HP 428B

428B
CLIP-ON DC
MILLIAMMETER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

HP 428B

OPERATING AND SERVICE MANUAL

(HP PART NO. 00428-90002)

MODEL 428B
CLIP-ON DC MILLIAMMETER

SERIALS PREFIXED: 131-, 601-

P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

Table 1-1. Specifications

CURRENT RANGE:
.1 ma to 10 amperes. Nine full scale ranges from 1 ma to 10 amperes in a 1, 3, 10, 30 .... sequence.

ACCURACY:
±3% of full scale from $0^{o}C$ to $+55^{o}C$ ± 0.1 ma

PROBE INDUCTANCE:
Less than 0.5 μh. No noticeable loading, even up to 1 mc.

PROBE INDUCED VOLTAGE:
Less than 15 mv peak (at 20 kc and harmonics)

OUTPUT:
Approximately 1.5 volts and 1 ma max for full scale; 100-ohm source. Variable linear output level with switch provision for calibrated 1 volt (corresponds to full scale deflection). Bandwidth dc to 400 cps.

NOISE LEVEL:
Less than ±0.015 ma

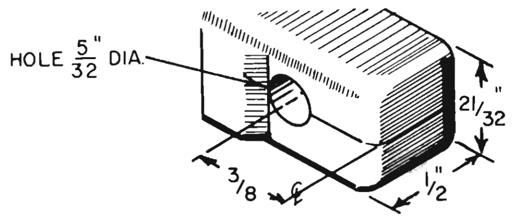
AC REJECTION:
AC with peak value less than full scale affects meter accuracy less than 2% at frequencies above 5 cps and different from the carrier (40 kc) and its harmonics, (on 10 ampere range ac is limited to 4 amperes peak).

Below 5 cps total instantaneous current must not exceed full scale.

PROBE INSULATION:
300 volts maximum, dc or peak

POWER:
115 or 230 volts ±10%, 50 to 60 cps, approximately 70 watts

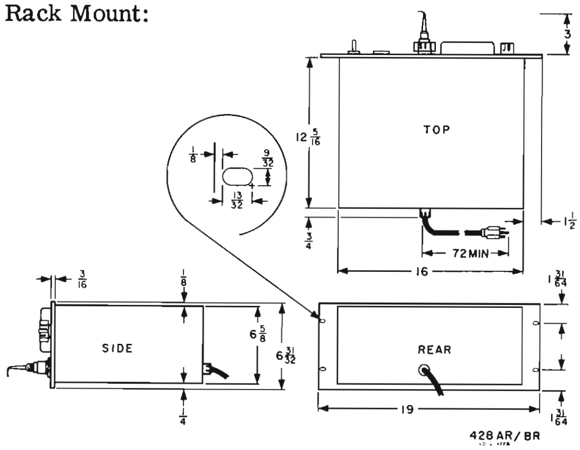
PROBE TIP SIZE:
Approximately 1/2 in. by 21/32 in. Aperture diameter 5/32 in.



LD-S-507

DIMENSIONS:
Cabinet Mount: 7-1/2 in. wide, 11-1/2 in. high, 14-1/4 in. deep.

Rack Mount:



428AR/BR

WEIGHT: Cabinet Mount: Net 19 lbs
Rack Mount: Net 24 lbs

ACCESSORIES AVAILABLE:
hp Model 3528A Large Aperture Probe
hp Model 3529A Magnetometer Probe

OPTIONS:
01. hp Model 3528A Current Probe (Aperture, 2-9/16 in.) in lieu of Model 428A-21A Probe normally supplied
02. hp Model 3529A Magnetometer Probe in lieu of Model 428A-21A Probe

SECTION I
GENERAL

1-1. INTRODUCTION.

1-2. The ⓗⓟ Model 428B Clip-On Milliammeter measures the magnetic field, which exists around the wire carrying dc current. Operating the instrument is simple. After zero setting, the two jaws of the probe are clamped around wire (arrow on probe head indicates direction of conventional current flow) and the meter will indicate the current.

1-3. There are nine current ranges starting from 1 ma to 10 amp full scale deflection. The sensitivity can be increased even further by looping the wire several times through the opening in the probe. The current indication is virtually insensitive to superimposed ac signals and the series loading of the circuit is less than 0.5 μh. A large amount of feedback provides great stability. With the Model 428B currents can be measured as easily as measuring voltages with a voltmeter.

1-4. OTHER PROBE HEADS.

1-5. Other probe heads are available to extend the usefulness of your Clip-On DC Milliammeter. Write to the factory for further information. At the time of publication of this manual the following accessory probe heads were available:

a. ⓗⓟ Model 3528A Large Aperture (2-1/2 inch probe head).

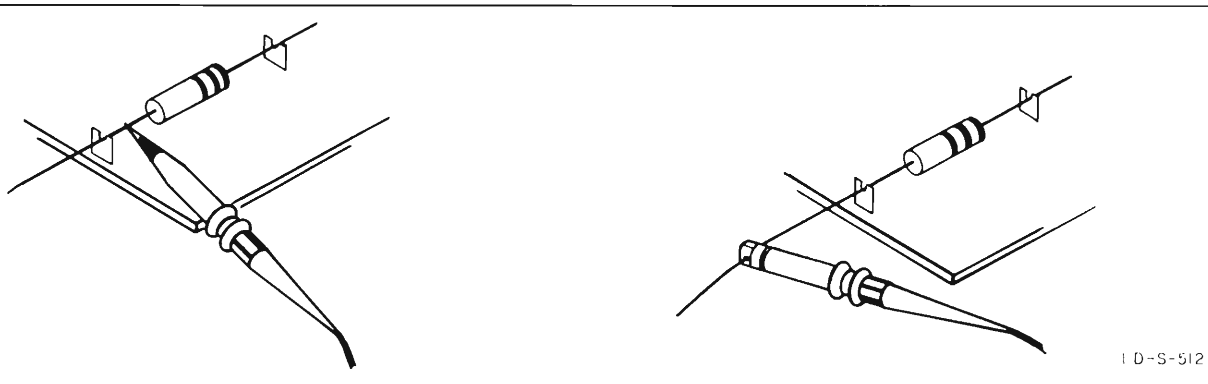
b. ⓗⓟ Model 3529A Magnetometer (1 gauss = 1 amp).

1-6. Write the factory stating your complete requirements for information concerning special applications.

1-7. INSTRUMENT IDENTIFICATION.

1-8. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 428B described in this manual.

Figure 1-1. ⓗⓟ Model 428B Clip-On Milliammeter



Usual clip-on voltmeter measurement of voltage without breaking circuit

Clip-on measurement of current with ⓗⓟ Model 428B without breaking circuit

Figure 1-2. Voltage and Current Measurement

SECTION II
PREPARATION FOR USE

2-1. UNPACKING AND MECHANICAL INSPECTION.

2-2. Inspect instrument for signs of damage incurred in shipment. This instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

2-3. Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Any damage to the instrument upon receipt is due to the carrier. File a claim with the carrier as instructed in the preceding paragraph.

2-4. OPERATION CHECK.

2-5. This instrument should be checked as soon as it is received to determine that its electrical characteristics have not been damaged in shipment. Refer to the FINAL CHECK, paragraph 5-37 at the end of this manual.

2-6. INSTALLATION.

2-7. The ⓗⓟ Model 428B depends on natural air convection cooling. Therefore it is advisable to place the instrument on the table or work bench so that the air can circulate freely through the instrument.

CAUTION

The current probe should not be exposed to temperatures exceeding 55°C (131°F) as high temperatures seriously affect the head of the probe, resulting in unbalance and eventual damage to the probe. Do not leave probe on top of the Model 428B (or any other hot place).

2-8. POWER REQUIREMENTS.

2-9. Power requirements are given in Specifications table at the front of this manual.

2-10. OPERATION ON 115 OR 230 VOLTS.

2-11. This instrument may be used with either a 115-volt or 230-volt supply with a frequency of 50 to 60 cps, single phase. This instrument is shipped from the factory ready for operation from a 115-volt source unless otherwise indicated.

2-12. To operate from a 230-volt source the 115-230 switch on the rear apron must be flipped to 230. First turn the instrument off or pull the power cable from the socket. Place a pointed tool, such as the sharpened end of a pencil, in the slot of the switch and pull down. Replace the fuse with the one given in table 6-1 for 230-volt operation.

2-13. THREE CONDUCTOR POWER CABLE.

2-14. The three-conductor power cable supplied with the instrument is terminated in a polarized, three-prong male connector recommended by the National Electrical Manufacturers' Association (NEMA). The third conductor grounds the instrument chassis for the PROTECTION OF THE OPERATING PERSONNEL. When using a three-prong to two-prong adapter ground third lead (green wire) externally.

2-15. RACK-MOUNT MODEL.

2-16. This instrument is also available in a rack-mount version in addition to the cabinet model shown in this manual. The rack-mount version is identical electrically and similar physically except that the Degausser has been moved to the front panel for greater convenience.

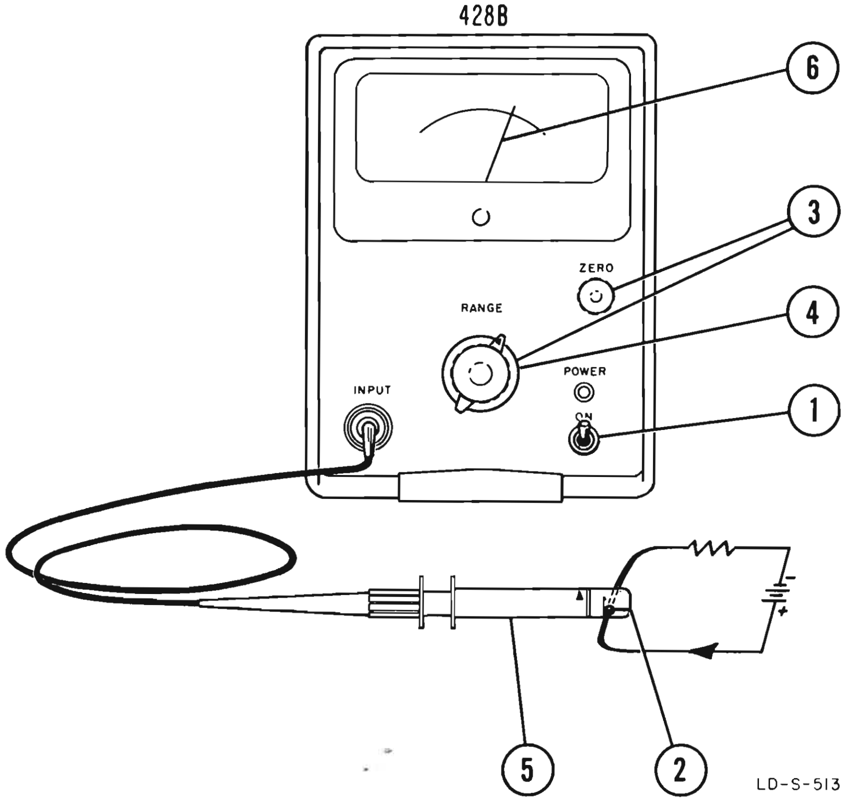
2-17. PREPARATION FOR STORAGE AND SHIPMENT.

2-18. The best method for packing this instrument is in the original shipping carton with the original fillers packed in the same manner as when received from the factory. Therefore, when unpacking note carefully the method of packing and save the original packing material for possible future re-use.

2-19. If the original packing material is not available and it is desired to package the instrument for storage or shipment, first wrap the instrument in heavy kraft paper to avoid scratching the paint. Then pack in a cardboard carton with a bursting strength of at least 150 lb per square inch. Pad the instrument on all sides with at least 2 inches of rubberized hair or at least 4 inches of tightly packed excelsior.

2-20. STORAGE.

2-21. No special precautions are necessary in storage except the usual protection against mechanical damage, salt air, etc.



1. Turn on power and allow approximately 2 minutes warmup time.
2. Check closure of probe jaws. Incomplete closure of the jaws is indicated by excessive zero-shift on the 1 ma current range when probe is rotated in earth's magnetic field. Clean probe jaws if necessary (see paragraph 5-9, Cleaning Probe Jaws).
3. Set RANGE switch to 1 ma. Zero-set instrument with ZERO control.
4. Set RANGE switch to a range that is higher than the anticipated current to be read.
5. Clip probe jaws around wire carrying dc current, pointing the arrow on the probe in the direction of conventional current (see arrows in figure above).
6. Read current on meter.

NOTE

After use of the Model 428B on the 1 thru 10 AMP RANGE degauss the probe head (Paragraph 3-10) if zero set cannot be accomplished.

Figure 3-1. Measurement Procedure

SECTION III
OPERATION

3-1. TURN-ON PROCEDURE.

3-2. Before operating the instrument, check the mechanical zero position of the meter. For the mechanical zero setting of the meter movement, refer to paragraph 5-7.

CAUTION

Be sure the RANGE switch is on 1 AMP or less before turning on this instrument. Otherwise the probe may become magnetized and need degaussing before using.

3-3. Figure 3-1 illustrates the measurement procedure for the instrument.

Note

Read paragraph 3-13, Measurement Precautions, before operating the instrument for the first time.

3-4. MECHANICAL OPERATION OF PROBE.

3-5. The probe jaws are opened by simply squeezing together the two flanges on the probe body. An internal spring returns the jaws to their proper position when the flanges are released.

CAUTION

Do NOT release the flanges abruptly so that the jaws snap together. This may cause binding and zero-shift.

3-6. ELECTRICAL ZERO SET.

3-7. If the instrument cannot be zero set electrically (with ZERO control) there are two probable causes: 1) Incomplete closure of probe jaws, 2) Magnetization of probe head.

3-8. INCOMPLETE CLOSURE OF PROBE JAWS. Dust deposits on the lapped surfaces of the probe jaws create an air gap. If the jaws are not completely closed the earth's magnetic field will affect the reading. With the RANGE switch at 1 ma, rotation of the closed probe should not vary the zero-set more than 0.1 ma. Cleaning of the jaws will restore proper operation conditions (see paragraph 5-9, Cleaning of Probe Jaws).

3-9. MAGNETIZATION OF PROBE HEAD. Magnetic shields protect the probe head from stray magnetic fields. However, excessive dc currents (such as short circuit discharge currents from electrolytic capacitors, etc.) will magnetize the probe. For demagnetization of probe head, see paragraph 3-10, Degaussing of Probe Head.

3-10. DEGAUSSING OF PROBE HEAD.

3-11. For demagnetizing the probe proceed as follows:

a. Insert probe into degausser at the rear of the instrument (located on front panel of rack-mount models) with arrow on probe in same position as arrow marked on chassis.

b. Depress degausser switch S3 to energize degausser.

c. Withdraw probe very slowly for the first few inches while depressing the degausser switch until probe is removed approximately one foot.

d. Zero instrument on 1 ma range with ZERO control.

3-12. Under normal operating conditions degaussing may be necessary after measuring current on the 1 thru 10 AMP RANGE.

CAUTION

The degausser is designed for intermittent operation only. It may be operated for periods up to three minutes continuously without excessive heating. Normal degaussing takes only about 10 seconds.

3-13. MEASUREMENT PRECAUTIONS.

3-14. It is recommended that this paragraph be read carefully before operating the Model 428B Clip-On Milliammeter for the first time. In general, currents can be measured with the Model 428B as conveniently as voltages with a vacuum tube voltmeter. However, there are situations that can cause inaccurate current readings. These situations are described as follows:

Handling of Probe
Magnetic Fields
AC Fields and Superimposed AC Currents
Effect of Instrument on Circuit
Effect of Circuit on Instrument

3-15. <u>HANDLING OF PROBE.</u>

3-16. MECHANICAL HANDLING OF PROBE. Do not close the jaws by letting go of the probe flanges abruptly (snapping), as this may magnetize the head. Also, do not drop the probe. The jaws are made from an alkyd plastic material, which is very durable under normal use, but is not made to withstand the shock of dropping.

3-17. For the cleaning of the probe jaws, refer to paragraph 5-9.

3-18. EXPOSURE TO HIGH TEMPERATURE. The probe must not be subjected to temperatures exceeding 131°F (55°C), as higher temperatures affect the calibration and permanently increase the susceptibility to stray fields. Do not lay the probe on top of the cabinet, as hot air from the instrument can heat the probe.

3-19. VOLTAGE INSULATION. It is preferable to clip the probe around insulated wire. However, the probe is insulated to make current measurements on bare wire at potentials up to 300 volts maximum, with respect to ground.

CAUTION

Do not use this probe on bare wire with over 300 volts peak on it.

3-20. INTERCHANGING PROBE HEADS. Each probe is calibrated at the factory with a particular instrument and carries the serial number of that instrument (serial number appears on probe connector). If a probe has to be replaced, a realignment and re-calibration of the instrument is necessary (see also section V Maintenance).

3-21. MAGNETIC FIELDS.

3-22. If the jaws of the probe are incompletely closed, the magnetic shielding and the magnetic circuit will have an air gap. The result is, that dc fields, not associated with the dc current being measured, will cause a shift in the meter reading.

3-23. However, there will be an indication of a strong external dc field even with the jaws perfectly closed. Usually zero setting with the ZERO control compensates such residual readings for a particular probe location.

3-24. EARTH'S MAGNETIC FIELD. The earth's magnetic field will affect the reading if the jaws of the probe are not completely shielded (jaws partially open). The effect of this field is relatively strong--comparable to deflection due to about 500 ma of current. Complete closure of the jaws can be checked by switching to the 1 ma range with no dc current input. If the jaws mate properly, the zero set should stay within 0.1 ma while rotating the probe head with respect to the earth's magnetic field.

3-25. If the zero shift is greater, the mating surfaces of the jaws need to be cleaned (see paragraph 5-9), or the probe wiring may be open (see paragraph 5-25).

3-26. FIELDS OF PERMANENT MAGNETS. Meter magnets have strong stray fields, which can cause shift in the current indication. Such fields are detected by bringing the closed probe in the area where the measurement is to be made and observing the zero shift (1 ma range).

3-27. FERROUS WIRE. Wires made out of magnetic materials can cause a current reading of 2-3 ma without any connection to the wire. This fact is important as leads of most transistors are made out of magnetic material.

3-28. AC FIELDS & SUPERIMPOSED AC CURRENT.

