INSTRUCTION MANUAL

Serial Number ____________

TYPE 130 L-C METER

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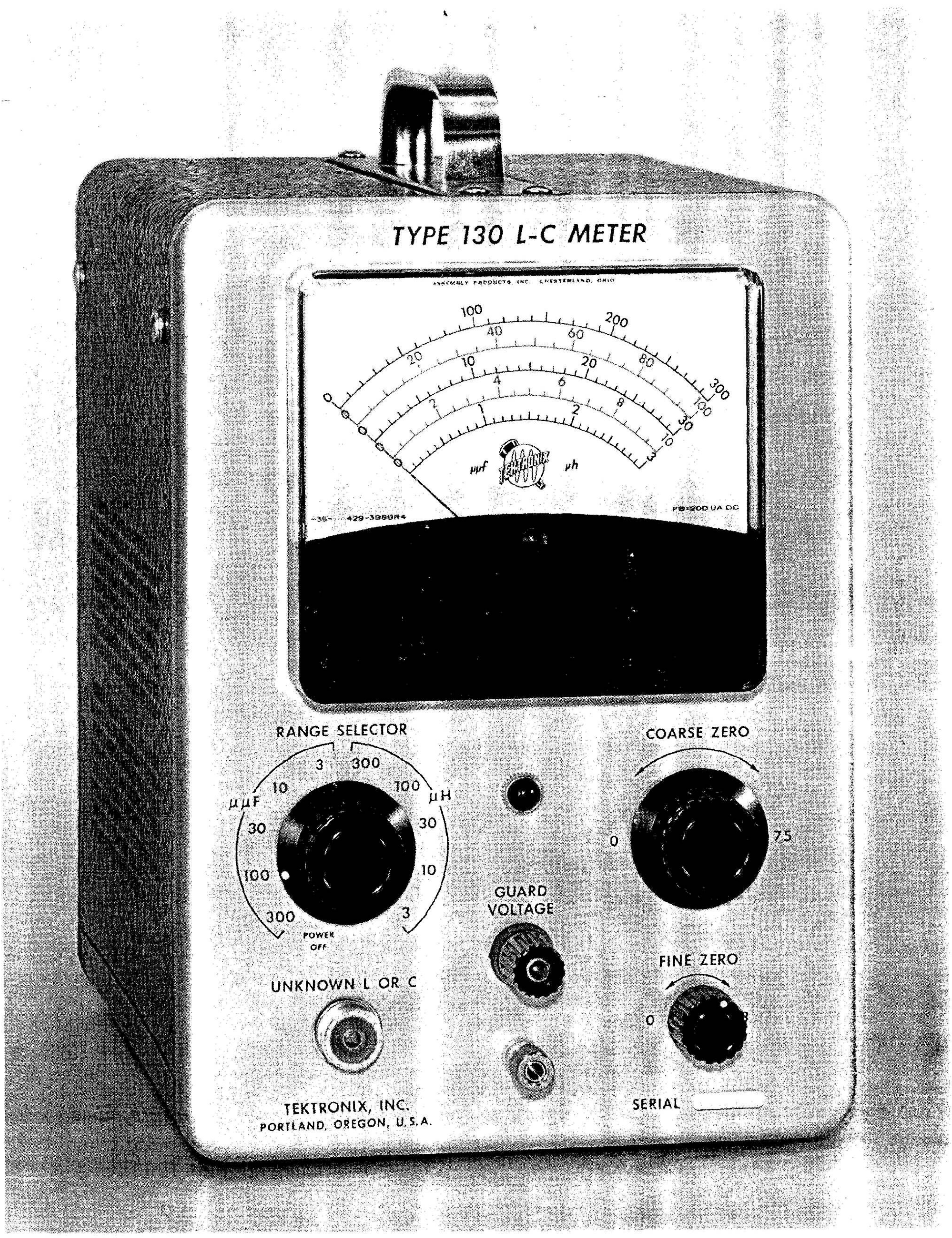


Fig. 1-1. Type 130 L-C Meter.

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 μH and capacitance up to 300$\mu\mu$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 μH and $\mu\mu$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 enviromental 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 μH or $\mu\mu$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 μH or 0.2 $\mu\mu$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 parellel 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 parellel 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 KΩ 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 kΩ. 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 Ω in series with the unknown (core losses appear as series resistance) or as low as 20 kΩ 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 Ω. 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 $\mu\mu$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 $\mu\mu$F maximum.

