOTE

Always adjust the FINE ZERO control with the RANGE SELECTOR switch set to the range to be used. Make the adjustment just before making the measurement.

When using the Production Test Fixture, adjust the FINE ZERO control for zero meter reading. Move your hand away from the instrument front panel and check that the meter remains at zero. If necessary, adjust the FINE ZERO so that it will give a zero reading when the hand is taken away from the front panel area.

Capacitors larger than  $300 \mu\mu\text{F}$  may cause the meter to read up scale, but at a value less than  $300 \mu\mu\text{F}$ . Capacitors just a few  $\mu\mu\text{F}$  above 300 will cause the meter to go off scale above 300. Capacitors between 450 and  $900 \mu\mu\text{F}$  will cause the meter to wander or fluctuate. Capacitors larger than about  $1200 \mu\mu\text{F}$  may stop the unknown oscillator and cause a zero meter reading.

**Using the P93C Probe.** The unknown capacitor can be handled in two ways when measuring it with the P93C Probe.

1. Secure one lead of the unknown to the Type 130 frame at the metal ground terminal. Hold the probe tip about 2 inches away from the other lead of the capacitor. Set the meter electrical zero. Then touch the probe to the open lead of the unknown and read the meter. If the reading is less than the value of the next lower scale, change the RANGE SELECTOR switch, zero the meter, and make the measurement. See Fig. 2-5.

2. The unknown ground lead may be held by an alligator clip at the end of one of the flexible leads supplied with the instrument. Do not lay the unknown on a conducting or dielectric surface. The ground clip can be used as the connection to a capacitor that has had the other end unsoldered from a circuit. Make the measurement as in 1 above. See Fig. 2-6.

**Capacitance Measurement Without A Probe or Fixture.** The most accurate method of measuring small capacitors is to use the flexible ground clip, and no probe or adapter at the UNKNOWN L OR C connector.

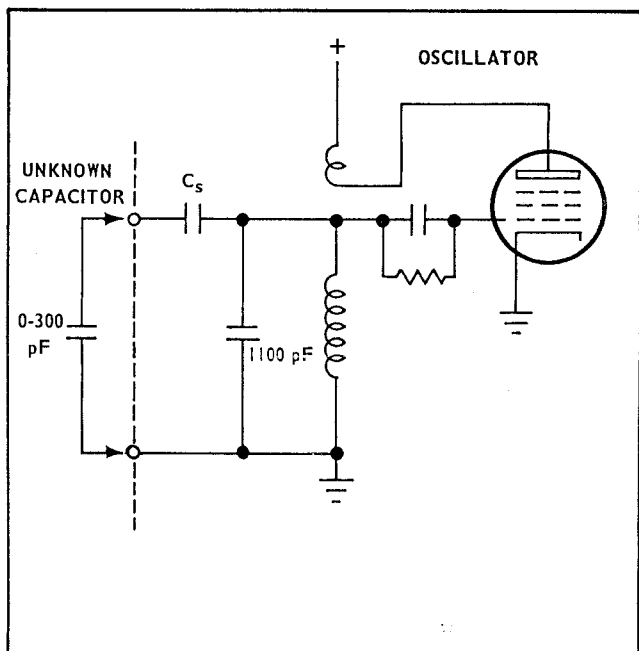


Fig. 2-4. Capacitance measurement.  $C_s$  permits unknown to be DC biased.

(providing the line voltage is at 117 volts AC).

The dielectric constant of modern capacitors (that are measurable on the Type 130) is usually the same at 140 kHz as it is at low frequencies. Thus the Type 130 capacitance accuracy can be checked at any value by measuring 1% capacitors that are initially measured on a low frequency bridge. Standard capacitors commercially available are usually calibrated at various frequencies, and data is available from the manufacturer.

## PRELIMINARY PROCEDURE

## LINE VOLTAGE

If desired you can convert the instrument from 117-volt operation to 234-volt operation, or vice versa, by changing the wiring at the primary of the power transformer.

A 0.4 ampere Slo-Blo fuse is required for 234 V, 60-cycle operation.

Check the meter mechanical zero adjustment before turning the instrument on. Do not tap the meter front panel, since the taut-band meter has no pivot friction. (Instruments before SN 8654 have a jeweled movement meter and it may help to lightly tap the meter face when zeroing.)

The Type 130 power transformer primary is wired for the line voltage labeled near the power cord socket on the rear panel. Connect the power cord to the correct line voltage and frequency.

All accurate measurements require a warm-up period of at least 20 minutes. Warm up the Type 130 with the RANGE SELECTOR switch at  $300 \mu\mu\text{F}$ .

## NOTE

Operate the Type 130 on a non-conducting surface when measuring small capacitors.

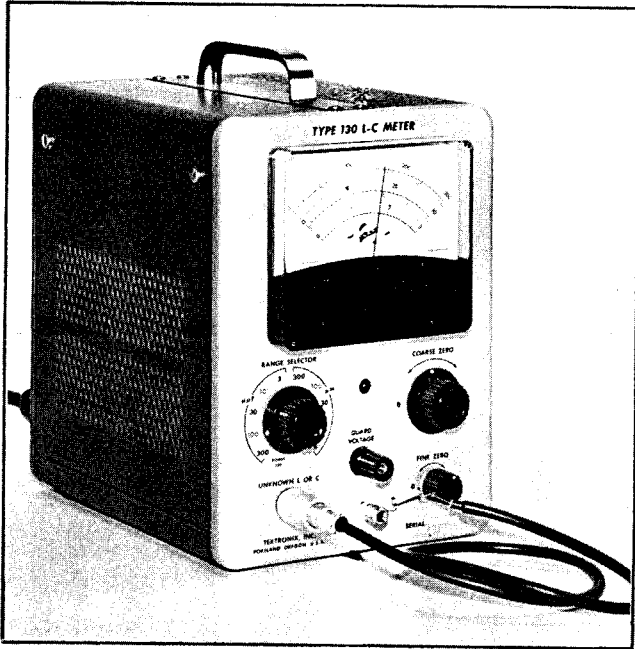


Fig. 2-5. Unmounted capacitor measurement using P93C Probe.

Balance the Type 130 zero controls at the correct range. Secure one end of the unknown in the ground lead alligator clip. Holding the clip in the hand, touch the open lead of

the capacitor to the center of the UNKNOWN L OR C connector and read the meter. See Fig. 2-7.

**Using the Production Test Fixture.** Zero the meter as previously described. Once zeroed, place the unknown in the clips of the fixture and read the meter. (The meter may go off scale when your hands touch the fixture hot terminal. This is normal and will not damage the Type 130.)

**Measuring Capacitors Less Than 1  $\mu\mu\text{F}$ .** Instead of carefully zeroing the meter, find the zero point of the 3  $\mu\mu\text{F}$  range and then turn the FINE ZERO control clockwise until the meter reads 1  $\mu\mu\text{F}$ . Connect the unknown in one of the three ways just suggested, read the meter, and subtract 1  $\mu\mu\text{F}$  from the reading. (If the FINE ZERO control is incorrectly turned counterclockwise, the meter will read downscale when an unknown less than 2  $\mu\mu\text{F}$  is connected.)

Always bend the excess lead that extends to the right of the production test fixture, back towards the unknown for accurate measurements.

**NOTE**

Methods of measuring capacitors larger than 300  $\mu\mu\text{F}$ , or increasing the accuracy of measuring capacitors slightly larger than 10 or 30  $\mu\mu\text{F}$  are described under special measurements later in this section.

**Inductance Electrical Zero**

The electrical zero for inductance measurements must be

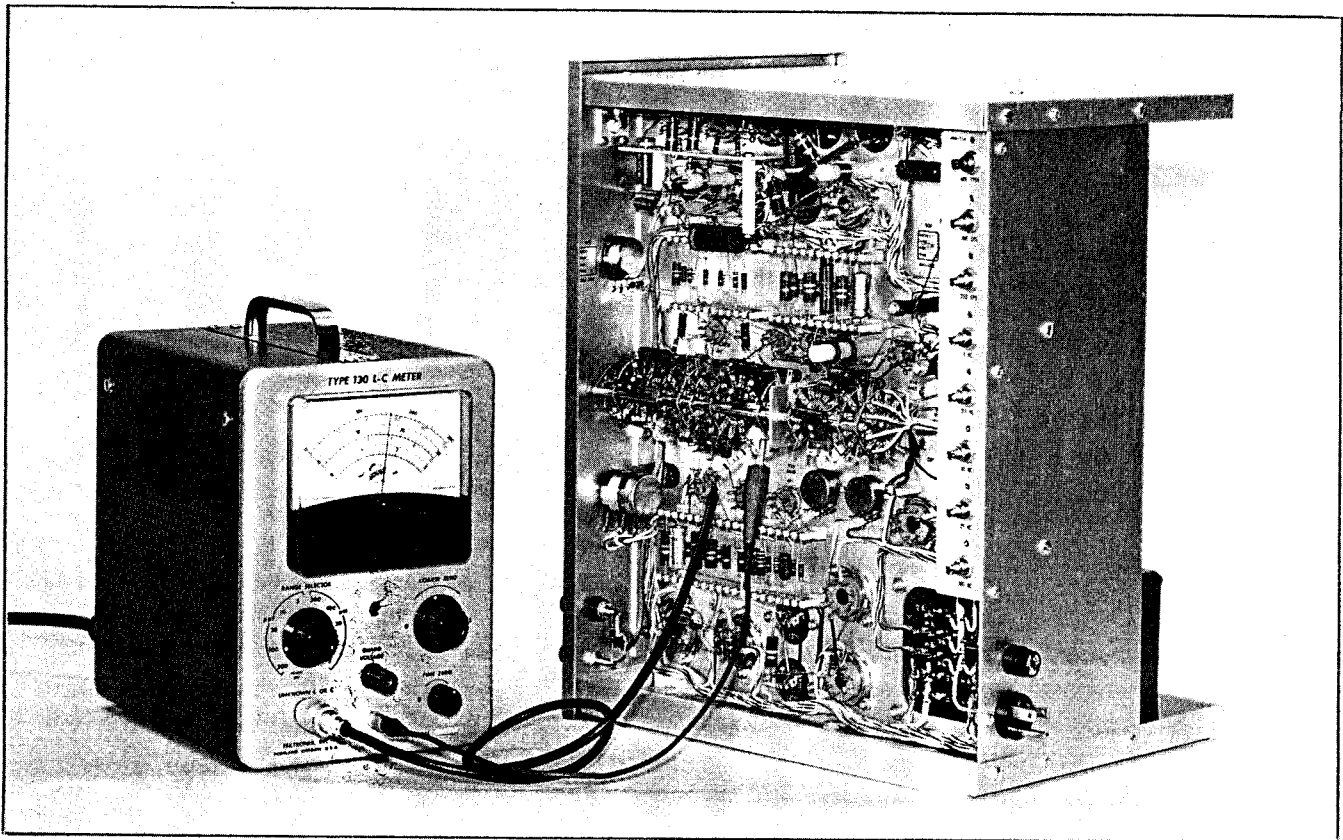


Fig. 2-6. Mounted capacitor measurement using P93C Probe.

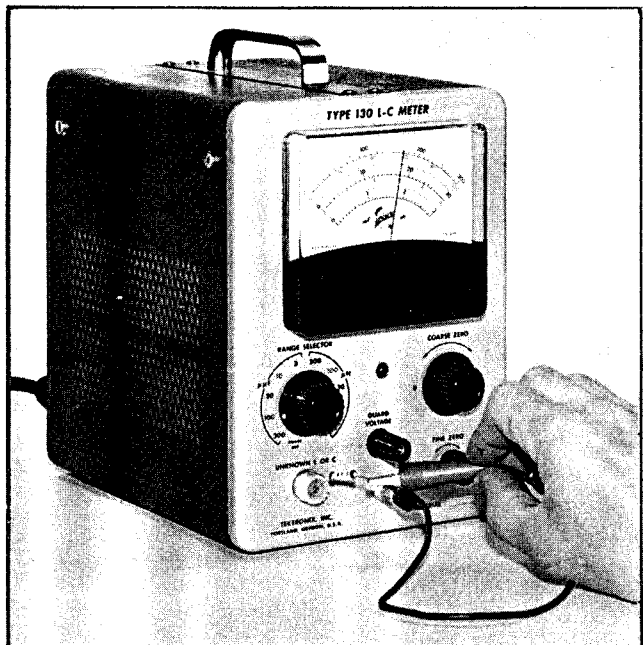


Fig. 2-7. Unmounted capacitor measurement using clip lead.

made including the total lead lengths used in the actual measurement.

Attach the measuring device (either the P93C Probe, the Production Test Fixture, or one of the supplied ground leads). Place all leads in approximately the same physical position they will occupy during the measurement. Turn on the Type 130 and let it warm up a few minutes.

Set the RANGE SELECTOR to 300  $\mu\text{H}$ .

Connect the UNKNOWN L OR C terminal to ground at the point where the unknown inductor will be grounded. Adjust the COARSE ZERO control so the meter goes to zero. Set the RANGE SELECTOR to the desired range and adjust both the COARSE ZERO and FINE ZERO controls so the meter goes to zero.

If the value of the unknown inductor is truly unknown, set the RANGE SELECTOR switch to 300  $\mu\text{H}$  before connecting the unknown.

#### NOTE

Inductors larger than 300  $\mu\text{H}$  may cause the meter to read upscale in an unstable fashion or prevent an indication. Never rely on a measurement when the meter wanders or fluctuates.

**Measuring Inductors Smaller Than 3  $\mu\text{H}$ .** Set the RANGE SELECTOR to switch to 3  $\mu\text{H}$ . Instead of carefully zeroing the meter, find the zero point while grounding the test terminal, then turn the FINE ZERO control clockwise until the meter reads not more than 1  $\mu\text{H}$ . Connect the unknown using a short ground lead (or the test fixture only), read the meter, and subtract 1  $\mu\text{H}$  from the reading. Do not use a flexible ground lead or the measurement will be inaccurate. A change in length of the measuring circuit of as little as one inch is noticeable using this test method.

## SPECIAL MEASUREMENTS

Included in this section on special measurements are the following:

1. A graph that gives data to permit extending the useful range of the Type 130 up to about 10,000  $\mu\text{H}$  or 10,000  $\mu\mu\text{F}$ . Accuracy of the extended ranges is  $\pm 15\%$  of full scale up to 1500  $\mu\text{H}$  or 1500  $\mu\mu\text{F}$ .
2. Use of the Guard Voltage when measuring in-circuit capacitors.
3. A table to aid in making corrections for resistance in parallel with a capacitor. The data is calculated, and correction values must be determined for each Type 130 instrument, after each calibration.

### Extending the Type 130 Ranges

To extend the inductance range of the Type 130 to values greater than 300  $\mu\text{H}$ , place an accurate 300  $\mu\text{H}$  inductor across the unknown terminals so that the larger unknown can be placed in parallel with it. The 300  $\mu\text{H}$  inductor must have a series resistance (including any core losses) less than 10 ohms at 125 kHz. It is preferable that the 300  $\mu\text{H}$  inductor be variable so it can be adjusted to full scale when the RANGE SELECTOR switch is at 300  $\mu\text{H}$ . Any inductance in parallel will cause the Type 130 to read less than 300  $\mu\text{H}$ . Read the meter for the parallel value and use Fig. 2-8 to obtain the value of the unknown.

To extend the capacitance range of the Type 130 to values greater than 300  $\mu\mu\text{F}$ , place an accurate 300  $\mu\mu\text{F}$  capacitor in series with the unknown. It is preferable that the 300  $\mu\mu\text{F}$  capacitor include a variable element so it can be adjusted to full scale when the RANGE SELECTOR switch is at 300  $\mu\mu\text{F}$ . The physical arrangement must be stable, using a wire in place of the unknown at initial adjustment of the 300  $\mu\mu\text{F}$  capacitor. With the unknown in series, read the meter and use Fig. 2-8 to obtain the value of the unknown.

To extend either the 10  $\mu\mu\text{F}$  or 30  $\mu\mu\text{F}$  ranges so capacitors of 10.1 to 20  $\mu\mu\text{F}$  and 30.1 to 50  $\mu\mu\text{F}$  can be measured more accurately, use the SUPPRESSED ZERO technique. The Suppressed Zero technique raises the Type 130 zero frequency a calibrated amount, so that capacitors larger than the full scale value of a range can be measured more accurately.

As an example to measure a 12  $\mu\mu\text{F}$  capacitor more accurately than is possible on the 30  $\mu\mu\text{F}$  range:

1. Zero the meter with the RANGE SELECTOR at 10  $\mu\mu\text{F}$ .
2. Change the RANGE SELECTOR to 3  $\mu\mu\text{F}$  and check the amount and polarity of indication away from zero. Record the deviation from zero so that proper correction can be made in step 5 below.
3. Set the RANGE SELECTOR to 10  $\mu\mu\text{F}$  (properly zeroed) and measure an adjustable 10  $\mu\mu\text{F}$  capacitor. Adjust the capacitor for exactly full scale 10  $\mu\mu\text{F}$  value.
4. With the 10  $\mu\mu\text{F}$  capacitor in place, adjust the zero controls for a new meter zero. Do so by turning the COARSE ZERO control counterclockwise.

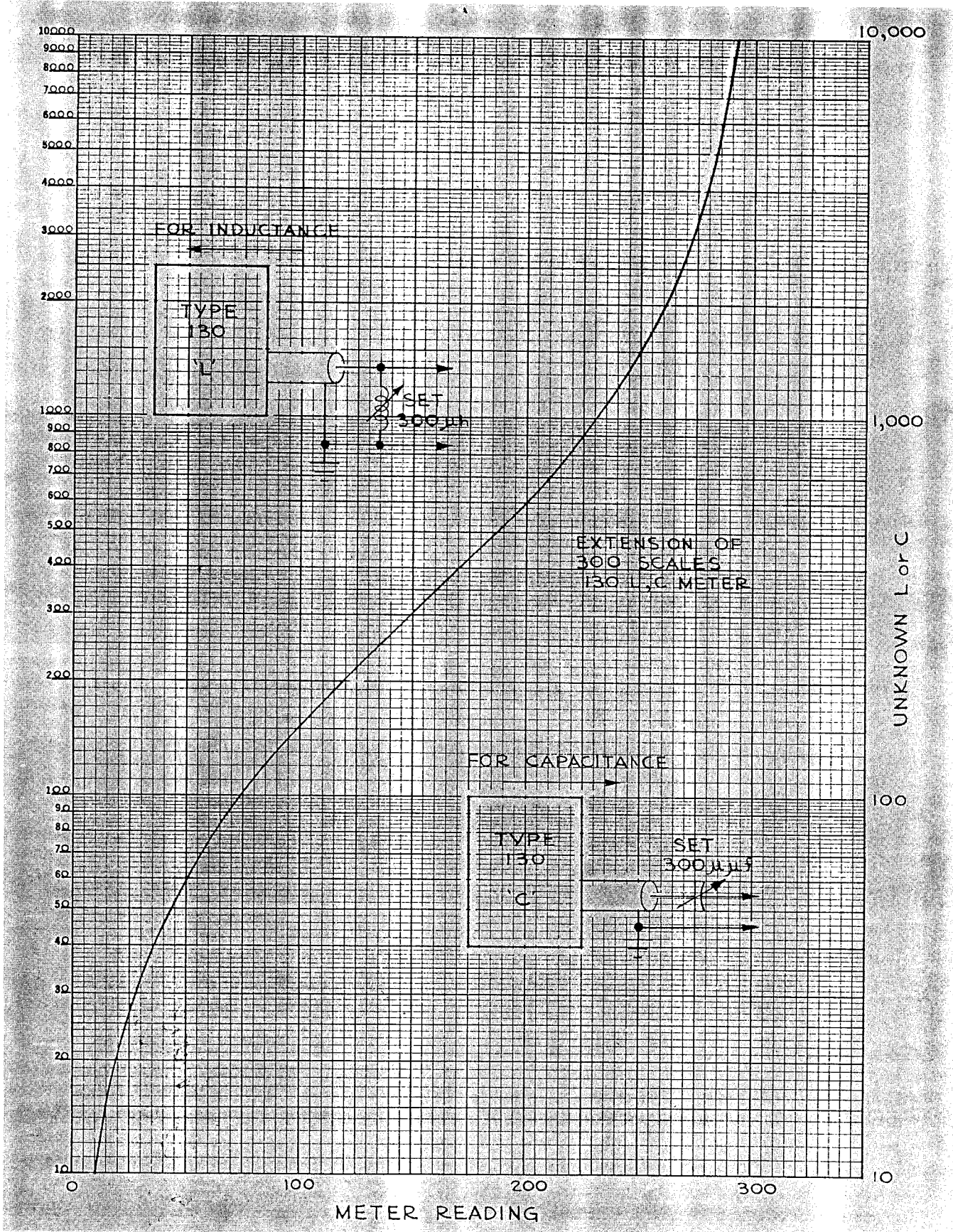


Fig. 2-8. Shunt inductance and series capacitance correction curve.

5. Remove the  $10\ \mu\text{F}$  capacitor and place the unknown  $12\ \mu\text{F}$  capacitor in the test position. The meter will read about  $2\ \mu\text{F}$ . Change the RANGE SELECTOR to  $3\ \mu\text{F}$ , read the meter, and algebraically add the zero error recorded in step 2 above. Add  $10\ \mu\text{F}$  to the corrected reading.

This same procedure can be used for capacitors as large as  $50\ \mu\text{F}$ , providing the Production Test Fixture is used, and the suppressed zero is obtained on the  $30\ \mu\text{F}$  range.

### Using the Guard Voltage

Capacitors within circuits, or capacitors with environmental strays can be measured in a manner that essentially disregards the environment.

The limits of environmental capacitance and circuit loading of the GUARD VOLTAGE terminal shown in Fig. 2-9 are:

1. Guarded environmental capacitance between the UNKNOWN L OR C and the GUARD VOLTAGE terminals can be as large as  $300\ \mu\text{F}$ .

2. Capacitance between the GUARD VOLTAGE terminal and ground must be  $200\ \mu\text{F}$  or less for added error limits to be not greater than  $+2$  to  $-1\ \mu\text{F}$  to the reading of the UNKNOWN capacitor.

Resistance loading between the GUARD VOLTAGE terminal and ground must be  $100\ \text{k}\Omega$  or greater when the shunt capacitance is  $200\ \mu\text{F}$ . The resistance loading can be as low as  $50\ \text{k}\Omega$  provided the shunt capacitance is not greater than  $100\ \mu\text{F}$ . (Resistance loading can be lower than  $50\ \text{k}\Omega$ , but the measurement limits are no longer valid.)

Measuring in-circuit capacitors often means the UNKNOWN L OR C terminal is also loaded with resistance.

The Type 130 is calibrated to ignore resistance of  $100\ \text{k}\Omega$  or greater in parallel with the unknown capacitor. Lower values of resistive loading require correction to the meter reading (described later in this section). Therefore it is essential that the resistances of the guarded circuit be known.

**Procedure.** Measure the DC resistance between both sides of the in-circuit unknown capacitor and ground. Measure the resistance across the unknown in-circuit capacitor. Check that these values of resistance are within limits just stated and diagrammed in Fig. 2-9B.

Connect the Type 130 to the unknown as shown in Fig. 2-9A. The instrument containing the in-circuit unknown capacitor must be completely disconnected from other equipment and from the power line. It must be isolated from ground (a varnished surface of a wooden bench is not enough isolation) and from the Type 130 except through direct connections.

The meter will read within  $-1$  to  $+2\ \mu\text{F}$  of the real value of the in-circuit unknown.

With the increasing use of lower impedance transistor circuits, the measurement of in-circuit capacitance may be impossible due to resistance loading. A special factory authorized modification extends the range of the guard circuit to allow usable measurements with: (1) larger guarded capacitance, and (2) lower resistance allowed between the GUARD VOLTAGE terminal and ground. The modification does not allow greater capacitance between the GUARD VOLTAGE terminal and ground. After modification, values shown in Fig. 2-9B can be:  $C_1$ , up to  $1000\ \mu\text{F}$ ;  $R_2$ , as low as  $20\ \text{k}\Omega$  if  $C_2$  is not greater than  $100\ \mu\text{F}$ ; and  $R_1 + R_2$  can be as low as  $40\ \text{k}\Omega$  in some cases. The details of the factory authorized modification are given at the end of this section.