3-29. AC WITH DC BEING MEASURED. The instrument is designed to allow a high amount of ac ripple in the dc being measured. The presence of ac whose peak value equals full-scale reading (limited to 4 amperes peak on 10-ampere range) will cause less than 2% error in the dc reading. Examples of such high ac currents are found in the input of dc filter sections of power supplies.

CAUTION

Do not use this probe to measure dc in a wire carrying more ac than full-scale reading on meter.

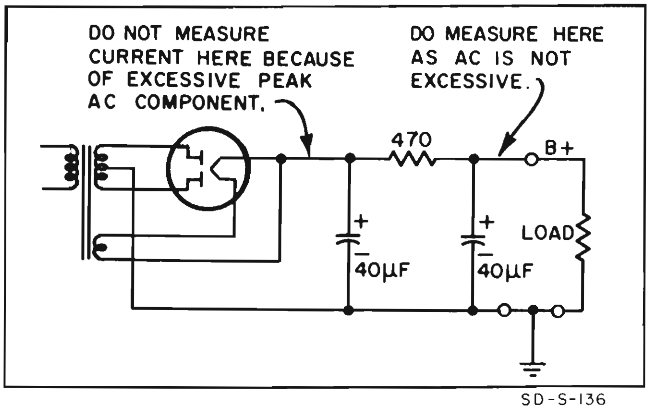


Figure 3-2. Typical Power Supply

3-30. 40 KC WITH DC BEING MEASURED. AC currents having frequency components of 40 kc or harmonics thereof will cause error, as such signals will interfere with the 40 kc output signal of the probe. The meter will indicate a beat reading if the interfering frequency is within approximately 15 cycles of 40 kc or its harmonics. Although this situation is very improbable, accurate dc current readings can be obtained by shifting the frequency of the external ac signal slightly.

3-31. STRAY AC FIELDS. The instrument as well as the probe head should not be used in strong ac stray fields. Such fields may exist in the vicinity of open core power transformers, or large dc filter chokes, etc.

CAUTION: Do not use this probe in the presence of strong rf fields.

3-32. EFFECT OF INSTRUMENT ON CIRCUIT.

3-33. REFLECTED IMPEDANCE. The probe will add a small inductance to the circuit of less than 0.5 microhenries due to the magnetic core and magnetic shield. This makes it ideal for measuring current in very low impedance paths such as ground loops where other instruments would disturb the circuit.

3-34. INDUCED VOLTAGE. The gating signal, driving the core in and out of saturation, will induce a voltage in the wire carrying the dc current. This induced voltage is less than 15 millivolts peak. If more than one loop is passed through the probe the induced voltage will be multiplied by the number of loops.

3-35. EFFECT OF CIRCUIT ON INSTRUMENT.

3-36. The impedance of the circuit being measured has practically no effect on the dc current measurement. A shorted loop inserted along with a wire carrying dc current will decrease the reading by only 0.2% of full scale.

3-37. MEASUREMENT PRACTICES.

3-38. POLARITY OF CURRENT.

3-39. The arrow on the probe head indicates the direction of the conventional current flow for upscale reading. Reversal of the current flow direction will reverse the indication on the meter (see figure 3-3).

3-40. INCREASING THE ABSOLUTE SENSITIVITY.

3-41. The sensitivity of the instrument can be increased by looping the wire (carrying the dc current) several times through the opening of the probe (see figure 3-4). For example, three turns increase the sensitivity three times. With an increased sensitivity however, the induced voltage between the probe and the circuit under measurements will increase also.

3-42. CURRENT CHECK LOOPS.

3-43. In restricted situations such as printed circuit boards, wire loops for the probe can be built into the circuit to allow convenient current measurements with the Model 428B. Here, currents can then be measured under operating conditions with the same ease as voltage measurement.

3-44. USE OF OUTPUT JACK.

3-45. The OUTPUT jack enables you to use the Model 428B as a dc amplifier (up to 400 cps). As such, it is the ideal instrument for measuring and viewing such quantities as surge currents through transformers, etc. The meter on the Model 428B measures the average dc (ignoring the ac). The output at the OUTPUT jack contains both the dc and the ac component of the signal being measured. Thus the ac component may be measured (within the band-pass limitations of the amplifier) with a suitable oscilloscope or meter, as follows:

a. Clip the probe around the wire carrying the signal to be amplified.

b. Plug the recording device into the OUTPUT jack. Use a BNC cable connector and wire the + terminal to the center pin and - terminal to the shell.

c. Adjust the RANGE switch until the meter on the Model 428B indicates on scale so the amplifier will not be overloaded.

3-46. The Model 428B can also be operated with a graphic recorder. Either a high-impedance or low-impedance recorder may be used. Recommended types are the Sanborn 299, the Moseley Autograph 3, the Varian G11, or the Esterline-Angus AW. With high impedance (greater than 100K ohms) recorders, 1 volt ±3% appears at the OUTPUT jack, when the OUTPUT LEVEL control is in the CAL (fully counterclockwise) position. For lower impedance (down to 1400 ohms) 1 ma recorders, the recorder must be calibrated. To calibrate a recorder proceed as follows:

a. Connect the recorder to the Model 428B by means of a BNC cable connector. The positive terminal of the recorder should be wired to the center pin and the negative terminal to the shell.

b. Calibrate the recorder:

1) High impedance recorders will be calibrated when the OUTPUT LEVEL control is in the CAL (fully counterclockwise) position.

2) Low impedance recorders must be adjusted for a particular sensitivity with the OUTPUT LEVEL control.

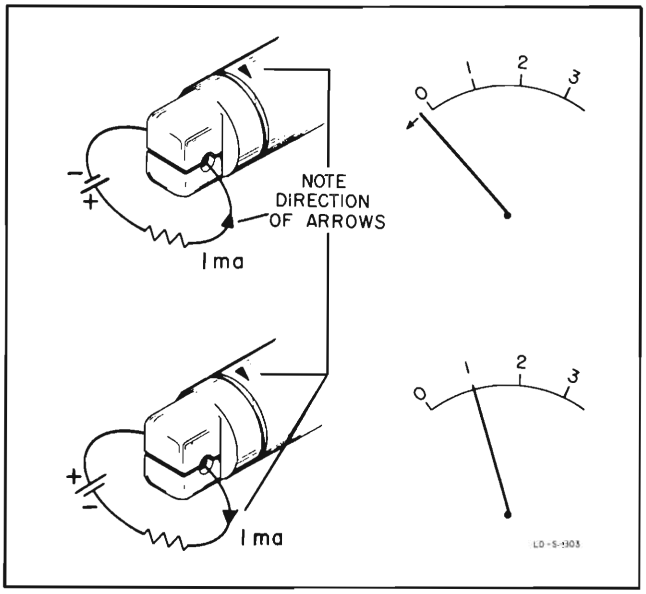


Figure 3-3. Clip Probe Around Wire with Arrow Pointing in Direction of Conventional Current

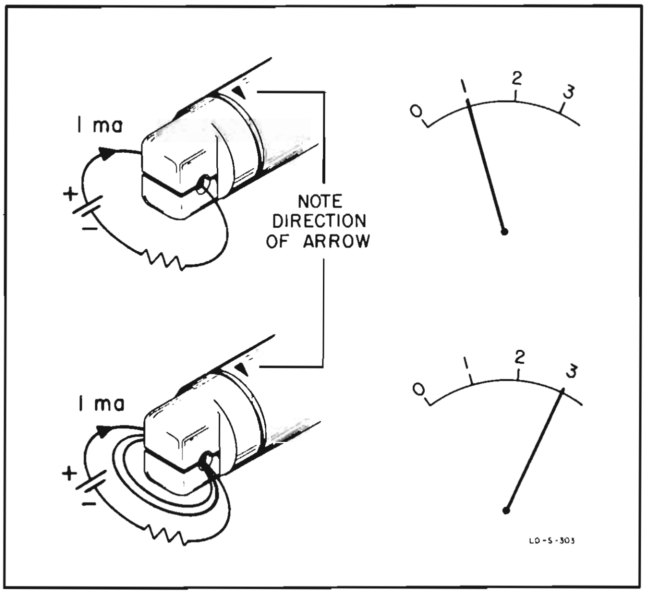


Figure 3-4. Increasing the Absolute Sensitivity by Looping Current Path through Jaws Several Times

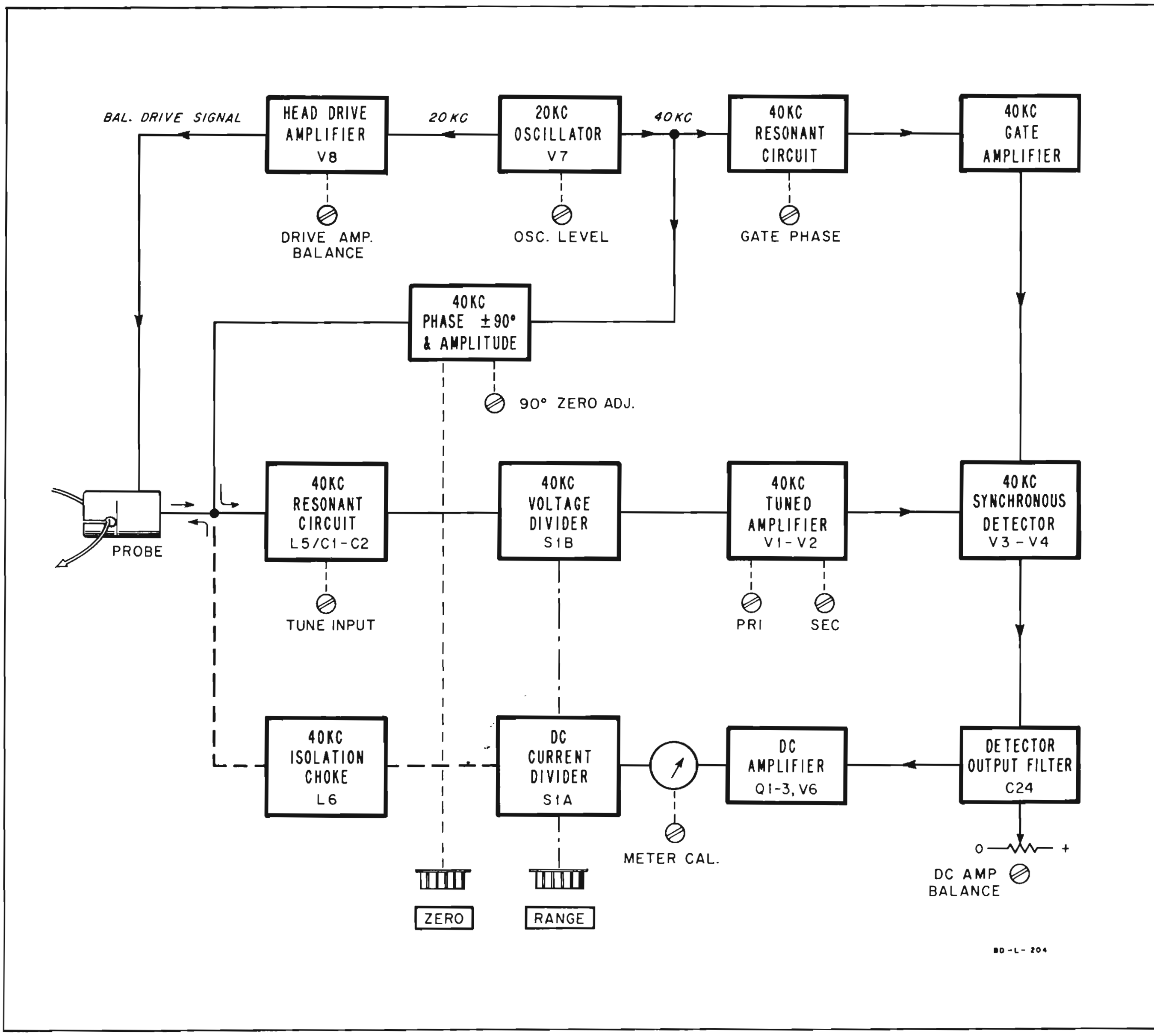


Figure 4-1. Block Diagram Model 428B

SECTION IV
THEORY

4-1. INTRODUCTION.

4-2. This section describes the overall operation of the Model 428B, the operating principle of the current probe and the function of the different circuits of the instrument.

4-3. OVERALL OPERATION.

4-4. The simplified block diagram of figure 4-2 shows the basic operation of the Model 428B Clip-ON Milliammeter.

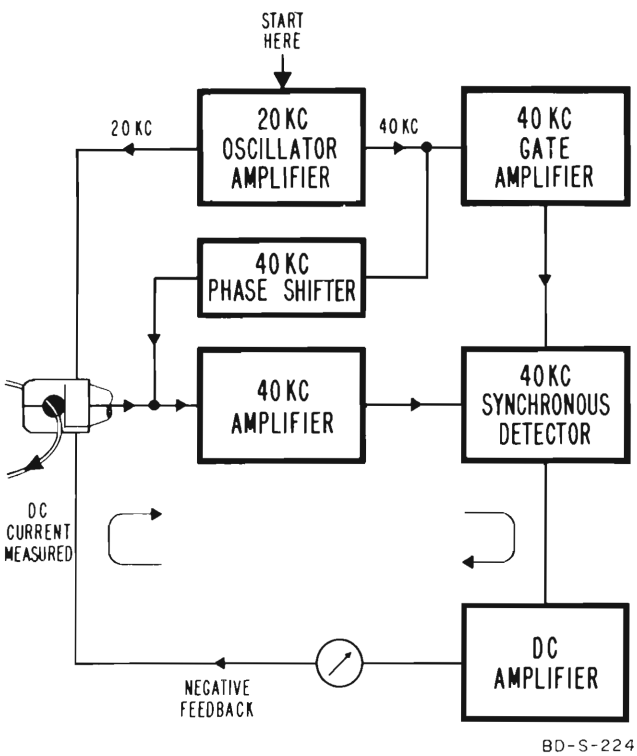


Figure 4-2. Simplified Block Diagram

4-5. 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 4-9, Current Probe.

4-6. 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 to and almost equal to the dc current of the inserted wire, is used to indicate the measured dc current.

4-7. 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 Synchrononous Detector.

4-8. Due to slight unbalances, the probe head output contains 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).

4-9. CURRENT PROBE.

4-10. 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.

4-11. The flux-gate principle is easily understood by referring to the mechanical model shown in figure 4-3.

4-12. Coil A (representing wire through probe), is energized with dc, producing a dc-flux in the core. Armature 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.

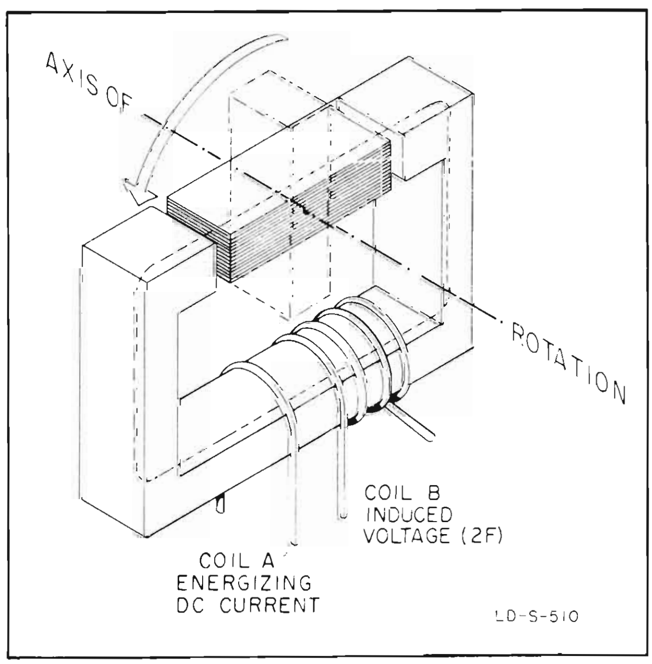


Figure 4-3. Mechanical Flux Gate

4-13. The Model 428B head uses this principle in a similar way. Figure 4-4 shows the basic concept of a saturable flux gate.

4-14. A magnetic core in saturation loses permeability and therefore is comparable to a core that has been mechanically opened (low permeability due to air gap).

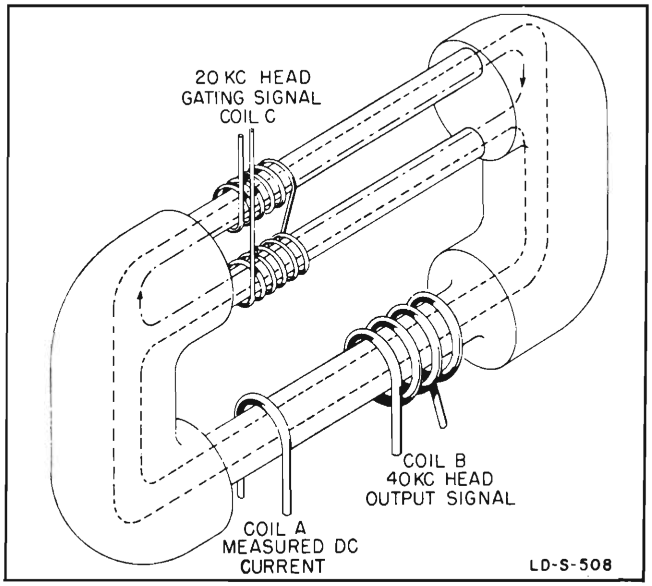


Figure 4-4. Saturable Flux Gate

4-15. 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.

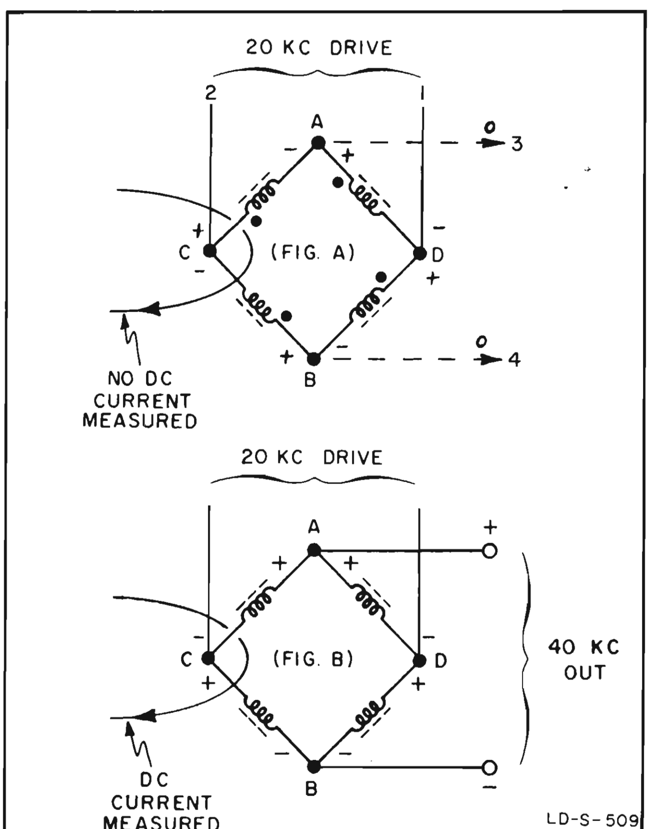


Figure 4-5. Current Probe Bridge Circuit

4-16. In the actual head there are four coils connected in a bridge configuration as shown in figure 4-5A. The cores of the coils are periodically saturated by a balanced 20 kc signal at points C and D.

