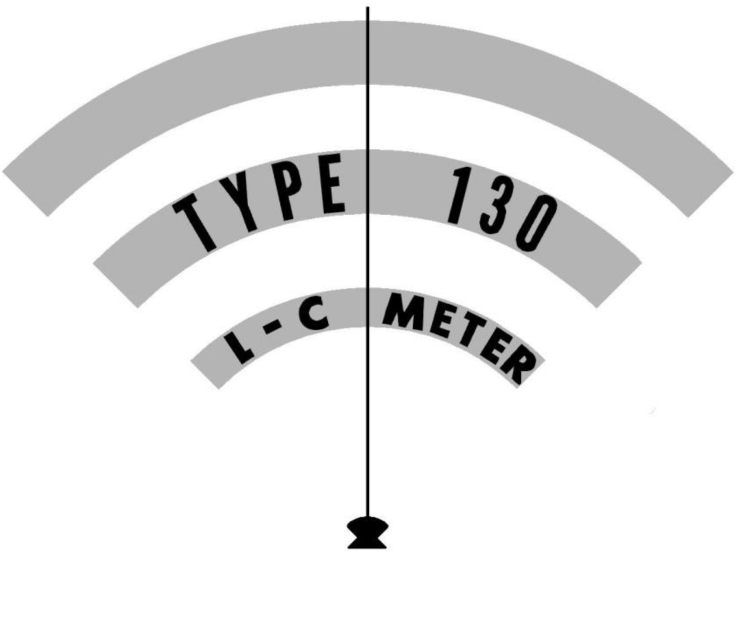
INSTRUCTION MANUAL

TYPE 130

L-C METER

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

INSTRUCTION MANUAL



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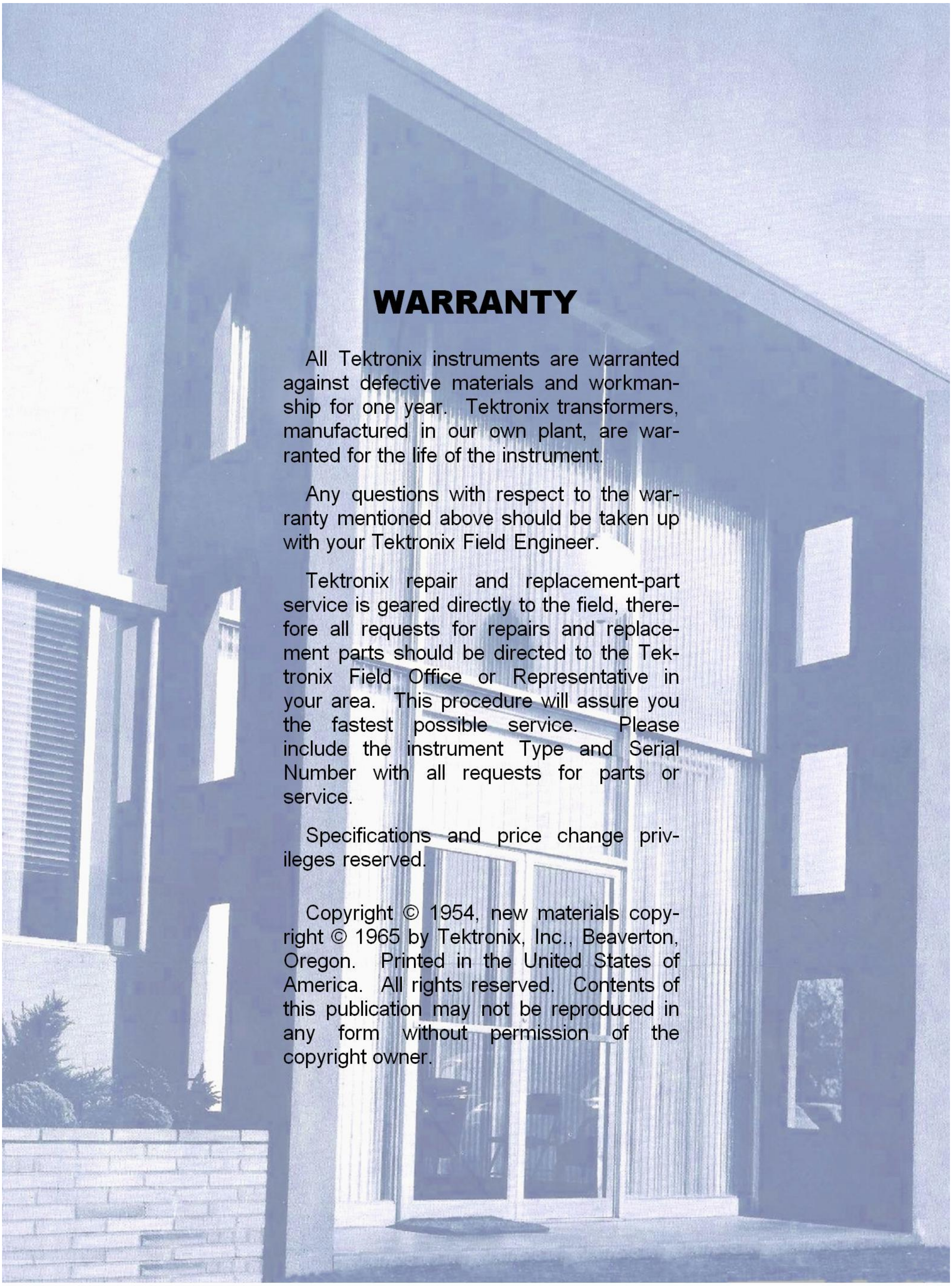

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All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

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

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

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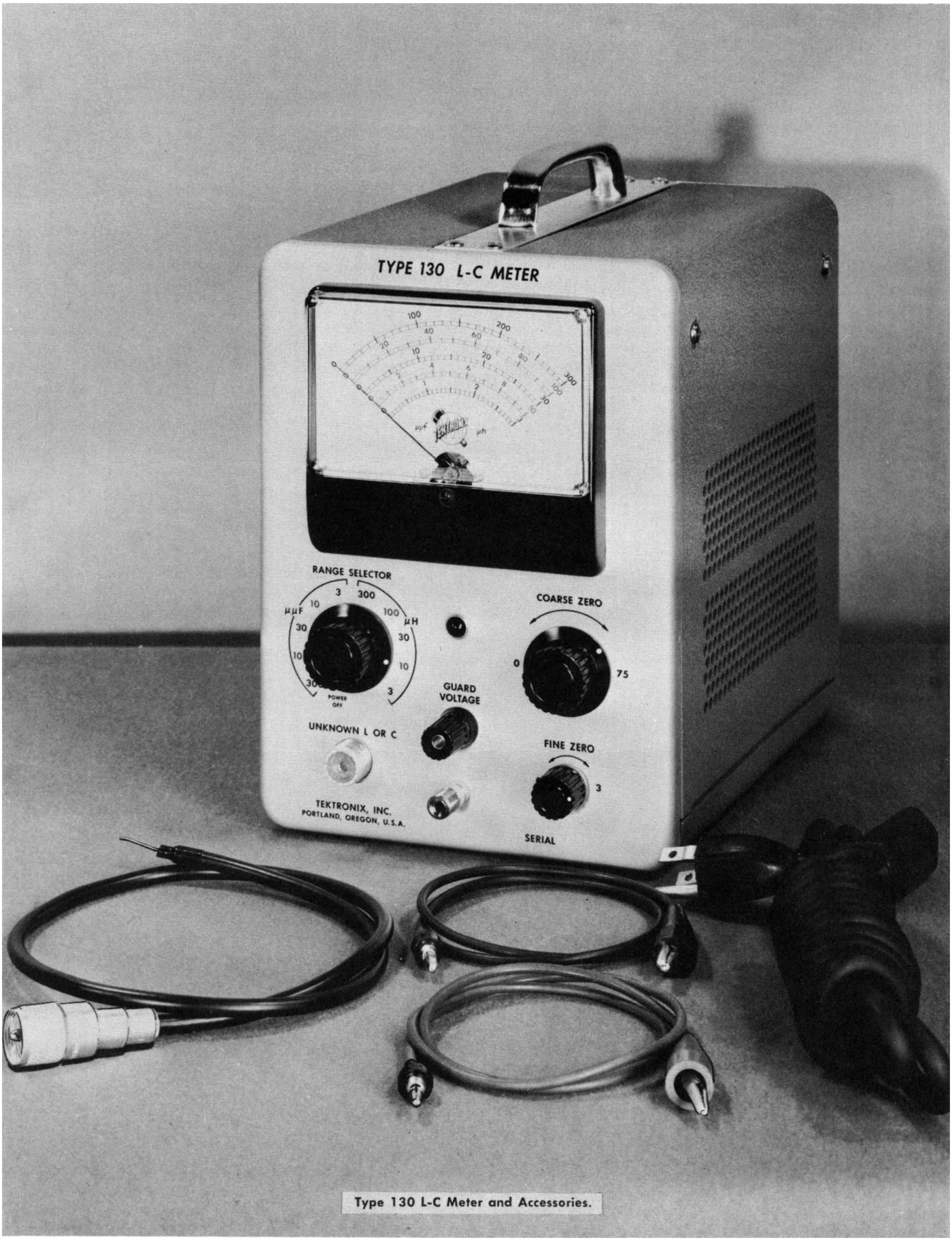
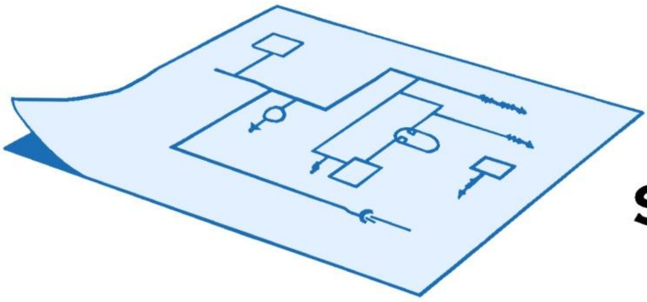
A list of abbreviations and symbols used in this manual will be found at the beginning of the Parts List and Diagrams section. Change information is included in the Parts List and the Circuit Diagram.



Type 130 L-C Meter and Accessories.



SECTION 1

SPECIFICATIONS

General

The Tektronix Type 130 L-C Meter indicates inductance and capacitance directly on a calibrated meter, and includes a guard-voltage circuit for separating the stray capacitance of nearby conducting materials. The meter is designed for rapid measurements of small inductances and capacitances where possible errors of the order of 5 per cent are permissible.

This meter directly reads accurate inductance and parallel capacitance. To insure accurate measurements of series capacitance and shunt inductance, a graph is included for interpolating the correct figures from the known meter reading. The accuracy of the graph is decreased somewhat for shunt inductance.

Uses

The Type 130 is particularly useful in circuit development for such uses as measuring components already in place in the circuit, for sorting components , for measuring vacuum-tube direct interelectrode capacitances and so forth.

Method of Operation

The instrument operates by measuring the change in frequency the unknown reactance causes when it is added to an oscillator tank circuit. The amount of change in frequency is measured by a direct-indicating electronic counter that counts the frequency difference between a fixed oscillator and the oscillator affected by the reactance. With zero reactance added, the two oscillators zero beat and the counter reads zero.

Indicator

The electronic counter produces a deflection on a direct-current meter calibrated in capacitance and inductance. A rotary switch makes the meter more sensitive for lower counts and less sensitive for higher counts to provide five ranges of capacitance and five of inductance.

Guard Voltage

Any oscillator current flowing into a capacitance affects the oscillator frequency. But current flowing into a capacitance from the guard-voltage does not, because this circuit is isolated from the frequency-determining part of the oscillator. The guard-voltage circuit can keep stray capacitance from drawing oscillator current by driving the strays at exactly the same instantaneous voltage as the capacitance being measured. Since no oscillator current will then flow from the capacitance being measured into the stray capacitance, the meter reds only the desired capacitance.

Probe

The probe at the end of a two-foot insulated shielded cable provides a means for measuring reactances wherever they are in a circuit. The zero adjustments can set the meter to read zero with or without the 30-$\mu\mu$f probe-cable capacitance so the meter reads directly.

Electrical Characteristics

Indicating Meter—D'Arsonval, 200-microamp movement.

Meter Ranges—All five scales begin at zero. Full-scale readings are 3, 10, 30, 100 and 300 microhenries or micro-microfarads. Minimum scale division, 0.1 microhenry or micromicrofarad.

Accuracy—within 3 per cent of full scale. The reset-ability is excellent. By calibrating with the type S-30 Delta Standard, the accuracy at full scale will be about 1 per cent.

Voltage Across Unknown—The instrument places an ac voltage across the unknown, 1 volt maximum across a capacitance, ¼-volt maximum across an inductance with frequency between 124 and 140 kc.

Maximum Permissible Load Resistance—The following loads will not appreciably alter the indication:

Capacitance, 0.1 megohm shunt.

Inductance, 20 kilohms shunt, 10 ohms series.

A table included in this instruction manual (in Operating Instruction Section) provides corrections for increased loads.

Guard-Voltage Output Impedance—A cathode follower with internal impedance of 250 ohms can safely drive 200 $\mu\mu$f.

Power Requirements—105 to 125 and 210 to 250 volts, 50 to 60 cycles ac. A voltage regulator keeps the instrument accurate over this voltage range. Power consumption 40 watts at 117 or 234 volts.

Physical Characteristics—Size, 6¾" wide by 9½" high by $9^3/_8$" deep. Weight, 9 lbs. Construction, welded aluminium alloy with blue-wrinkle baked enamel cabinet and photo-etched anodized aluminium panel.

Accessories

1 P93C probe (010-003)

1 W130R lead (012-015)

1 3-conductor power cord (161-008)

1 W130B lead (012-014)

2 Instruction Manuals

Functions of Controls and Connectors

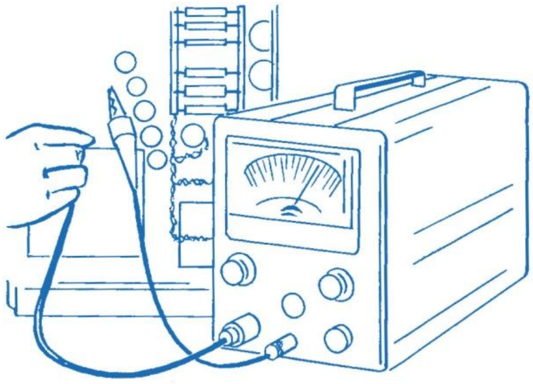
RANGE SELECTOR Eleven-position switch turns off ac power in one position and selects fives ranges of capacitance and five of inductance in the remaining 10 positions.

COARSE ZERO Adjustable capacitor sets the variable oscillator to the fixed-oscillator frequency to accommodate inclusion of the probe capacitance or other incidental capacitance. .

FINE ZERO Adjustable capacitor with one-twenty-fifth the range of the above control for accurately setting zero.

UNKNOWN L OR C UHF (SO-239) coax connector through selector switch to oscillator circuit.

GUARD VOLTAGE Binding post provides ac voltage through cathode follower equal to oscillator voltage but isolated from frequency-determining portion of oscillator. For removing effects of stray capacitances from measurements.



SECTION 2

OPERATING INSTRUCTIONS

General

No special operating precautions are necessary. The instrument will withstand the usual amount of shock and vibration that a meter movement can take, and any ambient temperature the operator is likely to tolerate.

First-Time Operation

Connect the power cord to a 117-volt 60 cycle source and connect the probe plug to the UNKNOWN uhf connector. Set the RANGE SELECTOR to 100$\mu\mu$f. The ac power switch energizes the pilot light, which indicates that the instrument is getting power. Connect a ground lead between the TYPE 130 and one end of the capacitance that you want to measure.

Centre the FINE ZERO control with the index up, and adjust the COARSE ZERO control so the meter reads zero. Keep the index line above horizontal. Do not be concerned if the meter goes off scale at any time. The maximum possible current through the meter movement is safe for any settings of the controls. Let the instrument warm up for a minute or two so that it can become stabilized.

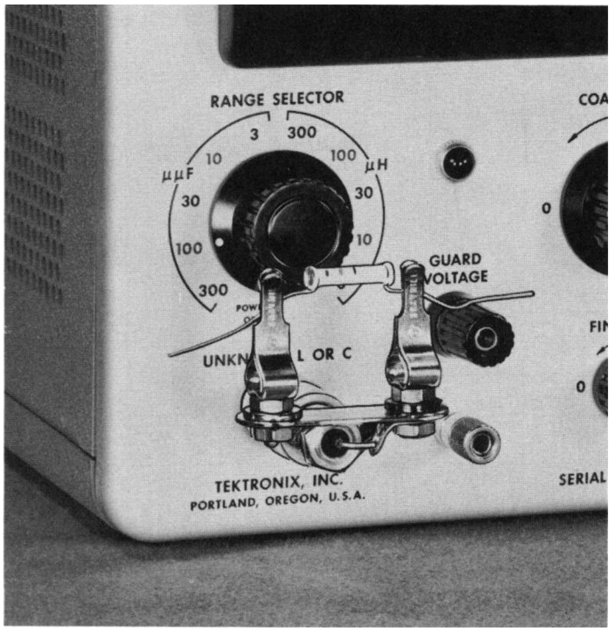


Fig. 2-1. Capacitance measurement using Production Test Fixture.

Capacitance Measurement

First set the meter accurately on zero with the capacitance disconnected. You can connect the capacitance you want to measure either directly at the instrument panel or at the end of the probe. Tektronix Type F30 Production Test Fixture (013-001) is an accessory that can be obtained for measuring inductance and capacitance directly at the instrument panel. It speeds sorting and testing of capacitors and inductors. The probe cable introduces an additional 30$\mu\mu$f which the COARSE ZERO can easily compensate. Set the COARSE ZERO control with the SELECTOR on 100 or 300 $\mu\mu$f and then switch to 3 or 10 $\mu\mu$f to set the FINE ZERO.

The meter needle will follow the beats below 10 cycles so you will have am accurate zero setting when the needle is at zero and not vibrating.

The percentage accuracy and resolution are better on the upper parts of the scales so you should shift to the next lower range where possible.

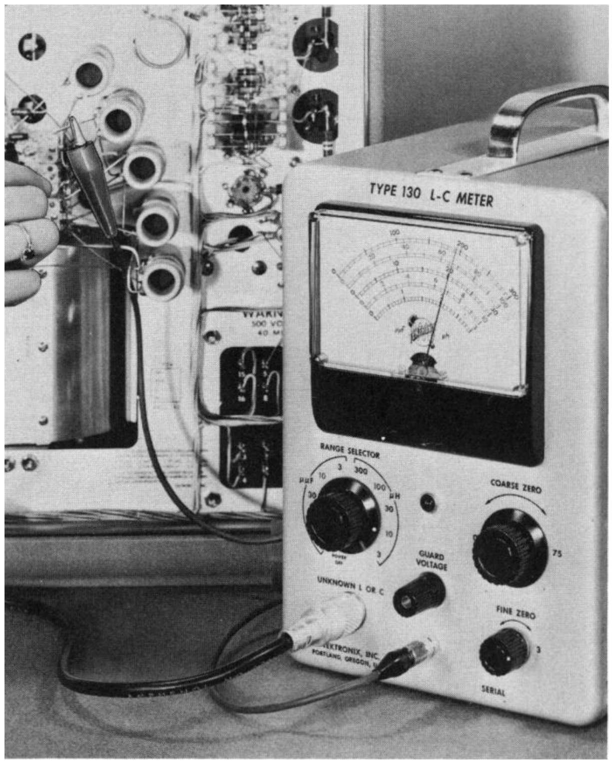


Fig. 2-2. Using the Type 130 L-C Meter to check inductance in a circuit.