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

Total series resistance between Unknown terminal and chassis ground must be $\geq$100 kΩ. (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 1/4 volt peak to peak across inductors. Capacitors above 100 $\mu\mu$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 10½″ high and 10¾″ deep.

Weight—Approximately 9 pounds.

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 $\mu\mu$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 $\mu\mu$F without an unknown attached. Connecting a 300 $\mu\mu$F unknown capacitor adds about 30% additional capacitance and reduces the frequency of oscillation from 140 kHz to 125 kHz.

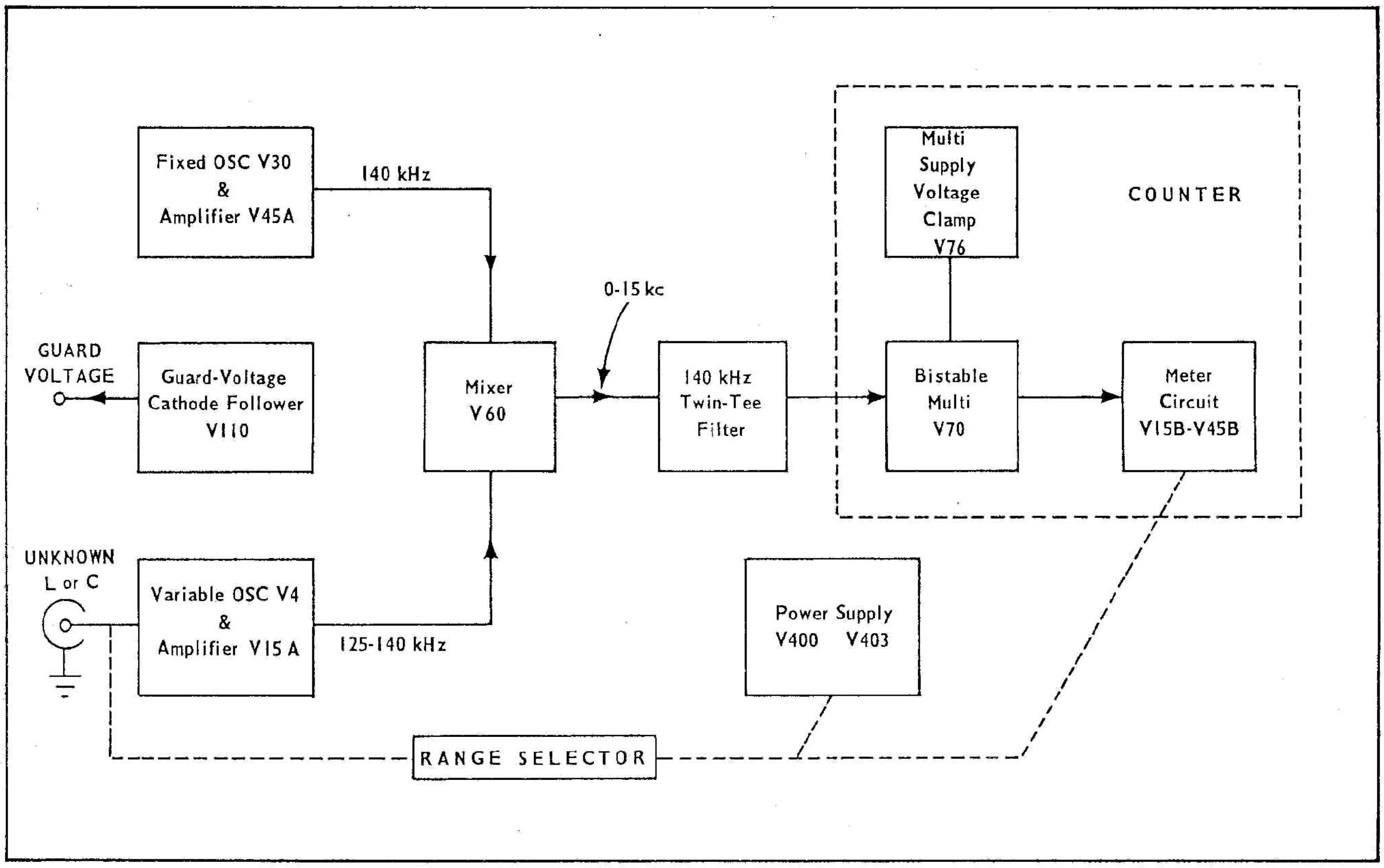


Fig. 3-1. Type 130 Block Diagram.

