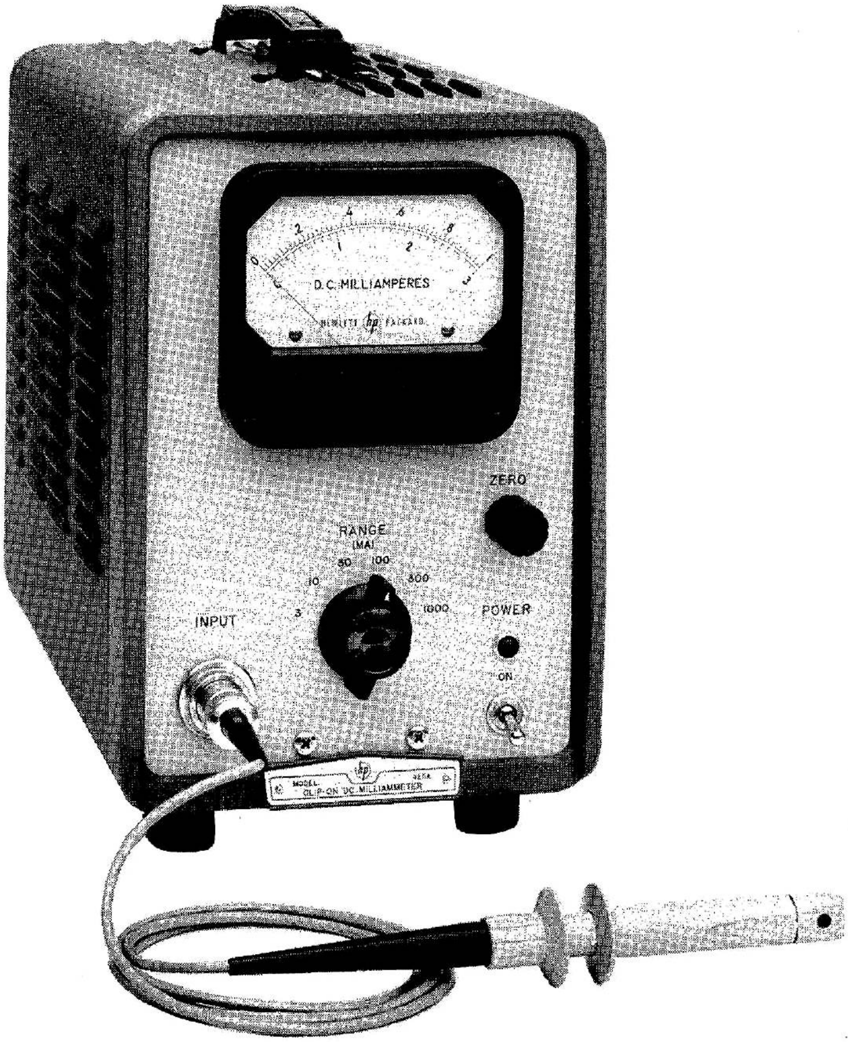
OPERATING AND SERVICING MANUAL

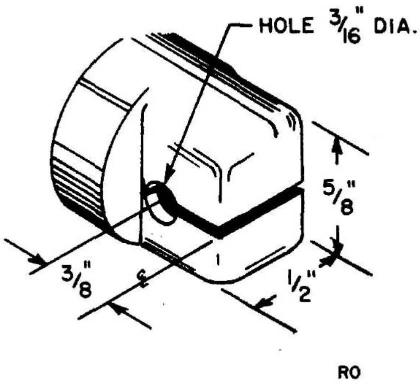
MODEL 428A
CLIP-ON MILLIAMMETER
SERIALS PREFIXED: 022 -



1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

SPECIFICATIONS

RANGE:	3 ma to 1 a full scale. Six ranges in a 3, 10, 30...sequence.
ACCURACY:	Within ±3% of full scale ±0.1 ma.
INDUCTANCE:	Less than 0.5 μh will be introduced into measured circuit.
INDUCED VOLTAGE:	Less than 15 mv peak into measured circuit.
AC REJECTION:	AC with a peak value less than full scale effects accuracy less than 2% at frequencies different from the carrier (≈ 40 kc) and its harmonics.
PROBE INSULATION:	300 volts when used on bare wire.
POWER:	115/230 volts ±10%, 50-60 cps, 70 watts.
DIMENSIONS:	Cabinet Mount: 7-1/2 in. wide, 11-1/2 in. high, 14-1/4 in. deep Rack Mount: 19 in. wide, 7 in. high, 13 in. deep behind panel
PROBE DIMENSIONS:	3/16 in. hole diameter



WEIGHT:	Cabinet Mount: Net 19 lbs., shipping 24 lbs Rack Mount: Net 24 lbs., shipping 35 lbs

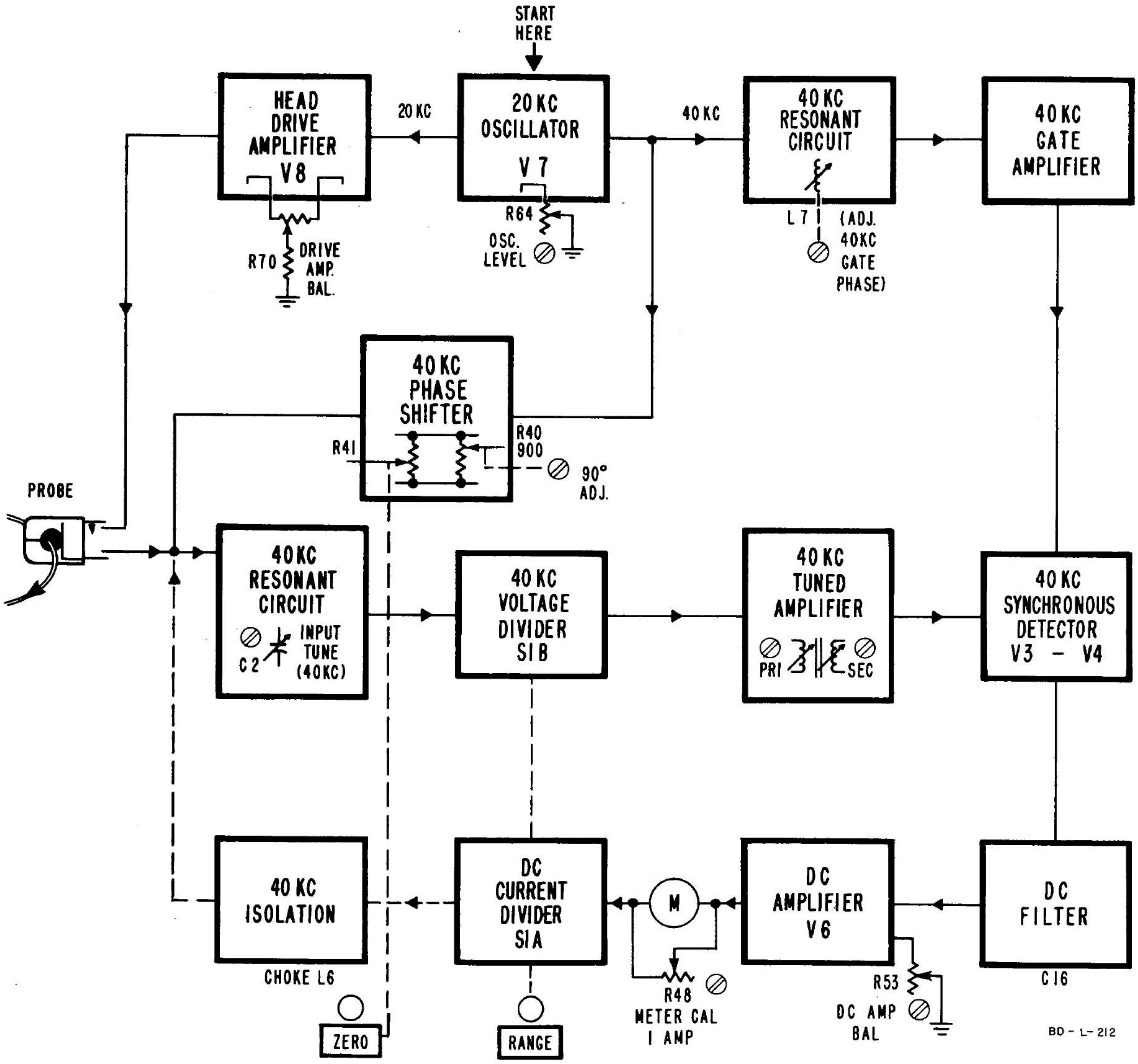


Figure 3-1. Block Diagram Model 428A

SECTION III
THEORY

3-1 INTRODUCTION

This section describes the overall operation of the 428A, the operating principle of the current probe and the function of the different circuits of the instrument.

3-2 OVERALL OPERATION

The simplified block diagram of figure 3-2 shows the basic operation of the 428A Clip-On Milliammeter.