4-17. 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.

4-18. When the probe jaws are clipped over a wire carrying dc, the instantaneous 40 kc voltages induced by the gated dc flux have the polarites shown in figure 4-5B 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°.)

4-19. 20 KC OSCILLATOR.

4-20. 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.

4-21. The circuit of the 20 kc oscillator is shown in figure 5-12. The oscillator V7 is operating in push-pull having a plate circuit tuned to 20 kc. Transformer coupling provides positive feedback through resistor R94 and R95 to the oscillator control grids. 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.

4-22. 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.

4-23. HEAD-DRIVE AMPLIFIER.

4-24. The head-drive amplifier V8 supplies the balanced 20 kc signal for the probe head. Drive balance adjustment R98 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.

4-25. DETECTOR GATE AMPLIFIER.

4-26. 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.

4-27. 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 signal to the Synchronous Detector. The function and the adjustment of the Detector Gate Amplifier will be discussed in paragraph 4-30.

4-28. 40-KC INPUT/AMPLIFIER CIRCUIT.

4-29. 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 S1B, 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 band-pass 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.

4-30. SYNCHRONOUS DETECTOR AND FILTER (C24).

4-31. 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.

4-32. The synchronous detector requires a large 40 kc gating signal, having the frequency of the desired signal. Figure 4-6 shows the synchronous detector drawn as a bridge circuit.

4-33. A large gating signal (300 volts peak) is fed to points 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 4-6b). The diodes function as switches operating at a rate of 40 kc (the gating frequency).

4-34. The 40 kc amplifier output transformer is returned to points 2 and 4 of the bridge, and its signal is superimposed on the gating signal (indicated by heavy line in figure 4-6b). Since the 40 kc output signal is considerably smaller than the 40 kc gating signal, the action of the gated diodes is to return alternately the top and bottom end of T_2 secondary to T_3 secondary center tap. The 40 kc output signal appears rectified across C24 (figure 4-7 shows the phase and amplitude relationship in the synchronous detector). Referring to figure 4-6, resistors R41 through R44 provide a bias voltage for the diodes in cutoff. In other words, when diodes V3A and V4A conduct, the voltage drop across R41 supplies a negative bias for V3B and the voltage drop across R43 supplies the back-bias voltage for diode V4B.

4-35. 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.

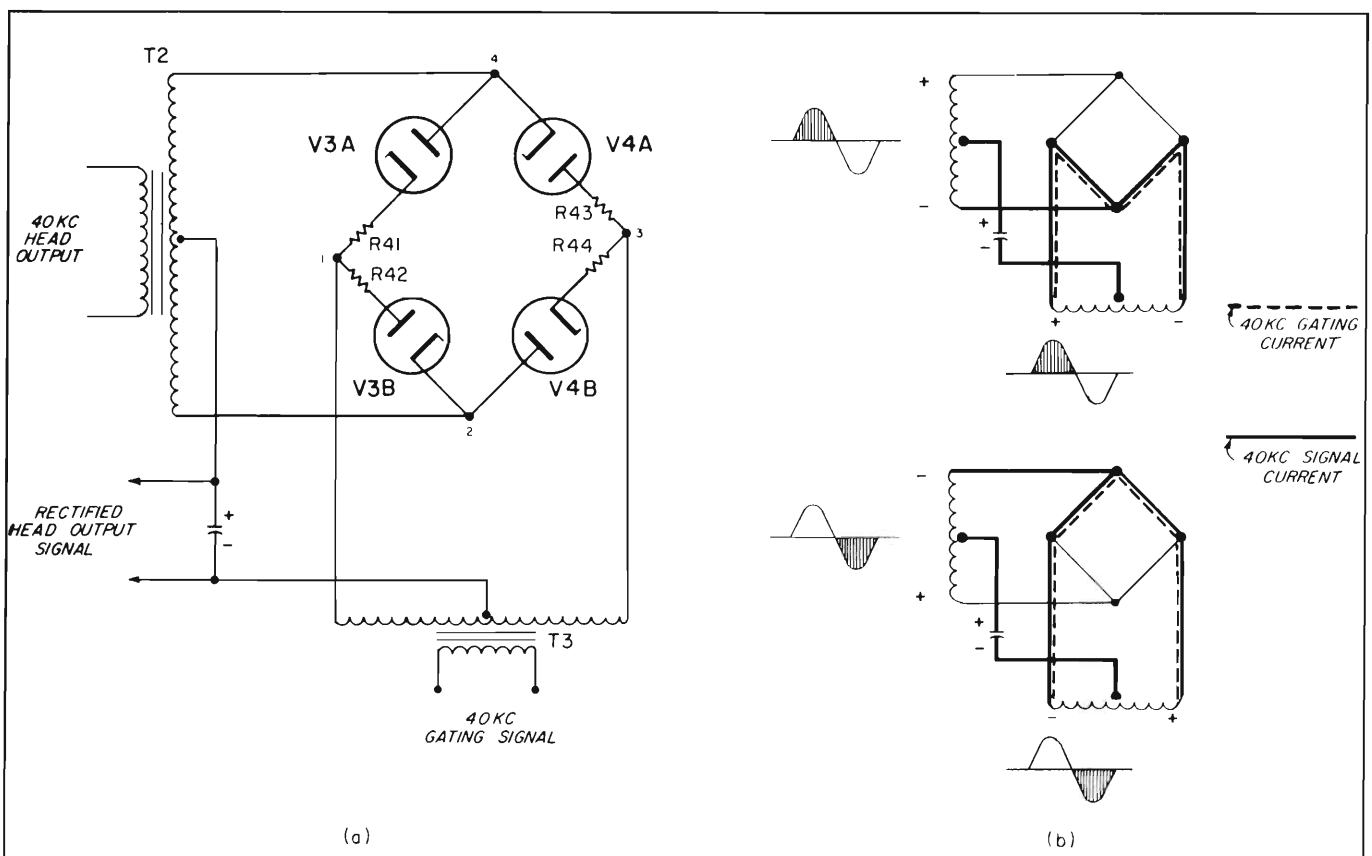


Figure 4-6. Synchronous Detector

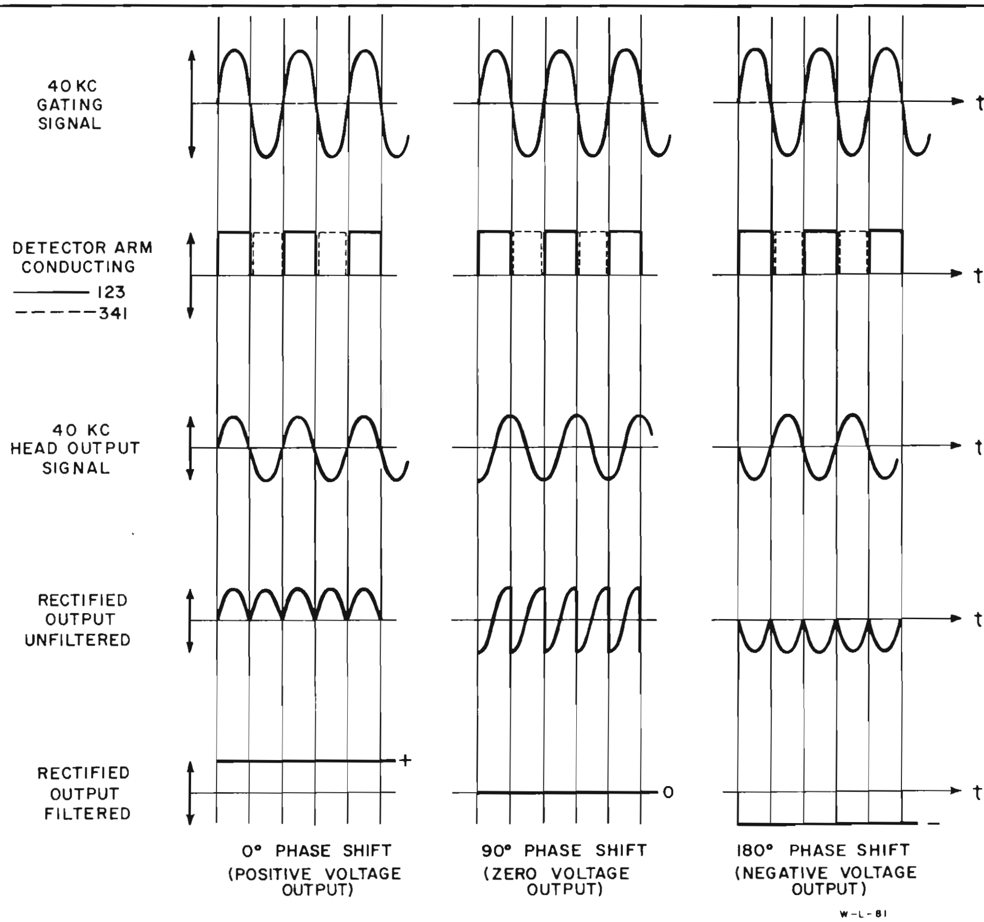


Figure 4-7. Change of Output of Synchronous Detector with Phase

4-36. DC AMPLIFIER.

4-37. The dc amplifier supplies a negative dc feedback current to the probe 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.

4-38. In addition, this local negative feedback loop stabilizes the gain of the DC Amplifier.

4-39. Tube V6 is a differential amplifier in which a signal of approximately 1 volt (for full-scale deflection) is fed to pin 7 and compared with the signal on pin 2. The output of V6 is fed to the base of Q3.

4-40. Transistor Q3 drives the current-amplifiers Q1 and Q2 which are used as emitter-followers in a push-pull NPN-PNP pair combination.

4-41. The output current from Q1 and Q2 goes through the meter circuit to the current divider S1A which feeds a portion of this current, appropriate for the range this instrument is working on, to the probe head as negative current feedback.

4-42. After passing through S1A and the probe head the combined current goes through the parallel resistor network R60-64. This develops a voltage at the junction of R61 and R62 which is proportional to the feedback current. This voltage is applied to pin 2 of V6 to complete the local feedback loop of the DC Amplifier. This circuit makes the output current of the DC Amplifier proportional to the voltage applied to the input grid, pin 7, of V6.

4-43. NEGATIVE FEEDBACK CURRENT CIRCUIT.

4-44. The negative feedback current path is shown in figure 4-8. Current divider S1A divides the feedback current in proportion to the dc current being measured*. For a dc input of 10 amperes, approximately 50 ma feedback current is fed to the probe head. Since an equal number of ampere-turns are necessary for canceling the main dc flux, the feedback coil inside the head requires approximately 200 turns.

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* 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.

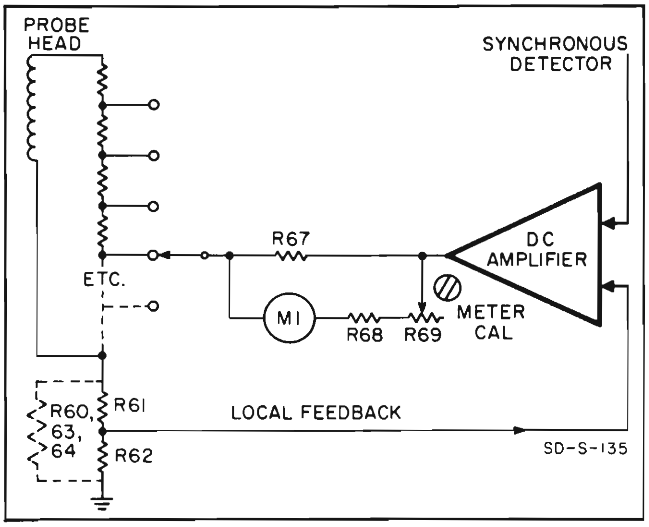


Figure 4-8. Feedback Current Circuit

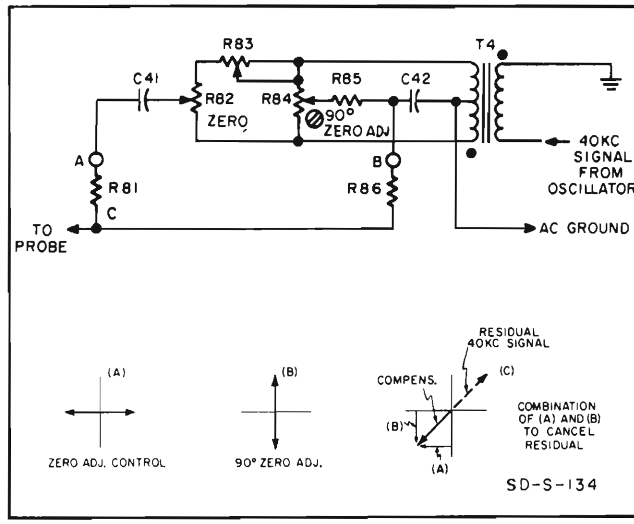


Figure 4-9. 40 KC Phase Shifter

4-45. 40 KC PHASE SHIFTER.

4-46. 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 4-9 shows the circuit and the idealized phase relationship of the two output voltages with respect to the 40-kc signal from the oscillator.

4-47. By adding the two output voltages (vector A and B) a 40-kc signal is obtained, having phase angle and amplitude to cancel exactly the residual 40-kc signal from the probe (vector 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.

4-48. POWER SUPPLY.

4-49. 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.

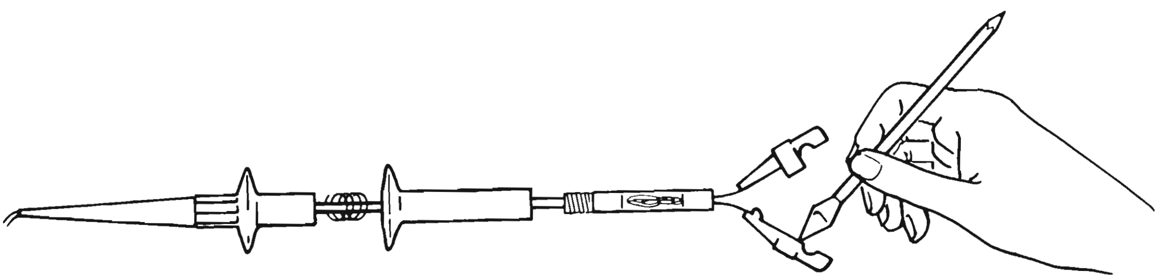


Figure 5-1. Cleaning Probe Jaws

Shows proper method of cleaning mating surfaces of probe jaw. If normal cleaning of jaws with brush will not permit jaws to mate perfectly, clean with pencil eraser. See paragraph 5-9, Cleaning of Probe Jaws.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information about servicing and maintaining the Model 428B.

5-3. A Final Check (paragraph 5-36) is included in this section to be used to verify instrument operation without removing the instrument from the cabinet. This is also a good test as part of preventive maintenance and incoming quality control inspection.

5-4. A tube replacement chart (table 5-1) has been included. Most tubes may be replaced without requiring adjustment because of the large amount of negative feedback. However, the Final Check should be done when replacing any tube. If the instrument does not meet the performance check, then the tests indicated under that particular tube in the tube replacement chart should be performed.

5-5. A troubleshooting section which will help isolate troubles more easily has been included. This section consists of a series of waveforms systematically covering the 40-kc signal, gate and oscillator circuits.

5-6. A complete test procedure covering all adjustments has been included. Normally only those parts of the procedure concerned with the particular section of the instrument that was faulty should be done. Do NOT perform this entire procedure as a part of preventive maintenance.

5-7. MECHANICAL ZERO-SET.

5-8. When meter is properly zero-set, pointer rests over the zero calibration mark on the meter scale when instrument is (1) at normal operating temperature, (2) in its normal operating position, and (3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

a. Allow instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.

b. Turn instrument off and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

d. Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer overshoots zero, repeat steps c and d.

e. When pointer is exactly on zero, rotate adjustment screw slightly counterclockwise to free adjustment screw from the meter suspension. If pointer moves during this step, repeat steps c through e.

5-9. CLEANING OF PROBE JAWS.

5-10. Cleaning of the probe jaws is done by squeezing together the probe flanges and cleaning the two mating surfaces with a brush (supplied with the instrument). If the foreign matter cannot be removed by the brush, then the probe head must be disassembled and the surfaces cleaned with an eraser (see figure 5-1). To disassemble the probe head, grasp the probe head in the palm of one hand and unscrew the probe center section (see figure 5-8) with the other hand. Make sure that you do not twist the cable while doing this.

Note

In reassembling the probe, be sure that the polarity arrow on the probe points toward the side of the terminal strip with the heavy red lead of the probe cable.

5-11. TEST EQUIPMENT.

5-12. This paragraph lists all the test equipment and auxiliary equipment necessary for completely servicing and adjusting the Model 428B.

5-13. TEST INSTRUMENTS.

a. Oscilloscope with dual channel plug-in, such as ℎ𝑝 Model 140A, 175A or equivalent.

b. AC Vacuum Tube Voltmeter, such as ℎ𝑝 Model 400D or equivalent.

c. DC Vacuum Tube Voltmeter, such as ℎ𝑝 Model 412A, 410C or equivalent (1% accuracy at 280 volts).

d. Electronic Counter, such as ℎ𝑝 Model 5212A, 5512A etc., or equivalent.

5-14. AUXILIARY EQUIPMENT.

a. One 1.0 μf capacitor; one 0.01 μf capacitor.

b. Supply of small fixed mica padding capacitors (up to 500 pf).

c. One 1500-ohm resistor.

d. Supply of 1/2-watt resistors (390 ohms to 47K ohms, Allen Bradley or equivalent).