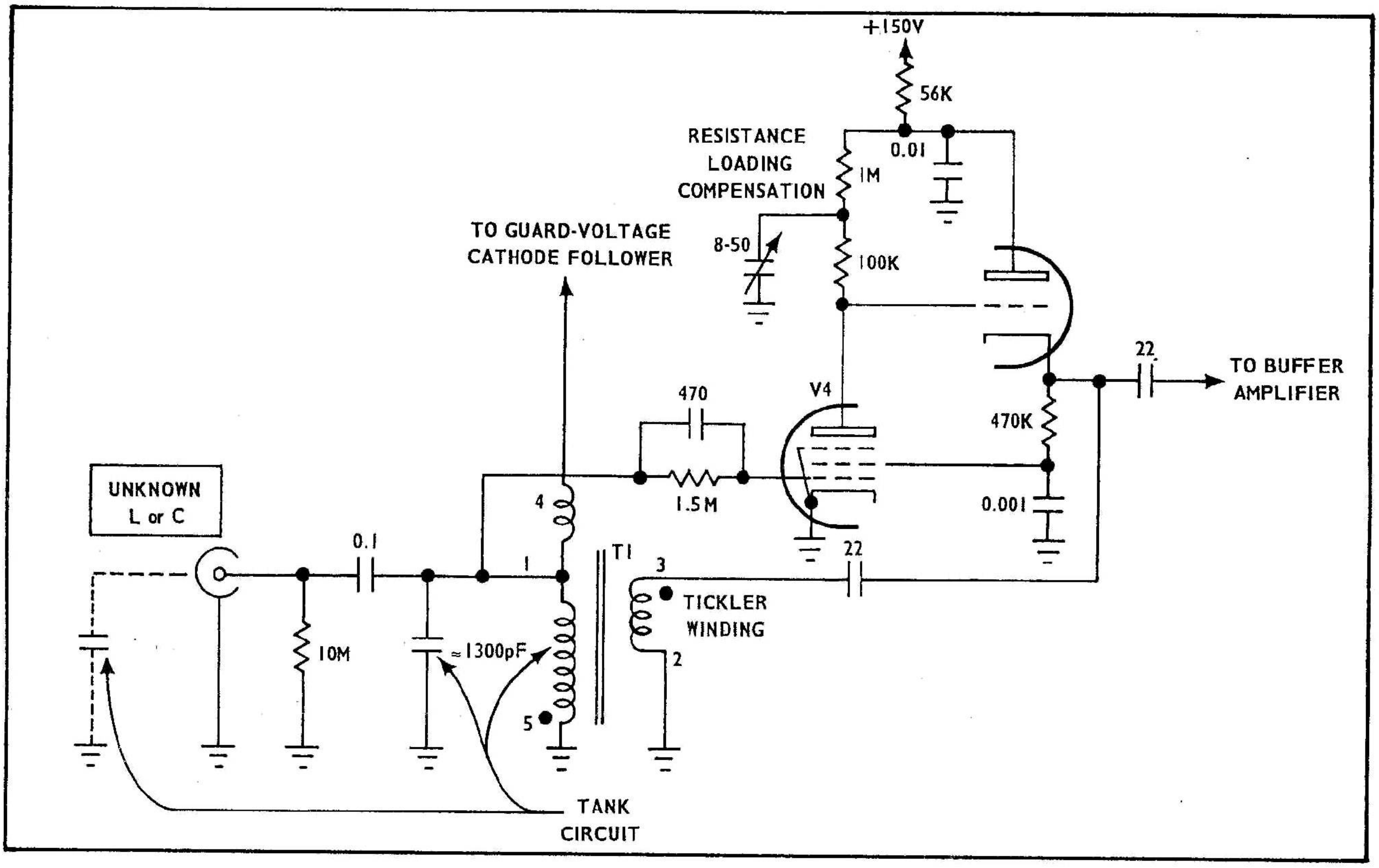


Fig. 3-2. Variable Oscillator active elements when Type 130 is set to measure capacitance.

