OPERATING AND SERVICE MANUAL

MODEL 5090A
STANDARD FREQUENCY RECEIVER

SERIALS PREFIXED: E538

This manual applies directly to hp Model 5090A Standard Frequency Receivers having serial number prefix E538. This manual with changes provided in Appendix III also applies to Models having serial prefix numbers E525, E512, E447, E502.

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

02177-1

Printed OCTOBER 1965

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

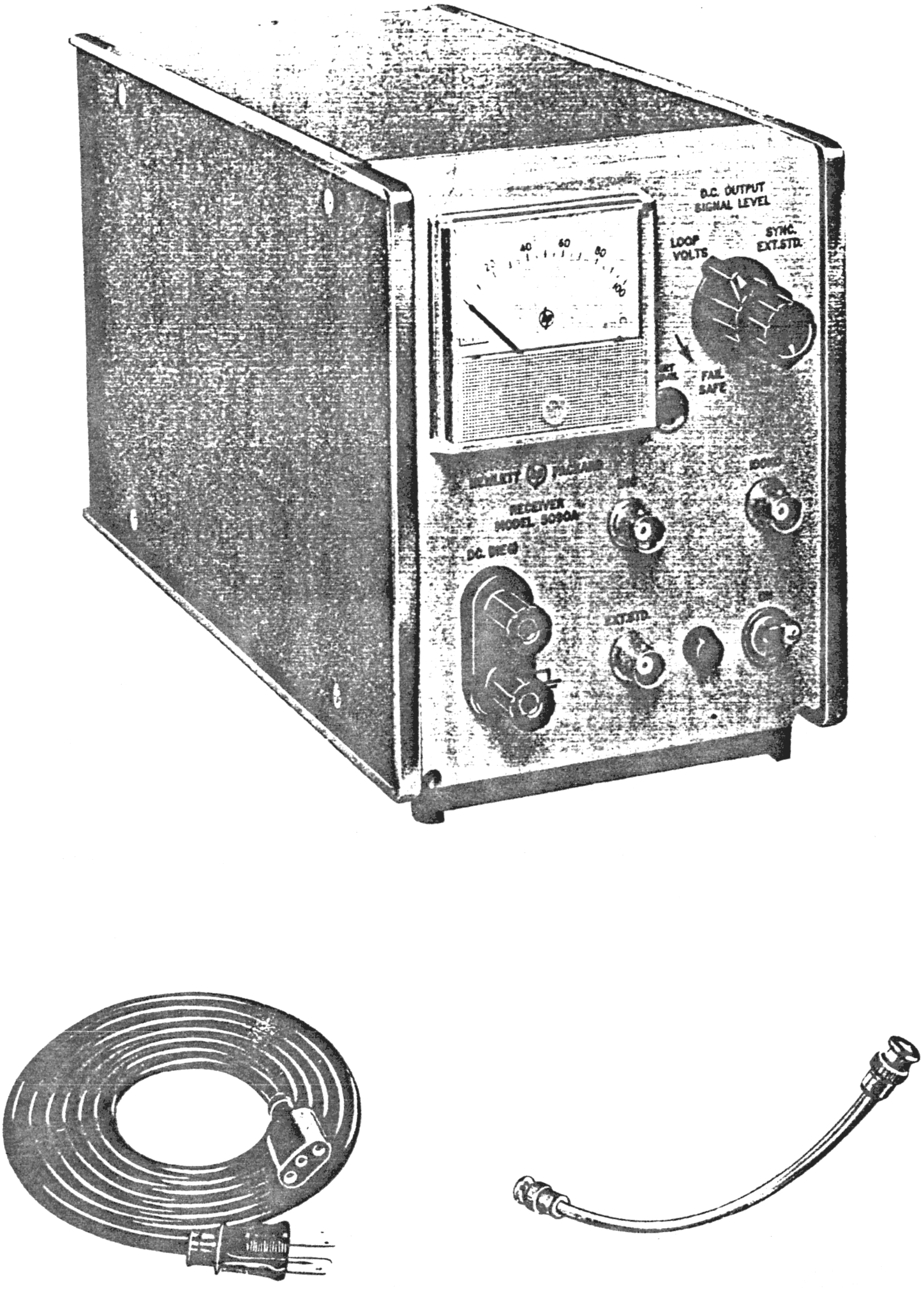


Figure 1-1 Model 5090A Standard Frequency Receiver

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. CONTENT. This manual provides instructions on operation and maintenance of the ⓗ Model 5090A Standard Frequency Receiver.

1-3. SERIAL PREFIX. The Model 5090A carries a five-digit serial number with a three-digit prefix (000-00000) engraved on a label on the rear panel. If the prefix number on the instrument agrees with the prefix number on the title page, this manual applies to the instrument directly. However, if the prefixes do not agree, change sheets with the manual describe changes which are necessary so that the manual can be used with the instrument.

1-4 GENERAL DESCRIPTION.

1-5. The Hewlett-Packard Model 5090A Standard Frequency Receiver is a general-purpose instrument which provides high-stability outputs at 100-kc and 1-Mc. The instrument can be used directly as a frequency standard, or employed as a frequency/phase measuring system to calibrate secondary frequency standards.

1-6. The instrument comprises a 100-kc crystal oscillator, phase-locked to the standard frequency carrier of the British Broadcasting Corporation (BBC) Light Programme broadcast on 200-kc from Droitwich, England. The stability of the output when locked to the transmitter is better than 5 parts in 10^{10} per day. Full European coverage is ensured by the high sensitivity and narrow bandwidth of the receiver.

1-7. In normal operation the user is protected against transmitter failure or shut-down by fail-safe gates which prevent erroneous outputs if the internal oscillator is not securely phase-locked to the received carrier. This facility can be by-passed if continuous outputs are required. Under these conditions, in the absence of the 200-kc Droitwich carrier, the stability of the internal oscillator is better than ± 2 parts in 10^6 per week at constant temperature.

1-8. Facilities are provided for comparing the frequency or phase of an external signal with the standard. The meter on the front panel can be used as a coarse indication, but for the most precise measurements a chart recorder or time-interval counter is necessary.

1-9. The instrument is self-contained and the only external items required are a mains supply and aerial. Printed circuits and transistors are used throughout to ensure reliability.

1-10. The receiver is constructed as a 1/3 rack-width module following the ⓗ modular cabinet system, and is intended for bench use. If required for rack mounting, a Rack Adaptor Frame (ⓗ Part No. 5060-0797) or a Model 1051A Combining Case may be used.

1-11. ACCESSORIES SUPPLIED WITH THE INSTRUMENT.

ⓗ 8120-0078	Power Cable with plugs.
ⓗ 10502-6001	Coaxial jumper cable with BNC plugs.

1-12. ACCESSORY AVAILABLE at EXTRA COST.

ⓗ 15500A Ferrite rod aerial.

1-13. SPECIFICATIONS

1-14. Table 1-1 lists the technical specifications for the Model 5090A.

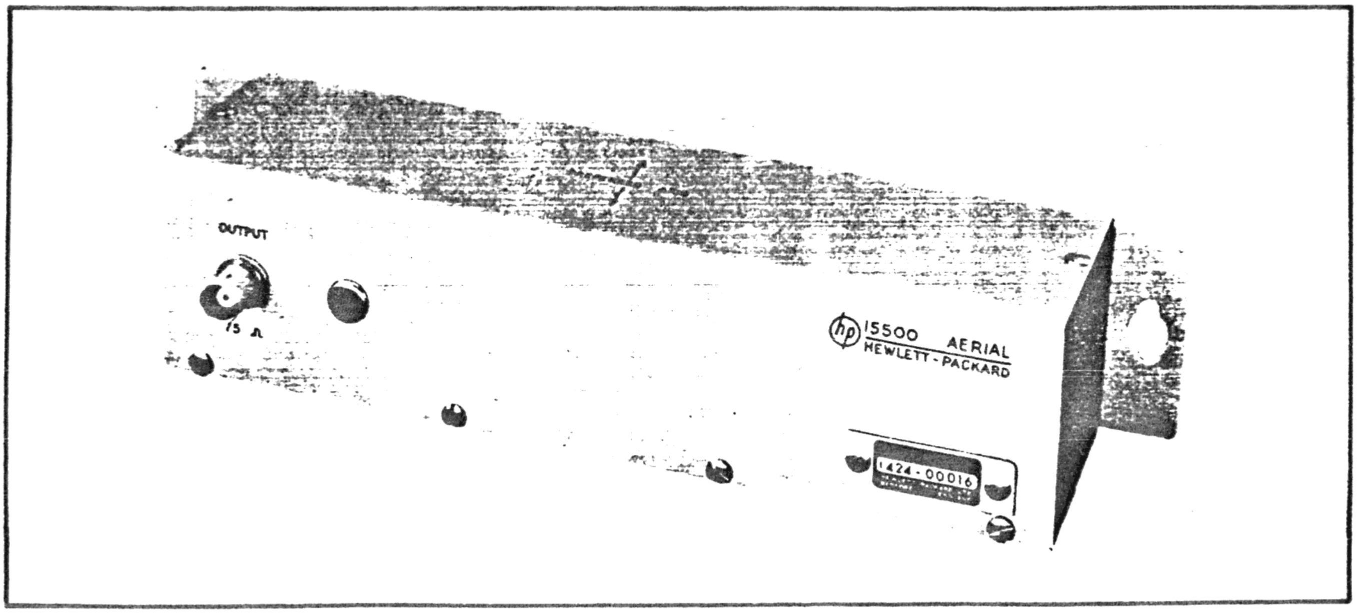


Figure 1–2 Accessory Available at Extra Cost for Model 5090A Standard Frequency Receiver

Table 1-1 SPECIFICATIONS

INPUT FREQUENCY:
200-kc British Broadcasting Corporation Light Programme Carrier

SENSITIVITY:
1 microvolt into 75 ohms

INPUT IMPEDANCE
75 ohms nominal B N C Coaxial input.

LOCKED FREQUENCY STABILITY:
Long-term stability will be that of the Droitwich transmitter. Short-term stability may be less than that of the Droitwich transmitter due to propagation effects, but these are expected to be small within the British Isles. The typical drift rate for the Droitwich transmitter arranged over several days can be less than 1 part in 10^{10}. Limits of 1 part in 10^9 are maintained by the B.B.C. (see Paragraphs 3-3 through 3-8).

UNLOCKED FREQUENCY STABILITY:
Unlocked stability will be that of the internal crystal oscillator, 2 parts in 10^6 per week at constant temperature.

BANDWIDTH:
Less than 1 cps.

ADJACENT SIGNAL REJECTION:
Signals 60db greater than the wanted signal and removed in frequency by at least 3-kc from the wanted signal cause phase-delay errors not exceeding 1 microsecond.
(Better than 70db rejection at 9-kc separation).

OUTPUTS:
100-kc and 1-Mc; 1 volt rms into 1000 ohms (Approximate Sine Wave).

PHASE-DELAY STABILITY:
Temperature changes in the range 0-50°C will cause phase-delay shifts not exceeding 1 microsecond. (1 microsecond error over an integration time of 24 hrs. represents a comparison error of 1 part in 8.64 x 10^{10}).

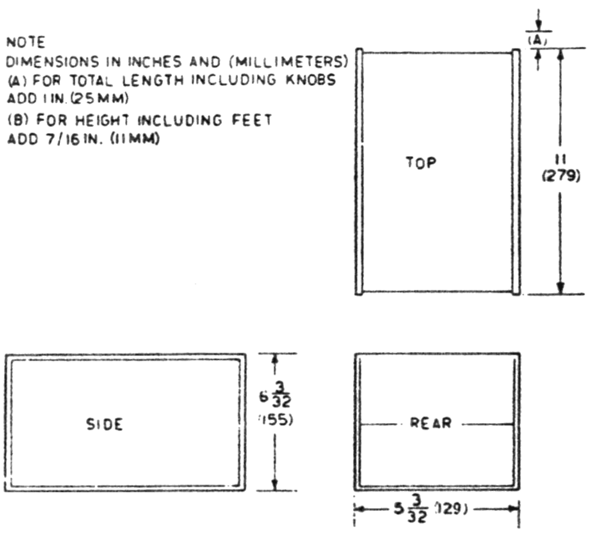
METER READINGS:
1) Loop Volts (Test Position)
2) Signal Level (Relative)
3) Sync. Ext. Std. In this position the meter indicates the output of the comparator. The reading is related to the phase difference between the two inputs of the comparator. The chart recorder output is shunted by approximately 100 ohms when the switch is in this position.

FAIL SAFE:
This facility ensures that outputs are available only when the instrument is securely locked to the input signal and a relative signal level indication of 25 or greater is available.

FREE RUN:
Outputs are available at all times whether instrument is locked or not.

ADJUSTMENTS:
Set Level is a Front Panel gain control and is used for day-to-day variations of signal level.
A D.C. output control enables the amplitude of the output from the phase comparator to be varied.

DIMENSIONS:



WEIGHT: 9 lb (4.1 Kg).

POWER:
115 or 230 volts ± 10%, 50/1000 c p s 8 watts.

LOCAL STANDARD INPUT: (For Phase Comparison only)
100-kc or 1-Mc 1 volt rms into 1000 ohms. 1000 ohms.

CHART RECORDER OUTPUT: (For Phase Comparison only)
1mA maximum into external resistance up to 1.2k ohms.

STORAGE TEMPERATURE:
0°C to 55°C (32°F to 131°F).

OPERATING TEMPERATURE:
0°C to 50°C (32°F to 122°F)
(see para. 2-30)

SECTION II
INSTALLATION

2-1. INITIAL INSPECTION.

2-2. MECHANICAL CHECK. Inspect instrument for shipping damage as soon as it is unpacked. If the shipping carton is damaged, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for mechanical damage (scratches, dents, broken knobs, etc.). Also check the cushioning for signs of severe stress.

2-3. PERFORMANCE CHECK. The electrical performance of Model 5090A should be verified as soon as possible after receipt. A performance check suitable for incoming inspection is given in Paragraph 5-6.

2-4. CLAIM FOR DAMAGE. If Model 5090A is mechanically damaged or fails to meet specifications on receipt, notify the carrier and the nearest Hewlett-Packard field office immediately. (A list of field offices is at the back of this manual). Retain the shipping carton and the padding material for the carrier's inspection. The field office will arrange for the repair or replacement of your instrument without waiting for the claim against the carrier to be settled.

2-5. RECEIVER INSTALLATION.

2-6. Model 5090A is shipped from the factory ready for operation as a bench instrument. For rack installations, a Combining Case or a Rack Adaptor Frame should be used. A permanent installation is not essential.

2-7. COMBINING CASE. Model 1051A Combining Case (see Figure 2-1) provides a convenient means for bench or rack mounting this instrument in combination with other small modular Hewlett-Packard instruments. In the bench application it may be used either singly or stacked with other combining cases or full modules. Two internal dividers are furnished so that the case accepts either 1/3- or 1/2-width modules. Blank panels and Accessory Drawers are available to give the case a finished appearance when not all the space is used. All units can be easily inserted or removed from the front. A Control Panel Cover (hp Part No. 5060-0828) with locking device and carrying handle converts the Combining Case into a carrying case. Each Combining Case is furnished with hardware that converts the case to a 19-in. wide x 7-in. high rack mounting unit which matches the appearance of full rack-width modules. Instructions