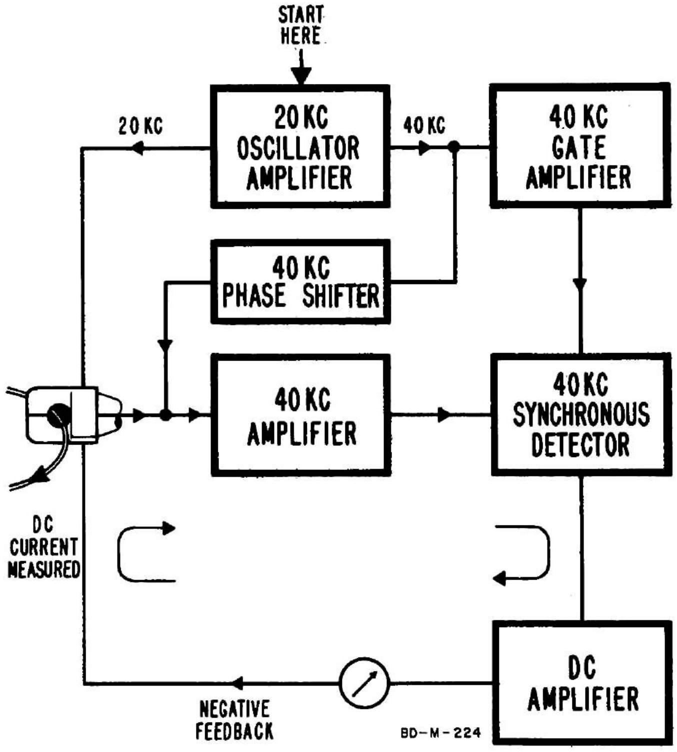


Figure 3-2. Simplified Block Diagram

The probe clips around a wire carrying dc current and delivers a 40 kc output signal which is proportional to the dc current. For transducing the dc current into a 40 kc signal, the probe requires a 20 kc gating signal, as described in detail in paragraph 3-5, 20 KC Head-Drive Amplifier.

The 40 kc output signal of the probe is amplified, detected and fed back as negative feedback current to the probe head cancelling the effect of the measured dc current and thus reducing the 40 kc output signal almost to zero. The negative feedback current being proportional, and almost equal to, the dc current of the inserted wire, is used to indicate the measured dc current.

The 20 kc oscillator has two functions: First, it supplies a 20 kc signal for driving the probe head, and also provides a 40 kc (second harmonic) signal for gating the 40 kc Synchronous Detector.

Due to slight unbalances, the probe head output shows a small 40 kc signal, even with no dc current being measured. A 40 kc phase-shifter output cancels such residual 40 kc signal (ZERO-SET controls).

3-3 CURRENT PROBE

The probe head is a specially designed second harmonic flux-gate type of a magnetometer used to measure the magnetic field around a wire carrying direct current.

The flux-gate principle is easily understood by referring to the mechanical model shown in figure 3-3.

Coil A (representing wire through probe), is energized with dc, producing a dc-flux in the core. Armature S is rotating at a constant rate (f), gating the flux 2f times per second, inducing a voltage of 2f frequency in coil B. The amplitude is determined by the dc in coil A.

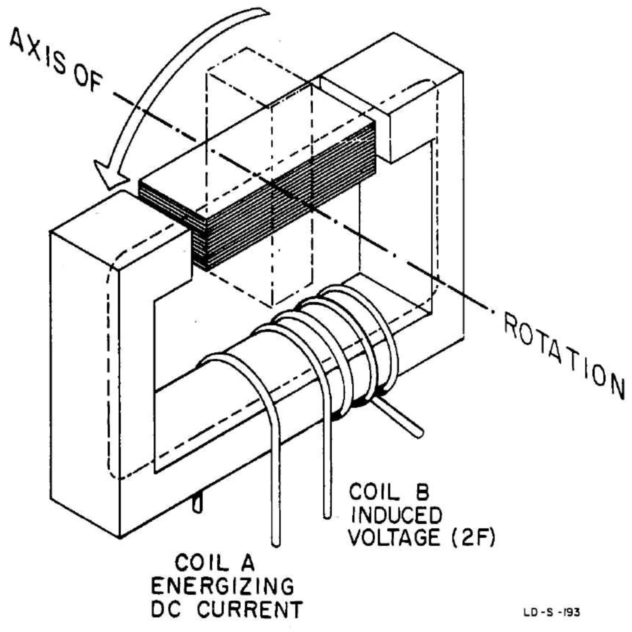


Figure 3-3. Mechanical Flux Gate

The 428A probe head uses this principle in a similar way. Figure 3-4 shows the basic concept of a saturable flux gate.

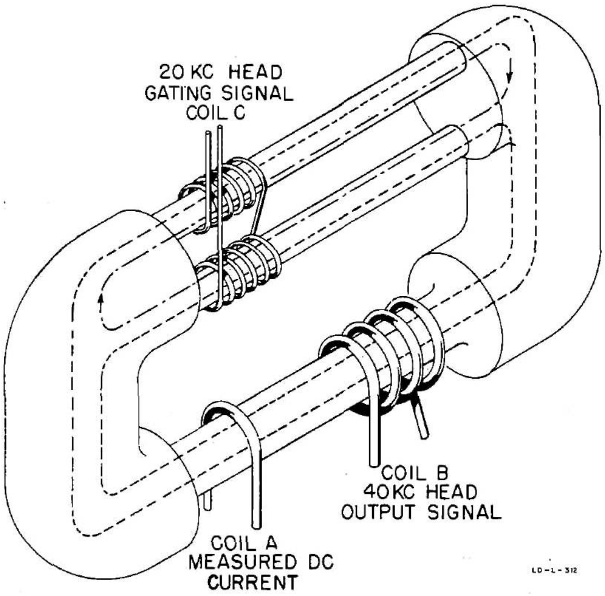


Figure 3-4. Saturable Flux Gate

A magnetic core in saturation loses its permeability and therefore is comparable to a core that has been mechanically opened (low permeability due to air gap).

Coil C saturates the core periodically with a 20 kc signal, driving the small cores in and out of saturation twice per cycle. This is the only function of the 20 kc signal, and this signal can be disregarded in further discussion. Coil A represents the wire through the probe carrying the dc current to be measured. This dc current determines the main flux between the two saturation phases. The resulting 40 kc signal is induced in coil B.

In the actual head there are four coils connected in a bridge configuration as shown in figure 3-5A. The cores of the coils are periodically saturated by a balanced 20 kc signal at points C and D.

With no dc being measured, no signal will appear between points A and B, since they are balanced as far as the 20 kc is concerned and since no dc flux exists, no 40 kc is generated.

When the probe jaws are clipped over a wire carrying dc, the instantaneous 40 kc voltages induced by the gated dc flux has the polarities shown in figure 3-5B and a 40 kc signal appears at points A and B. (If the direction of the measured dc changes, the phase of the instantaneous voltages will change by 180°.)

3-4 20 KC OSCILLATOR

The function of the 20 kc oscillator is to generate a balanced 20 kc signal, which after amplification is used for driving the probe head in and out of saturation.

The circuit of the 20 kc oscillator is shown in figure 4-15. The oscillator V7 is operating in push-pull having a plate circuit tuned to 20 kc. Transformer coupling provides positive feedback through resistor R66 and R67 to the oscillator control grid. The control grids of oscillator V7 supply the drive signal for the push-pull head drive amplifier V8. The oscillator level is adjusted by controlling the cathode current of V7.

The common cathodes of oscillator V7 supply the 40 kc signal (2 pulses per 20 kc cycle) needed for the synchronous detector gate amplifier V5 and the 40 kc phase shifter.

3-5 20 KC HEAD-DRIVE AMPLIFIER

The head-drive amplifier V8 supplies the balanced 20 kc signal for the probe head. Drive balance adjustment R70 controls the current ratio of the two triode sections, and hence the second harmonic output. The dc bias voltage for the oscillator and the head-drive amplifier is obtained from reference tube V11.

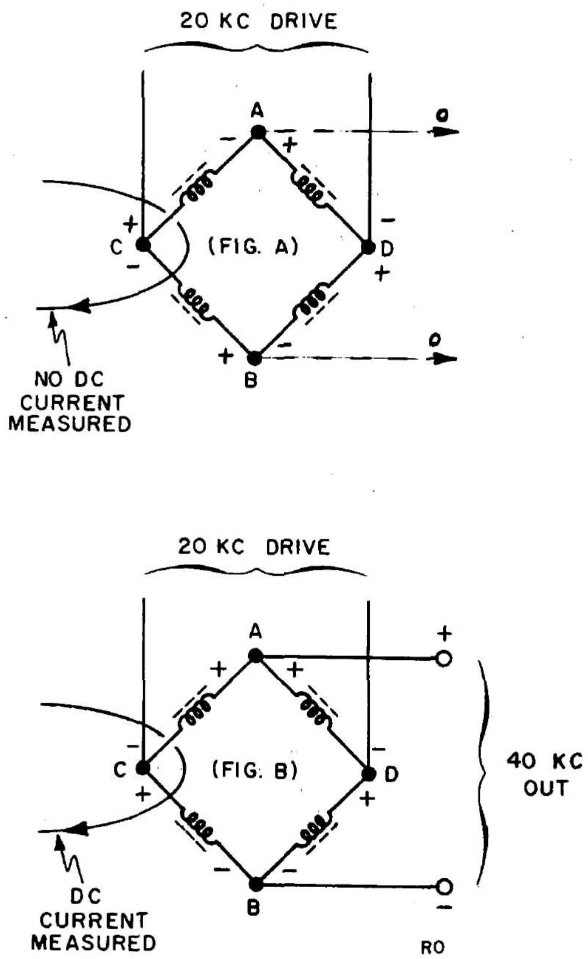


Figure 3-5. Current Probe Bridge Circuit

3-6 40 KC SYNCHRONOUS DETECTOR AMPLIFIER

The 40 kc resonant circuit C1, C2 and L5 increases the level of the gate signal and filters out all signals except 40 kc. It also allows phase adjustment of the signal to correspond to the phase of the Synchronous Detector.