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

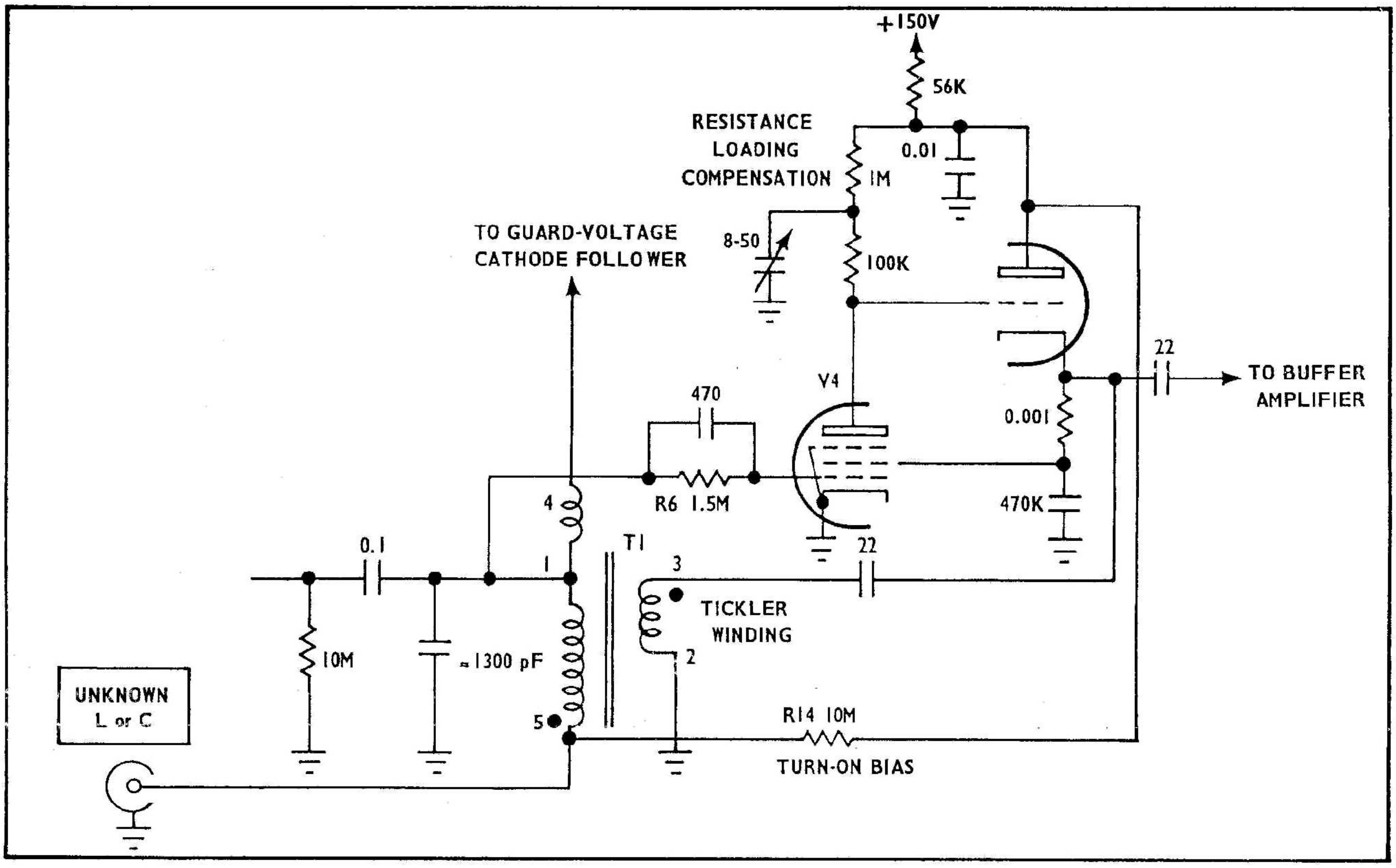


Fig. 3-3. Variable Oscillator active elements when Type 130 is set to measure inductance.