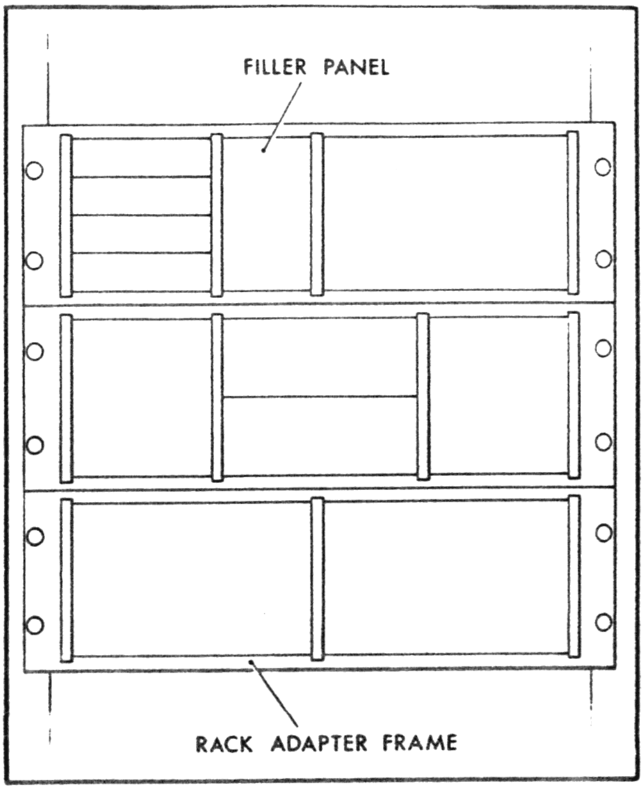


Figure 2-1 The Combining Case

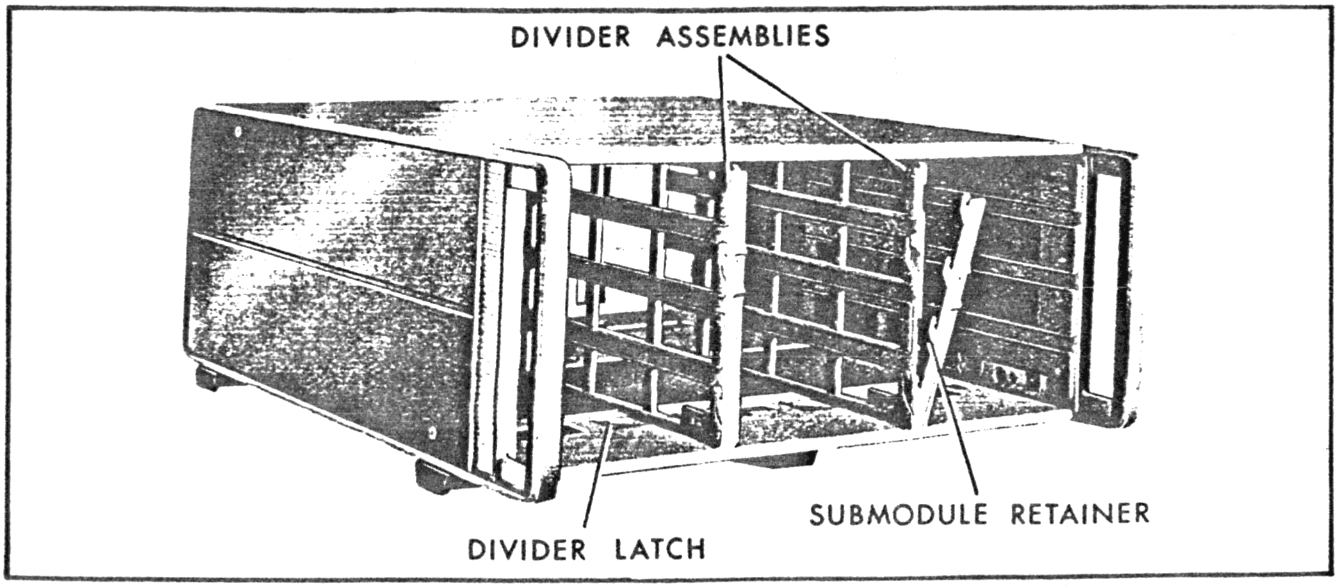


Figure 2-2 Adaptor Frame, Instrument Combinations

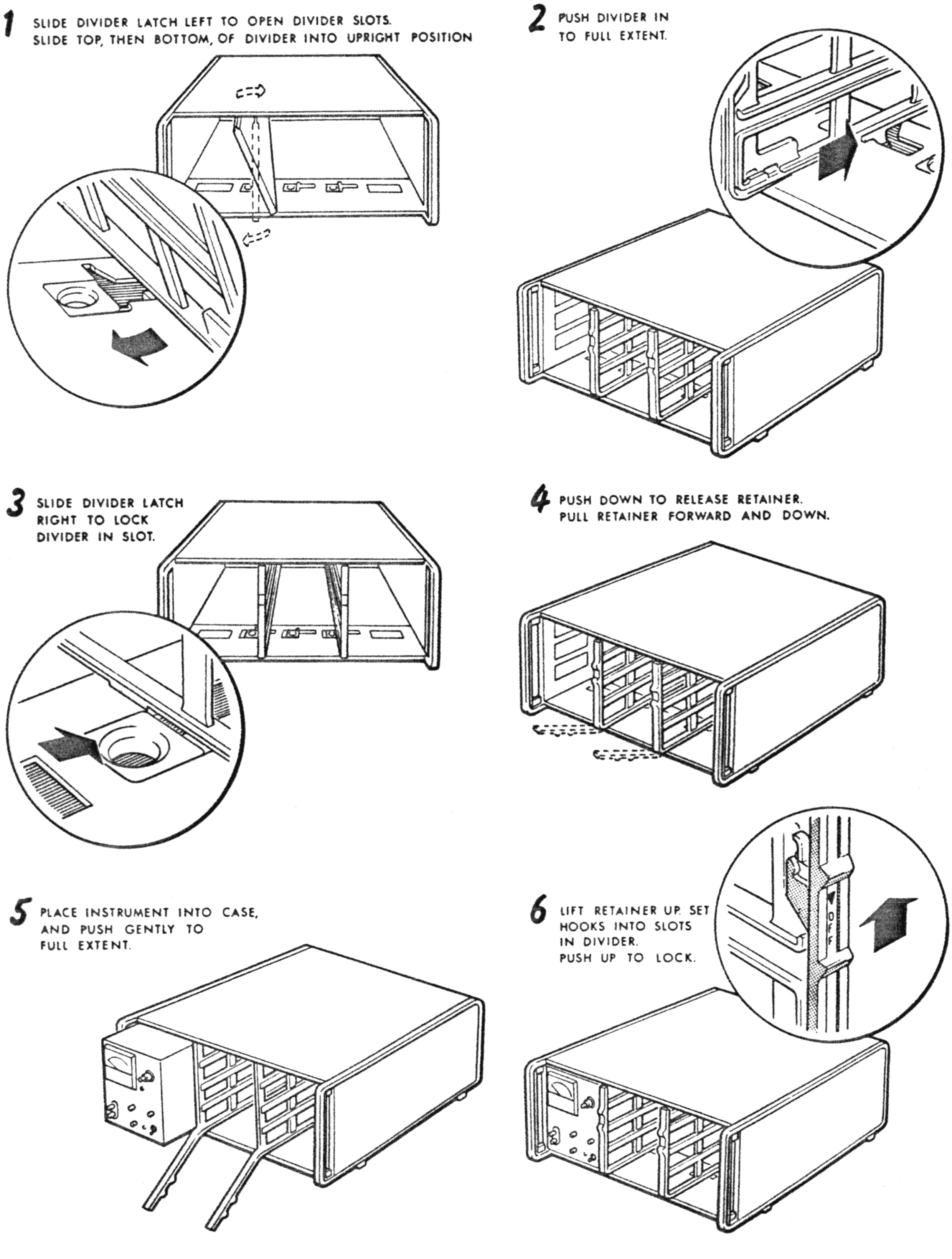


Figure 2-3 Steps to Place Instrument into Combining Case

for installing Model 5090A in a Combining Case are given graphically in Figure 2-3.

2-8. RACK ADAPTOR FRAME. A simple, but less versatile Adaptor Frame (hp Part No. 5060-0797) is also available to rack mount 1/3- or 1/2-width modular instruments. The blank panels or drawers described above may also be used to fill unused space in these frames (See Figure 2-2). An instrument mounted in this way cannot be removed without first removing the frame itself from the rack, hence the Combining Case is more convenient where quick and easy removal and re-installation of instruments is desired. For a permanent installation, however, this Adaptor Frame is fully adequate. Installation instructions are given in Figure 2-4.

2-9. AERIAL INSTALLATION.

2-10. The type of aerial required will depend upon where the Receiver is installed (see Appendix I). Hewlett-Packard recommend use of one of the following aerials, according to local signal levels.

a. FERRITE ROD. A ferrite rod aerial (hp Model 15500A) will provide adequate signal input to the Receiver throughout the greater part of the British Isles. Turn the rod to the maximum signal position before fixing.

b. SCREENED RESONANT LOOP. In low-signal areas, and where adjacent-channel interference is prevalent, the higher sensitivity and sharper directional properties of a screened resonant loop are advantageous. Turn the loop either to the maximum signal position, or to the minimum interference position, according to local conditions.

c. 50-FT. INVERTED-L. This type of aerial may be used as an alternative to (b) in low-signal areas free from interference and for shipboard use in Northern and Western waters.

2-11. The aerial must be located where it will not pick up spurious 200-kc radiation from other equipment. Frequency Counters, for example, often radiate a strong 200-kc component and can be a particularly serious source of interference. The Receiver itself is fully screened and may be mounted close to similar units without restriction.

2-12. Connect the aerial to the Receiver via a 75Ω co-axial feeder cable terminated in a BNC socket. The aerial connector is on the rear panel. With inverted-L aerials a coupling transformer may be used to match the aerial impedance to 75Ω if maximum sensitivity is required.

2-13. POWER CONNECTIONS.

2-14. Model 5090A can be operated from either 115V or 230V (±10%) power lines. A slide switch on the rear panel permits quick conversion for operation from either voltage (see Figure 2-5). Insert a narrow-blade screwdriver in the switch slot and move the switch to expose the number corresponding to your nominal line voltage.

CAUTION

Before connecting ac power to the instrument, ensure that this switch is correctly set.

2-15. The receiver is supplied with a 150mA fuse for 115V or 230V operation.

2-16. A 3-conductor power cable is supplied with the instrument. Connect the flat 3-conductor female plug to the jack on the rear panel of the instrument. Connect the male plug (two blades with round grounding pin) to a 3-conductor (grounded) outlet. Exposed portions

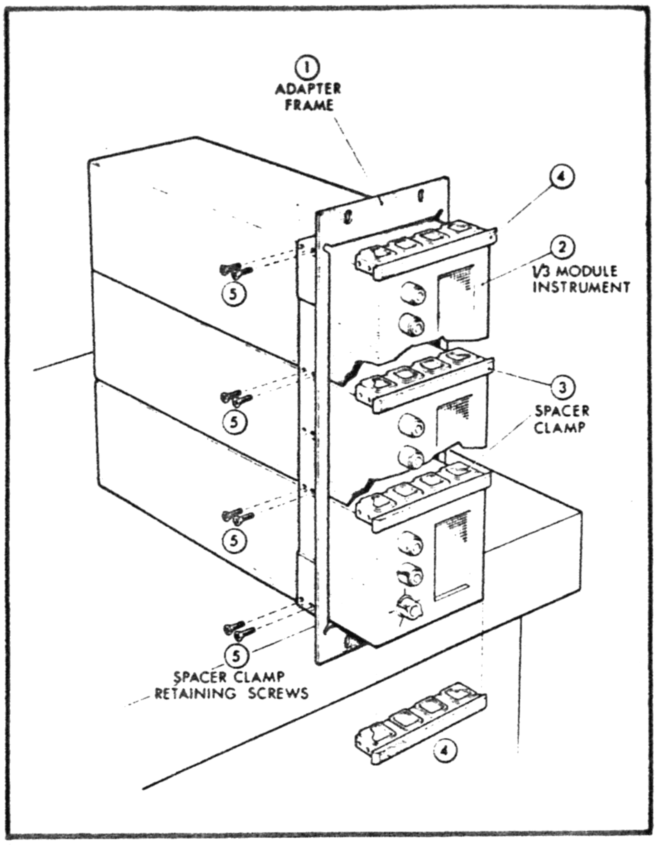


Figure 2-4 Three Third Modules in Rack Adaptor

of the instrument are grounded through the round pin for safety. When only two conductor outlets are available, use connector adaptor (hp Part No. 5060-0828) and Circuit a short wire from the adaptor to a suitable ground.

2.17. For British and European power outlets, a suitable adaptor may be available locally. Otherwise, cut the existing plug from the cable and connect a suitable plug

WARNING

HEWLETT-PACKARD POWER SUPPLY CABLES ARE COLOUR-CODED AS FOLLOWS:

LIVE = BLACK
NEUTRAL = WHITE
EARTH = GREEN

ENSURE THAT REPLACEMENT PLUGS ARE WIRED CORRECTLY BEFORE CONNECTING AC POWER.

2-18. SIGNAL CONNECTIONS.

2-19. The 100-kc and 1-Mc outputs are connected to BNC sockets on both the front and rear panels of the receiver. The mating connector is a BNC plug. Refer to Section III (OPERATION) for information on the use of these outputs.

2-20. The DC output for an external chart recorder is available at two dual banana jacks, one on the front panel and one on the rear panel. This output is suitable for driving either a moving-coil or a potentiometric recorder. The mating connector is a male dual banana plug (hp Part No. 1251-0005).

2-21. The INTERNAL and EXTERNAL STANDARD input sockets are described in Section III.

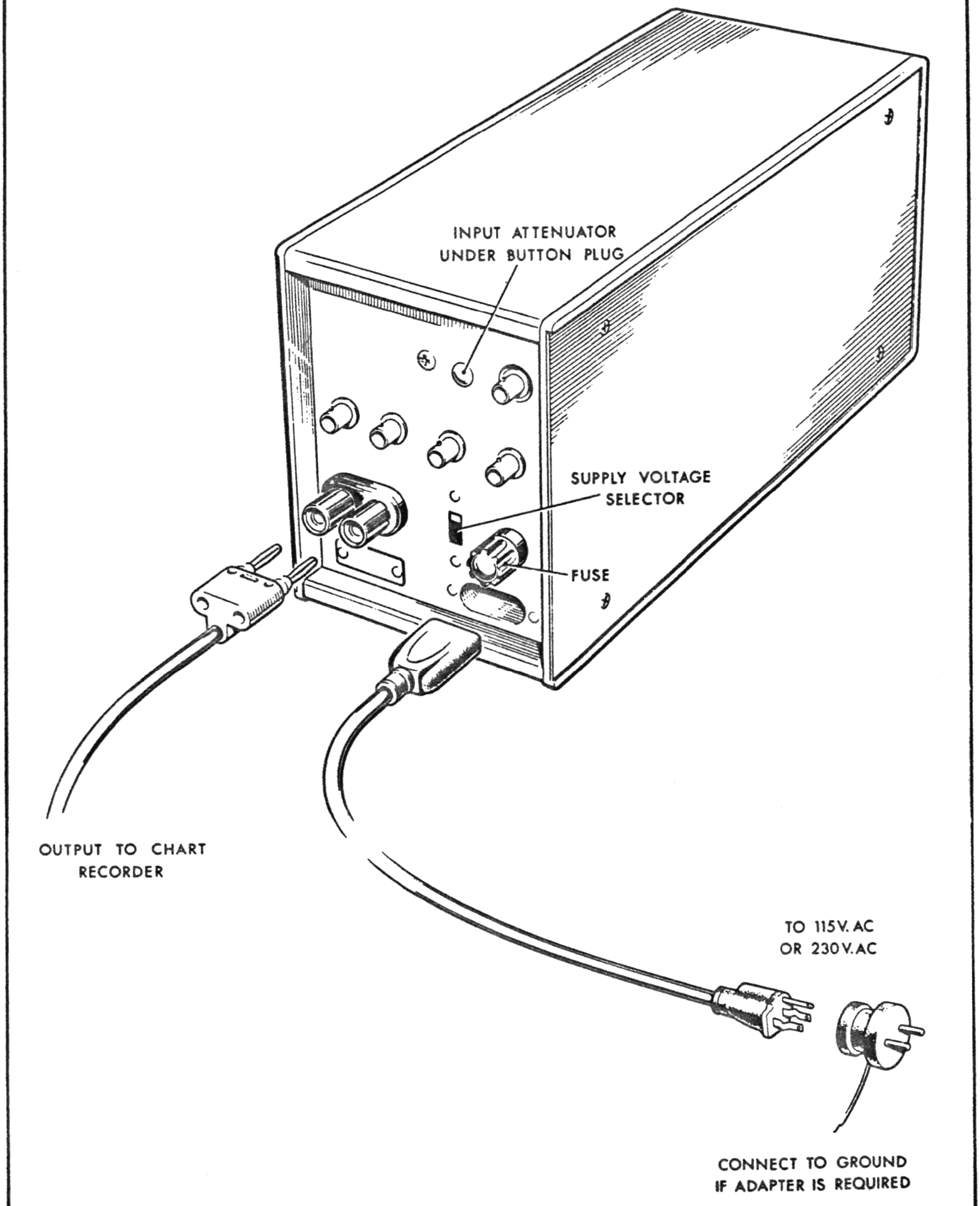


Figure 2-5 Rear Panel Connections

2-22. INITIAL SETTING UP.

2-23. For installations within the primary service area of Droitwich (see Figure IA-4) set the preset attenuator control located under the button plug on the rear panel fully counter-clockwise for maximum attenuation. For installations beyond this area set the control between the mid-position and fully clockwise.

2-24. Ensure that the rear panel selector switch is set to the correct voltage, and that ac power is connected to the instrument.

2-25.
a. Set the power switch to ON and observe that the red lamp glows.
b. Temporarily remove the aerial plug from the rear panel connector.
c. Set the meter function switch (black knob) to LOOP VOLTS.
d. The meter pointer should settle to a reading of 25 to 35 If this meter reading is not obtained within 10 minutes of switching on, the instrument is faulty. Refer to Fault Location, Paragraph 5-20.
e. Re-connect the aerial.
f. Set the meter function switch to SIGNAL LEVEL.
g. Check that the meter pointer shows small fluctuations in level which gradually increase in amplitude until, after about 3 to 4 minutes, a steady indication is shown.
h. Adjust the SET LEVEL control to set the meter reading to 30. If the SET LEVEL knob has insufficient control, adjust the attenuator under the button plug on the rear panel as necessary.

2-26. Check that the Receiver is not phase-locking to spurious 200-kc radiation from other equipment by temporarily switching off such equipment where possible.

2-27. If the SIGNAL LEVEL meter reading does not stabilize within 10 minutes the signal level is too low. Consideration should be given to improving the aerial system.

2-28. The Receiver is now ready for use.

2-29. OPERATION AT HIGH OR LOW TEMPERATURES.

2-30. If the instrument is to be used at temperatures outside the range +15°C to +35°C the internal oscillator may fail to lock within 10 minutes even with an adequate signal level. Under these conditions the following adjustment will be necessary:—
a. Remove the right hand side panel.
b. Connect the aerial.
c. Switch on power.
d. Set the meter function switch to SIGNAL LEVEL.
e. Turn the SET LEVEL control fully clockwise and check that the instrument is attempting to lock, i.e. that the meter pointer beats up and down.
f. Using a non-magnetic insulated screwdriver, adjust VC1 slowly in a direction which will decrease the frequency of the beats until the instrument locks.
g. Adjust the SET LEVEL control until the signal level reads 30.
h. Set the meter function switch to LOOP VOLTS.
j. Adjust VC1 very slowly until the meter reading is 30.
k. If the instrument goes out of lock during stage (j) repeat the procedure from (d) onwards.

2-31. STORAGE AND SHIPMENT.

2-32. ENVIRONMENT.

2-33. Temperatures during storage and shipment should normally be limited as follows:

Maximum temperature	131°F (55°C)
Minimum temperature	32°F (0°C)

2-34. PACKAGING.

2-35. The Model 5090A is shipped in a foam pack and cardboard carton (see Figure 2-6). When repacking the instrument for shipment the original foam pack and carton should be used if available. If not available, new packs and cartons can be purchased from Hewlett-Packard (see Section VI, Misc.). Use the following as a general guide for repackaging the instrument:
a. Place the instrument in the foam pack as shown in Figure 2-6.
b. Clearly mark the packaging box with 'Fragile', 'Delicate Instrument' etc., as appropriate.

Note

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach to the instrument a tag identifying the owner and indicating the service or repair required. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number and serial number prefix.

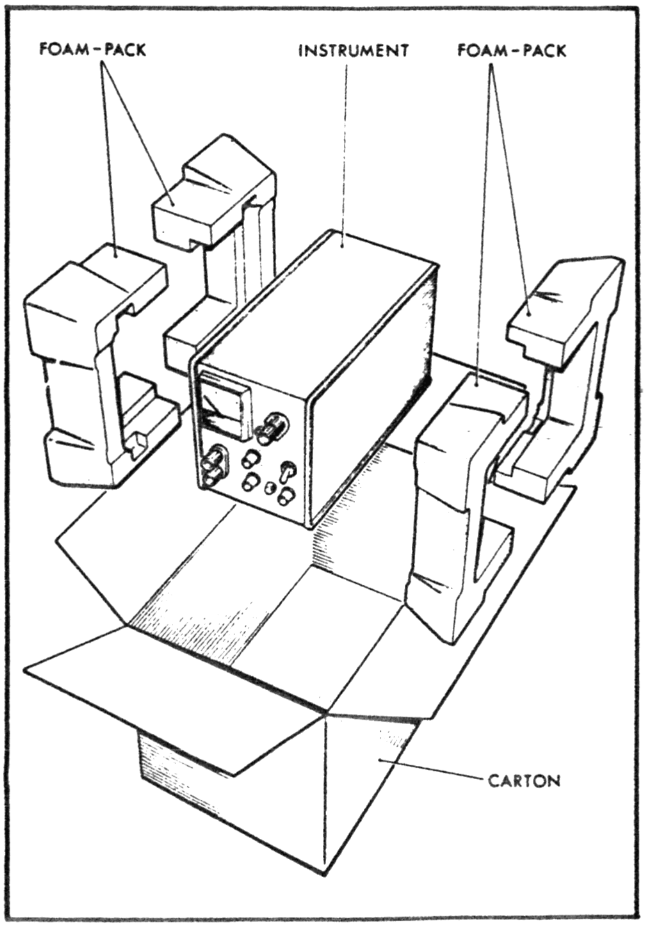


Figure 2–6 Repackaging for Shipment

2-36. If, for any reason, an alternative method of packing must be used, a double-walled carton from the following table should be specified:

Gross Shipping Weight	Carton Strength
Up to 20 lbs	200 lbs test
20 to 40 lbs	275 lbs test
40 to 120 lbs	350 lbs test
120 to 140 lbs	500 lbs test
140 to 160 lbs	600 lbs test

2-37. The Model 5090A weighs 9 lbs.

2-38. The instrument should be wrapped in kraft paper or plastic sheeting to avoid abrasion.

2-39. The front panel and other parts of the instrument that have damageable projecting parts should be protected with polyurethane or cushioned paper.

2-40. The instrument should be surrounded with at least 4 inches of tightly-packed shock-absorbing material.

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The Model 5090A Standard Frequency Receiver provides high-stability outputs of 100-kc and 1-Mc which can be used directly as frequency standards. The instrument also incorporates an independent comparator for accurate phase and frequency comparison of an external signal and the internal standard, or of two external signals. The front and rear controls, indicators and connectors are illustrated in Figures 3-2 and 3-3. Figures 3-4 to 3-6 outline the step-by-step procedures for operating the instrument as a frequency standard or phase and frequency comparator.

3-3. ACCURACY OF 200-kc TRANSMISSION.

3-4. In addition to its normal function as a broadcasting transmitter the 200-kc Light Programme Transmitter of the British Broadcasting Corporation at Droitwich, England, is maintained as a frequency standard. The convenient carrier frequency and high field strength throughout the British Isles give an excellent low-cost service which is widely used as a frequency reference by professional engineers. See Appendix I for details of area coverage.

3-5. New equipment recently installed provides a stability which is not normally exceeded by a crystal oscillator. Results published by the National Physical Laboratory (NPL) have shown average daily rates over several days of less tnan one part in 10^{10} per day.

3-6. To exploit this improved stability the BBC makes more frequent adjustments to the oscillator to maintain a very accurate 200-kc carrier. Limits are now set at $\pm$ 5 parts in 10^{10}. The requirements of the more accurate worker are met by the NPL monitoring service which compares the transmitted frequency daily against a caesium standard, and publishes the result to the nearest one part in 10^{10}. The careful design of the Model 5090A ensures that a transmission of this type is fully utilised and the stability of the signal is not degraded in any way.