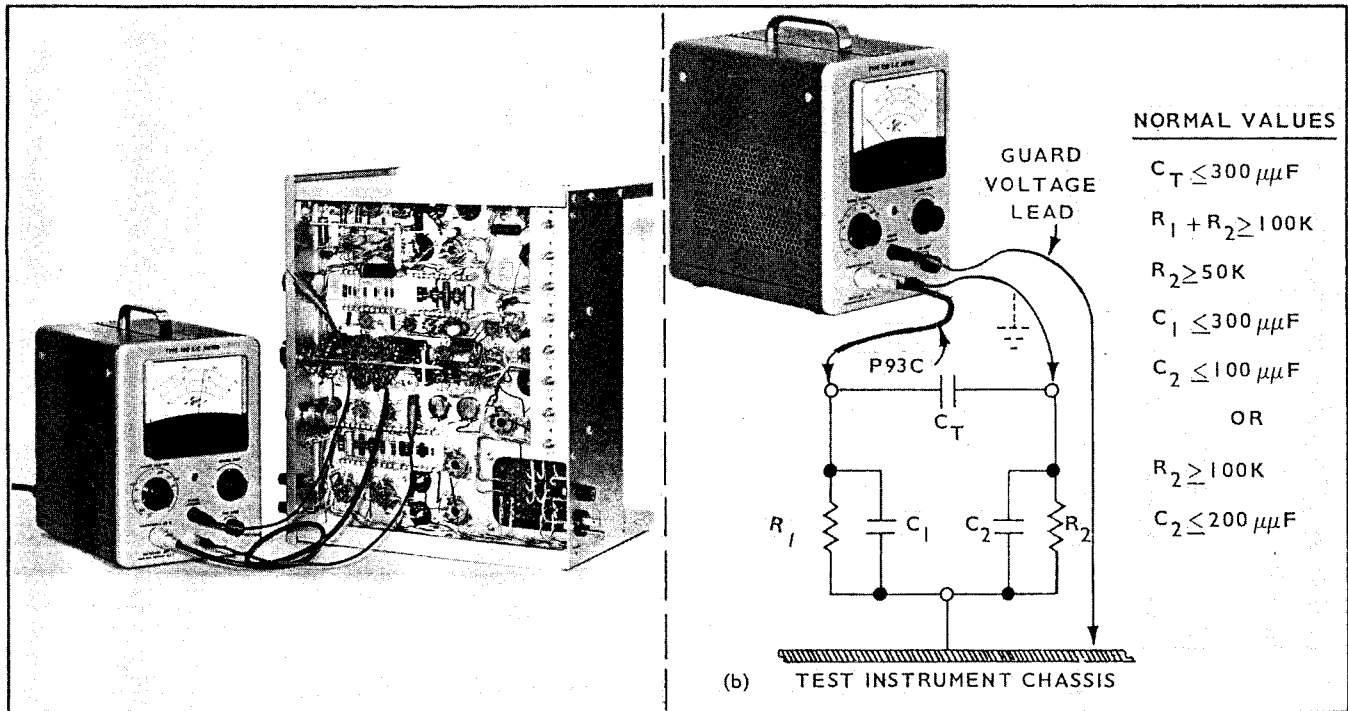


Fig. 2-9. Physical and electrical circuit using the Type 130 GUARD VOLTAGE to aid in measuring in-circuit capacitance.

### Resistance Corrections

**Inductors.** Resistance in series with unknown inductors usually has an effect upon the reading, but it is not always predictable. In general, inductors with low internal resistance and inductance less than about 30  $\mu\text{H}$ , will show a slight increase in reading as series resistance up to 10 ohms is added. These same inductors will generally show a reduction in reading as series resistance above 10 ohms is added. Inductors above about 30  $\mu\text{H}$  will usually show an increase in reading as series resistance of any value is added. There is no way to say that all Type 130 instruments will react the same to resistance in series with an unknown inductor; the actual amount must be determined experimentally in each case, after each calibration.

For example, in a random selected Type 130 instrument, a 10  $\Omega$  2 watt composition carbon resistor affected the electrical zero adjust (on the 3  $\mu\text{H}$  range) about +0.04  $\mu\text{H}$ . A 10  $\Omega$  1 watt resistor caused about +0.01  $\mu\text{H}$  reading, but an 11  $\Omega$  1/2 watt resistor caused a -0.13  $\mu\text{H}$  reading. This illustrates there is an effect upon the Type 130 that differs with various kinds of resistors. A spiral-cut deposited carbon or metal film resistor will actually add inductance to the circuit: a 2  $\Omega$  deposited carbon spiral resistor caused a +0.15  $\mu\text{H}$  shift of the electrical zero adjustment.

In general, it can be safely said that pure resistance under 10  $\Omega$  is of little consequence when measuring inductors. Series resistance values between 10 and 40  $\Omega$  have a marked affect upon the Type 130 accuracy. If such measurements are important, it is necessary to specially wind low resistance air inductors and add series resistance to determine the affect. In general, series resistance values above 40  $\Omega$  will cause erratic operation and make readings of questionable value.

**Capacitors.** The Type 130 is calibrated to ignore resistance in parallel with the unknown capacitor that is 100 k $\Omega$  or greater. This is not to say that such resistance has no affect, but that it is of no significance. However, resistance less than 100 k $\Omega$ , down to 30 k $\Omega$ , usually causes a decrease in reading.

In a factory test, 1/2 watt composition carbon resistors were placed in parallel with a 50  $\mu\mu\text{F}$  capacitor on a Type 130 selected at random. Resistors of values 100 k $\Omega$  and larger increased the reading by the amount of resistor end-to-end capacitance. A 68 k $\Omega$  resistor produced no change in reading, since the resistance cancelled the effects of its own end-to-end capacitance. A 43 k $\Omega$  resistor reduced the reading about 1.5  $\mu\mu\text{F}$ . However, the same resistance values affect the reading differently when placed across higher values of capacitance.

Table 2-2 gives calculated values of change to a reading for three values of capacitance. Each column is labeled with the sign of the needed correction. For example, as shown in the table, when measuring a 100  $\mu\mu\text{F}$  capacitor with 60 k $\Omega$  of pure resistance in parallel, add 1.45  $\mu\mu\text{F}$  to the meter reading to obtain the correct value.

**NOTE**

Table 2-2 values are calculated, and do not apply to each instrument. Therefore, when this type of

measurement is to be made, make your own table by actually paralleling known resistors across known capacitors. Do this after each calibration of the Type 130 while operating at a known line voltage.

**TABLE 2-2**

Calculated Corrections For Capacitance Measurements with Parallel Resistance

Shunt Resistance	At 0 $\mu\mu\text{F}$	Across 100 $\mu\mu\text{F}$	Across 300 $\mu\mu\text{F}$
4 meg	-.02	-.01	+.01
2 meg	-.04	-.02	+.02
1 meg	-.09	-.04	+.03
.5 meg	-.13	-.08	+.10
300 k $\Omega$	-.18	-.06	+.22
200 k $\Omega$	-.20	-.01	+.39
150 k $\Omega$	-.18	+.08	+.56
100 k $\Omega$	-.08	+.36	+.114
80 k $\Omega$	+.09	+.60	+.164
60 k $\Omega$	+.60	+1.45	+.270
50 k $\Omega$	+1.15	+2.15	+.368
40 k $\Omega$	+2.20	+3.35	+.540
30 k $\Omega$	+4.70	+6.05	+.900

### Factory Authorized Modification

The Guard circuit can be made to drive lower values of resistance as described under Using The Guard Voltage earlier in this section. V110 Guard Voltage Cathode Follower output impedance can be made slightly adjustable by inserting a 2 megohm rheostat in series with R112. R112 is located at V110 socket. The rheostat should be inserted in the ground side of R112, using heavy buss wire soldered to the metal disc at the front end of the RANGE SELECTOR switch. See Fig. 2-10. Mount the rheostat. Then unsolder the ground end of R112 and solder it to one end of the rheostat. (Be sure R112 is 2.2 megohms and not 3.3 megohms.)

Adjusting the Guard rheostat:

1. Install the Production Test Fixture to the UNKNOWN L OR C connector. Measure a small capacitor with a value between 4 and 10  $\mu\mu\text{F}$ . Record the value.
2. Connect a 100  $\mu\mu\text{F}$  capacitor from the GUARD VOLTAGE terminal to the ground terminal. Install the 4 to 10  $\mu\mu\text{F}$  capacitor into the Production Test Fixture.
3. Mount a 0.001  $\mu\mu\text{F}$  capacitor into the right side clip of the Production Test Fixture so its other lead is near the GUARD VOLTAGE terminal, but not touching it. Adjust the zero controls on the clockwise side of zero so the meter reads the 4 to 10  $\mu\mu\text{F}$  capacitor value.

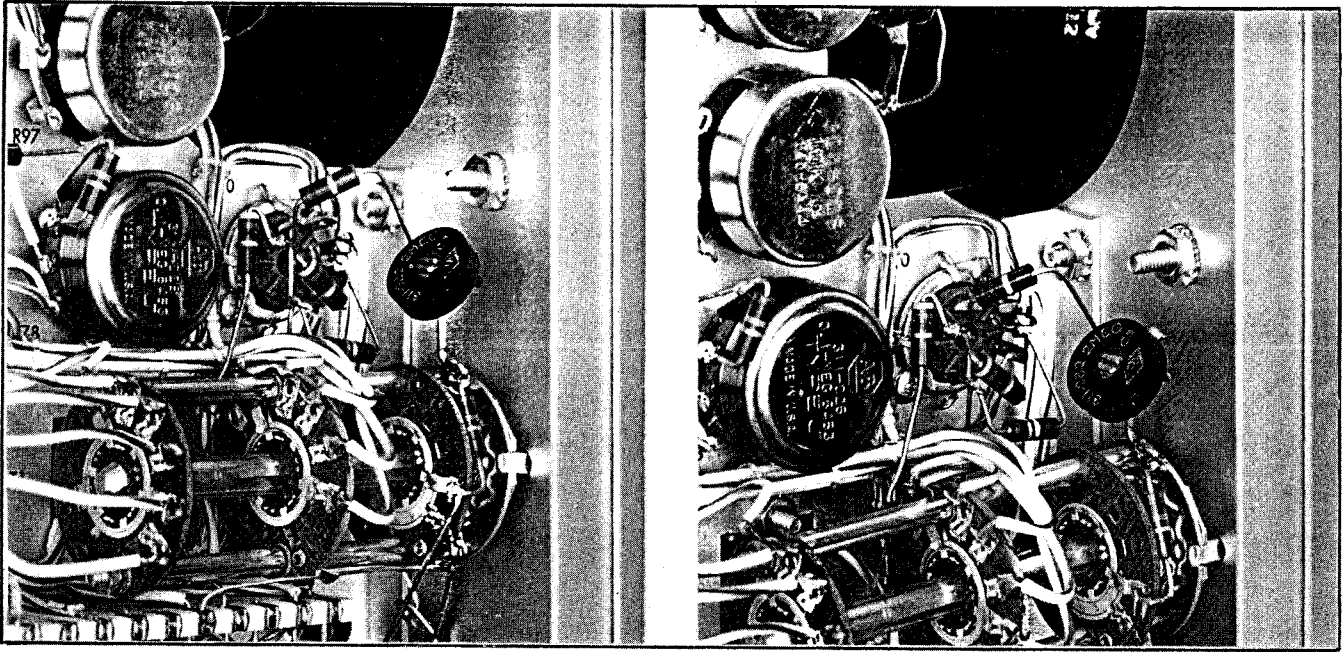


Fig. 2-10. Guard Voltage adjustment rheostat installation. (2 meg $\Omega$ , Tektronix Part No. 311-0082-00.)

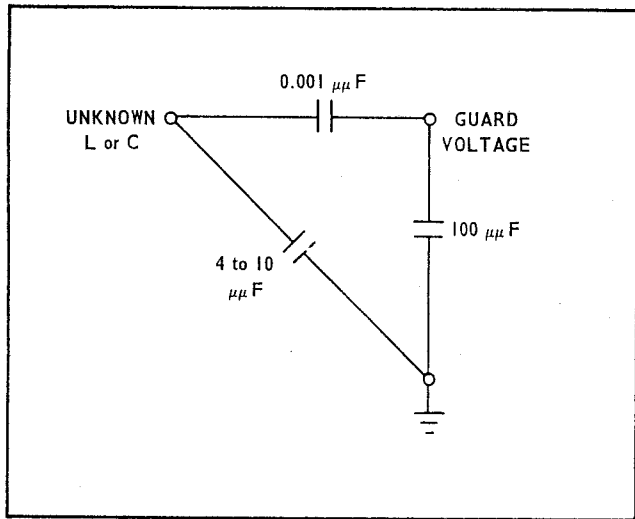


Fig. 2-11. Guard Voltage adjust external circuit.

4. Use a low capacitance tool and push the 0.001  $\mu\mu\text{F}$  capacitor open lead into the GUARD VOLTAGE terminal so it makes contact. The external circuit is now as shown in Fig. 2-11. Adjust the Guard rheostat so the meter gives the same reading with and without the 0.001  $\mu\mu\text{F}$  capacitor touching the GUARD VOLTAGE terminal.

5. With the 0.001  $\mu\mu\text{F}$  capacitor not touching the GUARD VOLTAGE terminal, again adjust the zero controls so the meter indicates the 4 to 10  $\mu\mu\text{F}$  capacitor value. Recheck the Guard rheostat setting by repeating step 4.

The Type 130 will now make in-circuit capacitance measurements within  $+1$  and  $-3/4$   $\mu\mu\text{F}$  in the typical circuits shown in Fig. 2-12. Performance limits are the responsibility of the user, and should be determined for each Type 130 modified.

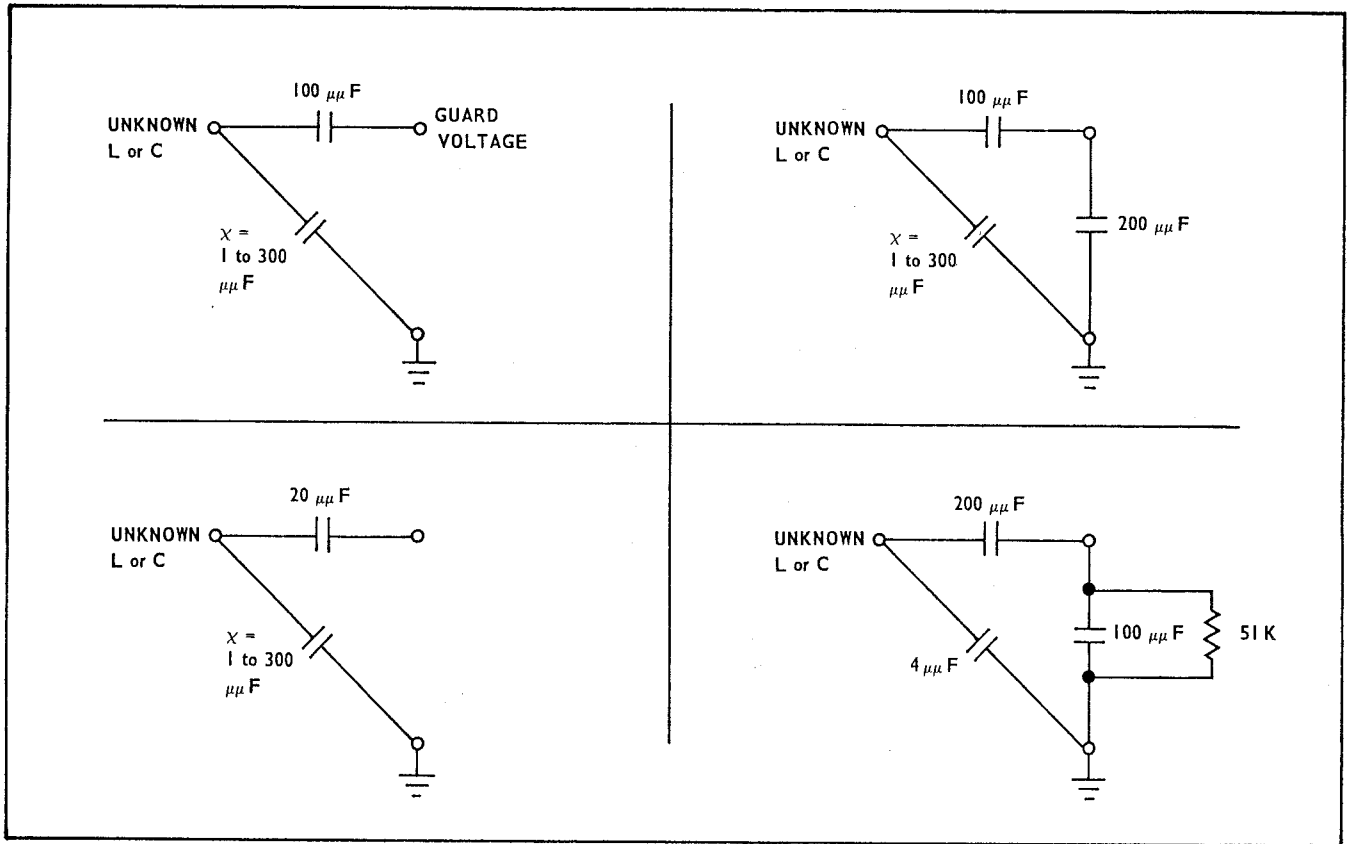


Fig. 2-12. Typical circuits that can be measured after modifying R112.



# SECTION 3

## CIRCUIT DESCRIPTION

The Tektronix Type 130 L-C Meter employs low power vacuum tubes in stable circuits for direct reactance measurements. The circuits include a Variable Oscillator with frequency controlled by the unknown, a fixed reference oscillator, buffer amplifiers, a mixer, a counter, and a power supply. The power supply is soft-tube regulated to stabilize the oscillators and counter circuits.

### Block Diagram

The block diagram of Fig. 3-1 shows the general layout of the Type 130 circuits. With the RANGE SELECTOR switch at any  $\mu\mu\text{F}$  position, and with no capacitor attached to the UNKNOWN L OR C terminal, the Mixer receives two identical 140 kHz signals. The oscillators are identical circuits with equal temperature compensation, so their output frequency changes with temperature are essentially the same after warmup. Connecting a capacitor to the UNKNOWN L OR C terminal reduces the frequency of the Variable Oscillator. At this time the Mixer produces an output frequency equal to the difference between the two oscillator frequencies.

A twin-tee filter prevents any 140 kHz signal from passing from the Mixer to the Counter circuits. Low frequency

Mixer output signals are DC coupled through the filter to a Bistable Multivibrator that standardizes their shape and amplitude. Consistent amplitude square waves drive a bucket and ladle circuit to deflect the meter by an amount proportional to frequency.

The Guard-Voltage Cathode Follower provides a front panel signal with equal amplitude and phase to that of the signal at the UNKNOWN L OR C terminal.

### Variable Oscillator (Capacitance Measurement)

The Variable Oscillator is a tuned-grid oscillator with energy to the tickler winding provided by a cathode follower. The grid tank circuit is made up of the winding between terminals 1 and 5 of T1 and capacitance consisting primarily of C5. Capacitance in parallel with C5 includes C2, C3, C4 and the unknown. The tank capacitance is approximately  $1060 \mu\mu\text{F}$  without an unknown attached. Connecting a  $300 \mu\mu\text{F}$  unknown capacitor adds about 30% additional capacitance and reduces the frequency of oscillation from 140 kHz to 125 kHz.

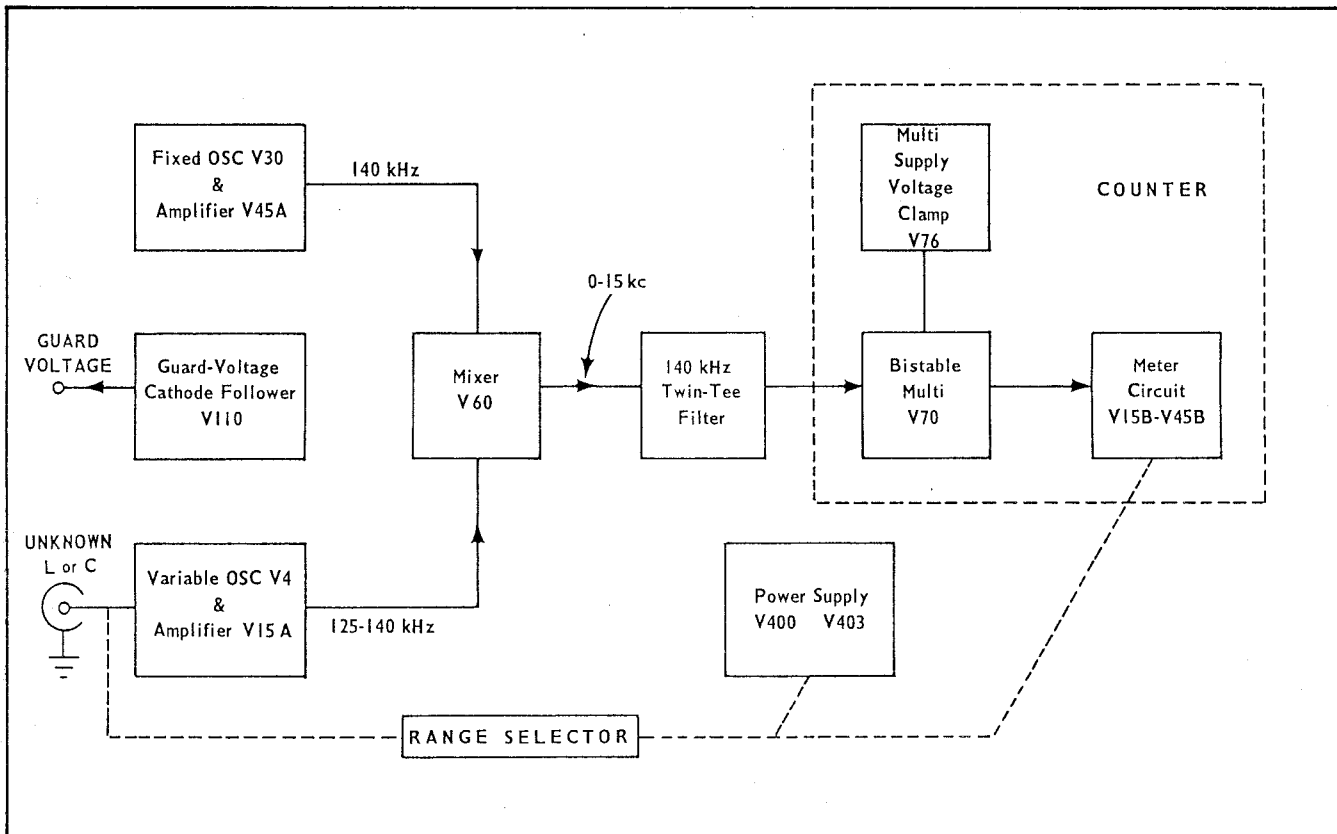


Fig. 3-1. Type 130 Block Diagram.

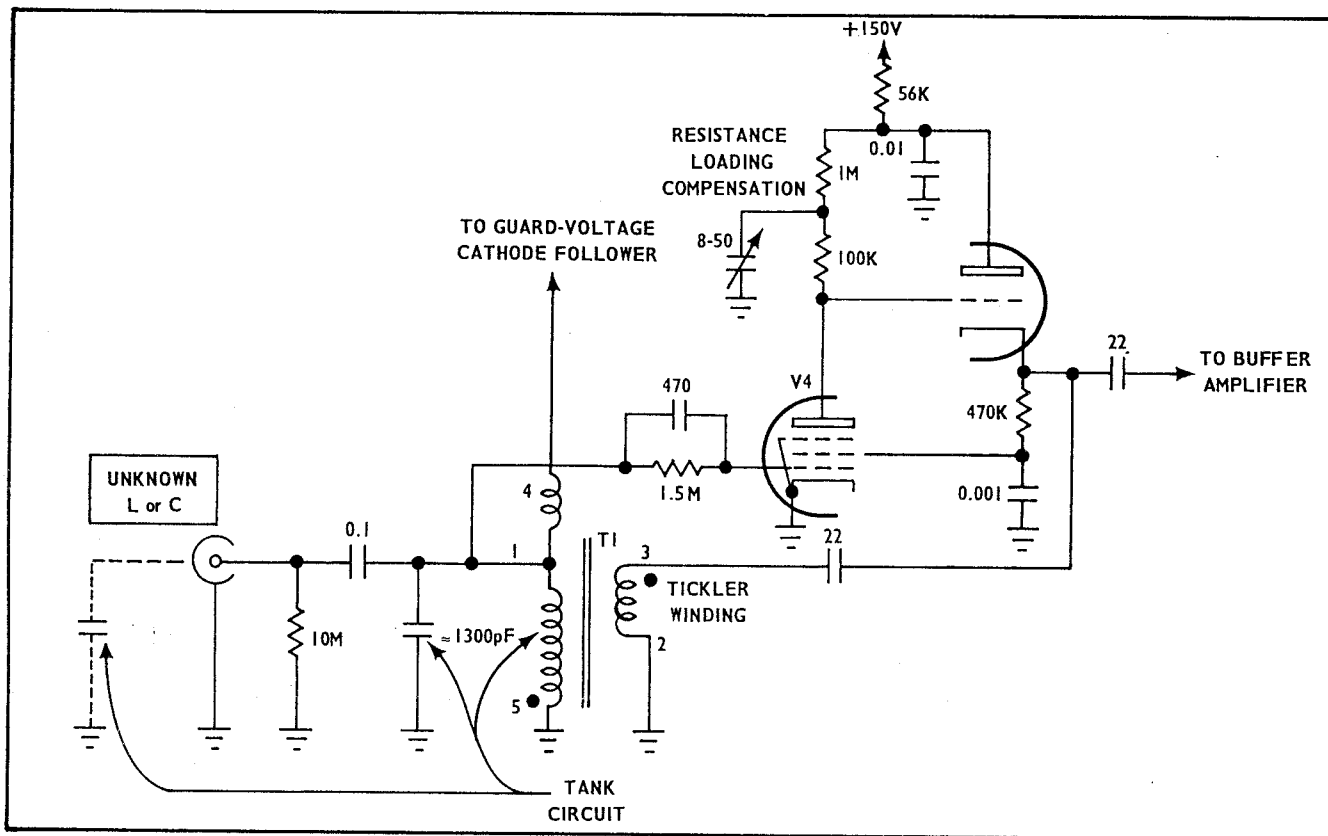


Fig. 3-2. Variable Oscillator active elements when Type 130 is set to measure capacitance.

