

OPERATING AND SERVICE MANUAL

(HP PART NO. 00428-90002)

MODEL 428B CLIP-ON DC MILLIAMMETER

SERIALS PREFIXED: 131-, 601-

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

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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°C to +55°C ± 0.1 ma

PROBE INDUCTANCE:

Less than 0.5 μ h. No noticeable loading, even up to 1 mc.

PROBE INDUCED VOLTAGE:

Less than 15 my 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:

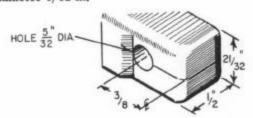
300 volts maximum, dc or peak

POWER:

115 or 230 volts $\pm 10\%$, 50 to 60 cps, approximately 70 watts

PROBE TIP SIZE:

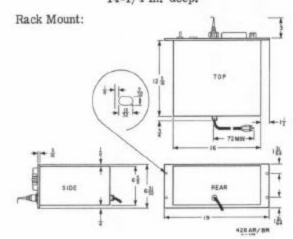
Approximately 1/2 in. by 21/32 in. Aperture diameter 5/32 in.



DIMENSIONS:

LD-5-507

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



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

ACCESSORIES AVAILABLE:

OPTIONS:

01. @Model 3528A Current Probe (Aperture, 2-9/16 in.) in lieu of Model 428A-21A Probe normally supplied

SECTION I

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 μ h. 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

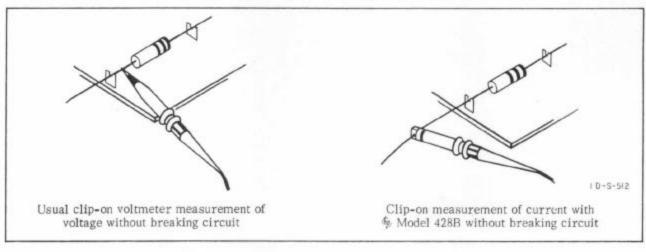


Figure 1-2. Voltage and Current Measurement

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 \$\overline{\text{M}}\$ 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 rackmount 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.

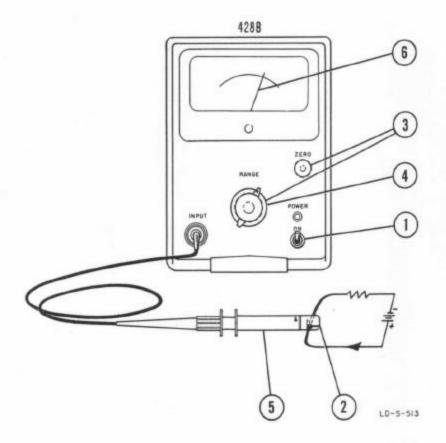
2-17. PREPARATION FOR STORAGE AND SHIPMENT.

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.



- Turn on power and allow approximately 2 minutes warmup time.
- 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).
- Set RANGE switch to 1 ma. Zero-set instrument with ZERO control.
- Set RANGE switch to a range that is higher than the anticipated current to be read.
- 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.

SECTION III

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 zeroset 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. HANDLING OF PROBE.

- 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 <u>important</u> 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 measuredc in a wire carrying more ac than full-scale reading on meter.

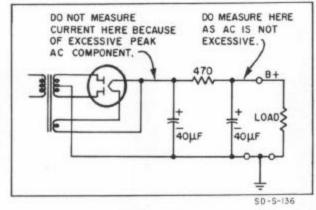


Figure 3-2. Typical Power Supply

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 invery 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

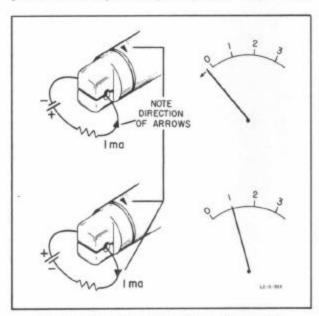


Figure 3-3. Clip Probe Around Wire with Arrow Pointing in Direction of Conventional Current

component may be measured (within the band-pass limitations of the amplifier) with a suitable oscilloscope or meter, as follows:

- 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 inthe CAL (fully counter-clockwise) 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:

- High impedance recorders will be calibrated when the OUTPUT LEVEL control is in the CAL (fully counterclockwise) position.
- Low impedance recorders must be adjusted for a particular sensitivity with the OUTPUT LEVEL control.

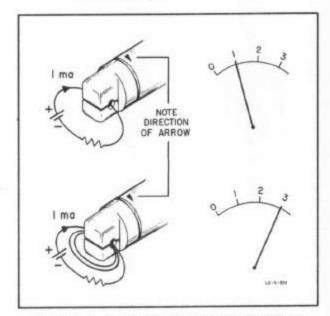


Figure 3-4. Increasing the Absolute Sensitivity by Looping Current Path through Jaws Several Times

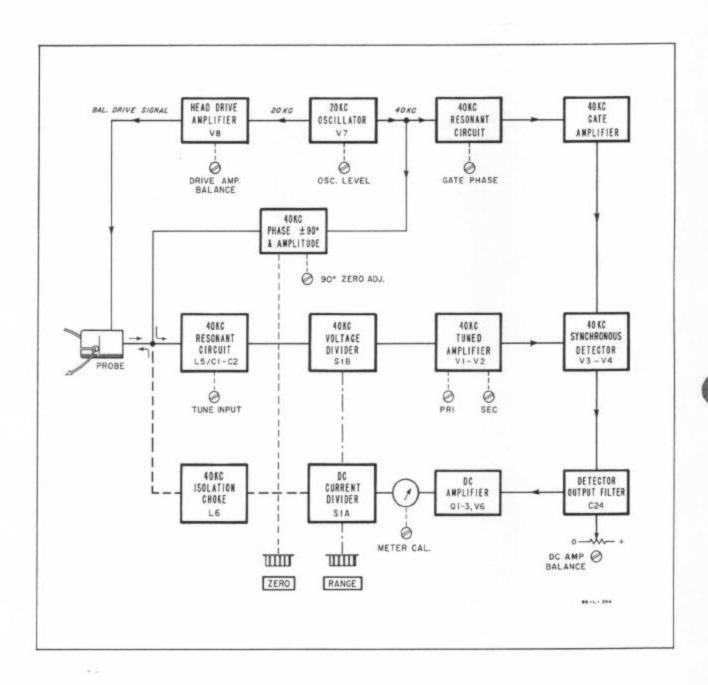


Figure 4-1. Block Diagram Model 428B

SECTION IV

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.

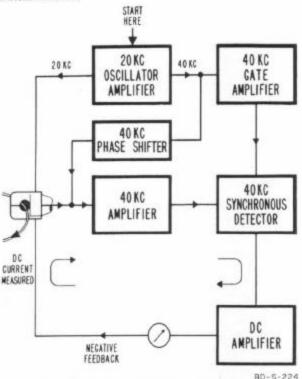


Figure 4-2. Simplified Block Diagram

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.

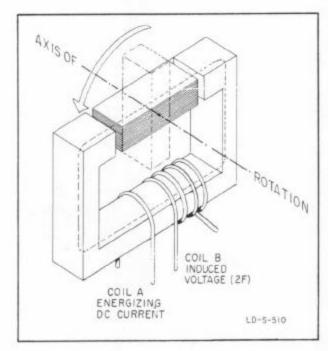


Figure 4-3. Mechanical Flux Gate

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).

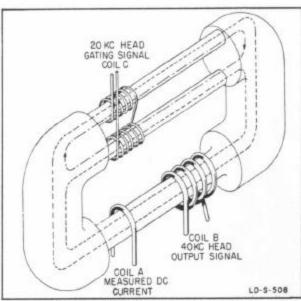


Figure 4-4. Saturable Flux Gate

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.

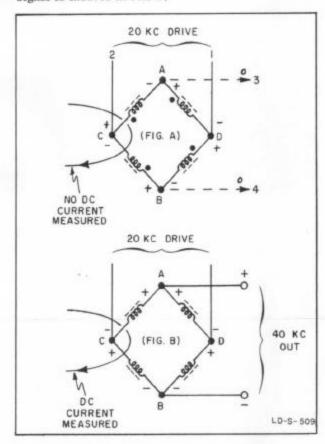


Figure 4-5. Current Probe Bridge Circuit

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 pushpull 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 T2 secondary to T3 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.

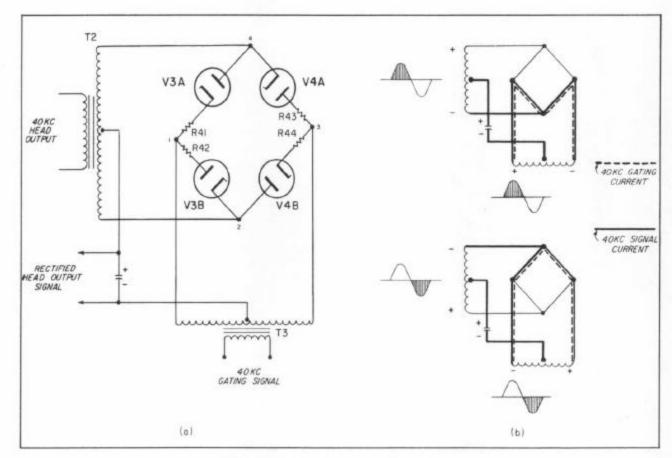


Figure 4-6. Synchronous Detector

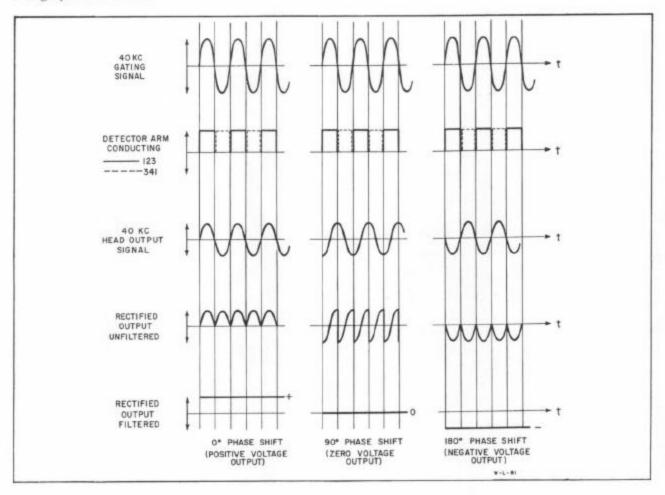


Figure 4-7. Change of Output of Synchronous Detector with Phase

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.