3-7. There are 8.64 x 10^{10} microseconds in one day —approximately 10^{11}. Consequently, if two frequencies, nominally of 100-kc but differing in frequency by one part in 10^{10}, are to be compared, it will be about 24 hours before one oscillator has completed a whole cycle more than the other. That there is some advantage to be gained by making the comparison at the highest possible frequency becomes apparent when one considers that two 1-Mc oscillators under similar circumstances to the example given would require only 2.4 hours to become one whole cycle out of step. However, frequency comparisons of the accuracy now available from the Droitwich transmitter can be made, at the frequencies most commonly used by frequency standards and counters, only over a considerable period of time. During this time the receiving and comparison equipment should not contribute any significant error, such as change of phase delay from input to output.

3-8. The use of time interval measuring equipment will shorten the time required if the signals are sufficiently pure, but care must be taken to ensure that the receiving equipment does not contribute short-term phase errors. It should be borne in mind that such errors can arise from the effects of temperature changes, large interfering signals on neighbouring frequencies, over modulation, or radio noise.

3-9. USE AS A STANDARD FREQUENCY SOURCE.

3-10. The 100-kc and 1-Mc outputs are available at BNC sockets on both the front and rear panels; the respective sockets are wired in parallel. An output level of at least 1 volt rms (approximately sinewave) is available into an impedance of 1000 ohms or greater.

3-11. With the DC OUTPUT control (red knob) turned towards FAIL SAFE, outputs are obtainable only when the receiver is phase-locked to the transmitter carrier with a signal level of greater than 25. This is the normal operating condition of the instrument in which the user is protected against signals of unstabilized frequency which might be generated by the internal oscillator during periods of transmitter shut-down.

3-12. By setting the DC OUTPUT switch fully clockwise to the FREE RUN (click) position, the fail-safe gate is by-passed and outputs are continuously available whether the internal oscillator is phase-locked or not. The instrument may be operated in this mode when the Droitwich signal is not available, e.g. during normal close-down (0200-0400 British Civil Time daily), under fault conditions at the transmitter, or when, for any other reason, the received signal strength is inadequate. When the Receiver is not locked to the Droitwich transmission the output stability is that of the internal oscillator ($\pm$2 parts in 10^6 per week at constant temperature).

3-13. USE AS A PHASE OR FREQUENCY COMPARATOR.

3-14. Phase or frequency comparisons can be made at 100-kc or 1-Mc by linking the comparator to the standard frequency output of the instrument at 100-kc and 1-Mc (see Figure 3-5). Alternatively, since the comparator is entirely separate from the other functions of the instrument, it can be used independently to compare signals at any other frequency within its frequency range of 50-kc to 10-Mc. However, the two frequencies to be compared must be approximately equal.

3-15. Satisfactory results may not be obtained if the level of the external signal is less than 1V rms, but in some circumstances an improvement may be effected by interchanging the connections to the INTERNAL and EXTERNAL STD. INPUT connectors.

3-16. A 5-Mc external signal can be compared directly with the 1-Mc standard, but the DC output level will be reduced and it will usually be necessary to interchange the inputs, as detailed in the previous paragraph.

3-17. For precise measurement a Chart Recorder or Time Interval Recorder should be connected to the DC output Terminals on either the front or the rear panel (see Figures 3-2 and 3-3). Where a high accuracy of measurement is not required the use of a Chart Recorder may be dispensed with, and the front panel meter can be used to indicate the beat frequency (see Figure 3-6).

3-18. PHASE MEASUREMENT ACCURACY.

3-19. The phase measurement accuracy of the comparator is primarily determined by the stability of the received external signal in the locality where the instrument is being operated. The charts given in Figure 3-1 may be used to resolve the chart recording into the stability of the external signal. The relationship used is:

$$\text{Frequency Error} = \frac{1.5 \times 10^{-6}}{3 \times 60 \times 60} = 1.39 \times 10^{-10}$$

For example, if the measured phase delay difference is 1.5 μs during 3 hours

$$\text{Frequency Error} = \frac{\text{measured phase delay difference}}{\text{elapsed time } (\mu s) \text{ during measurement}}$$

= Approximately 1.4 parts in 10^{10}

3-20. METER AND METER FUNCTION SWITCH.

3-21. The meter function switch selects the information to be indicated by the meter. It has three positions as follows:

LOOP VOLTS — This is a test position to check the frequency control loop. At an ambient temperature of 25°C the meter reading should normally be between 25 and 35 (30±1 minor division).

SIGNAL LEVEL — This is the normal operating position of the switch, in which the meter indicates the relative signal strength of the 200-kc input. During use the reading should be set to 30 by adjusting the SET LEVEL control.

SYNC. EXT. STD. — In this position the meter is switched to the dc output of the comparator, and the meter reading is related to the phase-difference between the two inputs to the comparator. The output level at the D.C output terminals will be reduced because of the shunting effect of the meter movement.

3-22. SWITCHING ON.

3-23. Where the Receiver has been set up as described in Section 2, Paragraphs 2-22 through 2-28, proceed as follows:

a. Set the mains switch to ON and observe that the red indicator lamp glows.
b. Check that the aerial is connected.
c. Set meter switch (black knob) to SIGNAL LEVEL.
d. Check that the meter pointer shows small fluctuations in level which gradually increase in amplitude until, after about 3 to 4 minutes, a steady indication is shown.
e. If necessary, adjust the SET LEVEL control to bring the meter indication to 30.
f. The instrument may now be used, but optimum phase stability will be reached after about one hour.

3-24. EXTERNAL RECORDER OUTPUTS.

3-25. Phase comparison outputs for a Chart Recorder are provided at both front and rear panels at terminal connectors labelled D.C. The two sets of connectors are wired in parallel.

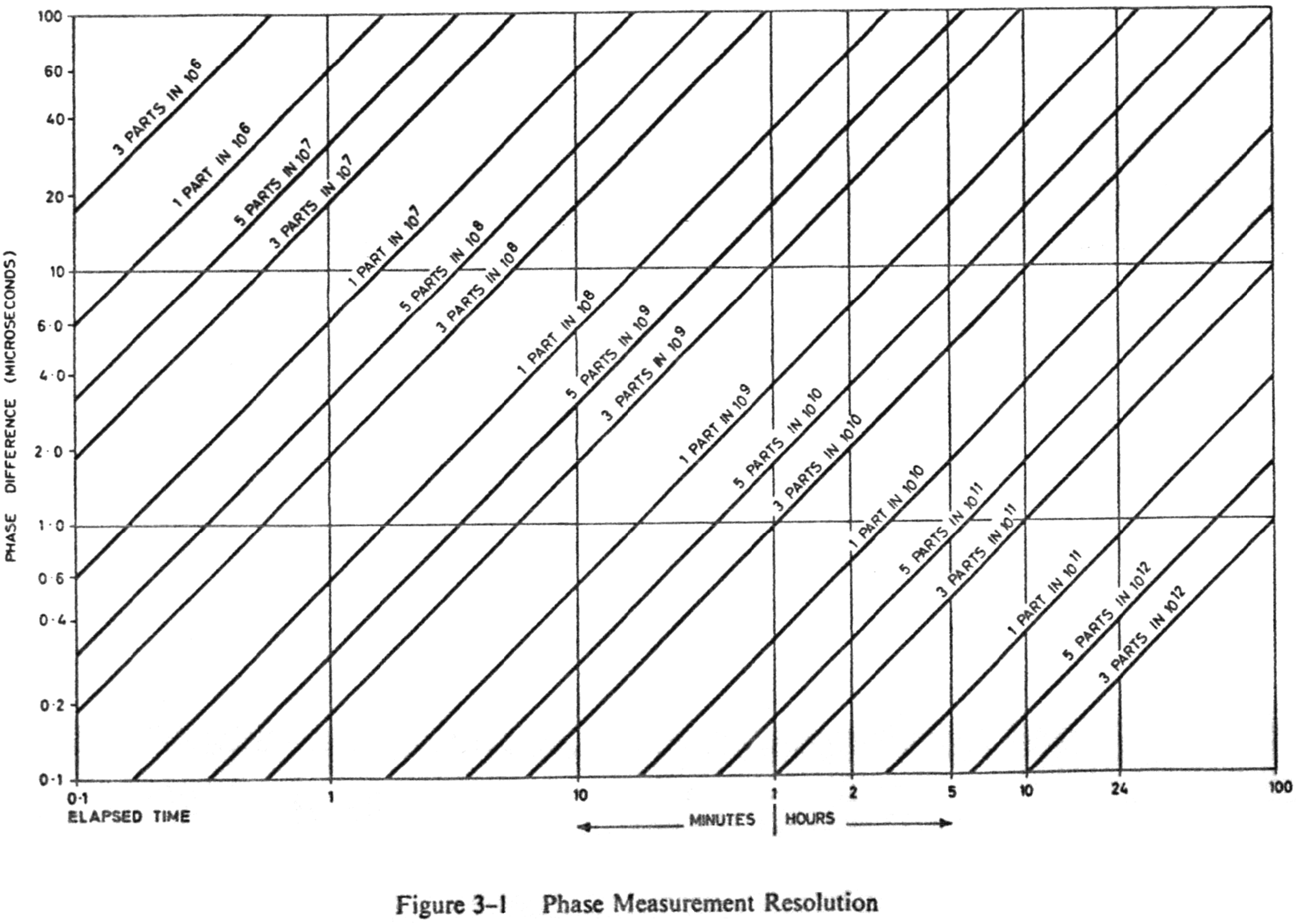
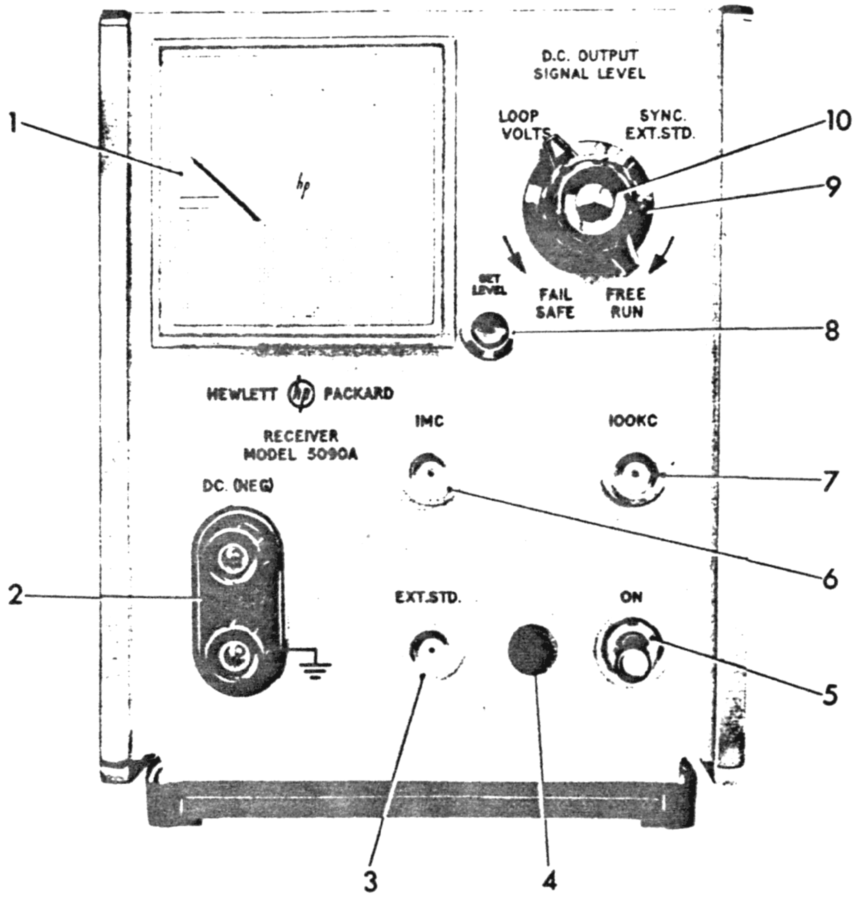


Figure 3-1 Phase Measurement Resolution

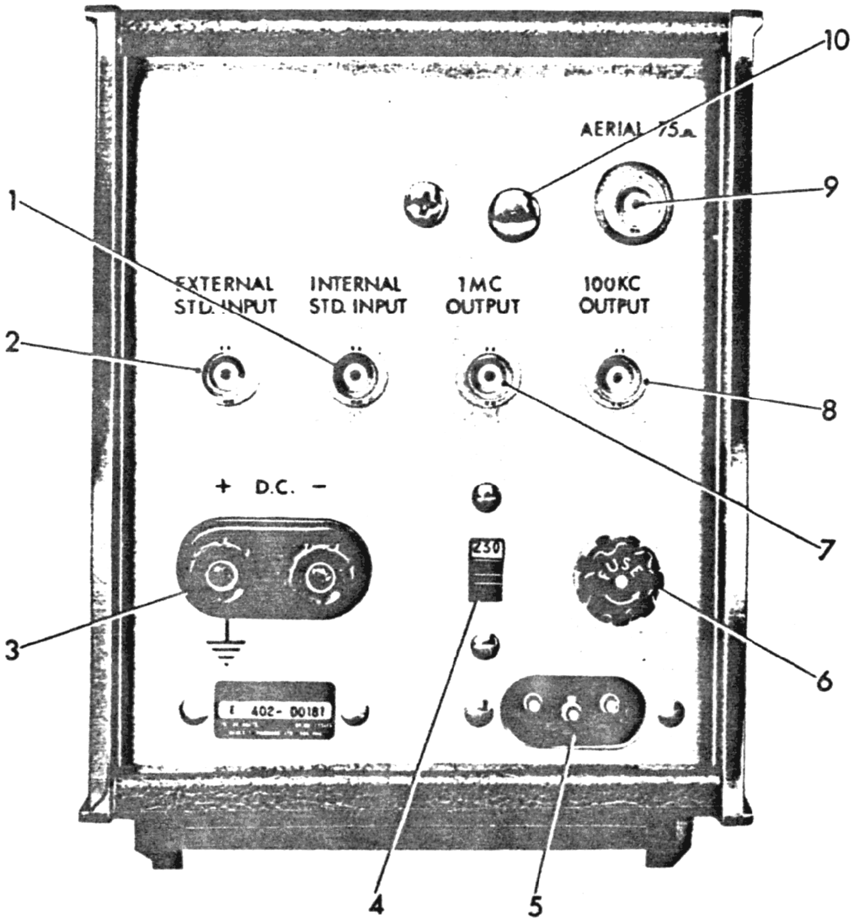
FRONT PANEL



1. FRONT PANEL METER: indicates control loop level, relative signal strength of 200-kc input, or phase difference between inputs to the comparator, depending on setting of Meter Function Switch (9).
2. D.C. OUTPUT: terminal connections for connection to Chart Recorder.
3. EXT. STD.: a BNC connector providing an input for either 100-kc or 1-Mc signal from a local frequency standard for phase comparison only.
4. MAINS INDICATOR LAMP: glows when power is applied to the instrument and the power switch is at ON.
5. A.C. POWER SWITCH: controls the ac mains input to the instrument.
6. 1-MC OUTPUT: wired in parallel with 1-MC connector on rear panel.
7. 100-KC OUTPUT: wired in parallel with 100-kc output connector on rear panel.
8. SET LEVEL: a screwdriver-adjusted gain control in the 200-kc amplifier. Used for day-to-day adjustments of signal level.
9. METER FUNCTION SWITCH: three-position switch to select meter indication of control loop level, relative signal strength of 200-kc input, or phase difference between inputs to the comparator.
10. D.C. OUTPUT Control: adjusts the output level of the comparator. In fully-clockwise (click) position the control operates a switch to bypass the fail-safe gate and bring the instrument in the FREE RUN mode. In this mode the D.C. output level is at maximum and cannot be varied.

Figure 3-2 Front Panel Controls, Indicators and Connectors

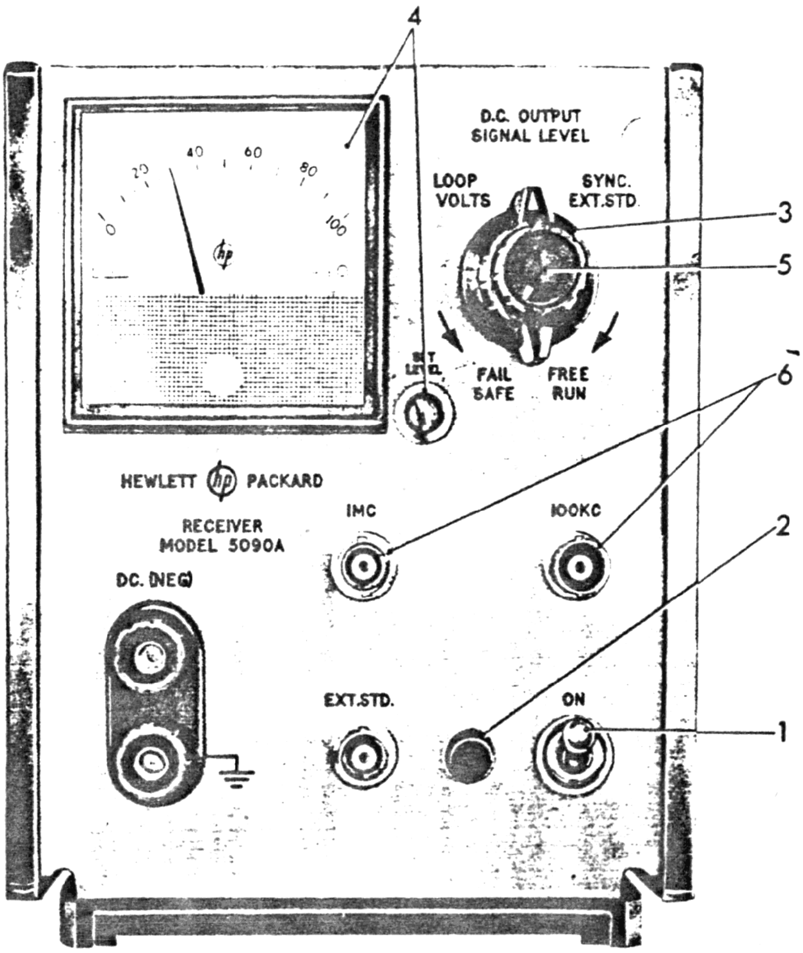
REAR PANEL



1. INTERNAL STD. INPUT: a BNC connector providing an input for either 100-kc or 1-Mc from a 100-kc or 1-Mc OUTPUT connectors at the front or rear of the instrument. Used for phase comparison only.
2. EXTERNAL STD. INPUT: a BNC connector providing an input for either 100-kc or 1-Mc from a local frequency standard for phase comparison only. Wired in parallel with the EXT. STD. connector on the front panel.
3. D.C. OUTPUT: Terminal connections for phase comparison output to Chart Recorder. Wired in parallel with D.C. terminals on front panel.
4. 115/230V MAINS SELECTOR SWITCH
5. A.C. MAINS INPUT CONNECTOR: a 3-pin plug which mates with the flat plug on the power lead.
6. A.C. MAINS FUSEHOLDER: insert 150mA fuse for both 115V and 230V operation.
7. 1-MC OUTPUT: in parallel with the 1-MC connector on the front panel.
8. 100-KC OUTPUT: in parallel with the 100-KC connector on the front panel.
9. AERIAL 75Ω: Aerial input connector.
10. INPUT ATTENUATOR ADJUSTMENT: remove plug to gain access to screwdriver adjustment, see Section V, para. 5-10.