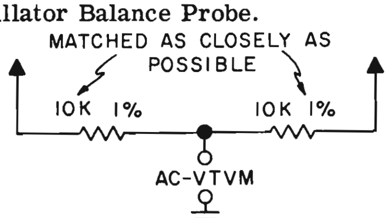
e. AC voltage source (6.3 volts), 60 cps.

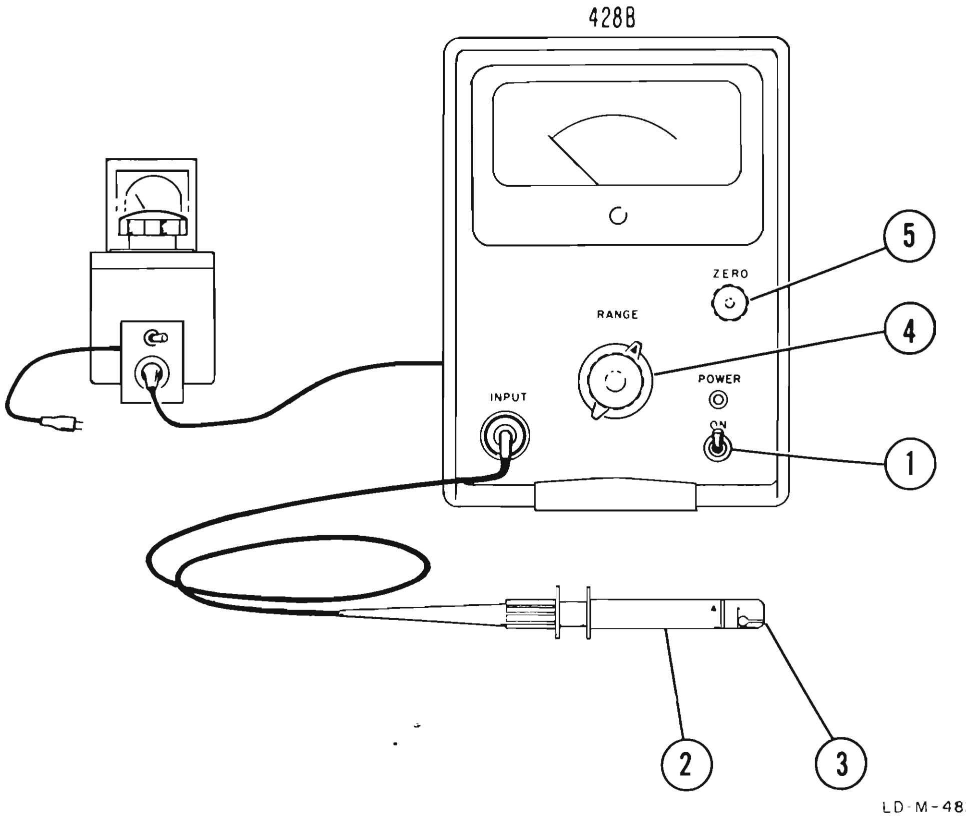
f. Precision resistor, 100 ohm ±1%, 1 watt; 1K ohm 1%, 1 watt; 1K potentiometer, 2 watts; 10 ohm, 1/4%.

g. Variable ac power supply, such as variable autotransformer.

h. Variable dc power supply, such as ℎ𝑝 Model 711A Laboratory Power Supply.

i. Oscillator Balance Probe.



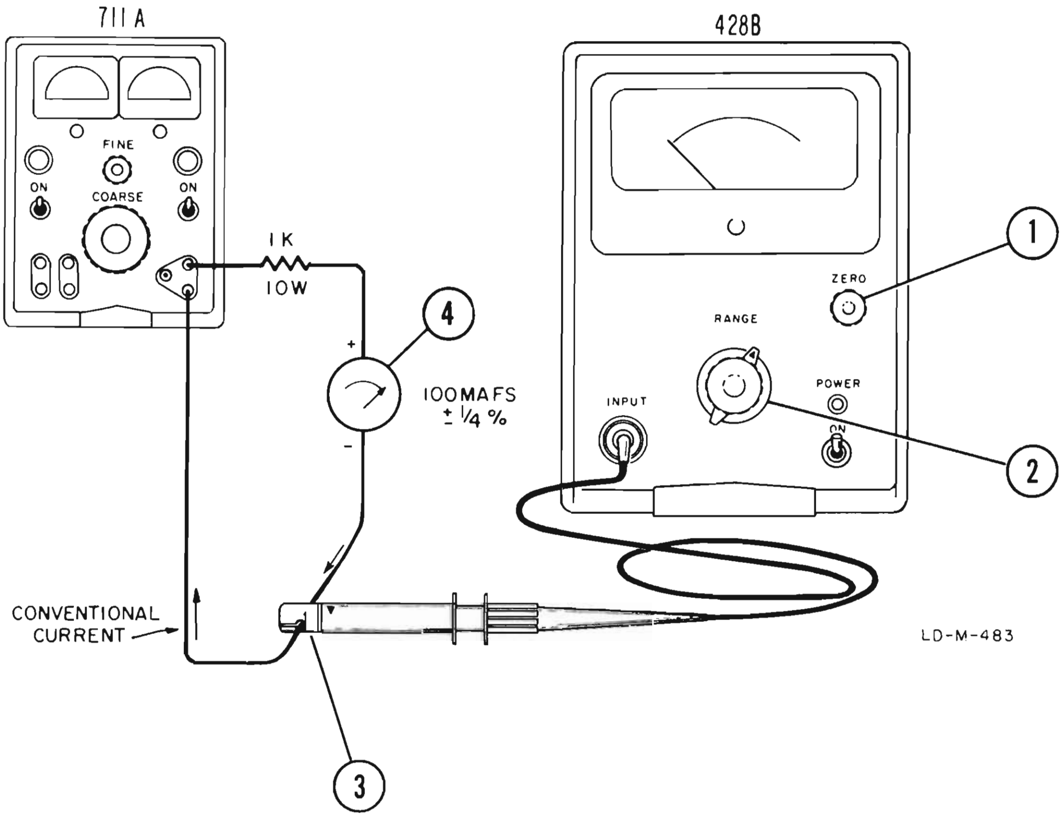


Connect Model 428B to a variable voltage supply, such as an autotransformer.

1. Turn ON power and allow approximately two minutes warmup time.
2. Place probe away from any stray fields (meter magnets, open-core transformers, etc.).
3. Check for complete closure of probe jaws (see paragraph 3-8).
4. Set RANGE switch to 1 ma.
5. Zero-set instrument with ZERO control. If zero-setting is not possible see paragraph 3-6.

Check: Change line voltage from 103 to 127 volts and observe meter on Model 428B. Zero-drift should remain within ±0.5 ma.

Figure 5-2. Electrical Zero-Set



1. Zero-set Model 428B on 3 ma range, with no direct current input to probe.

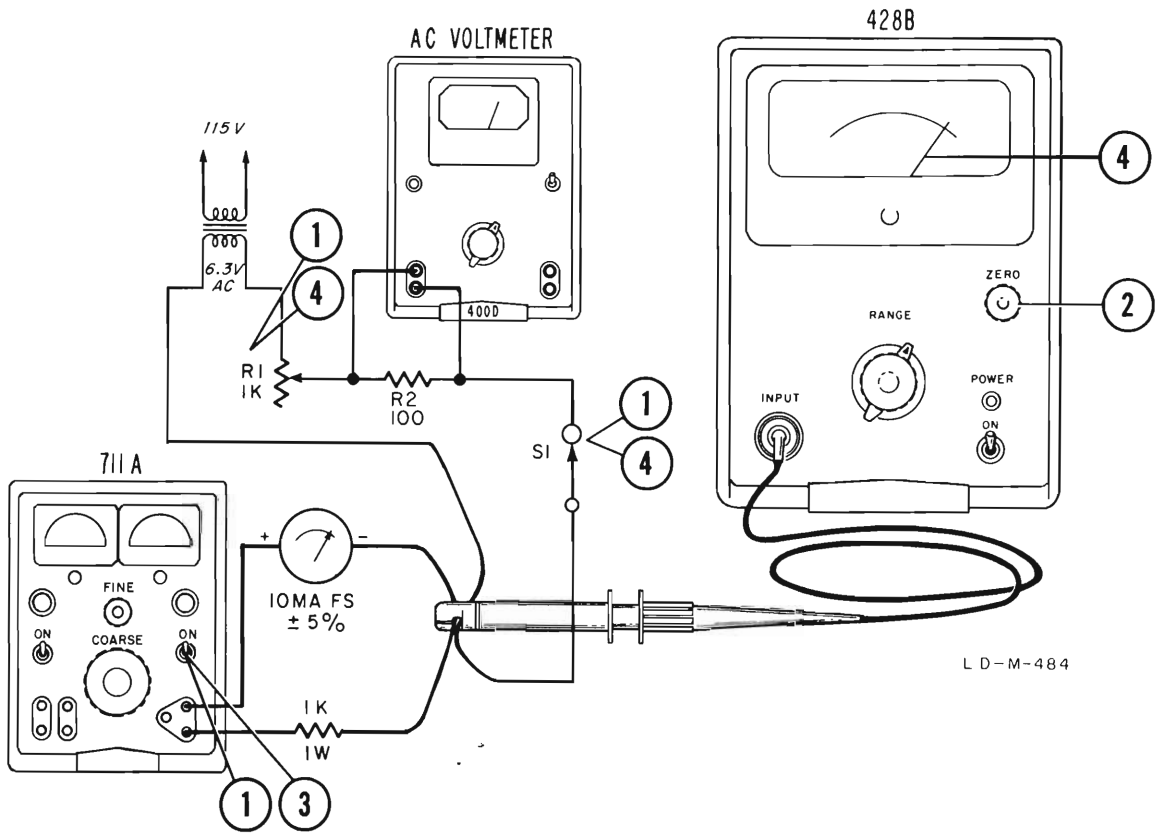
2. Switch current RANGE to 100 ma.

3. Clip probe around wire carrying current to be measured, pointing arrow on probe in direction of the conventional current flow (see arrows in figure above).

4. Increase current until milliammeter reads 100 ma.

Check: Reading on Model 428B should agree within ±3%.

Figure 5-3. DC Current Indication



Connect equipment as shown.

1. Open S1, set R1 to center and turn power supply off.
2. Zero-set Model 428B on 10 ma range with no input to probe.
3. Turn on power supply and adjust for 10 ma dc.
4. Close S1 and adjust R1 until Model 428B meter reading drops by approximately 2%.

Check: AC voltmeter should read 0.7 vrms (10 ma peak, 7 ma rms), or more.

Figure 5-4. AC Overload

5-15. ADJUSTMENT AFTER TUBE REPLACEMENT.

5-16. Experience has shown this instrument to be very reliable. Most troubles will be due to faulty tubes. Never disturb any adjustment until extensive tests have indicated adjustment is necessary!

5-17. This instrument is very sensitive to phase shifts. If any adjustments which affect phase are disturbed, complete alignment will be necessary.

5-18. Phase shifts can be caused by changes in the 20-kc oscillator frequency. Normal variations in interelectrode capacities of the oscillator tubes will not change the oscillator frequency enough to require realignment, provided the rest of the circuitry was previously adjusted properly.

5-19. Some tubes may shift the frequency too much. In this case, you must realign the instrument. Perhaps an easier way is to select an oscillator tube which makes the circuit oscillate at the same frequency (approximately) as the old tube. This can save considerable time if a choice of tubes is available.

5-20. Table 5-1 lists possible adjustment or checks after a tube has been replaced. Consult table 5-1 only if instrument does not meet specifications.

Table 5-1. Tube or Transistor Replacement

Ref. Desig	Type	Function	Check
V1	6AU6	40 kc Amplifier	No adjustment
V2	6AH6	40 kc Detector Driver	No adjustment
V3/4	6AL5	Synchronous Detector	No adjustment
V5	6AH6	Detector Gate Amplifier	No adjustment
V6	6DJ8	DC Amplifier	Table 5-2, DC Ampl.Bal.Adj.
V7	6DJ8	20 kc Oscillator	No adjustment
V8	5814/ 12AU7	20 kc Head Drive	Drive Bal.Adj.
V9	12B4	Series Regulator Tube	No adjustment
V10	6AU6	Control Tube	No adjustment
V11	5651	Reference Tube	Table 5-3, Power Supply
Q1	2N1218	Current Ampl.	Test loop gain, Adjust R46
Q2	2N1183	Current Ampl.	
Q3	2N1564/ 1854-0003	Driver	

5-21. TROUBLE LOCALIZATION.

5-22. Three simple tests performed with the instrument in its cabinet indicate whether the circuits are operating normally. The tests can be used as incoming inspection checks and are not intended to check the accuracy of the instrument. See the following figures:

Figure 5-2. Electrical Zero-Set
Figure 5-3. DC Current Indication
Figure 5-4. AC Overload

5-23. PERFORM THE STEPS IN THIS SECTION BEFORE MAKING ANY ALIGNMENT ADJUSTMENTS.

5-24. Refer to paragraph 5-37 FINAL CHECK for three tests to check instrument performance. DO NOT attempt alignment before determining the location of the trouble. If alignment is attempted first, in addition to the alignment not working, troubleshooting may be made more difficult. For instance, if the original trouble was a faulty component, you would have to find the misalignment in addition to the faulty component. Finding two troubles in an instrument is usually much more difficult than finding a single trouble.

5-25. Proceed with the following steps until the trouble is found.

5-26. <u>PROBE</u>.

5-27. The first check to make after you determine that the instrument does not meet specifications is to check the probe. 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. If the probe tests all right, connect it back to the instrument and degauss the probe.

5-28. <u>POWER SUPPLY</u>.

a. Remove the instrument from the cabinet by removing the two screws at the rear of the instrument and pushing the chassis free from the cabinet. Connect base of Q1 (pin furthest from chassis on 2N1218) to ground with a clip lead. Connect a voltmeter to any red lead on terminal board 428B-75F (board furthest from front panel). (It is assumed in all these directions that the ground lead of the voltmeter will be connected to the chassis unless specifically instructed otherwise.) This voltage should be +272 ±6 volts. If there is no voltage at all, check F3. If the voltage is not correct, try adjusting the Adj +272V control or replacing V9, 10, or 11.

b. With Q1 still grounded check the voltage on the +12V bus at pin 2 of V11. This voltage should be +12 ±1 volts. If not, check CR10 or Q1.

c. With Q1 still grounded check the voltage on the -7V bus (lower terminal of bottom diode on etched circuit board nearest front panel). This voltage should be -7 ±1 volts. If not, check CR9 or Q2.

d. With the +12V and -7V buses set to their correct voltages, recheck the voltage on the +272V bus as instructed above. Adjust the Adj +272V control if necessary. Connect a variable voltage power line source to the 115-volt input of the Model 428B. Vary the input voltage from 103 to 127 volts ac. The dc voltage should not vary more than ±2 volts dc. If it does, try replacing V9, 10, or 11.

5-29. <u>OSCILLATOR-HEAD DRIVE AMPLIFIER</u>.

a. Referring to the schematic for test details, check the waveform at testpoint 3. If the waveform is correct, go to paragraph 5-31. If not, go to step b.

b. Check the signal on test point (2). If the signal at testpoint (2) is not correct check V7. If the signal at testpoint (2) is correct, check V8. If V8 is replaced perform steps 16 through 19 of the adjustment procedure. Waveform (4) should be similar to the waveform on testpoint (3) except 180° out-of-phase.

5-30. HEAD DRIVE.

a. With Q1 still grounded connect the vertical input of an oscilloscope to pin 7 of V2 and the horizontal input to pin 7 of V5. Clip Model 428B probe around wire carrying 5 ma ac (0. 5 volt ac across 100 ohms monitored by an external meter, see figure 5-5).

b. Turn Model 428B RANGE switch to 10 MA. Pattern on oscilloscope should look like a "bow tie" with its knot symmetrical (see figure 5-6A or B). Note that an 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 pattern. Figure 5-6C illustrates another type of an incorrect adjustment with the top intersection not over the bottom intersection. If this pattern is correct, the 40-kc amplifier is functioning properly; proceed to paragraph 5-31. If not, check waveforms at junction of R1-L5 and waveforms at testpoints (7) and (8). No waveform is given at testpoint (7) since the waveshape will vary with different probes. Test for presence of . 01 volt waveform of any shape.

c. Check the waveform at the connection between R1 and L5 with the RANGE switch set to 1 MA and the probe clipped around 100 ma dc. This waveform should be a 2. 5 volt peak-to-peak sine wave. If not, check L5 and associated circuitry. If correct, proceed to step d.

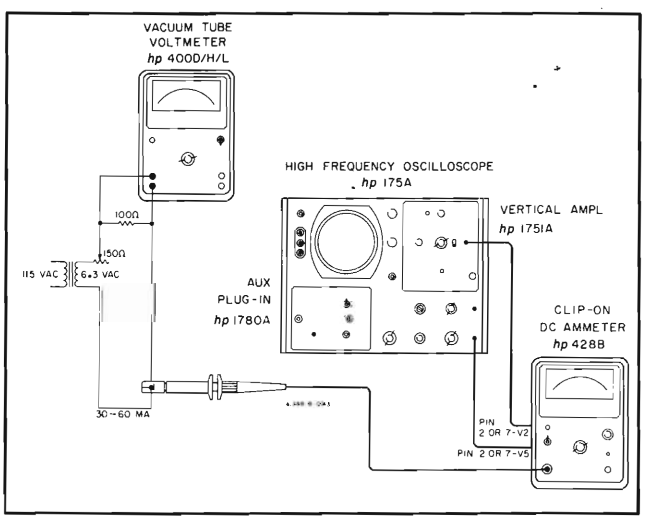


Figure 5-5. Detector Phase Adjustment Setup

d. Check the waveform on pin 7 of V1 with the RANGE switch set on 1 MA and the probe clipped around 100 ma dc. This waveform should be a 2. 5 volt peak-to-peak sine wave. If not, check V1, RANGE switch, etc. In addition this waveform should be in-phase with the waveform found in step b (note that this relationship can only be observed if a high impedance probe is used and the oscilloscope is synchronized externally as explained in the notes on the schematic). If this waveform is correct proceed to step e.

e. Check the waveform at pin 7 of V2 with the RANGE switch set to 100 MA and the probe clipped around 100 ma dc. This waveform should be a 1-volt peak-to-peak sine wave. If not, check V2 and T1. In addition, this waveform should be in-phase with the waveform found in step d. If not, check T1. If this waveform is correct proceed to paragraph 5-31.