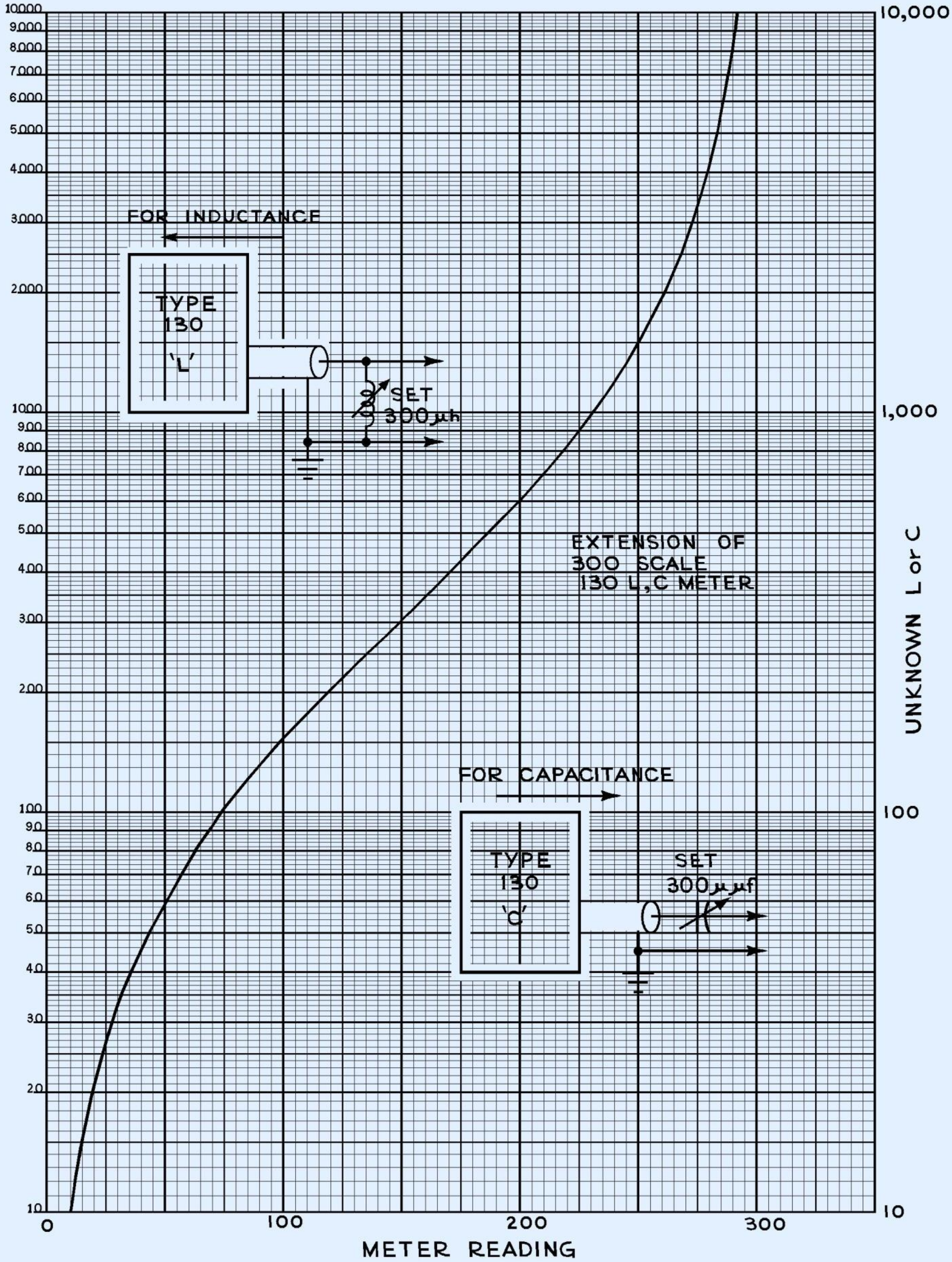


Fig. 2-3. Shunt inductance and series capacitance correction curve.

Inductance Measurements

Set the ZERO controls with the UNKNOWN terminal short circuited and the SELECTOR set to one of the five positions at the right marked μh. Set ZERO by the same adjustment technique you use for capacitance, using the 3-μH setting while setting the FINE ZERO control.

Guard Voltage

The purpose of the guard voltage is for measuring capacitances not isolated from other capacitances, such as vacuum-tube interelectrode capacitance, or the capacitance between switch points on a selector switch, or between terminals on a terminal strip.

The guard voltage drives the capacitance you want to exclude from the measurement, so connect the GUARD VOLTAGE terminal to all elements whose capacitance you want to exclude from the measurements and then make the capacitance measurement as usual. The driving impedance of the guard voltage is about 250 ohms. It can safely drive 200 $\mu\mu$f without appreciably affecting a measurement, or a shunt resistance to 50 kilohms.

For example, to measure the plate-to-grid capacitance of a pentode, ground the grid, connect the plate to the UNKNOWN terminal and connect the cathode, screen, suppressor, and shield to the GUARD VOLTAGE terminal. With this arrangement the cathode, screen, suppressor, and shield will stay at the same instantaneous ac voltage as the plate, and will not contribute to the meter reading.

As another example, consider the output capacitance of the pentode. This measurement should exclude the grid-to-plate capacitance. Connect the grid to the GUARD VOLTAGE circuit and ground the screen, suppressor, cathode and shield. The grid-to-plate capacitance will not be included in the measurement.

Small Reactances

Warm-up drift after a minute or so will not appreciably affect readings on the three highest scales but may be of consequence on the 0-3 μh or $\mu\mu$f scales. Let the Type 130 warm up for 10 to 15 minutes so it will have minimum drift for best accuracy when you use these scales.

For small capacitances or inductances in the order of 0.2 $\mu\mu$f or μh, where you use the 0-3 scales, the needle of the indicator will vibrate (about 62 cps/$\mu\mu$f). The vibrating needle is hard to read accurately, so a better way to measure smaller values is to preset zero reactance at 1.0 on the scale. You then subtract 1.0 from the readings. Be sure to turn the ZERO control clockwise and keep the index mark above horizontal when you advance the meter needle.

Large Reactances

The useful range of the Type 130 can be extended up to essentially 10,000 $\mu\mu$f or 10,0000 μh. Accuracy of the range extension is within 15% up to 1500 $\mu\mu$f or 15000 μh.

To extend the capacitance range, simply add an accurate 300 $\mu\mu$f capacitor in series with the unknown. To extend the inductance range, add an accurate 300 μh inductor in parallel with the unknown. Use Fig. 2-3 to obtain the value of the unknown.

An accurate 300 $\mu\mu$f capacitor can be obtained by setting the Type 130 RANGE SELECTOR to 300 $\mu\mu$f, connect a 270 $\mu\mu$f fixed, and a 5 to 25 $\mu\mu$f variable capacitor (in parallel) to the unknown L or C terminals. Adjust the variable capacitor for full scale reading. Then, place the large unknown in series with the new 300 $\mu\mu$f capacitor and read the meter. Fig. 2-3 will give you the value of the unknown.

An accurate 300 μh inductor can be made using a variable unit adjusted for full scale meter reading with the RANGE SELECTOR switch at 300 μh. Leave the inductor in place, the meter reading at full scale, and connect the unknown inductor across the new 300 μh inductor and read the meter. Fig. 2-3 will give you the value of the unknown.

Suppressed Zero

Comparisons between large capacitors can be made more accurately by setting the zero off scale to the left, and using a lower scale. Actually, the indicator never goes below zero. It rises again on scale as the oscillator goes through zero beat and on above the fixed oscillator. However, when you raise the frequency of the variable oscillator above the fixed oscillator in order to develop frequency difference to make the meter indicate, you operate the oscillator over an uncalibrated range. For this reason you cannot simply read the meter to see how far you have suppressed zero.

To use the suppressed-zero method therefore, you must first accurately determine the size of the capacitance that suppresses the zero, and then add this amount of capacitance to the meter indication you get.

You may use the suppressed zero method to determine the value of small capacitors more accurately than by reading their capacitance directly. For example, if you wish to make a more accurate determination of the value of a 12 $\mu\mu$f capacitor, first measure the value of a 10 $\mu\mu$f capacitor on the 10 $\mu\mu$f range. Make a notation of the exact value indicated. With the capacitor still connected to the instrument, zero the meter reading with the COARSE and FINE ZERO controls. Turn the RANGE SELECTOR to the 3 $\mu\mu$f range. Remove the first capacitor and connect the 12 $\mu\mu$f capacitor to the instrument. Adding this new reading to the notation already made will give you a more accurate reading of the capacitance than could be obtained by measuring it directly.

WARNING: Do not forget to zero the meter after completing the measurement.

Resistance-Loading Corrections

Add these corrections to the readings you get to increase accuracy or when there is more resistance loading than 10 ohms in series with an inductance, or 0.1 megohm shunt resistance. Interpolate between resistance and reactance values, if desired.

If you correct the zero reading in the presence of the loading, add the difference between the listed zero correction and the interpolated correction at the approximate inductance or capacitance you are measuring. Add the correction value when the sign is +, subtract when the sign is **–**.

Inductance with Series Resistance

Correction, μh

Series Resistance	At 0 μh	At 100 μH	At 300 μH
0 Ω	0.00	0.00	0.00
1 Ω	–0.06	–0.04	+0.03
2 Ω	–0.12	–0.08	+0.06
4 Ω	–0.18	–0.12	+0.18
6 Ω	–0.19	–0.11	+0.35
8 Ω	–0.15	–0.03	+0.55
10 Ω	–0.06	+0.10	+0.80
15 Ω	+0.37	+0.60	+1.66
20 Ω	+1.11	+1.40	+2.80
30 Ω	+3.60	+3.86	+6.08
40 Ω	+7.40	+7.90	+10.80

Capacitance with Parallel Resistance

Correction, μμf

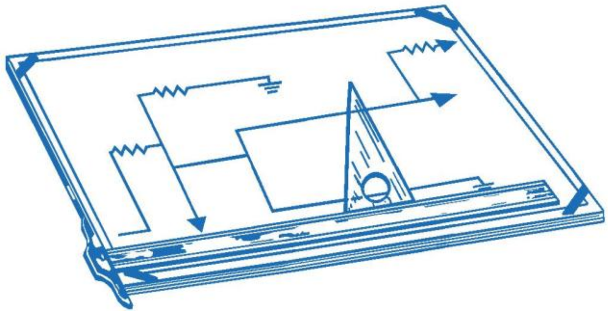
Shunt Resistance	At 0 μμf	At 100 μμf	At 300 μμf
4 meg	–0.02	–0.01	+0.01
2 meg	–0.04	–0.02	+0.02
1 meg	–0.09	–0.04	+0.03
.5 meg	–0.13	–0.08	+0.10
300 k	–0.18	–0.06	+0.22
200 k	–0.20	–0.01	+0.39
150 k	–0.18	+0.08	+0.56
100 k	–0.08	+0.36	+1.14
80 k	+0.09	+0.60	+1.64
60 k	+0.06	+1.45	+2.70
50 k	+1.15	+2.15	+3.68
40 k	+2.20	+3.35	+5.40
30 k	+4.70	+6.05	+9.00

Precautions

Reactors much greater than 300 μμf or μh can cause erroneous readings. The counter circuit may be unable to follow the large difference in frequency that results, but still develop dc current that will put the meter on scale. The meter needle will flutter and be unstable and the COARSE ZERO adjustment will give erratic results to warn you to question the reading. Be sceptical of any reading you get if it is at all unstable.

Be sure you raise the frequency of the oscillator when you suppress zero. You can be sure of this if turning ZERO control clockwise sends the needle toward zero, and the white index on the knob is up.

Do not suppress zero for inductance measurements, and do not compensate for large residual inductance with the ZERO adjustment. Additional inductance in the oscillator circuit changes the amount of total capacitance required to cause the meter to read zero, and therefore affects the scale accuracy. If there is unavoidable residual inductance in a measurement, measure the residual and subtract it from the total inductance you measure. Correction of 10 μh of residual inductance by the ZERO controls will cause noticeable error in the inductance reading.



SECTION 3

CIRCUIT DESCRIPTION

Variable Oscillator

V4 is the variable-oscillator tube, with T1, C2, C3, C4, C5 and the unknown in the tuned circuit. Feedback from the plate of the pentode section of V4 is coupled to its grid through the triode section, which is connected as a cathode follower. The output signal of the pentode is such as to drive the cathode follower below cutoff except during positive peaks, so that the cathode current consists of pulses. The pulses are fed back to a winding on the oscillator transformer, T1, through C10.

Screen current for the pentode is the cathode current for the cathode follower, filtered by means of R10, C11. This arrangement stabilizes the operating point of the pentode plate, which in turn determines the average current of the cathode follower. For example, if the average plate voltage becomes too high it will raise the cathode-follower grid and cathode voltage, which will raise the pentode screen. The increased pentode plate current returns the pentode plate back down toward its original level.

The phase of the pentode plate voltage can be adjusted by means of C7 so that the feed-back signal will be in phase with the tuned-circuit voltage. When this adjustment is properly made, reduction in Q of the tuned circuit, caused by resistance components in the unknown, will not appreciably affect the oscillator frequency for effective shunt resistance of 100 kilohms or higher. (10 ohms series resistance for inductance.)

When the selector switch is set for inductance measurement and no coil is connected, the grid of the oscillator is held toward positive by R6 and R14, which are connected to the plate supply, so that grid current flows. The resulting low grid-input impedance reduces the voltages coupled in to the grid through stray capacitances on the grid lead, and so reduces any tendency for the circuit to oscillate spuriously. Oscillator input to the mixer, V60, is coupled through buffer V15A.

The selector switch, sections A and B, arranges the oscillator tuned circuit so that the UNKNOWN terminal either shunts the tuned circuit for capacitance measurements, or is in series with the tuned circuit inductance for inductance measurements.

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 R122, R113, sets the dc grid voltage at about +50 volts so that about 5 ma of cathode current flows. The output impedance with this amount of cathode current is about 250 ohms.

Fixed Oscillator

V30 is the fixed oscillator that can be adjusted to 140 kc by means of the powered-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 the buffer amplifiers that reduce the coupling between the two oscillators. When two oscillators couple to each other, they tend to pull together to a common frequency when their natural frequencies are nearly the same, and actually lock together at the same frequency with enough coupling. The two buffer amplifiers reduce the coupling so that there is no lock-in above about one cycle per second, and the pull-in produces no error above about three cycles per second. Output from the buffers has approximately sawtooth waveform because of the high-resistance plate loads.

Mixer

V60 is the mixer. The purpose of the mixer is to produce an output at the frequency difference between the two oscillators. Higher frequency output components of the mixer are reduced by a low-pass rc filter with C61, C62, c^3, and R61, R62. The 124- to 140-kc carrier components are additionally reduced by a bridge-T rejection filter with R64, C64, and C65. The output dc level of the filter is adjustable by means of R68, labelled ADJ. 1.

Multivibrator

V70 is a multivibrator that generates a square pulse for each cycle of the difference frequency. The square wave is practically symmetrical, regardless of the frequency, when the ADJ. 1 control is properly set.

The multivibrator is arranged to shift rapidly from one stable state to a second stable state when the input grid goes past a transition point. For example when the B section of V70 is conducting its plate is down and divider R73, R72 between plate and ground hold the A-section grid below plate-current cutoff. The A-section plate will therefore be positive, and the common cathode voltage will be determined only by current through the B-section. If the B-section grid drops, its plate current will rise carrying the A-section grid more positive, and the common cathode voltage will drop placing the A-section grid-to-cathode bias nearer to conduction.

When the input grid drops far enough it reaches the transition point and the A section conducts thereby diverting some of the cathode current from the B section. The resulting positive signal at the plate further raises the A-section grid. C73 bypassing R73 improves the ac transmission so that a large positive signal reaches the grid and raises the cathode so high that the B section of V70 is cut off.

The plate of the A section generate a square pulse for each cycle. The positive level of the square pulse is determined by diode-connected V76B at about +150 volts. The bottom of the pulse is determined by cathode follower V76A. The grid voltage of this cathode follower determines the clipping level and provides a means of adjusting the meter sensitivity on the 300-μh and $\mu\mu$f ranges. The adjustment is labelled ADJ. 2 300.

Counter Circuit

The square pulses from the plate of multivibrator V70A are applied to the left-hand end of one of the capacitors, C90, C91, C92, C93 or C94, for example C90. Charge diode V15B holds the right-hand end of C90 at about +150 volts during the negative excursion while the multivibrator pulls down the left hand end to about +100 volts, thus charging C90 to about 50 volts.

During the positive excursion, the multivibrator raises the left-hand end of C90 to about +150 volts and the right-hand end thus goes above +150 volts toward +200 volts. This places the plate of diode V45B above its cathode so that it conducts and discharges C90 into the +150-volt bus through the indicating meter.

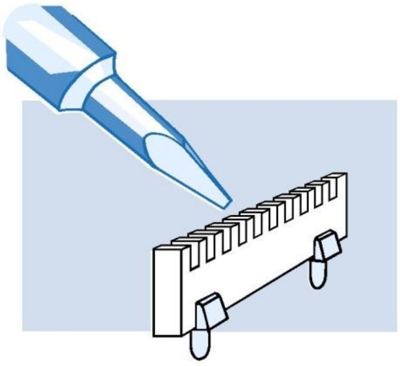
The capacitor always charges completely to the same voltage, so the current it discharges through the meter depends linearly on how many times it discharges per second and on the size of the capacitor. The range-selector switch selects the capacitor sizes in ratios of about 3 to provide ranges of 3, 10, 30, 100, and 300. The largest capacitor is used for the lowest range to increase the quantity of charge per cycle. Resistors R97, R98, R99 and R100 are adjustable shunts across the meter, selected by the range switch to provide individual sensitivity adjustment. The 300 range has no shunt and its sensitivity is adjusted by the negative-peak-clamper grid voltage.

Power Supply

DC power is furnished by a full-wave rectifier and capacitor filter. V403 is a voltage stabilizer that supplies the circuits likely to be affected by line-voltage variations. Heaters of all tubes are biased halfway between ground and +150 volts to reduce the heater-to-cathode voltage of several cathodes that operate at +150 volts.

The transformer primary has two equal 117-volt windings that are normally connected in parallel for 117-violt service. For 234-volt service, they can be connected in series.

The range selector switch opens the input to the primary in the OFF position.



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 be 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 the Tektronix specifications. These parts and most mechanical parts should be obtained directly from Tektronix or the local Tektronix filed 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. The hand-made changes show changes that have been made after the printing of the manual.

Since production of your instrument, some of the parts may have been superceded by improved components. In such cases, the parts numbers will not be listed in your Parts List. However, if you order a part from Tektronix and it has been superceded by an improved component, the new part will be shipped in place of the part ordered. Your local Tektronix Filed 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 6-digit Tektronix part number found in the Parts List. For example, if the serial number of your Type 130 L-C Meter were 352, a certain capacitor would be ordered as follows: C30, .001 microfarad, fixed, mica, 500 v, 1 %, part number 283-526, 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 .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 the check, you will need to remove the case.

Some cases have side panels held in place by small screwhead 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, counter-clockwise 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-μf 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 ones back, one at a time, until the bad tube is discovered.

Tube failure will often show up 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 (see Figure 5-3). The outside terminal should measure +150 volts ±5 volts and the terminal nearest 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. The +150 volt can be checked also at the check point indicated in Figure 5.2.

Total dc current from the rectifier should be about 40 ma, of which 21 ma goes to the circuits connected to the 150-volt bus and the remainder, about 20 ma, goes through the regulator tube, when the ac supply is at 115 volts. Current to other circuits connected to the 270-volt bus is but fraction of a milliampere.

You can check the indicating meter by connecting another milliameter across it. The meter is connected to the +150-volt bus, 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 one volt peak-to-peak at 124 to 140 kc. The fixed oscillator can be checked at point 6 of V45. These points can also be checked with an ac voltmeter capable of reading a fraction of a volt at 140 kc.

This is a fairly complex electronic device and there is no simple way to find troubles. With a good understanding of the circuits you will be able to make a good guess at the source of the trouble from the symptoms. Be sure that any difficulty you are having does not come from the settings of the front panel controls.

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 from radio-supply houses. If you prefer, you can order the solder directly from Tektronix in one-pound rolls. Order by Tektronix part number 251-514.