Figure 3-3 Rear Panel Controls and Connectors

OPERATION AS A STANDARD FREQUENCY SOURCE



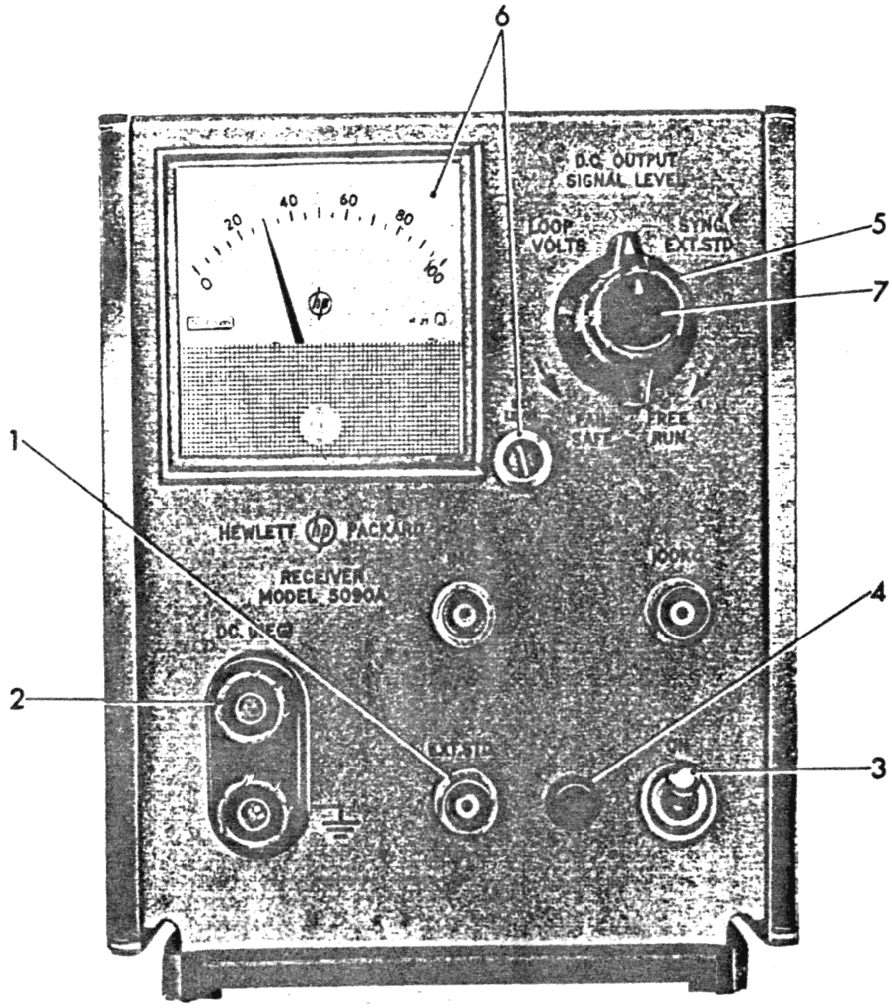
Connect the aerial and mains leads to the appropriate connectors on the rear panel of the instrument. Then proceed as follows:

1. Set the AC Power Switch to ON.
2. Check that the mains indicator lamp glows.
3. Set the meter function switch to SIGNAL LEVEL.
4. Check that the meter pointer shows small fluctuations in level which gradually increase in amplitude until a steady indication is obtained after about 3 to 4 minutes. If necessary, adjust the SET LEVEL control to bring the meter indication to 30.
5. Set the D.C. OUTPUT control towards FAIL SAFE to obtain output signals only when locked to the 200-kc input. Alternatively, set the control to FREE RUN to obtain outputs whether the instrument is locked or not.
6. Use the 100-kc and 1-Mc signals as required.

Figure 3-4 Operation as Standard Frequency Source

OPERATION AS A PHASE OR FREQUENCY COMPARATOR

(USING A CHART RECORDER FOR PRECISE MEASUREMENT)



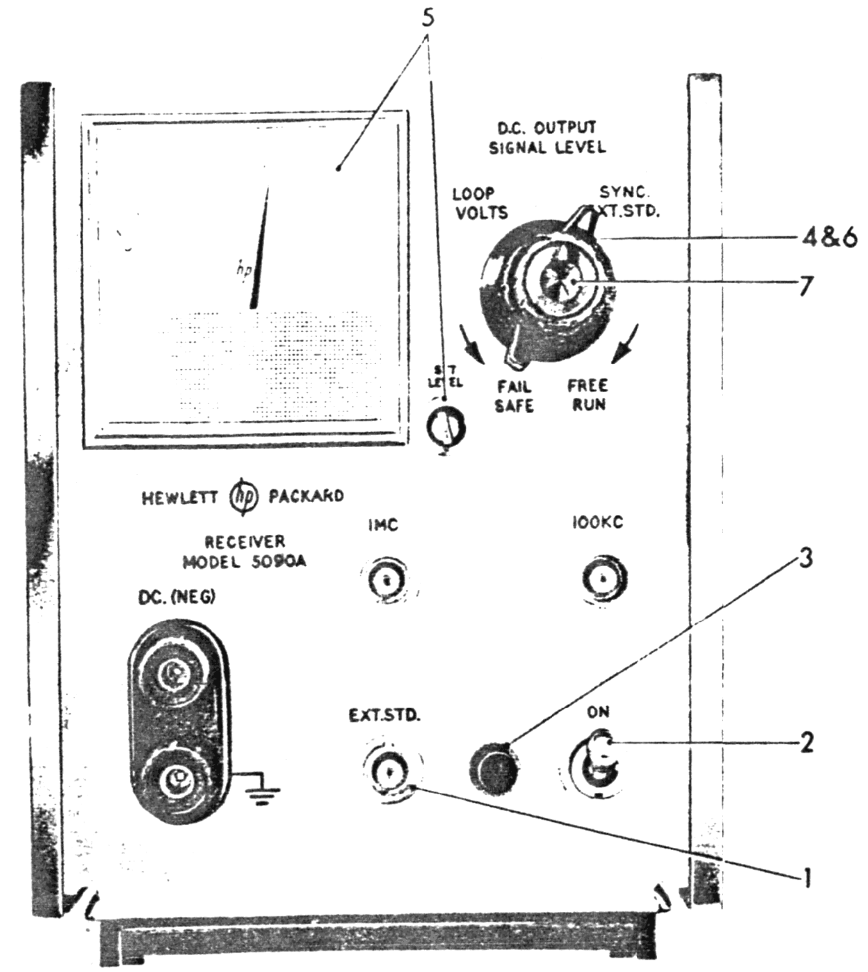
Connect the aerial and mains leads to the appropriate connectors on the rear of the instrument (see Figure 3-3). Connect the 9-inch jumper cable (hp Part No. 10502-6001) between the INTERNAL STD. INPUT connector on the rear panel and 1-MC OUTPUT and 100-KC OUTPUT connectors as appropriate. Then proceed as follows:

1. Connect the 100-kc or 1-Mc external signals to the EXT. STD. connector on the front panel or to the EXTERNAL STD. INPUT connector on the rear panel.
2. Connect a Chart Recorder or Time Interval Counter to the D.C. output terminals (front or rear panels).
   NOTE: Except for moving-coil recorders having a dc resistance less than 1.2kΩ connect a 1.2 kΩ resistor across the D.C. output terminals.
3. Set the AC Power Switch to ON.
4. Check that the mains indicator lamp glows.
5. Set the meter function switch to SIGNAL LEVEL.
6. Check the that meter pointer shows small fluctuations in level which gradually increase until a steady indication is obtained after about 3 to 4 minutes. If necessary, adjust the SET LEVEL control to bring the meter indication to 30.
7. Adjust the D.C. OUTPUT control to obtain a satisfactory sinewave trace on the recorder. This adjustment can be made only when the instrument is in the FAIL SAFE mode. The chart recording represents the phase difference between the external standard and the internal standard, and will change as the phase relationship changes.

Figure 3-5 Operation as a Phase or Frequency Comparator (Using a Chart Recorder for Precise Measurement)

OPERATION AS A PHASE OR FREQUENCY COMPARATOR

(LESS PRECISE MEASUREMENT WITHOUT A RECORDER)



Connect the aerial and mains leads to the appropriate connectors on the rear of the instrument (see Figure 3-3). Connect the 9-inch jumper cable (hp Part No. 10502-6001) between the INTERNAL STD. INPUT connector on the rear panel and 1-MC OUTPUT and 100-KC OUTPUT connectors as appropriate. Then proceed as follows:

1. Connect the 100-kc or 1-Mc. external signals to the EXT. STD. connector on the front panel or to the EXTERNAL STD. INPUT connector on the rear panel.
2. Set the AC Power Switch to ON.
3. Check that the mains indicator lamp glows.
4. Set the meter function switch to SIGNAL LEVEL.
5. Check that the meter pointer shows small fluctuations in level which gradually increase until a steady indication is obtained after about 3 to 4 minutes. If necessary, adjust the SET LEVEL control to bring the meter indication to 30.
6. Set the meter function switch to SYNC. EXT. STD.
7. Adjust the D.C. OUTPUT control to obtain a suitable meter deflection. The meter reading is related to the phase difference between the two inputs to the comparator.

Figure 3-6 Operation as a Phase or Frequency Comparator (Less Precise Measurement without a Chart Recorder)

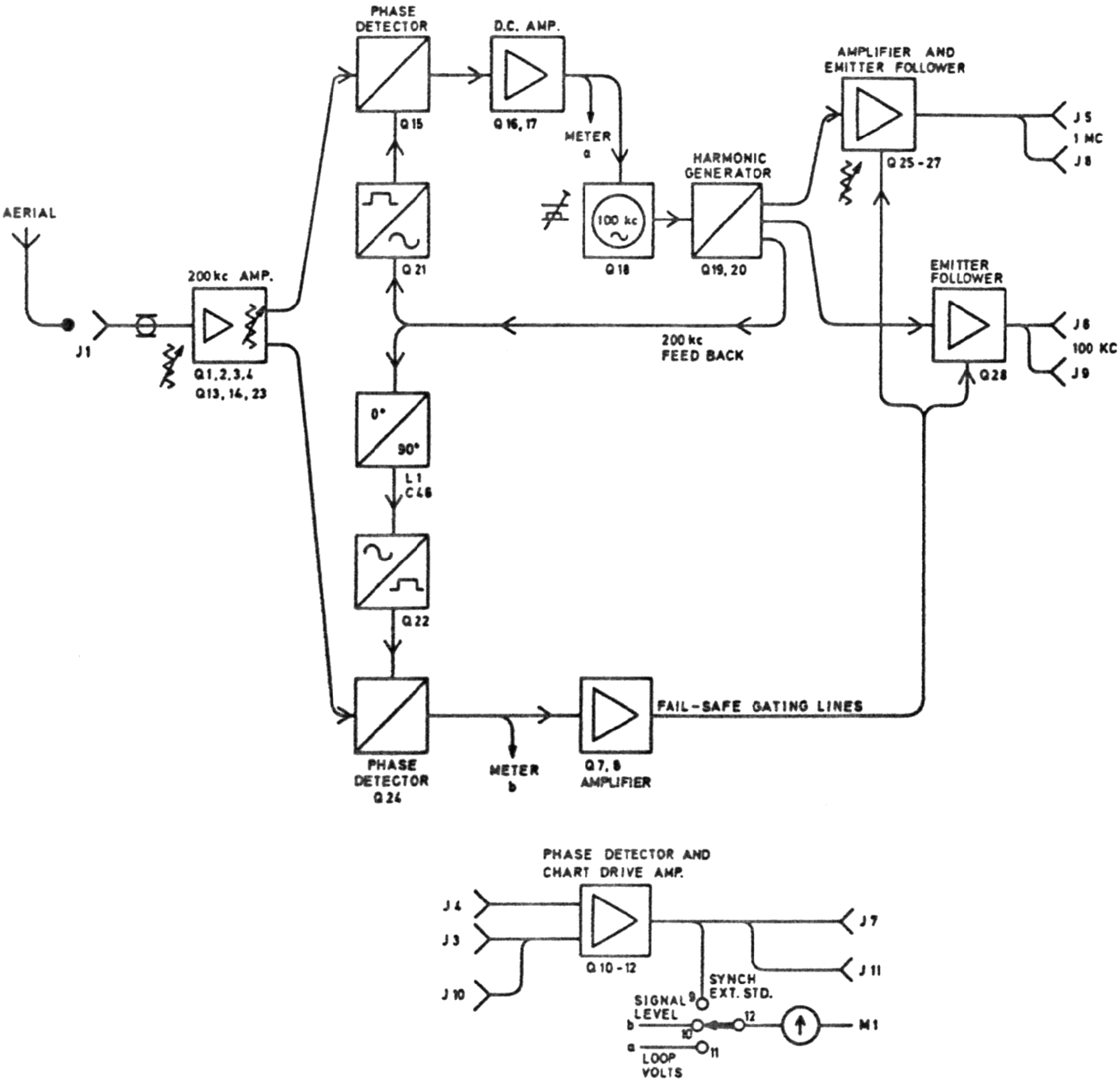


Figure 4–1 Functional Diagram of Model 5090A

SECTION IV
PRINCIPLES OF OPERATION

4-1 GENERAL.

4-2 A block diagram of the receiver is given in Fig. 4-1. The instrument comprises a 100-kc crystal oscillator which can be phase-locked to the received standard frequency carrier of Droitwich on 200-kc. The oscillator drives a harmonic generator to provide output frequencies at 100-kc, 200-kc and 1-Mc. The 200-kc output is applied to a phase-detector together with the amplified 200-kc Droitwich carrier, and the resulting d.c. output is fed to a variable-capacitance diode network in the oscillator circuit. Any phase difference between the oscillator and the Droitwich signal produces a d.c. output of appropriate polarity and magnitude to vary the capacitance and pull the oscillator frequency in the required direction to cancel the phase difference.

4-3 The fail-safe output gate is controlled by a second phase-detector, similar to the first but operating in quadrature, which gives a d.c. output only when the oscillator is locked to the Droitwich signal. This output is applied to the 100-kc and 1-Mc emitter-follower output stages to overcome a standing bias which otherwise holds them cut-off. The time-constant of the circuit which delays the opening of the gate after the oscillator has become locked is approximately three seconds. The gate can be bypassed by a front panel switch.

4-4 The output level of the second phase-detector is proportional to received signal strength and is therefore also used to provide a front panel SIGNAL LEVEL indication.

4-5 The phase-frequency comparator consists of a third phase-detector in which an external frequency at 100-kc or 1-Mc may be compared with the appropriate internally-generated signal. A co-axial link on the rear panel is provided for this purpose. The resulting output passes through a short time-constant integrator to an emitter-follower output stage which can supply up to 1 mA into 1.2 kΩ to an external chart recorder. The front panel meter can also be switched to the comparator output.

4-6 The comparator circuit is functionally separate from the receiver, and can be used independently to compare any two close frequencies within its frequency range of 50-kc to 10-Mc.

4-7 CIRCUIT DESCRIPTION.

For Circuit Diagrams, see Figures 5-6, 5-7, 5-8 and 5-10.

4-8 100-KC OSCILLATOR AND HARMONIC GENERATOR

4-9 The oscillator employs transistor Q18 with transformer-coupled feedback from collector to base via T11. The frequency of oscillation is determined by the series-resonant 100-kc crystal and the preset trimmer capacitor VC1 connected in series in the feedback path. Two variable-capacitance diodes, CR1 and CR2, in parallel with VC1 form part of the phase-locking system. The output of the oscillator is coupled to the harmonic generator via R61-C41.

4-10 The harmonic generator comprises transistors Q19, Q20 connected as a modified Schmitt Trigger to produce an output waveform rich in harmonics. The required outputs of 100-kc, 200-kc and 1-Mc are selected by the tuned circuits T6-C45, T7-C44, and T8-C43 which are connected in series with the collector of Q20. The drive level to the harmonic generator is controlled by the preset resistor VR6.

4-11 The 100-kc output from the secondary of T7 is applied to an emitter-follower Q28 which is connected to output sockets J6 and J9. The output level is at least 1 volt rms into 1 kΩ.

4-12 The 1-Mc output is taken from the secondary of T8 and is amplified by the two common-emitter stages Q25 and Q26 before passing to a similar emitter-follower Q27 connected to the 1-Mc output sockets J5 and J8. The diodes CR14 and CR15 form a limiter. The output level is at least 1 volt rms into 1 kΩ.

4-13 The 200-kc output of T6 is one of the inputs to the phase-locking system, and is also applied to the signal level circuit.

4-14 200-KC AMPLIFIER

4-15 The 200-kc Droitwich signal is amplified by a three-stage amplifier to the level required for operating the phase-locking system. The amplifier has a narrow band-width of about 1-kc to attenuate modulation frequencies. Preset input attenuator/gain controls enable a wide range of signal levels to be accommodated. An input level of 1 μV is sufficient to lock the oscillator, and the amplifier will handle output levels of up to 20 dB above the normal operating point without overloading. No a.g.c. or limiting circuits are used, so that unwanted phase-shift is avoided.

4-16 The 200-kc input from the aerial is connected to the receiver via the BNC connector J1. The input attenuator control VR1 is connected across the primary of the input transformer T1. The secondary of T1 is tuned to 200-kc by C4, and is suitably tapped to provide optimum impedance matching to the base of Q1.

4-17 The first "cascode" amplifier comprises transistors Q1 and Q2. Base bias is derived from the voltage divider R3 – R4 – R5. The output tuned circuit comprises the primary of T2 tuned by C6, with damping resistor R6 in parallel. The base and collector supplies are derived from the – 35V supply via R1 – 5, suitably decoupled.

4-18 The second "cascode" amplifier is of similar configuration, employing transistors Q3 and Q4. The gain control VR2 is connected in the emitter circuit of Q3 and varies the decoupling effect of capacitor C12. The amplifier gain is limited by R11, which is individually selected for each instrument. The output tuned circuit is formed by the primary of T3 tuned by C11, with damping resistor R34 connected in parallel.

4-19 The secondary of T3 is connected via a co-axial link to the third stage which comprises transistors Q13, Q14 and Q23. Transistors Q14 and Q23 have

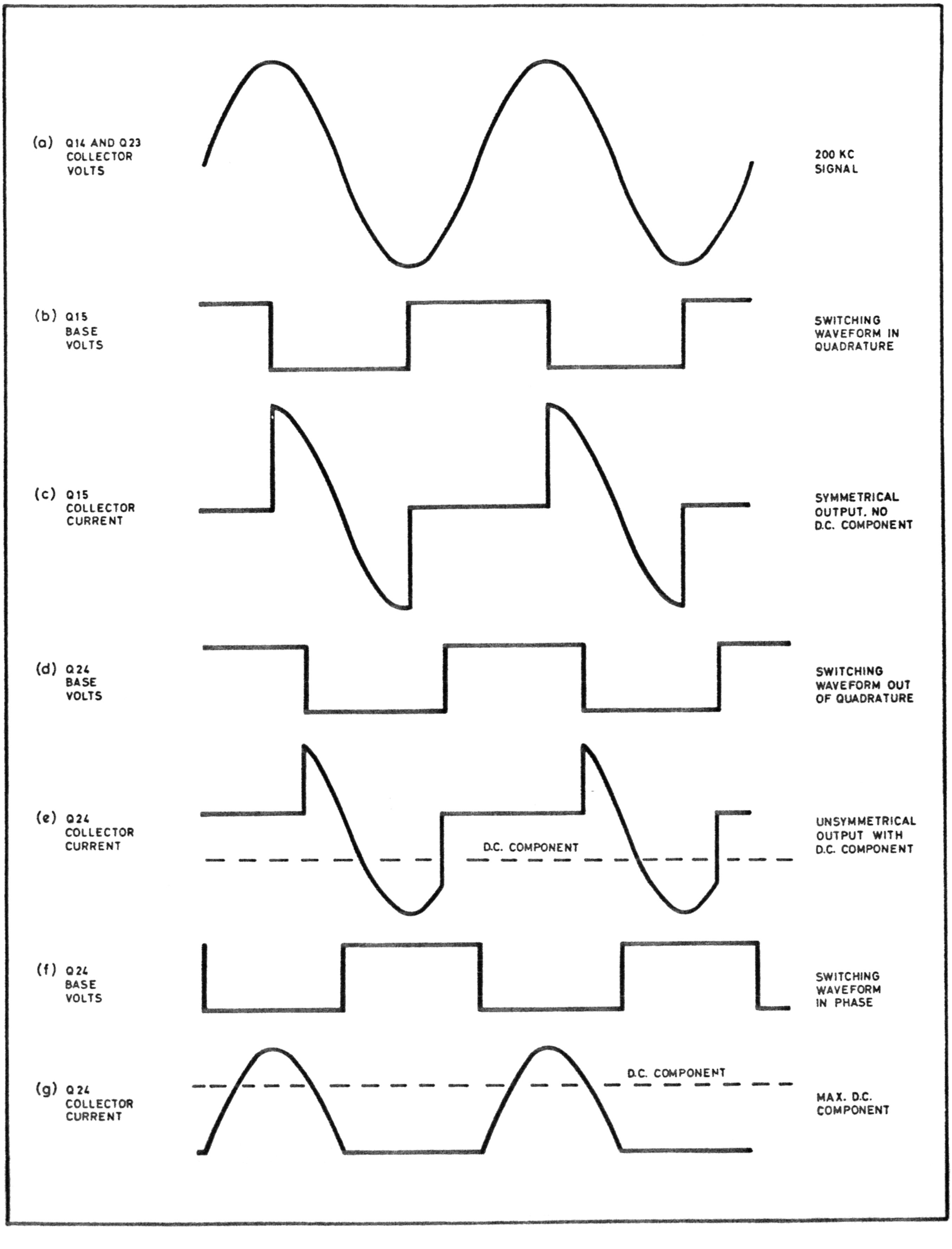


Figure 4-2 Theoretical Waveforms

common inputs, but independent output circuits. Q14 drives a tuned circuit formed by T4 - C34. The output of T4 is applied to the collector of the Control Loop Phase Detector Q15. Transistor Q23 drives a tuned circuit comprising T5 - C47. The output of T5 is applied to the collector of the second phase-detector Q24. Base bias for these transistors is provided by R41 - R42 - R43 connected across the -35V supply.