When operating to measure unknown capacitors (see Fig. 3-2), terminal 5 of T1 is grounded, causing the grid circuit of V4A to see a normal resonant grid tank through grid leak resistor R6 paralleled by C6. Any change in grid voltage of V4A is amplified and inverted at its plate and directly coupled to the grid of cathode follower V4B. V4B serves three purposes: (1) low impedance drive to buffer amplifier V15A, (2) DC stabilization and control of the screen grid voltage of V4A, and (3) drive to the tickler winding of T1 through C10. V4B assures that the oscillator power level is adequate to minimize the effect of changes in frequency due to resistive loading that may be placed in parallel with the unknown capacitor. As the UNKNOWN terminal is lightly loaded, the signal to V4A grid is reduced, lowering the normal negative grid bias. Reduced bias increases plate current, causing the plate voltage to drop. Reduced plate voltage reduces the cathode voltage of V4B and the screen voltage of V4A, reducing V4A plate current so the plate voltage returns to approximately its original value. This action keeps the transconductance of V4A essentially constant and assures constant feedback drive to T1. Heavy resistive loading of the UNKNOWN terminal will reduce V4A grid bias enough to stop oscillations. Then V4B reduces V4A screen voltage to a low value to limit dissipation of V4A and protect the circuit until the heavy loading is removed.

Terminals 1 and 4 of T1 are a tertiary winding that is described later under the Guard-Voltage circuit.

C7-R7 (in V4A plate circuit) allow a slight phase adjustment to the feedback loop. Adjusting C7 sets the oscillator regulation to the proper value so the meter will ignore resistive loading changes from infinity to 100 kΩ. Loading by resistance less than 100 kΩ will affect the meter accuracy, with corrections given near the end of Section 2 of this manual.

### Variable Oscillator (Inductance Measurements)

When operating to measure unknown inductors (see Fig. 3-3), terminal 5 of T1 is connected to the UNKNOWN L OR C terminal. This opens the Variable Oscillator tank circuit. With no unknown inductor, the oscillator is turned off. R14 supplies a few volts of charge to capacitors C2 through C5 so that there is reserve tank current available to start oscillations the instant an unknown inductor is connected. The grid and cathode of V4A act together as a diode that essentially grounds one end of R6, so the DC bleeder shown in Fig. 3-4 places about +12 volts charge on capacitors C2 through C5. With V4A grid current flowing, the protective circuit of V4B lowers V4A screen voltage (and current) limiting V4A plate dissipation to a safe value. As an unknown inductor is placed between the UNKNOWN L OR C terminal and ground, the charge on capacitors C2 through C5 forces current into the tank winding of T1, quickly setting up the proper magnetic flux

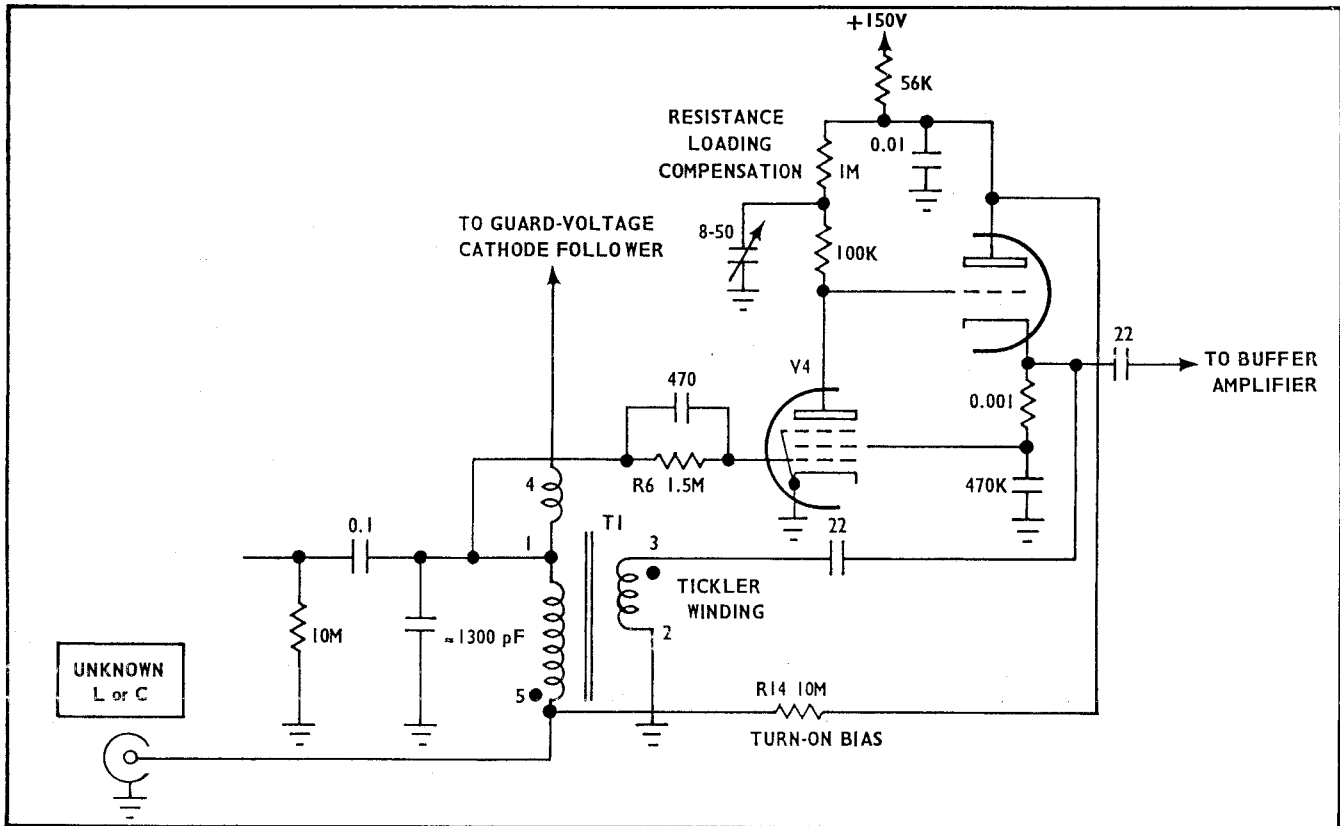


Fig. 3-3. Variable Oscillator active elements when Type 130 is set to measure inductance.

for oscillations. The Type 130 meter thus responds quickly to the connection of an unknown inductor.

The Variable Oscillator has two output signals; one to a buffer amplifier and thus the Mixer, and the other to the Guard-Voltage Cathode Follower.

### Fixed Oscillator

V30 is the 140 kHz fixed oscillator, adjusted by the powdered-iron tuning slug in T30. The circuit is similar to the variable oscillator circuit, but without the feedback phase adjustment. V45A is the buffer amplifier.

### Buffer Amplifiers

V15A and V45A are self-biased buffer amplifiers that provide isolation between the two oscillators and their mixer. Common grid coupling in the mixer would disturb both oscillators without the buffer isolation provided by the high output impedance pentode amplifiers. Each buffer stage plate dissipation is limited by the large screen grid resistor, and the tube will not be damaged in the event drive is removed.

### Guard-Voltage Circuit

V110 is a cathode follower whose gain is slightly less than one. The voltage at its grid is increased over the voltage at the UNKNOWN terminal by a small additive

winding on T1. The additional voltage is just enough to make up for the slight voltage loss in the cathode follower, so that the GUARD VOLTAGE output voltage is equal to the UNKNOWN terminal voltage. Voltage divider R112, R113, sets the DC grid voltage at about +50 volts so that about 5 mA of cathode current flows. The output impedance is about 250 ohms.

### Mixer

The Mixer V60 is a common type of dual-grid heterodyne mixer. Non-linear operation for proper mixing action is assured by the grounded-cathode self-biased circuit. The output circuit includes a series 140 kHz Twin-Tee filter (C64-R64-C65 and R61-C62-R62) with additional low-pass capacitors C61 and C63. This network assures that mixer output signals above about 30 kHz do not reach the multivibrator and counter circuits.

V60 plate current passes through R61 and R62 of the filter. R61-R62 make up 44 k $\Omega$  of the adjustable plate load resistors. The plate load resistor is adjustable so the DC input voltage to the following multivibrator can be set to the correct value for symmetrical output square waves. The high impedance plate circuit of V60 prevents significant change in mixer gain through the range of R68.

### Bistable Multivibrator

The Bistable Multivibrator converts the Mixer output signals to consistent amplitude square waves. As the grid

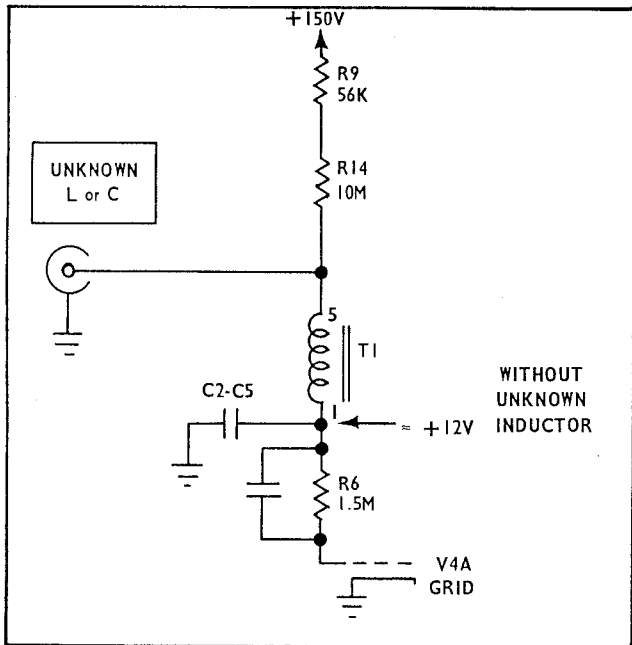


Fig. 3-4. DC bleeder network that charges capacitors C2 through C5 without unknown inductor.

of V70B rises positive past about +39 volts, V70B conducts and V70A turns off. The coupling from V70B plate to V70A grid, and their common cathode connection, assures fast regenerative switching. The multivibrator remains in a stable state until the grid voltage of V70B is taken below about +36 volts. This turns V70B off and V70A on.

The output signal from V70A switches between two voltage limits set by V76 and its associated resistors. When V70A is cut off, its plate voltage rises to near +150 volts. The upper voltage limit is set by the clamp diode connection of V76B and the +150 volt supply. When V70A is conducting, the plate voltage rests at about +100 volts as set by clamp cathode follower V76A. V76A grid voltage is set by R78 as adjusted in the Calibration Procedure. Thus, any frequency difference between the two 140 kHz oscillators is converted to square waves of approximately 50 volts peak to peak. The pentode plate circuit high impedance of V70A permits the multivibrator output voltage to be externally controlled without disturbing the multi's ability to switch properly.

Symmetry of the multivibrator output square wave is controlled by adjusting the DC level of the mixer output signal. Symmetry is important for proper operation of the counter circuit. Fig. 3-5A shows the mixer output signal at the grid of V70B. The arrows indicate the voltage at which the multivibrator switches. Note that the multivibrator square wave (Fig. 3-5B) is in time agreement with the arrows on the mixer output signal.

### Counter

The Counter is a two-diode, two-capacitor bucket and ladle circuit with a meter across the bucket capacitor. The Bistable Multivibrator pumps current pulses from the ladle

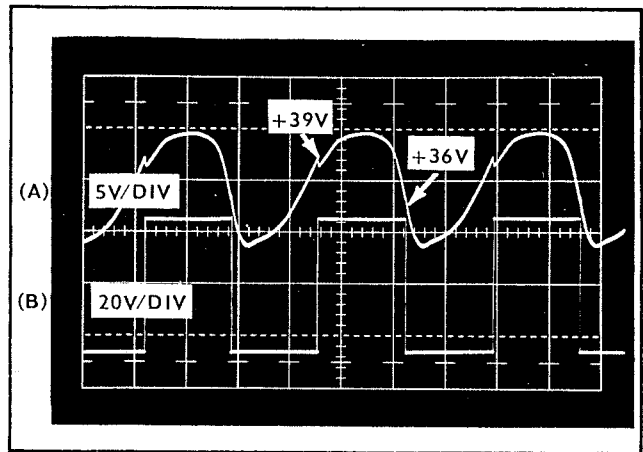


Fig. 3-5. (A) V70B grid. (B) V70A plate. Waveforms are time-related.

capacitor into the bucket capacitor. The meter quickly discharges the bucket capacitor, deflects upward, and its damping holds the meter there until the next current pulse.

To understand Counter operation, assume that the RANGE SELECTOR switch is set at 300  $\mu\mu\text{F}$ , the meter is electrically zeroed and V70A anode is at +100 volts. Under these conditions C90 has a charge of about 50 volts. The anode of V70A is at about +100 volts, and V15B cathode at +148 volts. C97 has equal voltage on each of its plates, and the meter is not conducting any current. V15B anode is at +148 volts to prevent V15B or V45B current, thus assuring no current flow at meter zero.

Any difference in frequency of the two oscillators will cause V70A anode to rise to +150 volts. Both plates of C90 try to rise 50 volts, but V45B diode connects C97 to C90, and the capacitors divide the 50 volt step. Fig. 3-6 shows waveforms taken at V70A anode and V45B cathode with a 240  $\mu\mu\text{F}$  capacitor connected to the UNKNOWN L OR C connector. The V70A waveform shows the RC rolloff of the square wave, with a time constant set by R74 and the series capacitance of C90 and C97 (the meter terminal resistance is about 1.8 k $\Omega$ ). The V45B cathode waveform shows the voltage pulse across C97 with the discharge slope caused by meter current. Thus, the V45B cathode waveform shows that the meter receives periodic current pulses. Changing the number of pulses per second changes the meter deflection in a linear manner. The meter receives pulses at a 15 kHz rate for full scale deflection at 300  $\mu\mu\text{F}$  or 300  $\mu\text{H}$ .

Changing the RANGE SELECTOR switch to 100  $\mu\mu\text{F}$  ( $\mu\text{H}$ ) and 30  $\mu\mu\text{F}$  ( $\mu\text{H}$ ) changes the bucket and ladle capacitors that allow full scale deflection at frequencies less than 15 kHz. Also a variable resistor (one for each range) is placed across the meter to allow calibrating each range. At 10  $\mu\mu\text{F}$  ( $\mu\text{H}$ ) and 3  $\mu\mu\text{F}$  ( $\mu\text{H}$ ) the ranges allow usable meter deflection from very low frequency pulses. Damping capacitors are placed across the meter on these two ranges to minimize needle vibration and permit valid readings when the meter would vibrate seriously without damping.

The counter circuit basic calibration is made on the 300  $\mu\mu\text{F}$  range with proper meter deflection set by adjusting the amplitude of V70A anode swing (adjusting R78, ADJ 2 300).

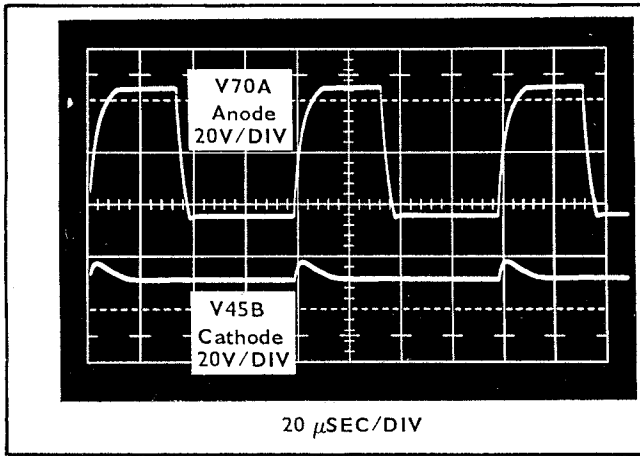


Fig. 3-6. Counter circuit waveforms.

The lower value ranges are adjusted by varying the value of the shunt resistor across the meter.

### Power Supply

DC power is furnished by a capacitor input full-wave rectifier circuit. V400 is the rectifier. V403 is a soft-tube regulator that provides the +150 volts for circuits that require a stable voltage throughout normal line voltage changes. The tube heaters are elevated to +75 volts to reduce the heater-to-cathode potential of V76, V15B and V45B. The Variable Oscillator heater has 1.5 ohms in series to partially stabilize cathode temperature with varying line voltage.

The power transformer has two equal primary windings that permit operating the Type 130 at either 117 volts or 234 volts AC RMS.



# SECTION 4

## MAINTENANCE

### Replacement of Components

Replacements for all parts in the Type 130 L-C Meter can be purchased directly from Tektronix at current prices. However, since most of the components are standard electronic and radio parts, they can generally be obtained locally in less time than is required to obtain them from the factory. Before purchasing or ordering parts, be sure to consult the parts list to determine the tolerances and ratings required. The parts list gives the values, tolerances, ratings and Tektronix parts number for each component in the instrument.

In addition to the standard components, special parts are manufactured by Tektronix or manufactured by other companies to Tektronix specifications. These parts and most mechanical parts should be obtained directly from Tektronix or the local Tektronix Field Office, since they are difficult or impossible to obtain from other sources.

### Parts Ordering Information

You will find a serial number in the frontispiece of this manual. This is the serial number of the instrument for which this manual was prepared. Be sure the manual number matches the number of the instrument when you order parts.

We make some of the changes in the instrument, the diagrams, parts list and manual to include the latest circuit improvements. Change information, if any, will be found at the back of the manual.

Since the production of your instrument, some of the parts may have been superseded by improved components. In such cases, the part numbers will not be listed in your Parts List. However, if you order a part from Tektronix and it has been superseded by an improved component, the new part will be shipped in place of the part ordered. Your local Tektronix Field Engineering Office has knowledge of these changes and may call you if a change in your purchase order is necessary. Replacement information sometimes accompanies the improved components to aid their installation.

When ordering parts, be sure to include both the description of the part and the 9-digit Tektronix part number found in the Parts List. For example, if the serial number of your Type 130 L-C Meter were 351, a certain capacitor would be ordered as follows: C30, .001 microfarad, fixed, mica, 500 V, 1%, part number 283-0526-00, for Type 130 L-C Meter, Serial Number 351.

### Trouble Shooting

If the instrument fails to operate and the pilot light does not light, check the source of AC power and see whether the connecting cord is firmly seated. Then check the 0.8-amp line fuse at the back of the instrument near the power plug. A good way to check the fuse is to replace it with a good one. The AC circuit to the power transformer is completed through the RANGE SELECTOR switch. Check the

switch contacts. To make this check, you will need to remove the case.

Some cases have side panels held in place by small screw-head fasteners. To remove the panels, use a screwdriver to rotate the fasteners approximately two turns counterclockwise. Then pull the upper portion of the panels outward from the handle. Other cases do not have the side panel fasteners, but the whole case is removed. To remove this case, twist the slotted fastener at the rear of the case counterclockwise and the case will come loose. Disconnect the power plug and you can then slide the instrument forward out of the case. Cases are replaced by reversing the order of their removal.

### WARNING

The power supply furnishes 270 volts DC across a 30- $\mu$ F capacitor, so be careful to avoid contact with it when the instrument is operating.

Troubles are usually caused by tube failure, and you can frequently correct them by simply finding the bad tube and replacing it with a good one. However, sometimes a bad tube burns resistors or overstresses capacitors when it fails, and in these cases you will also have to find the bad components. Sometimes you can find them by visual inspection.

Since troubles are usually caused by tube failure, be sure you investigate this possibility before adjusting the interior controls. One way to find bad tubes is to replace all the tubes with good ones. If this helps the troubles, try putting the old tubes back, one at a time, until the bad tube is discovered.

Tube failure will often show in the voltage readings of the power supply. So, another early step to take in looking for trouble is to check the DC voltages. The two supply voltages appear conveniently at the two ends of R403, a ceramic wire-wound resistor mounted behind the power transformer on the same side of the chassis. The outside terminal should measure +150 volts  $\pm$ 5 volts and the terminal nearest to the chassis should read approximately 270 volts, depending on the line voltage. There is no voltage adjustment, and if the voltages are off it is a sign of trouble elsewhere in the circuit.

Total DC current from the rectifier should be about 35 mA of which 21 mA goes to the circuits connected to the 150-volt buss and the remainder, about 14 mA goes through the regulator tube, when the AC supply is at 115 volts. Current to other circuits connected to the 270-volt buss is a fraction of a milliampere.

You can check the indicating meter by connecting another milliammeter across it. The meter is connected to the +150-volt buss, so be careful not to get a terminal grounded.

The variable oscillator may be checked for operation by connecting an oscilloscope to the GUARD VOLTAGE terminal. The guard voltage will be about half a volt peak-to-peak at 120 to 140 kHz. The fixed oscillator can be checked at pin 6 of V45. These points can also be checked with an

AC voltmeter capable of reading a fraction of a volt at 140 kHz.

The Circuit Description may prove a valuable aid during troubleshooting. Each circuit is described in detail, and several waveforms are included. Waveforms appearing on a test oscilloscope display can be compared with those found in a properly operating instrument.

### Soldering and Ceramic Strips

Many of the components in your Tektronix instrument are mounted on ceramic terminal strips. The notches in these strips are lined with silver alloy. Repeated use of excessive heat, or use of ordinary tin-lead solder will break down the silver-to-ceramic bond. Occasional use of tin-lead solder will not break the bond if excessive heat is not applied.

If you are responsible for the maintenance of a large number of Tektronix instruments, or if you contemplate frequent parts changes, we recommend that you keep on hand a stock of solder containing about 3% silver. This type of solder is used frequently in printed circuitry and should be readily available locally. If you prefer, you can order the solder directly from Tektronix in one-pound rolls. Order by Tektronix part number 251-0514-00.

Because of the shape of the terminals on the ceramic strips it is advisable to use a wedge-shaped tip on your soldering iron when you are installing or removing parts from the strips. Fig. 4-1 will show you the correct shape for the tip of the soldering iron. Be sure to file smooth all surfaces of the iron which will be tinned. This prevents solder from building up on rough spots where it will quickly oxidize.

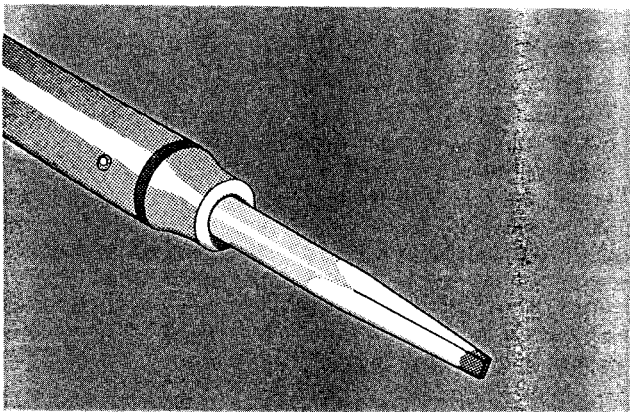


Fig. 4-1. Soldering tip preparation.

When removing or replacing components mounted on the ceramic strips you will find that satisfactory results are obtained if you proceed in the manner outlined below.

1. Use a soldering iron of about 75-watt rating.
2. Prepare the tip of the iron as shown in Fig. 4-1.
3. Tin only the first  $\frac{1}{16}$  or  $\frac{1}{8}$  inch of the tip. For soldering to ceramic terminal strips, tin the iron with solder containing about 3% silver.

4. Apply one corner of the tip to the notch where you wish to solder (see Fig. 4-2).
5. Apply only enough heat to make the solder flow freely.
6. Do not attempt to fill the notch on the strip with solder; instead, apply only enough solder to cover the wires adequately, and to form a slight fillet on the wire as shown in Fig. 4-3.

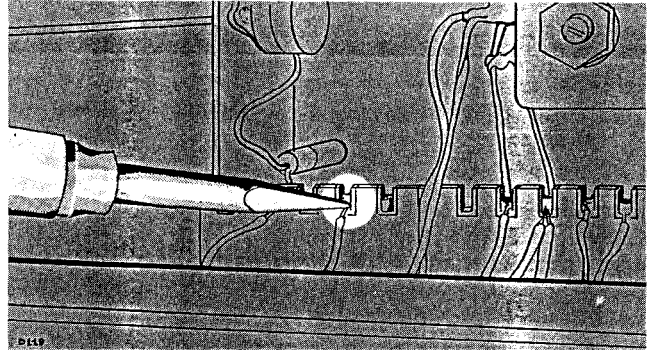


Fig. 4-2. Applying iron tip to strip.

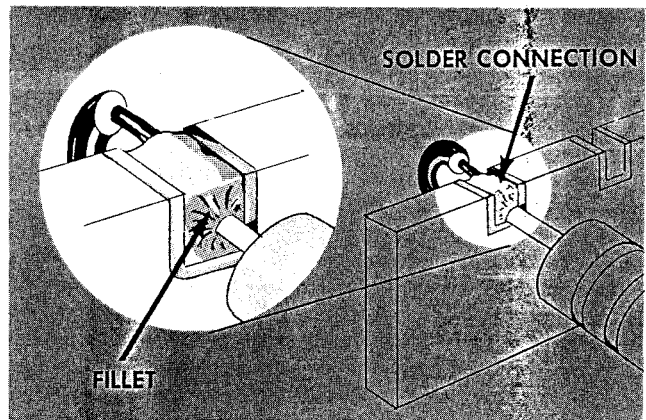


Fig. 4-3. Fillet on wire.

In soldering to metal terminals (for example, pins on a tube socket) a slightly different technique should be employed. Prepare the iron as outlined above, but tin with ordinary tin-lead solder. Apply the iron to the part to be soldered as shown in Fig. 4-4. Use only enough heat to allow the solder to flow freely along the wire so that a slight fillet will be formed as shown in Fig. 4-3.

### General Soldering Considerations

When replacing wires in terminal slots clip the ends neatly as close to the solder joint as possible. When clipping the ends of wires, remove the clippings from the chassis before applying power.