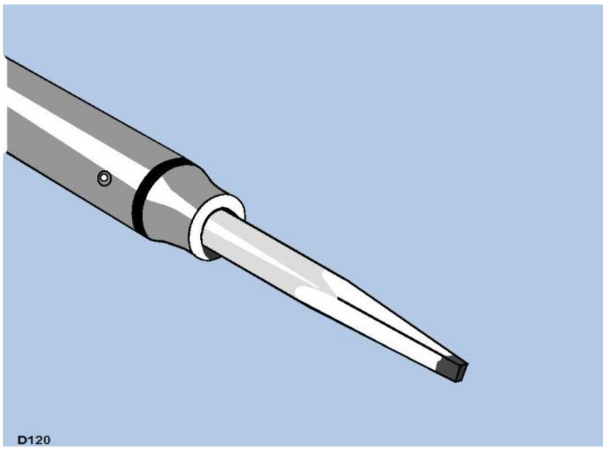


Fig. 4-1. Soldering tip preparation.

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 and 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.

When removing or replacing components mounted on the ceramic strips you will find that satisfactory results are obtained if you proceed in the manner outlines 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 1/16 or 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.

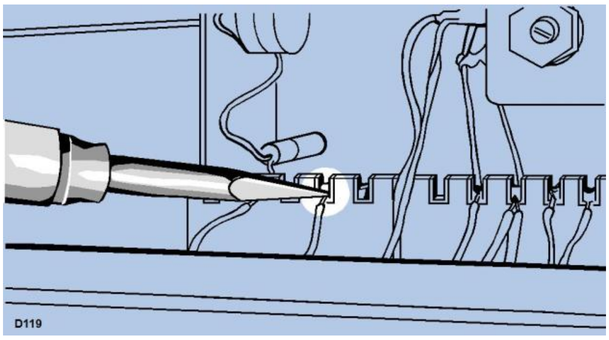


Fig. 4-2. Applying iron tip to strip.

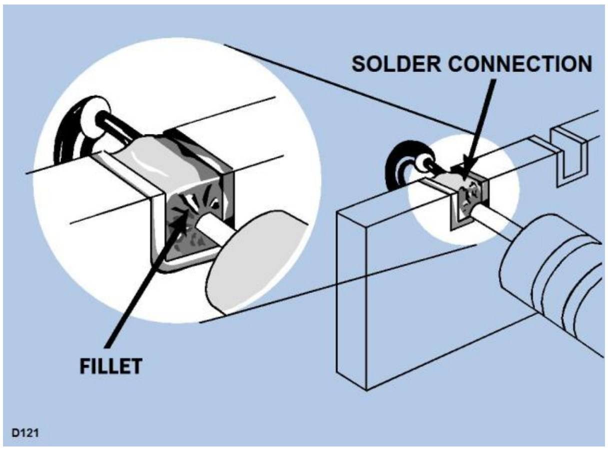


Fig. 4-3. Fillet on wire.

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. In clipping the ends of wires take care the end removed does not fly across the room as it is clipped.

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 log-nosed pliers (see Fig 4-6) makes a convenient tool for this purpose.

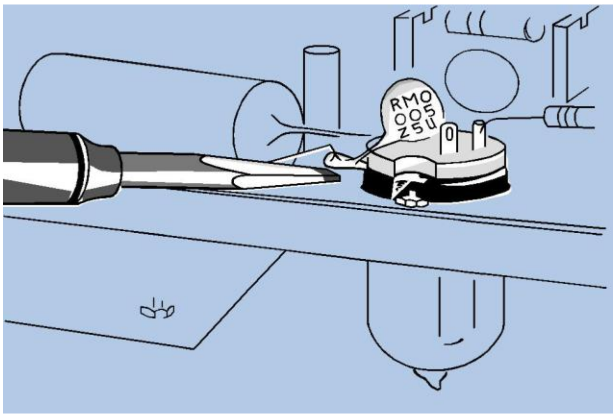


Fig. 4-4. Soldering to metal terminals.

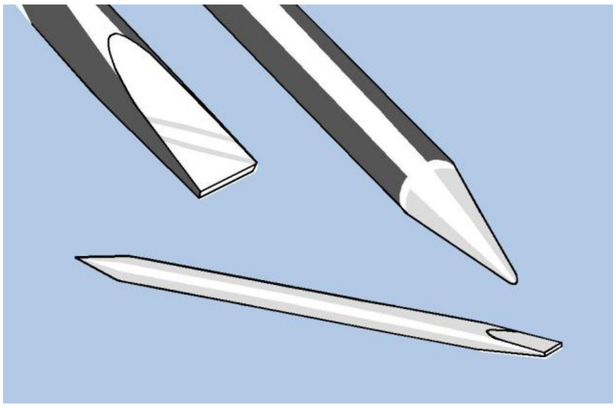


Fig. 4-5. Wooden dowel.

Ceramic Strips

Two distinct types of ceramic strips have been used in Tektronix instruments. The earlier type mounted on the chassis by means of #4-40 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 #4-40 nut onto each mounting bolt, positioning the bolt so that the distance between the bottom of the bolt and the

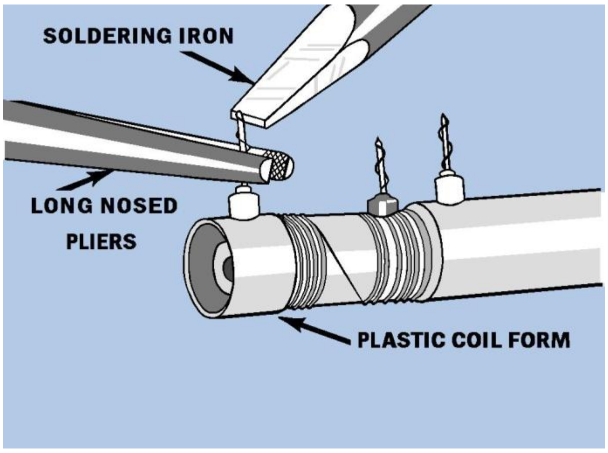


Fig. 4-6. Long-nosed pliers as "heat sink".

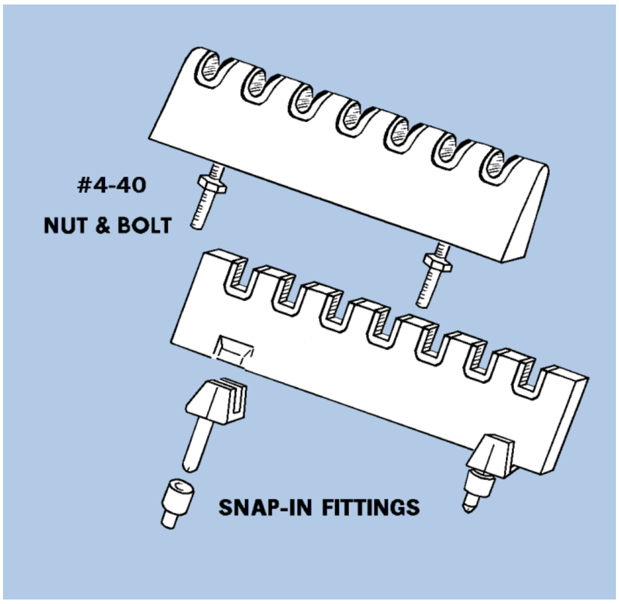


Fig. 4-7. Ceramic strips and fittings.

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 glyptal. Insert the bolts through the holes in the chassis where the original strip was mounted, placing a #4-40 lockwasher between each nut and the chassis. Place a second set of #4040 lockwashers on the protruding ends of the bolts, and fasten them firmly with another set of #4-40 nuts. Place a drop of red glyptal 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. Assemble the mounting post on the ceramic strip. Insert the nylon collar into the mounting holes in the chassis. Carefully force the mounting posts into the nylon collars. Snip off the portion of the mounting post which protrude below the nylon collar on the reverse side of the chassis.

Note: Considerable force may be necessary to push the mounting rods into the nylon collars. Be sure that you apply this force to the upper ends of the mounting rods rather than to the ceramic strip.

Cleaning

You will find that the time spent in properly cleaning an instrument will result in fewer calibration problems, a longer period between calibrations and greater operator satisfaction with both the instrument and the service centre.

Dry cleaning can be accomplished as follows. With the side, top, and bottom panels removed, compressed air and a small paint brush will remove most of the interior dust, unless the instrument has been in a greasy environment or been affected by cigarette smoke.

To clean the front panel you should reinstall the side, top, and bottom covers and lightly spray the front panel only, using a 5% Kelite solution and rinsing with water. Be careful not to get excess water in the instrument. Just a little spray applied on an angle works best.

Use a toothbrush and detergent to clean the knobs and connectors, and rinse with warm water. The side covers can be removed and, along with the bottom and top panels, be washed separately. They should be placed in an oven to dry. Compressed air is used to remove as much water as practicable from the front panel area, and the instrument is then placed in the oven for 15 to 20 minutes, or until you are ready to work on it.

Precautions against spraying detergent and water directly on the power transformer should be diligently observed. Cleaning agents such as trichloroethylene, Freon, and other containing halogens, should not be used. They can damage aluminium electrolytic capacitors and some other materials.

Lubrication

Anytime the instrument is cleaned, the components should be completely lubricated as outlined in this section.

At the time of recalibration, the instrument should be inspected for signs of components needing lubrication. It's usually good practice to lubricate exposed switch detent mechanisms at this time. Other components may also need attention, depending on the instrument's condition and use.

Components requiring lubrication often show up in the form of mechanical or electrical noise, such as unstable readings. This section covers the components that may require attention.

Figure 4-8 will acquaint you with some of the parts of a rotary switch. These will be referred to in describing the lubrication procedures.

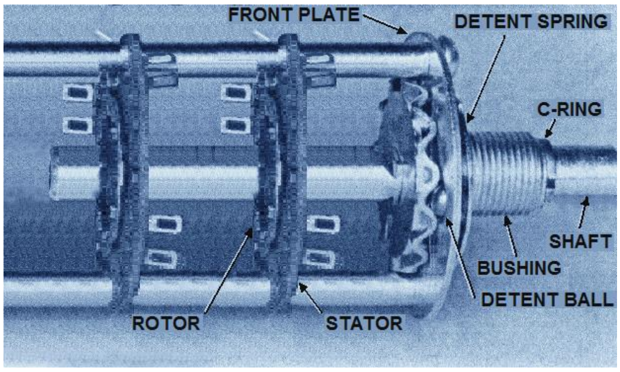


Fig. 4-8. Type F rotary switch components.

1. Lubricating Switch Mechanism

Apply DETENT LUBRICATING GREASE liberally between ball and index wheel.

Apply WD-40 to shaft at front of bushing. This is best done at the point where the ends of the “C” ring meet. Wipe away the excess.

2. Lubricating Switch Wafers

Contact lubrication will help to reduce electrical noise and extend switch life. However, care should be exercised not to over lubricate this part of the switch, as excess oil will tend to hold dust particles that can be detrimental to switch performance. If the interior of an instrument contains dust or other foreign material, it is desirable that it be cleaned as described in this manual prior to switch lubrication.

There are a half dozen or more insulating materials commonly used in rotary switches assembled in Tektronix instruments. All may be lubricated in the same manner without resulting detrimental effects, if the NO NOISE contact restorer-lubricant is used according to the following applicable suggestions and procedures.

The nozzle extension tube provided with each can of NO NOISE should be used to direct this fluid when applying it to rotary switches. To free switch contacting surfaces of resistive oxides and at the same time amply lubricate them, spray onto each switch wafer side having contact clips, a quantity of NO NOISE that will wet the rotor blade and ends of clips. Immediately rotate the switch from stop to stop, to distribute the volatile vehicle before it evaporates. By so doing, an invisible film of protective lubricating oil is left on the contacting surfaces after vehicle evaporation.

When applying NO NOISE as just described, direct the spray toward wafer from two opposite angles. Spraying should preferably be done from each side of the switch onto the same side of each wafer, to improve application to inner surfaces of rotor blades. When wetting the switch wafer with this contact restorer, spray surfaces until they appear wet, but not until they drip with excess fluid. Blot any excess immediately with clean soft cloth.

Detent Ball Replacement

Detent mechanisms of the "non-captive: type have, on occasion, "dropped the ball". This usually occurs because of a dry or poorly lubricated mechanism. The Type F switch uses a 5/32 inch ball.

Missing detent balls should be replaced by removing the "C" ring at the front of the bushing. This relieves the tension on the spring, allowing the ballot be clipped in place. If you are extremely careful, you can, in many cases, replace the ball by prying the spring back with a soldering iron or scriber. Care must be taken or the detent spring will be bent, lessening the tension required for normal detent action.

Lubricating Potentiometers

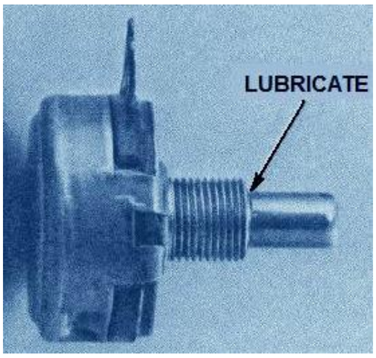
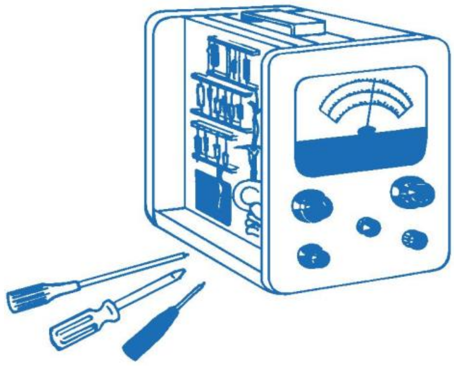


Fig. 4-9. Commercial Potentiometer Lubrication.

Lubricate the pot shaft at the front of the bushing, using WD-40.



SECTION 5

CALIBRATION PROCEDURE

Ordinarily you will not need to calibrate this instrument except after tube replacement, and then the calibration required will be less extensive than the calibration procedure which follows. If in doubt as to the effect of an adjustment you wish to make we suggest that you run through the complete calibration procedure.

Equipment Required

The following equipment is necessary for a complete calibration of the Type 130 L-C Meter:

(1.) Tektronix Type S-30 Delta Standards and connectors.

(2.) DC voltmeter.

(3.) Either an accurate frequency meter, such as a Type LM-13 or Type BC-221, or a local broadcasting station with an exact harmonic of 140 kc.

(4.) Low-Capacitance Calibration tools: See Figure 5.1.

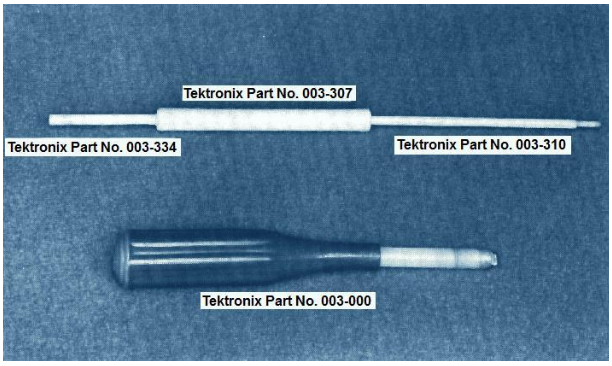


Fig. 5.1. Suggested Calibration Tools.

Adjustment Procedure

Remove side panels of L-C Meter. Zero adjust meter with screwdriver. Check power supply at check point (see Figure 5-3) for +150 volts ±5 volts. There is a 21 ma load plus 14 ma shunted through the regulator V402.

1. Fixed-Oscillator Frequency, T30 slug

The fixed oscillator should be set to a frequency of 140 kc ±½ kc by one of the following methods:

(a.) Measure the frequency by comparing a Type BC-221 or a Type LM-13 with the signal from the fixed oscillator at the FIXED OSCILLATOR CHECK POINT (R47), as shown in Fig. 5-3. Frequency adjustment is made with the slug in the top of the inductor T30 (see Figure 5-4).

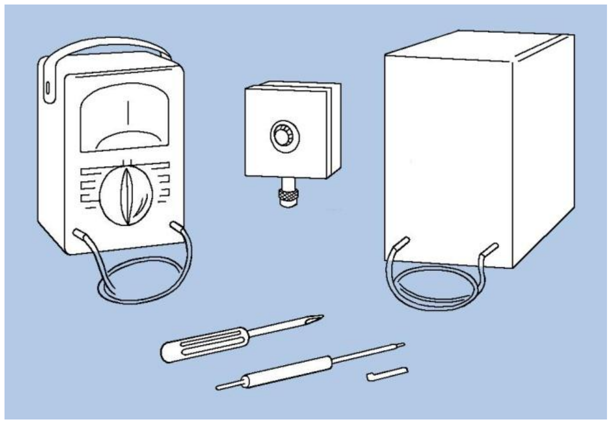


Fig. 5.2. Equipment needed for calibration of Type 130 L-C Meter.

(b.) An accurate source of 140-kc signal is connected to the UNKNOWN jack. The peak-to-peak value of the signal should be at least one-half volt. The internal impedance of the source should range between 100 ohm and 1000 ohm. Turn the RANGE SELECTOR switch to 300 $\mu\mu$f and note the deflection on the front panel meter. Adjust the slug on T30 until the deflection is zero. For more precise adjustment, turn the RANGE SELECTOR switch to 10 $\mu\mu$f or to the 3 $\mu\mu$f position and zero the meter deflection using T30.

(c.) If a local broadcast station has a harmonic of 140 kc, the fixed oscillator may be set to zero beat with a station frequency for the correct harmonic. For example, the fixed oscillator can be adjusted by checking the fifth harmonic against a station having a frequency of 700 kc.

2. Variable-Oscillator Frequency

Set the COARSE ZERO control about 10 degrees above right horizontal, and the FINE ZERO control at full capacitance index horizontal to the right. Set the internal screwdriver control, C2 (see Figure 503), at mid range, slot vertical. C2 is mounted on the FINE ZERO capacitor.

Set the variable oscillator also to 140 kc by adjusting the tuning slug in T1 (Figure 5-4). The variable –oscillator signal appears at the GUARD VOLTAGE terminal, and the VARIABLE OSCILLATOR CHECK POINT (C17), Fig. 5-3.

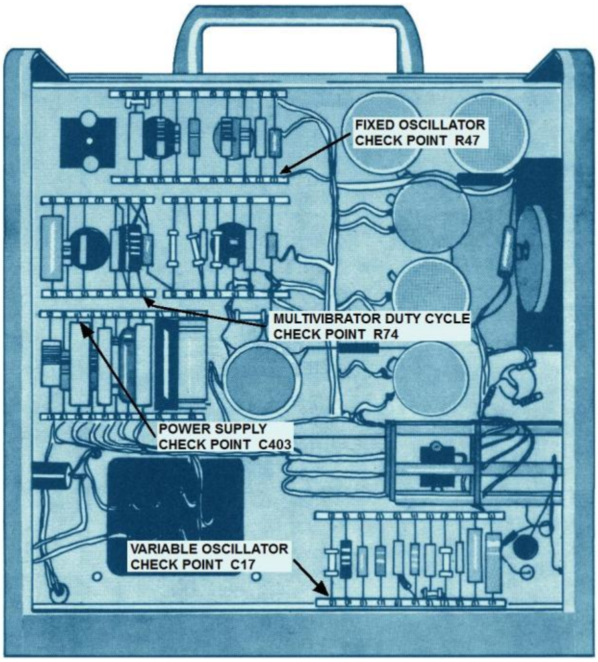


Fig. 5.3. Left side view showing test points.