^{*} 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.

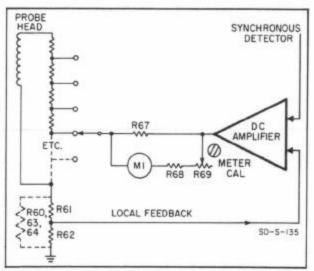


Figure 4-8, Feedback Current Circuit

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

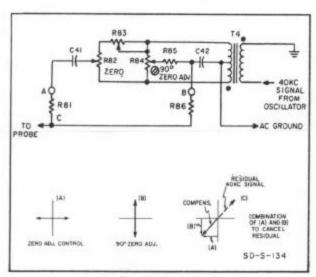


Figure 4-9. 40 KC Phase Shifter

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.

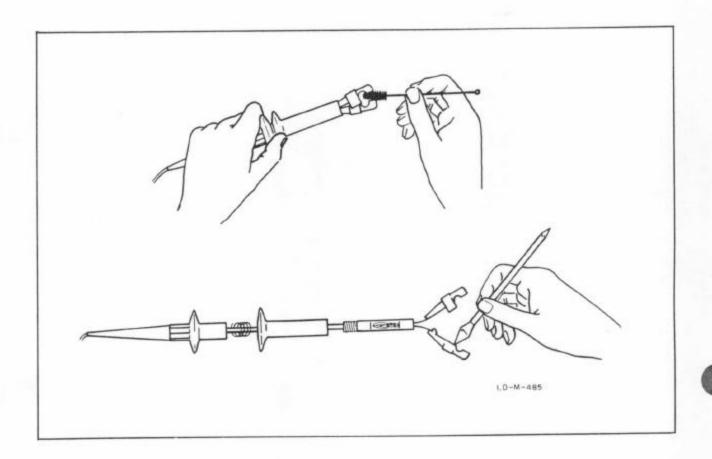


Figure 5-1. Cleaning Probe Jaws

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.
- 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 mat-

ing 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.

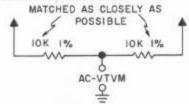
5-13. TEST INSTRUMENTS.

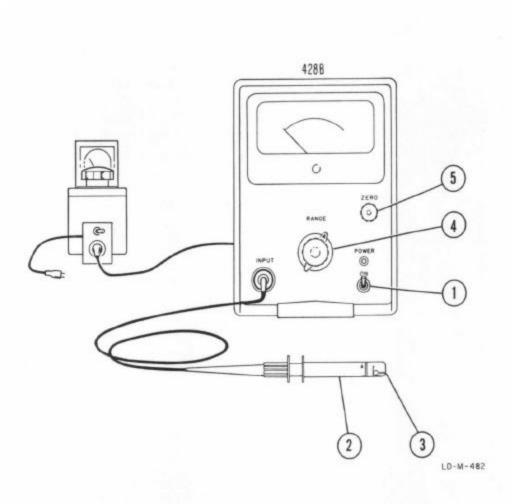
- a. Oscilloscope with dual channel plug-in, such as @ Model 140A, 175A or equivalent.
- b. AC Vacuum Tube Voltmeter, such as

 Model 400D or equivalent.
- c. DC Vacuum Tube Voltmeter, such as @ Model 412A, 410C or equivalent (1% accuracy at 280 volts).
- d. Electronic Counter, such as
 Model 5212A, 5512A etc., or equivalent.

5-14. AUXILIARY EQUIPMENT.

- a. One 1.0 µf capacitor; one 0.01 µf capacitor.
- 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 $\pm 1\%$, 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 \$\text{\text{\$\text{M}}}\$ Model 711A Laboratory Power Supply.
 - i. Oscillator Balance Probe.

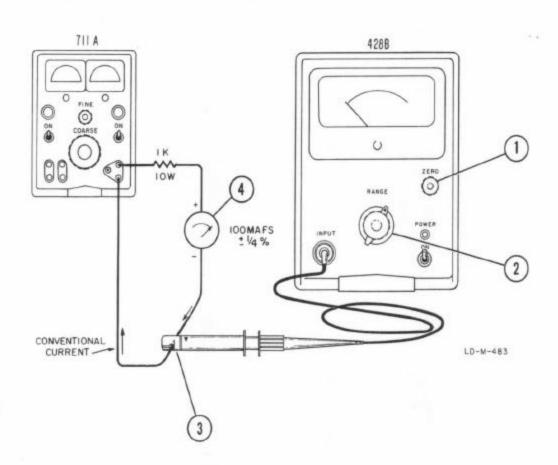




Connect Model 428B to a variable voltage supply, such as an autotransformer,

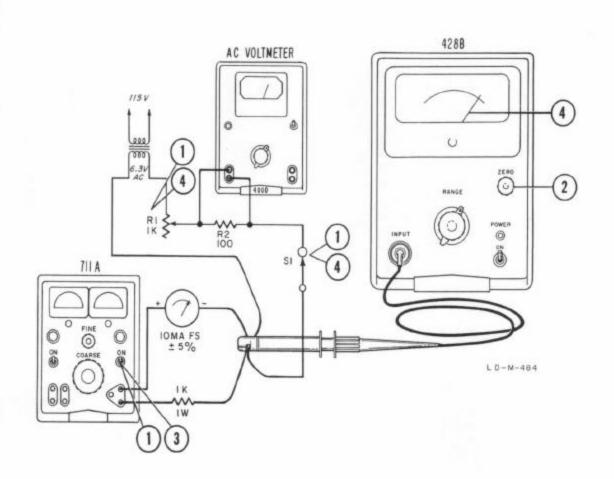
- Turn ON power and allow approximately two minutes warmup time,
- Place probe away from any stray fields (meter magnets, open-core transformers, etc.).
- Check for complete closure of probe jaws (see paragraph 3-8).
- 4. Set RANGE switch to 1 ma.
- Zero-set instrument with ZERO control. If zero-setting 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.



- Zero-set Model 428B on 3 ma range, with no direct current input to probe.
- 2. Switch current RANGE to 100 ma,
- 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).
- Increase current until milliammeter reads 100 ma.

Check: Reading on Model 428B should agree within $\pm 3\%$.



Connect equipment as shown.

- Open S1, set R1 to center and turn power supply off,
- Zero-set Model 428B on 10 ma range with no input to probe,
- 3. Turn on power supply and adjust for 10 ma dc.
- 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.

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	Туре	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	
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.	m .
Q2 Q3	2N1183 2N1564/ 1854-000	25	Test loop gain, Adjust R46

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 BE-FORE 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. $% \label{eq:final_steps} % \[\frac{1}{2} \left(\frac{1}{2} - \frac{1}{2} \right) \left(\frac{1}{2} - \frac{1}{2} - \frac{1}{2} \right) \left(\frac{1}{2} - \frac{1}{2$

5-26. PROBE.

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. POWER SUPPLY.

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. OSCILLATOR-HEAD DRIVE AMPLIFIER.

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.

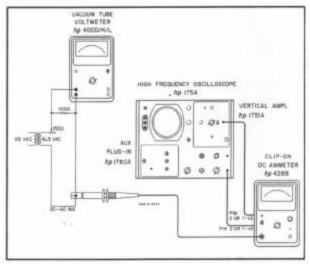


Figure 5-5. Detector Phase Adjustment Setup

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 voltpeak-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. IDEAL CORRECT
PATTERN.
(NO RESIDUAL)

(B) ANOTHER TYPE OF NOTE THAT THESE CORRECT PATTERN INTERSECTIONS ARE VERTICALLY OVER (WITH SOME RESIDUAL.) ONE ANOTHER. CENTER DIAMOND MUST BE FREE OF TRACES. (C) INCORRECT PATTERNS (INTERSECTIONS ARE -NOT VERTICALLY OVER ONE ANOTHER.)

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 <u>any</u> adjustment in the Model 428B, be sure that an adjustment is <u>necessary</u> 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.

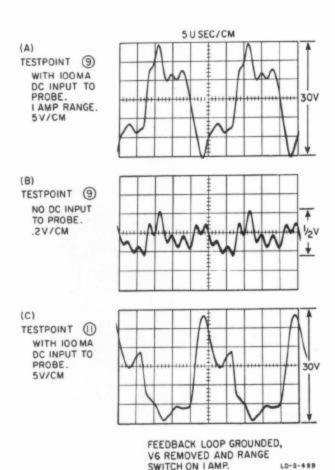


Figure 5-7. Trouble Localization Waveforms

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
 Model 410C Wacuum 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.
- 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-topeak. 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 greenwhite wires). Connect an AC Voltmeter, such as the \$\frac{1}{2}\$ 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.

Step 4. OSCILLATOR FREQUENCY.