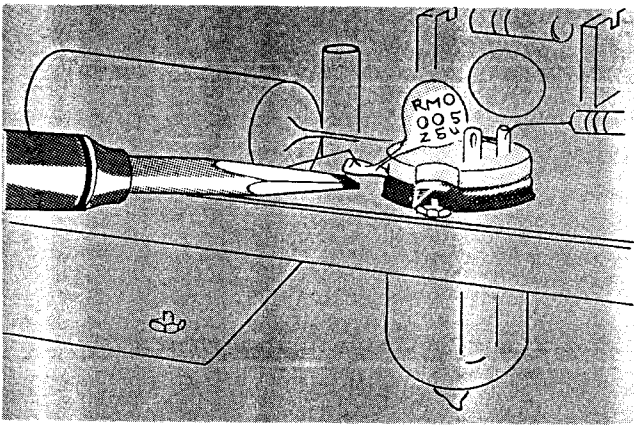


Fig. 4-4. Soldering to metal terminals.

Occasionally you will wish to hold a bare wire in place as it is being soldered. A handy device for this purpose is a short length of wooden dowel, with one end shaped as shown in Fig. 4-5. In soldering to terminal pins mounted in plastic rods it is necessary to use some form of "heat sink" to avoid melting the plastic. A pair of long-nosed pliers (see Fig. 4-6) makes a convenient tool for this purpose.

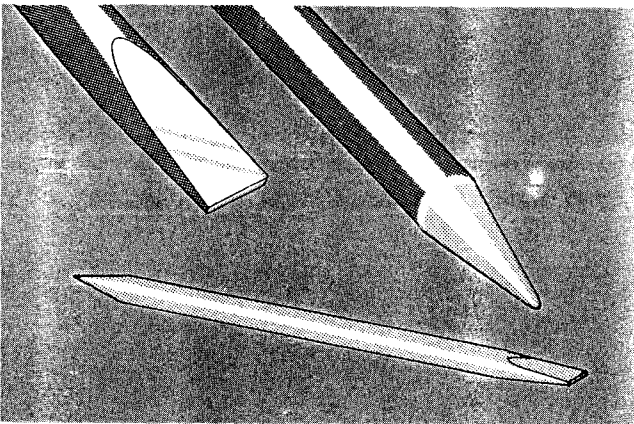


Fig. 4-5. Wooden dowel.

### Ceramic Strips

Two distinct types of ceramic strips have been used in Tektronix instruments. The earlier type mounted on the chassis by means of #2-56 bolts and nuts. The later type is mounted with snap-in, plastic fittings. Both styles are shown in Fig. 4-7.

To replace ceramic strips which bolt to the chassis, screw a #2-56 nut onto each mounting bolt, positioning the bolt so that the distance between the bottom of the bolt and the bottom of the ceramic strip equals the height at which you wish to mount the strip above the chassis. Secure the nuts to the bolts with a drop of red lacquer. Insert the bolts through the holes in the chassis where the original strip was mounted, placing a #2 flatwasher between each nut and the chassis. Place a set of #2 starwashers on the protruding ends of the

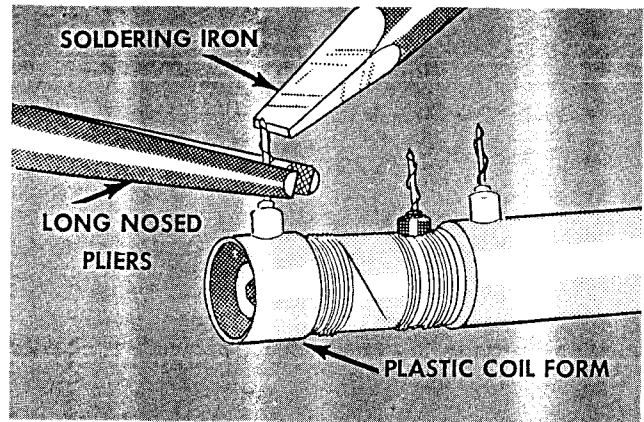


Fig. 4-6. Long-nosed pliers as "heat sink".

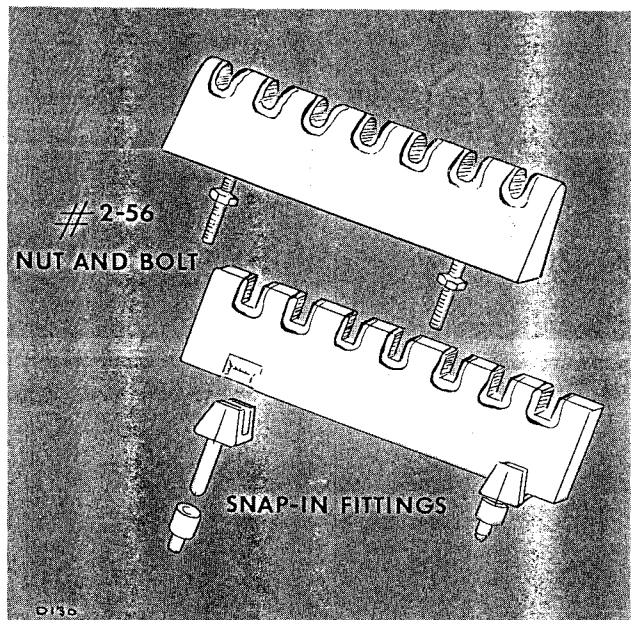


Fig. 4-7. Ceramic strips and fittings.

bolts, and fasten them firmly with another set of #2-56 nuts. Place a drop of lacquer over each of the second set of nuts after fastening.

To replace ceramic strips which mount with snap-in plastic fittings, first remove the original fittings from the chassis. Insert the spacers into the mounting holes in the chassis. Carefully force the mounting posts into the spacers. Snip off the portion of the mounting post which protrudes below the spacers on the reverse side of the chassis.

#### NOTE

Considerable force may be necessary to push the mounting rods into the spacers. Be sure you apply the force to that area of the ceramic strip directly above the mounting rods.



# SECTION 5

## PERFORMANCE CHECK

This section of the manual provides a means of rapidly checking the performance of the Type 130 L-C Meter. The procedure is intended to check the calibration of the instrument without performing the complete Calibration Procedure. The Performance Check does not provide for the adjustment of any internal controls. Failure to meet the requirements given in this procedure indicates the need for internal checks or adjustments, and the user should refer to the Calibration Procedure in this manual.

### Equipment Required

1. Tektronix S-30 Delta Standards. Tektronix Part No. 015-0001-00. (No other transfer standards are recommended.)
2. A 100  $\mu\mu\text{F}$  capacitor with mica or polystyrene dielectric. Tolerance,  $\pm 5\%$ .  
100  $\mu\mu\text{F}$   $\pm 5\%$  Mica Capacitor: Tektronix Part No. 283-0506-00.
3. A metered variable line voltage autotransformer.

### Tolerances

In the Characteristics Section, the Type 130 accuracy is stated as  $\pm 3\%$  of full scale meter deflection (not using the Guard Voltage). Because the ranges are individually adjustable, and are calibrated at the factory with a  $\pm 1\%$  transfer standard, full scale tolerance of a recently calibrated Type 130 is generally much better than  $\pm 3\%$ .

The Calibration Procedure in this manual requires the use of a  $\pm 1\%$  transfer standard. The procedure also states that each range shall be adjusted precisely to full scale value. Because the Type 130 is slightly sensitive to line voltage variations, it is factory calibrated at 117 volts RMS, the design center of the power supply regulation range. For that reason, it is recommended the following procedure be carried out at a line voltage of 117 volts (or 234 volts if the unit is wired for the higher line voltage).

Two sets of limits are given in the following procedure. The first is the required  $\pm 3\%$  limit, plus the possible 1% transfer standard accuracy. The second set of limits is given as a guide to the probable readings. The second set of limits at full scale is  $\pm 2\%$  of full scale based upon the worst case where two  $\pm 1\%$  transfer standards are used (one for calibration, and another for check out), and applies only at 117 (234) volts input line voltage. At  $\frac{1}{3}$  of full scale the second set of limits includes  $\pm 1\%$  meter tracking limits.

### Procedure

1. Mechanically zero the meter.
2. Connect the Type 130 to the variable line voltage autotransformer and set the line voltage to 117 (234) volts RMS. Set the Type 130 RANGE SELECTOR switch to 300  $\mu\mu\text{F}$  and let the instrument warm up for thirty minutes before proceeding.
3. Connect the Tektronix S-30 to the UNKNOWN L OR C connector. Set the S-30 control to 0 pF and carefully adjust the Type 130 zero controls for zero meter reading.

#### 4. Check 300 $\mu\mu\text{F}$ Range Accuracy

Requirement	$\pm 3\%$ +1%	Probable limit
Meter will indicate 300 $\mu\mu\text{F}$	$\pm 12 \mu\text{H}$	$\pm 6 \mu\mu\text{F}(\pm 2\%)$ .
Meter will indicate 100 $\mu\mu\text{F}$	$\pm 10 \mu\mu\text{F}$	$\pm 3 \mu\mu\text{F}(\pm 3\%)$ .

- a. Set the S-30 control to +300 pF and read the meter.  
Reading:\_\_\_\_\_.
- b. Set the S-30 control to +100 pF and read the meter.  
Reading:\_\_\_\_\_.

#### 5. Check 300 $\mu\text{H}$ Range Accuracy

Requirement:	$\pm 3\%$ +1%	Probable limit
Meter will indicate 300 $\mu\text{H}$	$\pm 12 \mu\mu\text{F}$	$\pm 6 \mu\text{H}(\pm 2\%)$ .

- a. Set the S-30 control to SHORT CIRCUIT. Set the Type 130 RANGE SELECTOR to 300  $\mu\text{H}$ . Carefully adjust the Type 130 zero controls for zero meter reading.
- b. Set the S-30 control to 300  $\mu\text{H}$  and read the meter.  
Reading:\_\_\_\_\_.

#### 6. Check 3 $\mu\mu\text{F}$ Range Accuracy

Requirement:	$\pm 3\%$ +1%	Probable limit
Meter will indicate 3 $\mu\mu\text{F}$	$\pm 12 \mu\mu\text{F}$	$\pm 0.06 \mu\mu\text{F}(\pm 2\%)$ .

- a. Set the S-30 control to SHORT CIRCUIT. Set the Type 130 RANGE SELECTOR to 300  $\mu\mu\text{F}$ . Set the S-30 control to 0 pF and adjust the Type 130 zero controls for a zero meter reading.  
  
Set the Type 130 RANGE SELECTOR to 3  $\mu\mu\text{F}$ . Carefully adjust the Type 130 zero controls for a zero meter reading. The FINE ZERO control should be set half way between the points where the meter kicks upward.
- b. Set the S-30 control first to +3 pF and then to -3 pF and check the FINE ZERO setting. If the FINE ZERO control is correctly adjusted, the meter will give the same indication for both +3 pF and -3 pF. Adjust the FINE ZERO control for equal 3  $\mu\mu\text{F}$  readings.  
Set the S-30 control to +3 pF and read the meter.  
Reading:\_\_\_\_\_.

#### 7. Check 10 $\mu\mu\text{F}$ Range Accuracy

Requirement:	$\pm 3\%$ +1%	Probable limit
Meter will indicate 10 $\mu\mu\text{F}$	$\pm 0.4 \mu\mu\text{F}$	$\pm 0.2 \mu\mu\text{F}(\pm 2\%)$ .
Meter will indicate 3 $\mu\mu\text{F}$	$\pm 0.33 \mu\mu\text{F}$	$\pm 0.1 \mu\mu\text{F}(\pm 3\%)$ .

- a. Set the Type 130 RANGE SELECTOR to 10  $\mu\mu\text{F}$ . Set the S-30 control to 0 pF. Carefully adjust the zero controls for a zero meter reading.
- b. Set the S-30 control to +10 pF and read the meter.  
Reading:\_\_\_\_\_.

## Performance Check—Type 130

c. Set the S-30 control to +3 pF and read the meter.  
Reading:\_\_\_\_\_.

### 8. Check 30 $\mu\mu\text{F}$ Range Accuracy

Requirement:	$\pm 3\%$ +1%	Probable limit
Meter will indicate 30 $\mu\mu\text{F}$	$\pm 1.2 \mu\mu\text{F}$	$\pm 0.6 \mu\mu\text{F}(\pm 2\%)$ .
Meter will indicate 10 $\mu\mu\text{F}$	$\pm 1.0 \mu\mu\text{F}$	$\pm 0.3 \mu\mu\text{F}(\pm 3\%)$ .

a. Set the Type 130 RANGE SELECTOR to 30  $\mu\mu\text{F}$ . Set the S-30 control to 0 pF. Carefully adjust the Zero controls for a zero meter reading.

b. Set the S-30 control to +30 pF and read the meter.  
Reading:\_\_\_\_\_.

c. Set the S-30 control to +10 pF and read the meter.  
Reading:\_\_\_\_\_.

### 9. Check 100 $\mu\mu\text{F}$ Range Accuracy

Requirement:	$\pm 3\%$ +1%	Probable limit
Meter will indicate 100 $\mu\mu\text{F}$	$\pm 4 \mu\mu\text{F}$	$\pm 2 \mu\mu\text{F}(\pm 2\%)$ .
Meter will indicate 30 $\mu\mu\text{F}$	$\pm 3.9 \mu\mu\text{F}$	$\pm 0.9 \mu\mu\text{F}(\pm 3\%)$ .

a. Set the Type 130 RANGE SELECTOR to 100  $\mu\mu\text{F}$ . Set the S-30 control to 0 pF. Carefully adjust the zero controls for a zero meter reading.

b. Set the S-30 control to +100 pF and read the meter.  
Reading:\_\_\_\_\_.

c. Set the S-30 control to +30 pF and read the meter.  
Reading:\_\_\_\_\_.

### 10. Check Type 130 Resistance Compensation

Requirement: Meter will indicate within +0.5 or -0.5  $\mu\mu\text{F}$  for 1 megohm and 100 k $\Omega$  load.

a. Set the S-30 control to 0 pF. Set the Type 130 RANGE SELECTOR to 3  $\mu\mu\text{F}$ . Adjust the zero controls for a zero meter reading.

b. Set the Type 130 RANGE SELECTOR to 300  $\mu\mu\text{F}$ . Change the S-30 control to 1 MEG  $\Omega$ , then return the RANGE SELECTOR switch to 3  $\mu\mu\text{F}$ . The meter should read in the vicinity of 1.5  $\mu\mu\text{F}$ . Note the meter reading.

c. Set the S-30 control to 100 k $\Omega$  and note the meter change. Tolerance is  $\pm 0.5 \mu\mu\text{F}$ .

d. Set the Type 130 RANGE SELECTOR to 30  $\mu\mu\text{F}$  and disconnect the S-30. Check out procedure is completed.

# SECTION 6

## CALIBRATION PROCEDURE

The Type 130 L-C Meter should receive a periodic calibration check at about six week intervals if used for precision measurements. Normal uses of the Type 130 will allow calibration once every six months or after 500 hours of use. The instrument should be calibrated after any of the tubes have been replaced. Special calibration aids are required for the Type 130 to be calibrated within limits stated in the Characteristics section of this manual. In particular, the inductance scales cannot be calibrated without a special inductor.

### NOTE

The performance standards described in this section of the manual are provided strictly as guides to calibration of the Type 130 and should not be construed as advertised performance specifications. However, if the Type 130 performs within the guide tolerances given in the Calibration Procedure, it will also perform as listed in the Characteristics section of this manual.

The following portion of this manual presents a step-by-step calibration and verification procedure. The title of each numbered step begins with Adjust or Check, thereby identifying the step function as calibration or verification. The steps are identified in this manner because any or all groups of numbers Checks can be omitted without disrupting the adjustment continuity of the procedure. However, all adjustments must be completed in the order given and none should be omitted. Remember that proper overall operation is ensured when all steps in the procedure have been completed and all adjustments have been made as accurately as possible.

Do not set any internal adjustments to midrange as a preliminary to recalibration. Presetting internal adjustments to midrange will only increase the time required for calibration.

### Equipment Required

Equipment required for the complete calibration of the Type 130 is shown in Fig. 6-1, and listed below. Alternate equipment may be substituted for that listed, if the performance specifications of the substituted equipment meet the particular requirements of the test. All test equipment must be calibrated and in good working order.

1. Test oscilloscope with accurate time base ( $\pm 3\%$ ), and bandwidth of at least 500 kHz. For example, the Tektronix Type 561A Oscilloscope with Type 2B67 Time Base and Type 3A75 Amplifier plug-in units.

2. A 10X Probe with BNC connector, Tektronix P6006 Probe.

3. An accurate 10 kHz frequency source, such as the Tektronix Type 180A Time-Mark Generator.

4. Variable line voltage autotransformer, such as General Radio VARIAC, Type W10MT3W, metered and capable of adjusting the line voltage from 105 to 125 volts RMS.

5. Voltmeter or bench multimeter, such as a Simpson Type 262. For measuring 150 volts  $\pm 5\%$  and up to 300 volts. Meter accuracy should be corrected at 150 volts to within 1%.

6. A Tektronix S-30 Delta Standards unit. Tektronix Part No. 015-0001-00.

7. A coaxial cable about 42 inches long, with connectors to mate the Type 180A Trigger Out connector.

BNC: Tektronix Part No. 012-0057-00.

UHF: Tektronix Part No. 012-0001-00.

8. A coaxial to clip lead adapter to match the cable of item 7.

BNC: Tektronix Part No. 013-0076-00.

UHF: Tektronix Part No. 013-0003-00.

9. A 100  $\mu\mu\text{F}$  mica or polystyrene dielectric capacitor,  $\pm 5\%$  (not shown).

10. A small insulated handle adjusting tool, such as Walsco 2519. Tektronix Part No. 003-0003-00.

11. A small screwdriver (not shown).

### CALIBRATION RECORD AND INDEX

- 1. Preliminary Control Check (Pg 6-3)
- 2. Check Power Supply voltages and Ripple (Pg 6-3)
  - +270-Volt supply; +240 to +280 volts.  
Value at 117 line: \_\_\_\_\_
  - +150-Volt supply; +142.5 to +157.5 volts.  
Value at 117 line: \_\_\_\_\_
  - +270-Volt ripple; 12 volts max. Value \_\_\_\_\_
  - +150-Volt ripple; 1 volt max. Value \_\_\_\_\_
- 3. Preliminary Adjust Fixed Oscillator Frequency to 140 kHz (Pg 6-4)
- 4. Final Adjust Fixed Oscillator Frequency (Pg 6-5)
- 5. Adjust Multivibrator Symmetry (Pg 6-6)
- 6. Adjust T1 and ADJ 2 (Pg 6-6)
  - (ADJ 2 = 300  $\mu\mu\text{F}$  full scale)
  - (T1 = Inductance balance at 300  $\mu\text{H}$ )
- 7. Adjust the ADJ 3, ADJ 4, ADJ 5 and ADJ 6 Controls (Pg 6-6)
  - a. ADJ 3 = 3  $\mu\mu\text{F}$  full scale. (Adjusted Deviation \_\_\_\_\_)
  - b. ADJ 4 = 10  $\mu\mu\text{F}$  full scale (Adjusted Deviation \_\_\_\_\_)
  - c. ADJ 5 = 30  $\mu\mu\text{F}$  full scale (Adjusted Deviation \_\_\_\_\_)
  - d. ADJ 6 = 100  $\mu\mu\text{F}$  full scale (Adjusted Deviation \_\_\_\_\_)

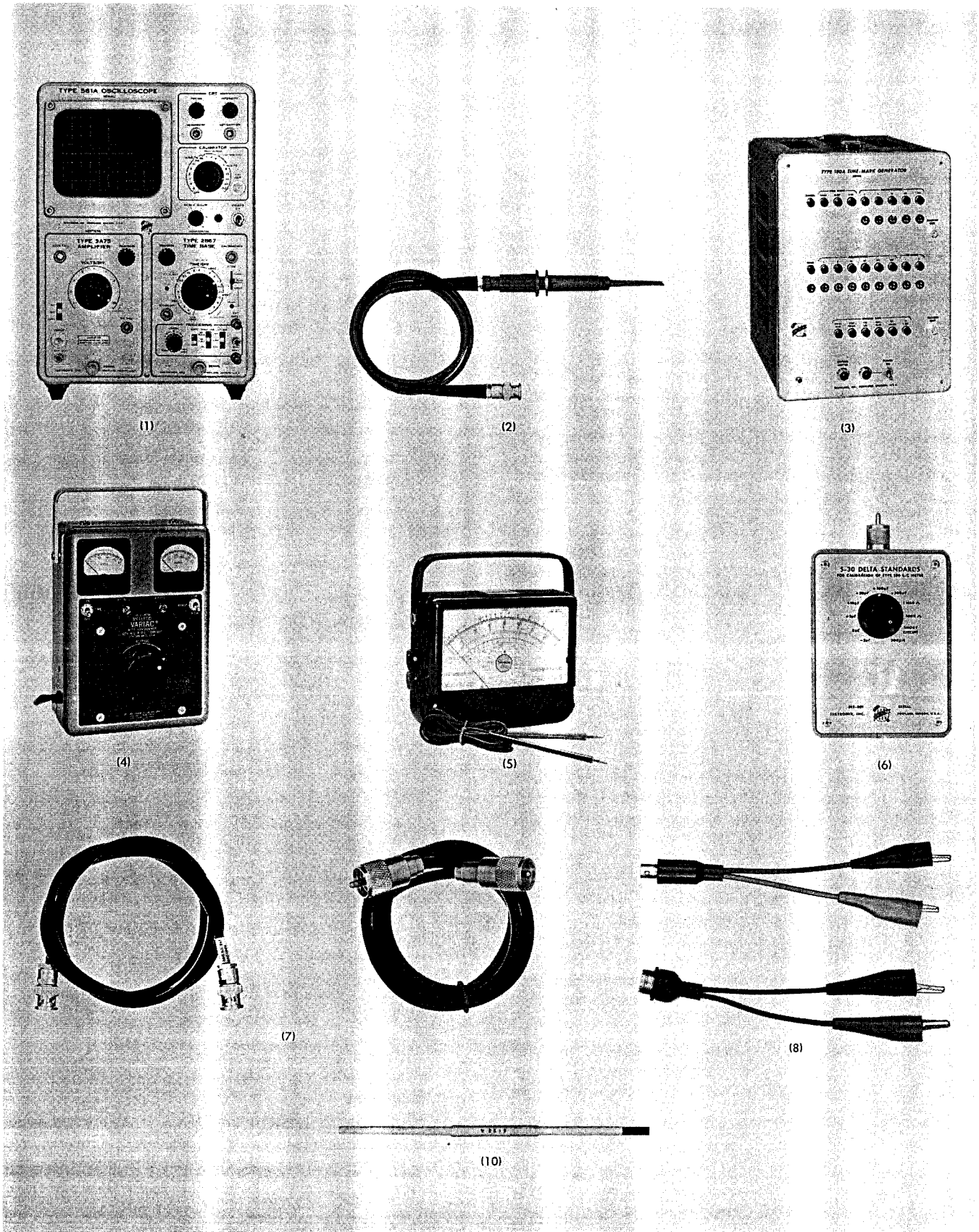


Fig. 6-1. Equipment required for calibrating the Type 130.

- 8. Adjust Resistance Compensation (Pg 6-7)  
No meter change measuring 1 MEG  $\Omega$  and 100 k $\Omega$ .
- 9. Check Voltage Across Unknown (Pg 6-7)  
Capacitance: 1 volt max. Value \_\_\_\_\_

- Inductance: 0.25 volt max. Value \_\_\_\_\_
- 10. Adjust Zero Controls Range (Pg 6-8)
- 11. Check GUARD VOLTAGE Accuracy (Pg 6-8)  
100 $\mu\mu\text{F}$  capacitor causes no more than  $-0.5$  to  $+1.5$   $\mu\mu\text{F}$  meter change.

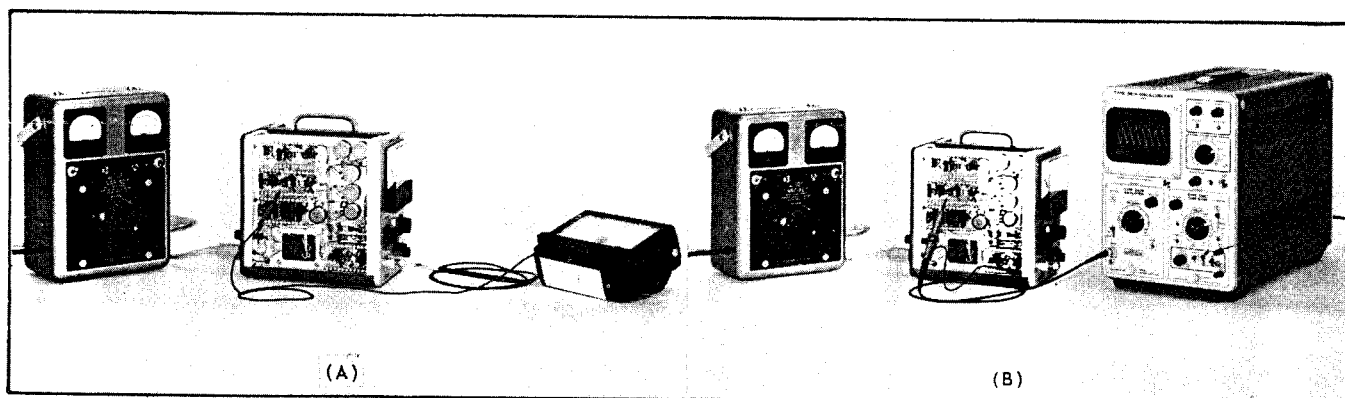


Fig. 6-2. Test set-up for checking Type 130 power supplies.