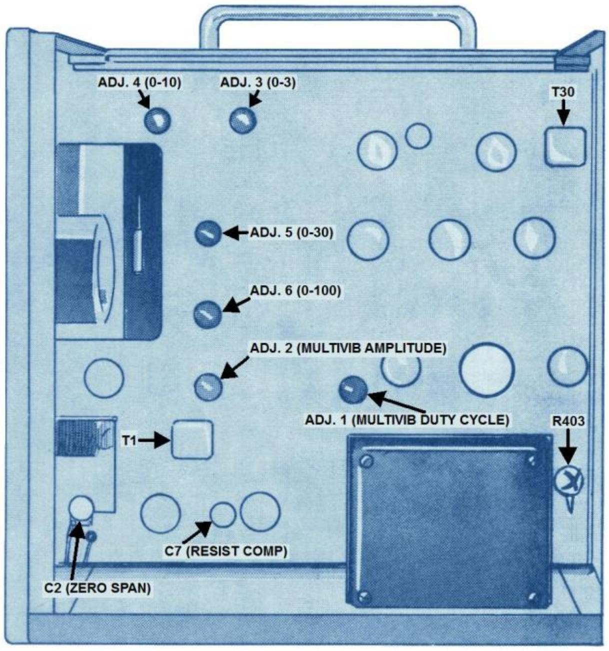


Fig. 5.4. Right side view showing calibration control points.

3. Multivibrator Duty Cycle, R68, ADJ. 1

Connect the Type S-30 Delta Standards to the UNKNOWN connector. Using the COARSE ZERO and Fine ZERO controls, set the L-C Meter accurately to zero indication with the S-30 at 0 $\mu\mu$f, and then switch both units to 300 $\mu\mu$F.

Without making any other changes, turn the ADJ. 1 control hard right and measure the voltage at the MULTIVIBRATOR DUTY CYCLE CHECK POINT (R74) with a DC voltmeter (see Figure 5-3). Carefully note the voltage reading, which should be around 155 volts.

Then, turn the ADJ. 1 control hard left and again measure the voltage at the MULTIVIBRATOR DUTY CYCLE CHECK POINT, and carefully note the reading, which should be around 105 volts.

Turn the ADJ. 1 control back until the voltage rises to midway between the two readings (i.e., around 130 volts). This will indicate that the duty cycle is 50%.

4. Multivibrator Amplitude, R78, ADJ. 2

With S-30 set to 0 $\mu\mu$f, recheck that the L-C Meter accurately reads zero.

Switch both units back to 300 $\mu\mu$f, and turn ADJ. 2 (see Figure 5-4) so that the indicating meter reads 300 $\mu\mu$f.

5. LC Balance, T1 slug

Set the S-30 to SHORT CIRCUIT and the L-C Meter to 3 μh. Now carefully adjust the L-C Meter to zero with the front panel controls.

Switch the S-30 to 300 μh and the L-C Meter to the 300 μh range. Carefully read the amount of error. Leaving all other controls as they are, adjust the tuning slug in T1 to increase the amount of error by a factor of three.

Repeat steps 4 and 5 until the L-C Meter reads both 300 $\mu\mu$f and 300 μH without error.

6. Resistance Compensator, C7

With the S-30 at 0 $\mu\mu$f, set the L-C Meter ZERO controls to get about a half-scale reading on the 10 $\mu\mu$f range. Set teh S-30 to 1 megohm and adjust the ZERO control so the meter deflection indicates an even scale division. Switch the S-30 to 100 kilohm and see if there is any change in teh deflection. If there is a change, adjust the RESIST. COMP. Control, (see Figure 5-3), so the deflection is the same as for the 1-megohm position and repeat a time or two.

If you cannot find a satisfactory adjustment, try a new tube for V4, and try the procedure again. Tubes that cannot be compensated by adjustment of C7 will drift in frequency when the line voltage changes.

7. 0-3 Range, ADJ. 3, R100

Set the S-30 to 0 $\mu\mu$f and the L-C Meter to 3 $\mu\mu$f. Carefully set the FINE ZERO control for zero deflection.

Then set the S-30 to +3 $\mu\mu$f and set the ADJ. 3 pot, R100, (see Figure 5-4), so that the indicating meter reads accurately at full scale.

Now set the S-30 to –3 $\mu\mu$f and check to see if the meter still reads full scale. If not, adjust the FINE ZERO so meter is at full scale.

Reset the S-30 to +3 $\mu\mu$f and reset ADJ. 3 if necessary for full scale reading.

This procedure minimizes a small error in zero setting that may occur in the case that the zero is off due to lock in of the two oscillators.

8. 0-10 Range, ADJ. 4, R99

Set the S-30 to 10 $\mu\mu$f and the L-C Meter to 10 $\mu\mu$f. Set the ADJ. 4 control so that the indicating meter reads full scale.

9. 0-30 Range, ADJ. 4, R98

Set the S-30 to 30 *μμ*f and the L-C Meter to 30 *μμ*f. Set the ADJ. 5 control (see Figure 5-4) so that the indicating meter reads full scale.

10. 0-100 Range, ADJ. 4, R97

Set the S-30 to 100 *μμ*f and the L-C Meter to 100 *μμ*f. Set the ADJ. 5 control (see Figure 5-4) so that the indicating meter reads full scale.

11. Zero Control Span, C2

Remove the S-30 and UHF coupling from the L-C Meter. Set the COARSE ZERO and FINE ZERO controls so that they are fully meshed. Check behind the panel to be positive that the meshing is absolutely completed. Set the RANGE SELECTOR to the 10 *μμ*f position and adjust C2, (see Figure 5-3) so the meter reads 7.5.

Check whether the meter can be made to read zero with a small rotation to the left of the COARSE ZERO control.

12. Check the accuracy of the Guard Voltage

With no external devices or leads connected to the UNKNOWN connector, set the RANGE SELECTOR to the 3 *μμ*f range.

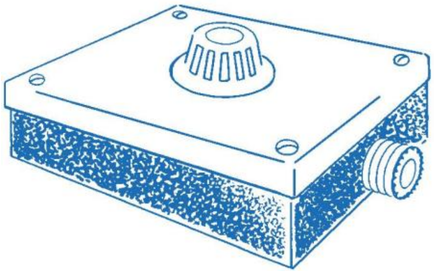
Adjust the ZERO control so the meter reads at mid scale of 1.5 *μμ*f.

Now touch the centre of the UNKNOWN connector with the tip of the finger and note which way the meter deflects.

Next, hold a 100 *μμ*f, ±5% capacitor in a pair of plastic tongs or other insulator, so as to avoid body capacity effects, touching one lead to the centre of the UNKNOWN connector, and the other lead to the GUARD VOLTAGE terminal. If the meter deflects in the same direction as when touched with the finger, GUARD VOLTAGE is low.

The deflection should be less than ½ *μμ*f. If out of tolerance, try changing V110. If this does not correct it, change R112 to 2.7 or 3.3 meg. To bring it in. If the meter deflects in the opposite direction as when touched with the finger, teh guard voltage is high, however, the meter deflection tolerance on the high side is + 1 *μμ*f.

NOTES



SECTION 6

DELTA STANDARD

Fig. 6.1. The S-30 Delta Standards.

The S-30 Delta Standards provides a means for calibrating the Type 130 L-C Meter. The accuracy of the S-30 is ±1% or better on all ranges.

The S-30 provides seven calibrated capacitance ranges, two precision resistors, and one standard inductance of 300 *µ*H at 140 kc.

Equipment Required for Calibration of Delta Standards

A commercial impedance bridge with tolerances of ± one quarter of one percent for capacitance, and one per cent for inductance.

Inductance Standardizer, to be constructed from the following specification in the circuit diagram preceding all sections on the S-30 Delta Standards. The value of the capacitor and resistor must be within 2% of those shown. Figure 6-2 is a pictorial representation of the completed Inductance Standardizer.

Operation

Only the stray capacitance of the connector and switch assembly is in the circuit in the –3 *µµ*fd position. The actual capacitance of these strays is approximately 10 to 20 *µµ*fd. No effort is made to standardize this value. As the switch is rotated, capacitors are switched into the circuit to provide a change (or "Delta") of capacitance as indicated. In the 0 *µµ*fd position, an additional 3 *µµ*fd has been added in addition to the strays.

Calibration of Capacitance Ranges

Calibration of the capacitance ranges is possible with most commercial bridges. The procedure is to measure the capacitance of the S-30 in the –3 *µµ*fd position, then switch to the 0 *µµ*fd position and determine if the "Delta" change is 3 *µµ*fd ±1%. Adjustment of C-2 will be necessary if not within tolerance. Continue to switch to each range and measure the capacitance, adjusting the trimmer as indicated in Table I to give the correct "Delta" changes.

TABLE I

Switch position	Typical Value	Adjustment
–3 *µµ*fd	13 *µµ*fd	None
0 *µµ*fd	16 *µµ*fd	C-2
+3 *µµ*fd	19 *µµ*fd	C-4
+10 *µµ*fd	26 *µµ*fd	C-6
+30 *µµ*fd	46 *µµ*fd	C-7
+100 *µµ*fd	116 *µµ*fd	C-9
+300 *µµ*fd	316 *µµ*fd	C-11

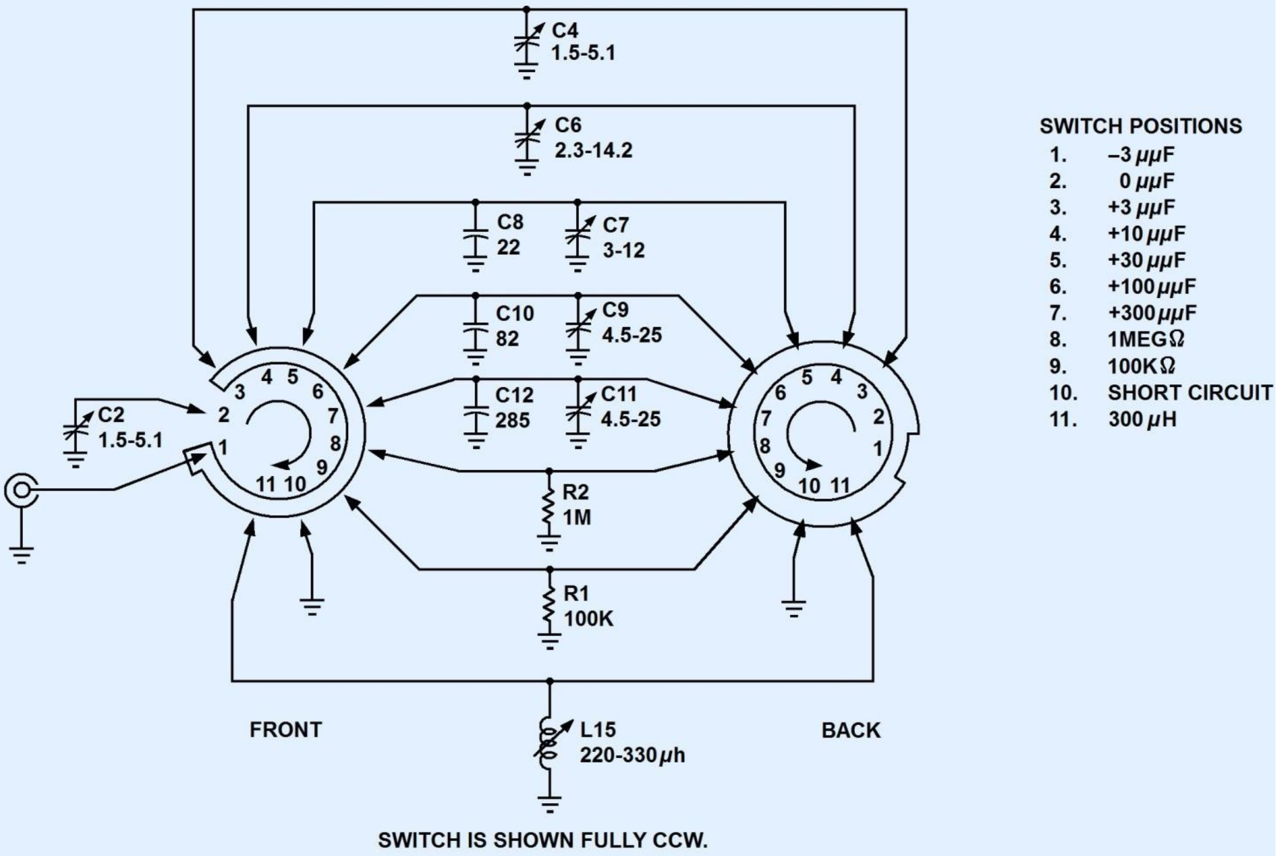
Calibration of Resistance Ranges

Two precision resistors of identical manufacture are used ro standardize the resistance compensation. These can be checked for resistance value with any reliable bridge. If either resistor is out of tolerance, it is advisable to change both to maintain the balance of capacity, unless a resistor of similar manufacture is available.

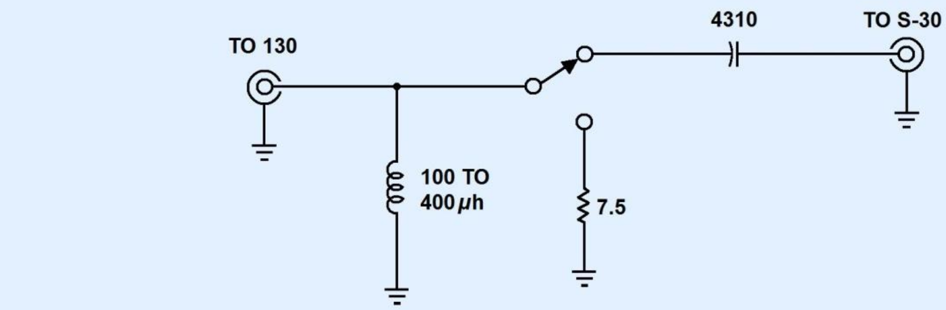
Calibration of Inductance Range

Standardization of the 300 *µ*H inductance is somewhat complicated since its value cannot be read directly with a "Bridge" type device, since these generally do not operate at 120–150 kc. Since L15 has a powdered iron core, its

S-30 Delta Standard — Type 130



TYPE S-30 DELTA STANDARD



INDUCTANCE STANDARDIZER

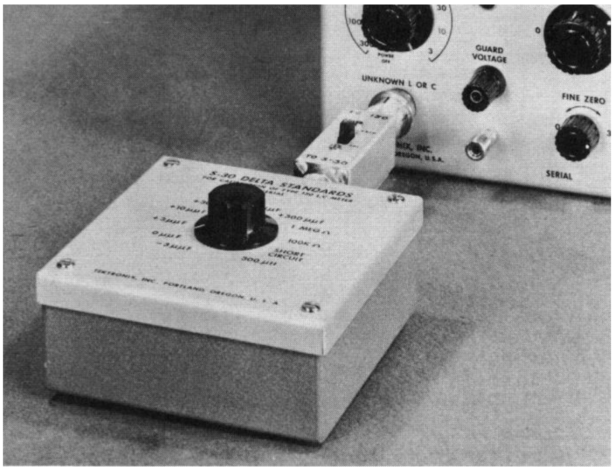


Fig. 6.2. The Type S-30 and the Type 130 L-C Meter connected with the Inductance Standardizer. .

inductance will not be the same at 1 kc or 1.59 kc. In addition, shunt capacitance across L15, representing about 1/3 or 1% of L15's admittance at 140 kc, will not have the same effect at typical bridge frequencies.

To calibrate the 300 μh range of the Type 130 construction of the Inductance Standardizer shown in Fig. 6-2 and in the circuit on page 6-2 is suggested. The value of the capacitor and resistor must be within 2% of those shown.

Connect the Type S-30, the Inductance Standardizer, and the Type 130 as shown in Fig. 6-2. Place the switch of the Type 130 in the 300 μh position. Depress the switch on the Inductance Standardizer. With the COARSE and FINE ZERO controls bring the meter reading of the Type 130 to 0.

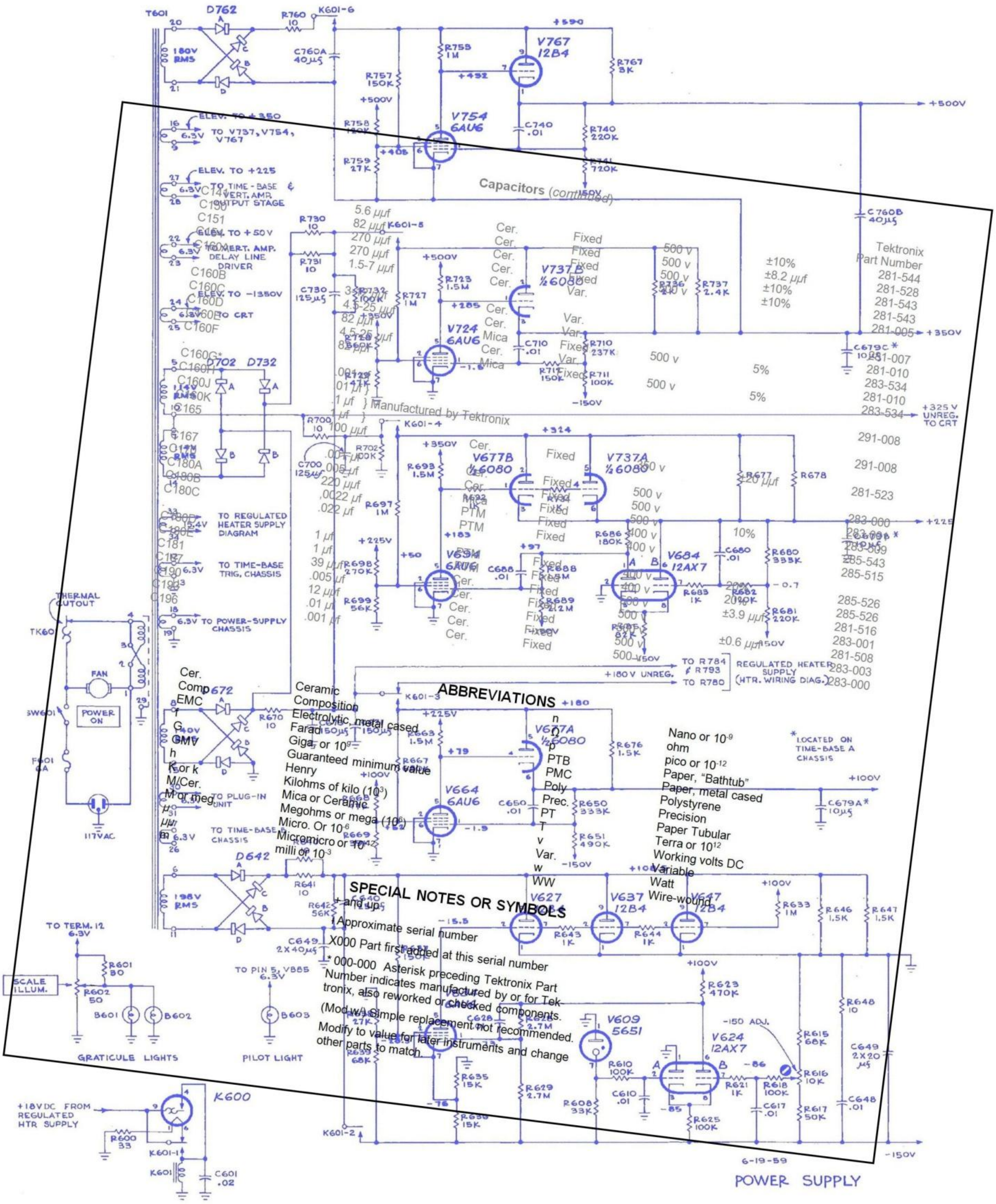
With the switch depressed, the 100-400 μh coil is parallel resonant with the internal capacity of the 130 LC Meter, and the 7.5 Ω resistor replaces the DC resistance of the 300 μh coil in the S-30.

Release the shorting switch on the Inductance Standardizer and adjust L15 in the S-30 until the Type 130 Meter reading is brought back to 0.

The 4310 $\mu\mu$F capacitor in the Inductance Standardizer is series resonant with the 300 μh coil in the S-30 at 140 kc, and the 130 sees only the 7.5 Ω resistance of the coil.

Replace the outer case of the Type S-30.

PARTS LIST *and* DIAGRAMS



MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

HOW TO ORDER PARTS

Replacement parts may be purchased at current net prices from your local Tektronix Field Office or from the factory. Most of the parts can be obtained locally. All of the structural parts, and those parts noted in the parts list "Manufactured by Tektronix", should be ordered from Tektronix.

When ordering from Tektronix include a complete description of the part, and its 6-digit part number. Give the type, serial number, and modification number (if any) of the instrument for which it is ordered.