Connect electronic counter, such as 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 @ Model 400D/H/L, to transformer T5 side of either R94 or R95 (usually green and green-white wire) on terminal board 428B-75E) 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
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
Model 400D/H/L to pin 2 or 7 of V2. Set 400D/H/L to 1 volt range. Clip 428B probe aroundwire 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 ALIGN-MENT.

Connect a 0.0082 μ f 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 @ Model 140A/175A, to pin 2 or 7 of V5. Connect vertical input to pin 2 or 7 of V2. Leave 428B probe aroundwire 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 ac 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 \$\phi\$ 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 \$\oldsymbol{\theta}\$ 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 made 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 CALI-BRATE 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)

- 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 \pm 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.

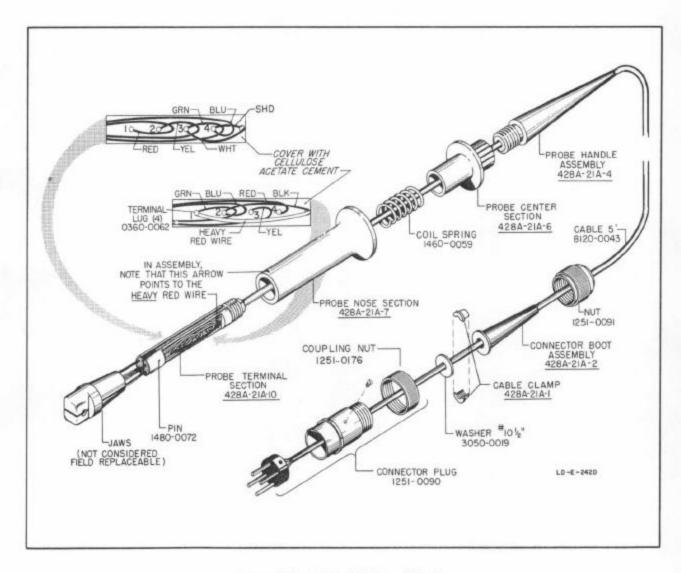


Figure 5-8. Exploded View of Probe

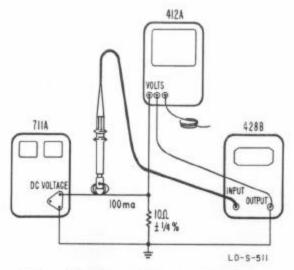


Figure 5-9. Output Calibration Test Setup

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.

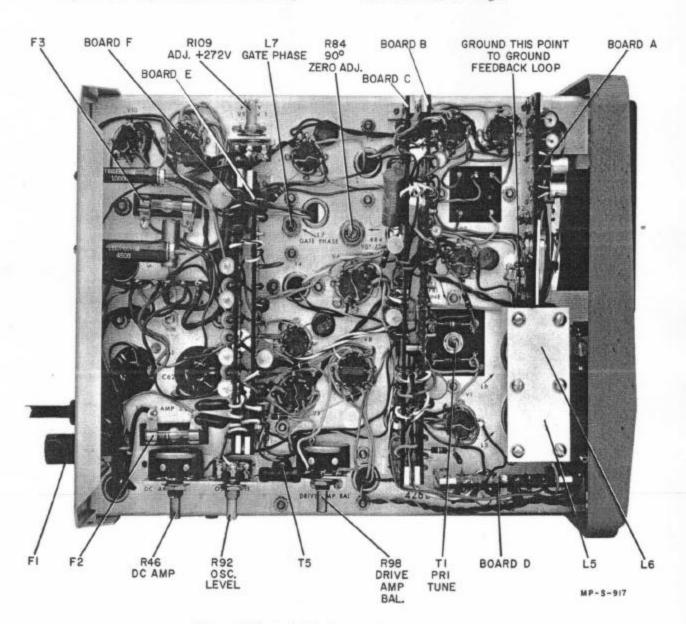


Figure 5-10. Left Side Internal View Model 428B

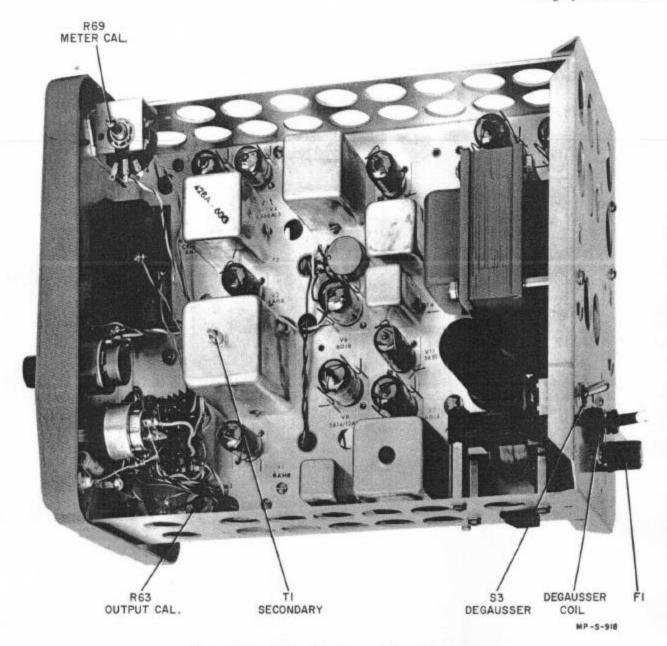


Figure 5-11. Right Side Internal View Model 428B

- 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.

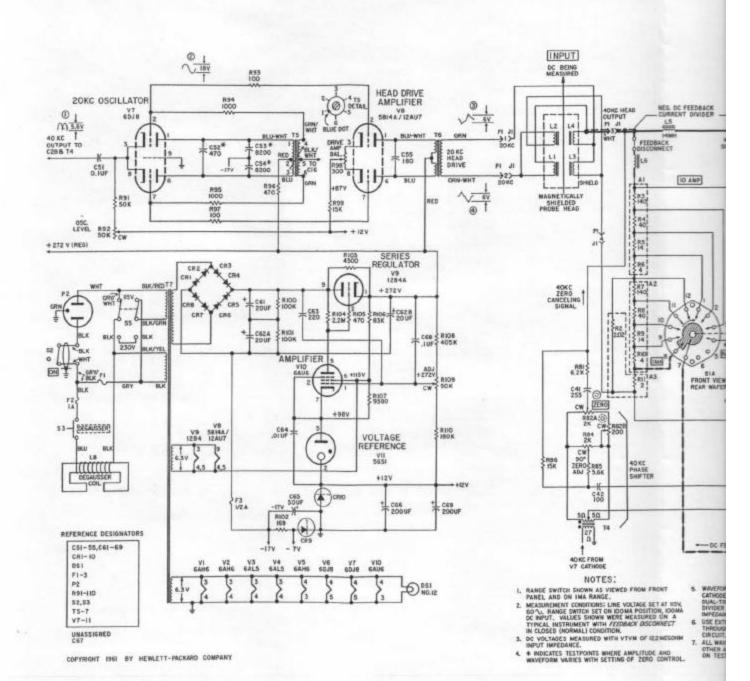
5-42. METER TRACKING.

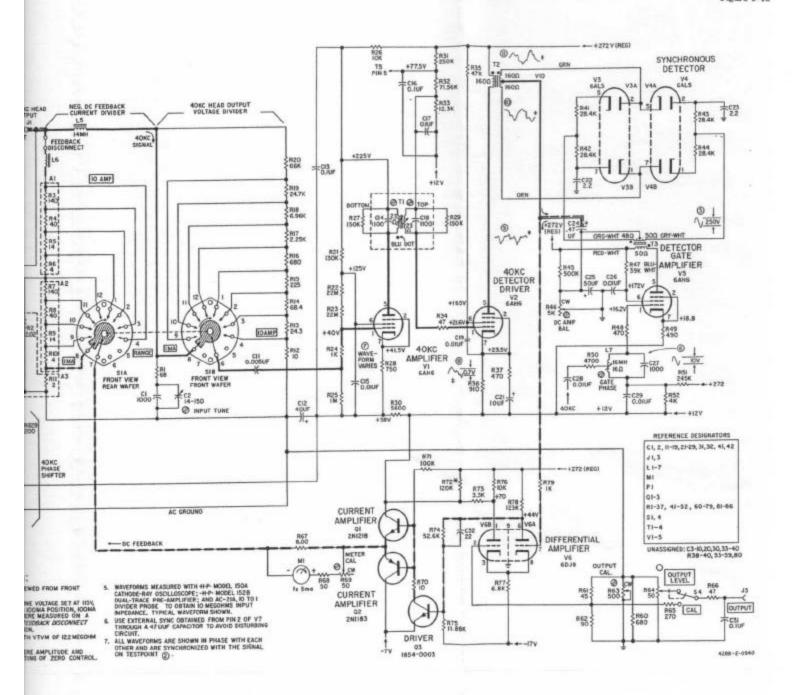
5-43. Check: Zero Model 428B on 1 MA range. Switch to 100 ma range.

5-44. Feed 100 ma dc current through probe, Monitor dc current with external $\pm\,0.25\%$ 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.