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 kΩ 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

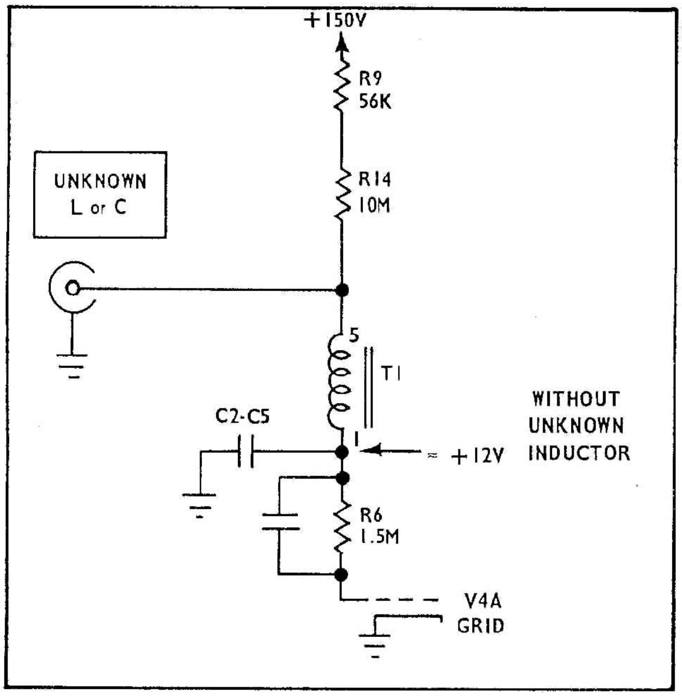


Fig. 3-4. DC bleeder network that charges capacitors C2 through C5 without unknown inductor.

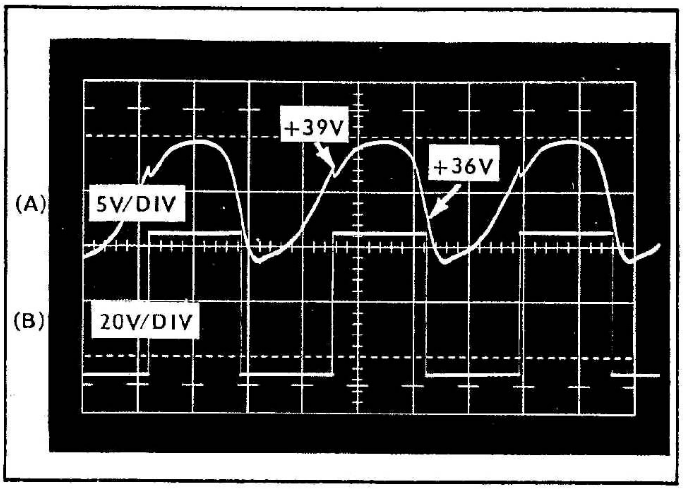


Fig. 3-5. (A) V70B grid. (B) V70A plate. Waveforms are time-related.

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 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 $\mu\mu$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 $\mu\mu$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 kΩ). 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 recieves 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 $\mu\mu$F or 300 μH.

Changing the RANGE SELECTOR switch to 100 $\mu\mu$F (μH) and 30 $\mu\mu$F (μH) 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 $\mu\mu$F (μH) and 3 $\mu\mu$F (μH) 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 $\mu\mu$F range with proper meter deflection set by adjusting the amplitude of V70A anode swing (adjusting R78, ADJ 2 300).