The operation of the Synchronous Detector requires a high level 40 kc signal. The 40 kc output signal of the oscillator V7 passes through a tuned circuit and drives the gate amplifier V5. The output of V5 delivers about a 300-volt peak 40-kc gate to the Synchronous Detector. The function and the adjustment of the Synchronous Detector Gate Amplifier will be discussed in paragraph 3-8.

3-7 40 KC INPUT/AMPLIFIER CIRCUIT

The 40 kc output voltage of the probe head is resonated by a 40 kc series resonant circuit (L5 and C1/C2). Resistor R1 broadens the resonance response by lowering the Q to minimize drift problems. The 40 kc signal passes through a voltage divider S1C, which keeps the loop gain constant for all current ranges, by maintaining a constant input level range to stage V1. The output of the 40 kc amplifier V1 is bandpass coupled to the 40 kc detector driver stage V2. The output signal of V2 is isolated from ground by transformer T2, and fed to the 40 kc synchronous detector.

3-8 40 KC SYNCHRONOUS DETECTOR AND FILTER (C16)

The Synchronous Detector detects the amplitude and the phase of the 40 kc signal. Phase detection is necessary to preserve negative feedback at all times. Since the probe may be clipped over the wire in either of two ways the phase of the signal may vary by 180°. If phase detection were not present this 180° phase reversal would cause positive feedback and the instrument would oscillate. With phase detection the polarity of the feedback will change also, maintaining the feedback negative around the system at all times.

Operation of the Detector

The synchronous detector requires a large 40 kc gating signal, having the frequency of the desired signal. Figure 3-6 shows the synchronous detector drawn as a bridge circuit.

A large gating signal (300 volts peak) is fed to point 1 and 3 of the bridge. Each half cycle of the gating signal drives the diodes of branch (123) and branch (341) alternately into strong forward conduction (dotted line in figure 3-6b). The diodes function as switches operating at a rate of 40 kc (the gating frequency).

The 40 kc amplifier output transformer is returned to point 2 and 4 of the bridge, and its signal is

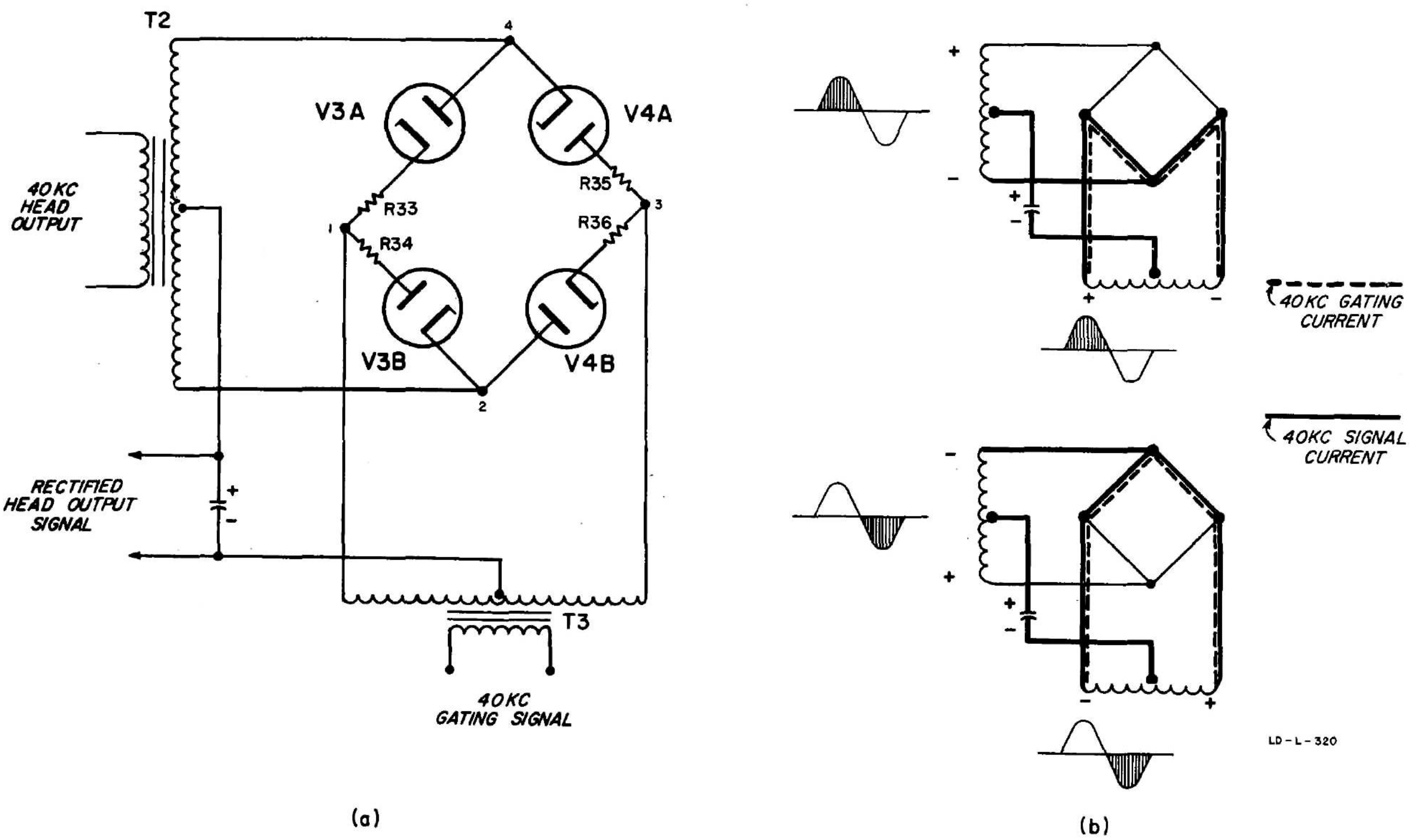


Figure 3-6. Synchronous Detector

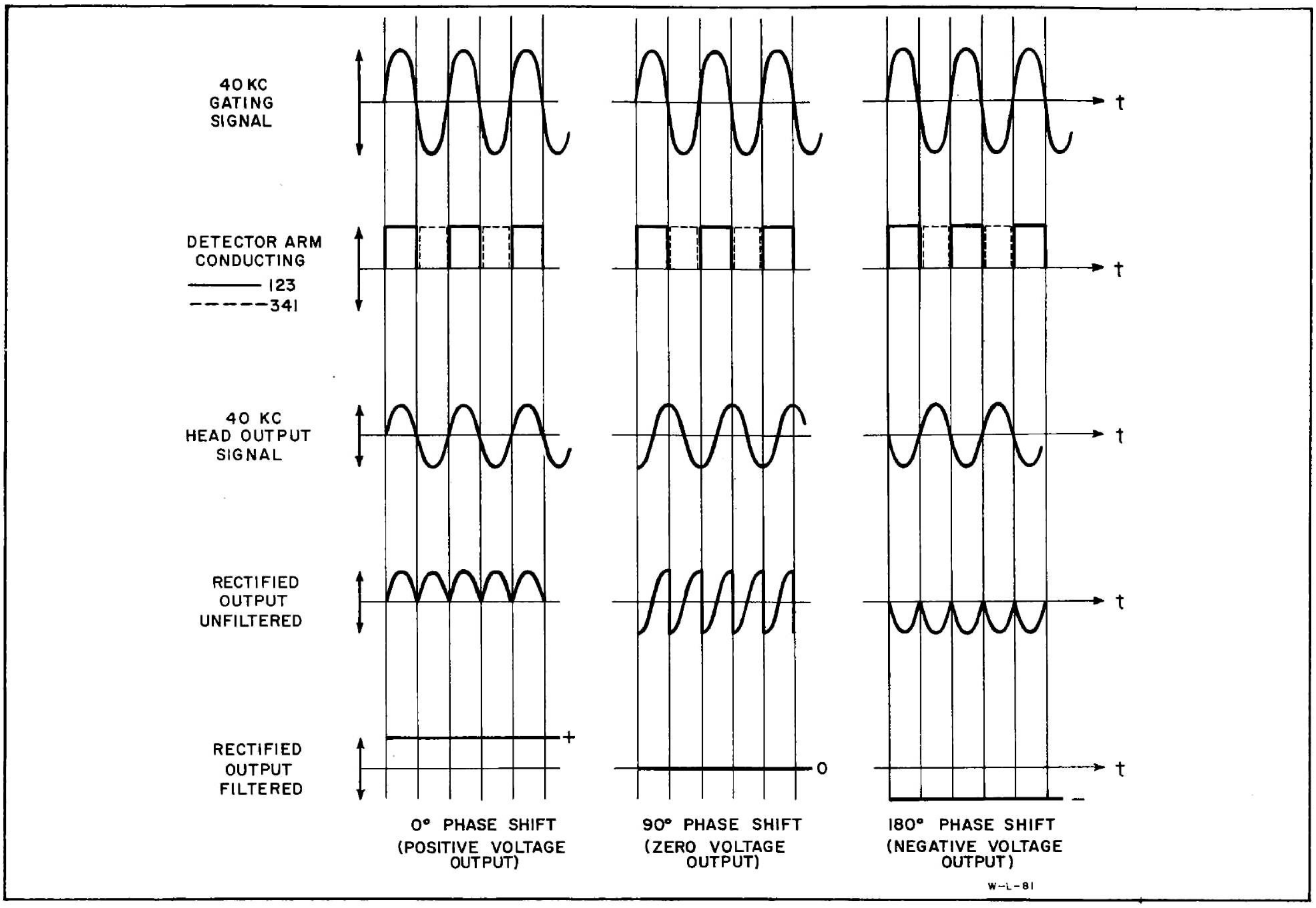


Figure 3-7. Change of Output of Synchronous Detector with Phase

superimposed on the gating signal (indicated by heavy line in figure 3-6b). Since the 40 kc output signal is considerably smaller than the 40 kc gating signal, the action of the gated diodes is to alternately return the top and bottom end of T_2 secondary to T_3 secondary center tap. The 40 kc output signal appears rectified across C16 (figure 3-7 shows the phase and amplitude relationship in the synchronous detector). Referring to figure 3-6, resistors R33 through R36 provide a bias voltage for the diodes in cutoff. In other words, when diodes V3A and V4A conduct, the voltage drop across R33 supplies a negative bias for V3B and the voltage drop across R35 supplies the back-bias voltage for diode V4B.