4-20 CONTROL LOOP PHASE-DETECTOR

4-21 The Control Loop Phase-Detector compares the phase of the 200-kc Droitwich signal with that of the internal crystal oscillator, and produces a d.c. output porportional to the phase difference.

4-22 The 200-kc signal at the output of T4 is applied to the collector of Q15 via an isolating resistor R48. The base of Q15 is driven by a 200-kc signal derived from the internal oscillator via the harmonic generator and squarer.

4-23 The 200-kc output of the harmonic generator is taken from the secondary of T6 to the base of Q21, which is an over-driven common-emitter amplifier giving a square output waveform. The output of Q21 is directly-coupled to the base of Q15 via R47

4-24 Fig. 4-2 shows the base and collector waveforms of the phase-detector circuit when locked. It will be seen that the action of Q15 is to chop the incoming Droitwich signal, shown at (a), to produce the waveform shown at (c). In this instance the signals are in phase-quadrature, and the output waveform is symmetrical; the resulting output of the phase-detector is zero. When the two signals are out of quadrature, as illustrated in (d), the output of Q15 is no longer symmetrical (e) and includes a d.c. component.

4-25 The output of Q15 is directly-coupled to the d.c. amplifier Q16, Q17 which produces an output to the variable-capacitance diodes in the crystal oscillator circuit. The potentiometer VR5 controls the operating point of the d.c. amplifier and R88 is a meter series resistor.

4-26 The resulting bias applied to the variable-capacitance diodes shifts the oscillator frequency in a direction to cancel the phase difference between it and the Droitwich signal.

4-27 The bandwidth of the control loop is set by the feedback components R53 - C35 - C36.

4-28 SECOND PHASE-DETECTOR

4-29 At the second phase-detector the crystal oscillator signal is 180° out-of-phase with the Droitwich signal. In consequence the output of this circuit is a voltage which is proportional to signal strength, and is present only when the oscillator is phase-locked. This output is used to operate the fail-safe gates of the 100-kc and 1-Mc emitter-follower output stages and also provides a signal strength indication on the front panel meter.

4-30 The 200-kc output of Q23 is transformer-coupled via T5 and isolating resistor R74 to the collector of the second phase-detector Q24.

4-31 The 200-kc input to the base of Q24 is derived from the internal oscillator and undergoes a 90° phase-shift before being amplified by Q22 to an approximate square wave. The output of Q22 is directly-coupled to the base of Q24 via R73.

4-32 The waveforms for the circuit of Q24 are shown in Fig. 4-2. (f) and (g). The d.c. output is produced only when both inputs are in phase, the output level being proportional to the signal input level. When the inputs are not in-phase, as shown at (b), the integrated output (c) is zero. The output of Q24 is integrated by R76 - C48 and applied to the input of a compound pair Q7 - Q8 which controls the gate action of the 100-kc and 1-Mc output circuits. A second integrator R75 - C49 is in the meter circuit.

4-33 FAIL-SAFE GATE

4-34 The emitter of Q8 is at a potential of approximately -24.8V obtained from a potential divider R21 - CR7 - CR8 - R22 connected between the -35V and -24V supplies. The collector of Q8 is connected to the lower ends of the base-bias potential dividers for Q28 and Q27, the 100-kc and 1-Mc output emitter followers. With no signal input to the instrument the bias conditions of Q7, Q8 are arranged so that the collector voltage of Q8 is about -13V. In the fail safe mode, this means that Q27 - Q28 are biased off. When the instrument is locked the signal level circuit current biases Q7, Q8 further on causing the collector of Q8 to rise to the -24V line, biasing Q27, Q28 into the on condition.

4-35 The gate action of Q7 - Q8 is over-ridden by -24V directly applied to Q8 collector when the FAIL-SAFE switch S4 is placed in the FREE RUN position.

4-36 COMPARATOR

4-37 The phase-frequency comparator consists of a third phase-detector, similar to the others, followed by a d.c. amplifier Q11 and Q12. The comparator circuits are untuned, the two inputs being connected directly to the base and collector of Q10 via isolating capacitors C15 and C16. The potentiometer VR4 controls the level of the d.c. output signal.

4-38 METERING

4-39 The three-position switch S3 connects the front panel meter to measure the following d.c. outputs:

LOOP VOLTS.........d.c. output of Q17
SIGNAL LEVEL......d.c. output of Q24
SYNC EXT STD......d.c. output of Q11, Q12

4-40 Diode CR16 limits switching transients.

4-41 POWER SUPPLIES

4-42 A conventional transformer-rectifier circuit is employed. The mains input is controlled by a double-pole switch S1, and protected by a 0.15 amp fuse F1 in the live connection. The mains transformer T10 has two primary windings which may be connected in series or in parallel by the changeover switch S2 for 230V or 115V operation. A red neon indicator lamp is connected across one primary winding in series with a resistor R31.

4-43 The output of the secondary is rectified by silicon diodes CR1 and CR2, and the resulting d.c. is applied to a series regulator circuit Q5 - Q6 - Q9 to provide a regulated output of -35V. A -24V supply is derived from this by zener diodes CR5 - CR6 in conjunction with R17.

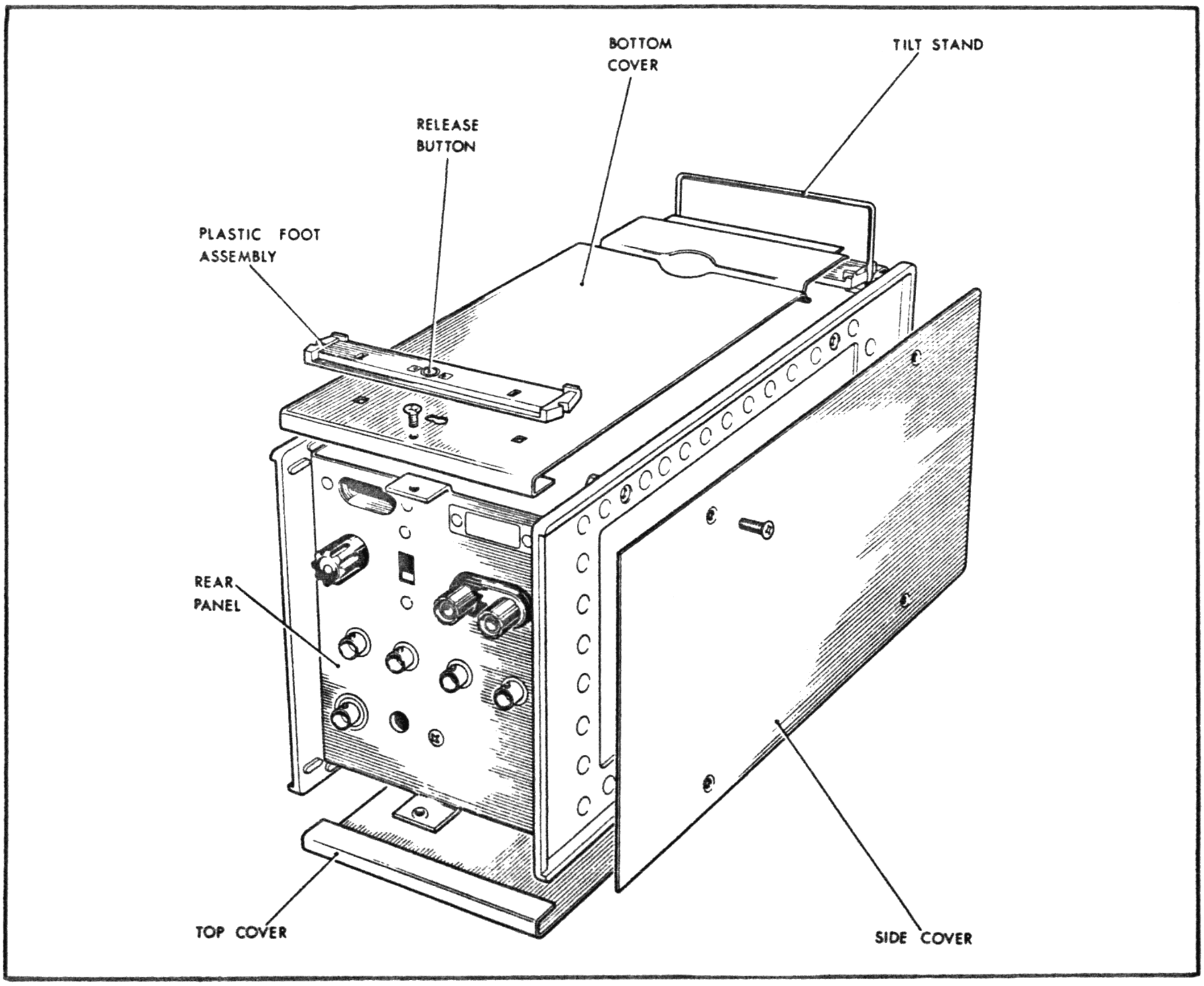


Figure 5-1 Cover Removal

Table 5-1 Test Equipment Required

Instrument Type	Required Characteristics	Use	Instrument Recommended
DC Valve Voltmeter	0 to 300vdc ±1%	Circuit adjustment and troubleshooting	hp Model 412A
AC Valve Voltmeter	1 mv to 10V f.s.d. Input impedance 1 megΩ	Check output level of 100 kc, 200 kc and 1 Mc signals	hp Model 400D/H/L
R.F. Signal Generator	200 kc ± 1% 1 μv into 75Ω	Performance check	hp Model 606A
Oscilloscope, with a. High gain Vertical Amplifier b. Auxiliary Plug in c. Probe	1 Mc bandwidth Dual Trace	Observe waveforms during adjustment and troubleshooting	hp Model 175A hp Model 1752A hp Model 1780A hp Model 10003A
Trimming Tools		Alignment of Receiver	Mullard Vinkor DT 2047

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. The performance Checks given in Paragraphs 5-6 through 5-12 verify that the overall performance of the Receiver is correct. These checks can be performed without removing covers, but where any adjustment is required the top, bottom and side covers must be removed (see Figure 5-1).

5-3. Paragraph 5-14 gives details of regular maintenance checks, and fault-finding procedures are dealt with in Paragraphs 5-20 through 5-22. The alignment procedures given in Paragraphs 5-28 through 5-33 should be attempted only when the specified test facilities are to hand.

CAUTION

Do not adjust any preset controls except as detailed in this Manual. The tuned circuits employed in this instrument have been adjusted for optimum stable phase operation. Indiscriminate adjustment will cause phase instability. Alignment must be carried out exactly as detailed in Paragraphs 5-28 through 5-33, and then only when a strong stable Droitwich signal is available.

Also for phase stable operation, the components for the tuned circuits have been selected for temperature coefficient compensation. The user is advised not to replace any of these components except with those types listed in Section VI.

5-4. TEST EQUIPMENT.

5-5. The test equipment required for the performance checks is listed in Table 5-1. Equipment having equivalent specifications may be substituted where required.

5-6. PERFORMANCE CHECKS.

5-7. Apply power to the Receivers as detailed in Section III, OPERATION.

5-8. INPUT SENSITIVITY.

a. Connect the Signal Generator to the 75Ω AERIAL connector of the Receiver using a fully-screened 75Ω cable.

b. Set the Signal Generator to give 1μv into 75Ω.

c. Set the input attenuator fully clockwise (maximum sensitivity).

d. Set the meter function switch to SIGNAL LEVEL.

e. Turn the SET LEVEL control fully clockwise.

f. Check that the meter pointer commences to swing, indicating the beat frequency between the internal oscillator and the input signal.

g. If this does not occur, very gradually vary the Signal Generator frequency until a beat is indicated.

h. As the internal oscillator frequency is pulled into alignment with the input signal the amplitude of the beat will increase until a steady reading is obtained when the oscillator is phase-locked.

5.9 CONTROL LOOP.

a. Set the input attenuator fully counter-clockwise (minimum sensitivity).

b. Turn the SET LEVEL control fully counter-clockwise.

c. Set the meter function switch to LOOP VOLTS.

d. Wait ten minutes for the circuits to stabilise, and then check that the meter reading is between 25 and 35.

5.10. FAIL-SAFE GATE.

a. Set the input attenuator fully clockwise.

b. Set the meter function switch to SIGNAL LEVEL.

c. Set the DC OUTPUT control (red knob) fully counter-clockwise.

d. Turn the SET LEVEL control to mid-position.

e. Connect an aerial and allow the Receiver to lock.

Note

The input signal level must be greater than 10μV

f. Adjust the input attenuator until the SIGNAL LEVEL meter reading is between 35 and 45.

g. Connect the AC Voltmeter, shunted with 1000Ω, to the 100-kc output connector. Note the amplitude of the output.

h. Turn the SET LEVEL control slowly counter-clockwise and check that while the SIGNAL LEVEL falls the 100-kc signal amplitude remains constant. At a SIGNAL LEVEL of 25 the 100-kc output level will begin to fall. Continue reducing the SET LEVEL control until a SIGNAL LEVEL reading of 10 is reached. At this point the 100-kc output should be less than 10% of its initial amplitude. If not, adjust VR8, Figure 5-2, to obtain this condition.

5-11. OUTPUT LEVEL.

a. Connect the AC Voltmeter in parallel with a 1 kΩ resistor across the 1 MC OUTPUT connector.

b. With the Receiver locked to a 200-kc input, check that the output level is greater than 1V rms. If not, adjust VR9 (see Figure 5-2).

c. Transfer the AC Voltmeter and test resistor to the 100-KC OUTPUT.

d. Check that the output level is greater than 1V rms. This output level is obtained by selecting R68 and R90.

5-12. COMPARATOR.

a. Connect the 9-inch coaxial jumper cable (10502-6001) between the INTERNAL STD. INPUT connector on the rear panel and the 1 MC OUTPUT connector.

b. Connect the Signal Generator to the EXTERNAL STD INPUT connector on the rear panel and set to give 1V rms at 1-Mc.

c. Connect a Chart Recorder in parallel with a 1.2kΩ resistor across the DC output terminals. (The resistor is not required for moving coil recorders with a coil resistance of less than 1.2kΩ).

d. Set the meter function switch to SIGNAL LEVEL.

e. Adjust the DC OUTPUT control to obtain a satisfactory sinewave trace on the recorder. This adjustment can only be made when the instrument is switched to FAIL SAFE, and fine adjustment of the signal generator frequency may be necessary.

5-13. ROUTINE MAINTENANCE.

5-14. Once the Receiver has been aligned and set up the only routine attention required is to compensate for