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Section V Pigure 5-12

Model 4283

SECTION VI REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphanumerical 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 alphanumerical order of their ® stock numbers and provides the following information on each part:

 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	F = fuse	P = plug	V = vacuum tube, neon
В	= motor	FL = filter	Q = transistor	bulb, photocell, etc.
C	= capacitor	J = jack	R = resistor	W = cable
CR	= diode	K = relay	RT = thermistor	X = socket
DL	= delay line	L = inductor		XF = fuseholder
DS	= device signaling (lamp)	M = meter	S = switch	XV = tube socket
E	= misc electronic part	MP = mechanical part	T = transformer	XDS = lampholder
		ABBREV	IATIONS	
a	= amperes	elect = electrolytic	mtg = mounting	rot = rotary
4.0	- handanan	encap= encapsulated	my = mylar .	rms = root-mean-square
pp	= bandpass			rmo = rack mount only
bwo	= backward wave	f = farads	NC = normally closed	
	oscillator	fxd = fixed	Ne = neon	s-b = slow-blow
c	= carbon		NO = normally open	Se = selenium
cer	= ceramic	Ge = germanium	NPO = negative positive zero	sect = section(s)
cmo	= cabinet mount only	grd = ground (ed)	(zero temperature	Si = silicon
coef	= coefficient		coefficient)	sl = slide
com	= common	h = henries	nsr = not separately	
comp	p = composition	Hg = mercury	replaceable	td = time delay
	= connection			TiO ₂ = titanium dioxide
crt	= cathode-ray tube	impg = impregnated	obd = order by de-	
		incd = incandescent	scription	tog = toggle
dep	- deposited	ins = insulation (ed)		tol = tolerance
			p = peak	trim = trimmer
EIA	= Tubes or transistors meeting Electronic	K = kilo = 1000	pc = printed circuit board	twt = traveling wave tube
	Industries' Associa-	lin = linear taper	pf = picofarads =	var = variable
	tion standards will	log = logarithmic taper	10-12 farads	w/ = with
	normally result in		pp = peak-to-peak	W = watts
	instrument operating	m = milli = 10 ⁻³	piv = peak inverse	ww = wirewound
	within specifications;	M = megohms	voltage	w/o = without
	tubes and transistors	ma = milliamperes	pos = position(s)	 e optimum value
	selected for best	μ = micro = 10 ⁻⁶	poly = polystyrene	selected at factory,
en .	performance will be	minat = miniature	pot = potentiometer	average value
01194-3	supplied if ordered	mfgl = metal film on glass	por posentionierer	shown (part may
Ξ	by @ stock numbers.	mfr = manufacturer	rect = rectifier	be omitted)
-	of the anner manner of	THE SHIP SHIP STATE OF	The second of	

Table 6-1. Reference Designation Index

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: www 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	THE STATE PRODUCTION	Not Assigned	
C21	0180-0059	fxd, elect, 10 uf -10% + 100%, 25 vdcw	
C22, 23	0150-0015	fxd, Ti0, 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	Construction of the Construction	Not Assigned	1
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	
255	0140-0147	fxd, mica, 180 pf +5%, 500 vdcw	
C56 thru C60	400000000000000000000000000000000000000	Not Assigned	
261	0180-0011	fxd, elect, 20 uf, 450 vdcw	
C62A/B	0180-0012	fxd, elect, 2 sect, 20 uf/sect, 450 vdcw	
263	0140-0031	fxd, mica, 220 pf +10%, 500 vdcw	
		w:	

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

C64	Circuit Reference	Stock No.	Description #	Note
C66		0150-0012	fxd, cer, 10K pf ±20%, 1000 vdcw	
Not Assigned fxd, my, 0.1 μf ±20%, 600 vdcw fxd, elect, 200 μf, 15 vdcw Diode, Sl	C65	0180-0058	fxd, elect, 50µf -10% +100%, 25 vdcw	
C68 0170-0022 fxd, my, 0.1 μf ±20%, 600 vdcw C69 0180-0104 fxd, elect, 200 μf, 15 vdcw D10de, Si D10de, Si D10de, Si D10de, Si D11 1902-0013 Diode, Si D11 2140-0012 Lamp: indicating, #12, 2 pin base F1, 2 2110-0007 Fuse: 1 amp, s-b (F1 115 V operation) F1 2110-0008 Fuse: 1/2 amp F1 2110-0012 Fuse: 1/2 amp F1 1 1251-0089 Connector: female, 4 pin Not Assigned C7 Connector: BNC, female D1 1 1250-0118 Connector: assembly (see misc.) D1 1 1250-0090 Inductor: var, 16 mh D1 1250-0090 Connector: male, 4 pin D1 1251-0090 Cable, power D1 1854-0039 Transistor: Si NPN 2N3053 D2 1853-0016 Transistor: Si NPN 2N3053 D1 1854-0003 Transistor: Si NPN 2N3053 D1 18	C66	0180-0104	fxd, elect, 200 μf, 15 vdcw	
C69 0180-0104 fxd, elect, 200 μf, 15 vdcw CR1 thru CR8 1901-0028 Diode, Si CR9 1902-0013 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) F13 2110-0012 Fuse: 1/2 amp J1 1251-0089 Connector: female, 4 pin Not Assigned Connector: BNC, female 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 Cable, power Q1 1854-0039 Transistor: Si NPN 2N3053 R2 1853-0016 Transistor: Si PNP 2N3638 R1 0687-6801 fxd, comp, 68 ohms ±10%, 1/2 W nsr; part of A3 assembly	C67		Not Assigned	
CR1 thru CR8	C68	0170-0022	fxd, my, 0.1 \(\mu f \pm 20\%, 600 \) vdcw	
CR9	C69	0180-0104	fxd, elect, 200 μf, 15 vdcw	
Diode, Si	CR1 thru CR8	1901-0028	Diode, Si	
DS1	CR9	1902-0013	Diode, Si	
F1, 2	CR10	1902-0014	Diode, Si	
2110-0008 Fuse: 1/2 amp, s-b (F1 230 V operation)	DS1	2140-0012	Lamp: indicating, #12, 2 pin base	
F3	F1, 2	2110-0007	Fuse: 1 amp, s-b (F1 115 V operation)	
1251-0089 Connector: female, 4 pin	12.	2110-0008	Fuse: 1/2 amp, s-b (F1 230 V operation)	
Not Assigned Not Assigned Connector: BNC, female nsr; part of probe assembly (see misc.)	F3	2110-0012	Fuse: 1/2 amp	
1250-0118 Connector: BNC, female nsr; part of probe assembly (see misc.)	J1	1251-0089	Connector: female, 4 pin	
L1 thru L4	J2		Not Assigned	
L5, 6 428B-60K Assembly, choke L7 9140-0049 Inductor: var, 16 mh 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 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 0727-0060 fxd, dep c, 680 ohms ±1%, 1/2 W R15 0727-0085 fxd, dep c, 680 ohms ±1%, 1/2 W R17 0727-0120 fxd, dep c, 6960 ohms ±1%, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W R19 fxd, dep c, 6960 ohms ±1%, 1/2 W	J3	1250-0118	Connector: BNC, female	
1.7	L1 thru L4		nsr; part of probe assembly (see misc.)	
Mil 1120-0116 Meter: 0-5 ma, 6-10 ohms	L5, 6	428B-60K	Assembly, choke	
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 0727-0060 fxd, dep c, 68.4 ohms ±1/2%, 1/2 W R15 0727-0060 fxd, dep c, 680 ohms ±1%, 1/2 W R16 0727-0120 fxd, dep c, 2250 ohms ±1%, 1/2 W R17 0727-0120 fxd, dep c, 6960 ohms ±1%, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms ±1%, 1/2 W	L7	9140-0049	Inductor: var, 16 mh	
P1	L8	9110-0025	Inductor: degaussing	
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 A3 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, 680 ohms ±1%, 1/2 W R16 0727-0085 fxd, dep c, 680 ohms ±1%, 1/2 W R17 0727-0120 fxd, dep c, 6960 ohms ±1%, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms ±1%, 1/2 W	M1	1120-0116	Meter: 0-5 ma, 6-10 ohms	
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 A3 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, 6960 ohms ±1%, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms ±1%, 1/2 W	P1	1251-0090	Connector: male, 4 pin	
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 A3 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, 68.4 ohms ±1%, 1/2 W R16 0727-0085 fxd, dep c, 680 ohms ±1%, 1/2 W R17 0727-0120 fxd, dep c, 6960 ohms ±1%, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms ±1%, 1/2 W	P2	8120-0050	Cable, power	
Q3	Q1	1854-0039	Transistor: Si NPN 2N3053	
R1	Q2	1853-0016	Transistor: Si PNP 2N3638	
nsr; part of A3 assembly nsr; part of A1, A2 assembly nsr; part of A3 assembly nsr; part of A1, A2 assembly nsr; part of A3 assembly nsr; part of A3 assembly nsr; part of A1, A2 assembly nsr; part of A3 assembly nsr; part of A	Q3	1854-0003	Transistor: 2N1564	
R3 thru R10 R11 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, 6960 ohms ±1%, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms ±1%, 1/2 W	R1	0687-6801	fxd, comp, 68 ohms ±10%, 1/2 W	
R11 nsr; part of A3 assembly fxd, dep c, 10 ohms $\pm 10\%$, 1/2 W R13 0757-0002 fxd, mfg, 24.3 ohms $\pm 1\%$, 1/2 W R14 0727-0035 fxd, dep c, 68.4 ohms $\pm 1/2\%$, 1/2 W R15 0727-0060 fxd, dep c, 225 ohms $\pm 1\%$, 1/2 W R16 0727-0085 fxd, dep c, 680 ohms $\pm 1\%$, 1/2 W R17 0727-0120 fxd, dep c, 2250 ohms $\pm 1\%$, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms $\pm 1\%$, 1/2 W	R2		nsr; part of A3 assembly	
R12 0727-0335 fxd, dep c, 10 ohms $\pm 10\%$, 1/2 W R13 0757-0002 fxd, mfg, 24.3 ohms $\pm 1\%$, 1/2 W R14 0727-0035 fxd, dep c, 68.4 ohms $\pm 1/2\%$, 1/2 W R15 0727-0060 fxd, dep c, 225 ohms $\pm 1\%$, 1/2 W R16 0727-0085 fxd, dep c, 680 ohms $\pm 1\%$, 1/2 W R17 0727-0120 fxd, dep c, 2250 ohms $\pm 1\%$, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms $\pm 1\%$, 1/2 W	R3 thru R10		nsr; part of A1, A2 assembly	
R13 0757-0002 fxd, mfg, 24.3 ohms $\pm 1\%$, 1/2 W R14 0727-0035 fxd, dep c, 68.4 ohms $\pm 1/2\%$, 1/2 W R15 0727-0060 fxd, dep c, 225 ohms $\pm 1\%$, 1/2 W R16 0727-0085 fxd, dep c, 680 ohms $\pm 1\%$, 1/2 W R17 0727-0120 fxd, dep c, 2250 ohms $\pm 1\%$, 1/2 W R18 0727-0145 fxd, dep c, 6960 ohms $\pm 1\%$, 1/2 W	R11		nsr; part of A3 assembly	
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	R12	0727-0335	fxd, dep c, 10 ohms ±10%, 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	R13	0757-0002	fxd, mfg, 24.3 ohms ±1%, 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	R14	0727-0035	fxd, dep c, 68.4 ohms ±1/2%, 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	R15	0727-0060		
R18 0727-0145 fxd, dep c, 6960 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	
R19 0727-0178 fxd, dep c, 24.7K ohms ±1%, 1/2 W	R18	0727-0145	fxd, dep c, 6960 ohms ±1%, 1/2 W	
ACTIVATION OF THE PROPERTY OF	R19	0727-0178	fxd, dep c, 24.7K ohms ±1%, 1/2 W	