The input of the gate amplifier V5 contains a tunable 40 kc resonant circuit, also used as a phase shifter for the 40 kc gating signal. The phase of the 40 kc gating signal is adjusted to synchronize exactly with the probe output signal as it appears at V2.

3-9 DC AMPLIFIER

The dc amplifier supplies a negative dc feedback current to the probe which is proportional to the output of the synchronous detector. The polarity of the negative feedback current changes if the polarity of the dc current (measured in the probe) changes. In this way the feedback of the system remains negative at all times thus maintaining the stability of the instrument.

Triode section V6A is a cathode follower, used to lower the source impedance of the synchronous detector output, and provide the dc feedback current. Cathode follower V6B provides a low impedance return path for the feedback current. The cathode of V6B also serves as the ac ground of the 40 kc head-output signal.

With no dc input at the probe, the dc output of the detector bridge is zero, the two cathodes of V6 have equal voltages, and there is no feedback current flowing through the meter to the probe head. DC amplifier balance is accomplished by varying the bias of V6A by means of R53.

When full-scale dc is being measured (e.g. 3 ma on the 3 ma range) the control grid of V6A raises by approximately 1.3 volts. The increased cathode potential of V6A causes feedback current to flow, which is returned through the feedback current divider and the probe head, to cathode of V6B. The negative feedback reduces the original flux of the dc input current (of clamped wire) to approximately 1%, corresponding to 40 db of negative feedback.

3-10 NEGATIVE FEEDBACK CURRENT CIRCUIT

The negative feedback current path is shown in figure 3-8. Current divider S1B divides the feedback current in proportion to the dc current being measured*. For a dc input of 1 ampere, approximately 5 ma feedback current is fed to the probe head. Since an equal number of ampere-turns is necessary for canceling the main dc flux, the feedback coil inside the head requires approximately 200 turns.

3-11 40 KC PHASE SHIFTER

The output of the 40 kc phase shifter is fed to the head of the probe to cancel any residual 40 kc output signal which exists when zero dc is being measured. The canceling signal is obtained by adding two voltages which are 90° out of phase and variable in amplitude. Figure 3-9 shows the circuit and the idealized phase relationship of the two output voltages with respect to the 40 kc signal from the oscillator.

By adding the two output voltages (point A and B) a 40 kc signal is obtained, having a phase angle within 0-360° and a given maximum amplitude (point C). Once the residual 40 kc signal of the probe has been canceled, the ZERO control compensates for any normal variations of zero shift. This control is necessary only on the lower ranges.

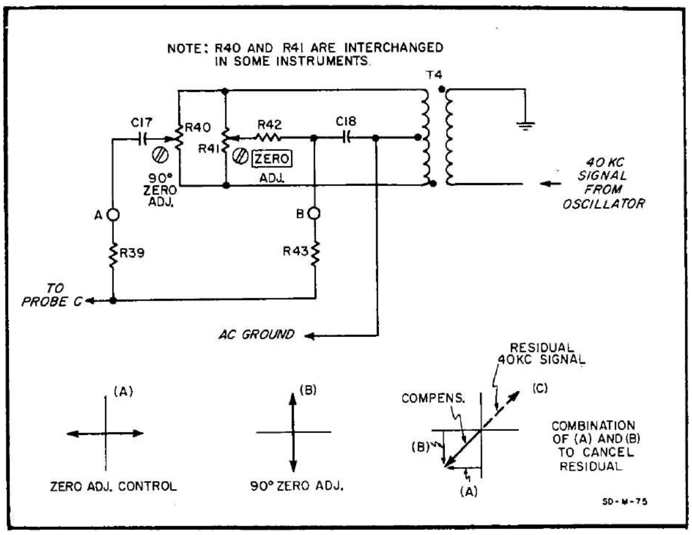


Figure 3-9. 40 KC Phase Shifter

3-12 POWER SUPPLY

A single series-regulated power supply of the conventional type provides 280 volts regulated for the circuits of the instrument. Voltage reference tube V11 provides a constant cathode potential at control tube V10 and this is the reference potential for the control grid of V10.

* Maintaining the current through meter M1 constant (5 ma maximum) for all current ranges. Inductance L6 isolates the 40 kc signal from the dc current circuit.