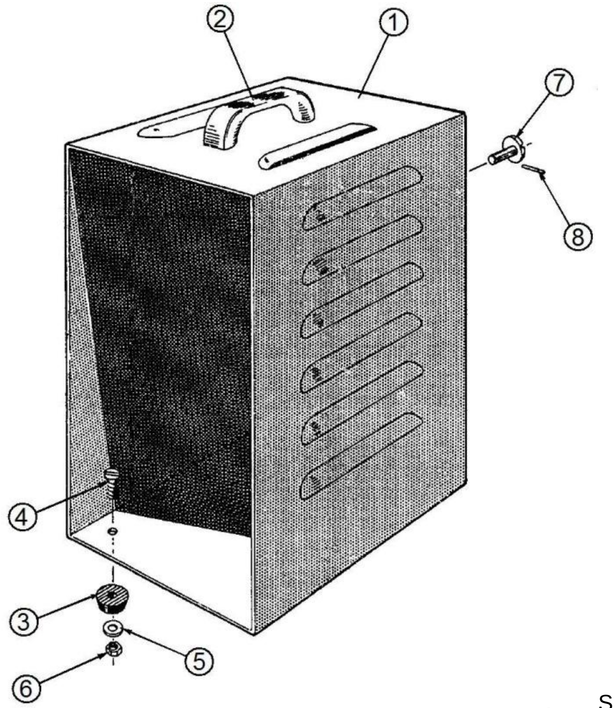
If the part which you have ordered has been replaced by a new or improved part, the new part will be shipped instead. Tektronix Field Engineers are informed of such changes. Where necessary replacement information comes with new parts.

PARTS LIST ABBREVIATIONS

BHB	binding head brass	keps	shaKEProof (nut w/- free-spinning washer)
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	Metal
cer.	Ceramic	mtg hdw	mounting hardware
comp.	Composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head screw
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	sems	screw pre-asSEMbled with Star washer
GMV	guaranteed minimum value	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
int	interna	WW	wire-wound l

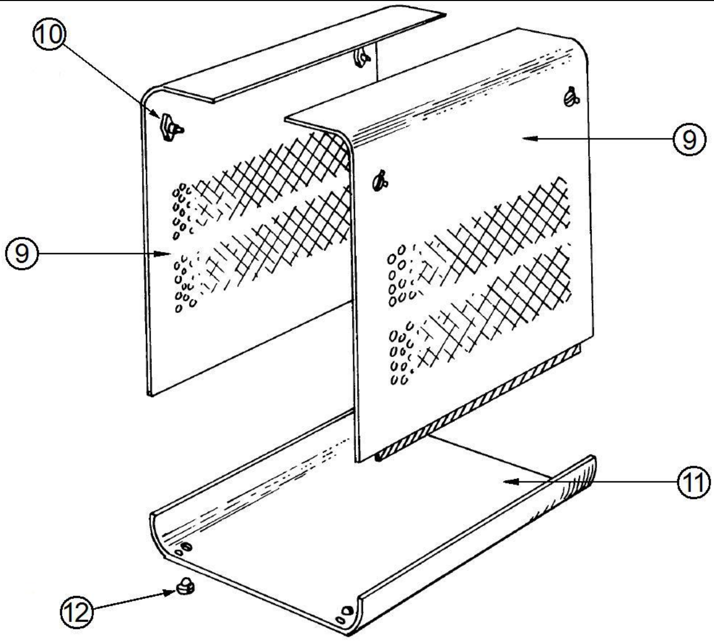
MECHANICAL PARTS LIST

CABINET



SN 101-5000

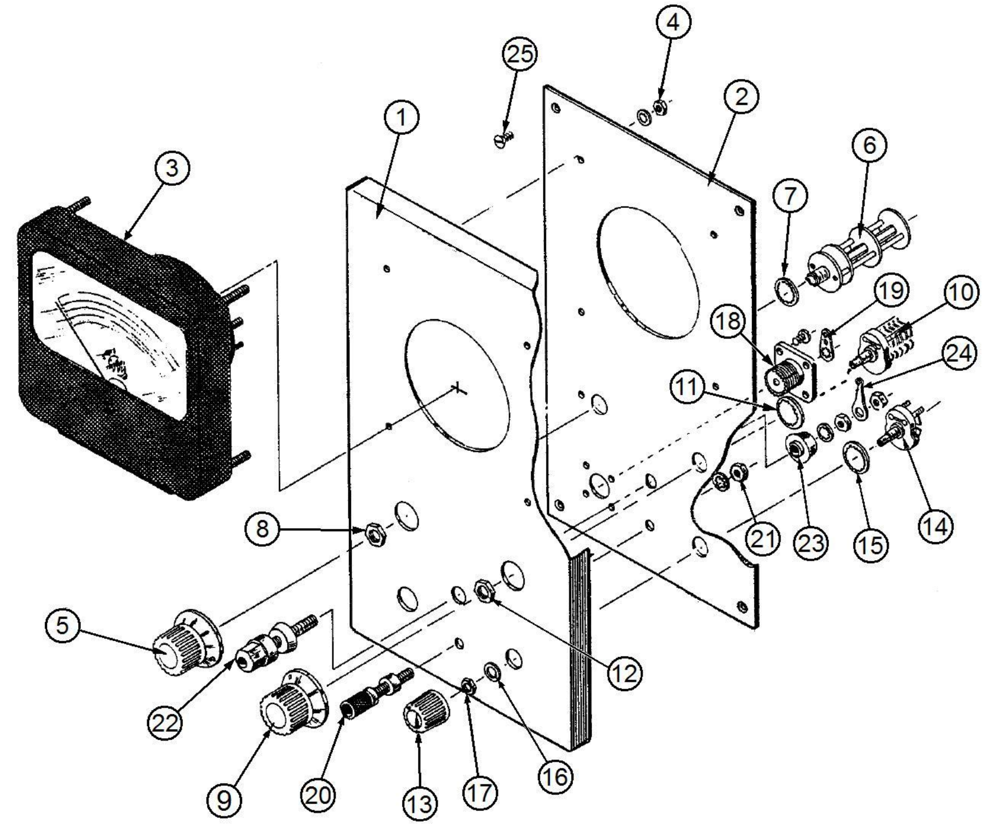
REF NO.	PART NO.	Serial/Model No.		QTY.	DESCRIPTION
		Start	End		
1	437-021	101	5000	1	ASSEMBLY, cabinet
	- - - - - -				Assembly includes:
2	367-007	101	5000	1	HANDLE, 4 inches
	- - - - -				Mounting hardware: (not included w/handle)
	210-008	101	5000	2	LOCKWASHER, internal, #8
	212-001	101	5000	2	SCREW, #8-32 x ¼ inch, PHS
3	348-001	101	5000	4	FOOT, rubber, 1 inch
	- - - - - -				Mounting hardware for each: (not included w/foot)
4	211-507	101	5000	1	SCREW, #6-32 x $^{5}/_{16}$ inch, PHS
5	210-006	101	5000	1	LOCKWASHER, internal, #6
6	210-407	101	5000	1	NUT, he., #6-32 x ¼ inch
7	355-014	101	5000	1	STUD, cowl fastener, #5
8	384-507	101	5000	1	ROD, pin



SN 5001-up

REF NO.	PART NO.	Serial/Model No.		QTY.	DESCRIPTION
		Start	End		
9	386-539	5001	6213	2	PLATE, cabinet side, blue wrinkle
	387-027	6214			PLATE, cabinet side, blue vinyl
	- - - - - -				Each plate includes:
10	105-009	5001		2	STOP
	210-047	5001		2	NUT, special, plastic
	210-087	5001		2	WASHER, flat, $^{9}/_{64}$ ID x $^{5}/_{16}$ inch OD
	213-040	5001		2	SCREW, #8-32 x ½ inch, THS
11	386-538	5001	6213	1	PLATE, cabinet bottom, blue wrinkle
	386-028	6214		1	PLATE, cabinet bottom, blue vinyl
	- - - - - -				Plate includes:
12	348-013	5001		4	FOOT, rubber, ½ inch
	- - - - - -				Plate mounting hardare: (not included w/plate)
	211-537	5001		4	SCREW, #6-32 x $^{3}/_{8}$ inch, THS (not shown)
	210-457	5001		4	NUT, keps, #6-32 x $^{5}/_{16}$ inch (not shown)

FRONT



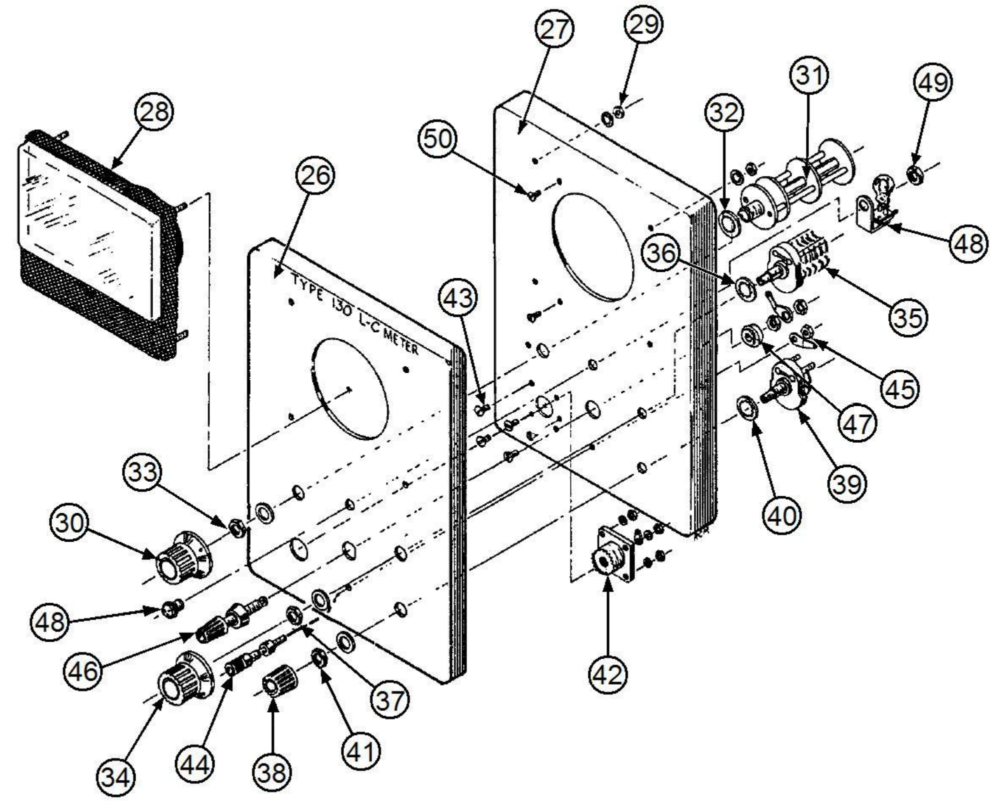
SN 101-5000

REF NO.	PART NO.	Serial/Model No. Start	Serial/Model No. End	QTY.	DESCRIPTION
1	333-023	101	5000	1	PANEL, front
2	386-354	101	5000	1	PLATE, sub-panel
3	- - - - - -				METER, 4700 Ω
	- - - - - -				mounting hardware: (not included w/meter)
	210-006	101	5000	4	LOCKWASHER, internal, #6
4	210-407	101	5000	4	NUT, hex., #6-32 x ¼ inch
5	366-011	101	535	1	KNOB, large black—RANGE SELECTOR
	366-042	536		1	KNOB, large black—RANGE SELECTOR
	- - - - - -				Knob includes:
	213-004	101	5000		SCREW, set, #6-32 x $^{3}/_{16}$ inch, HSS
6	260-072			1	SWITCH, unwired—RANGE SELECTOR
	- - - - - -				mounting hardware: (not included w/switch)
7	210-012	101		1	LOCKWASHER, internal, $^{3}/_{8}$ ID x ½ inch OD
8	210-413	101		`1	NUT, hex., $^{3}/_{8}$-32 x ½ inch
5	366-011	101	535	1	KNOB, large black—COARSE ZERO
	366-042	536		1	KNOB, large black—COARSE ZERO
	- - - - - -				Knob includes:
	213-004	101	5000		SCREW, set, #6-32 x $^{3}/_{16}$ inch, HSS
10	281-016			1	CAPACITOR, variable, 5-80 $\mu\mu$F
	- - - - - -				mounting hardware: (not included w/capacitor)
11	210-012	101	5000	1	LOCKWASHER, internal, $^{3}/_{8}$ ID x ½ inch OD
12	210-413	101	5000	1	NUT, hex., $^{3}/_{8}$-32 x ½ inch
13	366-014	101	535	1	KNOB, small black—FINE ZERO
	366-033	536		1	KNOB, small black—FINE ZERO
	- - - - - -				Knob includes:
	213-004	101	5000		SCREW, set, #6-32 x $^{3}/_{16}$ inch, HSS

FRONT (continued)

REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
14	281-015				CAPACITOR, variable, 1-4 $\mu\mu$F
	- - - - - -				mounting hardware: (not included w/capacitor)
15	210-012	101	5000	1	LOCKWASHER, internal, $^3/_8$ ID x ½ inch OD
16	210-840	101		1	WASHER, flat, 0.390 ID x $^9/_{16}$ OD
17	210-413	101		1	NUT, hex., $^3/_8$-32 x ½ inch
18	131-012	101		1	Connector, coaxial, 2-contact, female (SO239)
	- - - - - -				mounting hardware: (not included w/connector)
19	210-202	101	5000	1	LUG, solder, SE #6
	211-007	101	5000	4	SCREW, #4-40 x $^3/_{16}$ inch, PHS
20	129-020	101		1	ASSEMBLY, binding post
	- - - - - -				assembly includes:
	355-503	101		1	STEM
	200-072	101		1	CAP
	- - - - - -				mounting hardware: (not included w/assembly)
	210-223	101	5000	1	LUG, solder, ¼ ID x $^7/_{16}$ inch OD, SE
21	210-455	101	5000	1	NUT, hex., ¼-28 x $^3/_8$ inch
22	129-030	101	5000	1	POST, binding, black
	- - - - - -				mounting hardware: (not included w/post)
23	358-036	101	5000	1	BUSHING, nylon, black
	210-010	101	5000	1	LOCKWASHER, internal, #10
24	210-206	101	5000	1	LUG, solder, SE #10
	210-445	101	5000	2	NUT, hex., 10-32 x 3/8 inch
25	211-538	101	5000	4	SCREW, #6-32 x 5/16 inch, 100º csk, FHS

FRONT (continued)

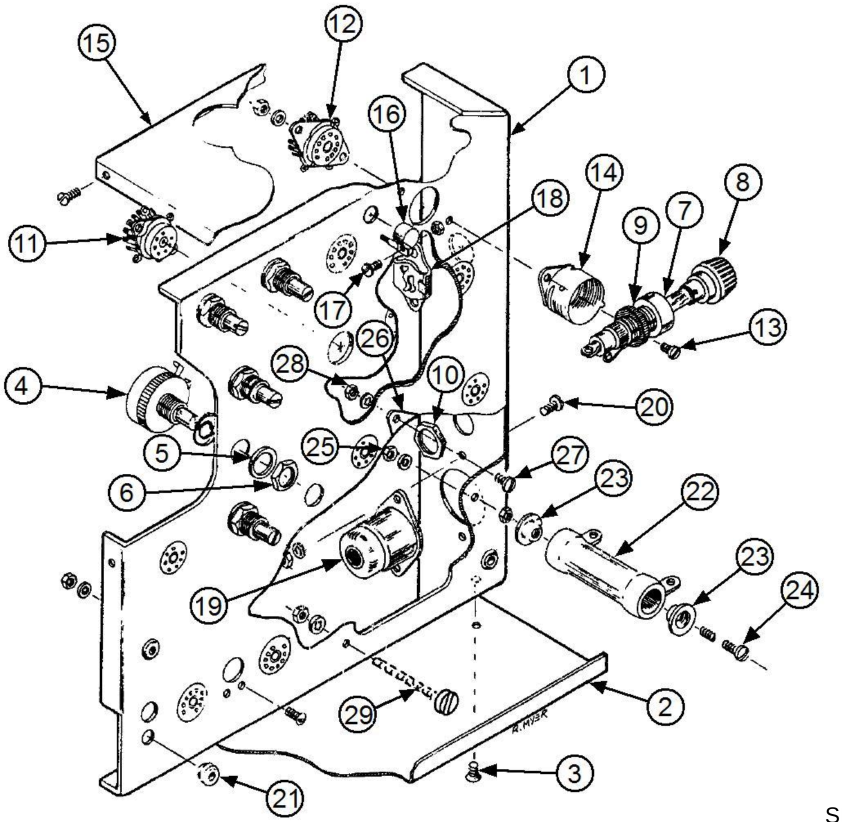


SN 5001-up

REF NO.	PART NO.	Serial/Model No. Start	Serial/Model No. End	QTY.	DESCRIPTION
26	333-334	5001	5167	1	PANEL, front
	333-427	5168		1	PANEL, front
27	386-604	5001	5167		PLATE, sub-panel
	386-763	5168			PLATE, sub-panel
28	149-010	5001		1	Meter, 200 μa
	- - - - - -				mounting hardware: (not included w/meter)
	210-085	5001		4	WASHER, flat, 0.204 ID x 0.438 inch OD
29	210-458	5001		4	NUT, keps, 8-32 x $^{11}/_{32}$ inch
30	366-042	536	8749	1	KNOB, large black—RANGE SELECTOR
	366-117	8750		1	KNOB, large charcoal—RANGE SELECTOR
	- - - - - -				Knob includes:
	213-004	101	5000		SCREW, set, #6-32 x $^{3}/_{16}$ inch, HSS
31	260-072			1	SWITCH, unwired—RANGE SELECTOR
	- - - - - -				mounting hardware: (not included w/switch)
32	210-012	101		1	LOCKWASHER, internal, $^{3}/_{8}$ ID x ½ inch OD
33	210-413	101		1	NUT, hex., $^{3}/_{8}$-32 x ½ inch
34	366-042	536	8749	1	KNOB, large black—COARSE ZERO
	366-117	8750		1	KNOB, large charcoal—COARSE ZERO
	- - - - - -				Knob includes:
	213-004	101	5000		SCREW, set, #6-32 x $^{3}/_{16}$ inch, HSS
35	281-016			1	CAPACITOR, variable, 5-80 $\mu\mu$F
	- - - - - -				mounting hardware: (not included w/capacitor)
36	210-013	5001		1	LOCKWASHER, internal, $^{3}/_{8}$ ID x $^{11}/_{64}$ inch OD
	210-840	5001		1	WASHER, flat, 0.390 ID x $^{9}/_{16}$ inch OD
37	210-413	101		1	NUT, hex., $^{3}/_{8}$-32 x ½ inch
38	366-033	536	8749	1	KNOB, small black—FINE ZERO
	366-148	8750		1	KNOB, small charcoal—FINE ZERO
	- - - - - -				Knob includes:

FRONT (continued)