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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 $\pm 1\%$, 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, c omp 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%, 1W	
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	

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

Circuit Reference		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	7.8
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 $\pm 10\%$, 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 $\pm 1\%$, $1/2$ 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%, 3W	
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 $\pm 10\%$, 1/2 W	
R105	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R106	0730-0063	fxd, dep c, 83K ohms $\pm 1\%$, 1W	
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%	

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

Circuit Reference	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	
Г2	428A-60G	Transformer, detector signal	
Г3	428A-60C	Transformer, gate	
Г4	428B-60J	Transformer, zero balance	
r 5	9120-0051	Transformer, osc	
r6	428A-60D	Transformer, head drive	
r7	9100-0104	Transformer, power	
71, 2	1923-0017	Tube, electron: 6AH6	
73, 4	1930-0013	Tube, electron: 6AL5	
75	1923-0017	Tube, electron: 6AH6	
76, 7	1932-0022	Tube, electron: 6DJ8/ECC88	
78	1932-0029	Tube, electron: 12AU7	
79	1921-0010	Tube, electron: 12B4A	
710	1923-0021	Tube, electron: 6AU6	
711	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 R26, 27 C15 R35, 36 C21 R41, 42 C25 R45 R21 thru R23 R73	
	428B-75C	Assembly: circuit board "C" includes C16, C17, C24 C41, C42 R30 thru R33 R43, R44 R77 thru R79 R81 R85, R86	
	428B-75D	Assembly: resistor board 'D" includes C1, C2 C11, C12 R1 R25	

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

Circuit		Description#	Not
Reference	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 8520-0017	Jewel, pilot light Electric shaver brush	
	1205-0011	Heat dissipator, semiconductor	
		*	

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: www resistor, A1 includes R3 thru R6 A2 includes R7 thru R10	28480	428B-26A	2
428B-26B	Assembly: www 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 ρ f ±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 ρ f ±5%, 500 vdcw	76433	RCM15E101J	1
0140-0099	fxd, mica, 1K ρ f ±1%, 500 vdcw	00853	KR1210 E1	2
0140-0108	fxd, mica, 253 ρ f ±2%, 300 vdcw	76433	RCM15E(253)G	1
0140-0147	fxd, mica, 180 ρ f ±5%, 500 vdcw	72136	DM15F181J	1
140-0149*	fxd, mica, 470 pf ±5%, 300 vdew	72136	DM15F471J	1
0140-2102	fxd, mica, 8.2K ρ f ±2%, 500 vdew	72136	DM30F822G	2
0150-0012	fxd, cer, 10K of ±20%, 1000 vdcw	71590	13C Disc	6
0150-0014	fxd, cer, 5K ρf, 500 vdcw	96095	D1-4	1
0150-0015	fxd, TiO2, 2.2 pf ±10%, 500 vdcw	82142	type JM	2
0170-0019	fxd, my, 0.1 \(\mu f \pm 5\%, 200 \text{ vdew} \)	84411	type 620S	3
170-0022	fxd, my, 0.1 μ f ±20%, 600 vdcw	09134	type 27	2
170-0078	fxd, my, 0,47 μ f ±5%, 150 vdcw	83125	107V474J	1
180-0011	fxd, elect, 20 μ f, 450 vdcw	56289	D32550	1
180-0012	fxd, elect, 2 sect, 20µf/sect, 450 vdcw	56289	obd#	1
180-0050	fxd, elect, 40 μ f -15% +100%, 50 vdcw	56289	D32538	1
180-0058	fxd, elect, 50 μf -10% + 100%, 25 vdcw	56289	30D186A1	2
180-0059	fxd, elect, 10 μ f -10% + 100%, 25 vdcw	56289	30D182A1	1
180-0104	fxd, elect, 200 μ f, 15 vdcw	56289	30D174A1	2
686-1345	fxd, comp, 130K ohms $\pm 5\%$, 1/2 W	01121	EB-1345	1
686-6225	fxd, comp, 6.2K ohms $\pm 5\%$, $1/2$ W	01121	EB-6225	1
687-1001	fxd, comp, 10 ohms $\pm 10\%$, 1/2 W	01121	EB-1001	1
687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	01121	EB-1011	2
687-1021	fxd, comp, 1K ohms ±10%, 1/2 W	01121	EB-1021	4
687-1031	fxd, comp, 10K ohms $\pm 10\%$, 1/2 W	01121	EB-1031	1
687-1051	fxd, comp, 1M ±10%, 1/2 W	01121	EB-1051	1
687-1531	fxd, comp, 15K ohms ±10%, 1/2 W	01121	EB-1531	1

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, $2.2M \pm 10\%$, $1/2~W$	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 $\pm 10\%$, 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 $\pm 10\%$, 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 $\pm 5\%$, 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 $\pm 5\%$, 1 W	01121	GB-9115	1
0690-1041	fxd, comp, 100K ohms $\pm 10\%$, 1 W	01121	GB-1041	2
0690-1241*	fxd, comp, 120K ohms $\pm 10\%$, 1 W	01121	GB-1241	1
0690-4731	fxd, comp, 47K ohms $\pm 10\%$, 1 W	01121	GB-4731	1
0693-1041	fxd, comp, 100K ohms $\pm 10\%$, 2 W	01121	HB-1041	1
0727-0021	fxd, dep c, 45 ohms $\pm 1\%$, 1/2 W	19701	DC-1/2CR5, obd#	1
0727-0023	fxd, dep c, 50 ohms $\pm 1\%$, 1/2 W	19701	DC-1/2CR5, obd#	1
0727-0035	fxd, dep c, 68.4 ohms $\pm 1/2\%$, $1/2$ 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 $\pm 1\%$, $1/2$ W	19701	DC-1/2 CR5, obdi	1
0727-0075	fxd, dep c, 490 ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0085	fxd, dep c, 680 ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0120	fxd, dep c, 2250 ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0132	fxd, dep c, 4K ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0145	fxd, dep c, 6960 ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0154	fxd, dep c, 9380 ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0163	fxd, dep c, 11.88K ohms $\pm 1\%$, 1/2 W	19701	DC-1/2CR5, obd#	1
0727-0178	fxd, dep c, 24.7K ohms $\pm 1\%$, 1/2 W	19701	DC-1/2AR5, obd#	1
0727-0184	fxd, dep c, 28.4K ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2BR5, obd#	4
0727-0195	fxd, dep c, 50K ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2BR5, obd#	1
0727-0196	fxd, dep c, 52.6K ohms $\pm 1\%$, 1/2 W	19701	DC-1/2CR5, obd#	1
0727-0198	fxd, dep c, 66K ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0201	fxd, dep c, 71.56K ohms $\pm 1\%$, $1/2$ W	19701	DC-1/2CR5, obd#	1
0727-0218	fxd, dep c, 180K ohms ±1%, 1/2 W	19701	DC-1/2CR5, obd#	1