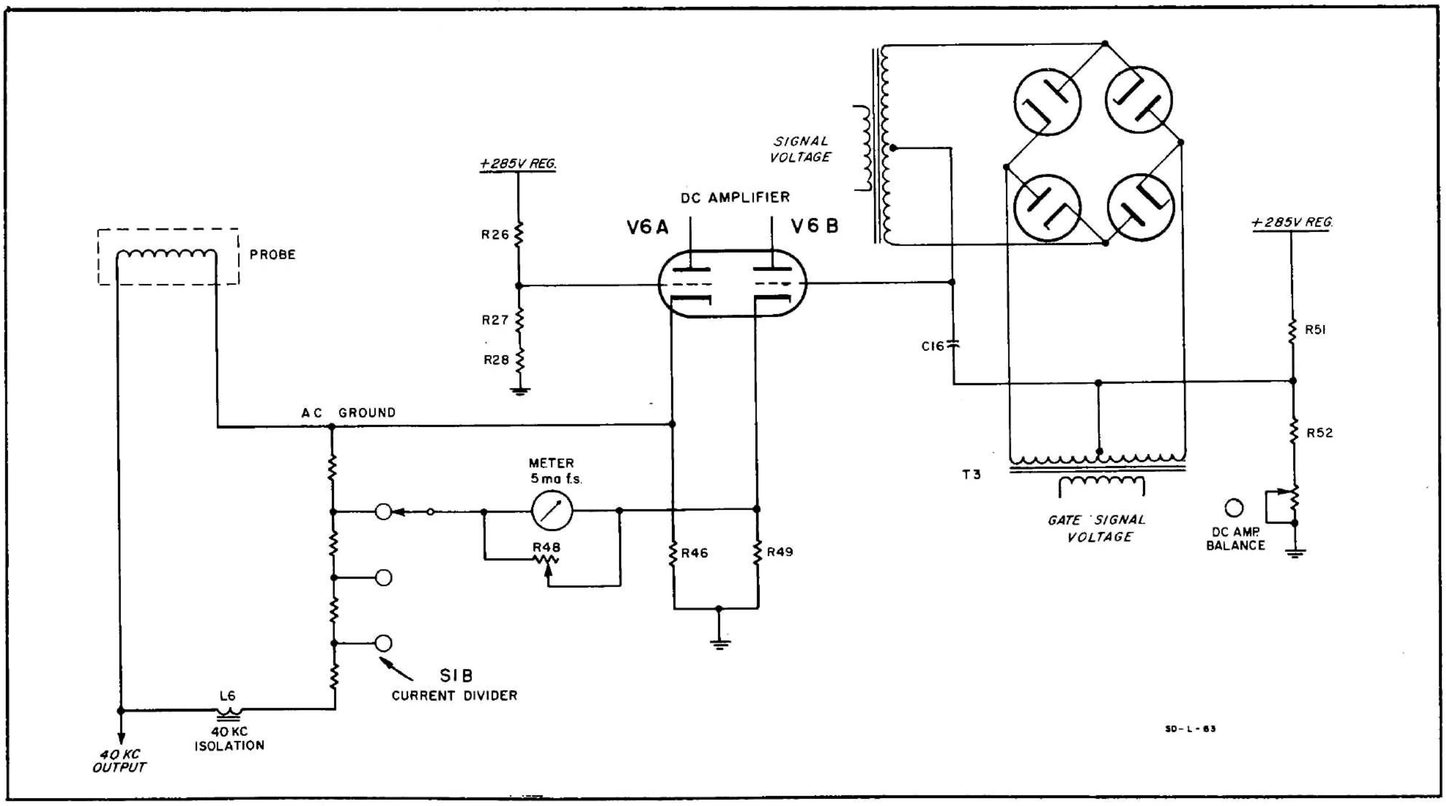


Figure 3-8. Feedback Current Circuit

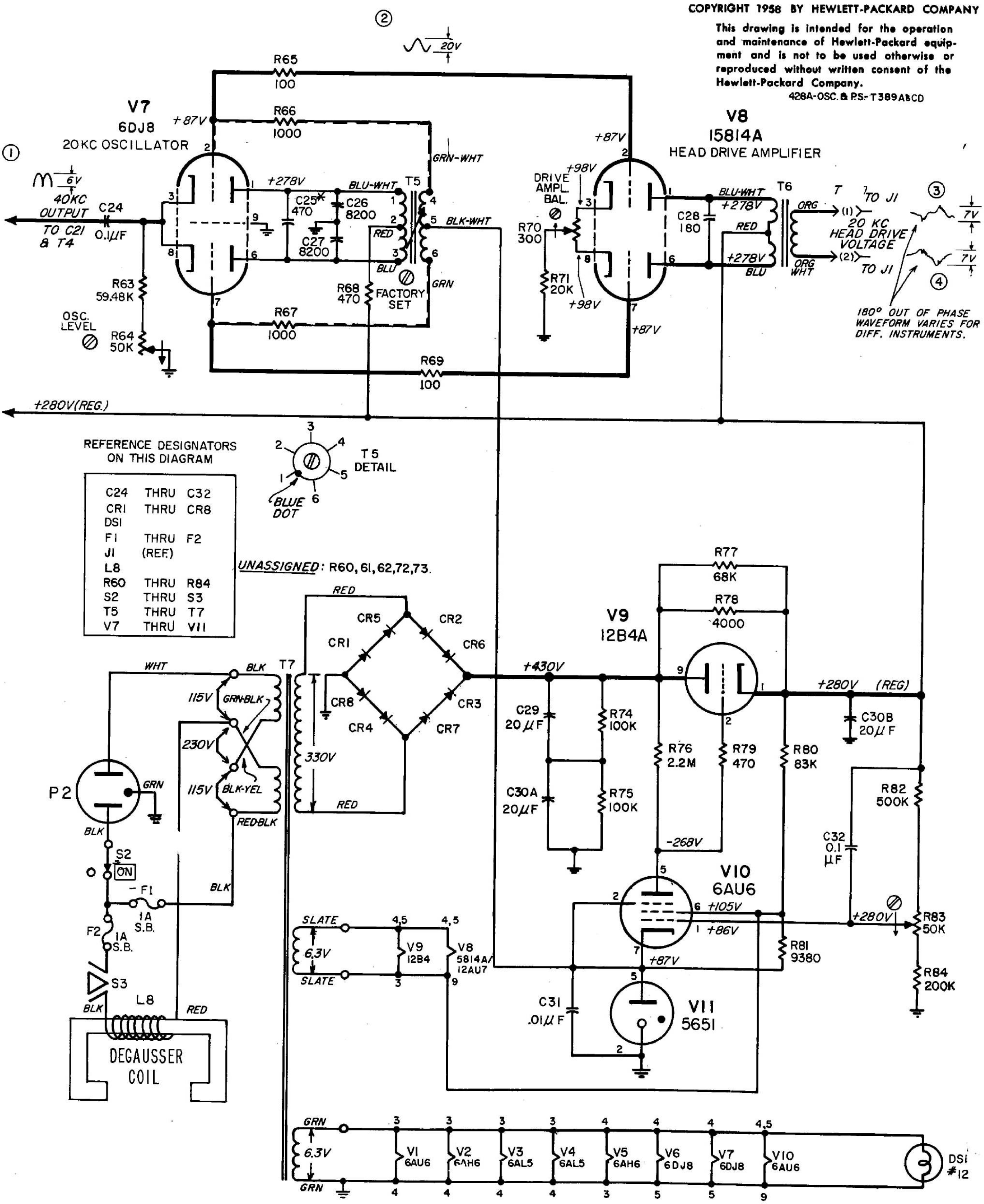


Figure 4-15. Oscillator and Power Supply

REFERENCE DESIGNATORS ON THIS DIAGRAM

C1 THRU C23
J1 — P1
L1 THRU L7
M1
R1 THRU R59
S1A, B, C
T1 THRU T4
V1 THRU V6

UNASSIGNED: C3, C4
R37, R38, R44

NOTES:

1. RANGE SWITCH SHOWN AS VIEWED FROM FRONT PANEL.
2. *MEASUREMENT CONDITIONS:* LINE VOLTAGE SET AT 115V, 60∿. RANGE SWITCH SET ON 100 MA POSITION, 100 MA DC INPUT. VALUES SHOWN WERE MEASURED ON A TYPICAL INSTRUMENT WITH *FEEDBACK DISCONNECT* IN CLOSED (NORMAL) CONDITION.
3. DC VOLTAGES MEASURED WITH VTVM OF 122 MEGOHM INPUT IMPEDANCE.
4. WAVEFORMS MEASURED WITH *-hp-* MODEL 150A CATHODE-RAY OSCILLOSCOPE; *-hp-* MODEL 152B DUAL-TRACE PRE-AMPLIFIER; AND AC-21A, 10 TO 1 DIVIDER PROBES TO OBTAIN 10 MEGOHMS INPUT IMPEDANCE. TYPICAL WAVEFORM SHOWN.
5. USE EXTERNAL SYNC OBTAINED FROM PIN 2 OF V7 THROUGH A 47 μμF CAPACITOR TO AVOID DISTURBING CIRCUIT
6. ALL WAVEFORMS ARE SHOWN IN PHASE WITH EACH OTHER AND ARE SYNCHRONIZED WITH THE SIGNAL ON TESTPOINT ②

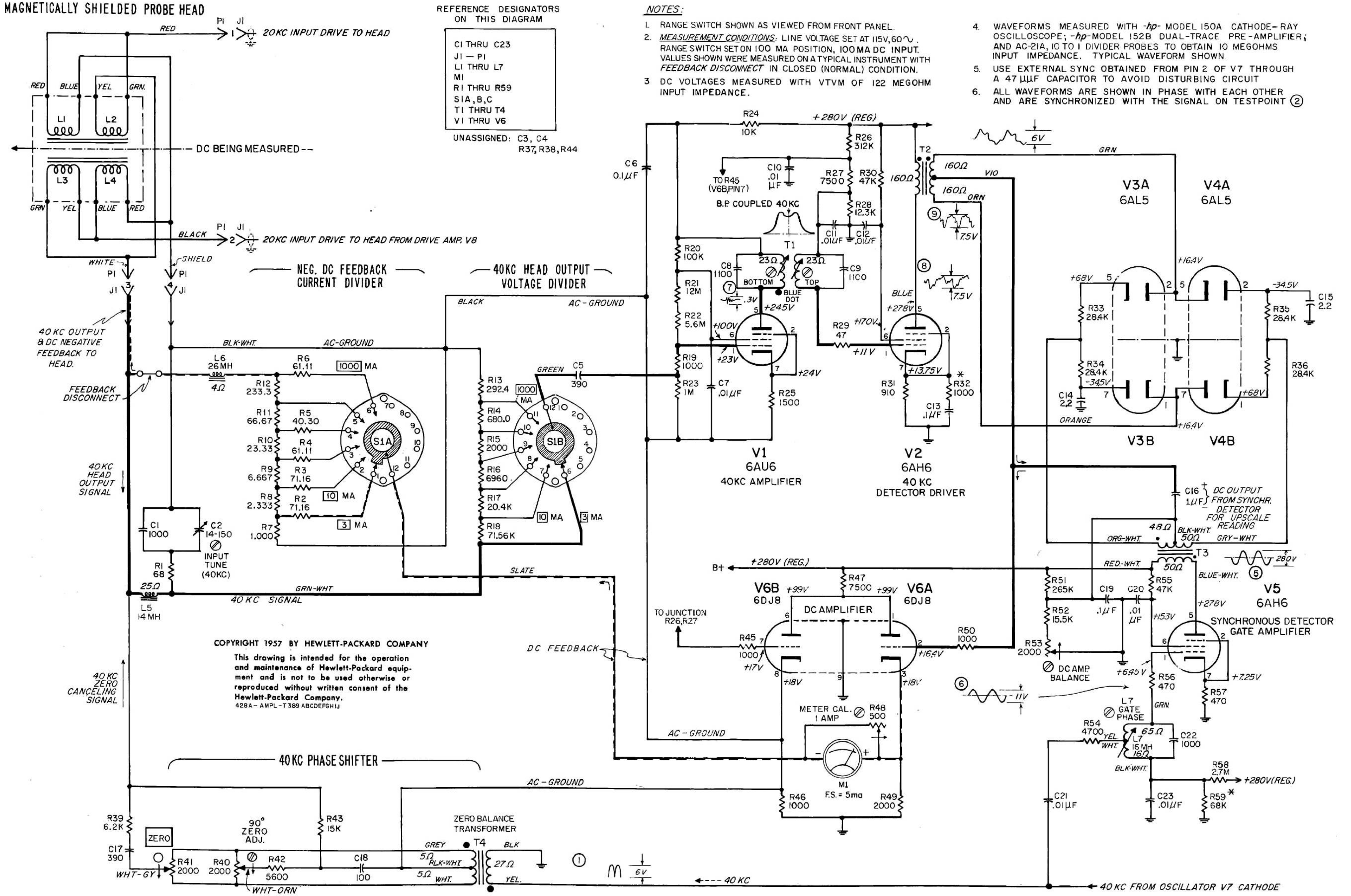


FIGURE 4-16

AMPLIFIER

7) To check the waveform developed by the input signal, without the interacting effect of the Synchronous Detector as described in step 2, remove V3 and V4. Tube V6 should also be removed if it was not already removed. Check the waveforms on the terminals of T2. With the probe clipped around a wire carrying 100 ma and the RANGE switch set to 1000 ma (1 ampere) these waveforms should be fairly close to sine waves (see figure 4-9). Check these waveforms at the points indicated in figure 4-9. If these waveforms are correct, replace V3, V4, V6, the wire to R78 removed in the previous step, and the feedback jumper removed in step 4. Recheck the instrument under normal operation as instructed in step 2. If the waveforms still do not agree with the waveforms on the schematic, check V3, V4 and Synchronous Detector circuitry.

4-9 ADJUSTMENT AFTER CURRENT PROBE REPLACEMENT

If the current probe has to be replaced, it is not necessary to perform the complete adjustment procedure. In table 4-2 perform only step 16 through 23.