Note

If V1, 2, or T1 are changed check the loop gain (table 5-2, Alignment Procedure, step 13).

5-31. SYNCHRONOUS DETECTOR.

a. With Q1 still grounded and Model 428B set on the 100 MA range, check the voltage on pin 7 of V6. This voltage should swing from approximately -5 volts to +2 volts as the ZERO control is rotated throughout its range. If it does, go to paragraph 5-33. If not, go to step b.

b. With Q1 still grounded, check waveforms (figure 5-7) at transformer T2 (testpoints (9), (10), and (11) on the schematic). Note that the amplitude and shape of these waveforms vary as you rotate the ZERO control. The waveform at testpoint (10) should be in-phase with the waveform at testpoint (9) while the waveform at testpoint (11) should be out-of-phase. If these waveforms are not correct, check V3, 4, and C19 and associated circuitry. If these waveforms are correct check the waveform at testpoint (5). If waveform (5) is correct go to step d. If waveform (5) is not correct, go to step c.

c. Check the waveform at testpoint (6). This waveform should be at 10 volt sine wave. If this waveform is good check V5 and associated circuitry. If the trouble is not found check the waveform at testpoint (1). If this waveform is correct, check V5. If the waveform at testpoint (1) is correct but the waveform at testpoint (6) is still not correct, the trouble may be in L7 or T4.

d. To check T2 remove V3, 4 and 6. With the base of Q1 still grounded and the RANGE switch on 30 MA, check the waveforms on testpoints (9), (10), and (11). These waveforms should be sine waves whose amplitude varies as you rotate the ZERO control. The peak of the waveform should sweep through at least 7 volts of space on the oscilloscope screen as the ZERO control is rotated throughout its range. In addition the amplitude of these waveforms should be approximately the same with (9) and (10) in-phase and (11) out-of-phase (oscilloscope must be externally triggered, see notes on schematic). If not, check circuitry connected to transformer T2 or tubes V3 and V4. If correct, replace transformer T2.

5-32. DC AMPLIFIER.

a. Remove probe from front panel. Remove the ground from Q1 and compare the voltage on pin 7 of V6 with the voltage on pin 2 of V6. These two voltages should track when the ZERO control is turned to give different values of voltage. These voltages should follow one another within 0. 05 volt for a ±1 volt swing on pin 2 of V6. If so, the dc amplifier is functioning properly. If not, go to step b.

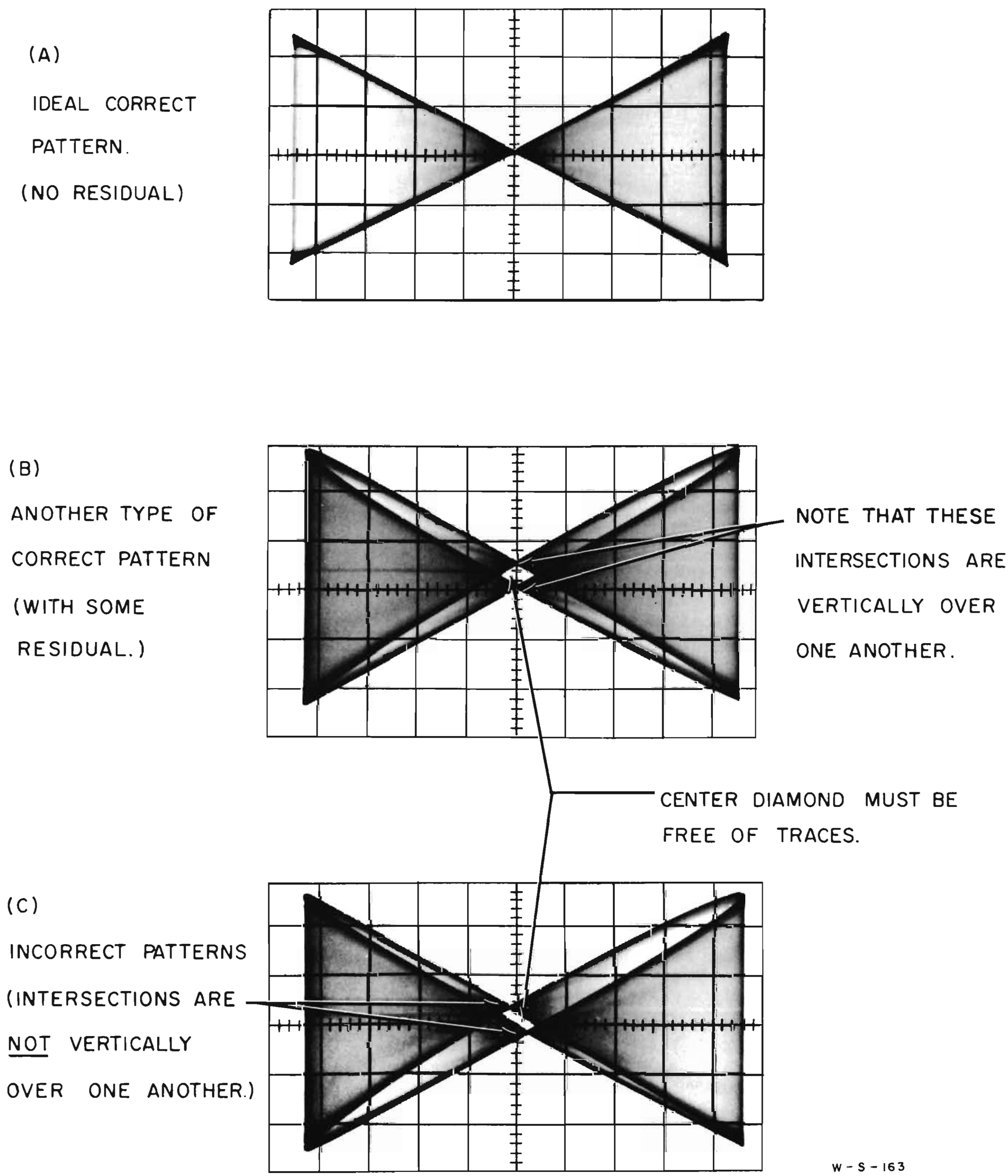


Figure 5-6. Detector Phase Adjustment Waveforms

b. With the base of Q1 grounded and the RANGE switch on 100 MA measure the voltage on pin 6 of V6. Rotating the ZERO control over its range should swing this voltage from +50 to +250 volts. If so, go to step c. Remove the clip-lead grounding Q1.

c. With Q1 ungrounded and RANGE switch set to 3 MA measure the voltage on base and emitter of Q1. The voltage on the emitters should track the base voltages and ZERO control should swing the emitters ±2.5 volts. If not, check Q1, 2, and 3 and check for shorts in the RANGE switch.

5-33. ADJUSTMENT AFTER CURRENT PROBE REPLACEMENT.

5-34. If the current probe has to be replaced, it is not necessary to perform the complete adjustment procedure. In table 5-2 perform only steps 15 thru 23.

5-35 COMPLETE ADJUSTMENT PROCEDURE.

CAUTION

> Before changing any adjustment in the Model 428B, be sure that an adjustment is necessary as indicated by the trouble localization procedure (paragraph 5-23). Always consult the trouble localization procedure first to determine which sections of the adjustment procedure to perform. Do not perform the complete adjustment procedure either as a trouble localization or preventive maintenance procedure.

5-36. The procedure given in table 5-2 is complete and enables you to do a systematic alignment of all circuits. Refer to paragraph 5-14, Auxiliary Equipment listing auxiliary equipment needed for adjustment.

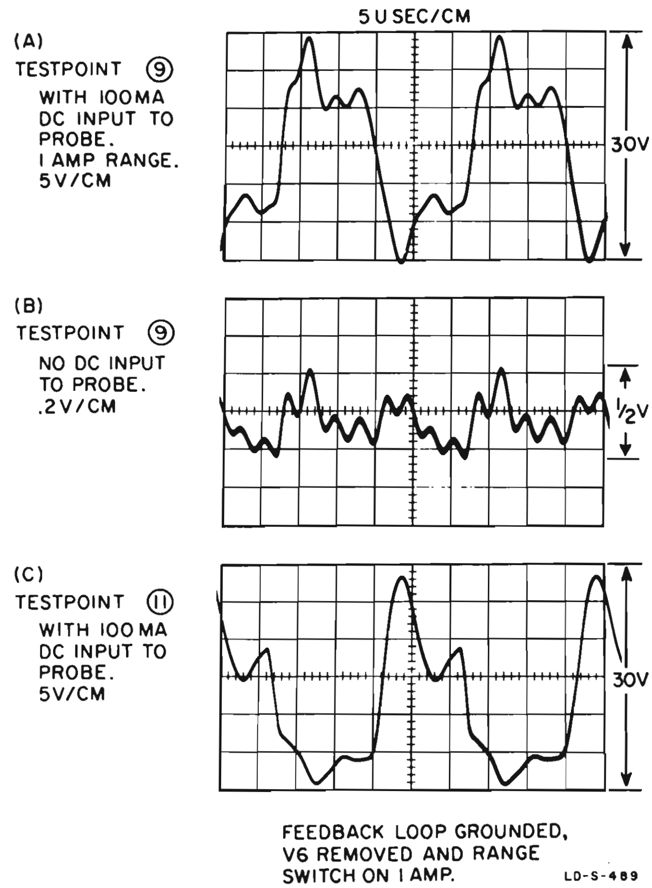


Figure 5-7. Trouble Localization Waveforms

Table 5-2. Adjustment Procedure

Step 1. PRELIMINARY ADJUSTMENT.

The feedback loop must be disconnected for all tests up to Step 17. Disconnect bare wire jumper on terminal board 428B-75D (board nearest front panel). Ground base of Q1. Zero-set the mechanical zero on the meter (see paragraph 5-7). Clean probe jaws (see paragraph 5-9).

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 Model 428B chassis, unless otherwise specified.

Step 2. POWER SUPPLY.

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

a. Connect a vtvm, such as the hp Model 410C Vacuum Tube Voltmeter, to any red lead on 428B-75F (rearmost) terminal board. This voltage should be 266 to 278 volts. If not, check F3 or adjust R109 (Adj +272V) for 272V.

b. Connect an oscilloscope to the same red lead as in Step a. The pattern on the screen will be 40 kc with 120 cps superimposed. Vary the input voltage to the Model 428B from 103 to 127 volts. The 120 cps component of this waveform should be less than 50 mv peak-to-peak. If not, replace V9, 10, or 11. Remove voltmeter and oscilloscope.

c. Turn RANGE switch to 3 AMP. Check the voltage on anode of CR10 (front board). This voltage should be 10.8 to 13.2 volts. If out of these limits, check Q1 and CR10.

d. Check voltage on the cathode of CR9 (front board). This voltage should be 6.1 to 7.5 volts. If low or high, check CR9, Q2, or C65.

Step 3. OSCILLATOR BALANCE.

Refer to paragraph 5-14, Auxiliary Equipment, above for the construction of the Oscillator Balance probe necessary for this test. Connect oscillator balance test assembly to transformer T5 side of R94 and R95 (usually green and green-white wires). Connect an AC Voltmeter, such as the hp 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 of T5 for minimum reading (should be less than 50 millivolts). Lock slug and remove meter and probe.

Table 5-2. Adjustment Procedure (Cont'd)

Step 4. OSCILLATOR FREQUENCY.

Connect electronic counter, such as (hp) Model 5212A/5512A Electronic Counter, to one side of T3 secondary--either orange-white or green-white wires at top of 428B-75B (center) terminal board. Frequency should be 40 kc ±200 cycles. If not, pad C52 to set the frequency. Remove counter.

Step 5. OSCILLATOR LEVEL.

Connect ac voltmeter, such as (hp) Model 400D/H/L, to transformer T5 side of either R94 or R95 (usually green and green-white wire) on terminal board 428B-75 E) board furthest from front panel). Level should be 7.6 to 8.4 volts rms. If not, adjust oscillator level control R92 to set level to 8 volts rms. Remove meter.

Step 6. DETECTOR GATE.

Connect ac voltmeter, such as (hp) 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. SETUP FOR ALIGNMENT OF TUNED AMPLIFIER.

Connect an ac voltmeter, such as the (hp) Model 400D/H/L to pin 2 or 7 of V2. Set 400D/H/L to 1 volt range. Clip 428B probe around wire carrying 35ma rms ac monitored by an external meter as appears in the ac generator portion of figure 5-5. Adjust 150 ohm potentiometer for 3.5 vac across the 100-ohm resistor. Set 428B RANGE switch to 100 MA. Keep this setup for the next three steps.

Step 9. INPUT ALIGNMENT.

Adjust C2 (input tune) on smallest terminal board (428B-75D) for a maximum reading on 400D (approximately 0.1 volt).

Step 10. INTERSTAGE PRIMARY ALIGNMENT.

Connect a 0.0082 μf capacitor across secondary of T1 (green and white/orange leads). 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 11. INTERSTAGE SECONDARY ALIGNMENT.

Connect a 0.0082 μf capacitor across primary of T1 (red and blue leads). Adjust top (secondary) slug of T1 for maximum reading of 400D/H/L (0.01 volt range) and lock slug. Remove capacitor and voltmeter. Keep the base of Q1 grounded by means of the clip-lead.

Step 12. DETECTOR PHASE ADJUSTMENT.

Clip a 390 ohm resistor across the "FEEDBACK DISCONNECT" terminals. Connect the horizontal input of an oscilloscope, such as (hp) Model 140A/175A, to pin 2 or 7 of V5. Connect vertical input to pin 2 or 7 of V2. Leave 428B probe around wire carrying 35ma ac (3.5volt ac) across 100-ohm monitored by an external meter (see figure 5-5). Turn 428B to 100 ma range. Turn slug L7 so pattern on oscilloscope looks like a "bow tie" with its knot symmetrical (see figure 5-6A 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 5-6C illustrates an incorrect adjustment with the top intersection, not over the bottom intersection. Remove 390-ohm resistor.

Step 13. DC AMPLIFIER LOOP GAIN.

Remove the clip-lead from the base of Q1 and connect a short (6 inch or less) clip-lead across the secondary of T1. Turn Meter Cal. potentiometer R69 to its maximum clockwise position (minimum resistance). Connect a 1500-ohm resistor between pin 2 V6 and pin 4 of V6. Connect ac voltmeter (set to 30 mv range) between pin 2 of V6 and chassis ground. Connect a dc voltmeter in parallel with the ac voltmeter and vary dc voltmeter indication from -0.5 volt to +0.5 volt by adjusting R46 DC Amp. Bal. The ac voltmeter should read less than 25 mv for both the -0.5 and +0.5 volt readings. Zero Model 428B meter with R46. Remove clip-lead, 1500 ohm resistor, and voltmeters.

Step 14. NOISE.

Turn Model 428B on with no input to probe, feedback still disconnected. Set RANGE switch to 30 MA. In any 5 second period the 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.

Table 5-2. Adjustment Procedure (Cont'd)

Step 15
PRELIMINARY ADJUSTMENT OF ZERO POTS

Ground base of Q1. Always perform this step before steps 16 and 17. Do NOT alter the position of these potentiometers until step 17. Turn the 90° Zero Adj. R84 and front panel ZERO potentiometer R82 to center position as follows:

Turn Model 428B RANGE switch to 300 MA. Connect an ac voltmeter, such as the hp Model 400D/H/L Vacuum Tube Voltmeter, to the center arm of the 90° Zero Adj. potentiometer R84. Adjust R84 for minimum reading on the 400D/H/L(0. 1 volt range). Connect an ac voltmeter (400D/H/L) to center arm of ZERO adjust potentiometer R82. Adjust R82 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 17.

Step 16
DRIVE BALANCE ADJUSTMENT

Thoroughly clean probe head jaws (see paragraph 5-9). Degauss probe head completely (see paragraph 3-10). Set Model 428B RANGE switch to 1 MA. Connect an ac voltmeter, such as the hp Model 400D/H/L to pin 2 or 7 of V2. With no input to 428B probe set Dr. Amp. Bal. potentiometer R98 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 0. 5 volt. If no minimum can be reached, replace V8. Leave 400D/H/L connected.

Step 17
RECONNECT FEEDBACK AND CANCELLATION OF HEAD RESIDUAL OUTPUT

Replace the lead removed in step 1 and remove clip-lead to Q1. Leave 400D/H/L connected to pin 2 or 7 of V2. Leave 428B on 1 ma range. Degauss probe. Zero 428B meter with front panel ZERO adjustment knob (see figure 3-1). With 400D/H/L set to 0. 3 volt range, adjust 90° Zero Adj. potentiometer R84 for a minimum 400D reading (approximately 0. 02 volt). Adjusting R84 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 18
EARTH'S FIELD EFFECT

Point probe east and west, and rotate about its axis. Note peak-to-peak change in meter reading on the 1 ma range. This swing should not exceed 0. 1 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 14.

Step 19
RANGE TO RANGE ZERO

Turn the Model 428B RANGE switch to 1 MA. Zero-set meter with ZERO panel knob R82. Turn RANGE switch slowly through all ranges and check that zero falls right on for all ranges. If the needle does not fall on zero (±1. 2%) for all ranges, recheck steps 15, 16, and 17. Recheck the mechanical zero setting.

Step 20
ZERO CONTROL RANGE

Switch Model 428B RANGE switch to 30 MA. Zero meter with ZERO control knob R82. Clip 428B probe around wire carrying 10 ma dc monitored by an external meter (see figure 5-4). Note reading on 428B. Turn ZERO control in both directions: 428B should have at least 5 ma zero adjustment range in each direction.

Step 21
CHANGE OF ZERO SETTING WITH LINE VOLTAGE

Connect the Model 428B to a variable source of line voltage, such as a variable auto-transformer. Set the needle on a scale division with the ZERO adjust knob R82. 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 15, 16, 17 and 20.

Step 22
OUTPUT CALIBRATION

Connect the 428B probe as shown in figure 5-9 looping the wire through the probe ten times (see figure 3-4). Connect a dc voltmeter as in figure 5-9 so that it acts as a differential voltmeter measuring the difference between the 1 volt developed across the 10 ohm resistor (by the 100 ma) and the voltage out of the front panel OUTPUT jack.

Turn the OUTPUT LEVEL control to the CALIBRATE position (fully counterclockwise). Turn RANGE switch on 428B to 1 AMPERE. Adjust R63 until there is an indication of less than 5 millivolts on the dc voltmeter.