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

0727-0226 0727-0240 0727-0244 0727-0335 0730-0032	fxd, dep c, 250K ohms $\pm 1\%$, 1/2 W fxd, dep c, 405K ohms $\pm 1\%$, 1/2 W fxd, dep c, 500K ohms $\pm 1\%$, 1/2 W fxd, dep c, 10 ohms $\pm 1\%$, 1/2 W	19701 19701 19701	DC-1/2CR5, obd#	1
0727-0244 0727-0335 0730-0032	fxd, dep c, 500K ohms $\pm 1\%$, 1/2 W		DC 1/9CDE	The second of the second
0727-0335 0730-0032		10701	DC-1/2CR5, obd#	1
0730-0032	fxd, dep c, 10 ohms ±1%, 1/2 W	19101	DC-1/2AR5, obd#	1
		19701	CF-1/2, obd#	1
	fxd, dep c, 12.3K ohms $\pm 1\%$, 1W	19701	DC1 R5, obd#	1
0730-0063	fxd, dep c, 83K ohms $\pm 1\%$, 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 $\pm 1\%$, $1/2$ W	07115	N20	1
0764-0003	fxd, mfg, 3300 ohms ±5%, 2 W	07115	C-42	1
0767-0010	fxd, mfg, 15K ohms ±5%, 3W	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 $\pm 10\%$, 10 W	35434	type C-10	1
0819-0011	fxd, ww, 4.5K ohms $\pm 10\%$, 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
1901-00 28	Diode, Si	28480	1901-0028	8
1902-0013	Diode, Si	04713	1.5M6.8Z10	1
1902-0014	Diode, Si	04713	1.5M12Z10	1
921-0010	Tube, electron: 12B4A	33173	obd#	1
923-0017	Tube, electron: 6AH6	33173	obd#	3
923-0021	Tube, electron: 6AU6	33173	obd#	1
930-0013	Tube, electron: 6AL5	33173	obd#	2
932-0022	Tube, electron: 6DJ8/ECC88	00001	6DJ8	2
932-0029	Tube, electron: 12AU7	80131	obd#	1
940-0001	Tube, electron: 5651	86684	5651	1
100-0002	var, ww, 50 ohms ±10%, 2 W	11237	type 252, obd#	1
100-0006	var, ww, 5K ohms $\pm 10\%$, 2 W	11237	type 252, obd#	1
100-0013	var, comp, lin, 50K ohms ±20%	71590	obd#	2
100-0022	var, ww, lin, 500 ohms ±20%, 1 W	11237	type 112	1
100-0038	var, ww, 300 ohms	11237	type 252, obd#	1
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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, $\pm 10\%$, 2 W R82A, 2K ohms R82B, 200 ohms	11237	C252-45	1
2100-0270	var, ww, lin, 50 ohms $\pm 10\%$, 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	АН&Н80994-Н	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

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

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ
28B-75F	Assembly: resistor board "F" includes, C53,C54 C68 CR1 thru CR8 R106 R108 R110	28480	428B-75F	1
200-0003	Socket, tube: 9 pin miniat	71785	44B-20965	4
200-0017	Socket, tube: 7 pin miniat	71785	53B-22005	7
400-0008	Fuseholder	75915	3510-11	2
400-0084	Fuseholder	75915	342014	1
450-0020	Jewel, pilot light	72765	14L-15	1
520-0017	Electric shaver brush			1
205-0011	Heat dissipator, semiconductor			
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Address

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.

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86175 Studen and Lamb Certical Co. Rechester, N. Y. 8642 E. T. A. Prinkets Co. of America Chicago, III. 86430 Pestion Devices, Inc., Inglewood, Calif. 86540 Analon Electronic Hardware Co. Inc. New Rochells, N. Y. 8555 Shede Electrical Instituted Co., Inc. Penacom, R. H. 86153 U. S. Sencer Givision of Machael Coig. of America of America Tarrisphore Mg. Co., West Dw. Van Nays, Calif.			Bridgenar Core
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Wally Western Devices, Inc., Inglewood, Calif. 26546 Anatom Electronic Hardware Co., Inc., New Rochelle, N. Y. 26555 Beefic Electrical Instrument Co., Inc., Penacoes, E. M. 26753 U. S. Sencer Division of Nuclear Cosp., Of America, Of America, Cosp., 26740 Co., Sent Div., Van Nays, Calif.			
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16812 Tavington Mtg. Co., West Div. Van Nays, Calif.		of America	Phoenix, Arizona
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	1708E K	etvin Esective Co.	Var Neys, Calif.

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No.	Manufacturer	Address
87115	Cowing Class Works Electronic Components	Dept. Bradleri, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137 07138	Transister Electronics Car Westinghouse Electric Con	p. Minneapolic, Minn. D.
07149	Electronic Tube Div. Filestin Corp.	Eleira, W.Y.
07233		New York, N. Y. City of Industry, Calif.
07261	Avest Corp.	Les Angeles, Calif.
65363	Fainthild Senicreductor Co	HJ.
01253	Minnesota Retter Co.	Montain View, Calif. Minneapolis, Mins.
67287	The Birtitler Corp.	Los Angeles, Calif.
81106	Technical Wire Products	Springfield, R.J.
6751.0	Continental Device Corp.	Hawthome, Calif.
07933 07966	Rheen Senicoeductor Cera. Shockley Seni-Gooductor Labolatories	
07380	Booston Radio Corp.	Pale Ato, Catif. Boonton, N. J.
08145	U.1. Engineering Co.	Lon Angeles, Calif.
04289	Blice, Debett, Co.	Pemore, Calif.
08358	Burgess Buttery Co.	
*****	Napa I	Falls, Ortanio, Canada,
08717 08718	Steam Company Common Electric Co., Phoesi	Burbank, Galif.
88792	CBS Electronics Semicondu	MID
31554	Operations, Div. at C. B.: Mel Rain	
09026	Beboook Relays, Inc.	Reflamaçolis, Ind., Coste Mesa, Calif.
01134	Texas Capacitor Ca.	Noveton, Texas
09145	Atom Electronics	Noveton, Texas Ses Valley, Calif.
08250 08549	Electro Assemblies, Inc. Mallary Baltery Co. of	Obicago, III.
		storte, Ortado, Canada
19664	The Bristol Co.	Waterbury, Conn.
19214	General Translictor Western	
10411	Ti-Tal, Inc.	Lus Angeles, Calif. Berkeley, Calif.
10646	Carboranden Cv.	Mirgan Fells, N.Y.
	CTE of Benne, Inc.	Sens, Ind.
11227	Chicago Telephone of Califo	smia, Inc., So. Pasadero, Calif.
11312	Microwave Electronics Cara	Pale Alto, Carif.
11534	Duncee Electronic, Inc.	Santa Anu., Calif.
11711	General Instrument Corporat	
11767	Semiconductor Division	Nevari, H. J.
	Imperial Electronic, Inc. Melabs, Jec.	Buene Pork, Calif.
	Philadelphia Handle Co.	Palo Atta, Calif. Canden, N. J.
	Clarestat Mig. Co.	Sover, N.H.
12859	Nipper Electric Co., Ltd.	Tukyo, Japan
12930	Della Semiconductor Inc.	Revoort Beach, Calif.
13100	Thermation	Darino, Texas
	Telefunken (G. N. B. H.) Widfund Mig. Co.	Hannover, Germany Keesas City, Kansas
	len-lich	Newbory Park, Calif.
14193	Catil. Resister Carp.	Santa Monica, Culif.
14256	American Composents, Inc.	Conshohocken, Fa.
	Constit Dubilier Elec. Corp.	
	Williams Wfg. Co. Webster Electronics Co. Inc.	San Jose, Calif.
19291	Adjustable Bushing Co.	H. Mollywood, Calif.
15772	Twestieth Century Coil Spring Co.	Santa Clare, Celif.
15909	The Oyuen Co.	Uningston, N.J.
16037	foruce Pine Mics Co.	Spruce Pine, N. C.
	Congular Diade Corp. De Jus-Amoco Corporation	Lodi, N. J.
	Los	g Island City 1, N.Y.
16758 1	Delez Radio Div. of G.M. Co	
13474 1		George Park, Calif.
	ladis Industries	Mountain View, Calif. Des Plaines, III.
14583 (Durtis instrument inc.	Mt. Hisco, M.Y.
	. I. Di Fort and Co., Inc.	Wilmington, Bet.
19315 8	Slipse Floreer, Div. of Bendix Aviation Corp.	Telerboro, N. J.
19500 1	homes A. Edison Industries	
16311 -	Div. of McGraw-Edison Co	
10117 - 2	Jectra Manufacturing Co. Jectronic Tube Corp.	Marsan City, Re.
	recours rube cary.	Philadelphia, Pa. New York, W.Y.
	ansteel Wetaflurgical Corp.	No. Chicago, III.
21335 T	he Fathir Bearing Co.	New Britain, Cons.
21564 F	nd. Telephone and Radio Co	ep. Ciffee, N. J.
	eneral Electric Co.	Schenectady, N.Y.
24455 G	.E., Lang Division Wells ?	ark, Cleveland, Ohio