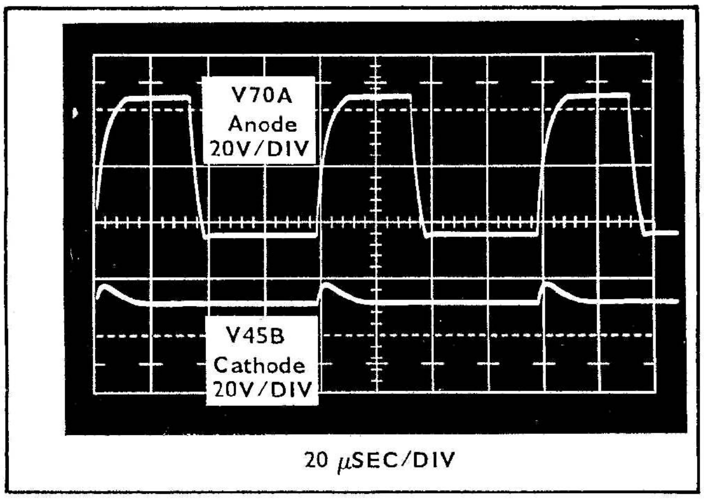


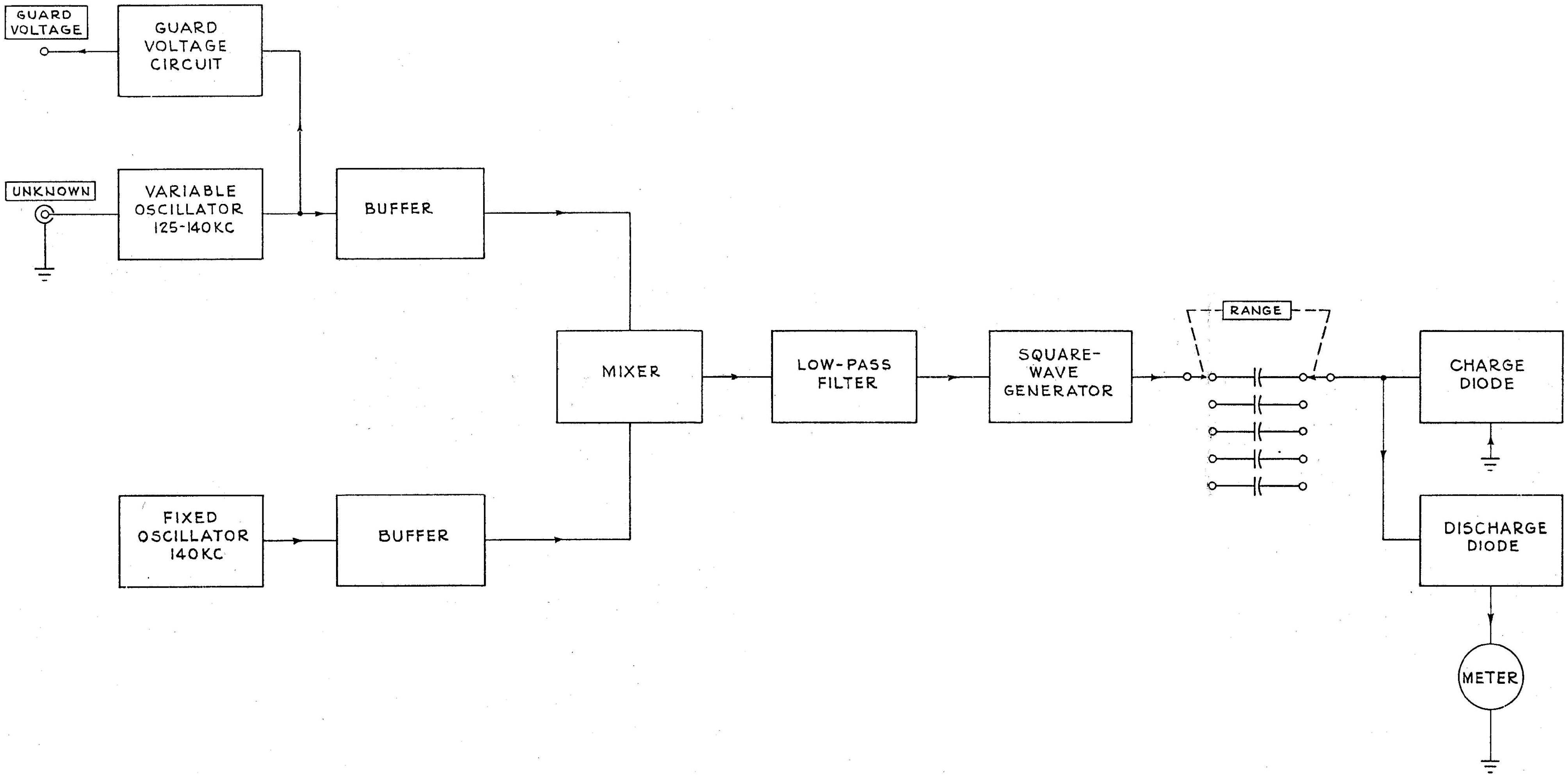
Fig. 3-6. Counter circuit waveforms.