Step 23
RANGE CALIBRATION

Set Model 428B RANGE switch to 1 MA. Zero-set needle with ZERO panel knob R82. 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. R69 so meter reads 100 ma exactly.

Table 5-2. Adjustment Procedure (Cont'd)

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

c. Check calibration on all other current ranges, starting with 1 ma range, etc. Full scale reading should remain within 3% on all ranges.

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

Step 24
CURRENT CHECK

Turn Model 428B to 100 MA range and clip 428B probe over lead (usually violet) going to F3 from board 428B-75F. Meter on 428B should read 66 ± 2 ma. If not, determine which section of the instrument is not drawing the proper current.

Step 25
AC OVERLOAD

Zero-set Model 428B on 3 ma range. Supply ac through probe (see figure 5-4). With ZERO control set needle on Model 428B to full scale. Increase ac until dc indication on Model 428B drops 2%. This ac voltage should be at least 0.25 volts rms (2.5 ma rms, 3.6 ma peak). If not, recheck loop gain.

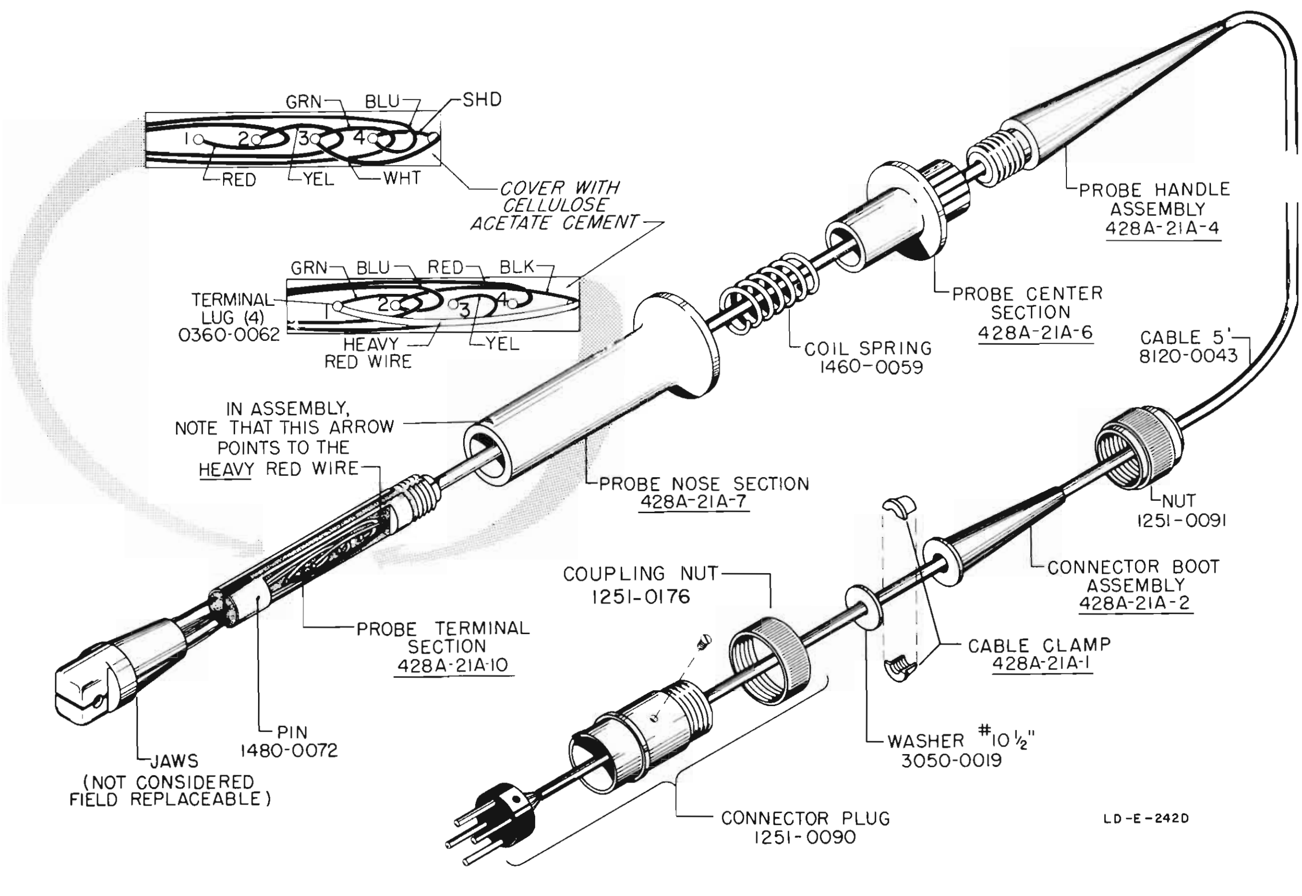


Figure 5-8. Exploded View of Probe

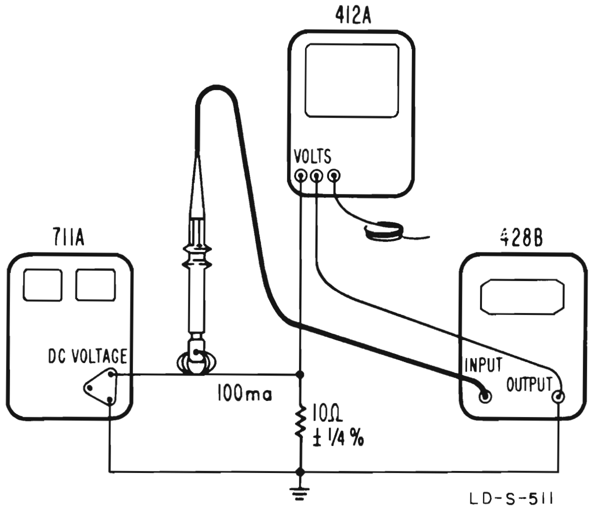


Figure 5-9. Output Calibration Test Setup

5-37. FINAL CHECK.

5-38. Three tests (paragraphs 5-40, 5-42, and 5-45) performed with the instrument in its cabinet indicate whether the circuits are operating normally. The tests can be used as incoming inspection checks. See the following figures for equipment setups for these tests:

Figure 5-2. Electrical Zero Set
Figure 5-3. DC Current Indication

5-39. For the accuracy check use setup of figure 5-3, DC Current Indication. The accuracy check consists of Range Calibration and Meter Tracking.

5-40. RANGE CALIBRATION.

5-41. Check: Zero Model 428B on 1 MA range. Switch to 100 ma current range.

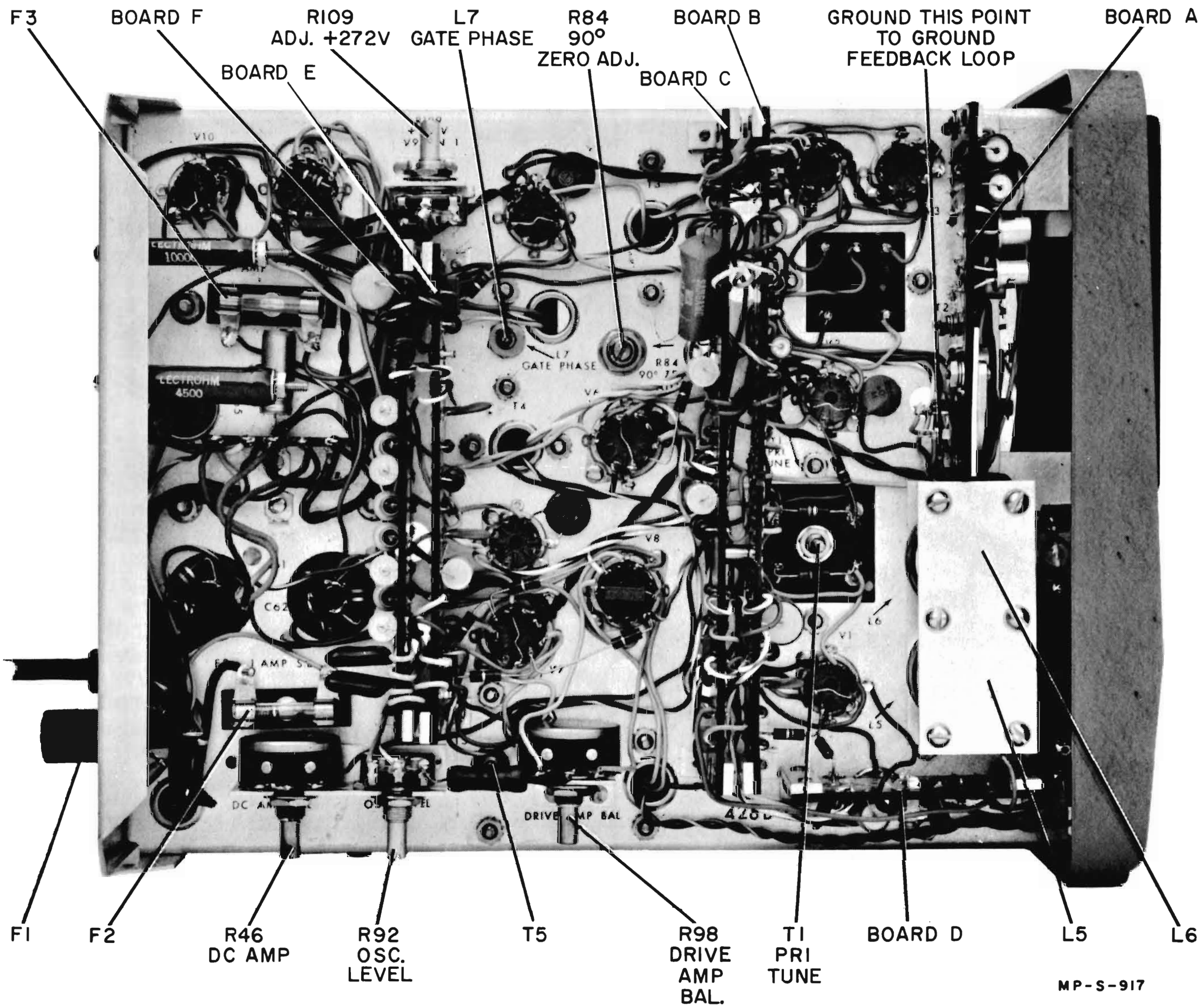


Figure 5-10. Left Side Internal View Model 428B

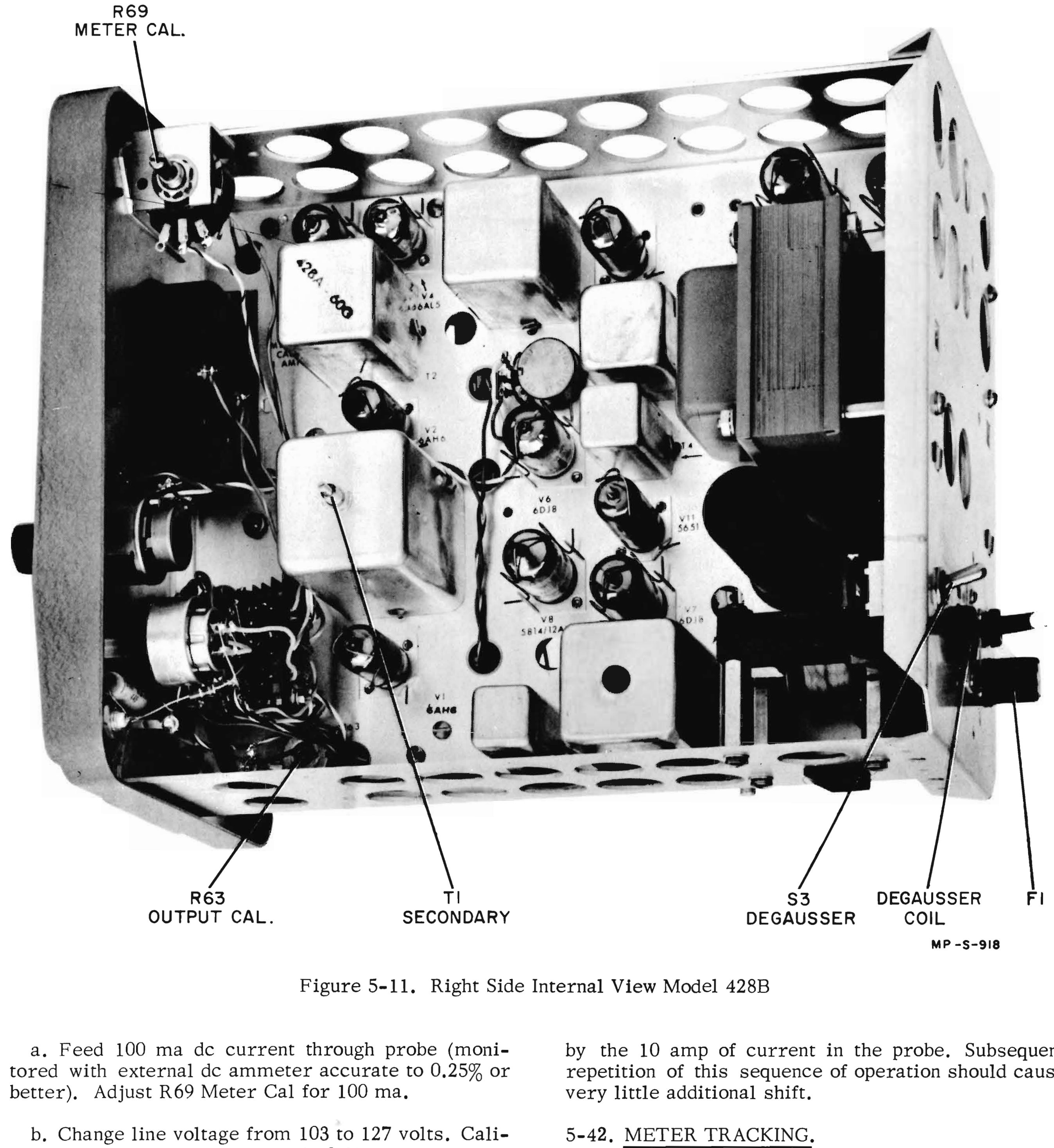


Figure 5-11. Right Side Internal View Model 428B

a. Feed 100 ma dc current through probe (monitored with external dc ammeter accurate to 0.25% or better). Adjust R69 Meter Cal for 100 ma.

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

c. Repeat step a for all other current ranges, i.e. 300 ma, 100 ma, etc. Full-scale reading should remain within 3% on all ranges. If not, check range switch.

NOTE: Be sure that zero-set is adjusted each time in this check. If the meter is zero-set on 1 ma range and current ranges are gradually increased to the 10 amp range, it is normal for the zero-set to be off when the instrument is returned to the 1 ma range. This is caused by a slight residual magnetism induced by the 10 amp of current in the probe. Subsequent repetition of this sequence of operation should cause very little additional shift.

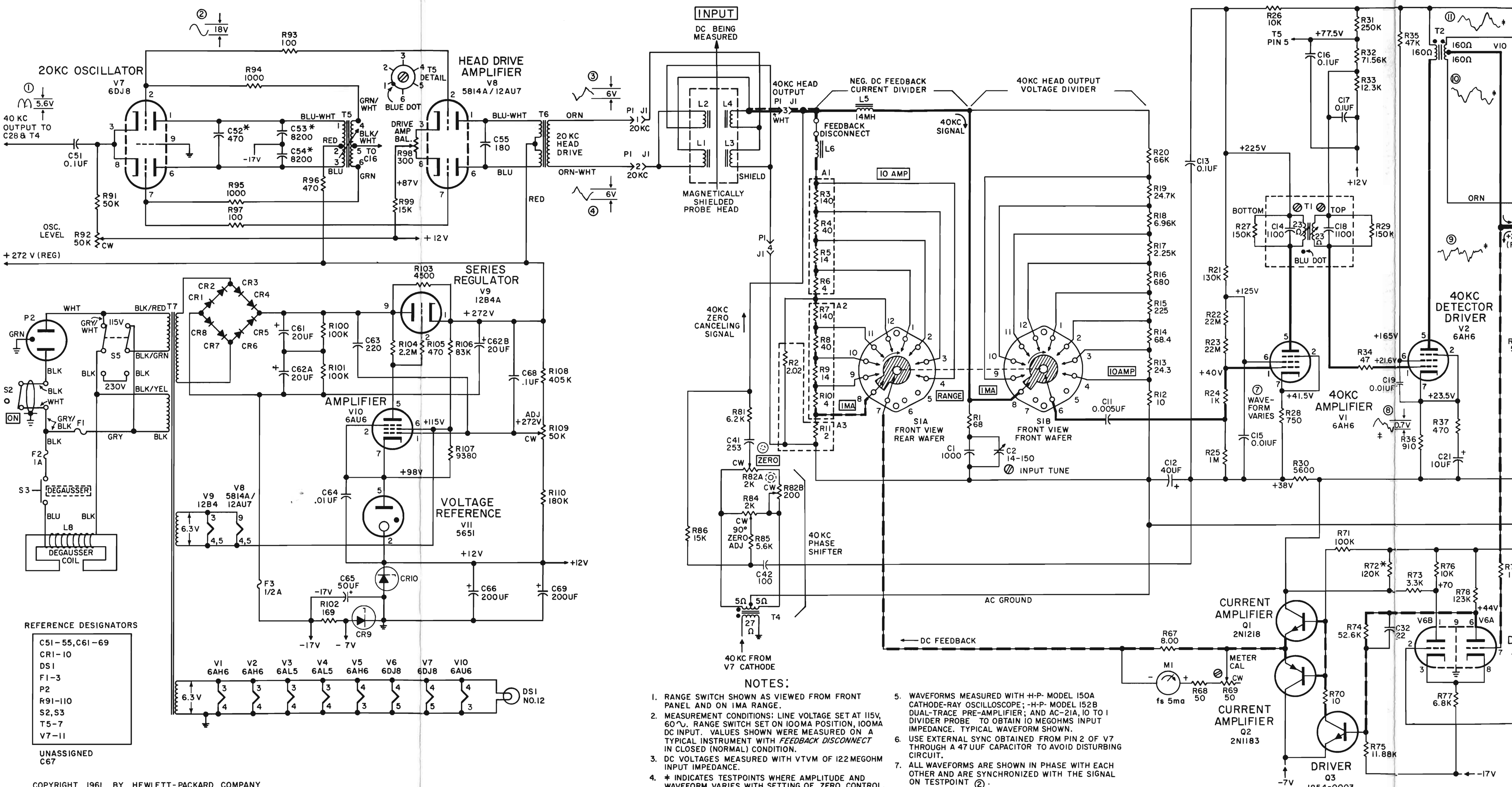
5-42. METER TRACKING.