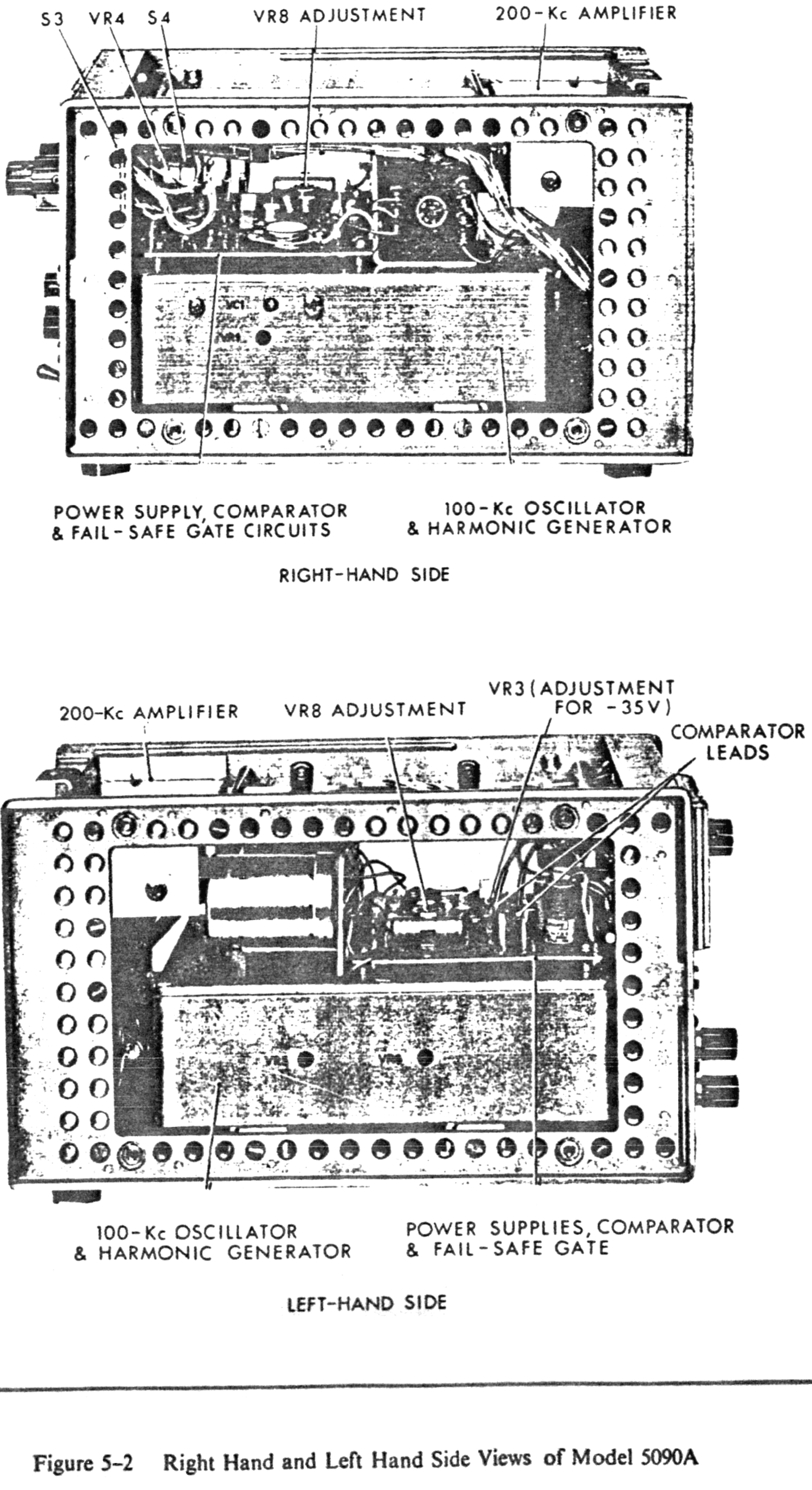


Figure 5-2 Right Hand and Left Hand Side Views of Model 5090A

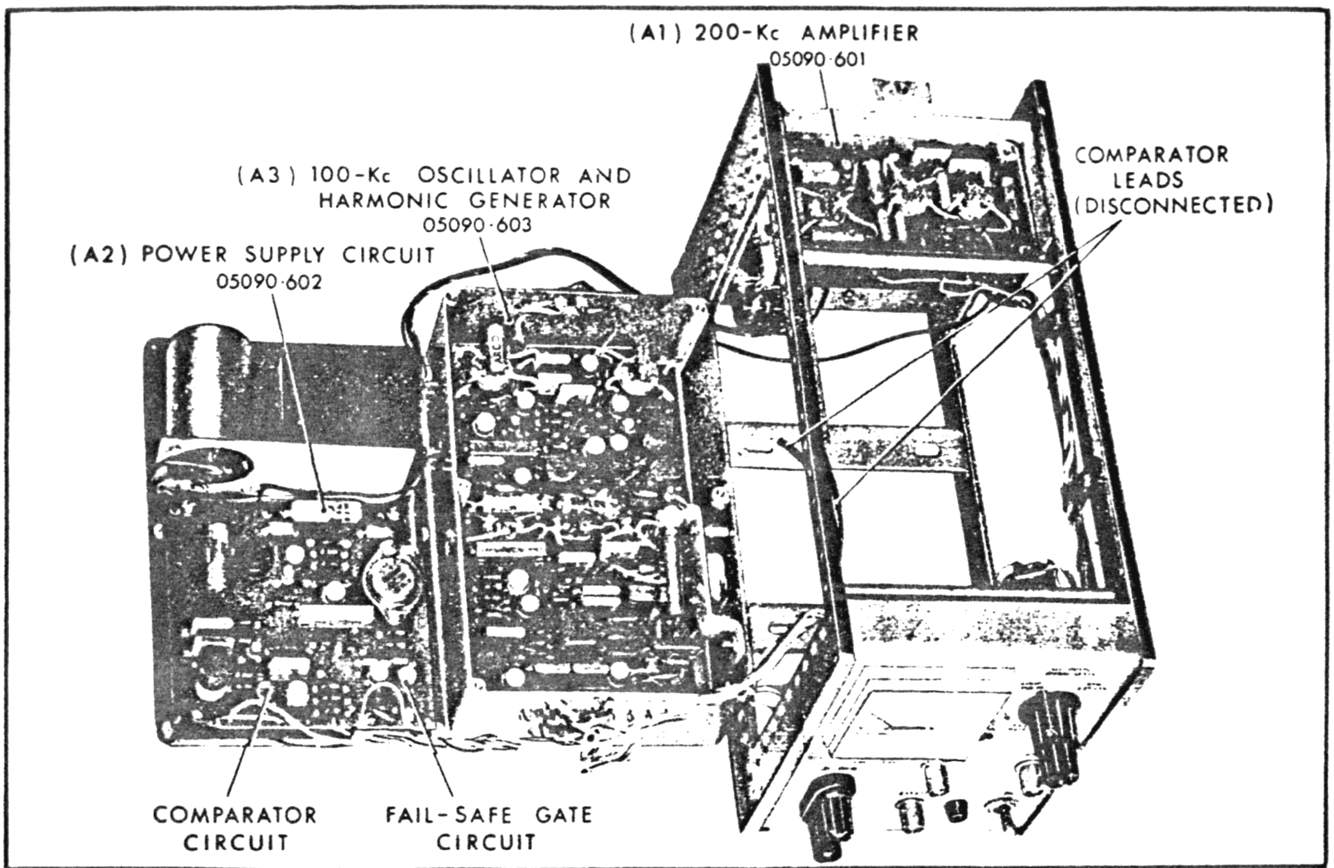


Figure 5-3 Partial Disassembly of Instrument

crystal ageing about every two months. The procedure is as follows:

a. Disconnect the aerial. Switch to LOOP VOLTS. Wait 10 minutes for the voltage to stabilise, then check that the meter reading is between 25 and 35.

b. If the meter reading is outside these limits, remove the left-hand side panel and adjust VR5 (see Figure 5-2) to bring the reading to 30. (Clockwise rotation decreases the reading). Allow ten minutes between each adjustment for voltage to stabilise.

c. Re-connect the aerial and allow the Receiver to phase-lock.

d. Adjust the SET LEVEL control and the input attenuator VR1 on the rear panel (see Figure 3-3) to obtain a SIGNAL LEVEL reading of 30.

e. Switch to LOOP VOLTS and check that the reading is still 30. If it is not, remove the RHS panel and adjust VC1 slowly (see Figure 5-2) to bring the reading to 30. If the receiver goes out of lock during this adjustment, wait for the circuits to re-lock before continuing the adjustment of VC1.

CAUTION

Do not disturb other preset controls. If faulty operation is suspected refer to FAULT LOCATION, paragraph 5-20.

5-15. DISASSEMBLY.

5-16. Figure 5-1 shows how the instrument covers are secured. With the covers removed all the preset controls and components on the Comparator and Power Supply circuits are accessible.

WARNING
DISCONNECT POWER SUPPLY CABLE BEFORE ATTEMPTING DISASSEMBLY.

5-17. The 200-kc RF Amplifier Board is housed in the small screening box at the rear of the instrument and is accessible when the cover of this box is removed.

5-18. The 100-kc Oscillator Board is mounted in the large screening box. To obtain access to the interior of this box, or to the front panel wiring, the box must be removed as follows:

a. Disconnect the 100-kc and 1-Mc output leads from the feed-through terminals on the front of the box.

b. Disconnect both Comparator input leads from the Comparator board.

c. Remove the bottom cover of the Receiver and release the four screws holding the Oscillator box in place.

d. Slide the box to the left through the side frame to the extent of the cableform, taking care not to strain the leads unduly. See Figure 5-3.

e. The cover of the box may now be removed.

5-19. To remove the printed wiring board, first release the retaining nuts on the Vinkor inductors T1-T9 (Amplifier and Oscillator Boards only). Disconnect the leads from the board. Remove the nuts holding the board in place. The board spacers are captive and will remain in position.

5-20. FAULT LOCATION.

5-21. The procedure to be adopted in fault-finding will vary according to the indications obtained. Possible faults are listed in Table 5-2. Wiring information is

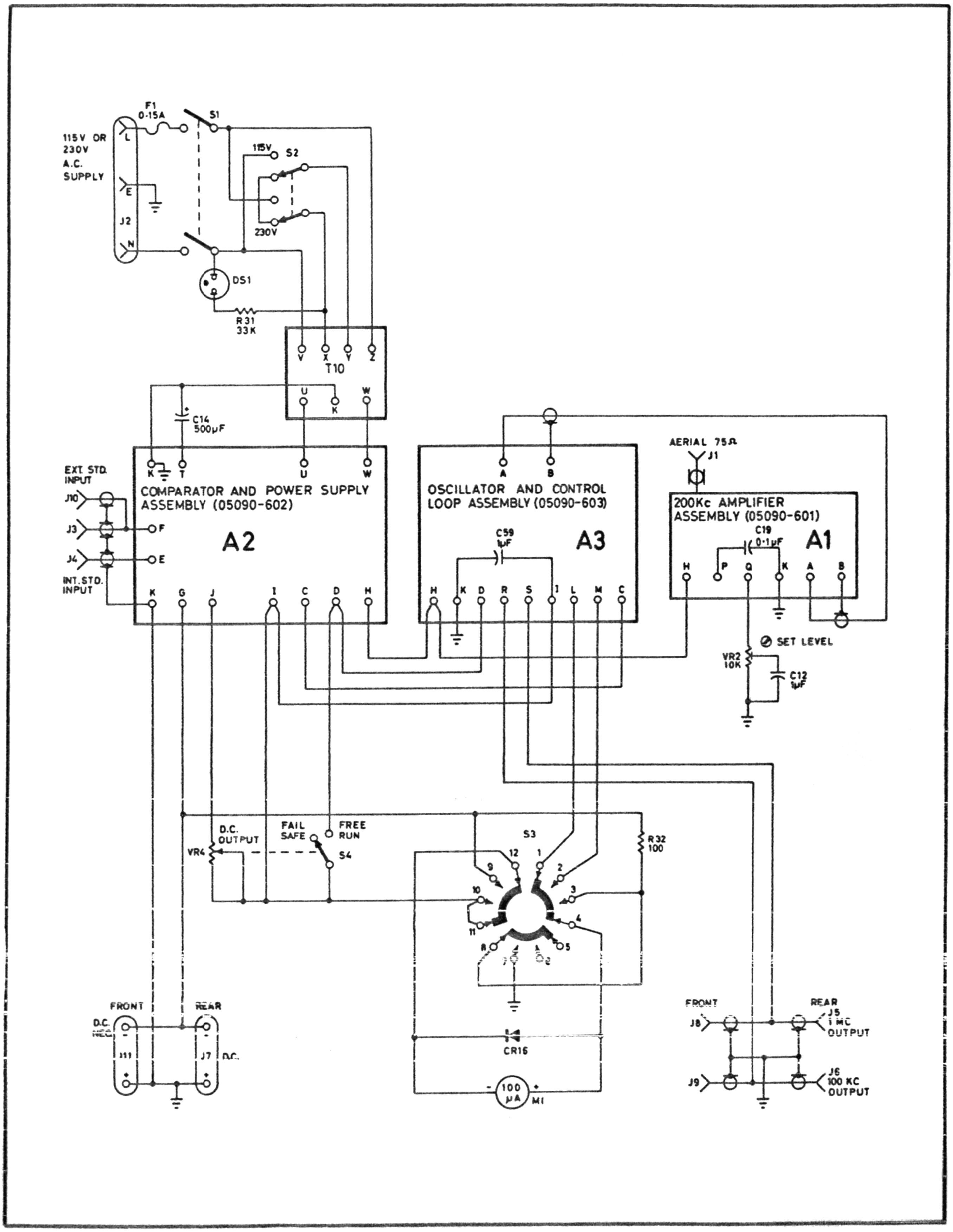


Figure 5-4 Wiring Diagram of Model 5090A

given in Figure 5-4. Typical voltages and waveforms throughout the instrument are given in Table 5-9 facing the circuit diagram, Figure 5-10. The relevant monitor points throughout the circuit should be checked using an AC Voltmeter or Oscilloscope as appropriate.

5-22. PRELIMINARY TESTS.

a. Ensure that the mains input is correct.

b. Check the -35V supply. If necessary adjust VR3 (see Figure 5-2).

c. Using an oscilloscope, check that the ripple voltage of the —35V line, at twice the supply frequency, does not exceed 10mv peak-to-peak.

d. Check the -24V supply. There is no adjustment, but the voltage should be between -23V and -25V.

e. Check that the 200-kc signal input level is at least 10μV.

f. Locate fault as described in Table 5-2.

5-23. REPAIR.

5-24. The printed wiring boards and their component layout are illustrated in Figures 5-6 through 5-8. A defective board must be removed from the instrument before repair. Recommended methods of repair are described in Paragraph 5-26. Refer to Paragraphs 5-15 through 5-19 for disassembly procedures.

5-25. On completion of repairs carry out a performance check of the complete instrument. Re-adjustment of preset controls will not usually be required after repair unless these parts of the circuit have themselves been at fault, or unless the performance check indicates that re-adjustment is necessary.

5-26. PRINTED CIRCUIT COMPONENT REPLACEMENT.

5-27. The component lead holes in the printed circuit boards have plated walls to ensure good electrical contact between the conductors on opposite sides of the board. To prevent damage to this plating and to the replacement components, apply heat sparingly and work carefully. The following replacement procedure is recommended:

a. Remove the defective components.

b. Melt the solder in component lead holes. Use clean dry soldering iron to remove excess solder. Clean holes with toothpick or wooden splinter. Do not use metal tool for cleaning as this may damage through-hole plating.

c. Bend leads of replacement component to the correct shape and insert component leads into component lead holes. Use heat and solder sparingly; solder leads in place. Heat may be applied to either side of the board. A heat sink (longnose pliers, commercial heat-sink tweezers, etc.) should be used when replacing transistors and diodes in order to prevent conduction of excessive heat from the soldering iron to the component.

d. Through-hole plating breaks are indicated by the separation from the boards of the round conductor pads on either side of the board. To repair breaks, press conductor pads against board and solder replacement component leads to conductor pads on both sides of the board.

5-28. ALIGNMENT.

5-29. The Receiver will remain in alignment over a fairly long period, consequently all other possible causes of malfunctioning should be eliminated before re-alignment is considered.

5-30. The Mullard Vinkor trimming tool must be used for all Vinkor adjustments (see Figure 5-5). A long trimming tool will be required for adjusting T1, T2 and T3. Taking care not to over-turn, set the tuning slug to the first maximum from the bottom, fully-clockwise, position. Every effort should be made to complete the adjustments in the least number of steps.

5-31. HARMONIC GENERATOR.

a. Connect the AC Voltmeter to the secondary of T6 (Monitor Point 12). Tune T6 for maximum 200-kc

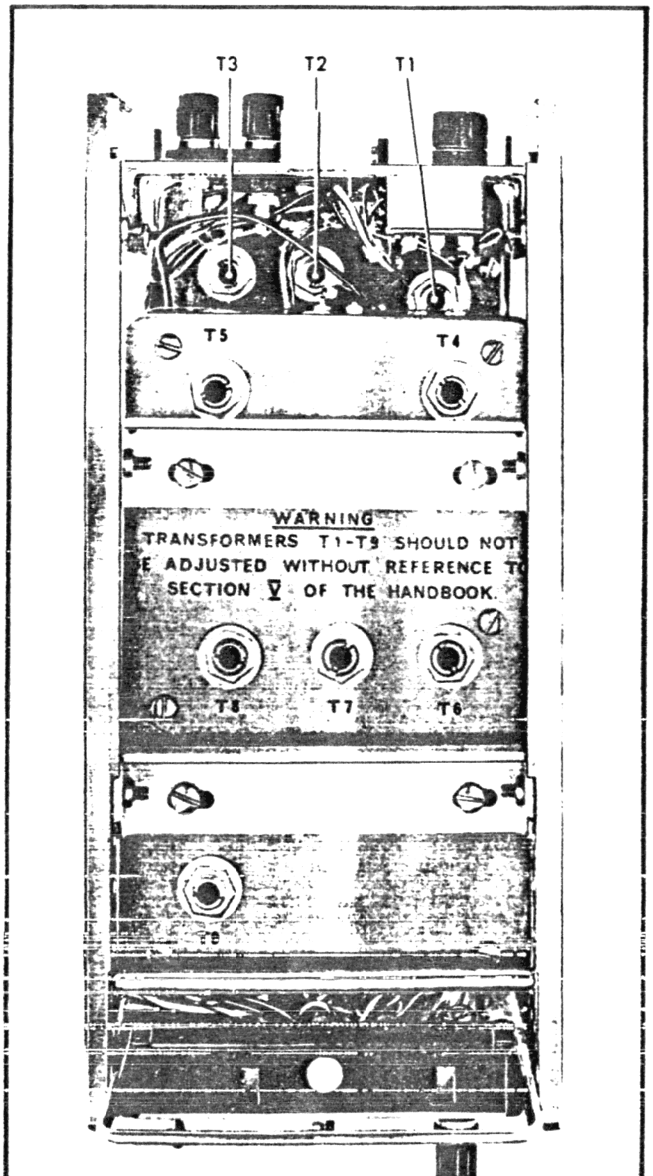


Figure 5–5 Transformer Adjustments

output. If there is no 200-kc output tune VC1 slowly to start the oscillator.

b. Connect the AC Voltmeter to the secondary of T7 (Monitor Point 16). Tune T7 for maximum 100-kc output.

* c. Connect the AC Voltmeter to the secondary of T8 (Monitor Point 13). Tune T8 for maximum 1-Mc output.

d. Connect the AC Voltmeter to the 1-MC output connector (J5 or J8). Tune T9 for maximum 1-Mc output.

e. Connect the Oscilloscope to the 1-MC output connector J5 or J8. Check with at least 10 cycles visible on the screen that there is no 100-kc phase-modulation.

5-32. 200-KC AMPLIFIER.

a. Connect the aerial to J1 on the Receiver. Verify that a strong(>10μv) 200-kc Droitwich carrier is present at the input. During alignment adjust the input attenuator VR1 on the rear panel as necessary to prevent overloading.

b. Connect the Oscilloscope probe to the secondary of T5 (Monitor Point 5). Tune T5 for maximum 200-kc output.

c. Connect the Oscilloscope probe to the secondary of T4 (Monitor Point 4).

Tune T4 for maximum 200-kc output.
Tune T3 ,, ,, ,, ,,
Tune T2 ,, ,, ,, ,,
Tune T1 ,, ,, ,, ,,

d. Repeat all adjustment for maximum 200-kc output.

5-33. Disconnect all test gear.

* FOLLOW WITH: ADJUST VR6 FOR MAX 1MC OUTPUT

Table 5-2 Fault Location

FAULT INDICATION	FAULT LOCATION TEST PROCEDURE	PROBABLE LOCATION OF FAULT
No 100-kc output	Set meter function switch to FREE RUN. Check that 1-Mc output is available (J5 or J8). Check that instrument locks satisfactorily.	Fault lies in either T6 or emitter-follower stage Q28.
No 1-Mc output	Set meter function switch to FREE RUN. Check that 100-kc output is available (J6 or J9). Check that instrument locks satisfactorily.	Fault lies in 1-Mc output stages. Check waveforms at: secondary of T8 (Monitor Point 13); junction of CR14-CR15-C52, (Monitor Point 14); collector of Q26; base of Q27, (Monitor Point 15); junction R84-C56.
No 100-kc or 1-Mc outputs. Instrument makes no attempt to lock.	Set meter function switch to FREE RUN.	Oscillator probably not functioning. Adjust VC1 and look at 100-kc output (J6 or J9). When oscillator starts, connect aerial and adjust signal level to 30. Set meter function switch to LOOP VOLTS and adjust VC1 very slowly until meter reads 30.
1-Mc and 100-kc outputs in FREE RUN mode but not in FAIL SAFE mode.	Set meter function switch to SIGNAL LEVEL. Connect aerial and adjust SET LEVEL for a reading of 30. Observe 100-kc or 1-Mc outputs at the BNC sockets J6, J9 or J5, J8 using Oscilloscope or AC Voltmeter.	If still no output, adjust VR8. If output appears, adjust VR8 and SET LEVEL controls so that gate is fully open at signal levels of 25 and closed at 10. If still no outputs for very high signal level, fault is in the gate.
No signal level, but outputs present in the FAIL SAFE mode.	Remove aerial to check gate is functioning. Replace aerial and observe that output appears.	Fault indicates instrument is locking satisfactorily and can be checked by observing waveform at collector Q15 (Monitor Point 9). Fault lies in circuit Q22 or Q23.
Instrument does not attempt to lock, but output present in the FREE RUN mode.	Connect aerial with at least 10μV signal to the receiver. Check that amplifier is operating correctly by observing waveform at output of amplifier (Monitor Point 3). Check inputs to Q15 (Monitor Point 8).	If both inputs are being applied to Q15 then fault is in stage Q15 or control loop. Check dc amplifier by switching to LOOP VOLTS. Meter reading should be 25 to 35.