4-10 COMPLETE ADJUSTMENT PROCEDURE

BEFORE CHANGING ANY ADJUSTMENT IN THE 428A, BE SURE THAT AN ADJUSTMENT IS NECESSARY AS INDICATED BY THE TROUBLE LOCALIZATION PROCEDURE (paragraph 4-8). ALWAYS CONSULT THE TROUBLE LOCALIZATION PROCEDURE FIRST TO DETERMINE THE SECTIONS OF THE ADJUSTMENT PROCEDURE TO PERFORM. DO NOT PERFORM THE COMPLETE ADJUSTMENT PROCEDURE EITHER AS A TROUBLE LOCALIZATION OR PREVENTIVE MAINTENANCE PROCEDURE.

The procedure given in table 4-2 is complete and enables you to do a systematic alignment of all circuits. Refer to paragraph 4-4, Test Equipment, listing auxiliary equipment needed for adjustment.

TABLE 4-2. ADJUSTMENT PROCEDURE

Step 1
PRELIMINARY ADJUSTMENT

The feedback loop must be disconnected for all tests up to step 18. Disconnect bare wire jumper on terminal board 428A-75A (board nearest front panel). Zero-set the mechanical zero on the meter (see paragraph 4-2). Clean probe jaws (see paragraph 4-3).

Note: In the following instructions directions are given for connecting only single leads of the voltmeters, etc. In each case it is understood that the ground lead will be connected to the 428A chassis, unless otherwise specified.

Step 2
POWER SUPPLY CHECK

Plug Model 428A into 115-volt line. Turn on and allow to warm up 15 minutes.

a. Connect a vtvm, such as the ⓗⓟ Model 410B Vacuum Tube Voltmeter, to any red lead on 428A-75C (rearmost) terminal board. This voltage should be 274.4 to 285.6 volts. If not, adjust R83 (Adj. +280V) for 280 volts.

b. Connect ac voltmeter, such as ⓗⓟ Model 400D/H/L Vacuum Tube Voltmeter to same red lead as in step a. Ripple should be less than 50 mv. Vary input voltage from 103 to 127 volts. Voltage measured should stay within ±2 volts of +280 volts and ripple should remain less than 50 mv. If not, try replacing V9, 10, 11. Remove both voltmeters.

Step 3
OSCILLATOR BALANCE

Refer to paragraph 4-4B, Test Equipment (Auxiliary), for the construction of the Oscillator Balance Probe necessary for this test. Connect oscillator balance test assembly to transformer T5 side of R66 and R67 (usually green and green-white wires). Connect an ac voltmeter, such as the ⓗⓟ Model 400D/H/L, to the center point of the test assembly. With 400D/H/L set to 0.1 volt range, adjust oscillator balance slug T5 for minimum reading (should be less than 50 millivolts). Lock slug and remove meter and probe.

Step 4
CHECK OSCILLATOR FREQUENCY

Connect electronic counter, such as ⓗⓟ Models 522/523/524 Electronic Counters to one side of T3 secondary--usually orange-white or green-white wires at top of 428A-75B (center) terminal board. Frequency should be 40 kc ±200 cycles. If not, pad C25 to set the frequency. Remove counter.

Step 5
CHECK OSCILLATOR LEVEL

Connect ac voltmeter, such as ⓗⓟ Model 400D/H/L, to transformer T5 side of either R66 or R67 (usually green and green-white wire) on terminal board 428A-75C (board furthest from front panel). Level should be 7.1 to 7.9 volts rms. If not, adjust Oscillator Level control R64 to adjust level to 7.5 volts rms. Remove meter.

TABLE 4-2. ADJUSTMENT PROCEDURE (Cont'd)

Step 6
CHECK DETECTOR GATE

Connect ac voltmeter, such as ℗ Model 400D/H/L, to pin 2 or 7 of V5. Adjust L7 for peak. Voltage should be 3.5 to 4.7 volts rms. If not, replace V5. Remove voltmeter.

Step 7
RECHECK OSCILLATOR LEVEL

If L7 was adjusted in step 6, repeat step 5.

Step 8
CHECK DC AMPLIFIER ZERO SET

Zero-set mechanical zero (see paragraph 4-2). Set 428A RANGE switch to 100 ma. Connect a 1μfd low leakage capacitor, such as mylar, between pin 1 of V2 and ground. Zero-set panel meter by turning R53 (DC Amp. Bal). Remove the capacitor.

Step 9
SET-UP FOR ALIGNMENT OF TUNED AMPLIFIER

Connect an ac voltmeter, such as the ℗ Model 400D/H/L, to pin 2 or 7 of V2. Set 400D/H/L to 1 volt range. Clip 428A probe around wire carrying 35 ma rms ac monitored by an external meter as shown in the ac generator portion of figure 4-5. Adjust R3 until 3.5 volts appears across the 100 ohm resistor. Set 428A RANGE switch to 100 ma. Keep this setup for the next three steps.

Step 10
INPUT ALIGNMENT

Adjust Input Tune C2 on 425A-75A (smallest) terminal board for a maximum reading on 400D (approximately 0.5 volt). Leave setup connected.

Step 11
INTERSTAGE PRIMARY ALIGNMENT

Connect a 0.0082 μfd capacitor from chassis ground to terminal on T1 which has 47 ohm resistor attached. Adjust bottom (primary) slug of T1 for maximum 400D/H/L reading (0.01 volt range) and lock slug. Remove capacitor but leave rest of setup.

Step 12
INTERSTAGE SECONDARY ALIGNMENT

Connect a 0.0082 μfd capacitor from pin 5 of V1 to ground. Adjust top (secondary) slug of T1 for maximum reading of 400D/H/L (.01 volt range) and lock slug. Remove capacitor and setup.

Step 13
DETECTOR PHASE ADJUSTMENT

Connect the horizontal input of an oscilloscope, such as the ℗ Model 120A/130B/150A/160B, to pin 2 or 7 of V5. Connect the vertical input to pin 2 or 7 of V2. Leave 428A probe around wire carrying 35 ma ac (3.5 vac) across 100 ohm monitored by an external meter (see figure 4-10). Turn 428A to 100 ma range. Turn slug L7 so pattern on oscilloscope looks like a "bow tie" with its knot symmetrical (see figure 4-11A or B). Note that in addition to the top and bottom intersections being in a vertical line, the center section must be free of traces. It is possible to get the top and bottom intersections in a vertical line with traces in the center section but this is not a correct adjustment. Lock L7. Figure 4-11C illustrates an incorrect adjustment with the top intersection not over the bottom intersection.

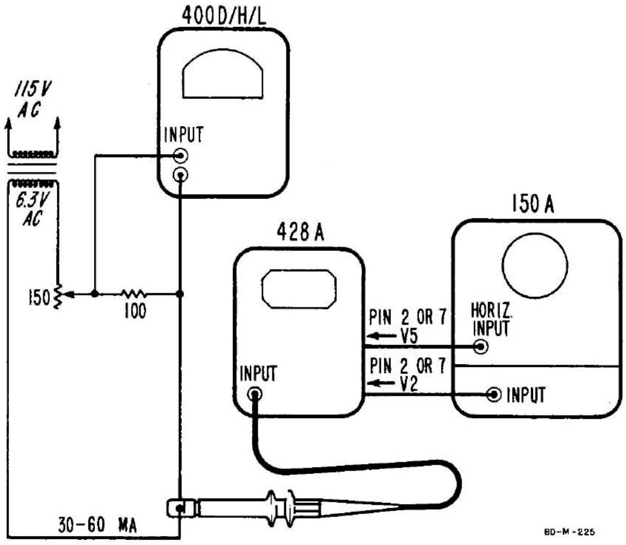


Figure 4-10. Detector Phase Adjustment Setup

Step 14
CHECK TUNED AMPLIFIER GAIN SETTING

Turn Calib. Adj. R48 fully clockwise for maximum resistance (this control is next to the meter and V3). Set RANGE switch to 100 ma. Zero-set 428A meter mechanically (see paragraph 4-2). Clip 428A probe around wire carrying 1 ma dc monitored by an external meter (similar to figure 4-4). The 428A meter should read from 90 to 110. If not, replace V1, 2 or 6. If replacing tubes will not obtain the correct reading pad R32 on resistor board 428A-75B. Remove setup.