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	West Concord, Hann,
26365 Gries Reproducer Corp. 26462 Grobet File Co. of Ameri	New Sochelle, N.Y.
26992 Hamilton Watch Co.	ta, Inc. Carlstadt, N.J. Lancaster, Pa.
28480 Hewlett-Packard Co.	Falo Alfa, Calif.
33173 G.E. Receiving Tube De	
35454 Lectroin ltc.	Chicago, III.
	kentury, Outrio, Canada
17942 P.R. Mallery & Co., Inc.	. Indianapalis, Ind.
39543 Wechanical Industries Pro	
40928 Miniature Precision Bear	
42199 Muter Co.	Chicago, Itt.
43990 G.A. Norpre Co.	Englewood, Colo.
44655 Ohnite Mg. Co.	Stokie, III,
47904 Poternid Corp.	Cambridge, Nass,
48520 Precision Theraumeter ar	of terminage, mana,
Inst., Co.	Philisdelphia, Pa.
49956 Raytheon Company	Lexingles, Mass.
32790 Rowan Controller Co.	Gallinso, Md.
13743 Ward Leonard Electric	Mt. Ventos, S.Y.
54294 Shallereen Wig. Co.	Seina, R.C.
55125 Simpler Electric Co.	
55933 Senotone Curp.	Chicago, III.
55958 Severson & Co., Ibc.	Elesfort, N.Y., Sr. Nerwijk, Core.
55137 Speciding Fibre Co., Inc.	So, Norwalk, Cont.
56289 Sprague Electric Co.	Toruwanda, S.Y.
55465 Telex, fac.	Borth Adams, Mass, St. Paul, Nine,
99/30 Thomas & Betta Co.	Elizabeth 1, N.J.
6674) Trippleit Electrical Inc.	Bluffton, Obio
62775 Union Switch and Signal, Westinghouse Air Stak	e Co. Swisswale, Pa.
52119 Universal Electric Co.	
63741 Ward-Lasenard Electric Co.	Oworse, Mich.
64959 Western Electric Co., Inc.	Mr. Verson, R.Y.
64959 Western Electric Co., Inc 65092 Western Brat. Din. of Days	Story for Street S. J.
66255 Wittek Manufacturing Co.	Chicago 23, 18,
66346 Rollensak Optical Co.	Rochester, N.Y.
70276 Alles Mg. Co.	Rartford, Cone.
70389 Allied Centrel Co., Inc.	New York, N.Y.
70315 Alimetal Strew Frod. Co.	No.
	Garden City, N.Y.
75485 Atlantic India Robber Wash	in, Inc. Chicago, III.
J0563 Amperits Co., Inc.	Rew York, N.Y.
78903 Beiden Mig. Co.	Chicago, III.
70996 Bird Electronic Corp.	Cleveland, Ohio
71002 Birshach Radio Co.	New York, N.Y.
7104) Boston Gear Works Div. of	men rank, No. 1.
Warray Co. of Texas	Quincy, Mass,
71218 Bud Sadie Inc.	Cleveland, Ohio
71296 Cambic Fastenet Corp.	Paramas, N. J.
71313 Alles D. Cardwell Electro	Patanes, A.J.
Prod. Corp.	Plairwille, Core.
71400 Bussnann Fuse Sir. of Mc	Carrier Comm.
Edinox Ca.	II. Louis, Me.
71416 Chicago Condenser Corp.	
71410 CTS Corp.	Chicago, III.
71468 Camon Electric Co.	Elitart, Ind.
	List Angeles, Calif.
71471 Cinema Engineering Co. 71482 C. P. Clare & Co.	Butsenk, Calif.
71598 Centratab Div. of Elebe U	Chicago, III.
The second of the second of	Milwauken, Win.
71616 Campercial Plantics Co.	Chicago, III.
71760 The Cornish Wile Co.	New York, N.Y.
71748 Chicago Ministere Lang W.	
71753 A.G. Snith Corp., Crowle	eks Ohicago, III.
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71785 Circh Mtg. Curp.	Chicago, III.
71964 Dow Coming Dorp.	Hidland, Nich,
72092 Eitel-McCallough, Inc.	
	San Bruns, Calif.
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71707 Cute Ceit Co., Inc.	Previdence, R. I.
2154 John E. Fast & Co.	CONTRACTOR OF THE PARTY
	Chicago, III.
2519 Dialight Corp.	Chicago, III. Brosklyn, N.Y.
2519 Dialight Corp. 2556 General Coranica Corp.	Chicago, III.
7519 Dishight Corp. 7556 General Cotamics Corp. 7599 General Instrument Corp.	Chicago, III. Brosklyn, M.Y. Reesbey, W.J.
2529 Dishight Carp. 2556 General Cotamics Corp. 2599 General Instrument Corp., Seniconductor Div.	Chicago, III. Bronklyn, M.Y. Keesbey, W.J. Newark, N.J.
19529 Dialight Carp. 19556 General Cetamics Corp. 19699 General Instrument Corp., Seniconductor Div. 19758 Siturd-Hopkins	Chicago, III. Bronklyn, N.Y. Reastey, N.J. Newark, N.J. Oakland, Calif.
2509 Disright Corp. 2556 General Counties Corp., 2599 General Enstance Corp., Senicontector Div. 2758 Strait-Hopkins 2765 Orake Mtg. Cx.	Chicago, III. Brosklyn, M.Y. Reastey, N.J. Hewark, N.J. Oukland, Calif. Chicago, III.
2502 Dialight Corp. 2556 General Connects Corp. 2559 General Instrument Corp. 2559 Seneral Instrument Corp. 2558 Start Hepkons 2756 Drake Mg. Cx. 2623 Hagh H. Eby Inc.	Chicago, III. Brosklyn, N.Y. Kensbey, N.J. Newark, N.J. Oakland, Calif. Chicago, III. Philadelphis, Pa.
2519 Dialoght Cop. 2516 General Cotanics Cop., 2519 General Instrument Corp., Senicondector Div. 2758 Sitsed Hopkins 2765 Dialo Mg. Cs., 2825 Mgb H. Ep Inc., 2828 Nugh H. Ep Inc., 2828 Nugh H. Ep Inc.	Chicago, III. Brooklyn, R.Y. Resabey, K.J. Newark, K.J. Osklond, Calif. Chicago, III. Philadelphia, Pa. Chicago, III.
2512 Dallight Cop. 2556 General Cotanics Cop. 2559 General featurest Cop., 2660 Cop., 26	Chicago, III. Brosklyn, N. Y. Kessbay, N. J. Newark, N. J. Osklond, Calif. Chicago, III. Philadelphia, Pa. Chicago, III. Lez Angelas, Calif.
2519 Dullight Cop. 2556 Genesi Consmics Cop. 2599 Genesi Instituted Cop. 2600 Conscious Div. 2705 Ginard Helpins 2705 Dullis My Co. 2725 Hugh H. Etp Inc. 2725 Robert M. Helley Co. 2726 Robert M. Helley Co. 2728 Est Resister Corp.	Chicago, III. Brosklyn, N.Y. Beadbay, N.J. Oakland, Callf. Chicago, III. Philadelphia, Pa. Chicago, III. Let Aspelsa, Calif. Eise, Pa.
2512 Distinger Care. 2555 General Consmice Corp., 2556 General Consmice Corp., 2566 Confect Instrument Corp., 2566 Standard Mayber Div., 2758 Standard Mayber Div., 2758 Standard Mayber Div., 2758 Standard Mayber Div., 2758 General Mayber Mayber Div., 2758 General Mayber Mayber Div., 2561 Resistant Corp., 2561 Nature May Corp., 2561 Nature May Corp.,	Chicago, III. Brosklyn, H.Y. Heastey, H.J. Osklond, Calif. Chicago, III. Philadelphia, Pa. Chicago, III. Lez Angelea, Calif. Eile, Pa. Princeton, Ind.
2519 Dusignt Carp. 2529 Central Countries Corp. 2559 Central Countries Corp. 2559 Care of the Dust Countries Corp. 2758 Care of Care of Countries Corp. 2758 Care of C	Chicago, III. Brosklyn, N.Y. Beadbay, N.J. Oakland, Callf. Chicago, III. Philadelphia, Pa. Chicago, III. Let Aspelsa, Calif. Eise, Pa.
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7325	1) Highes Products Division	of
	Highes Aircraft Co.	Newport Beach, Calif.
734		Dix. of North
770.00	American Phillips Co.	Inc. Bickeylle, S.Y.
734		So. Pasadera, Calif.
7350		
7355		Harfford, Comn.
7377		 Philodelphia, Pa. Chicago, III.
7374		Cincinnati, Ohio
73.19		Cincienati, Ohie Elyria, Ohie
7364	6 Gosten Stamping & Tool (ic. Goobee, Ind.
738		Brooklyn, R. Y.,
7390		San Jose, Calif,
7427		Septine, S.J.
7445		Mirchester, Wass.
7486 7486		
7488	Borg Electronics Corp.	
7497		Western, Minn.
7504	I låtersational Resistance C	
7517		
	of Cinch Wig. Corp.	Chicago, III.
7537		Sandwich, III.
7538		Mt. Venue, N.Y.
7588		Chicago, III.
7550		Des Plaites, III.
7921		Erie, Pa. San Francisco, Calil.
7843		Tern Brankler W.V.
76.40		c. Malfen, Hous.
7649	J.W., Miller Co.	Los Aspeles, Calif.
7653		Son Leandra, Calif.
7654		Cleveland, Ohio,
76854		Crystel Lake, III.
7706	and the second s	
7167	Bendin Dorp.	No. Hallywood, Calif.
7722		San Francisco, Galit.
*****	Electronic Co.	Sact Pasadens, Calif.
77250		Chicago, III.
77253		
		Philadelphia, Ps.
77342		
200	Rochine and Foundry	Princeton, Ind.
77630		Candin, N.J.
77638		Brooklyn, N.Y.
77764		Harrisburg, Fa.
76189		Tonnece, Calif.
10000	Tool Marks	Elgin, III.
78283		New York, N.Y.
78290	Strathers-Dune Inc.	Pitnan, N.J.
18452		Chicago, III.
38471		Saw Francisco, Calif.
78468		St. Marys, Pa.
18493		Waltham, Nocs.
78553 78750		Cleveland, Ohio
78947		Pasadesa, Calif. Newtoniille, Mass.
79142		Hartford, Cons.
79251	Wenco My. Co.	Chicago, IV.
79.727		
		Philadelphia, Fa.
79963		New Rochelly, N.Y.
80631		
80120	Clock Co.	Monietews, H.J.
80130		Elizabeth, N. J.
80130	Electronic Industries Assoc	New York, N.Y. lation. Any brand
	tabe needing EIA standa	
80707	Unimax Switch, Div. of	
	W. L. Margen Corp.	Wallingland, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248		Chicago, III.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acre Div. of Robertsham	Patrick of the Co.
11416	Fultes Centrals Co. All Star Products Inc.	Columbus 15, Obio
80501	Avery Adhesive Label Cosp.	Befigace, Ohio Mossovia, Calif.
81582	Hammerland Co., Inc.	New York, N.Y.
89646	Slevens, Arnold, Co., Inc.	Borton, Wass.
81036	International Instruments, In	L
		Men Haven, Goss.
81073	Graybill Cs.	LaGrange, 10.
81095	Tried Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co.,	inc. Norwalk, Cons.