REF NO.	PART NO.	Serial/Model No. Start	Serial/Model No. End	QTY.	DESCRIPTION
	213-004	101	5000		SCREW, set, #6-32 x $^{3}/_{16}$ inch, HSS
39	281-015				CAPACITOR, variable, 1-4 $\mu\mu$F
	- - - - - -				mounting hardware: (not included w/capacitor)
40	210-013	5001		1	LOCKWASHER, internal, $^{3}/_{8}$ ID x $^{11}/_{64}$ inch OD
	210-840	101		1	WASHER, flat, 0.390 ID x $^{9}/_{16}$ OD
41	210-413	101		1	NUT, hex., $^{3}/_{8}$-32 x ½ inch
42	131-012	101		1	Connector, coaxial, 2-contact, female (SO239)
	- - - - - -				mounting hardware: (not included w/connector)
43	211-101	5001	10439	4	SCREW, #4-40 x ¼ inch, 100º csk, FHS
	211-038	10440		4	SCREW, #4-40 x 5/16 inch, 100º csk, FHS
	210-001	X10440		1	LOCKWASGER, internal, #4
	210-201	5001		1	LUG, solder, SE #4
	210-586	5001		4	NUT, keps, 4-40 x ¼ inch
44	129-020	101		1	ASSEMBLY, binding post
	- - - - - -				assembly includes:
	355-503	101		1	STEM
	200-072	101		1	CAP
	- - - - - -				mounting hardware: (not included w/assembly)
	210-223	101		1	LUG, solder, ¼ ID x $^{7}/_{16}$ inch OD, SE
45	210-455	101		1	NUT, hex., ¼-28 x $^{3}/_{8}$ inch
46	129-030	101	5616	1	POST, binding, black
	129-036	5167	8749	1	POST, binding, black
	129-063	8750		1	POST, binding, black
	- - - - - -				mounting hardware: (not included w/post)
47	358-036	101	8749	1	BUSHING, nylon, black
	358-169	8750		1	BUSHING, nylon, charcoal
	210-010	101	8069	1	LOCKWASHER, internal, #10
	210-206	101	8069	1	LUG, solder, SE #10
	210-445	101	8069	2	NUT, hex., 10-32 x $^{3}/_{8}$ inch
	220-410	8070		1	NUT, keps, 10-32 x $^{3}/_{8}$ inch
48	136-047	5168	9829	1	ASSEMBLY, pilot light mounting, w/red jewel
	136-079	9830		1	ASSEMBLY, pilot light mounting, w/green jewel
	- - - - - -				assembly includes:
49	- - - - - -	5168		1	NUT
50	211-538	101		4	SCREW, #6-32 x 5/16 inch, 100º csk, FHS

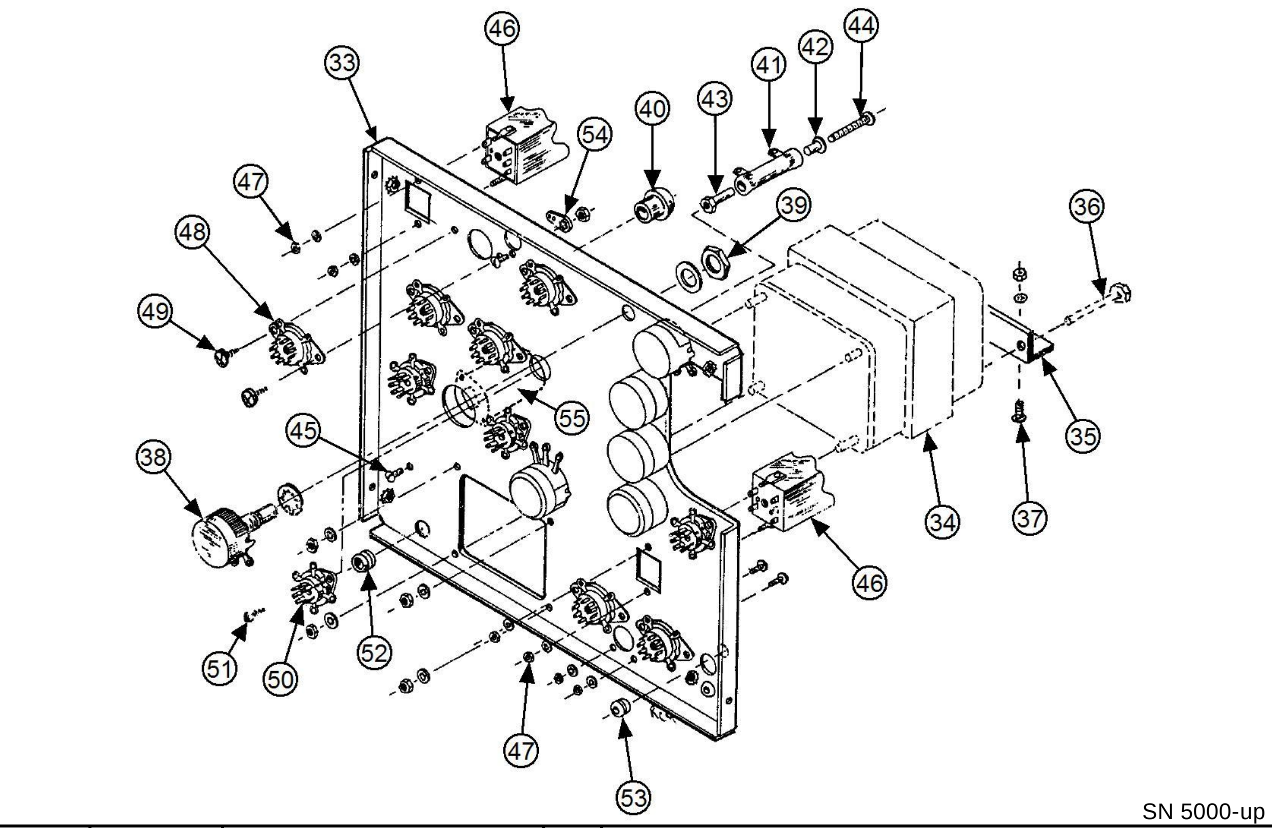


SN 101-5000

REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
1	441-074	101	5000	1	CHASSIS
2	387-533	101	5000	1	PLATE, bottom
3	211-538	101	5000	4	SCREW, #6-32 x $^{5}/_{16}$ inch, 100º csk, FHS
4	311-015	101		4	RESISTOR, variable 10 kohm
	311-023	101		1	RESISTOR, variable 50 kohm
	311-026	101		1	RESISTOR, variable 100 kohm
	------				mounting hardware for each: (not included w/resistor)
	210-012	101		1	LOCKWASHER, internal, $^{3}/_{8}$ ID x $^{1}/_{2}$ inch OD
5	210-840	101		1	WASHER, flat, 0.390 ID x $^{9}/_{16}$ OD
6	210-413	101		1	NUT, hex., $^{3}/8$-32 x $^{1}/_{2}$ inch
7	352-002	101		1	ASSEMBLY, fuse holder
	------				Assembly includes:
	352-010	101		1	HOLDER, fuse 3AG
8	200-582	101		1	CAP, fuse
9	210-873	101		1	WASHER, rubber, ½ ID x $^{11}/_{16}$ inch OD
10	------	101		1	NUT, $^{1}/_{2}$-24 x $^{1}/_{8}$ inch
11	136-008	101		4	SOCKET, tube, 7-pin, w/ground lugs
	------				mounting hardware for each: (not included w/socket)
	211-033	101		2	SCREW, sems, #4-40 x $^{5}/_{16}$ inch, PHS
	210-004	101		2	LOCKWASHER, internal, #4
	210-406	101		2	NUT, hex., 4-40 x $^{3}/_{16}$ inch
12	136-015	101		6	SOCKET, tube, 9-pin, w/ground lugs
	------				mounting hardware for each: (not included w/socket)
13	211-033	101		2	SCREW, sems, #4-40 x $^{5}/_{16}$ inch, PHS
	210-004	101		2	LOCKWASHER, internal, #4
	210-406	101		2	NUT, hex., 4-40 x $^{3}/_{16}$ inch
14	337-005	101	5000	1	SHIELD, socket, $^{29}/_{32}$ inch ID

CHASSIS (continued)

REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
15	387-534	101		1	PLATE, top
16	343-015	101		1	CLAMP, stainless steel, ½ inch
	------				mounting hardware: (not included w/clamp)
17	211-504	101		1	SCREW, #6-32 x ¼ inch, PHS
	210-407	101		2	NUT, hex., 6-32 x ¼ inch
	214-012	101		1	BOLT, spade, #6-32 x $^{3}/_{8}$ inch
	210-006	101		2	LOCKWASHER, internal, #6
18	214-024	101		1	FASTENER, spring
19	131-010	101		1	CONNECTOR, 2-contact, male recessed NEMA
	------				mounting hardware: (not included w/connector)
20	211-507	101		2	SCREW, #6-32 x $^{5}/_{16}$ inch, PHS
	210-006	101		2	LOCKWASHER, internal, #6
	210-407	101		2	NUT, hex., #6-32 x ¼ inch
21	348-002	101	5000	2	GROMMET, rubber, ¼ inch diameter
22	308-032	101	753	1	RESISTOR, 3.5 k 20 w
	308-020	754		1	RESISTOR, 3 k 10 w
	------				mounting hardware: (not included w/resistor)
23	210-808	101	753	2	WASHER, centering
	210-601	754		1	EYELET, 0190 ID x 0.323 inch OD
24	212-037	101	753	1	SCREW, #8-32 x 1$^{3}/_{4}$ inches, Fil HS
	211-553	754		1	SCREW, #6-32 x 1½ inches, RHS
25	210-409	101	753	2	NUT, hex., 8-32 x $^{5}/_{16}$ inch
	210-008	101	753	1	LOCKWASHER, internal, #8
	210-478	754		1	NUT, hex., resistor mounting
26	290-034	101		1	CAPACITOR, 2 x 15 μf 350 v
	------				mounting hardware: (not included w/capacitor)
	386-253	101		1	PLATE, capacitor flange, metal
27	211-534	101		2	SCREW, sems, #6-32 x $^{5}/_{16}$ inch, PHS
	210-006	101		2	LOCKWASHER, external, #6
28	210-407	101		2	NUT, hex., 6-32 x ¼ inch
29	120-038	101		1	TRANSFORMER, power 240-0-240 v & 6.5 v
	------				mounting hardware: (not included w/transformer)
	212-039	101	5000	4	SCREW, #8-32 x 3 inches, RHS
	210-008	101	5000	4	LOCKWASHER, internal, #8
	210-409	101	5000	4	NUT, hex., 8-32 x $^{5}/_{16}$ inch
	120-053	101		2	TRANSFORMER, oscillator adjustable
	------				mounting hardware for each: (not included w/transformer)
	210-457	101		2	NUT, keps, 6-32 x $^{5}/_{16}$ inch



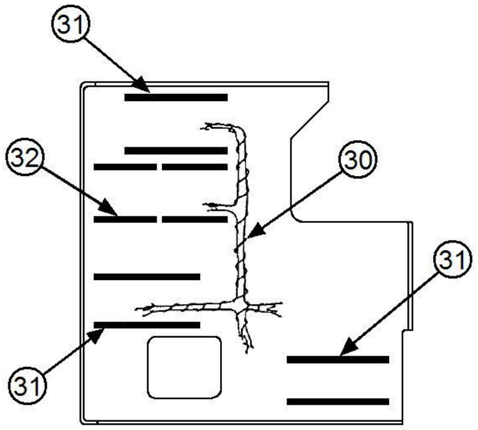
SN 5000-up

REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
33	441-153	5001		1	CHASSIS
	------				mounting hardware: (not included w/chassis)
	210-457	5001		6	NUT, keps, 6-32 x $^5/_{16}$ inch
34	120-038	101		1	TRANSFORMER, power 240-0-240 v & 6.5 v
	------				Transformer includes:
35	406-872	7580		1	BRACKET, transformer support
36	212-029	5001		4	SCREW, #8-32 x 3 inches, HHS
	------				mounting hardware: (not included w/transformer)
	210-008	101	5000	4	LOCKWASHER, internal, #8
	210-409	101	5000	4	NUT, hex., 8-32 x $^5/_{16}$ inch
37	211-537	7580		3	SCREW, #6-32 x $^3/_8$ inch, THS
	210-803	7580		3	WASHER, flat, 0.150 ID x 0.375 inch OD
	210-457	7580		3	NUT, keps, 6-32 x $^5/_{16}$ inch
38	311-015	101		4	RESISTOR, variable 10 kohm
	311-023	101		1	RESISTOR, variable 50 kohm
	311-026	101		1	RESISTOR, variable 100 kohm
	------				mounting hardware for each: (not included w/resistor)
	210-012	101		1	LOCKWASHER, internal, $^3/_8$ ID x $^1/_2$ inch OD
	210-840	101		1	WASHER, flat, 0.390 ID x $^9/_{16}$ OD
39	210-413	101		1	NUT, hex., ^{3}/8-32 x $^1/_2$ inch
40	343-015	5001	5453	1	CLAMP, stainless steel, ½ inch
	------				mounting hardware: (not included w/clamp)
	211-504	5001	5453	1	SCREW, #6-32 x ¼ inch, PHS
	210-006	5001		2	LOCKWASHER, internal, #6
	210-407	5001	5453	2	NUT, hex., 6-32 x ¼ inch
	214-012	5001	5453	1	BOLT, spade, #6-32 x $^3/_8$ inch
	354-068	5454		1	RING, securing

CHASSIS (continued)

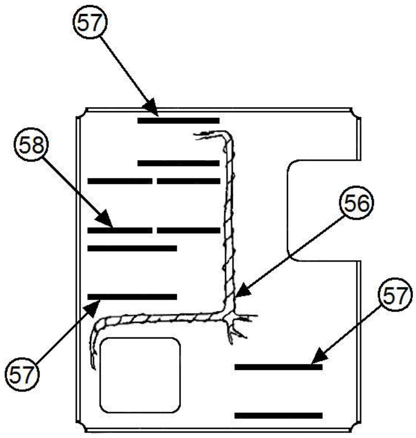
REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
41	308-020	754		1	RESISTOR, 3 k 10 w
	- - - - - -				mounting hardware: (not included w/resistor)
42	210-601	754		1	EYELET, 0190 ID x 0.323 inch OD
43	210-478	754		1	NUT, hex., resistor mounting
44	211-553	754		1	SCREW, #6-32 x 1½ inches, RHS
45	211-507	5001		1	SCREW, #6-32 x $^{5}/_{16}$ inch, PHS
46	120-053	101		2	TRANSFORMER, oscillator adjustable
	- - - - - -				mounting hardware for each: (not included w/transformer)
47	210-457	101		2	NUT, keps, 6-32 x $^{5}/_{16}$ inch
48	136-015	101		6	SOCKET, tube, 9-pin, w/ground lugs
	- - - - - -				mounting hardware for each: (not included w/socket)
49	211-033	101		2	SCREW, sems, #4-40 x $^{5}/_{16}$ inch, PHS
	210-004	101		2	LOCKWASHER, internal, #4
	210-406	101		2	NUT, hex., 4-40 x $^{3}/_{16}$ inch
50	136-008	101		4	SOCKET, tube, 7-pin, w/ground lugs
	- - - - - -				mounting hardware for each: (not included w/socket)
51	211-033	101		2	SCREW, sems, #4-40 x $^{5}/_{16}$ inch, PHS
	210-004	101		2	LOCKWASHER, internal, #4
	210-406	101		2	NUT, hex., 4-40 x $^{3}/_{16}$ inch
52	348-003	5001		1	GROMMET, rubber, $^{5}/_{16}$ inch diameter
53	348-002	5001		3	GROMMET, rubber, ¼ inch diameter
54	210-202	5454		1	LUG, solder, SE #6
	- - - - - -				mounting hardware: (not included w/lug)
	211-504	5454		1	SCREW, #6-32 x ¼ inch, PHS
	210-407	5454		1	NUT, hex., 6-32 x ¼ inch
55	290-034	101		1	CAPACITOR, 2 x 15 μf 350 v
	- - - - - -				mounting hardware: (not included w/capacitor)
	386-253	101		1	PLATE, capacitor flange, metal
	211-534	101		2	SCREW, sems, #6-32 x $^{5}/_{16}$ inch, PHS
	210-006	101		2	LOCKWASHER, external, #6
	210-407	101		2	NUT, hex., 6-32 x ¼ inch

CHASSIS (continued)



SN 101-5000

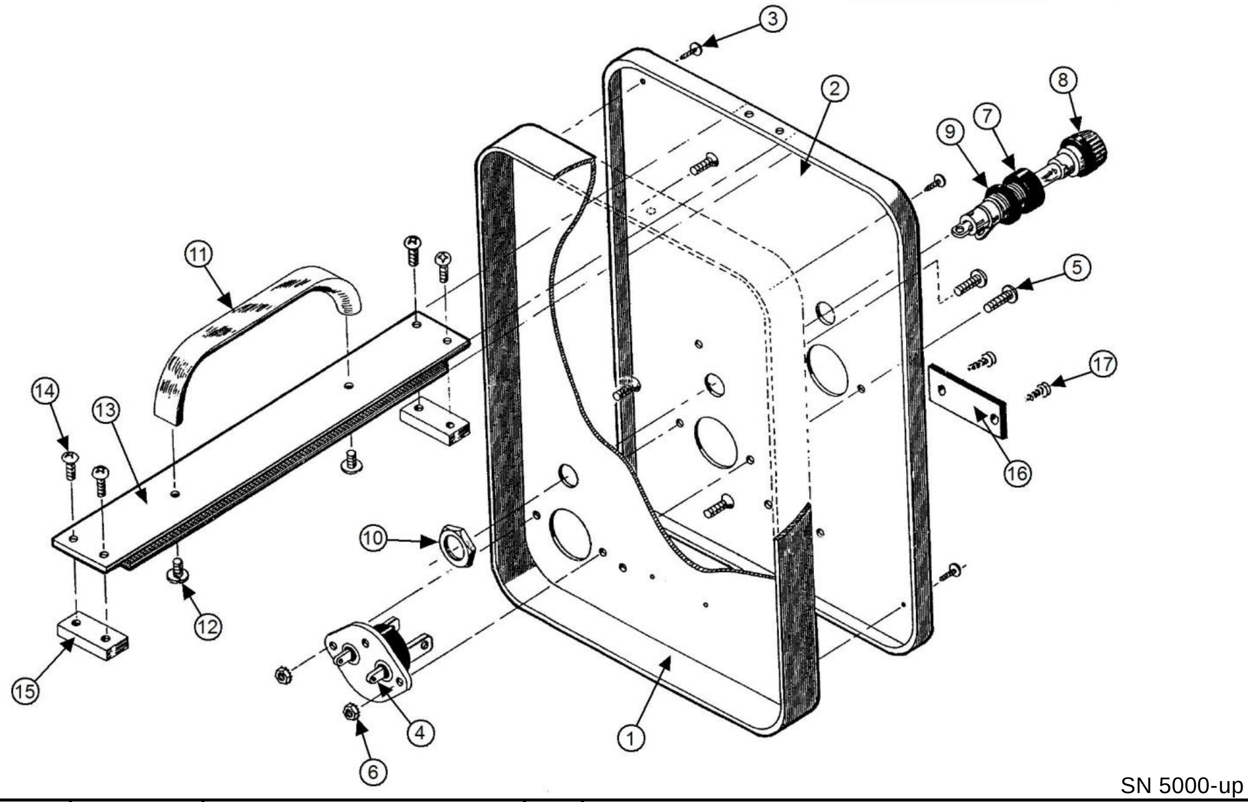
REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
30	179-051	101		1	CABLE HARNESS
31	124-016	101	5689	6	STRIP, ceramic, ¾ inch h, w/11 notches
	- - - - - -				mounting hardware for each: (not included w/strip)
	210-085	101	5689	2	WASHER, flat, 0.093 ID x $^{9}/_{32}$ inch OD
	210-002	101	5689	2	LOCKWASHER, external, #2
	210-045	101	5689	4	NUT, hex., 2-56 x $^{3}/_{16}$ inch
32	124-014	101	5689	4	STRIP, ceramic, ¾ inch h, w/7 notches
	- - - - - -				mounting hardware for each: (not included w/strip)
	210-085	101	5689	2	WASHER, flat, 0.093 ID x $^{9}/_{32}$ inch OD
	210-002	101	5689	2	LOCKWASHER, external, #2
	210-045	101	5689	4	NUT, hex., 2-56 x $^{3}/_{16}$ inch