## CALIBRATION PROCEDURE

### Preliminary

In the procedure that follows, test equipment setups are illustrated at important points, with control settings called out for the Type 130 and associated instruments. Control setting changes from the preceding step are always indicated in bold-face type.

### Checks and Adjustments

#### 1. Preliminary Control Check

Check all front-panel controls for proper indexing. Check the variable controls for smooth operation. Check that both variable control knobs index correctly at 0 and turn 180° clockwise. Correct any defects found. Mechanically zero the meter.

#### Control Settings

Type 130	
RANGE SELECTOR	300 $\mu\mu\text{F}$
COARSE ZERO	Midrange
FINE ZERO	Midrange

#### Variable Line Voltage Transformer

Output 117 volts

#### Voltmeter

Selector Switch 400 volts DC

#### Type 3A75

Volts/div 0.5  
Variable Calibrated  
Coupling AC

#### Type 2B67

Time/div 5 msec  
Variable Calibrated  
Mode Normal  
Triggering  
Level Auto  
Slope +  
Coupling AC slow  
Source Line

#### 2. Check Power Supply Voltages and Ripple

a. Set the variable line voltage autotransformer for 117 volts output. Connect the Type 130 power cord to the autotransformer and set the controls as stated under Fig. 6-2A. Let the Type 130 warm up for 15 minutes before proceeding.

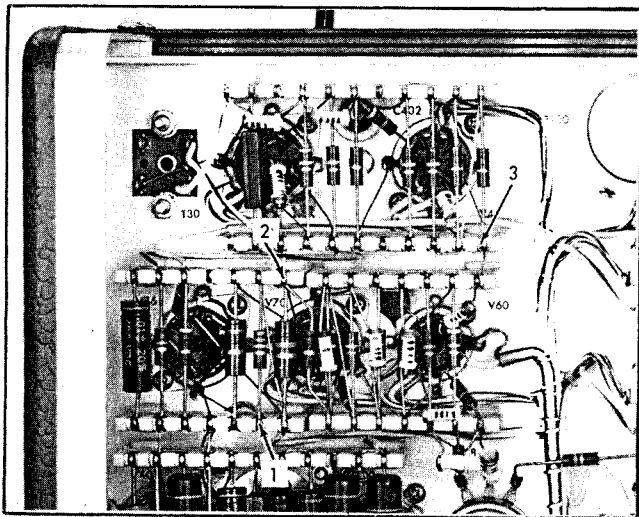


Fig. 6-3. Power supply test points No. 1 and No. 2. Fixed Oscillator test point No. 3.

b. Measure the +270-volt supply voltage at test point #1 shown in Fig. 6-3. The supply voltage must be within the limits of +240 to +280 volts. With a meter equivalent to that stated in the Equipment Required list, the supply voltage must be within the limits of +240 volts plus the meter scale tolerance and +280 volts minus the meter scale tolerance.

If the voltage is less than +240 volts when the line voltage is 117 volts RMS, check that the power line voltage is a sine wave. Greater than 5% distortion of the line voltage, such as flattening of the wave peaks, will prevent C401 from being charged to the correct value. If the line voltage is not distorted, change V400. Let the instrument warm up about three minutes before checking the supply voltage again. If still unable to obtain sufficient voltage, change C401.

c. Change the voltmeter selector switch to the 160 volt DC range. Measure the +150-volt supply voltage at test point #2 shown in Fig. 6-3. Vary the line voltage slowly from 105 to 125 volts. The +150-volt supply voltage must remain within 5% of 150 volts. With a  $\pm 1\%$  meter equivalent to that stated in the Equipment Required list, the supply voltage limits are from +144 to +156 volts on the meter scale.

If the supply voltage is out of tolerance, change V403. Let the instrument warm up for five minutes before remeasuring the +150-volt supply.

d. Set the equipment and controls as shown with Fig. 6-2B. Connect the 10X Probe ground lead to the Type 130 chassis

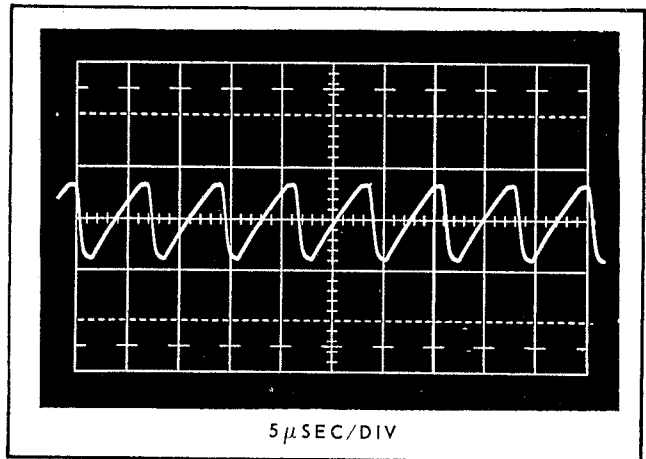


Fig. 6-4. Fixed oscillator signal at test point No. 3.

and the probe tip to test point #1 shown in Fig. 6-3. With the line voltage at 117 volts RMS the 120 Hz ripple should be less than 12 volts peak to peak.

e. Connect the 10X Probe tip to test point #2 shown in Fig. 6-3. Vary the line voltage slowly from 105 to 125 volts. The 120 Hz ripple should be less than 1 volt peak to peak. If the ripple is greater than 1 volt peak to peak, check that the +150-volt supply load current is not greater than about 22 milliamperes by inserting a milliammeter in series with R403. If the load current is correct, change V403 and start back at step 2c.

### 3. Preliminary Adjust Fixed Oscillator Frequency

a. Operate the Type 130 longer than 30 minutes before making this adjustment.

b. Set the test oscilloscope controls:

Volts/div	2
Coupling	AC
Time/div	5 $\mu$ sec
Triggering	+ Int AC

c. Connect the 10X Probe tip to test point #3 shown in Fig. 6-3. Adjust the test oscilloscope triggering controls for a stable display similar to Fig. 6-4. The display should show exactly seven complete cycles in ten CRT major divisions. If other than seven cycles, adjust T30 screwdriver adjustable slug until the display is correct.



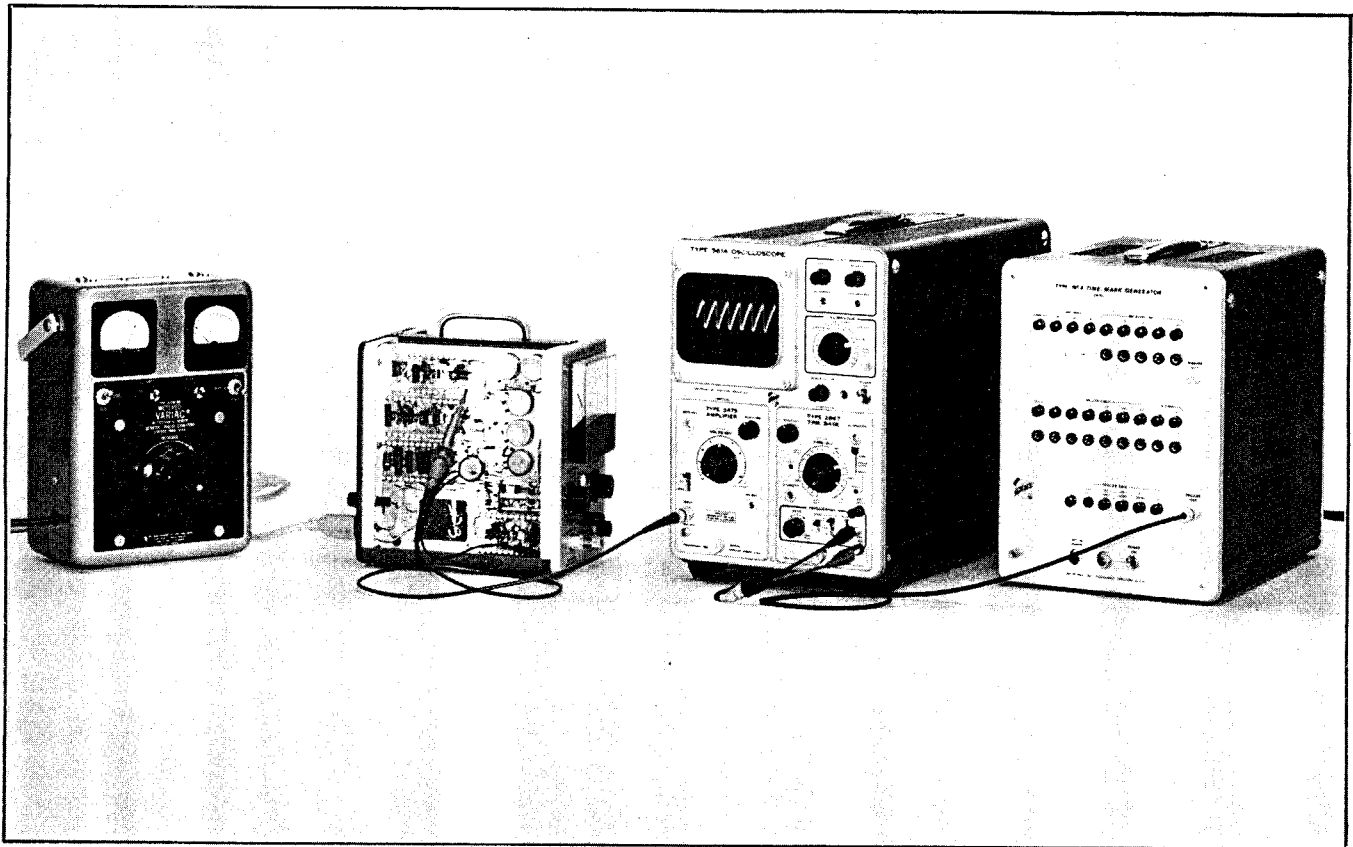


Fig. 6-5. Step 4 test set-up for accurate adjustment of Fixed Oscillator frequency.

## Control Settings

### Type 180A

Trigger Rate 10 kHz/100  $\mu$ sec

### Test Oscilloscope

Vertical unit no change  
Time/div 5  $\mu$ sec  
Triggering + External AC

## Connections

Connect the Type 180A Trigger Out connector to the Type 2B67 External Trigger input terminal through a coaxial cable. Attach the cable directly to the Trigger Out connector and use a Cable To Clip Lead Adapter at the Type 2B67. Attach the black clip lead to the Type 2B67 front-panel ground post and the red clip lead to the Type 2B67 External Trigger terminal.

Connect the 10 $\times$  Probe tip to test point  $\equiv$ 3 shown in Fig. 6-3.

## 4. Final Adjust Fixed Oscillator Frequency ①

a. Connect the test setup shown in Fig. 6-5. The display will be a smear of the stable waveform shown in Fig. 6-4 if

there is any difference between the Type 180A and the Type 130 Fixed Oscillator frequencies.

Although the test oscilloscope sweep repetition rate is triggered at a 10 kHz rate, the Type 130 Fixed Oscillator signal display can be made to stand still. The display will remain almost stationary when the two signals (trigger and Type 130) are harmonically related.

Slowly adjust T30 screwdriver adjust slug clockwise. Do not turn it more than one complete turn. If the display does not stabilize, and remains a smear, return the adjustment counterclockwise one turn and then go slowly up to one turn counterclockwise. T30 has now been adjusted plus one and minus one turn from its original position. If the display does not stabilize in the one turn adjustment area, repeat going no more than plus two and minus two turns. Once the Fixed Oscillator waveform appears clearly out of the smear, carefully adjust T30 slug for the least display drift.

b. Press each Type 180A Trigger Rate button in sequence from the 10 kc button through the 100 cps button. Each change in trigger rate should leave the display with the same slow drift, but change display brilliance. If the drift becomes a smear except at 10 kc, the Type 130 T30 is not adjusted to 140 kHz. Repeat step 4c and this step until the display remains the same through the various trigger rates.

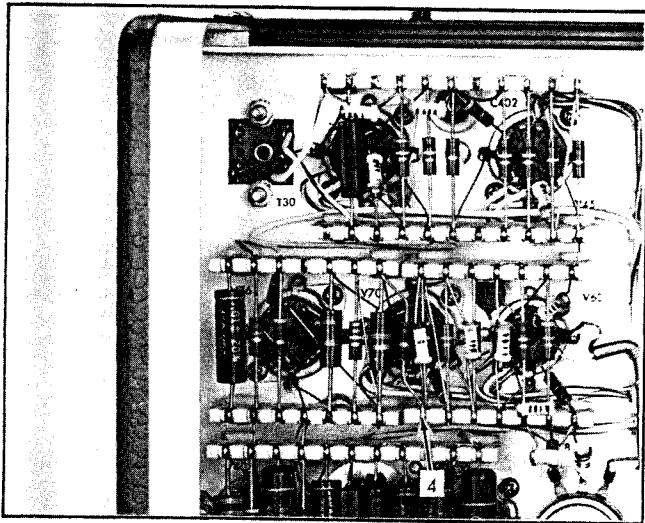


Fig. 6-6. Multivibrator symmetry test point No. 4.

### 5. Adjust Multivibrator Symmetry

a. Set the test oscilloscope controls:

Vertical Unit

Volts/div 2  
Coupling AC

Horizontal Unit

Time/div 5  $\mu$ sec  
Position Trace begins as in Fig. 6-7.  
Variable Counterclockwise for one cycle in 8 div.  
Triggering + Internal AC

Set Type 130 controls:

Range Selector 300  $\mu$ F  
Zero controls Meter zero

### Connections

Install the Tektronix S-30 Delta Standards unit to the Type 130 UNKNOWN L OR C connector with the S-30 control set to 0 pF.

Connect the 10 $\times$  Probe tip to test point #4 shown in Fig. 6-6.

b. Set the Type 130 FINE ZERO control to midrange, adjust the COARSE ZERO control for zero meter reading; touch up the adjustment with the FINE ZERO control.

c. Set the S-30 control to +300 pF and observe the test oscilloscope display. Adjust the test oscilloscope Position and Variable controls for a display of one cycle in 8 divisions like Fig. 6-7. If the multivibrator signal is not symmetrical (equal time both positive and negative), adjust R68 ADJ. 1 control for balanced symmetry. ADJ. 1 and other internal controls are shown in Fig. 6-8.

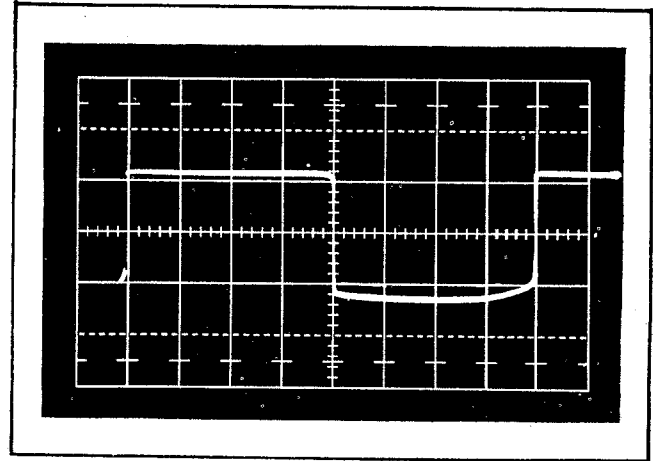


Fig. 6-7. Multivibrator waveform when adjusting symmetry.

### 6. Adjust T1 and ADJ. 2

a. Set the Type 130 RANGE SELECTOR switch to 300  $\mu$ F. Set the S-30 control to 0 pF. Carefully adjust the Type 130 zero controls for a zero meter reading.

b. Set the S-30 control to +300 pF and adjust the Type 130 ADJ. 2 control for exact full scale reading.

c. Set the S-30 control to Short Circuit. Set the Type 130 RANGE SELECTOR switch to 300  $\mu$ H. Carefully adjust the Type 130 zero controls for a zero meter reading.

d. Set the S-30 control to 300  $\mu$ H. Note the meter reading. Adjust the Type 130 T1 screwdriver adjust slug (location shown in Fig. 6-8) to increase the meter deviation (error) from 300  $\mu$ H by a factor of three. Adjust T1 so the greater error is on the same side of 300  $\mu$ H meter reading as first noted.

e. Set the S-30 control to Short Circuit, then set the Type 130 RANGE SELECTOR switch to 300  $\mu$ F.

Set the S-30 control to 0 pF and carefully adjust the zero controls for a zero meter reading.

Set the S-30 control to +300 pF and adjust the ADJ. 2 control for exact full scale reading of 300  $\mu$ F.

f. Repeat steps 6c through 6e several times until there is no difference in error of the 300  $\mu$ F and 300  $\mu$ H readings. Be sure to re-zero the zero controls each time the RANGE SELECTOR switch position is changed. T30, T1 and ADJ. 2 are now all three adjusted for proper Type 130 capacitance and inductance tracking.

### 7. Adjust the ADJ. 3, ADJ. 4, ADJ. 5, and ADJ. 6 Controls

a. Set the S-30 control to 0 pF and the Type 130 RANGE SELECTOR switch to 3  $\mu$ F. Carefully adjust the zero controls for a zero meter reading.

Set the S-30 control to +3 pF and adjust the Type 130 ADJ. 3 control for an exact full scale reading. Set the S-30 control to -3 pF. Note the meter difference from when the S-30 control was at +3 pF. Adjust the Type 130 FINE ZERO

control until the meter reads the same value for both the +3 pF and -3 pF positions of the S-30 control. The meter will probably not be at 3  $\mu\mu\text{F}$  full scale.

Set the S-30 control to +3 pF and make the final adjustment of the ADJ. 3 control for exact full scale reading.

b. Set the S-30 control to 0 pF and the Type 130 RANGE SELECTOR switch to 10  $\mu\mu\text{F}$ . Carefully adjust the zero controls for a zero meter reading.

Set the S-30 control to +10 pF and adjust the Type 130 ADJ. 4 control for an exact full scale reading of 10  $\mu\mu\text{F}$ .

Set the S-30 control to +3 pF and check that the meter reads 3  $\mu\mu\text{F}$  within the 3% of full scale tolerance between the values 2.80 and 3.20  $\mu\mu\text{F}$  on the 10  $\mu\mu\text{F}$  scale. These limits include the Type 130 3% of full scale tolerance and the S-30 1% tolerance.

c. Set the S-30 control to 0 pF and the Type 130 RANGE SELECTOR switch to 30  $\mu\mu\text{F}$ . Carefully adjust the zero controls for a zero meter reading.

Set the S-30 control to +30 pF and adjust the Type 130 ADJ. 5 control for an exact full scale reading of 30  $\mu\mu\text{F}$ .

Set the S-30 control to +10 pF and check that the meter reads between the values of 9.2 and 10.8  $\mu\mu\text{F}$  on the 30  $\mu\mu\text{F}$  scale.

d. Set the S-30 control to 0 pF and the Type 130 RANGE SELECTOR switch to 100  $\mu\mu\text{F}$ . Carefully adjust the zero controls for a zero meter reading.

Set the S-30 control to +100 pF and adjust the Type 130 ADJ. 6 control for an exact full scale reading of 100  $\mu\mu\text{F}$ .

Set the S-30 control to +30 pF and check that the meter reads between the values of 28 and 32  $\mu\mu\text{F}$ .

e. Set the S-30 control to 0 pF and the Type 130 RANGE SELECTOR switch to 300  $\mu\mu\text{F}$ . Carefully adjust the zero controls for a zero meter reading.

Set the S-30 control to +300 pF and check the full scale value. Set the S-30 control to +100 pF and check that the meter reads between the limits of 92 and 108  $\mu\mu\text{F}$ .

**NOTE**

If any scale produces readings near a tolerance limit, it may be practical to alter that scale's full scale adjustment value in a direction to bring the 1/3 of full scale reading closer to the true value measured. It is suggested that such corrections never be more than  $\pm 1\%$  away from the exact full scale value. Record any such corrections in your instrument history records.

**8. Adjust Resistance Compensation** ①

a. Set the S-30 control to 0 pF. Set the Type 130 RANGE SELECTOR switch to 3  $\mu\mu\text{F}$ . Carefully adjust the zero controls for a zero meter reading.

Set the RANGE SELECTOR switch to 300  $\mu\mu\text{F}$ . Set the S-30 control to 100 k $\Omega$ . Set the RANGE SELECTOR to 3  $\mu\mu\text{F}$ . The meter will now read near midscale. If the meter is not near midscale, adjust the zero controls for a near midscale reading.

b. Set the S-30 control to 1 MEG  $\Omega$  and note the meter change from its position when the S-30 control was at 100 k $\Omega$ . Use a non-conducting screwdriver and adjust C7 (shown in Fig. 6-8) for the same meter reading for both resistance positions of the S-30 control. It may be necessary to adjust a zero control to keep the meter reading near midscale. Adjust C7 while switching the S-30 control back and forth between the two resistance ranges.

If C7 reaches the end of its adjustment range at or before the correct adjustment, change V4. Allow 15 minutes warm up and repeat step 7b. (Changing V4 does not upset all prior adjustments. It does affect C7 and the adjustment of C2 in step 10.)

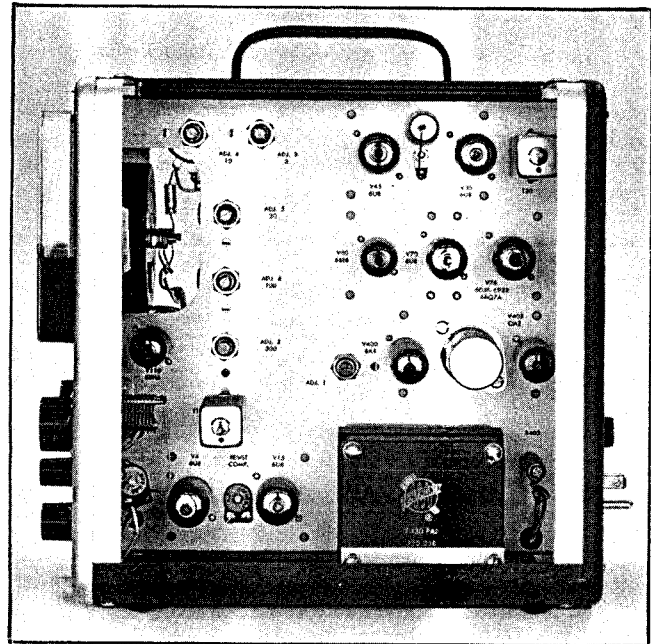


Fig. 6-8. Adjustment controls located on the right side of the Type 130.

**9. Check Voltage Across Unknown**

a. Set the Type 130 RANGE SELECTOR switch to 300  $\mu\mu\text{F}$ . Connect the test oscilloscope 10X Probe tip to the bare wire that is soldered to the center conductor of the UNKNOWN L OR C connector. Set the S-30 control to 0 pF and adjust the zero controls for a zero meter reading.

b. Set the test oscilloscope controls:

Vertical Unit	
Volts/div	0.02
Coupling	AC
Horizontal Unit	
Time/div	5 $\mu\text{sec}$
Variable	Calibrated
Triggering	+ Internal AC

c. Adjust the test oscilloscope triggering for a stable display. The signal peak-to-peak value should not be greater than 1.0 volt.

d. Set the S-30 control to +300 pF. This signal peak-to-peak value should not be greater than 1.0 volt.

e. Set the S-30 control to Short Circuit. Set the Type 130 RANGE SELECTOR switch to 300  $\mu$ H. Carefully adjust the zero controls for a zero meter reading.

Set the S-30 control to 300  $\mu$ H and readjust the test oscilloscope triggering level control for a stable display. The signal peak-to-peak value should not be greater than 0.25 volt. Disconnect the 10 $\times$  Probe.

## 10. Adjust Zero Controls Range



a. Remove the S-30 from the UNKNOWN L OR C connector. Set the Type 130 RANGE SELECTOR to 10  $\mu$  $\mu$ F. Set the two zero controls to maximum capacitance, at the clockwise end of rotation. Maximum capacitance may not occur at the end of rotation. Set both controls for maximum meter reading.

b. Use a non-conducting screwdriver adjustment tool and adjust C2 (shown in Fig. 6-8) for a meter reading of 7.5  $\mu$  $\mu$ F. Turn the COARSE ZERO control slightly counterclockwise and check that the meter can still be zeroed.

## 11. Check GUARD VOLTAGE Accuracy

### NOTE

If the factory authorized modification mentioned at the end of the Operating Instructions has been installed, omit this step from the Calibration Procedure. Follow the directions for adjustment given with the modification information.

a. Set the Type 130 RANGE SELECTOR to 3  $\mu$  $\mu$ F and adjust the zero controls clockwise from zero for a 1.5  $\mu$  $\mu$ F reading. Place a finger over the UNKNOWN L OR C connector to obtain an upscale reading. If the meter changes downscale, readjust the zero controls through meter zero for a +1.5  $\mu$  $\mu$ F reading.

b. Connect a 100  $\mu$  $\mu$ F capacitor between the UNKNOWN L OR C connector center conductor and the GUARD VOLTAGE terminal. Hold the capacitor by clamping one lead under the GUARD VOLTAGE terminal. Then place the other lead near the UNKNOWN L OR C center conductor and push it toward the Type 130 to make contact. (Push the capacitor with a low capacitance plastic tool.) The meter should not change more than  $-0.5 \mu\mu$ F to  $+1.0 \mu\mu$ F. If it does, select V110 by substituting another tube and rechecking. Also, R112 can be changed from 2.2 meg $\Omega$  to 3.3 meg $\Omega$ . A combination of R112 and V110 tube will permit the 100  $\mu$  $\mu$ F capacitor to change the reading within tolerance.

## PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connecior	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	P/O	part of
DE	double end	PHB	pan head brass
dia	diameter	PHS	pan head steel
div	division	plstc	plastic
elect.	electrolytic	PMC	paper, metal cased
EMC	electrolytic, metal cased	poly	polystyrene
EMT	electrolytic, metal tubular	prec	precision
ext	external	PT	paper, tubular
F & I	focus and intensity	PTM	paper or plastic, tubular, molded
FHB	flat head brass	RHB	round head brass
FHS	flat head steel	RHS	round head steel
Fil HB	fillister head brass	SE	single end
Fil HS	fillister head steel	SN or S/N	serial number
h	height or high	S or SW	switch
hex.	hexagonal	TC	temperature compensated
HHB	hex head brass	THB	truss head brass
HHS	hex head steel	thk	thick
HSB	hex socket brass	THS	truss head steel
HSS	hex socket steel	tub.	tubular
ID	inside diameter	var	variable
inc	incandescent	w	wide or width
		WW	wire-wound

## PARTS ORDERING INFORMATION

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

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, instrument type or number, serial or model number, and modification number if applicable.

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

## SPECIAL NOTES AND SYMBOLS

- |                 |   |
|-----------------|---|
| ×000            | Part first added at this serial number  |
| 00×             | Part removed after this serial number   |
| *000-0000-00    | Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components. |
| Use 000-0000-00 | Part number indicated is direct replacement.  |

# SECTION 7

## ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description			SN Range
<b>Bulb</b>					
B401	150-0018-00	Incandescent	Pilot Light		
<b>Capacitors</b>					
Tolerance $\pm 20\%$ unless otherwise indicated.					
C1	285-0526-00	0.1 $\mu\text{F}$	MT		400 V
C2	281-0011-00	5-25 pF	Cer	Var	
C3	281-0015-00	1-4 pF	Air	Var	
C4	281-0016-00	5-80 pF	Air	Var	
C5	283-0526-00	0.001 $\mu\text{F}$	Mica		500 V 1%
C6	281-0525-00	470 pF	Cer		500 V
C7	281-0011-00	5-25 pF	Cer	Var	
C7	281-0013-00	8-50 pF	Cer	Var	
C9	285-0510-00	0.01 $\mu\text{F}$	MT		400 V
C10	281-0511-00	22 pF	Cer		500 V 10%
C11	283-0000-00	0.001 $\mu\text{F}$	Cer		500 V
C15	281-0510-00	22 pF	Cer		500 V
C17	281-0523-00	100 pF	Cer		350 V
C18	283-0001-00	0.005 $\mu\text{F}$	Cer		500 V
C30	283-0526-00	0.001 $\mu\text{F}$	Mica		500 V 1%
C31	281-0525-00	470 pF	Cer		500 V
C33	285-0510-00	0.01 $\mu\text{F}$	MT		400 V
C35	283-0000-00	0.001 $\mu\text{F}$	Cer		500 V
C36	281-0511-00	22 pF	Cer		500 V 10%
C45	281-0510-00	22 pF	Cer		500 V
C47	281-0523-00	100 pF	Cer		350 V
C48	283-0001-00	0.005 $\mu\text{F}$	Cer		500 V
C60	283-0004-00	0.02 $\mu\text{F}$	Cer		150 V
C61	281-0524-00	150 pF	Cer		500 V
C62	281-0523-00	100 pF	Cer		350 V
C63	281-0525-00	470 pF	Cer		500 V
C64	281-0519-00	47 pF	Cer		500 V 10%
C65	281-0519-00	47 pF	Cer		500 V 10%
C73	281-0501-00	4.7 pF	Cer		500 V $\pm 1$ pF
C90	283-0543-00	250 pF	Mica		500 V 5%

Capacitors (Cont)

Ckt. No.	Tektronix Part No.		Description		SN Range
C91	285-0504-00	0.0015 $\mu$ F	MT	400 V	
C92	285-0506-00	0.0047 $\mu$ F	MT	400 V	
C93	285-0512-00	0.015 $\mu$ F	MT	400 V	
C94	285-0519-00	0.047 $\mu$ F	MT	400 V	
C97	281-0525-00	470 pF	Cer	500 V	X259-up
C99	290-0125-00	5 $\mu$ F	EMT	6 V	X6040-up
C100	290-0124-00	25 $\mu$ F	EMT	6 V	X6040-up
C110	285-0515-00	0.022 $\mu$ F	MT	400 V	
C112	283-0000-00	0.001 $\mu$ F	Cer	500 V	
C401	Use 290-0006-00	2 x 15 $\mu$ F	EMC	350 V	-20% + 50%
C402	290-0000-00	6.25 $\mu$ F	EMT	300 V	-20% + 50%
C403	285-0515-00	0.022 $\mu$ F	MT	400 V	

Fuses

F401	159-0018-00	0.8 A, 3AG, Slo-Blo; for 117 V operation
F401	159-0031-00	0.4 A, 3AG, Slo-Blo; for 234 V operation

Meter

M1	Use *050-0013-00	4700 $\Omega$	101-5167
M1	149-0010-00	0-200 $\mu$ A	5168-8653
M1	149-0022-00	0-200 $\mu$ A	8654-up

Resistors

Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R1	302-0106-00	10 M $\Omega$	1/2 W
R6	302-0155-00	1.5 M $\Omega$	1/2 W
R7	302-0104-00	100 k $\Omega$	1/2 W
R8	302-0105-00	1 M $\Omega$	1/2 W
R9	302-0563-00	56 k $\Omega$	1/2 W
R10	302-0474-00	470 k $\Omega$	1/2 W
R14	302-0106-00	10 M $\Omega$	1/2 W
R15	302-0155-00	1.5 M $\Omega$	1/2 W
R16	302-0470-00	47 $\Omega$	1/2 W
R17	302-0105-00	1 M $\Omega$	1/2 W
R18	302-0105-00	1 M $\Omega$	1/2 W
R19	302-0155-00	1.5 M $\Omega$	1/2 W
R31	302-0155-00	1.5 M $\Omega$	1/2 W
R32	302-0104-00	100 k $\Omega$	1/2 W
R33	302-0563-00	56 k $\Omega$	1/2 W



Resistors (Cont)

Ckt. No.	Tektronix Part No.		Description				SN Range
R35	302-0474-00	470 kΩ	1/2 W				
R45	302-0155-00	1.5 MΩ	1/2 W				
R46	302-0470-00	47 Ω	1/2 W				
R47	302-0105-00	1 MΩ	1/2 W				
R48	302-0105-00	1 MΩ	1/2 W				
R49	302-0155-00	1.5 MΩ	1/2 W				
R60	302-0473-00	47 kΩ	1/2 W				
R61	301-0223-00	22 kΩ	1/2 W			5%	
R62	301-0223-00	22 kΩ	1/2 W			5%	
R64	301-0113-00	11 kΩ	1/2 W			5%	
R67	302-0104-00	100 kΩ	1/2 W				
R68	311-0023-00	50 kΩ	2 W	Var		20%	
R69	302-0103-00	10 kΩ	1/2 W				X435-up
R70	302-0682-00	6.8 kΩ	1/2 W				
R71	303-0562-00	5.6 kΩ	1 W			5%	
R72	301-0184-00	180 kΩ	1/2 W			5%	
R73	301-0474-00	470 kΩ	1/2 W			5%	
R74	304-0153-00	15 kΩ	1 W				
R75	302-0334-00	330 kΩ	1/2 W				
R76	302-0470-00	47 Ω	1/2 W				
R77	302-0475-00	4.7 MΩ	1/2 W				
R78	311-0026-00	100 kΩ	2 W	Var		20%	
R79	302-0823-00	82 kΩ	1/2 W				
R80	302-0470-00	47 Ω	1/2 W				
R81	302-0470-00	47 Ω	1/2 W				
R95	306-0333-00	33 kΩ	2 W				
R96	302-0471-00	470 Ω	1/2 W				
R97	311-0015-00	10 kΩ	2 W	Var	WW	20%	
R98	311-0015-00	10 kΩ	2 W	Var	WW	20%	
R99	311-0015-00	10 kΩ	2 W	Var	WW	20%	
R100	311-0015-00	10 kΩ	2 W	Var	WW	20%	
R110	302-0105-00	1 MΩ	1/2 W				
R111	302-0103-00	10 kΩ	1/2 W				
R112	302-0225-00	2.2 MΩ	1/2 W				101-10519
R112	302-0335-00	3.3 MΩ	1/2 W	Selected (nominal value)			10520-up
R113	302-0475-00	4.7 MΩ	1/2 W				
R116	302-0470-00	47 Ω	1/2 W				
R401	302-0104-00	100 kΩ	1/2 W				
R402	302-0104-00	100 kΩ	1/2 W				
R403	308-0032-00	3.5 kΩ	20 W		WW	5%	101-753
R403	308-0020-00	3 kΩ	10 W		WW	5%	754-up
R405	308-0058-00	1.5 Ω	1 W		WW		

Switch

	Unwired	Wired		
SW1	260-0072-00		Rotary	RANGE SELECTOR

Transformers

Ckt. No	Tektronix Part No.	Description	SN Range
T1	120-0053-00	Oscillator	
T30	120-0053-00	Oscillator	
T400	*120-0038-00	Plate and Heater Supply, T130 PA 1 Primary: 117-234 VAC, 60 cycles Secondary: 240-0-240 VAC at 40 MA	

Electron Tubes

V4	154-0033-00	6U8
V15	154-0033-00	6U8
V30	154-0033-00	6U8
V45	154-0033-00	6U8
V60	154-0025-00	6BE6
V70	154-0033-00	6U8
V76	Use 154-0187-00	6DJ8
V110	154-0026-00	6BH6
V400	154-0035-00	6X4
V403	154-0001-00	OA2

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

*Assembly and/or Component*  
*Detail Part of Assembly and/or Component*  
*mounting hardware for Detail Part*  
*Parts of Detail Part*  
*mounting hardware for Parts of Detail Part*  
*mounting hardware for Assembly and/or Component*

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

**Mounting hardware must be purchased separately, unless otherwise specified.**

## PARTS ORDERING INFORMATION

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

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, instrument type or number, serial or model number, and modification number if applicable.

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

Change information, if any, is located at the rear of this manual.

## ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

**INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS**

- |        |             |
|--------|-------------|
| FIG. 1 | FRONT       |
| FIG. 2 | CHASSIS     |
| FIG. 3 | REAR        |
| FIG. 4 | CABINET     |
| FIG. 5 | ACCESSORIES |

# SECTION 8

## MECHANICAL PARTS LIST

FIG. 1 FRONT

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
1-1	333-0023-00	101	5000	1						PANEL, front
-2	386-0354-00	101	5000	1						PLATE, sub-panel
-3	- - - - -			1						METER
				-						mounting hardware: (not included w/meter)
	210-0006-00	101	5000	4						LOCKWASHER, internal, #6
-4	210-0407-00	101	5000	4						NUT, hex., 6-32 x 1/4 inch
-5	366-0011-00	101	535	1						KNOB, large black—RANGE SELECTOR
	366-0042-00	536		1						KNOB, large black—RANGE SELECTOR
				-						knob includes:
	213-0004-00	101	5000	1						SCREW, set, 6-32 x 3/16 inch, HSS
-6	260-0072-00			1						SWITCH, unwired—RANGE SELECTOR
				-						mounting hardware: (not included w/switch)
-7	210-0012-00	101	5000	1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-8	210-0413-00	101	5000	1						NUT, hex., 3/8-32 x 1/2 inch
-9	366-0011-00	101	535	1						KNOB, large black—COURSE ZERO
	366-0042-00	536		1						KNOB, large black—COURSE ZERO
				-						knob includes:
	213-0004-00	101	5000	1						SCREW, set, 6-32 x 3/16 inch, HSS
-10	- - - - -			-						CAPACITOR, variable
				-						mounting hardware: (not included w/capacitor)
-11	210-0012-00	101	5000	1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-12	210-0413-00	101	5000	1						NUT, hex., 3/8-32 x 1/2 inch
-13	366-0014-00	101	535	1						KNOB, small black—FINE ZERO
	366-0033-00	536		1						KNOB, small black—FINE ZERO
				-						knob includes:
	213-0004-00	101	5000	1						SCREW, set, 6-32 x 3/16 inch, HSS
-14	- - - - -			-						CAPACITOR, variable
				-						mounting hardware: (not included w/capacitor)
-15	210-0012-00	101	5000	1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-16	210-0840-00	101	5000	1						WASHER, flat, 0.390 ID x 3/16 inch OD
-17	210-0413-00	101	5000	1						NUT, hex., 3/8-32 x 1/2 inch
-18	131-0012-00	101	5000	1						CONNECTOR, coaxial, 1-contact, female
				-						mounting hardware: (not included w/connector)
-19	210-0202-00	101	5000	1						LUG, solder, SE #6
	211-0007-00	101	5000	4						SCREW, 4-40 x 3/16 inch, PHS
-20	129-0020-00	101	5000	1						ASSEMBLY, binding post
				-						assembly includes:
	355-0503-00	101	5000	1						STEM
	200-0072-00	101	5000	1						CAP
				-						mounting hardware: (not included w/assembly)
	210-0223-00	101	5000	1						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-21	210-0455-00	101	5000	1						NUT, hex., 1/4-28 x 3/8 inch

FIG. 1 FRONT (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	Description					
					1	2	3	4	5	
1-22	129-0030-00	101	5000	1						POST, binding, black
	- - - - -			-						mounting hardware: (not included w/post)
-23	358-0036-00	101	5000	1						BUSHING, nylon, black
	210-0010-00	101	5000	1						LOCKWASHER, internal, #10
-24	210-0206-00	101	5000	1						LUG, solder, SE #10
	210-0445-00	101	5000	2						NUT, hex., 10-32 x 3/8 inch
-25	211-0538-00	101	5000	4						SCREW, 6-32 x 5/16 inch, 100° csk, FHS
-26	333-0334-00	5001	5167	1						PANEL, front
	333-0427-00	5168		1						PANEL, front
-27	386-0604-00	5001	5167	1						PLATE, sub-panel
	386-0763-00	5168		1						PLATE, sub-panel
-28	- - - - -			-						METER
	- - - - -			-						mounting hardware: (not included w/meter)
	210-0805-00	5001		4						WASHER, flat, 0.204 ID x 0.438 inch OD
-29	210-0458-00	5001		4						NUT, keps, 8-32 x 1 1/32 inch
-30	366-0042-00	5001	8749	1						KNOB, large black—RANGE SELECTOR
	366-0117-00	8750		1						KNOB, large charcoal—RANGE SELECTOR
	- - - - -			-						knob includes:
	213-0004-00	5001		1						SCREW, set, 6-32 x 3/16 inch, HSS
-31	260-0072-00			1						SWITCH, unwired—RANGE SELECTOR
	- - - - -			-						mounting hardware: (not included w/switch)
-32	210-0013-00	5001		1						LOCKWASHER, internal, 3/8 ID x 1 1/16 inch OD
	210-0840-00	5001		1						WASHER, flat, 0.390 ID x 7/16 inch OD
-33	210-0413-00	5001		1						NUT, hex., 3/8-32 x 1/2 inch
-34	366-0042-00	5001	8749	1						KNOB, large black—COURSE ZERO
	366-0117-00	8750		1						KNOB, large charcoal—COURSE ZERO
	- - - - -			-						knob includes:
	213-0004-00	5001		1						SCREW, set, 6-32 x 3/16 inch, HSS
-35	- - - - -			1						CAPACITOR, variable
	- - - - -			-						mounting hardware: (not included w/capacitor)
-36	210-0013-00	5001		1						LOCKWASHER, internal, 3/8 ID x 1 1/16 inch OD
	210-0840-00	5001		1						WASHER, flat, 0.390 ID x 7/16 inch OD
-37	210-0413-00	5001		1						NUT, hex., 3/8-32 x 1/2 inch
-38	366-0033-00	5001	8749	1						KNOB, small black—FINE ZERO
	366-0148-00	8750		1						KNOB, small charcoal—FINE ZERO
	- - - - -			-						knob includes:
	213-0004-00	5001		1						SCREW, set, 6-32 x 3/16 inch, HSS
-39	- - - - -			-						CAPACITOR, variable
	- - - - -			-						mounting hardware: (not included w/capacitor)
-40	210-0013-00	5001		1						LOCKWASHER, internal, 3/8 ID x 1 1/16 inch OD
	210-0840-00	5001		1						WASHER, flat, 0.390 ID x 7/16 inch OD
-41	210-0413-00	5001		1						NUT, hex., 3/8-32 x 1/2 inch

FIG. '1 FRONT (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-42	131-0012-00	5001		1	CONNECTOR, coaxial, 2-contact, female
	- - - - -			-	mounting hardware: (not included w/connector)
-43	211-0101-00	5001	10439	4	SCREW, 4-40 x 1/4 inch, 100° csk, FHS
	211-0038-00	10440		3	SCREW, 4-40 x 5/16 inch, 100° csk, FHS
	210-0001-00	X10440		1	LOCKWASHER, internal, #4
	210-0201-00	5001		1	LUG, solder, SE #4
	210-0586-00	5001		4	NUT, keps, 4-40 x 1/4 inch
-44	129-0020-00	5001		1	ASSEMBLY, binding post
	- - - - -			-	assembly includes:
	355-0503-00			1	STEM
	200-0072-00			1	CAP
	- - - - -			-	mounting hardware: (not included w/assembly)
	210-0223-00	5001		1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-45	210-0455-00	5001		1	NUT, hex., 1/4-28 x 3/8 inch
-46	129-0030-00	5001	5616	1	POST, binding, black
	129-0036-00	5617	8749	1	POST, binding, black
	129-0063-00	8750		1	POST, binding, charcoal
	- - - - -			-	mounting hardware (not included w/post)
-47	358-0036-00	5001	8749	1	BUSHING, nylon, black
	358-0169-00	8750		1	BUSHING, nylon, charcoal
	210-0206-00	5001	8069X	1	LUG, solder, SE #10
	210-0010-00	5001	8069X	1	LOCKWASHER, internal, #10
	210-0445-00	5001	8069	2	NUT, hex., 10-32 x 3/8 inch
	220-0410-00	8070		1	NUT, keps, 10-32 x 3/8 inch
-48	136-0047-00	X5168	9829	2	ASSEMBLY, socket, w/red jewel
	136-0079-00	9830		1	ASSEMBLY, socket, w/green jewel
	- - - - -			-	assembly includes:
-49	- - - - -			1	NUT
-50	211-0538-00	5001		3	SCREW, 6-32 x 5/16 inch, 100° csk, FHS

FIG. 2 CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † Y	Description				
					1	2	3	4	5
2-1	441-0074-00	101	5000	1	CHASSIS				
-2	387-0533-00	101	5000	1	PLATE, bottom				
-3	211-0538-00	101	5000	4	SCREW, 6-32 x 5/16 inch, 100° csk, FHS				
-4	- - - - -	101	5000	6	RESISTOR, variable				
	- - - - -			-	mounting hardware for each: (not included w/resistor)				
	210-0012-00	101	5000	1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD				
-5	210-0840-00	101		1	WASHER, flat, C.390 ID x 3/16 inch OD				
-6	210-0413-00	101		1	NUT, hex., 3/8-32 x 1/2 inch				
-7	352-0002-00	101		1	ASSEMBLY, fuse holder				
	- - - - -			-	assembly includes:				
	352-0010-00	101		1	HOLDER, fuse				
-8	200-0582-00	101		1	CAP, fuse				
-9	210-0873-00	101		1	WASHER, rubber, 1/2 ID x 1 1/16 inch OD				
-10	- - - - -	101		1	NUT, fuse holder				
-11	136-0008-00	101		4	SOCKET, tube, 7 pin, w/ground lugs				
	- - - - -			-	mounting hardware for each: (not included w/socket)				
	211-0033-00	101		2	SCREW, sems, 4-40 x 5/16 inch, PHS				
	210-0004-00	101		2	LOCKWASHER, internal, #4				
	210-0406-00	101		2	NUT, hex., 4-40 x 3/16 inch				
-12	136-0015-00	101		6	SOCKET, tube, 9-pin, w/ground lugs				
	- - - - -			-	mounting hardware for each: (not included w/socket)				
-13	211-0033-00	101		2	SCREW, sems, 4-40 x 5/16 inch, PHS				
	210-0004-00	101		2	LOCKWASHER, internal, #4				
	210-0406-00	101		2	NUT, hex., 4-40 x 3/16 inch				
-14	337-0005-00	101		1	SHIELD, socket, 2 3/32 inch ID				
-15	387-0534-00	101		1	PLATE, top				
-16	343-0015-00	101		1	CLAMP, stainless steel, 1/2 inch				
	- - - - -			-	mounting hardware: (not included w/clamp)				
-17	211-0504-00	101		1	SCREW, 6-32 x 1/4 inch, PHS				
	210-0407-00	101		2	NUT, hex., 6-32 x 1/4 inch				
	214-0012-00	101		1	BOLT, spade, 6-32 x 3/8 inch				
	210-0006-00	101		2	LOCKWASHER, internal, #6				
-18	214-0024-00	101		1	FASTENER, spring				
-19	131-0010-00	101		1	CONNECTOR, 2-contact, male				
	- - - - -			-	mounting hardware: (not included with connector)				
-20	211-0507-00	101		2	SCREW, 6-32 x 5/16 inch, PHS				
	210-0006-00	101		2	LOCKWASHER, internal, #6				
	210-0407-00	101		2	NUT, hex., 6-32 x 1/4 inch				
-21	348-0002-00	101	5000	2	GROMMET, rubber, 1/4 inch diameter				
-22	- - - - -	101	5000	1	RESISTOR				
	- - - - -			-	mounting hardware: (not included w/resistor)				
-23	210-0808-00	101	753	2	WASHER, centering				
	210-0601-00	754		1	EYELET, 0.190 ID x 0.323 inch OD				
-24	212-0037-00	101	753	1	SCREW, 8-32 x 1 3/4 inches, Fil HS				
	211-0553-00	754		1	SCREW, 6-32 x 1 1/2 inches, RHS				



FIG. 2 CHASSIS (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	Description				
					1	2	3	4	5
2-25	210-0409-00	101	753	2	NUT, hex., 8-32 x 5/16 inch				
	210-0008-00	101	753	1	LOCKWASHER, internal, #8				
	210-0478-00	754		1	NUT, hex., resistor mounting				
-26	-	101	5000	1	CAPACITOR				
	-	-	-	-	mounting hardware: (not included w/capacitor)				
-27	386-0253-00	101	5000	1	PLATE, capacitor flange, metal				
	211-0534-00	101	5000	2	SCREW, sems, 6-32 x 5/16 inch, PHS				
	210-0006-00	101	5000	2	LOCKWASHER, internal, #6				
-28	210-0407-00	101	5000	2	NUT, hex., 6-32 x 1/4 inch				
-29	212-0039-00	101	5000	4	SCREW, 8-32 x 3 inches, RHS				
	210-0008-00	101	5000	4	LOCKWASHER, internal, #8				
	210-0409-00	101	5000	4	NUT, hex., 8-32 x 5/16 inch				
-30	179-0051-00	101	5000	1	CABLE HARNESS				
-31	124-0016-00	101	5000	6	STRIP, ceramic, 3/4 inch h, w/11 notches				
	-	-	-	-	mounting hardware for each: (not included w/strip)				
	210-0850-00	101	5000	2	WASHER, flat, 0.093 ID x 7/32 inch OD				
	210-0002-00	101	5000	2	LOCKWASHER, external, #2				
-32	210-0405-00	101	5000	4	NUT, hex., 2-56 x 3/16 inch				
	124-0014-00	101	5000	4	STRIP, ceramic, 3/4 inch h, w/7 notches				
	-	-	-	-	mounting hardware for each: (not included w/strip)				
	210-0850-00	101	5000	2	WASHER, flat, 0.093 ID x 7/32 inch OD				
-33	210-0002-00	101	5000	2	LOCKWASHER, external, #2				
	210-0405-00	101	5000	4	NUT, hex., 2-56 x 3/16 inch				
-34	441-0153-00	5001		1	CHASSIS				
	-	-	-	-	mounting hardware: (not included w/chassis)				
-35	210-0457-00	5001		6	NUT, keps, 6-32 x 5/16 inch				
	-	-	-	-	-				
-34	-	5001		1	TRANSFORMER				
-35	-	-	-	-	transformer includes:				
	406-0872-00	X7580		1	BRACKET, transformer support				
-36	212-0029-00	5001		4	SCREW, 8-32 x 3 inches, HHS				
	-	-	-	-	mounting hardware: (not included w/transformer)				
	210-0008-00	5001		4	LOCKWASHER, internal, #8				
-37	210-0409-00	5001		4	NUT, hex., 8-32 x 5/16 inch				
	211-0537-00	X7580		3	SCREW, 6-32 x 3/8 inch, THS				
	210-0803-00	X7580		3	WASHER, flat, 0.150 ID x 0.375 inch OD				
	210-0457-00	X7580		3	NUT, keps, 6-32 x 5/16 inch				
-38	-	5001		6	RESISTOR, variable				
	-	-	-	-	mounting hardware for each: (not included w/resistor)				
	210-0012-00	5001		1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD				
-39	210-0840-00	5001		1	WASHER, flat, 0.390 ID x 7/16 inch OD				
	210-0413-00	5001		1	NUT, hex., 3/8-32 x 1/2 inch				