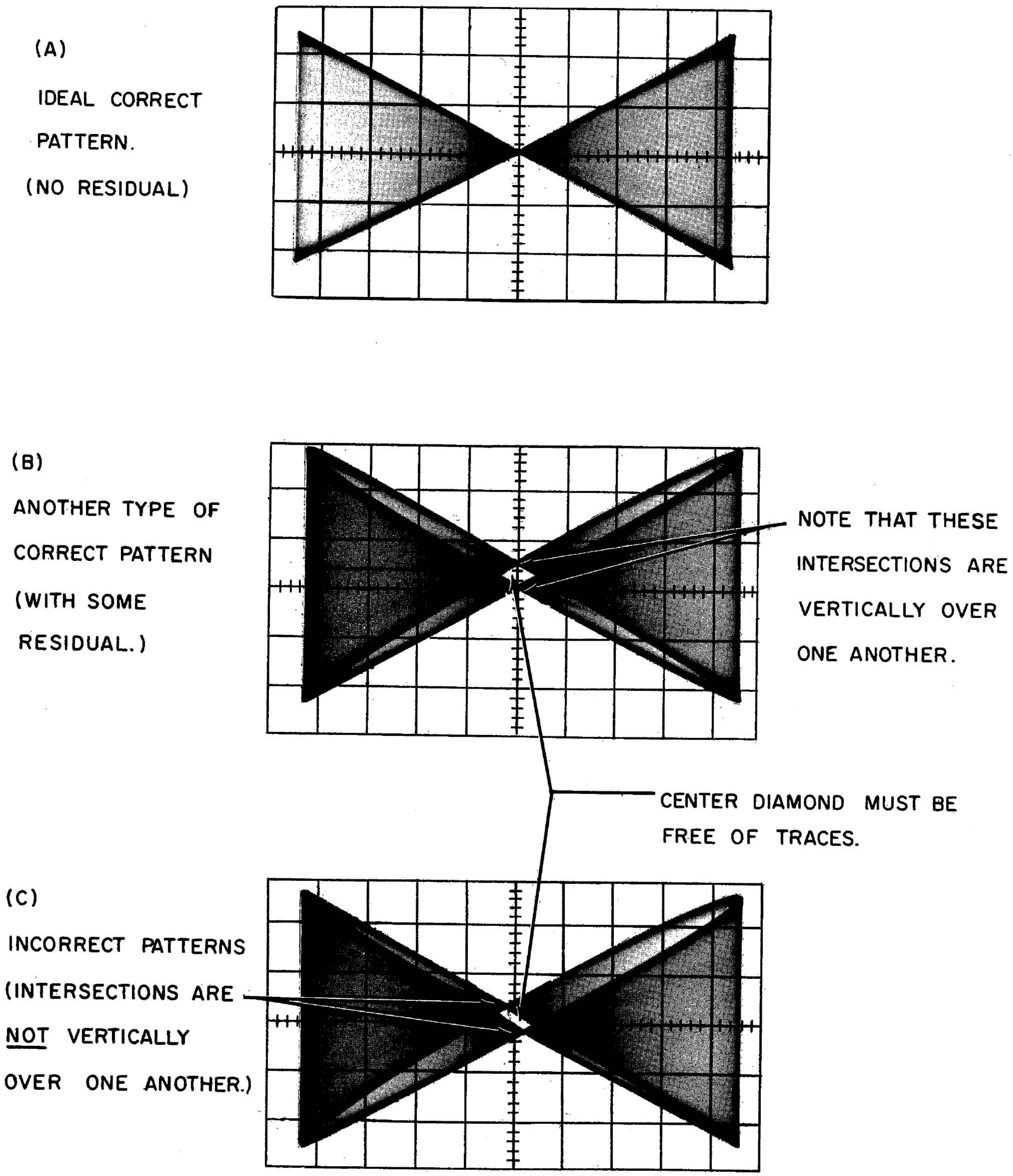


Figure 4-11. Detector Phase Adjustment Waveforms

TABLE 4-2. ADJUSTMENT PROCEDURE (Cont'd)

Step 15

CHECK NOISE

Turn 428A on with no input to probe, feedback still disconnected. Set RANGE switch to 10 ma. In any 5 sec period to peak-to-peak swing of the needle should be less than 5 ma. If noise is excessive, one of the coils in the head may be open. Remove probe connector from instrument and measure resistance between connector pins. The coils in the probe head are connected in the form of a bridge with each pin connected to a corner. The resistance between any adjacent pair of pins should be about 5 ohms. If not, one of the coils in the probe is probably open. If the reading is ∞ the cable is probably open.

Step 16

PRELIMINARY ADJUSTMENT OF ZERO POTS

Always perform this step before steps 17 and 18. Do NOT alter the position of these potentiometers until step 18. Turn the 90° Zero Adj. R40 and front panel ZERO potentiometer R41 to center position as follows:

Turn 428A RANGE switch to 300 ma. Connect an ac voltmeter, such as the ⓗ Model 400D/H/L Vacuum Tube Voltmeter, to the center arm of the 90° Zero Adj. potentiometer R40. Adjust R40 for minimum reading on the 400D/H/L (0.1 volt range). Connect 400D/H/L to center arm of ZERO adjust potentiometer R41. Adjust R41 for minimum reading on the 400D/H/L. Minimum is approximately 0.02 volt.

Note: Do NOT alter this position of the potentiometers until step 18.

Step 17

CHECK DRIVE BALANCE ADJUSTMENT

Thoroughly clean probe head jaws (see paragraph 4-3). Degauss probe head completely (see paragraph 2-4). Set 428A RANGE switch to 3 ma. Connect an ac voltmeter, such as the ⓗ Model 400D/H/L, to pins 2 or 7 of V2. With no input to 428A probe set Dr. Amp. Bal. potentiometer R70 for a minimum reading on the 400D/H/L. On the .1 volt range of the 400D/H/L the minimum should be less than .05 volt. If no minimum can be reached, replace V8. Leave 400D/H/L connected.

Step 18

RECONNECT FEEDBACK AND CHECK CANCELLATION OF HEAD RESIDUAL OUTPUT

Replace the lead removed in step 1. Leave 400 D/H/L connected to pins 2 or 7 of V2. Leave 428A on 3 ma range. Zero 428A meter with front panel ZERO adjustment knob (see figure 2-1 step 3). With 400D/H/L set to 0.3 volt range, adjust 90° Zero Adj. potentiometer R40 for a minimum 400D reading (approximately .02 volt). Adjusting R40 will throw off the setting of the ZERO adjust knob, so repeat this procedure until both controls are set properly. Remove the 400D/H/L.

Step 19

CHECK EARTH'S FIELD EFFECT

Point probe east and west, and rotate about its axis. Note peak-to-peak change in meter reading on the 3 ma range. This swing should not exceed about 0.15 ma. If it does, the probe head is not sufficiently shielded, probably because the jaws are not completely closed. Check jaws for alignment and for foreign material. If an open lead in the head is suspected check as in step 15.

Step 20

RANGE TO RANGE ZERO CHECK

Turn 428A RANGE switch to 3 ma. Zero-set meter with ZERO panel knob R41. Turn RANGE switch slowly through all ranges and check if zero falls right on for all ranges. If the needle doesn't fall on zero (±1/2%) for all ranges, recheck steps 16, 17 and 18. Recheck the mechanical zero setting.

Step 21

CHECK ZERO CONTROL RANGE

Switch 428A RANGE switch to 10 ma. Zero meter with ZERO control knob R41. Clip 428A probe around wire carrying 5 ma dc monitored by an external meter (see figure 4-4). Note reading on 428A. Turn ZERO control in both directions: 428A should have at least 2 ma zero adjustment range in each direction.

Step 22

CHECK CHANGE OF ZERO SETTING WITH LINE VOLTAGE

Connect the 428A to a variable source of line voltage, such as a variable autotransformer. Set the needle on a scale division with the ZERO adjust knob R41. Change the line voltage from 103 to 127 volts. The needle should change less than 0.5 ma. If not, try several V8's and repeat steps 16, 17, 18, 20, and 21.

TABLE 4-2. ADJUSTMENT PROCEDURE (Cont'd)

Step 23
RANGE CALIBRATION

Set 428A RANGE switch to 3 ma. Zero-set needle with ZERO panel knob R41. Set RANGE switch to the 100 ma range.

a. Feed 100 ma dc through probe (monitored with external dc ammeter, accurate to 1/4%). Adjust Meter Cal. R48 so meter reads 100 ma exactly.

b. Change line voltage from 103 to 127 volts. Calibration should stay within 0.2%.

c. Check calibration on all other current ranges, i.e. 300 ma, 100 ma, etc. Full scale reading should remain within 2% on all ranges.

Caution: Check zero-set on 3 ma range between each current range check.

Step 24
AC OVERLOAD

Zero-set 428A on 3 ma range. Set RANGE switch to 10 ma range. Feed 10 ma dc through probe. In addition supply ac through probe (see figure 4-5). Increase ac until dc indication on 428A drops 2%. This ac voltage should be at least 1 volt rms (14 ma peak, 10 ma rms). If not, replace V5.