SN 5001-up

REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
56	179-051	101		1	CABLE HARNESS
57	124-016	101	5689	6	STRIP, ceramic, ¾ inch h, w/11 notches
	- - - - - -				mounting hardware for each: (not included w/strip)
	210-085	101	5689	2	WASHER, flat, 0.093 ID x $^{9}/_{32}$ inch OD
	210-002	101	5689	2	LOCKWASHER, external, #2
	210-045	101	5689	4	NUT, hex., 2-56 x $^{3}/_{16}$ inch
	124-091	5690		6	STRIP, ceramic, ¾ inch h, w/11 notches
	- - - - - -				Each strip includes:
	355-046	5690		2	STUD, plastic, clip-on
	- - - - - -				mounting hardware for each: (not included w/strip)
	361-009	5690		2	SPACER, plastic, 0.406 inch long
58	124-014	101	5689	4	STRIP, ceramic, ¾ inch h, w/7 notches
	- - - - - -				mounting hardware for each: (not included w/strip)
	210-085	101	5689	2	WASHER, flat, 0.093 ID x $^{9}/_{32}$ inch OD
	210-002	101	5689	2	LOCKWASHER, external, #2
	210-045	101	5689	4	NUT, hex., 2-56 x $^{3}/_{16}$ inch
	124-089	5690		6	STRIP, ceramic, ¾ inch h, w/7 notches
	- - - - - -				Each strip includes:
	355-046	5690		2	STUD, plastic, clip-on
	- - - - - -				mounting hardware for each: (not included w/strip)
	361-009	5690		2	SPACER, plastic, 0.406 inch long

REAR



SN 5000-up

REF NO.	PART NO.	Serial/Model No. Start	End	QTY.	DESCRIPTION
1	386-603	5001		1	PLATE, rear sub-panel
2	386-643	5001	6213	1	PLATE, rear overlay, blue wrinkle
	387-035	6214		1	PLATE, rear overlay, blue vinyl
	- - - - - -				mounting hardware for each: (not included w/plate)
3	213-088	5001		3	SCREW, thread forming, #4-40 x ¼ inch, PHS
4	131-010	5001	5496	1	CONNECTOR, 2-contact, male recessed NEMA
	- - - - - -				mounting hardware for each: (not included w/connector)
	213-041	5001	5496	2	SCREW, thread cutting, #6-32 x $^{3}/_{8}$ inch, PHS
	131-102	5497		1	CONNECTOR, 3-contact, male projecting
	- - - - - -				Connector includes
	129--041	5497		1	POST, ground
	121-003	5497		2	LOCKWASHER, external, #4
	210-551	5497		2	NUT, hex., 4-40 x ¼ inch
	- - - - - -				mounting hardware: (not included w/connector)
5	211-537	5497		2	SCREW, #6-32 x $^{3}/_{8}$ inch, THS
6	210-457	5497		2	NUT, keps, 6-32 x $^{5}/_{16}$ inch
7	352-010	101		1	ASSEMBLY, fusheholder
	- - - - - -				assembly includes
	352-010	101		1	HOLDER, fuse 3AG
8	200-582	101		1	CAP, fuse
9	210-873	101		1	WASHER, rubber, ½ ID x $^{11}/_{16}$ inch OD
10	- - - - - -	101		1	NUT, $^{1}/_{2}$-24 x $^{1}/_{8}$ inch
11	367-007	5001		1	HANDLE, 4 inches
	- - - - - -				mounting hardware: (not included w/handle)
12	212-004	5001		2	SCREW, 8-32 x $^{5}/_{16}$ imnch, PHS
13	381-062	5001	6213	1	BAR, chrome
	381-159	6214		1	BAR, blue painted
	- - - - - -				mounting hardware: (not included w/bar)

REAR (continued)

REF NO.	PART NO.	Serial/Model No.		QTY.	DESCRIPTION
		Start	End		
14	211-537	5001		4	SCREW, #6-32 x $^3/8$ inch, THS
15	381-084	5001		2	BAR, w/2 #6-32 holes
16	334-0649	5001		1	TAG, voltage rating 117 v 50-60 c/s
	- - - - - -				mounting hardware: (not included w/bar)
17	213-088	5001		2	SCREW, thread forming, #4 x ¼ inch, PHS

ELECTRICAL PARTS LIST

***000-000 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, also reworked or checked components.**

Bulb

							Tektronix Part Number
B401	5168-up	Incandescent		Pilot Light			150-018

Capacitors

C1		.1 μF	PT	Fixed	400V	20%	285-526
C2		5-25 μμF	Cer.	Var.	500 v		281-011
C3		1-4 μμF	Air	Var.			281-015
C4		5-80 μμF	Air	Var.			281-016
C5		.001 μF	Mica	Fixed	500 v	1%	283-526
C6		470 μμF	Cer.	Fixed	500 v	20%	281-525
C7	101-5108	5-25 μμF	Cer.	Var.			281-011
	5109-up	8-50 μμF	Cer.	Var.			281-013
C9		0.01 μF	PT	Fixed	400 v	20%	285-510
C10		22 μμF	Cer.	Fixed	500 v	10%	281-511
C11		.001 μF	Cer.	Fixed	500 v	GMV	283-000
C15		22 μμF	Cer.	Fixed	500 v	10%	281-511
C17		100 μμF	Cer.	Fixed	350 v	20%	281-523
C18		.005 μF	Cer.	Fixed	500 v	GMV	283-001
C30		.001 μF	Mica	Fixed	500 v	1%	283-526
C31		470 μμF	Cer.	Fixed	500 v	20%	281-525
C33		0.01 μF	PT	Fixed	400 v	20%	285-510
C35		.001 μF	Cer.	Fixed	500 v	GMV	283-000
C36		22 μμF	Cer.	Fixed	500 v	10%	281-511
C45		22 μμF	Cer.	Fixed	500 v	20%	281-510
C47		100 μμF	Cer.	Fixed	350 v	20%	281-523
C48		.005 μF	Cer.	Fixed	500 v	GMV	283-001
C60		.02 μF	Cer.	Fixed	150 v	GMV	283-004
C61		150 μμF	Cer.	Fixed	500 v	20%	281-524
C62		100 μμF	Cer.	Fixed	350 v	20%	281-523
C63		470 μμF	Cer.	Fixed	500 v	20%	281-525
C64		47 μμF	Cer.	Fixed	500 v	10%	281-519
C65		47 μμF	Cer.	Fixed	500 v	10%	281-519
C73		4.7 47 μμF	Cer.	Fixed	500 v	±0.1 μμF	281-519
C90		250 μμF	Mica	Fixed	500 v	5%	283-543
C91		.0015 μF	PT	Fixed	400 v	20%	285-504
C92		.0047 μμF	PT	Fixed	400 v	20%	285-506
C93		.015 μF	PT	Fixed	400 v	20%	285-512
C94		.047 μF	PT	Fixed	400 v	20%	285-519
C97	X259-up	470 μμF	Cer.	Fixed	500 v	20%	281-525
C99	X6040-up	5 μF	EMT	Fixed	6 v		290-125
C100	X6040-up	25 μF	EMT	Fixed	6 v		290-124
C110		.022 μF	PT	Fixed	400 v	20%	285-515
C112		.001 μF	Cer.	Fixed	500 v	GMV	283-000
C401		2x15 μF	EMC	Fixed	350 v	–20+50%	290-034
C402		6.25 μF	EMC	Fixed	300 v	–20+50%	285-515
C403		.022 μF	PT	Fixed	400 v	20%	285-515

Fuses

			Tektronix Part Number
Fuse		0.8 amp 3 AG Slo-Blo for 117 v operation	159-018
Fuse		0.4 amp 3 AG Slo-Blo for 234 v operation	159-031

Meters

Meter	101-5167	4700Ω	*149-003
	5168-up	0-200 μa	*149-010

Resistors

R1		10 meg	½ w	Fixed	Comp.	10%	302-106
R6		1.5 meg	½ w	Fixed	Comp.	10%	302-155
R7		100 k	½ w	Fixed	Comp.	10%	302-104
R8		1 meg	½ w	Fixed	Comp.	10%	302-105
R9		56 k	½ w	Fixed	Comp.	10%	302-563
R10		470 k	½ w	Fixed	Comp.	10%	302-474
R14		10 meg	½ w	Fixed	Comp.	10%	302-106
R15		1.5 meg	½ w	Fixed	Comp.	10%	302-155
R16		47 Ω	½ w	Fixed	Comp.	10%	302-470
R17		1 meg	½ w	Fixed	Comp.	10%	302-105
R18		1 meg	½ w	Fixed	Comp.	10%	302-105
R19		1.5 meg	½ w	Fixed	Comp.	10%	302-155
R31		1.5 meg	½ w	Fixed	Comp.	10%	302-155
R32		100 k	½ w	Fixed	Comp.	10%	302-104
R33		56 k	½ w	Fixed	Comp.	10%	302-563
R35		470 k	½ w	Fixed	Comp.	10%	302-474
R45		1.5 meg	½ w	Fixed	Comp.	10%	302-155
R46		47 Ω	½ w	Fixed	Comp.	10%	302-470
R47		1 meg	½ w	Fixed	Comp.	10%	302-105
R48		1 meg	½ w	Fixed	Comp.	10%	302-105
R49		1.5 meg	½ w	Fixed	Comp.	10%	302-155
R60		47 k	½ w	Fixed	Comp.	10%	302-473
R61		22 k	½ w	Fixed	Comp.	5%	302-223
R62		22 k	½ w	Fixed	Comp.	5%	302-223
R64		11 k	½ w	Fixed	Comp.	5%	302-113
R67		100 k	½ w	Fixed	Comp.	10%	302-104
R68		50 k	2 w	Var.	Comp.	20%	311-023
R69	X435-up	10k	½ w	Fixed	Comp.	10%	302-103
R70		6.8 k	½ w	Fixed	Comp.	10%	302-682
R71		5.6 k	1 w	Fixed	Comp.	5%	304-562
R72		180 k	½ w	Fixed	Comp.	5%	302-184
R73		470 k	½ w	Fixed	Comp.	5%	302-474
R74		15 k	1 w	Fixed	Comp.	10%	304-153
R75		330 k	½ w	Fixed	Comp.	10%	302-334
R76		47 Ω	½ w	Fixed	Comp.	10%	302-470
R77		4.7 meg	½ w	Fixed	Comp.	10%	302-475
R78		100 k	2 w	Var.	Comp.	20%	311-026
R79		82 k	½ w	Fixed	Comp.	10%	302-823
R80		47 Ω	½ w	Fixed	Comp.	10%	302-470
R81		47 Ω	½ w	Fixed	Comp.	10%	302-470

Resistors *(continued)*

							Tektronix Part Number
R95		33 k	2 w	Fixed	Comp.	10%	306-333
R96		470 Ω	½ w	Fixed	Comp.	10%	302-471
R97		10 k	2 w	Var.	WW	20%	311-015
R98		10 k	2 w	Var.	WW	20%	311-015
R99		10 k	2 w	Var.	WW	20%	311-015
R100		10 k	2 w	Var.	WW	20%	311-015
R110		1 meg	½ w	Fixed	Comp.	10%	302-105
R111		10 k	½ w	Fixed	Comp.	10%	302-103
R112		2.2 meg	½ w	Fixed	Comp.	10%	302-225
R113		4.7 meg	½ w	Fixed	Comp.	10%	302-475
R116		47 Ω	½ w	Fixed	Comp.	10%	302-470
R401		100 k	½ w	Fixed	Comp.	10%	302-104
R402		100 k	½ w	Fixed	Comp.	10%	302-104
R403	101-753	3.5 k	20 w	Fixed	WW	5%	308-032
R403	754-up	3 k	10 w	Fixed	WW	5%	308-020
R405		1.5 Ω	1 w	Fixed	WW	10%	308-058

Switches

SW1	3 wafer, 11 position, rotary RANGE SELECTOR	*260-072

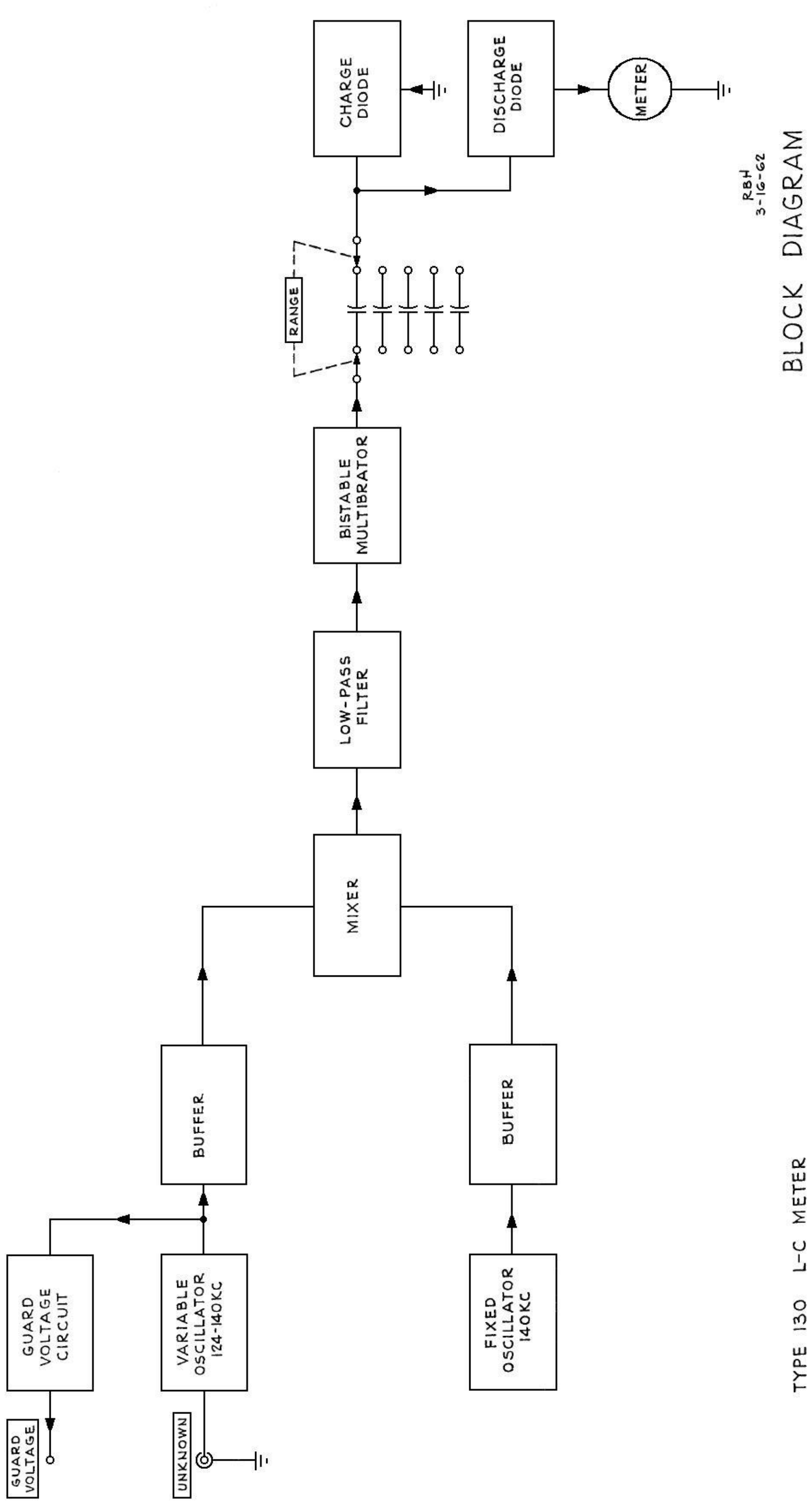
Transformers

T1	Oscillator Transformer	*120-053
T30	Oscillator Transformer	*120-053
T400	Plate and Heater Supply T130 PA 1 Primary: 117-234 vac, 60 cycles Secondary 240-0-240 vac at 40 ma 6.5 vac at 4 amp	*120-038

Vacuum Tubes

V4	6U8	154-033
V15	6U8	154-033
V30	6U8	154-033
V45	6U8	154-033
V60	6BE6	154-025
V70	6U8	154-033
V76	6BW7A	154-028
V110	6BH6	154-026
V400	6X4	154-035
V403	OA2	154-001

DIAGRAMS


CHARGE DIODE
DISCHARGE DIODE
METER
RANGE
BISTABLE MULTIBRATOR
LOW-PASS FILTER
MIXER
BUFFER
BUFFER
GUARD VOLTAGE CIRCUIT
VARIABLE OSCILLATOR 124-140KC
FIXED OSCILLATOR 140KC
GUARD VOLTAGE
UNKNOWN
RBH 3-16-62
BLOCK DIAGRAM
TYPE 130 L-C METER