FIG. 2 CHASSIS (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description
				†	1	2	3	4	
				Y					
2-40	343-0015-00	5001	5453	1					CLAMP, stainless steel, 1/2 inch
	-----	-----	-----	-					mounting hardware: (not included w/clamp)
	211-0504-00	5001	5453X	1					SCREW, 6-32 x 1/4 inch, PHS
	210-0006-00	5001		2					LOCKWASHER, internal, #6
	210-0407-00	5001	5453X	2					NUT, hex., 6-32 x 1/4 inch
	214-0012-00	5001	5453X	1					BOLT, spade, 6-32 x 3/8 inch
	354-0068-00	5454		1					RING, securing
-41	-----	5001		1					RESISTOR
	-----	-----	-----	-					mounting hardware: (not included w/resistor)
-42	210-0601-00	5001		1					EYELET, 0.190 ID x 0.323 inch OD
-43	210-0478-00	5001		1					NUT, hex., resistor mounting
-44	211-0553-00	5001		1					SCREW, 6-32 x 1 1/2 inches, RHS
-45	211-0507-00	5001		1					SCREW, 6-32 x 5/16 inch, PHS
-46	-----	5001		2					TRANSFORMER, variable
	-----	-----	-----	-					mounting hardware for each: (not included w/transformer)
-47	210-0803-00	5001		2					WASHER, flat, 0.150 ID x 0.375 inch OD
	210-0457-00	5001		2					NUT, keps, 6-32 x 5/16 inch
-48	136-0015-00	5001		6					SOCKET, tube, 9 pin, w/ground lugs
-49	-----	-----	-----	-					mounting hardware for each: (not included w/socket)
	213-0044-00	5001		2					SCREW, thread forming, 5-32 x 3/16 inch, PHS
-50	136-0008-00	5001		4					SOCKET, tube, 7 pin, w/ground lugs
-51	-----	-----	-----	-					mounting hardware for each: (not included w/socket)
	213-0044-00	5001		2					SCREW, thread forming, 5-32 x 3/16 inch, PHS
-52	348-0003-00	5001		1					GROMMET, rubber, 5/16 inch diameter
-53	348-0002-00	5001		3					GROMMET, rubber, 1/4 inch diameter
-54	210-0202-00	X5454		1					LUG, solder, SE #6
	-----	-----	-----	-					mounting hardware: (not included w/lug)
	211-0504-00			1					SCREW, 6-32 x 1/4 inch, PHS
	210-0407-00			1					NUT, hex., 6-32 x 1/4 inch
	-----	-----	-----	-----	-				mounting hardware: (not included w/capacitor)
-55	-----	5001		1					CAPACITOR
	-----	-----	-----	-					mounting hardware: (not included w/capacitor)
	386-0253-00	5001		1					PLATE, capacitor flange, metal
	211-0534-00	5001		2					SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0006-00	5001		2					LOCKWASHER, internal, #6
	210-0407-00	5001		2					NUT, hex., 6-32 x 1/4 inch
-56	179-0051-00	5001		1					CABLE HARNESS
-57	124-0016-00	5001	5689	6					STRIP, ceramic, 3/4 inch h, w/11 notches
	-----	-----	-----	-					mounting hardware for each: (not included w/strip)
	210-0850-00	5001	5689	2					WASHER, flat, 0.093 ID x 3/32 inch OD
	210-0002-00	5001	5689	2					LOCKWASHER, external, #2
	210-0405-00	5001	5689	4					NUT, hex., 2-56 x 3/16 inch
	-----	-----	-----	-----	-				mounting hardware for each: (not included w/strip)

FIG. 2 CHASSIS (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1 2 3 4 5					
	124-0091-00	5690		6	STRIP, ceramic, $\frac{3}{4}$ inch h, w/11 notches
	- - - - -			-	each strip includes:
	355-0046-00	X5690		2	STUD, plastic
	- - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00	5690		2	SPACER, plastic, 0.406 inch long
2-58	124-0014-00	5001	5689	4	STRIP, ceramic, $\frac{3}{4}$ inch h, w/7 notches
	- - - - -			-	mounting hardware for each: (not included w/strip)
	210-0850-00	5001	5689	2	WASHER, flat, 0.093 ID x $\frac{9}{32}$ inch OD
	210-0002-00	5001	5689	2	LOCKWASHER, external, #2
	210-0405-00	5001	5689	4	NUT, hex., 2-56 x $\frac{3}{16}$ inch
	124-0089-00	5690		4	STRIP, ceramic, $\frac{3}{4}$ inch h, w/7 notches
	- - - - -			-	each strip includes:
	355-0046-00	X5690		2	STUD, plastic
	- - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long

FIG. 3 REAR

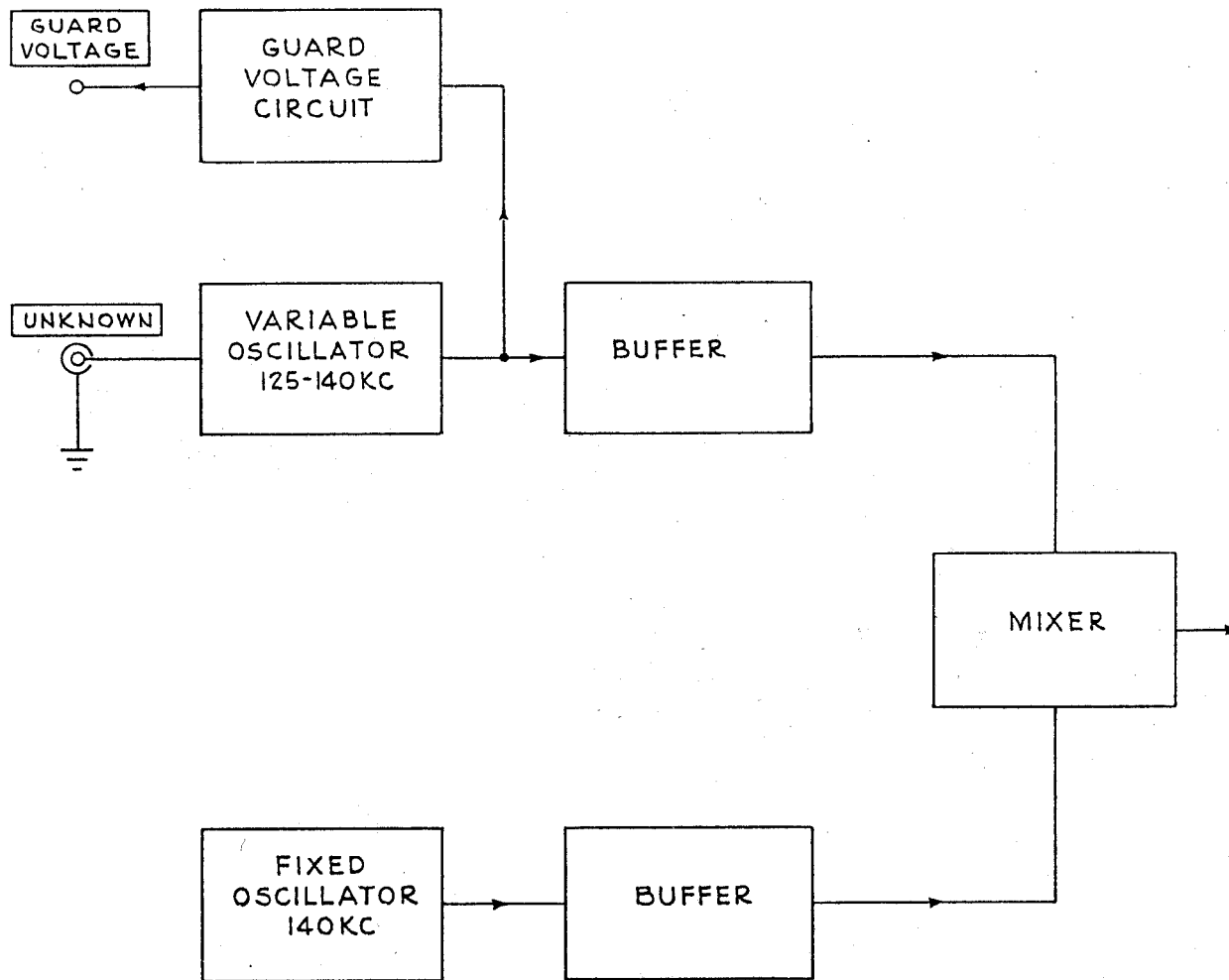
Fig. & Index	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description		
				t	Y	1	2	3		4	5
3-1	386-0603-00	5001				1				1	PLATE, rear sub-panel
-2	386-0643-00	5001				1				1	PLATE, rear overlay
	387-0035-00	6214	6213			1				1	PLATE, rear overlay, blue vinyl
-3	-	-	-			-				-	mounting hardware: (not included w/plate)
	213-0088-00	5001				3				3	SCREW, thread forming, 4-40 x 1/4 inch, PHS
	-	-	-			-				-	mounting hardware: (not included w/connector)
-4	131-0010-00	5001	5496			1				1	CONNECTOR, 2-contact, male
	213-0041-00	5001	5496			2				2	SCREW, thread cutting, 6-32 x 3/8 inch, THS
	131-0102-00	5497	9419			1				1	CONNECTOR, 3 contact, male
	131-0102-01	9420	9879			1				1	CONNECTOR, 3 contact, male
	131-0102-02	9880				1				1	CONNECTOR, 3 contact, male
	-	-	-			-				-	connector includes:
	129-0041-00	5497	9419			1				1	POST, ground
	129-0041-01	9420	9879			1				1	POST, ground
	200-0185-00	5497	9419			1				1	COVER, plastic
	200-0185-01	9420	9879			1				1	COVER, plastic
	204-0335-00	9880				1				1	BODY-CONTACT ASSEMBLY
	210-0003-00	5497	9419X			2				2	LOCKWASHER, external, #4
	210-0551-00	5497	5419X			2				2	NUT, hex., 4-40 x 1/4 inch
	211-0132-00	X9420	9819			1				1	SCREW, sems, 4-40 x 1/2 inch, PHS
	211-0534-00	9880	10759			1				1	SCREW, sems, 6-32 x 5/16 inch, PHS
	211-0614-00	10760				1				1	SCREW, sems, 6-32 x 1/4 inch, PHS
	211-0015-00	101				1				1	SCREW, 4-40 x 1/2 inch, RHS
	213-0088-00	9420	9879			1				1	SCREW, thread forming, 4-40 x 1/4 inch, PHS
	213-0146-00	9880				1				1	SCREW, thread forming, #6 x 0.313 inch, PHS
	214-0078-00					2				2	PIN, connecting
	377-0041-00	101	9419			1				1	INSERT
	377-0051-00	9420	9879			1				1	INSERT
	214-1016-00	9880				1				1	INSULATOR, connector
	386-0933-00	101	9879			1				1	PLATE, mounting
	386-1356-01	9880				1				1	PLATE, mounting
	-	-	-			-				-	mounting hardware: (not included w/connector)
-5	211-0537-00	5497				2				2	SCREW, 6-32 x 3/8 inch, THS
-6	210-0457-00	X5497				2				2	NUT, keps, 6-32 x 5/16 inch
-7	352-0002-00	5001				1				1	ASSEMBLY, fuse holder
	-	-	-			-				-	assembly includes:
	352-0010-00	5001				1				1	HOLDER, fuse
-8	200-0582-00	5001				1				1	CAP, fuse holder
-9	210-0873-00	5001				1				1	WASHER, rubber, 1/2 ID x 11/16 inch OD
-10	-	-	-			1				1	NUT, fuse holder
-11	367-0007-00	5001				1				1	HANDLE, 4 inches
	-	-	-			-				-	mounting hardware: (not included w/handle)
-12	212-0004-00	5001				2				2	SCREW, 8-32 x 5/16 inch, PHS

## FIG. 3 REAR

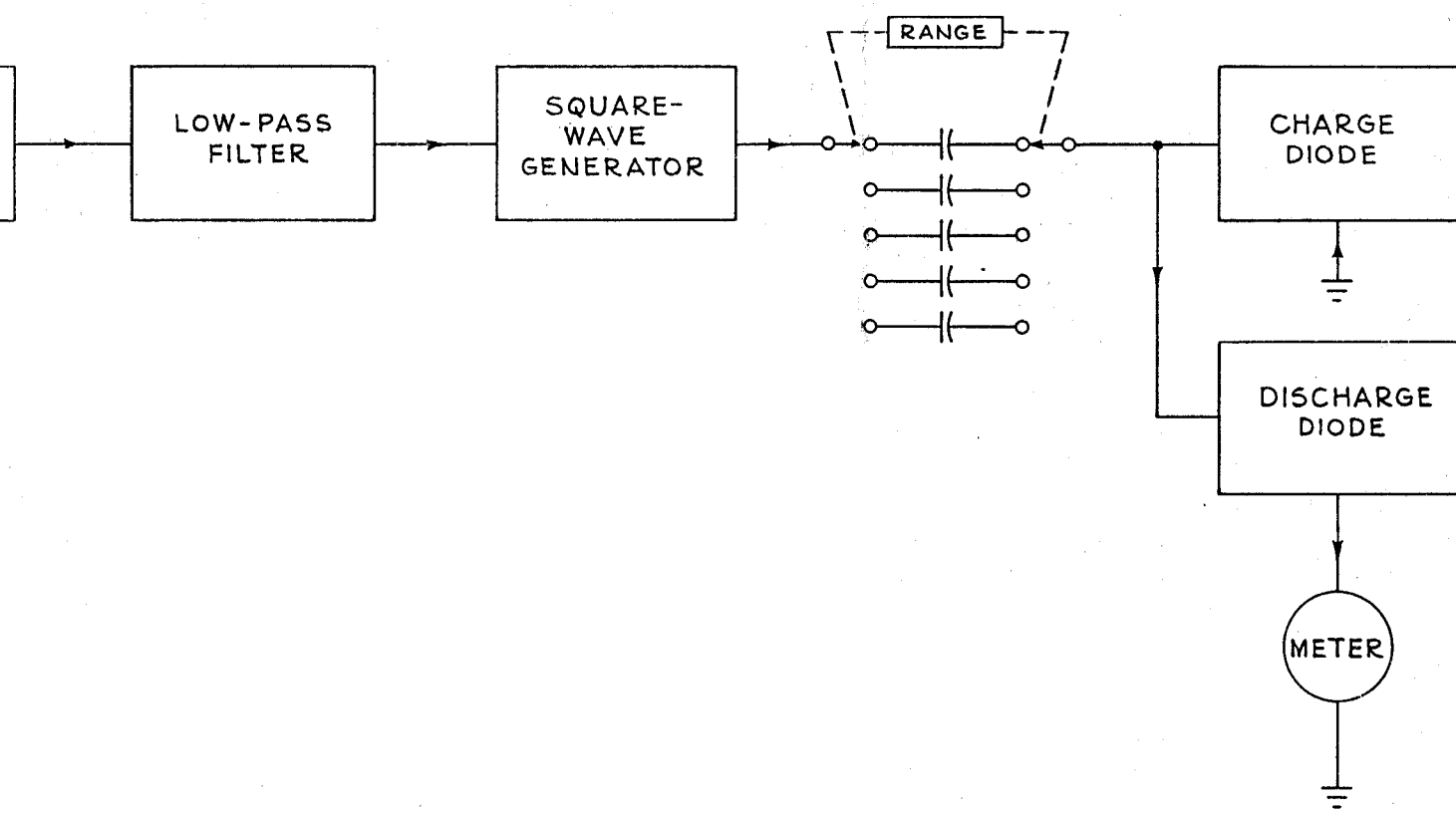
Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † γ	Description	
		Eff	Disc			1
-13	381-0062-00	5001	6213	1	BAR, chrome	
	381-0159-00	6214		1	BAR, blue vinyl	
	- - - - -			-	mounting hardware: (not included w/bar)	
-14	211-0537-00	5001		4	SCREW, 6-32 x 3/8 inch, THS	
-15	381-0084-00	5001		2	BAR, w/2 6-32 holes	
-16	334-0649-00	5001		1	TAG, voltage rating	
	- - - - -			-	mounting hardware: (not included w/tag)	
-17	213-0088-00	5001		2	SCREW, thread forming, #4 x 1/4 inch, PHS	

FIG. 4 CABINET

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t y						Description
					1	2	3	4	5	
4-1	437-0021-00	101	5000	1						ASSEMBLY, cabinet
-2	367-0007-00	101	5000	1						assembly includes: HANDLE, 4 inches
	210-0008-00	101	5000	-						mounting hardware: (not included w/handle)
	212-0001-00	101	5000	2						LOCKWASHER, internal, #8
				2						SCREW, 8-32 x 1/4 inch, PHS
-3	348-0001-00	101	5000	4						FOOT, rubber, 1 inch
-4	211-0507-00	101	5000	-						mounting hardware for each: (not included w/foot)
-5	210-0006-00	101	5000	1						SCREW, 6-32 x 5/16 inch, PHS
-6	210-0407-00	101	5000	1						LOCKWASHER, internal, #6
				1						NUT, hex., 6-32 x 1/4 inch
-7	355-0014-00	101	5000	1						STUD, cowl fastener, #5
-8	384-0507-00	101	5000	1						ROD, pin
-9	386-0539-00	5001	6213	2						PLATE, cabinet side, blue wrinkle
	387-0027-00	6214		2						PLATE, cabinet side, blue vinyl
				-						each plate includes:
-10	105-0009-00	5001		2						STOP
	210-0470-00	5001		2						NUT
	210-0870-00	5001		2						WASHER, flat, 9/64 ID x 5/16 inch OD
	213-0040-00	5001		2						SCREW, fastening
-11	386-0538-00	5001	6213	1						PLATE, cabinet bottom, blue wrinkle
	387-0028-00	6214		1						PLATE, cabinet bottom, blue vinyl
				-						plate includes:
-12	348-0013-00	5001		4						FOOT, rubber, 1/2 inch
				-						mounting hardware: (not included w/plate)
	211-0537-00	5001		4						SCREW, 6-32 x 3/8 inch, THS (not shown)
	210-0457-00	5001		4						NUT, keps, 6-32 x 5/16 inch (not shown)



TYPE 130 L-C METER



RBH  
3-16-62

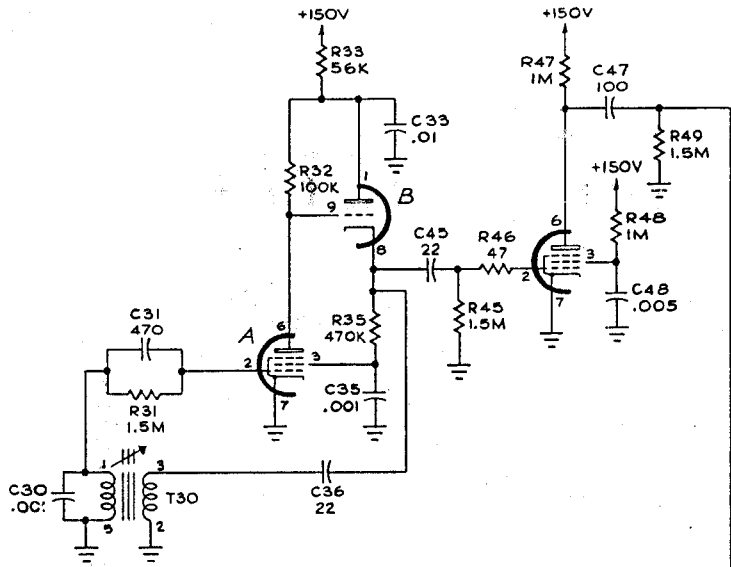
### BLOCK DIAGRAM

AA<sub>1</sub>



V30 6U8  
VARIABLE OSCILLATOR

V45A 6U8  
AMPLIFIER

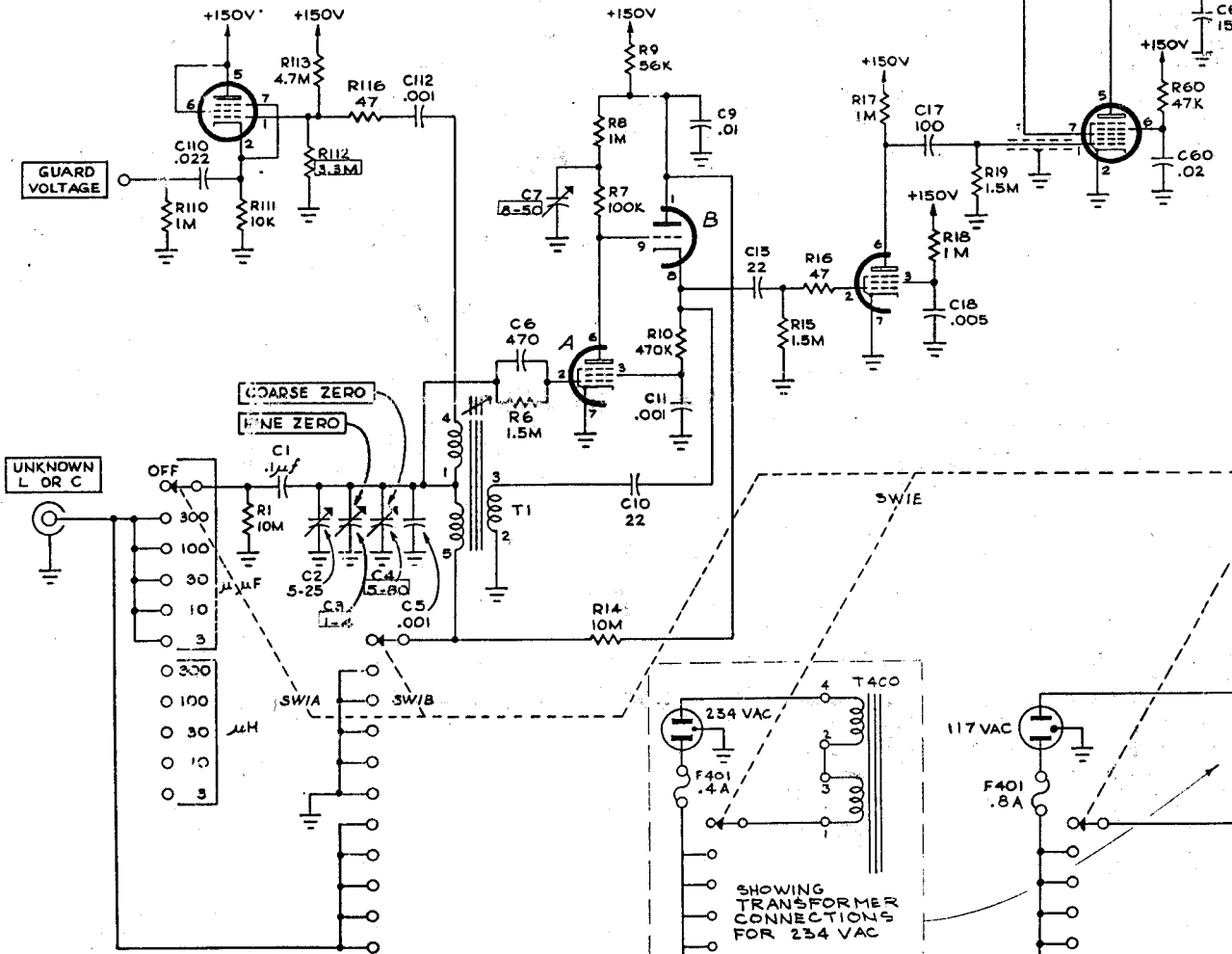


V60 6BE6  
MIXER

V110 6BH6  
GUARD-VOLTAGE CATHODE FOLLOWER

V4 6U8  
VARIABLE OSCILLATOR

V15A 6U8  
AMPLIFIER



SEE PARTS LIST FOR EARLIER  
VALUES AND SERIAL NUMBER  
RANGES OF PARTS MARKED  
WITH BLUE OUTLINE.