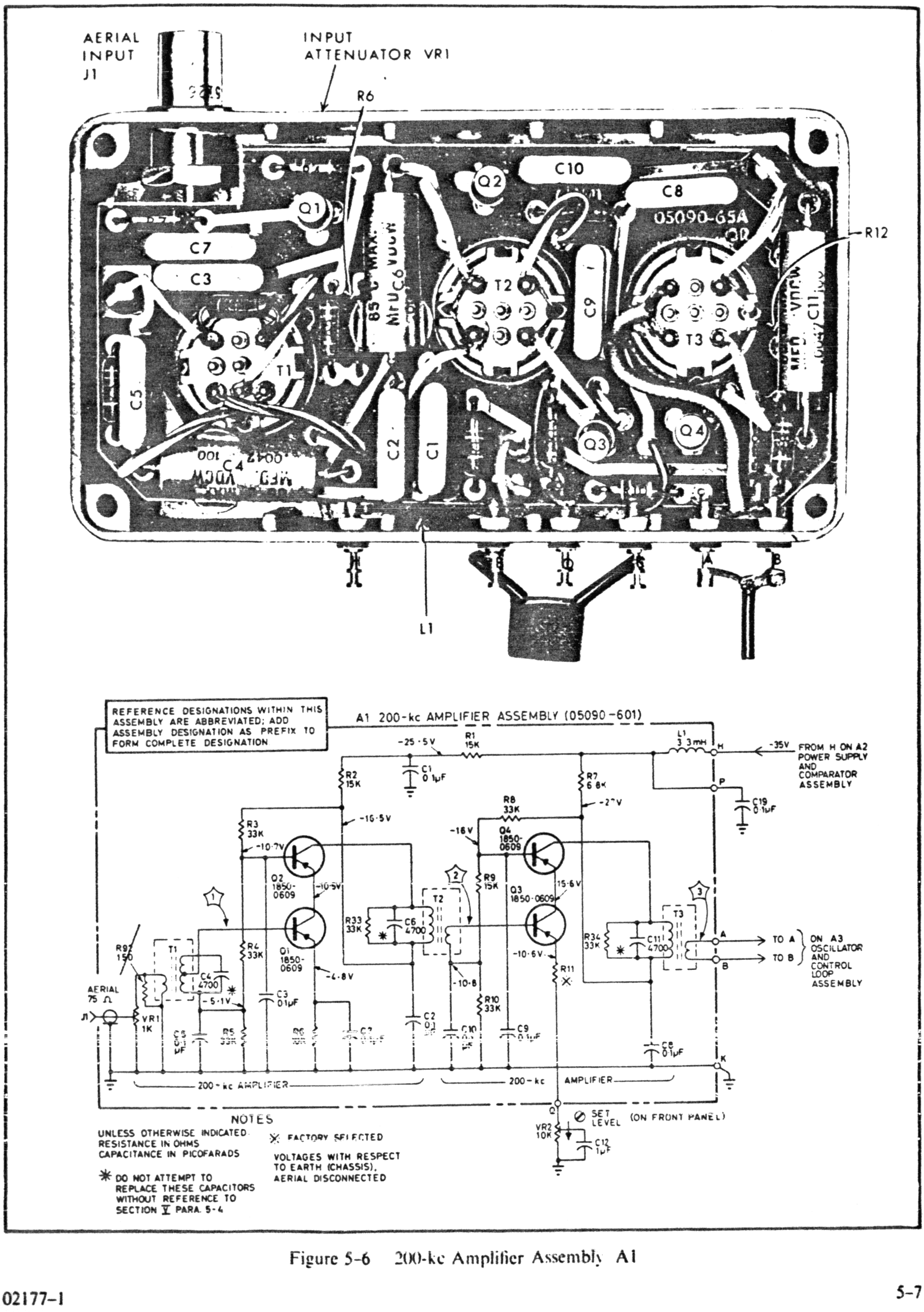


Figure 5-6 200-kc Amplifier Assembly A1

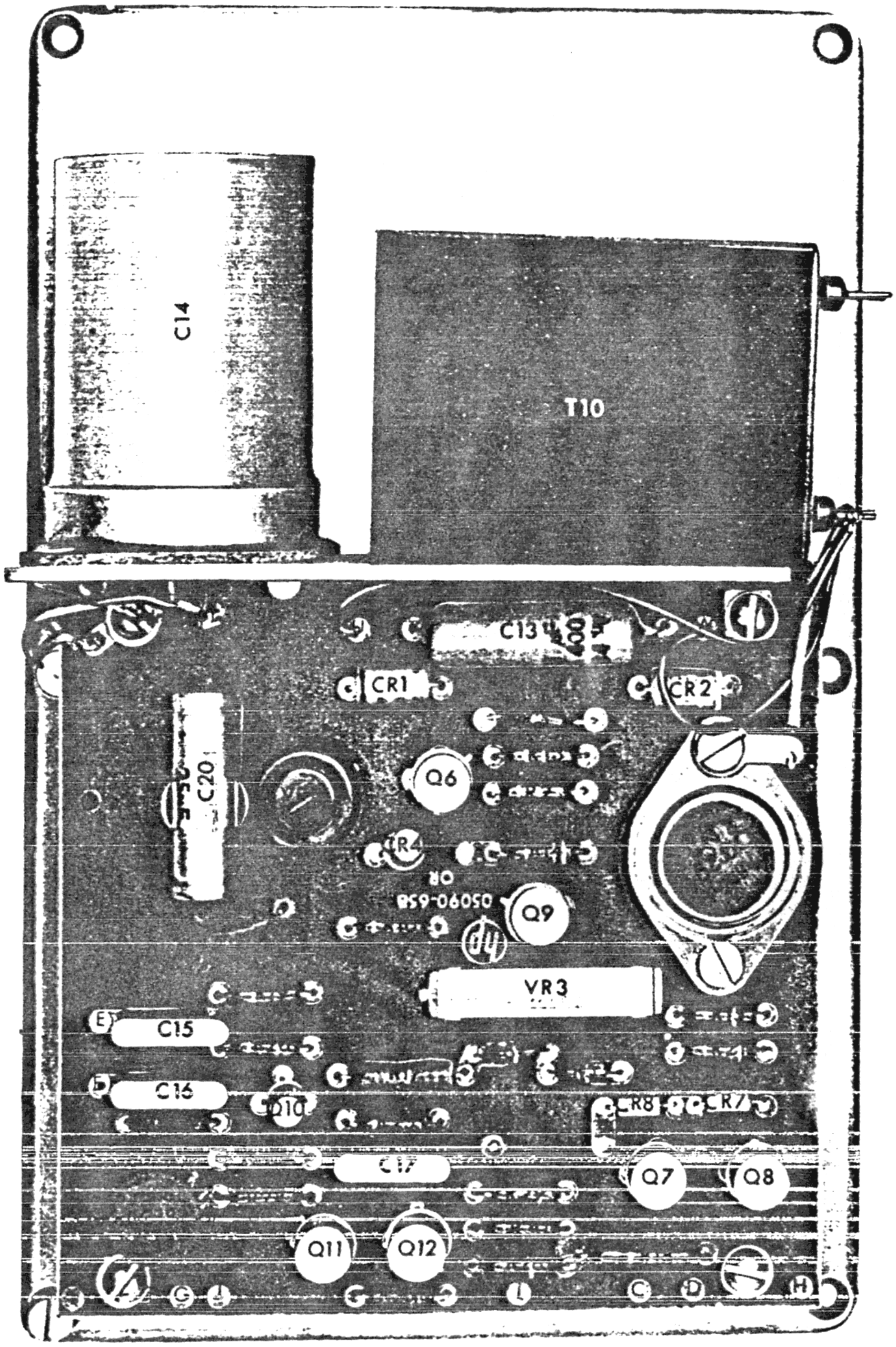


Figure 5-7 Power Supply and Comparator Assembly A 2

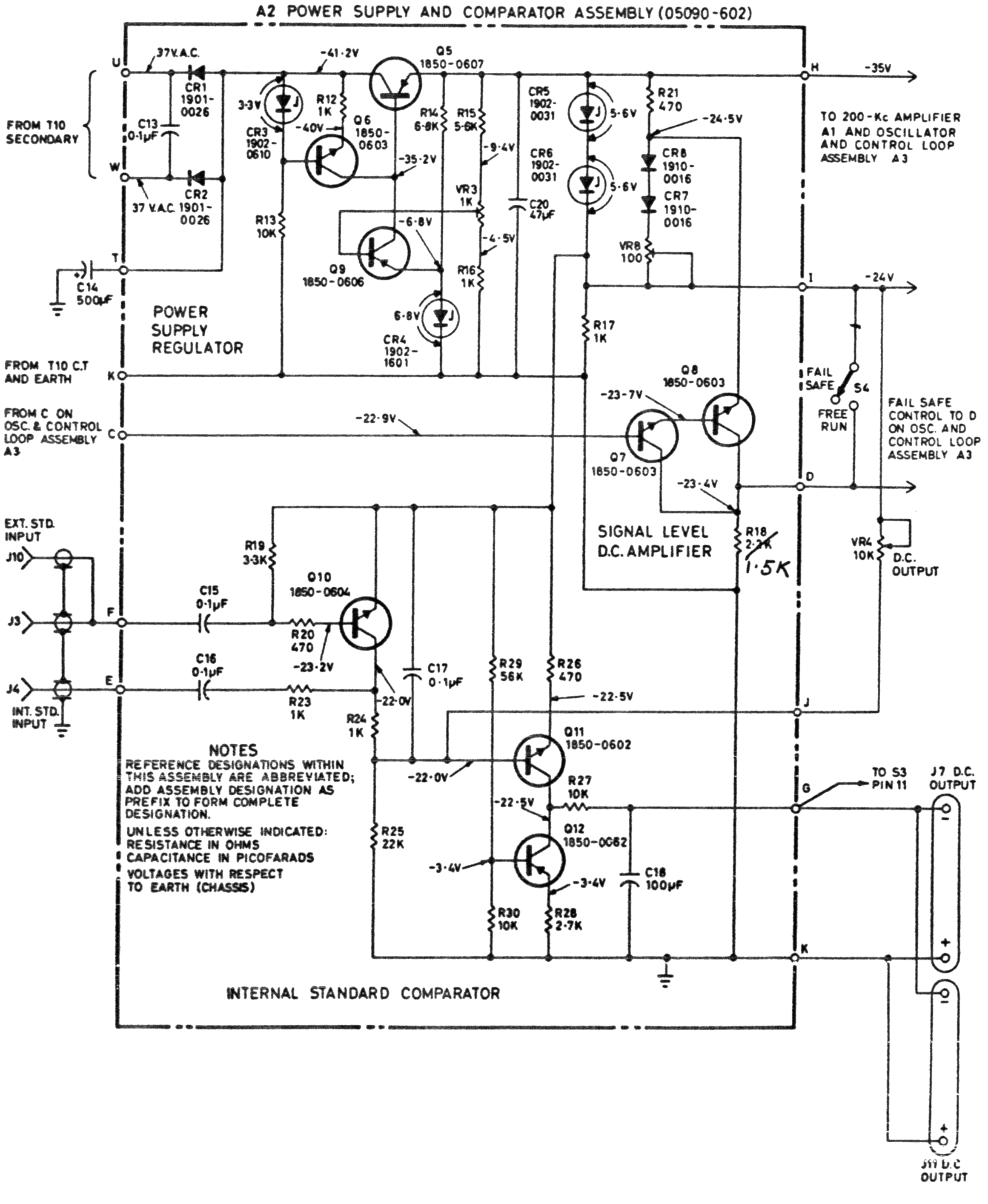


Figure 5–7 Power Supply and Comparator Assembly Circuit Diagram A2

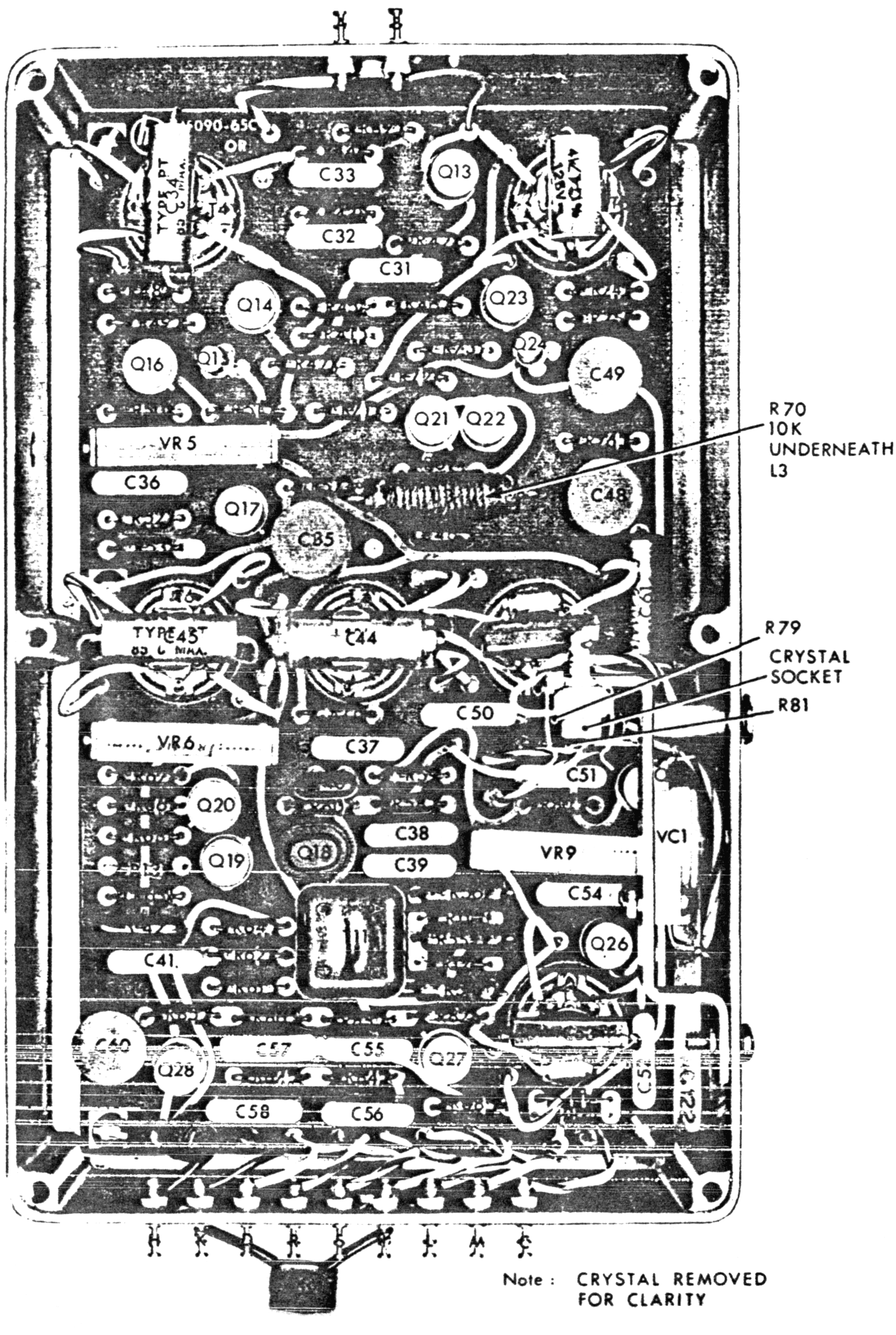
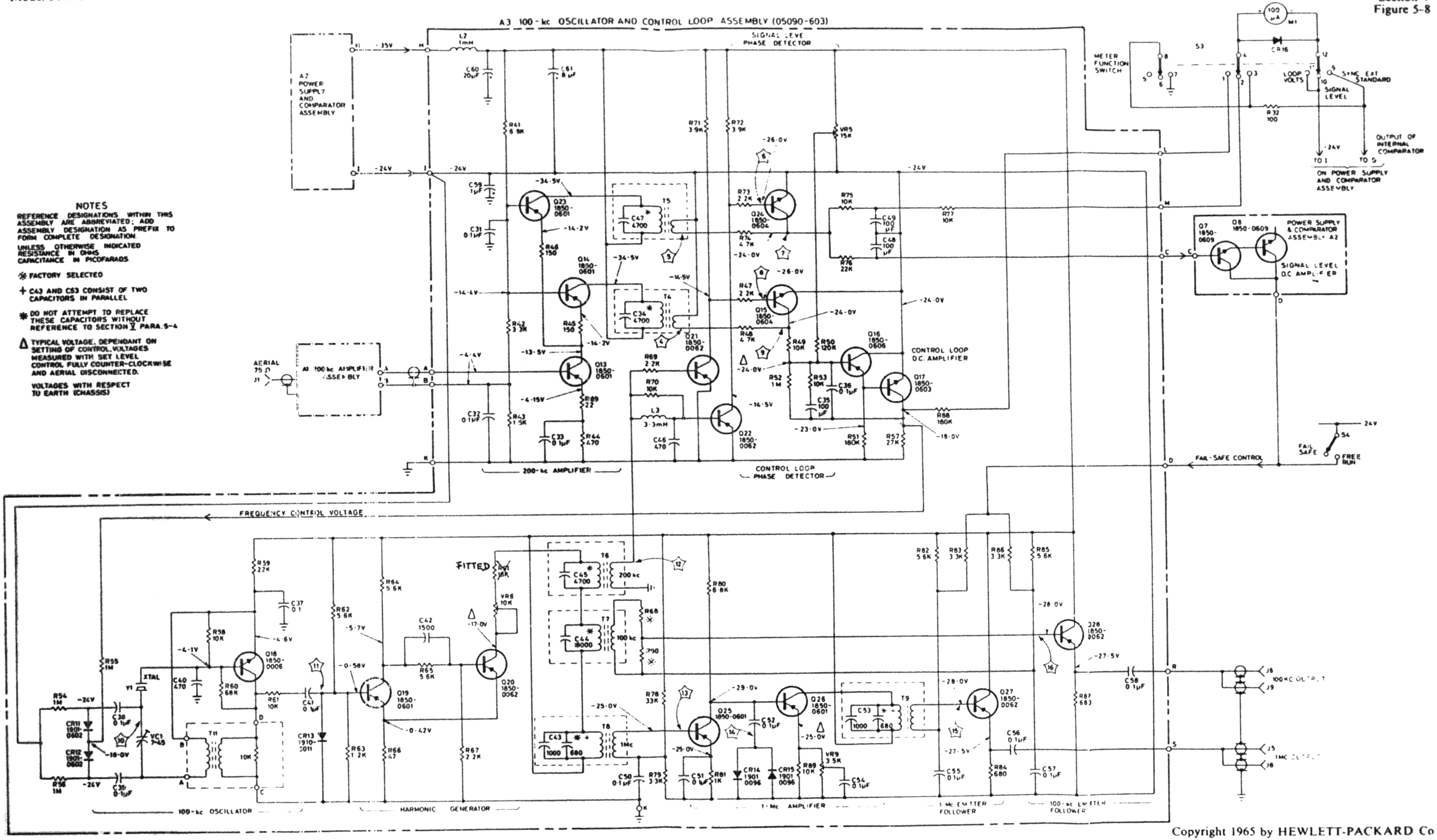


Figure 5-8 100-kc Oscillator and Control Loop Assembly A3



NOTES

REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED; ADD ASSEMBLY DESIGNATION AS PREFIX TO FORM COMPLETE DESIGNATION.

UNLESS OTHERWISE INDICATED RESISTANCE IN OHMS CAPACITANCE IN PICOFARADS.

※ FACTORY SELECTED

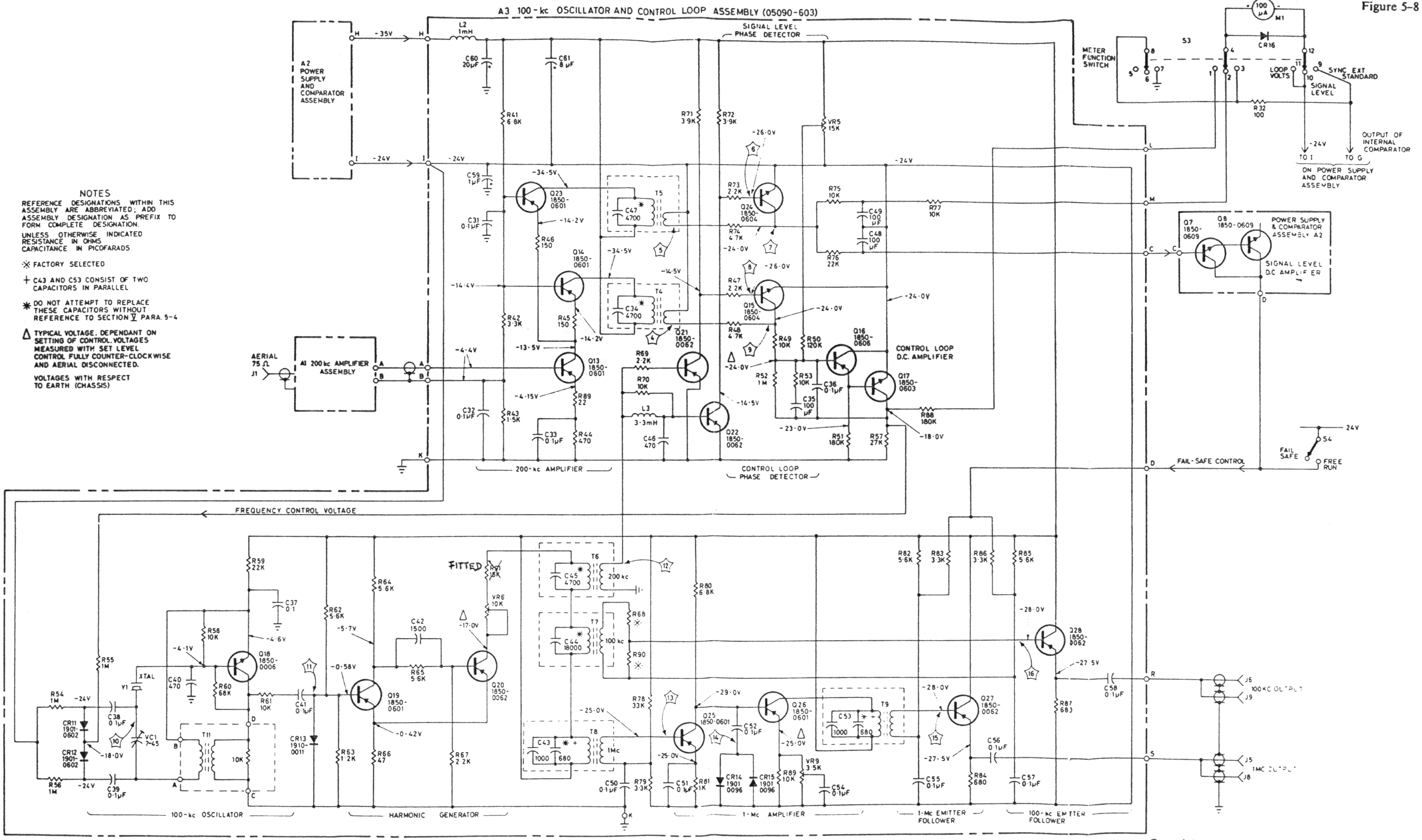
+ C43 AND C53 CONSIST OF TWO CAPACITORS IN PARALLEL

✱ DO NOT ATTEMPT TO REPLACE THESE CAPACITORS WITHOUT REFERENCE TO SECTION V PARA. 5-4

Δ TYPICAL VOLTAGE, DEPENDANT ON SETTING OF CONTROL VOLTAGES MEASURED WITH SET LEVEL CONTROL FULLY COUNTER-CLOCKWISE AND AERIAL DISCONNECTED.