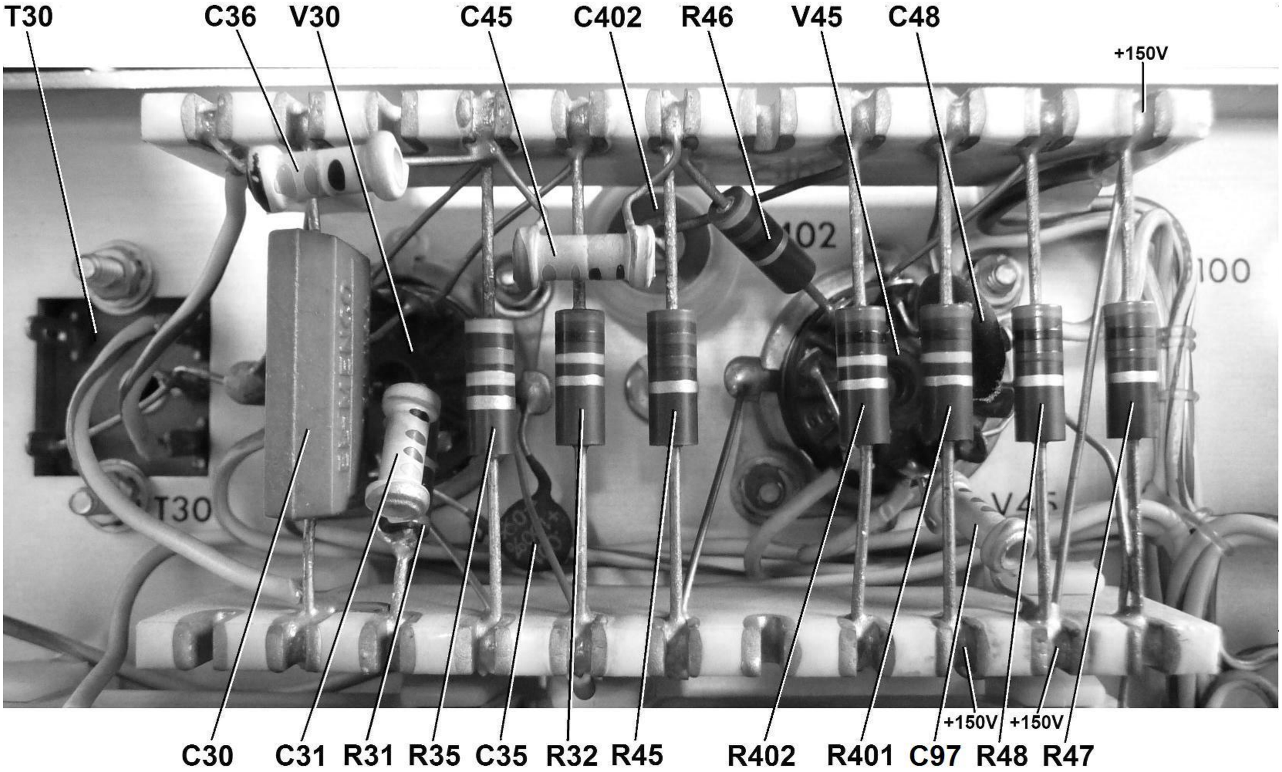


Figure 7.1 Fixed Oscillator, Buffer, and Discharge Diode

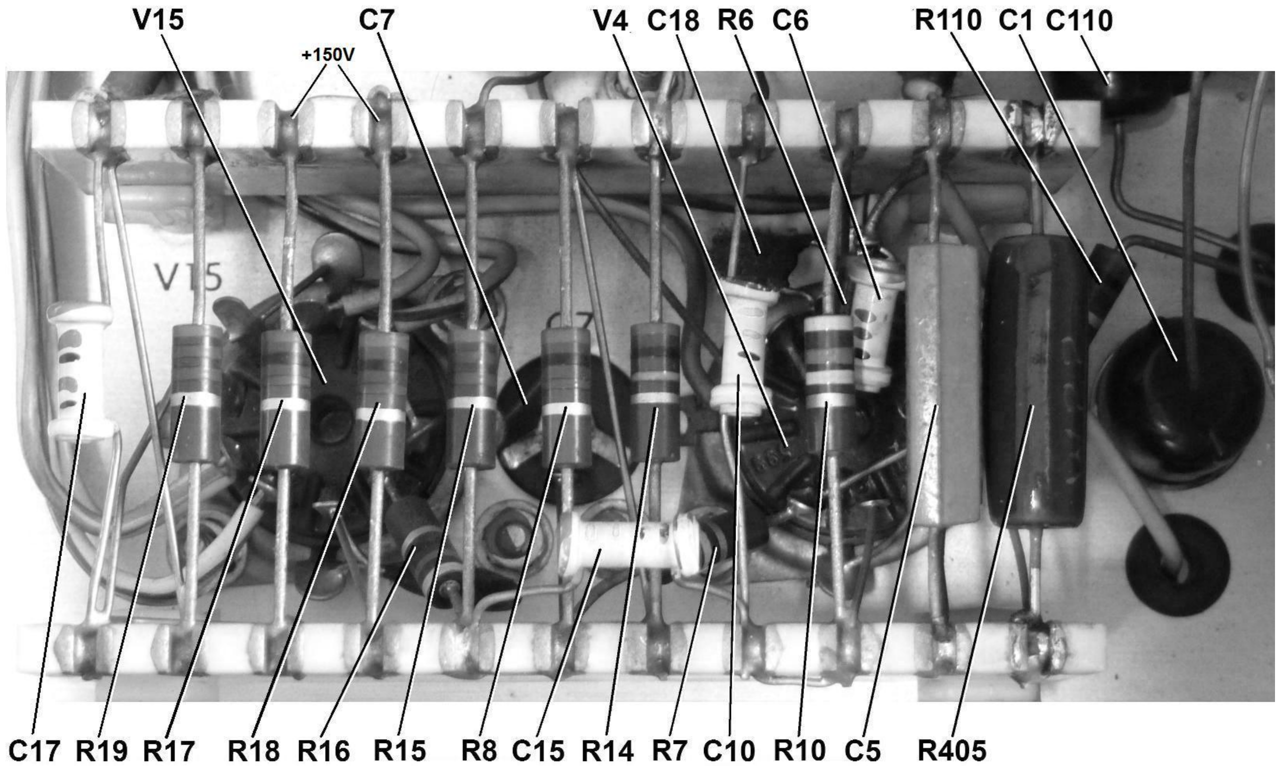


Figure 7.2 Variable Oscillator, Buffer, and Charge Diode

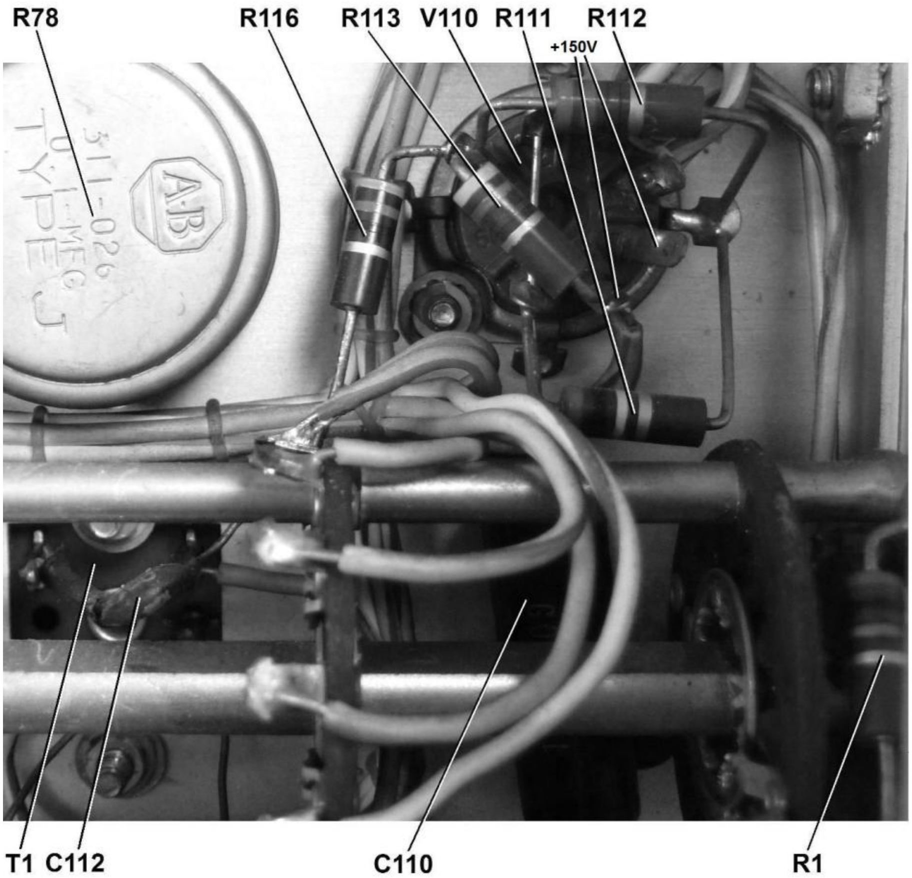


Figure 7.3 Cathode Follower

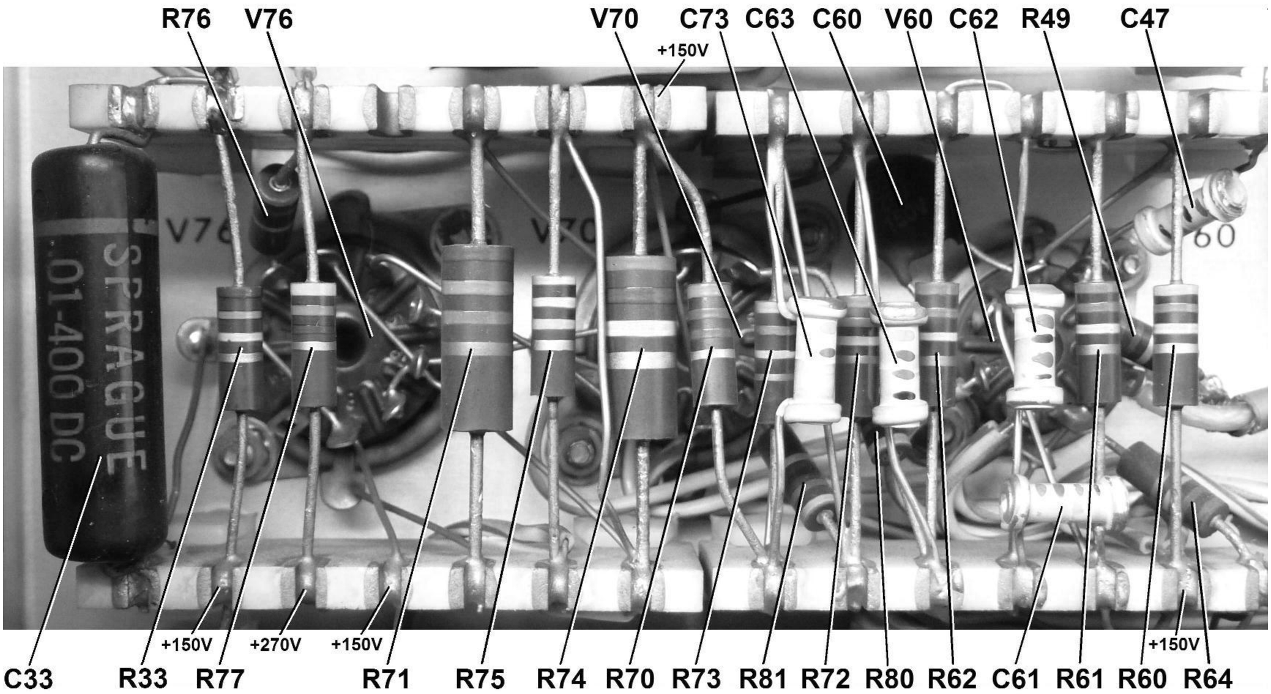


Figure 7.4 Mixer, Multivibrator and Clamp

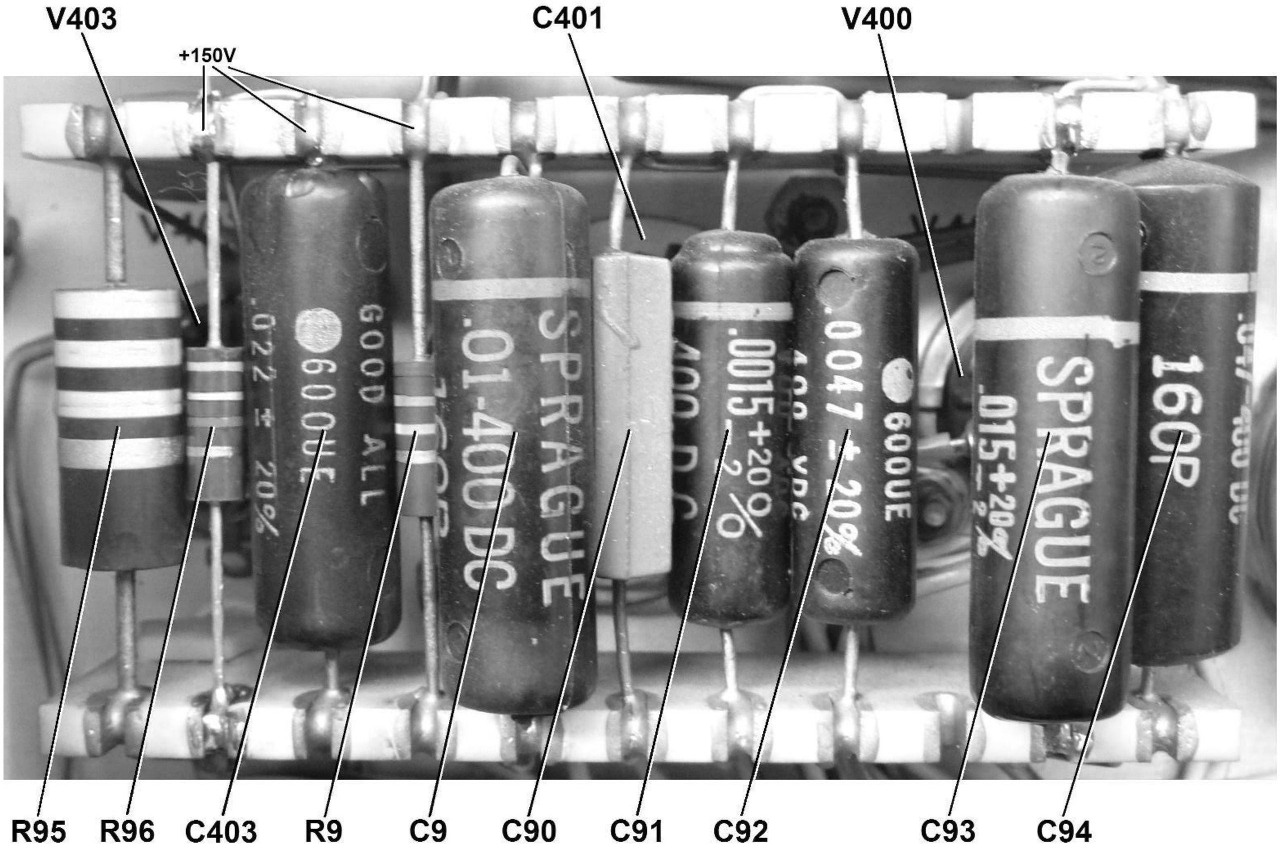
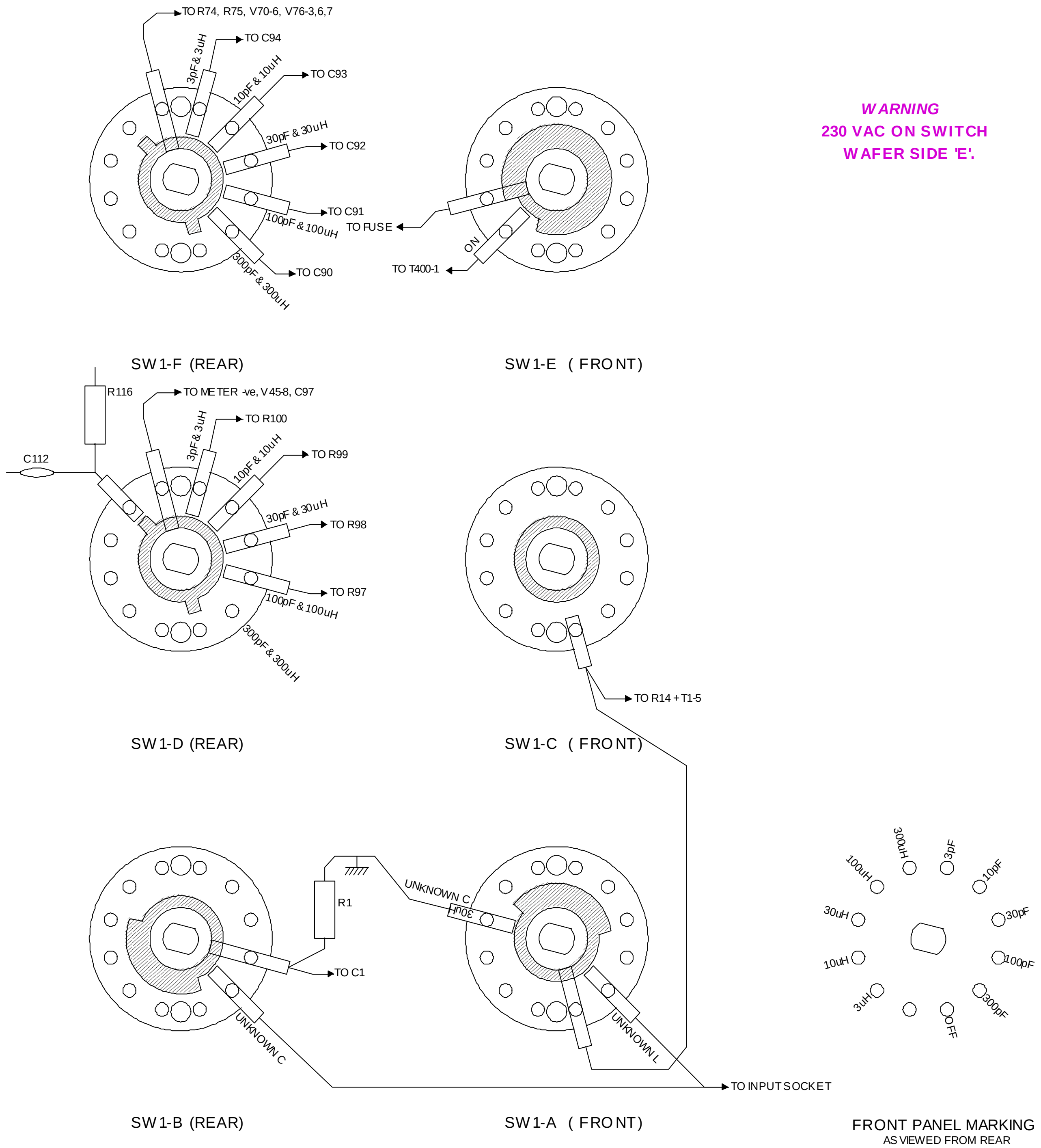
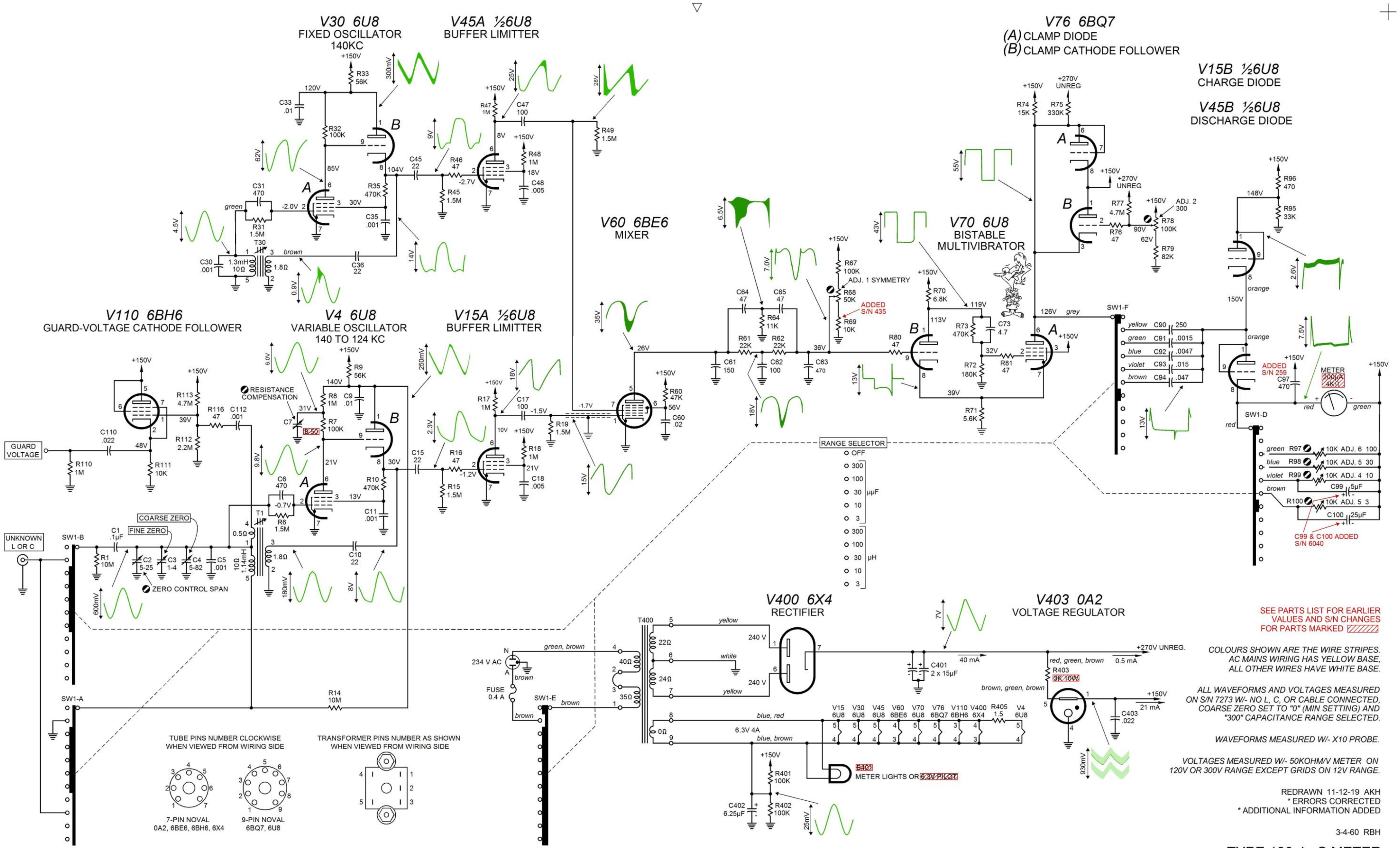


Figure 7.5 Range Capacitors and Power Supply



TYPE 130 RANGE SWITCH SHOWN IN OFF POSITION
EACH DECK SHOWN AS VIEWED FROM REAR



SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES FOR PARTS MARKED

COLOURS SHOWN ARE THE WIRE STRIPES.
AC MAINS WIRING HAS YELLOW BASE,
ALL OTHER WIRES HAVE WHITE BASE.

ALL WAVEFORMS AND VOLTAGES MEASURED ON S/N 7273 W/- NO L, C, OR CABLE CONNECTED, COARSE ZERO SET TO "0" (MIN SETTING) AND "300" CAPACITANCE RANGE SELECTED.

WAVEFORMS MEASURED W/- X10 PROBE.

VOLTAGES MEASURED W/- 50KOHM/V METER ON 120V OR 300V RANGE EXCEPT GRIDS ON 12V RANGE.

REDRAWN 11-12-19 AKH
* ERRORS CORRECTED
* ADDITIONAL INFORMATION ADDED

3-4-60 RBH

TYPE 130 L, C METER