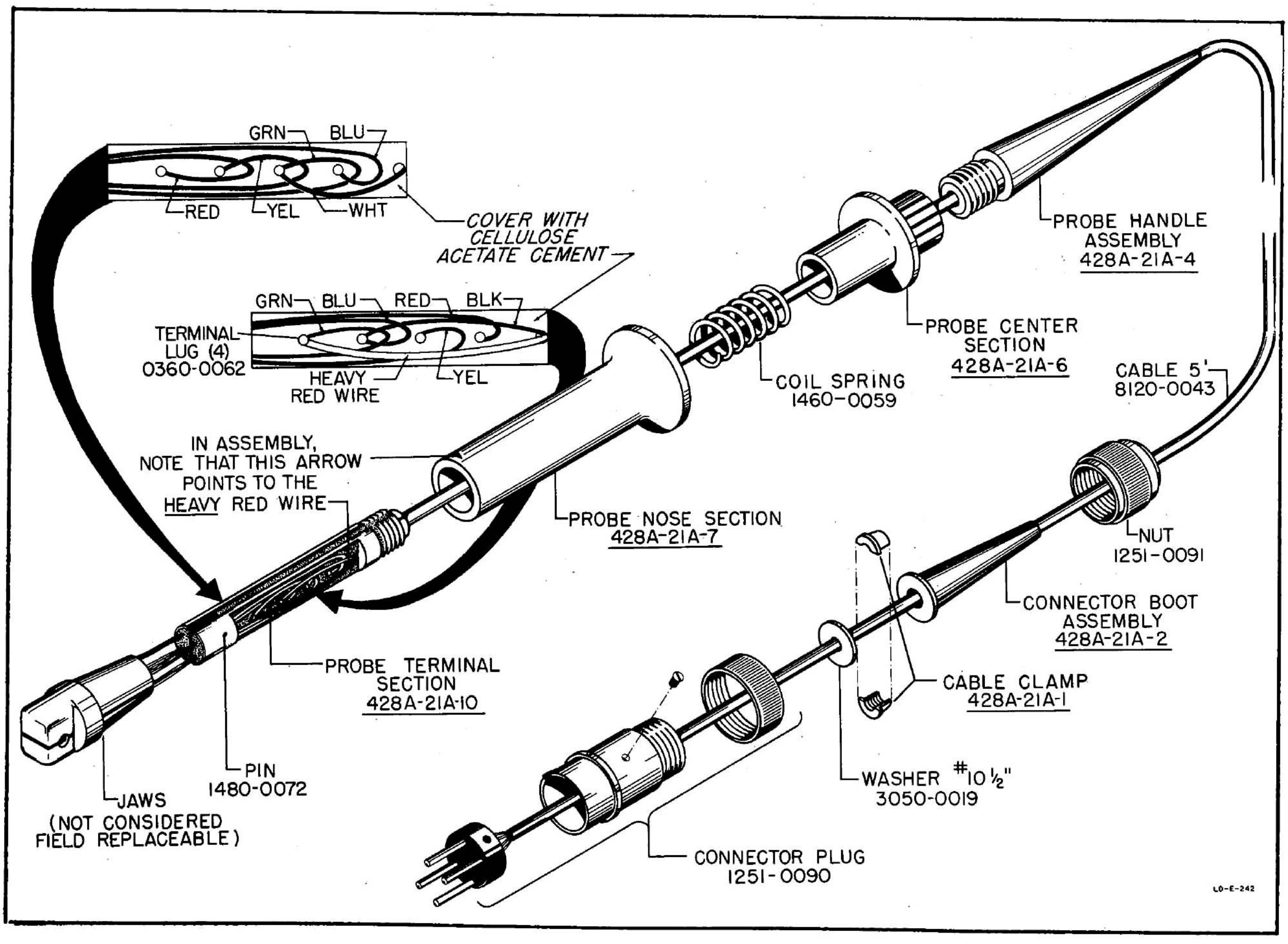


Figure 4-12. Exploded View of Probe

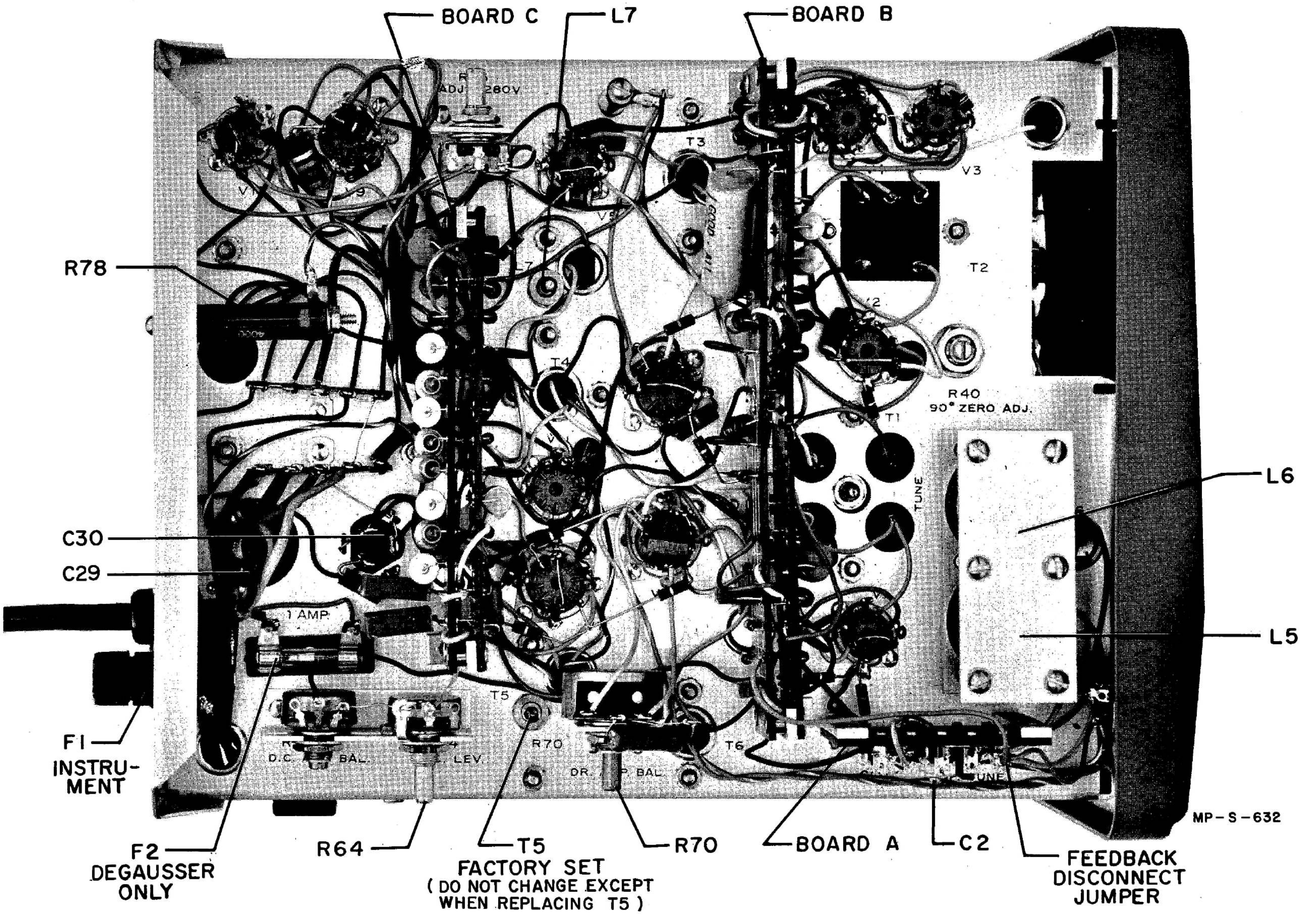


Figure 4-13. Left Side Internal View Model 428A

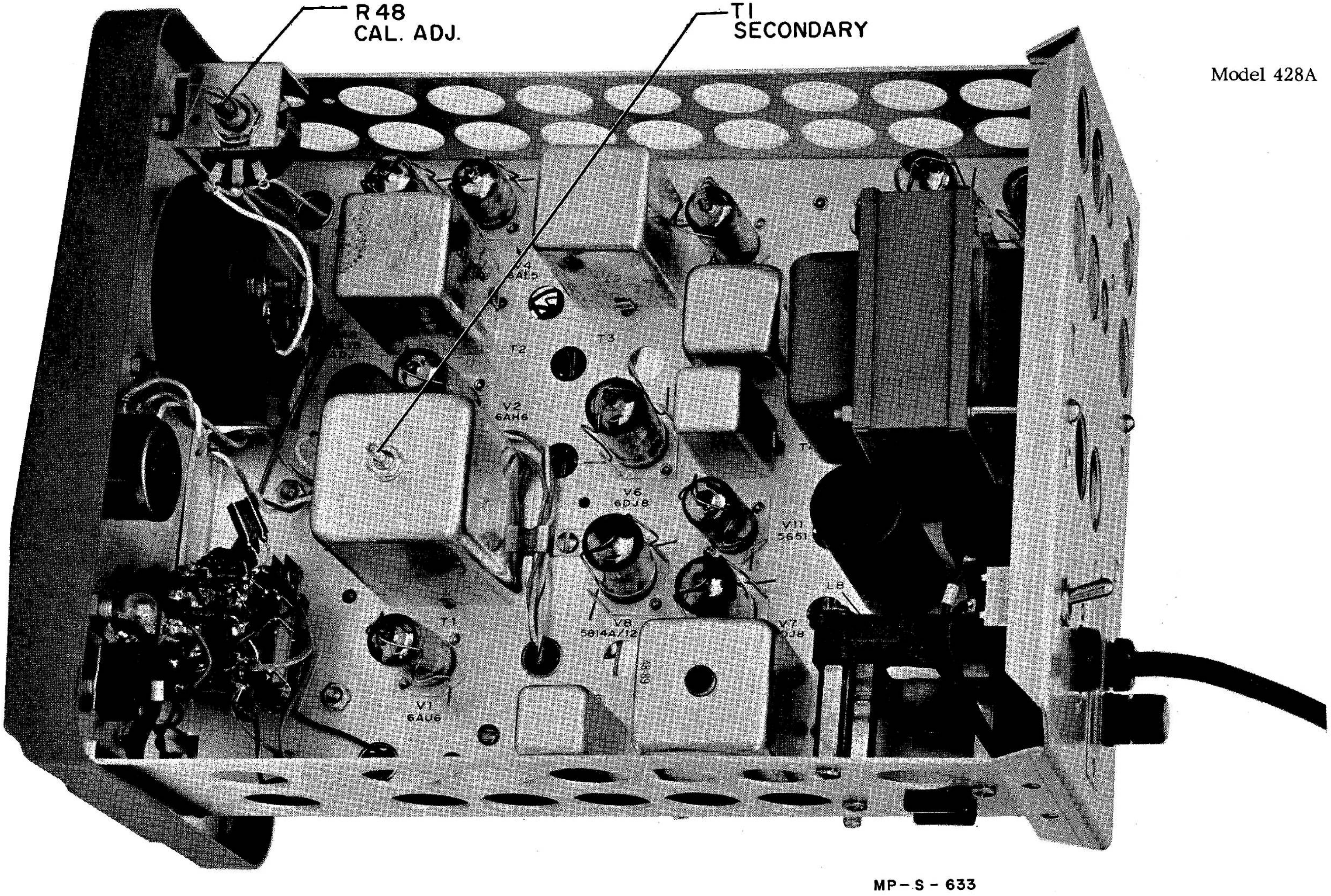


Figure 4-14. Right Side Internal View Model 428A