SHOWING  
TRANSFORMER  
CONNECTIONS  
FOR 234 VAC

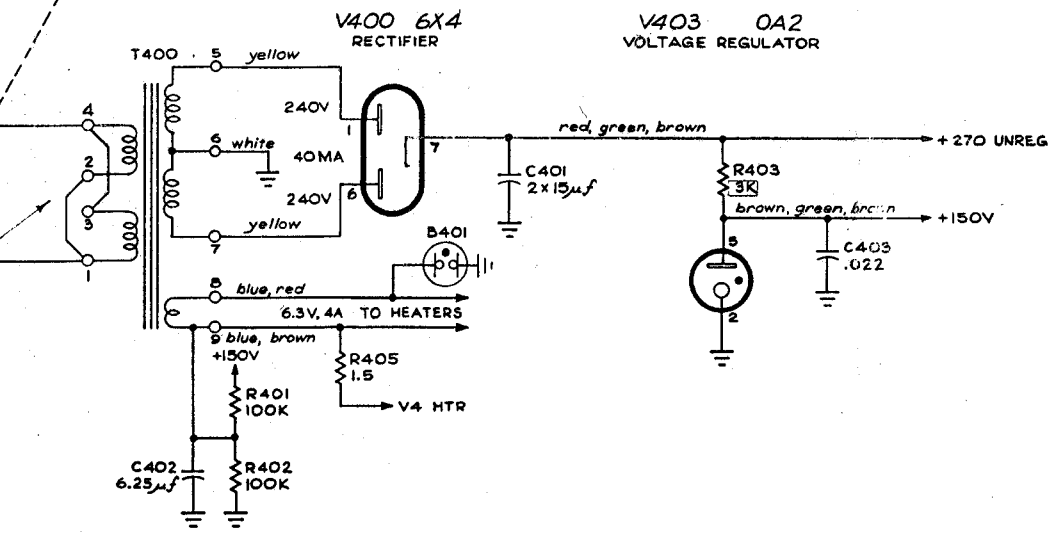
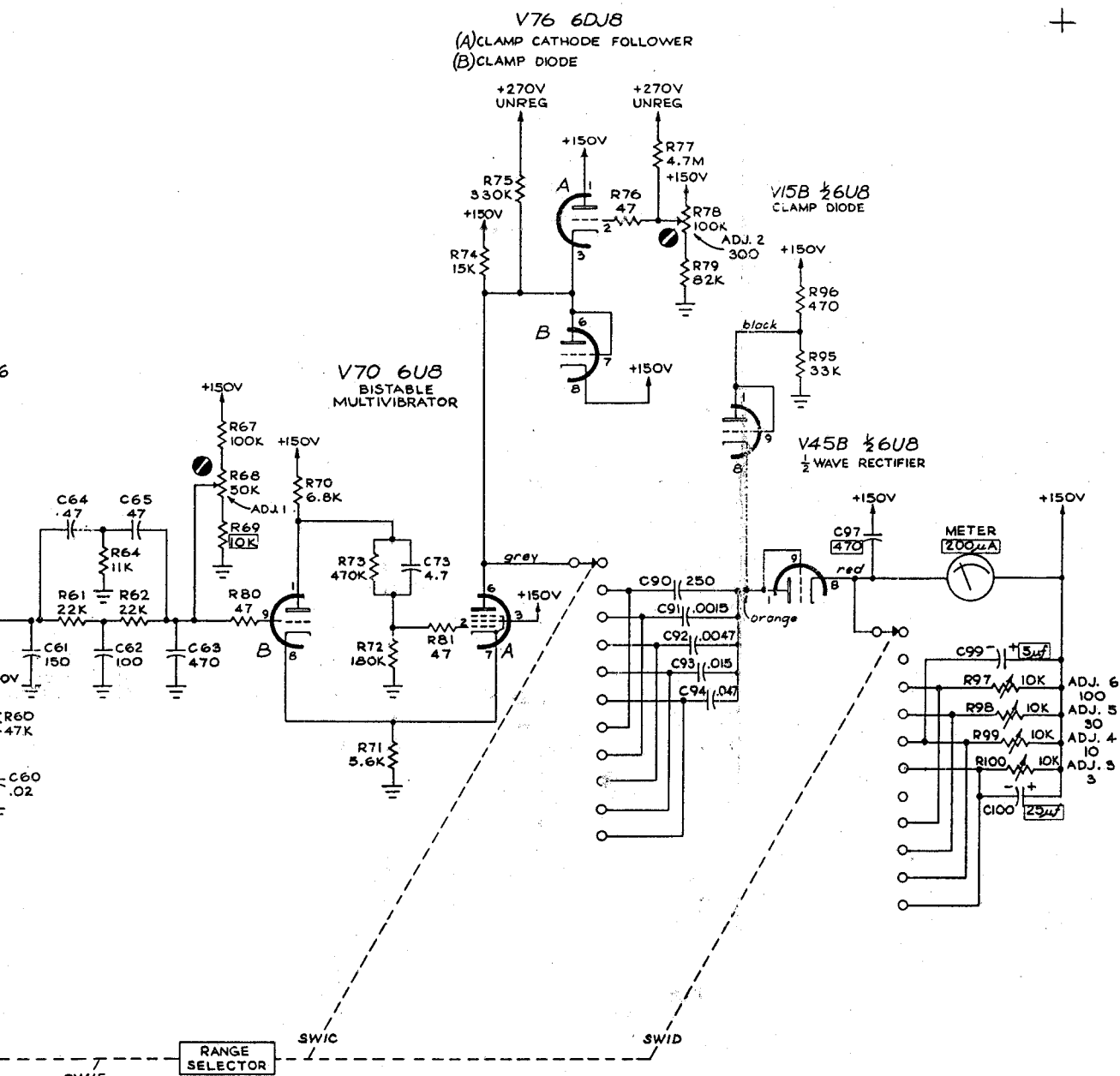
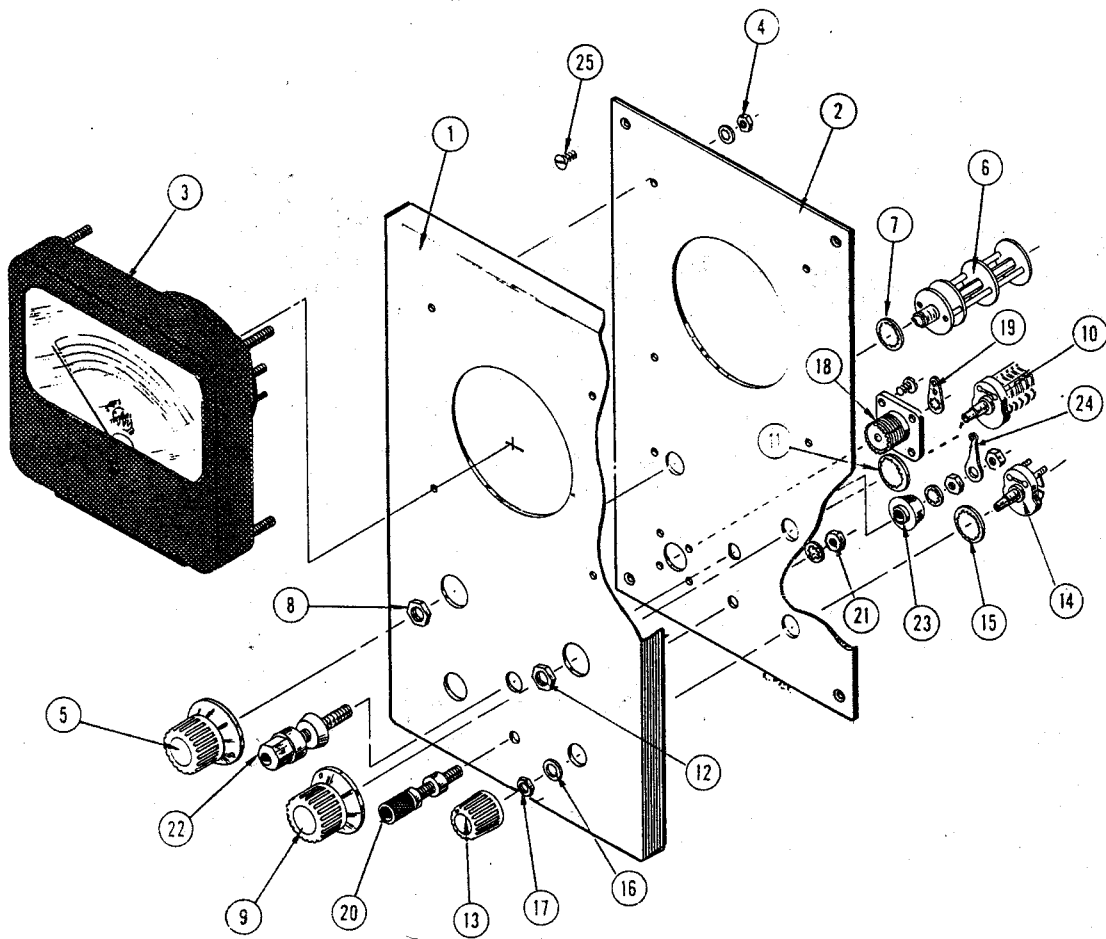


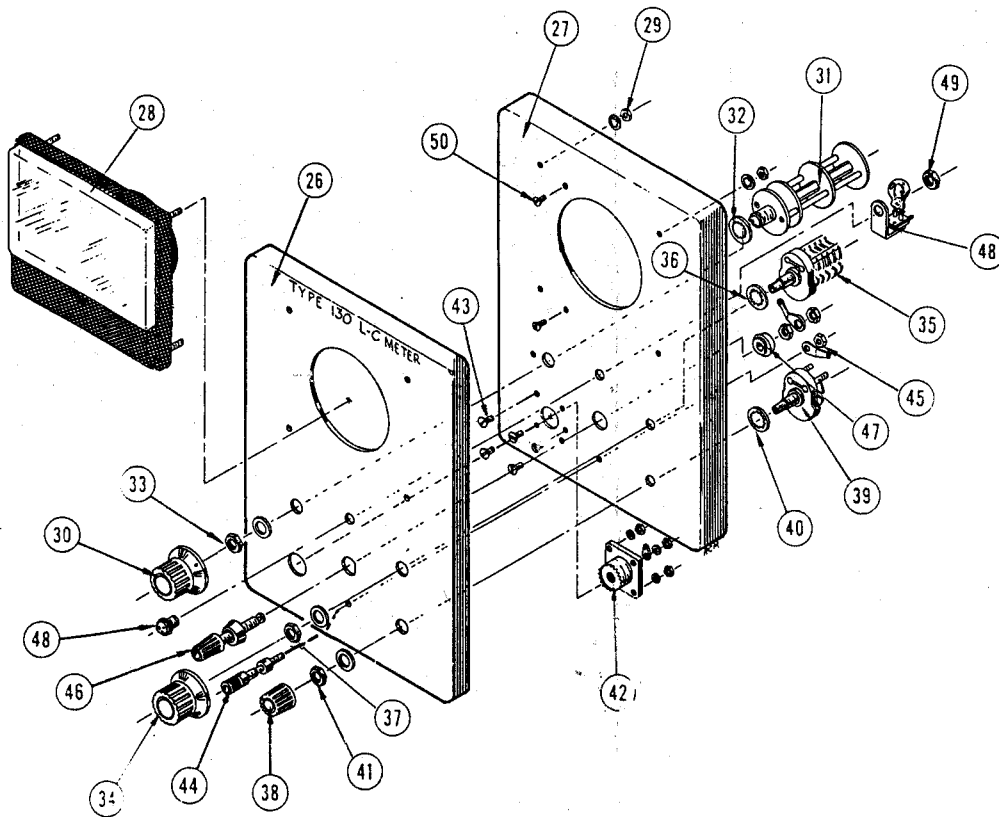
FIG. 1 FRONT



SN 101-5000

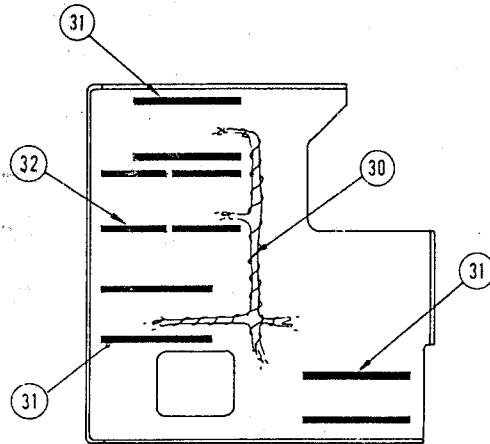
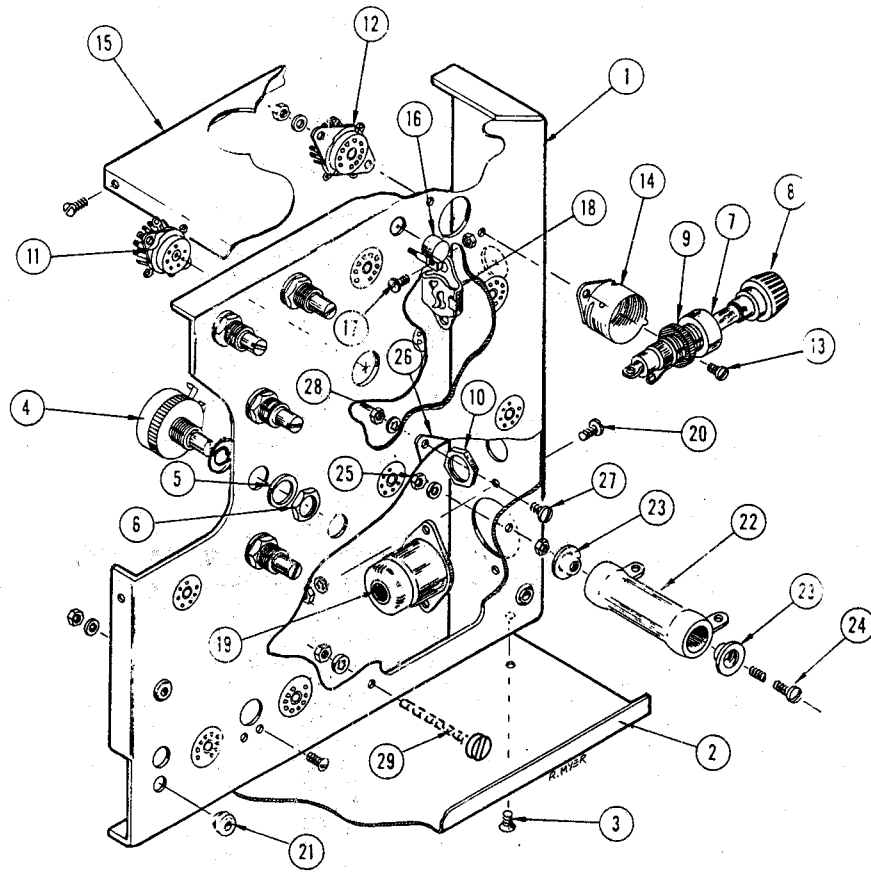
A  
E

FIG. 1 FRONT



SN 5001-up

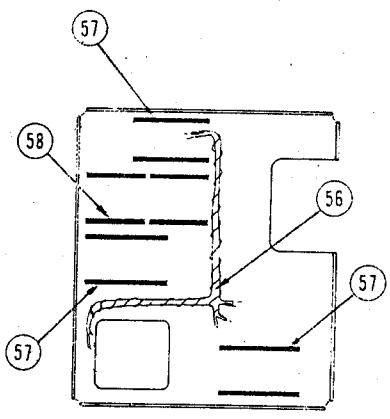
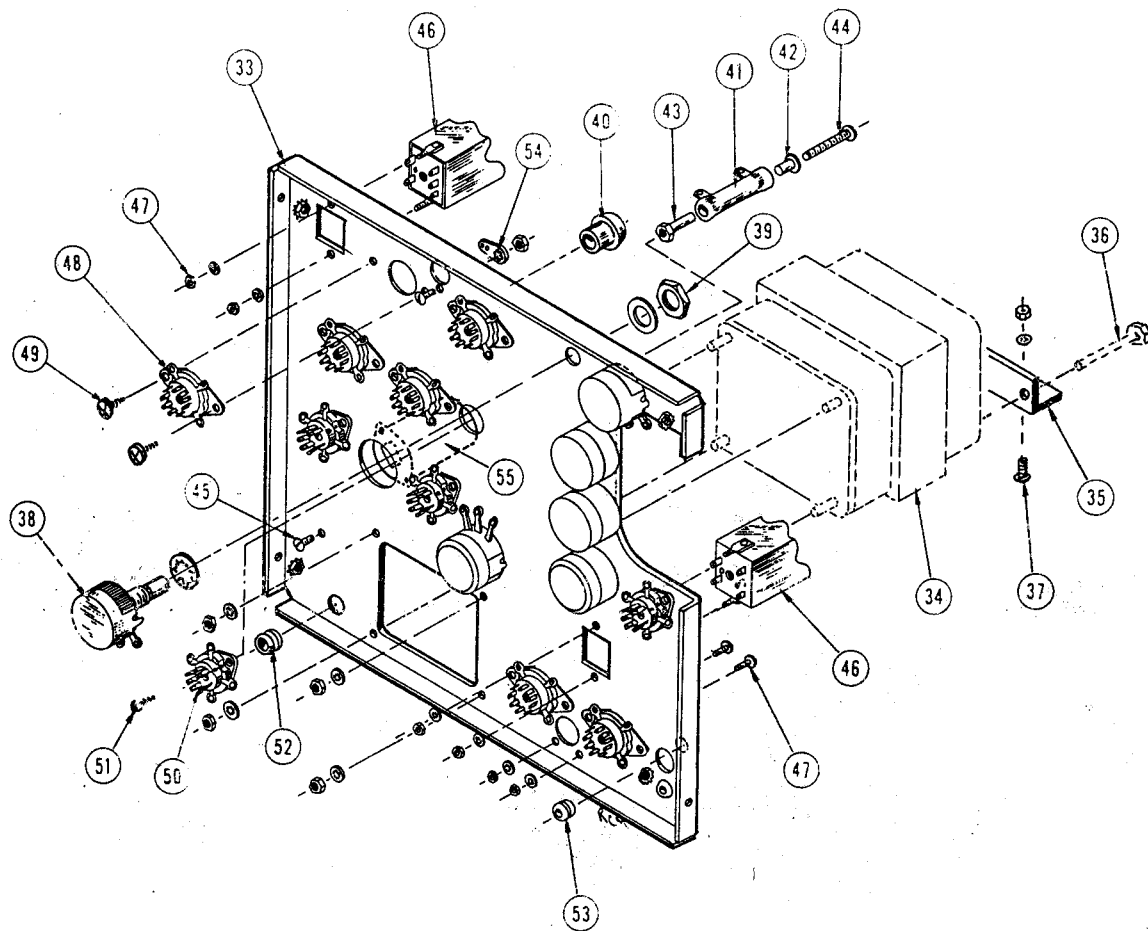
TYPE 130 L-C METER



SN 101-5000

L A

FIG. 2 CHASSIS



SN 5001-up

TYPE 130 L-C METER

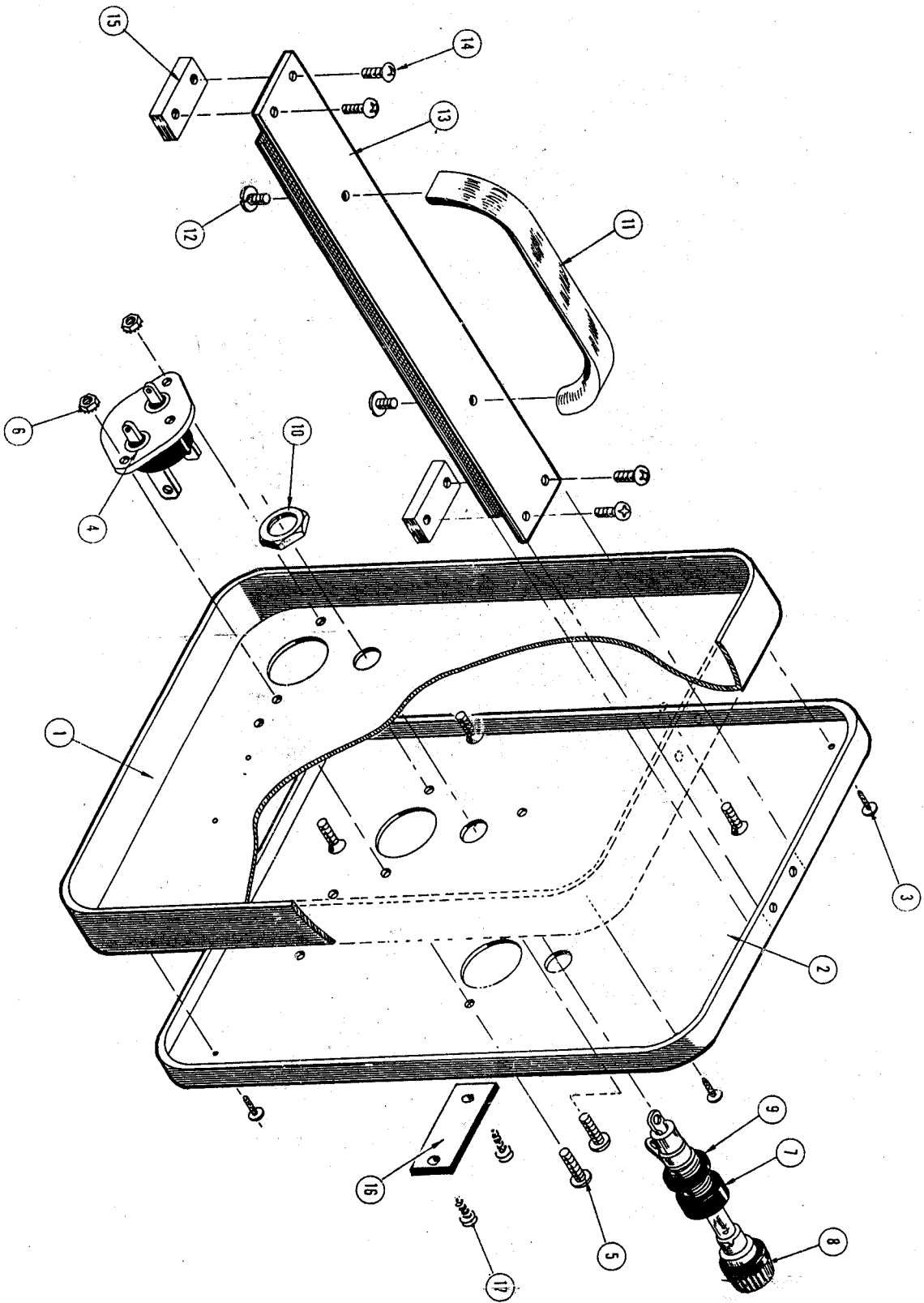
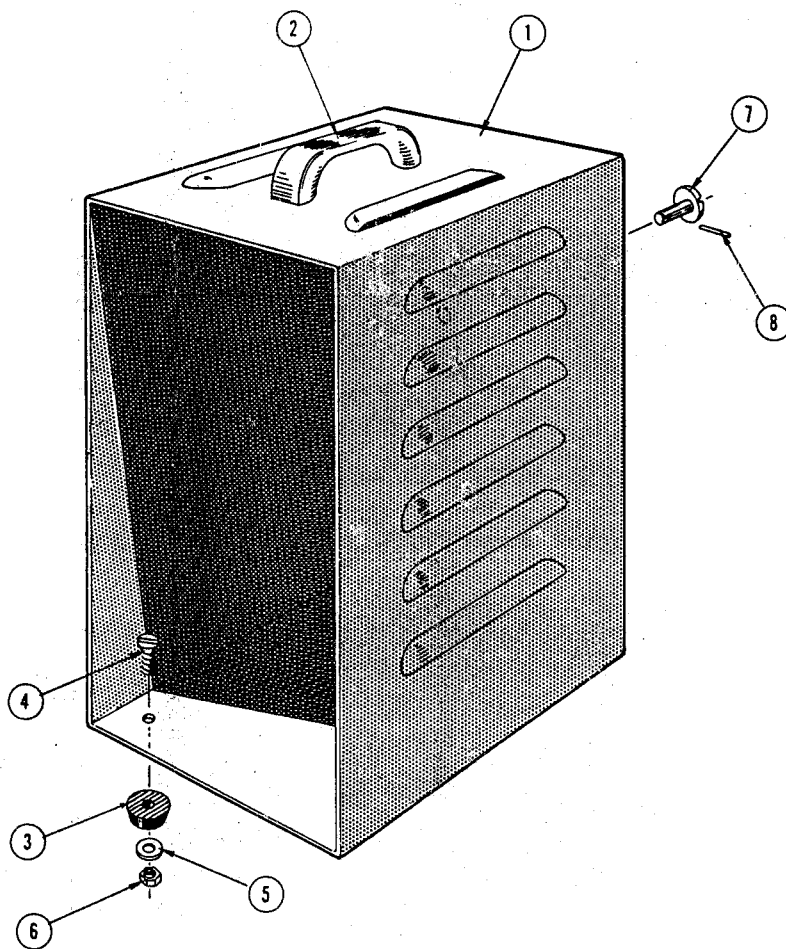


FIG. 3 REAR

FIG. 4 CABINET

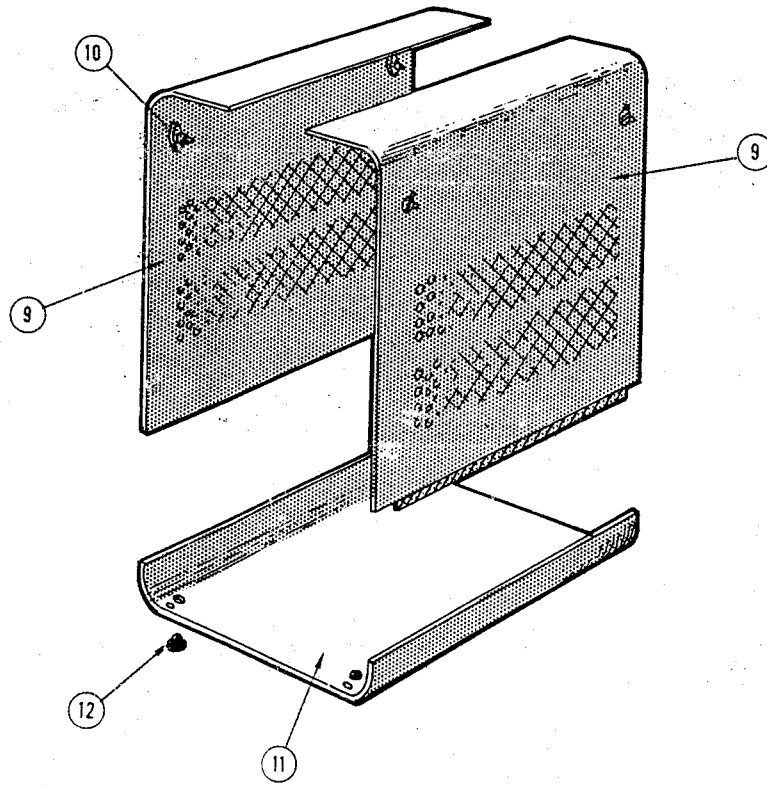


SN 101-5000

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FIG. 4 CABINET



SN 5001-up

TYPE 130 L-C METER

# **K4XL's** **BAMA**

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