APPENDIX CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

			Code			Code			Code			
Code No.	Manufacturer	Address	Me.	Manufacturer	Address	No.	Manufacturer	Address	No.	Manufecturer	7	Address
Ma.	Manufacturer	Address										
81769	William Specification	The second second second	85474	R.M. Bucaminin & Co.	San Francisco, Calif.	91829	G. V. Controls	Livingstor, N. J.	98270	Francis L. Wasley	Pasadera	a. Calif.
81415		Cleveland, Ohio	85660	Keiled Kords, Inc.	New Hanns, Core.	51981	legative-Van Horsus Inc. 1	loc.	99278	Wicipfol, lec.	So. Pasadeta	
81453			85411	Seamless Rubber Co.	Chicago, 65,	-	Electronic Divinion	Nanchester, N. H.	96291	Sealeche Cora.	Mameranec	
81.00	Div., Industr. Tube Operation		86197	Cliffing Precipion Products	Clifton Heights, Fa.	94117	General Cable Corp.	Baycone, N.J.	38435		Redwood City	
81483		El Seguedo, Catif.	86579	Precision Rubber Products	Corp. Bayton, Ohio	94144	Raytheon Mig. Co., Industr	al Consensats	96731	General Will's	Winneagons	
81541	The Airpes Products Co.	Cambridge, Mass.	16414	Redio Corp. of America, R			Div., Receiving Tube Op		98921			a. N.Y.
81860				Electron Tube Div.	Ratrison, W.J.	64146	Fastleon My, Co., Senico		98975			
82082		Waterbown, Mass., Skotie, III,	87716	Philips Corporation (Lavado		enene	California Street Plant	Newton, Mass.	2000	Dix, of Clevite Corp.	No. Street	, Mass.
				Division)	Lanadale, Pa.	24146	Scientific Radio Products, 1		82018	International Electronic	and the same	,
82342	Jeffers Electronics Division of		87479	Western Fibrous Glass Proj		91110	scientific wasto Products, i		90918	Research Carp.	Debes	L Calif.
****	Speer Carbos Co.	Du Bois, Pa.	0.472	POSIZIO FIGURES GRESS FIRM	Son Francisco, Calif.	marks.	Time Sal Plantile, Sec.	Lovetand, Cala. Newark, N. J.	991 09		New York	
	Allen B. Diffort Lats, Inc.	Cliffon, N. J.	87668	Van Waters & Hagers Inc.	Sentile, Wash.		Tung Gel Electric, Inc.	newars, n. J.	91313		Palo Alto	
82299		Greenwich, Donn.	87930		Providence, R. L.	94177	Certiss-Wright Corp.,	Witness Co., Wall		Marshall Industries, Electron		C CHIC
81219	Sylvania Electric Prod. Inc					6000	Electronics Dis.	East Paterson, N. J. Corp. Lester, Pa.	31013	Products Division		200
	Electronic Tube Div.	Emporium, Pa.	88140		Lineals, III.		Southce Div. of S. Chester		100000		Pasadeta	L GRISS
	Astron Cs.	East Newsrit, N. J.	88220	Goold-National Batteries, I		94310	Tru Ohn Pred. Div. of Rode		30181	Control Switch Division, Con		
	Switchcraft, Inc.	Chicago, III.	19658		Buffalo, N.Y.		Engineering and Mrg. Co			of America	El Segundo	
82647	Wets is and Controls, Inc., Dir	, et	89231	Graybar Electric Co.	Gustant, Calif.		Nim Cloth Protects Inc.	Chicago, III.	99800		East Aurer	
	Teams Sentements, Inc.,		89462		Contridge, Mass.	34682	Baicester Pressed Aluminum			Wilco Corporation	Indianapol	
	Spencer Freds.	Allieboro, Rass.	89473	General Electric Distribution		42347	Language and a contract of the	Wordester, Mass.		Rentrandt, Inc.		r, Mass.
82866	Research Products Corp.	Madison, Wis.			Schenectady, N.Y.	95023	Philbrick Streambers, Mc.		23947	Hoffman Senicandector Div.		
82877	Rotron Manufacturing Co., Inc.	. Woodstock, N.Y.	89636	Carter Parts Div. of Econo	ny Baler Co.	95236	Allies Products Corp.	Winni, Fla.		Hoffman Electronics Corp.	Evanst	tm, III.
82893	Vector Electronic Co.	Glendale, Calif.			Chicago, III.	95238	Continental Connector Corp.	Woodside, N.Y.	99957	Technology Instrument Corp		
83053	Western Washer Mtr. Co.	Los Angeles, Calil.	89165	United Transferent Co.	Chicago, Iti.	95253	Leecsaft Mtg. Co., Inc.	New York, N.Y.		of Calif.	Revious Park	, Calit.
83058	Carr Fastener Co.	Cambridge, Muss.	90179	U.S. Rubber Co., Rechanic	tal	95264	Lexen Electronics, Inc.	Burbank, Calif.				
83886	New Hanophire Sall Searing, I	80.		Goods Dix.	Passaic, N.J.	95295	National Call Co.	Derider, Wre.		FOLLOWING H-P VENDOR		
		Petrobarough, H.H.	90978	Bearing Engineering Co.	San Francisco, Calif.	99275	Vitzanon, Inc.	Bridgeport, Core.		ASSIGNED IN THE LATEST		
#3125	Pyramid Electric Co.	Durlingine, S. C.	91.751	Cennor Spring Mig. Co.	San Francisco, Calif.	95348	Gordan Carp.	Bloomfield, N. J.	THE	FEDERAL SUPPLY CODE	FOR MAN	IUFAC-
8014B	Electro Cords Co.	Les Aspeles, Calif.	91345	Miller Dial & Rameplate Co.	El Weste, Calif.	95354	Wethole Wig, Cs.	Chicago, III.	TURE	RS HANDBOOK.		
83196	Victory Engineering Corp.	Springfield, &. J.	31413	Radio Materials Co.	Chicago, NI.	9171.2	Dage Electric Co., Inc.	Franklin, Ital.				
83298		Red Basi, N. J.	91506	August Brothers*, Inc.	Attlebers, Mann.	95987	Weckesser Co.	Chicago, III.	J0000	Winchester Electronics, Inc.		
83315		Mundelein, III,	91637	Date Electronics, Inc.	Columbus, Nebr.	96067	Huggies Laboratories	Sunnyvale, Carit.			Santa Monics.	Calif.
83330		Brookles, N.Y.	91062	Elco Corp.	Philadelphia, Pa.	96095	HI-Q Division of Autovoc	Oleus, W.Y.	6000F	Malca Tool and Die	Los Angeles	Calif.
87385		Chicago, III.	51737	Grenur Mig. Co., Inc.	Wakefield, Mass.	96256	Thordarson-Meissner Div. of		0000M	Bestern Coil Div. of Automat	ie.	
			91 627	K F Development Co.	Redwood City, Calif.		Magain Industries, Inc.	W., Carnet, III.		led., lec.	Redwood City.	Calif.
00000	Div. of Amerace Corp.	Brookfield, Mac .	91123	Minnapolis-Roseywell Reg.		96296	Selar Manufacturing Co.	Lys Aspeles, Calil.	9900P		Helliste.	Mass.
01554	Burntaghs Carp	B13100000000000000000000000000000000000		Migroswitch Div.	Freeged, III.	96330	Cartton Screw Co.	Chicago, III.	0000Z		Breat	k. N.J.
- Spinist	Electronic Tabe Div.	Plainfield, N. J.	91961	Nation-Bros., Spring Co.	Dakland, Calif.	96343	Microwaye Associates, Inc.	Burlington, Mann.	000AA	British Radio Electronics Ltd		
201240	Eversaly Baltery	Hew York, N. Y.	92180	Try-Connector Carp.	Peabody, Many.	96500	Eccel Transfermer Co.	Cublent, Calil.	800AB			England
83777	Model Eng. and Mig., Inc.	Hantington, Inc.	97196	Universal Metal Pred., Inc.		97464	Industrial Retaining Ring Co.			Indiana General Curp., Elect		Indiana
			92367	Elgent Optical Co., Inc.	Rochester, N.Y.		Automatic and Precision Mig			Precision Instrument Compone		,
83821	Layd Striggs Co.	Festus, No. New York, N.Y.	52607	Tieselite legalated Wire Co.		21462	commence and a consider met	Yorkers, N.Y.	-	Contract of Contract Contract	Van Boys,	CARE
84171.	Arice Electronis, Inc.	as Francisco, Calif.		Sylvania Electric Prod. Inc.		37966	CBS Electronics.	Territory, M. F.	00000	Robber Eng. & Development	Hayward,	
			orest.	Semiconductor Div.	Webste, Mass.	21,769	Dir. of C. B. S., inc.	Danvers, Mass.		A "B" D Handscluring Co.	San Jone 27,	
94411	Good All Electric Wfg. Co.	Ogaltais, Neb.	91359	Pobbins and Myers, Inc.	New York, N. Y.	37674	Rose Register Corp.	Yorkern, M.Y.		Cooling	Cuklant,	
	Stekes Tatzion, Inc.	Disconington, Ind.	93410		Mansfield, Ohio		Azel Brothers Inc.	Jamaica, N.Y.	12800	Control of Eigen Nation Co.	Burbank,	
85454		Booston, N. J.		Howard J. Smith Inc.	Port Mosmorth, N. J.		Rubber Teck, Inc.	Gardera, Calif.		California Eastern Lab.	Bulingary,	
65471	A.B. Boyd Co. Si	yn Francisco, Calif.	-30.64			-44.13	Autom 1966, 860	serent, same			springers,	



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