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

Power Supply

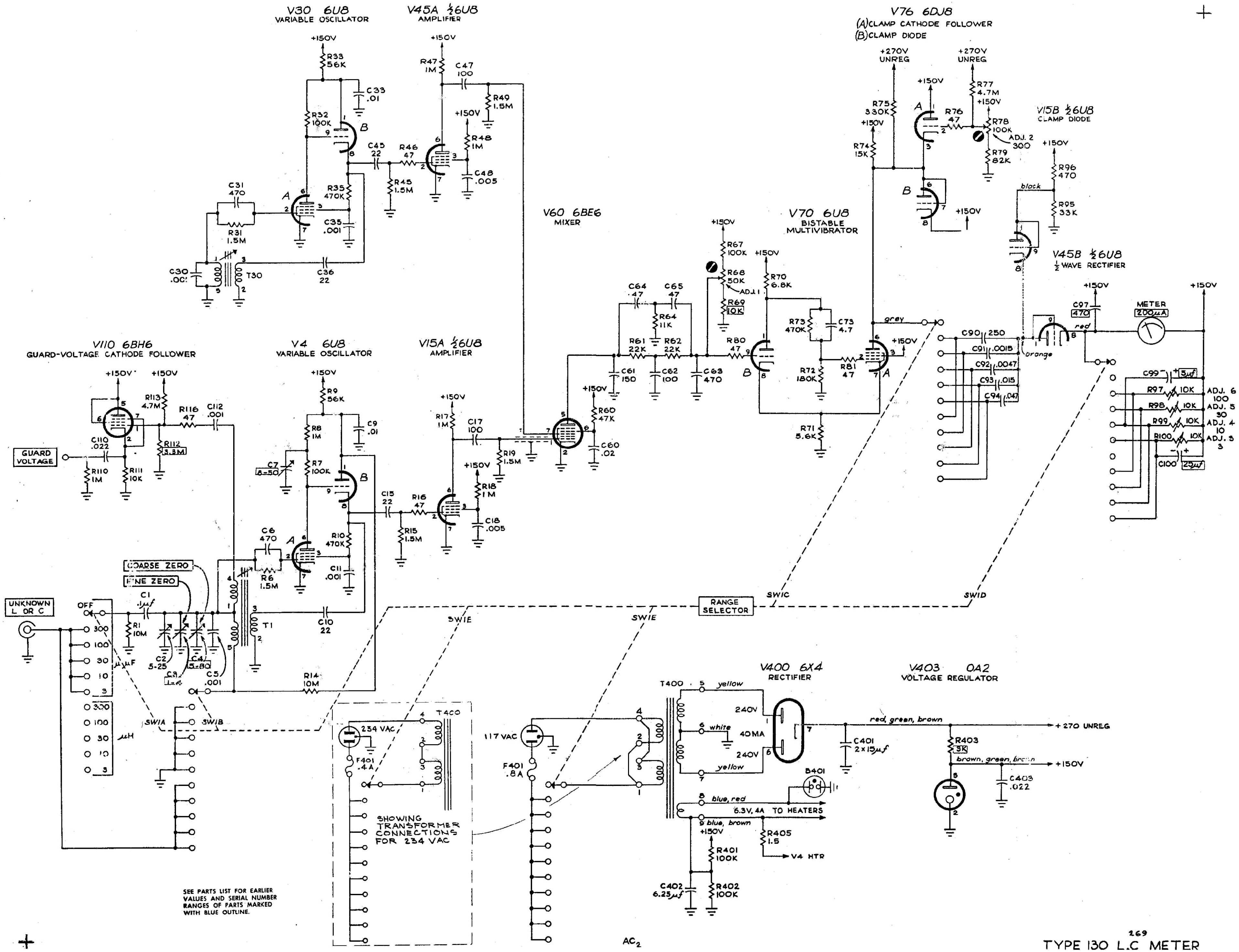
DC power is furnished by a capacitor input full-wave rectifier circuit. V400 is the rectifier. V403 is a soft-tube regulator that provides the +150 volts for circuits that require a stable voltage throughout normal line voltage changes. The tube heaters are elevated to +75 volts to reduce the heater-to-cathode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



TYPE 130 L-C METER

BLOCK DIAGRAM



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

AC2

TYPE 130 L.C METER