5-43. Check: Zero Model 428B on 1 MA range. Switch to 100 ma range.

5-44. Feed 100 ma dc current through probe. Monitor dc current with external ±0.25% accuracy or better dc ammeter. Reduce current and check tracking of Model 428B meter with inserted dc ammeter. Reading should stay within 3% of full scale at any point of the range.

5-45. BANDWIDTH (LOOP GAIN).

5-46. Check loop gain as indicated in step 18 of table 5-2, Adjustment Procedure.



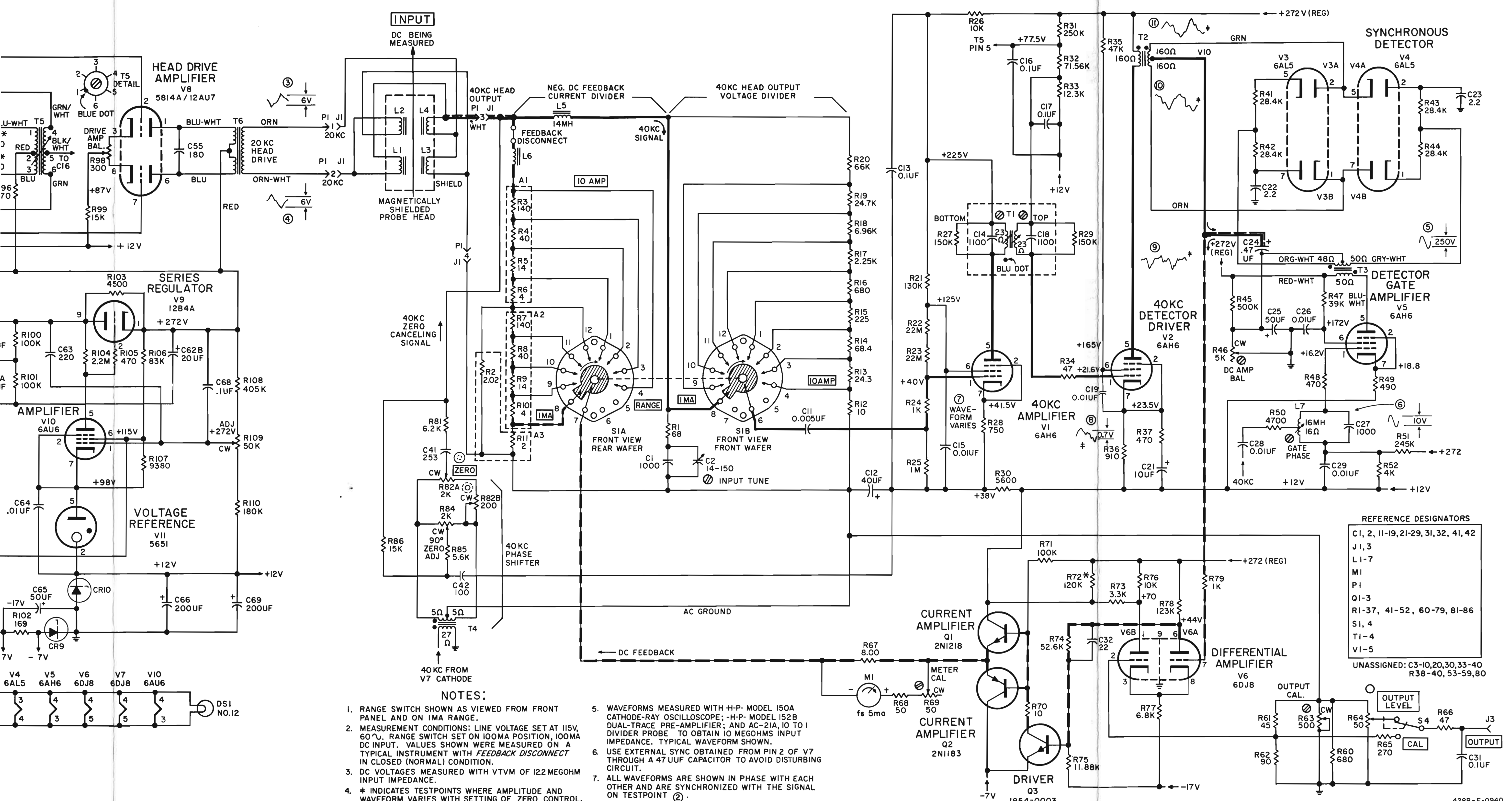
REFERENCE DESIGNATORS

C51-55,C61-69
CR1-10
DS1
F1-3
P2
R91-110
S2,S3
T5-7
V7-11

UNASSIGNED
C67

NOTES:

1. RANGE SWITCH SHOWN AS VIEWED FROM FRONT PANEL AND ON 1MA RANGE.
2. MEASUREMENT CONDITIONS: LINE VOLTAGE SET AT 115V, 60∿. RANGE SWITCH SET ON 100MA POSITION, 100MA 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. * INDICATES TESTPOINTS WHERE AMPLITUDE AND WAVEFORM VARIES WITH SETTING OF ZERO CONTROL.
5. WAVEFORMS MEASURED WITH -hp- MODEL 150A CATHODE-RAY OSCILLOSCOPE; -hp- MODEL 152B DUAL-TRACE PRE-AMPLIFIER; AND AC-21A, 10 TO 1 DIVIDER PROBE TO OBTAIN 10 MEGOHMS INPUT IMPEDANCE. TYPICAL WAVEFORM SHOWN.
6. USE EXTERNAL SYNC OBTAINED FROM PIN 2 OF V7 THROUGH A 47 UUF CAPACITOR TO AVOID DISTURBING CIRCUIT.
7. ALL WAVEFORMS ARE SHOWN IN PHASE WITH EACH OTHER AND ARE SYNCHRONIZED WITH THE SIGNAL ON TESTPOINT ②.



NOTES:

1. RANGE SWITCH SHOWN AS VIEWED FROM FRONT PANEL AND ON 1MA RANGE.
2. MEASUREMENT CONDITIONS: LINE VOLTAGE SET AT 115V, 60∿. RANGE SWITCH SET ON 100MA POSITION, 100MA 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. * INDICATES TESTPOINTS WHERE AMPLITUDE AND WAVEFORM VARIES WITH SETTING OF ZERO CONTROL.
5. WAVEFORMS MEASURED WITH -H-P- MODEL 150A CATHODE-RAY OSCILLOSCOPE; -H-P- MODEL 152B DUAL-TRACE PRE-AMPLIFIER; AND AC-21A, 10 TO 1 DIVIDER PROBE TO OBTAIN 10 MEGOHMS INPUT IMPEDANCE. TYPICAL WAVEFORM SHOWN.
6. USE EXTERNAL SYNC OBTAINED FROM PIN 2 OF V7 THROUGH A 47 UUF CAPACITOR TO AVOID DISTURBING CIRCUIT.
7. ALL WAVEFORMS ARE SHOWN IN PHASE WITH EACH OTHER AND ARE SYNCHRONIZED WITH THE SIGNAL ON TESTPOINT ②.

REFERENCE DESIGNATORS
C1, 2, 11-19, 21-29, 31, 32, 41, 42
J1, 3
L1-7
M1
P1
Q1-3
R1-37, 41-52, 60-79, 81-86
S1, 4
T1-4
V1-5

UNASSIGNED: C3-10, 20, 30, 33-40
R38-40, 53-59, 80

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ⓗⓟ stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their ⓗⓟ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

6-3. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

6-4. ORDERING INFORMATION.

6-5. To order a replacement part, address order or inquiry either to your nearest Hewlett-Packard field office or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S.A.
54 Route des Acacias
Geneva, Switzerland.

6-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

6-7. To order a part not listed in tables 6-1 and 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly
B = motor
C = capacitor
CR = diode
DL = delay line
DS = device signaling (lamp)
E = misc electronic part
F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter
MP = mechanical part
P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer
V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
XF = fuseholder
XV = tube socket
XDS = lampholder

ABBREVIATIONS

a = amperes

bp = bandpass
bwo = backward wave oscillator

c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube

dep = deposited

EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by ⓗⓟ stock numbers.

elect = electrolytic
encap = encapsulated

f = farads
fxd = fixed

Ge = germanium
grd = ground (ed)

h = henries
Hg = mercury

impg = impregnated
incd = incandescent
ins = insulation (ed)

K = kilo = 1000

lin = linear taper
log = logarithmic taper

m = milli = 10^{-3}
M = megohms
ma = milliamperes
μ = micro = 10^{-6}
minat = miniature
mfgl = metal film on glass
mfr = manufacturer

mtg = mounting
my = mylar

NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero (zero temperature coefficient)
nsr = not separately replaceable

obd = order by description

p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
piv = peak inverse voltage
pos = position(s)
poly = polystyrene
pot = potentiometer

rect = rectifier

rot = rotary
rms = root-mean-square
rmo = rack mount only

s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sl = slide

td = time delay
TiO_2 = titanium dioxide

tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube

var = variable
w/ = with
W = watts
ww = wirewound
w/o = without

* = optimum value selected at factory, average value shown (part may be omitted)

01194-3

Table 6-1. Reference Designation Index

Circuit Reference	Stock No.	Description #	Note
A1, 2	428B-26A	Assembly: ww resistor, A1 includes, R3 thru R6 A2 includes, R7 thru R10	
A3	428B-26B	Assembly: ww resistor, includes R2, 11	
C1	0140-0099	fxd, mica, 1K pf ±1%, 500 vdcw	
C2	0131-0004	var, mica, 14-150 pf, 175 vdcw	
C3 thru C10		Not Assigned	
C11	0150-0014	fxd, cer, 5K pf, 500 vdcw	
C12	0180-0050	fxd, elect, 40 uf -15% + 100%, 50 vdcw	
C13	0170-0022	fxd, my, 0.1 uf ±20%, 600 vdcw	
C14		nsr, part of T1 assembly	
C15	0150-0012	fxd, cer, 10K pf ±20%, 1000 vdcw	
C16, 17	0170-0019	fxd, my, 0.1 uf ±5%, 200 vdcw	
C18		nsr, part of T1 assembly	
C19	0150-0012	fxd, cer, 10K pf ±20%, 1000 vdcw	
C20		Not Assigned	
C21	0180-0059	fxd, elect, 10 uf -10% + 100%, 25 vdcw	
C22, 23	0150-0015	fxd, TiO_2 2.2 pf ±10%, 500 vdcw	
C24	0170-0078	fxd, my, 0.47 uf ±5%, 150 vdcw	
C25	0180-0058	fxd, elect, 50 uf -10% + 100%, 25 vdcw	
C26	0150-0012	fxd, cer, 10K pf ±20% 1000 vdcw	
C27	0140-0099	fxd, mica, 1K pf ±1%, 500 vdcw	
C28, 29	0150-0012	fxd, cer, 10K pf ±20%, 1000 vdcw	
C30		Not Assigned	
C31	0170-0019	fxd, my, 0.1 uf ±5%, 200 vdcw	
C32	0140-0034	fxd, mica, 22 pf ±5%, 500 vdcw	
C33 thru C40		Not Assigned	
C41	0140-0108	fxd, mica, 253 pf ±2%, 300 vdcw	
C42	0140-0041	fxd, mica, 100 pf ±5%, 500 vdcw	
C43 thru C50		Not Assigned	
C51	0170-0019	fxd, my, 0.1 uf ±5%, 200 vdcw	
C52	0140-0149	fxd, mica, 470*pf ±5%, 300 vdcw	
C53, 54	0140-2102	fxd, mica, 8.2K*pf ±2%, 500 vdcw	
C55	0140-0147	fxd, mica, 180 pf ±5%, 500 vdcw	
C56 thru C60		Not Assigned	
C61	0180-0011	fxd, elect, 20 uf, 450 vdcw	
C62A/B	0180-0012	fxd, elect, 2 sect, 20 uf/sect, 450 vdcw	
C63	0140-0031	fxd, mica, 220 pf ±10%, 500 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description #	Note
C64	0150-0012	fxd, cer, 10K ρf ±20%, 1000 vdcw	
C65	0180-0058	fxd, elect, 50μf -10% + 100%, 25 vdcw	
C66	0180-0104	fxd, elect, 200 μf, 15 vdcw	
C67		Not Assigned	
C68	0170-0022	fxd, my, 0.1 μf ±20%, 600 vdcw	
C69	0180-0104	fxd, elect, 200 μf, 15 vdcw	
CR1 thru CR8	1901-0028	Diode, Si	
CR9	1902-0013	Diode, Si	
CR10	1902-0014	Diode, Si	
DS1	2140-0012	Lamp: indicating, #12, 2 pin base	
F1, 2	2110-0007	Fuse: 1 amp, s-b (F1 115 V operation)	
	2110-0008	Fuse: 1/2 amp, s-b (F1 230 V operation)	
F3	2110-0012	Fuse: 1/2 amp	
J1	1251-0089	Connector: female, 4 pin	
J2		Not Assigned	
J3	1250-0118	Connector: BNC, female	
L1 thru L4		nsr; part of probe assembly (see misc.)	
L5, 6	428B-60K	Assembly, choke	
L7	9140-0049	Inductor: var, 16 mh	
L8	9110-0025	Inductor: degaussing	
M1	1120-0116	Meter: 0-5 ma, 6-10 ohms	
P1	1251-0090	Connector: male, 4 pin	
P2	8120-0050	Cable, power	
Q1	1854-0039	Transistor: Si NPN 2N3053	
Q2	1853-0016	Transistor: Si PNP 2N3638	
Q3	1854-0003	Transistor: 2N1564	
R1	0687-6801	fxd, comp, 68 ohms ±10%, 1/2 W	
R2		nsr; part of A3 assembly	
R3 thru R10		nsr; part of A1, A2 assembly	
R11		nsr; part of A3 assembly	
R12	0727-0335	fxd, dep c, 10 ohms ±10%, 1/2 W	
R13	0757-0002	fxd, mfg, 24.3 ohms ±1%, 1/2 W	
R14	0727-0035	fxd, dep c, 68.4 ohms ±1/2%, 1/2 W	
R15	0727-0060	fxd, dep c, 225 ohms ±1%, 1/2 W	
R16	0727-0085	fxd, dep c, 680 ohms ±1%, 1/2 W	
R17	0727-0120	fxd, dep c, 2250 ohms ±1%, 1/2 W	
R18	0727-0145	fxd, dep c, 6960 ohms ±1%, 1/2 W	
R19	0727-0178	fxd, dep c, 24.7K ohms ±1%, 1/2 W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
R20	0727-0198	fxd, dep c, 66K ohms ±1%, 1/2 W	
R21	0686-1345	fxd, comp, 130K ohms ±5%, 1/2 W	
R22, 23	0687-2261	fxd, comp, 22M ±10%, 1/2 W	
R24	0687-1021	fxd, comp, 1K ohms ±10%, 1/2 W	
R25	0687-1051	fxd, comp, 1M ±10%, 1/2 W	
R26	0687-1031	fxd, comp, 10K ohms ±10%, 1/2 W	
R27	0687-1541	fxd, comp, 150K ohms ±10%, 1/2 W	
R28	0689-7515	fxd, comp, 750 ohms ±5%, 1 W	
R29	0687-1541	fxd, comp, 150K ohms ±10%, 1/2 W	
R30	0687-5621	fxd, comp, 5.6K ohms ±10%, 1/2 W	
R31	0727-0226	fxd, dep c, 250K ohms ±1%, 1/2 W	
R32	0727-0201	fxd, dep c, 71.56K ohms ±1%, 1/2 W	
R33	0730-0032	fxd, dep c, 12.3K ohms ±1%, 1 W	
R34	0687-4701	fxd, comp, 47 ohms ±10%, 1/2 W	
R35	0690-4731	fxd, comp 47K ohms ±10%, 1 W	
R36	0689-9115	fxd, comp, 910 ohms ±5%, 1 W	
R37	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R38 thru R40		Not Assigned	
R41 thru R44	0727-0184	fxd, dep c, 28.4K ohms ±1%, 1/2 W	
R45	0727-0244	fxd, dep c, 500K ohms ±1%, 1/2 W	
R46	2100-0006	var, ww, 5K ohms ±10%, 2 W	
R47	0689-3935	fxd, comp, 39K ohms ±5%, 1 W	
R48	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R49	0727-0075	fxd, dep c, 490 ohms ±1%, 1/2 W	
R50	0687-4721	fxd, comp, 4.7K ohms ±10%, 1/2 W	
R51	0730-0080	fxd, dep c, 245K ohms ±1%, 1 W	
R52	0727-0132	fxd, dep c, 4K ohms ±1%, 1/2 W	
R53 thru R59		Not Assigned	
R60	0687-6811	fxd, comp, 680 ohms ±10%, 1/2 W	
R61	0727-0021	fxd, dep c, 45 ohms ±1%, 1/2 W	
R62	0727-0038	fxd, dep c, 90 ohms ±1%, 1/2 W	
R63	2100-0022	var, ww, lin, 500 ohms ±20%, 1 W	
R64	2100-0270	var, ww, lin, 50 ohms ±10%, 2 W	
R65	0687-2711	fxd, comp, 270 ohms ±10%, 1/2 W	
R66	0687-4701	fxd, comp, 47 ohms ±10%, 1/2 W	
R67	0812-0015	fxd, ww, 8 ohms ±3%, 2 W	
R68	0727-0023	fxd, dep c, 50 ohms ±1%, 1/2 W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description #	Note
R69	2100-0002	var, ww, 50 ohms ±10%, 2 W	
R70	0687-1001	fxd, comp, 10 ohms ±10%, 1/2 W	
R71	0693-1041	fxd, comp, 100K ohms ±10%, 2 W	
R72	0690-1241	fxd, comp, 120K ohms ±10%, 1 W	
R73	0764-0003	fxd, mfg, 3300 ohms ±5%, 2 W	
R74	0727-0196	fxd, dep c, 52.6K ohms ±1%, 1/2 W	
R75	0727-0163	fxd, dep c, 11.88K ohms ±1%, 1/2 W	
R76	0816-0008	fxd, ww, 10K ohms ±10%, 10 W	
R77	0687-6821	fxd, comp, 6.8K ohms ±10%, 1/2 W	
R78	0730-0072	fxd, dep c, 123K ohms ±1%, 1 W	
R79	0687-1021	fxd, comp, 1K ohms ±10%, 1/w	
R80		Not Assigned	
R81	0686-6225	fxd, comp, 6.2K ohms ±5%, 1/2 W	
R82A/B	2100-0197	var, comp, dual pot, ±10%, 2 W R82A, 2K ohms R82B, 200 ohms	
R83		Not Assigned	
R84	2100-0153	var, comp, 2K ohms ±20% 1/3 W	
R85	0687-5621	fxd, comp, 5.6K ohms ±10%, 1/2 W	
R86	0687-1531	fxd, comp, 15K ohms ±10%, 1/2 W	
R87 thru R90		Not Assigned	
R91	0727-0195	fxd, dep c, 50K ohms ±1%, 1/2 W	
R92	2100-0013	var, comp, lin, 50K ohms ±20%	
R93	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R94, 95	0687-1021	fxd, comp, 1K ohms ±10%, 1/2 W	
R96	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R97	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R98	2100-0038	var, ww, 300 ohms	
R99	0767-0010	fxd, mfg, 15K ohms ±5%, 3 W	
R100, 101	0690-1041	fxd, comp, 100K ohms ±10%, 1 W	
R102	0811-0041	fxd, ww, 169 ohms ±1%, 3 W	
R103	0819-0011	fxd, ww, 4.5K ohms ±10%, 20 W	
R104	0687-2251	fxd, comp, 2.2M ±10%, 1/2 W	
R105	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R106	0730-0063	fxd, dep c, 83K ohms ±1%, 1 W	
R107	0727-0154	fxd, dep c, 9380 ohms ±1%, 1/2 W	
R108	0727-0240	fxd, dep c, 405K ohms ±1%, 1/2 W	
R109	2100-0013	var, comp, lin, 50K ohms ±20%	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	hp Stock No.	Description#	Note
R110	0727-0218	fxd, dep c, 180K ohms ±1%, 1/2 W	
S1	428B-19A	Assembly: range switch, includes, R2 thru R20, R61, R62	
S2	3101-0001	Switch: tog, SPST	
S3	3101-0018	Switch: tog, SPST, momentary	
S4		Not Assigned	
S5	3101-0033	Switch, sl: DPDT	
T1	9120-0052	Assembly: transformer, interstage, includes, C14, C18	
T2	428A-60G	Transformer, detector signal	
T3	428A-60C	Transformer, gate	
T4	428B-60J	Transformer, zero balance	
T5	9120-0051	Transformer, osc	
T6	428A-60D	Transformer, head drive	
T7	9100-0104	Transformer, power	
V1, 2	1923-0017	Tube, electron: 6AH6	
V3, 4	1930-0013	Tube, electron: 6AL5	
V5	1923-0017	Tube, electron: 6AH6	
V6, 7	1932-0022	Tube, electron: 6DJ8/ECC88	
V8	1932-0029	Tube, electron: 12AU7	
V9	1921-0010	Tube, electron: 12B4A	
V10	1923-0021	Tube, electron: 6AU6	
V11	1940-0001	Tube, electron: 5651	
		MISCELLANEOUS	
	428A-21A	Assembly: probe, includes L1 thru L4, P1	
	428B-65C	Assembly: circuit board "C" includes R65, R67, R68	
	428B-75H	Assembly: circuit board "A" includes C32, C66, C69, CR9, CR10, Q1 thru Q3, R70, R71 R74, R75, R102	
	428B-75B	Assembly: resistor board "B" includes C13, C15, C21, C25, R21 thru R23, R26, 27, R35, 36, R41, 42, R45, R73	
	428B-75C	Assembly: circuit board "C" includes C16, C17, C24, R43, R44, R77 thru R79, C41, C42, R81, R30 thru R33, R85, R86	
	428B-75D	Assembly: resistor board "D" includes C1, C2, C11, C12, R1, R25	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description#	Note
	428B-75E	Assembly: resistor board "E" includes C27 thru C29 C51 R47 thru R52 R72 R91 R94 thru R96	
	428B-75F	Assembly: resistor board "F" includes C53, C54 C68 CR1 thru CR8 R106 R108 R110	
	G-74AW	Knob: red, 3/4" w/arrow	
	G-74J	Knob: black, 1", concentric shaft ZERO	
	G-74N	Knob: bar, RANGE	
	1200-0003	Socket, tube: 9 pin miniat	
	1200-0017	Socket, tube: 7 pin miniat	
	1400-0008	Fuseholder	
	1400-0084	Fuseholder	
	1450-0020	Jewel, pilot light	
	8520-0017	Electric shaver brush	
	1205-0011	Heat dissipator, semiconductor	

See introduction to this section

Table 6-2. Replaceable Parts

ⓗ Stock No.	Description#	Mfr.	Mfr. Part No.	TQ			
428A-60C	Transformer, gate	28480	428A-60C	1			
428A-60D	Transformer, head drive	28480	428A-60D	1			
428A-60G	Transformer, detector signal	28480	428A-60G	1			
428B-19A	Assembly: range switch, includes R2 thru R20 R61 R62	28480	428B-19A	1			
428B-26A	Assembly: ww resistor, A1 includes R3 thru R6 A2 includes R7 thru R10	28480	428B-26A	2			
428B-26B	Assembly: ww resistor, includes R2, R11	28480	428B-26B	1			
428B-60J	Transformer, zero balance	28480	428B-60J	1			
428B-60K	Assembly, choke	28480	428B-60K	2			
0131-0004	var, mica, 14-150pf, 175 vdcw	72136	obd#	1			
0140-0031	fxd, mica, 220 pf ±10%, 500 vdcw	00853	K1322 B10	1			
0140-0034	fxd, mica, 22 pf ±5%, 500 vdcw	00853	DR1422 E5	1			
0140-0041	fxd, mica, 100 pf ±5%, 500 vdcw	76433	RCM15E101J	1			
0140-0099	fxd, mica, 1K pf ±1%, 500 vdcw	00853	KR1210 E1	2			
0140-0108	fxd, mica, 253 pf ±2%, 300 vdcw	76433	RCM15E(253)G	1			
0140-0147	fxd, mica, 180 pf ±5%, 500 vdcw	72136	DM15F181J	1			
0140-0149*	fxd, mica, 470 pf ±5%, 300 vdcw	72136	DM15F471J	1			
0140-2102	fxd, mica, 8.2K pf ±2%, 500 vdcw	72136	DM30F822G	2			
0150-0012	fxd, cer, 10K pf ±20%, 1000 vdcw	71590	13C Disc	6			
0150-0014	fxd, cer, 5K pf, 500 vdcw	96095	D1-4	1			
0150-0015	fxd, TiO_2, 2.2 pf ±10%, 500 vdcw	82142	type JM	2			
0170-0019	fxd, my, 0.1 μf ±5%, 200 vdcw	84411	type 620S	3			
0170-0022	fxd, my, 0.1 μf ±20%, 600 vdcw	09134	type 27	2			
0170-0078	fxd, my, 0.47 μf ±5%, 150 vdcw	83125	107V474J	1			
0180-0011	fxd, elect, 20 μf, 450 vdcw	56289	D32550	1			
0180-0012	fxd, elect, 2 sect, 20μf/sect, 450 vdcw	56289	obd#	1			
0180-0050	fxd, elect, 40 μf -15% + 100%, 50 vdcw	56289	D32538	1			
0180-0058	fxd, elect, 50 μf -10% + 100%, 25 vdcw	56289	30D186A1	2			
0180-0059	fxd, elect, 10 μf -10% + 100%, 25 vdcw	56289	30D182A1	1			
0180-0104	fxd, elect, 200 μf, 15 vdcw	56289	30D174A1	2			
0686-1345	fxd, comp, 130K ohms ±5%, 1/2 W	01121	EB-1345	1			
0686-6225	fxd, comp, 6.2K ohms ±5%, 1/2 W	01121	EB-6225	1			
0687-1001	fxd, comp, 10 ohms ±10%, 1/2 W	01121	EB-1001	1			
0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	01121	EB-1011	2			
0687-1021	fxd, comp, 1K ohms ±10%, 1/2 W	01121	EB-1021	4			
0687-1031	fxd, comp, 10K ohms ±10%, 1/2 W	01121	EB-1031	1			
0687-1051	fxd, comp, 1M ±10%, 1/2 W	01121	EB-1051	1			
0687-1531	fxd, comp, 15K ohms ±10%, 1/2 W	01121	EB-1531	1			

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

℗ Stock No.	Description#	Mfr.	Mfr. Part No.	TQ			
0687-1541	fxd, comp, 150K ohms ±10%, 1/2 W	01121	EB-1541	2			
0687-2251	fxd, comp, 2.2M ±10%, 1/2 W	01121	EB-2251	1			
0687-2261	fxd, comp, 22M ±10%, 1/2 W	01121	EB-2261	2			
0687-2711	fxd, comp, 270 ohms ±10%, 1/2 W	01121	EB-2711	1			
0687-4701	fxd, comp, 47 ohms ±10%, 1/2 W	01121	EB-4701	2			
0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	01121	EB-4711	4			
0687-4721	fxd, comp, 4.7K ohms ±10%, 1/2 W	01121	EB-4721	1			
0687-5621	fxd, comp, 5.6K ohms ±10%, 1/2 W	01121	EB-5621	2			
0687-6801	fxd, comp, 68 ohms ±10%, 1/2 W	01121	EB-6801	1			
0687-6811	fxd, comp, 680 ohms ±10%, 1/2 W	01121	EB-6811	1			
0687-6821	fxd, comp, 6.8K ohms ±10%, 1/2 W	01121	EB-6821	1			
0689-3935	fxd, comp, 39K ohms ±5%, 1 W	01121	GB-3935	1			
0689-7515	fxd, comp, 750 ohms ±5%, 1 W	01121	GB-7515	1			
0689-9115	fxd, comp, 910 ohms ±5%, 1 W	01121	GB-9115	1			
0690-1041	fxd, comp, 100K ohms ±10%, 1 W	01121	GB-1041	2			
0690-1241*	fxd, comp, 120K ohms ±10%, 1 W	01121	GB-1241	1			
0690-4731	fxd, comp, 47K ohms ±10%, 1 W	01121	GB-4731	1			
0693-1041	fxd, comp, 100K ohms ±10%, 2 W	01121	HB-1041	1			
0727-0021	fxd, dep c, 45 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0023	fxd, dep c, 50 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0035	fxd, dep c, 68.4 ohms ±1/2%, 1/2 W	19701	DC-1/2AR5, obd#	1			
0727-0038	fxd, dep c, 90 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0060	fxd, dep c, 225 ohms ±1%, 1/2 W	19701	DC-1/2 CR5, obd#	1			
0727-0075	fxd, dep c, 490 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0085	fxd, dep c, 680 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0120	fxd, dep c, 2250 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0132	fxd, dep c, 4K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0145	fxd, dep c, 6960 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0154	fxd, dep c, 9380 ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0163	fxd, dep c, 11.88K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0178	fxd, dep c, 24.7K ohms ±1%, 1/2 W	19701	DC-1/2AR5, obd#	1			
0727-0184	fxd, dep c, 28.4K ohms ±1%, 1/2 W	19701	DC-1/2BR5, obd#	4			
0727-0195	fxd, dep c, 50K ohms ±1%, 1/2 W	19701	DC-1/2BR5, obd#	1			
0727-0196	fxd, dep c, 52.6K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0198	fxd, dep c, 66K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0201	fxd, dep c, 71.56K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0218	fxd, dep c, 180K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

ⓗ Stock No.	Description#	Mfr.	Mfr. Part No.	TQ			
0727-0226	fxd, dep c, 250K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0240	fxd, dep c, 405K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1			
0727-0244	fxd, dep c, 500K ohms ±1%, 1/2 W	19701	DC-1/2AR5, obd#	1			
0727-0335	fxd, dep c, 10 ohms ±1%, 1/2 W	19701	CF-1/2, obd#	1			
0730-0032	fxd, dep c, 12.3K ohms ±1%, 1 W	19701	DC1 R5, obd#	1			
0730-0063	fxd, dep c, 83K ohms ±1%, 1 W	19701	type DC-1, obd#	1			
0730-0072	fxd, dep c, 123K ohms ±1%, 1 W	19701	DC1 R5, obd#	1			
0730-0080	fxd, dep c, 245K ohms ±1%, 1 W	19701	DC-1, obd#	1			
0757-0002	fxd, mfg, 24.3 ohms ±1%, 1/2 W	07115	N20	1			
0764-0003	fxd, mfg, 3300 ohms ±5%, 2 W	07115	C-42	1			
0767-0010	fxd, mfg, 15K ohms ±5%, 3 W	07115	LP1-3	1			
0811-0041	fxd, ww, 169 ohms ±1%, 3 W	91637	3W-169-1%	1			
0812-0015	fxd, ww, 8 ohms ±3%, 2 W	91637	RS-2C	1			
0816-0008	fxd, ww, 10K ohms ±10%, 10 W	35434	type C-10	1			
0819-0011	fxd, ww, 4.5K ohms ±10%, 20 W	35434	type C-20	1			
1120-0116	Meter: 0-5 ma, 6-10 ohms	55026	1150H	1			
1250-0118	Connector: BNC, female	91737	UG-1094A/U	1			
1251-0089	Connector: female, 4 pin	02660	91-PC4F	1			
1251-0090	Connector: male, 4 pin	02660	obd#	1			
1853-0016	Transistor: Si PNP 2N3638	07263	2N3638	1			
1854-0039	Transistor: Si NPN 2N3053	86684	2N3053	1			
1854-0003	Transistor: 2N1564	01281	PT1844	1			
1901-0028	Diode, Si	28480	1901-0028	8			
1902-0013	Diode, Si	04713	1.5M6.8Z10	1			
1902-0014	Diode, Si	04713	1.5M12Z10	1			
1921-0010	Tube, electron: 12B4A	33173	obd#	1			
1923-0017	Tube, electron: 6AH6	33173	obd#	3			
1923-0021	Tube, electron: 6AU6	33173	obd#	1			
1930-0013	Tube, electron: 6AL5	33173	obd#	2			
1932-0022	Tube, electron: 6DJ8/ECC88	0000I	6DJ8	2			
1932-0029	Tube, electron: 12AU7	80131	obd#	1			
1940-0001	Tube, electron: 5651	86684	5651	1			
2100-0002	var, ww, 50 ohms ±10%, 2 W	11237	type 252, obd#	1			
2100-0006	var, ww, 5K ohms ±10%, 2 W	11237	type 252, obd#	1			
2100-0013	var, comp, lin, 50K ohms ±20%	71590	obd#	2			
2100-0022	var, ww, lin, 500 ohms ±20%, 1 W	11237	type 112	1			
2100-0038	var, ww, 300 ohms	11237	type 252, obd#	1			

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

ⓗⓟ Stock No.	Description	Mfr.	Mfr. Part No.	TQ			
2100-0153	var, comp, 2K ohms ±20%, 1/3 W	11237	type 45	1			
2100-0197	var, comp, dual pot, ±10%, 2 W R82A, 2K ohms R82B, 200 ohms	11237	C252-45	1			
2100-0270	var, ww, lin, 50 ohms ±10%, 2 W	71450	VF252	1			
2110-0007	Fuse: 1 amp, s-b (for 115V operation)	71400	MDL1	2			
2110-0008	Fuse: 1/2 amp, s-b (for 230V operation)	71400	obd#	0			
2110-0012	Fuse: 1/2 amp	75915	312.500	1			
2140-0012	Lamp: indicating, #12, 2 pin base	24455	GE-12	1			
3101-0001	Switch: tog, SPST	04009	AH&H80994-H	1			
3101-0018	Switch: tog, SPST, momentary	88140	SW 7506K3	1			
3101-0033	Switch, sl: DPDT	42190	4633	1			
8120-0050	Cable, power	70903	CS-9941/PH-151/ 7.5 ft.	1			
9100-0104	Transformer, power	98734	8345	1			
9110-0025	Inductor: degaussing	98734	5185	1			
9120-0051	Transformer, osc	09250	obd#	1			
9120-0052	Assembly: transformer, interstage, includes C14 C18	09250	obd#	1			
9140-0049	Inductor: var, 16 mh	09250	obd#	1			
	MISCELLANEOUS						
G-74AW	Knob: red, 3/4", w/arrow	28480	G-74AW	1			
G-74J	Knob: black, 1", concentric shaft ZERO	28480	G-74J	1			
G-74N	Knob: bar, RANGE	28480	G-74N	1			
428A-21A	Assembly: probe, includes, L1 thru L6 P1 S1 T2 thru T4 T6	28480	428A-21A	1			
428B-65C	Assembly: circuit board "C" includes, R65 R67, R68	28480	428B-65C	1			
428B-75H	Assembly: circuit board "A" includes, C32 C66 C69 CR9, 10 Q1 thru Q3 R70, R71 R74, R75 R102	28480	428B-75H	1			
428B-75B	Assembly: resistor board "B" includes, C13 C15 C21 C25 R21 thru R23 R26, 27 R35, R36 R42 R45 R73	28480	428B-75B	1			
428B-75C	Assembly: circuit board "C" includes, C16, 17 C24 C41, C42 R30 thru R33 R43, R44 R77 thru R79 R81 R85, R86	28480	428B-75C	1			
428B-75D	Assembly: resistor board "D" includes, C1, C2 C11, C12 R1 R25	28480	428B-75D	1			
428B-75E	Assembly: resistor board "E" includes, C27 thru C29 C51 R47 thru R52 R72 R91 R94 thru R96	28480	428B-75E	1			

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

℗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ			
428B-75F	Assembly: resistor board "F" includes, C53,C54 C68 CR1 thru CR8 R106 R108 R110	28480	428B-75F	1			
1200-0003	Socket, tube: 9 pin miniat	71785	44B-20965	4			
1200-0017	Socket, tube: 7 pin miniat	71785	53B-22005	7			
1400-0008	Fuseholder	75915	3510-11	2			
1400-0084	Fuseholder	75915	342014	1			
1450-0020	Jewel, pilot light	72765	14L-15	1			
8520-0017	Electric shaver brush	-----	---------	1			
1205-0011	Heat dissipator, semiconductor						

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00334	Humidail Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermolloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16352	Computer Diode Corp.	Lodi, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association. Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mas .
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

Code No.	Manufacturer	Address
J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

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