VOLTAGES WITH RESPECT TO EARTH (CHASSIS)

Figure 5-8 100-kc Oscillator and Control Loop Assembly Circuit Diagram A3



NOTES

REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED; ADD ASSEMBLY DESIGNATION AS PREFIX TO FORM COMPLETE DESIGNATION.

UNLESS OTHERWISE INDICATED RESISTANCE IN OHMS CAPACITANCE IN PICOFARADS

⁑ FACTORY SELECTED

+ C43 AND C53 CONSIST OF TWO CAPACITORS IN PARALLEL

✱ DO NOT ATTEMPT TO REPLACE THESE CAPACITORS WITHOUT REFERENCE TO SECTION V PARA. 5-4

Δ TYPICAL VOLTAGE, DEPENDANT ON SETTING OF CONTROL. VOLTAGES MEASURED WITH SET LEVEL CONTROL FULLY COUNTER-CLOCKWISE AND AERIAL DISCONNECTED.

VOLTAGES WITH RESPECT TO EARTH (CHASSIS)

Figure 5-8 100-kc Oscillator and Control Loop Assembly Circuit Diagram A3

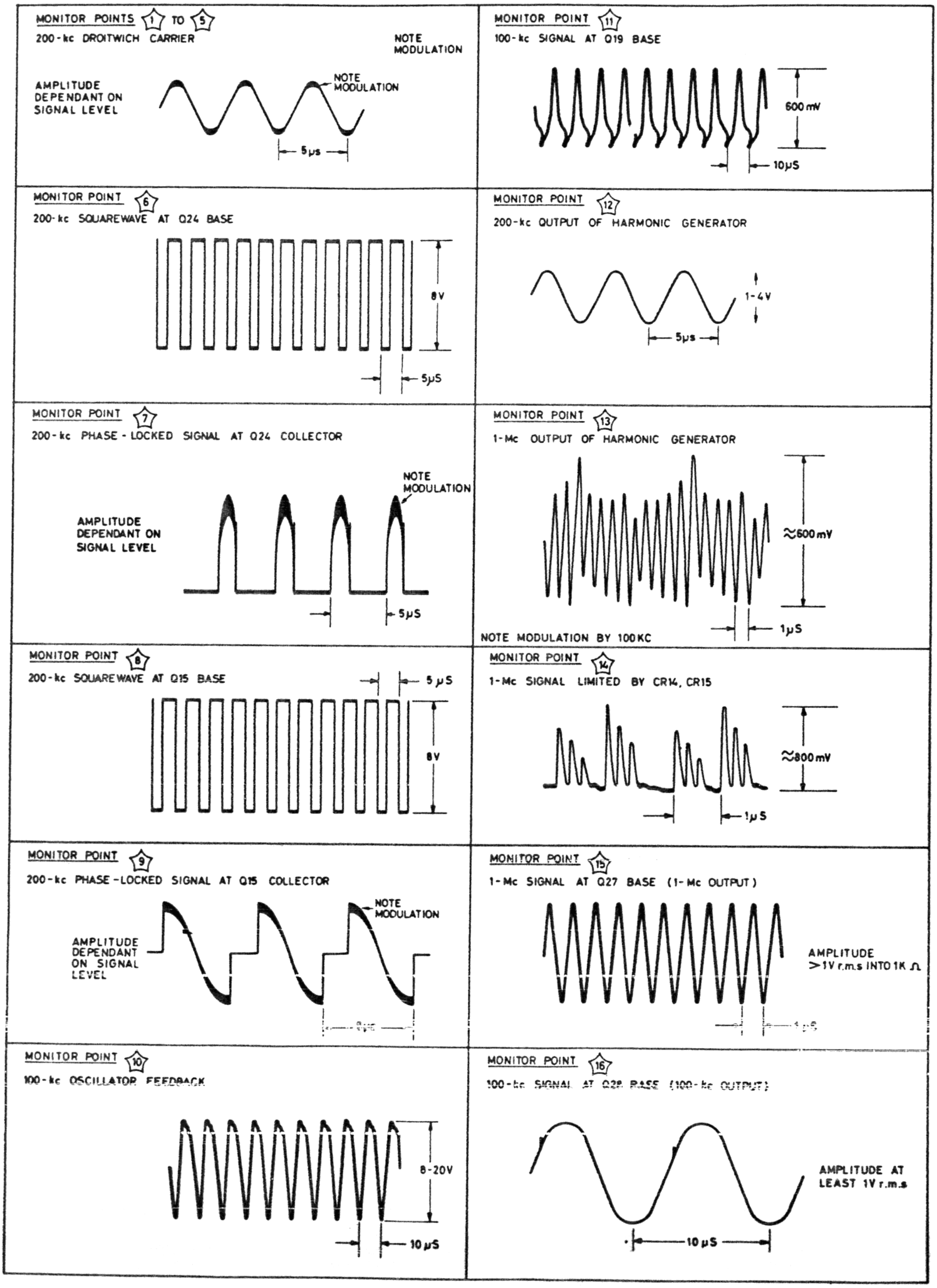


Figure 5-9 Typical Waveforms

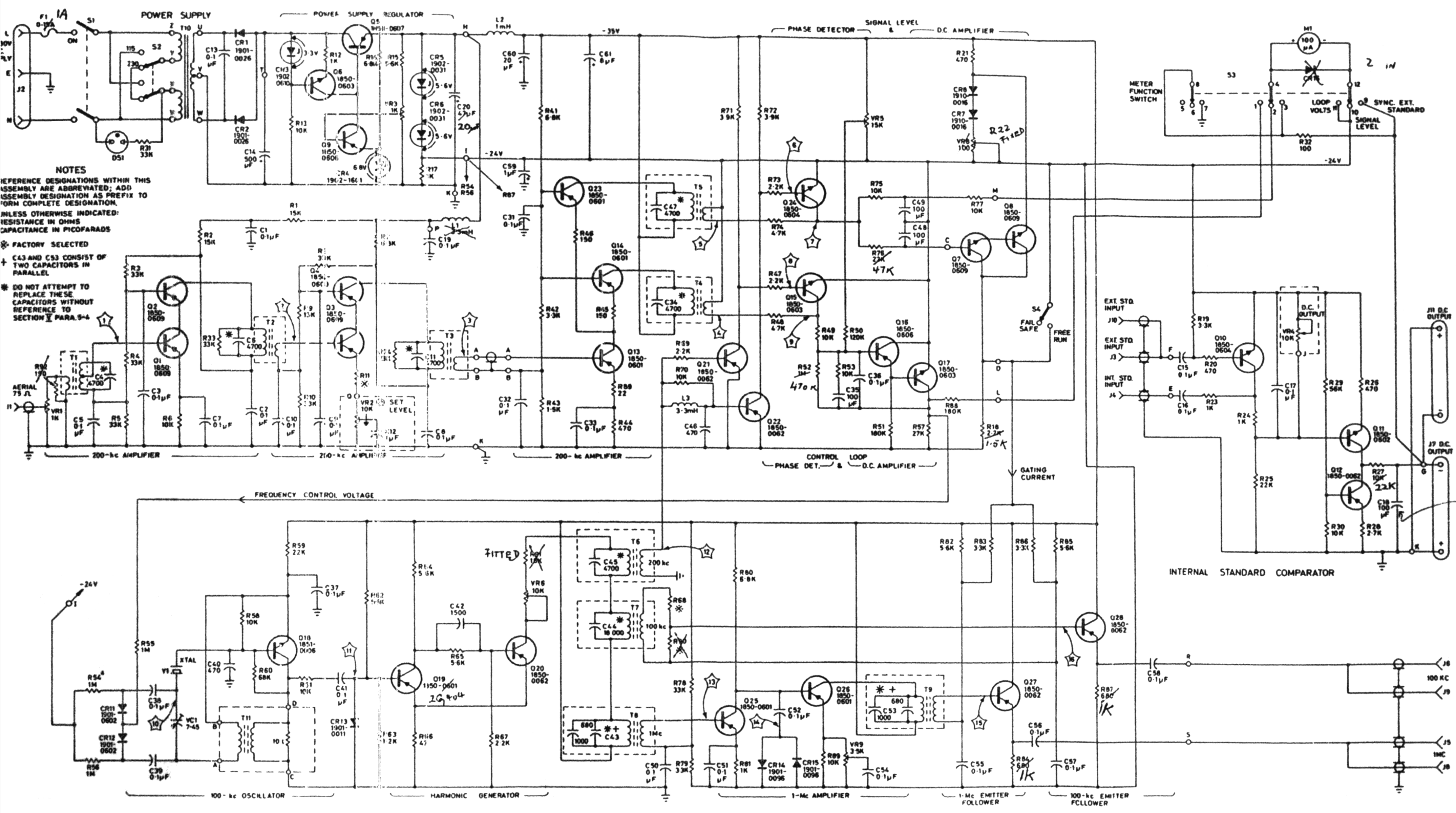


Figure 5-10 Circuit Diagram of 5090A

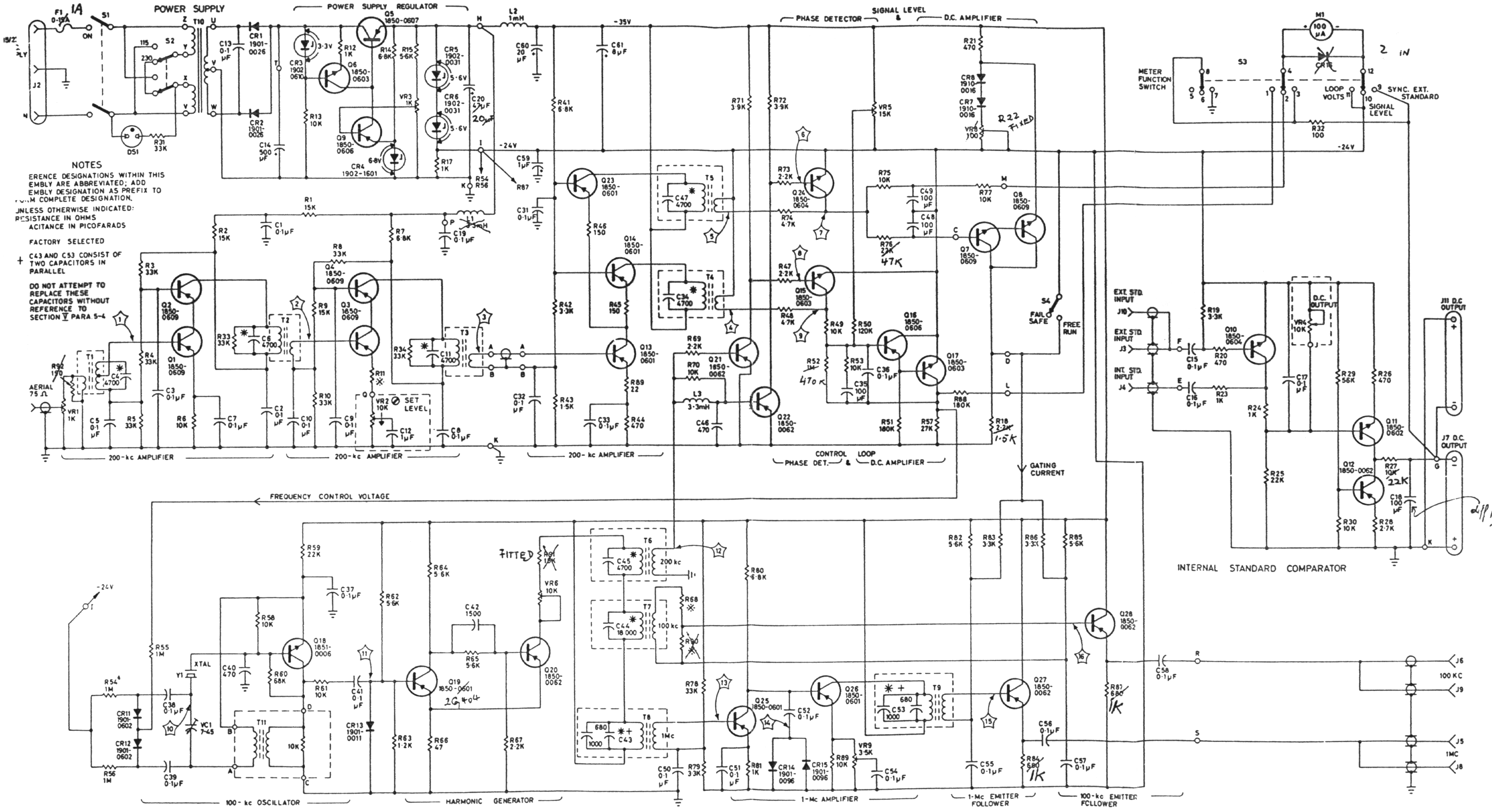


Figure 5-10 Circuit Diagram of 5090A

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION.

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

a. Description of the part (see list of abbreviations below).
b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in Table 6-3
c. Manufacturer's part number.
d. Total quantity used in the instrument (TQ column).

6-3 ORDERING INFORMATION.

6-4. To order replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see addresses at the rear of this manual).

6-5. Specify the following information for each part:
a. Model and complete serial number of instrument.
b. Hewlett-Packard part number.
c. Circuit reference designator.
d. Description.

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

REFERENCE DESIGNATORS

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

ABBREVIATIONS

A = amperes
A.F.C. = automatic frequency control
AMPL = amplifier

B. F. O. = beat frequency oscillator
BE CU = beryllium copper
BH = binder head
BP = bandpass
BRS = brass
BWO = backward wave oscillator

CCW = counter-clockwise
CER = ceramic
CMO = cabinet mount only
COEF = common coefficient
COM = common
COMP = composition
CONN = connector
CP = cadmium plate
CRT = cathode-ray tube
CW = clockwise

DEPC = deposited carbon
DR = drive

ELECT = electrolytic
ENCAP = encapsulated
EXT = external

F = farads
FH = flat head
FIL H = fillister head
FXD = fixed

GE = germanium
GL = glass
GRD = ground(ed)

H = henries
HEX = hexagonal
HG = mercury
HR = hour(s)

IF = intermediate freq
IMPG = impregnated
INCD = incandescent
INCL = include(s)
INS = insulation(ed)
INT = internal

K = kilo = 1000

LIN = linear taper
LK WASH = lock washer
LOG = logarithmic taper
LPF = low pass filter

M = milli 10^{-3}
MEG = meg = 10^6
METFLM = metal film
MFR = manufacturer
MINAT = miniature
MOM = momentary
MTG = mounting
MY = "mylar"

N = nano (10^{-9})

N/C = normally closed
NE = neon
NI PL = nickel plate
N/O = normally open
NPO = negative positive zero (zero temperature coefficient)

NRFR = not recommended for field replacement
NSR = not separately replaceable

OBD = order by description
OH = oval head
OX = oxide

P = peak
PC = printed circuit
PF = picofarads 10^{-12} farads
PH BRZ = phosphor bronze
PHL = Phillips
PIV = peak inverse voltage
P/O = part of
POLY = polystryrene
PORC = porcelain
POS = position(s)
POT = potentiometer
PP = peak-to-peak
PT = point
RECT = rectifier
RF = radio frequency
RH = round head

RMO = rack mount only
RMS = root-mean-square

S-B = slow-blow
SCR = screw
SE = selenium
SECT = section(s)
SEMICON ... semiconductor
SI = silicon
SIL = silver
SL = slide
SPL = special
SST = stainless steel
SR = split ring
STL = steel

TA = tantalum
TD = time delay
TGL = toggle
TI = titanium
TOL = tolerance
TRIM = trimmer
TWT = travelling wave tube

U = micro = 10^{-6}

VAR = variable
VDCW = dc working volts

W/ = with
W = watts
WW = wirewound
W/O = without

Table 6–1 Reference Designation Index

Reference Designation	ⓗ Part No.	Description*	Note
A1	05090–601	Amplifier Assembly	
	05090-201	Board, Blank printed circuit	
A1C1	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A1C2	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A1C3	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A1C4	0160–0603	C: fxd. polystyrene 4700 pf ±1% 100 vdc	
A1C5	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A1C6	0160–0603	C: fxd. polystyrene 4700 pf ±1% 100 vdc	
A1C7 Thru			
A1C10	0150–0121	C: fxd. cer. 0.1 μf. +80%—20% 50 vdcw	
A1C11	0160–0603	C: fxd. polystyrene 4700 pf ±1% 100 vdc	
A1L3	9140–0601	Choke	
A1Q1 Thru			
A1Q4	1850–0601	Transistor 2G403S	
A1R1	0758–0018	R: fxd. met. flm. 15K ohm 5% ½W	
A1R2	0758–0018	R: fxd. met. flm. 15K ohm 5% ½W	
A1R3 Thru			
A1R5	0758–0049	R: fxd. met. flm. 33K ohm 5% ½W	
A1R6	0758–0006	R: fxd. met. flm. 10K ohm 5% ½W	
A1R7	0758–0009	R: fxd. met. flm. 6.8K ohm 5% ½W	
A1R8	0758–0049	R: fxd. met. flm. 33K ohm 5% ½W	
A1R9	0758–0018	R: fxd. met. flm. 15K ohm 5% ½W	
A1R10		Not assigned	
A1R11	0758–0003	R: fxd. met. flm. 1000 ohms 5% ½W	
A1R33	0758–0049	R: fxd. met. flm. 33K ohm 5% ½W	
A1R34	0758–0049	R: fxd. met. flm. 33K ohm 5% ½W	
A2	05090–602	Power Supply Assembly	
	05090-202	Board, blank printed circuit	
A2C13	0160–0602	C: fxd. polystyrene 0.1 μf +10% 200 vdcw	
A2C14	0180–0047	C: fxd. elect. 500 μf 75vdcw	
A2C15 Thru			
A2C17	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A2C18	0180–0606	C: fxd. elect. 100 μf —20%+100% 25 vdcw	
A2C20	0180–0151	C: fxd. elect. 47 μf 35V	
A2C20	0180–0151	C: fxd. elect. 47 μf 35V	
A2CR1	1901–0026	Diode-silicon	
A2CR2	1901–0026	Diode-silicon	
A2CR3	1902–0610	Diode-zener 6.8V	
A2CR4	1902–0601	Diode-zener 3.3V 250 MW	
A2CR5	1902–0031	Diode-breakdown 12.7V 5% 400 MW	
A2CR6	1902–0031	Diode-breakdown 12.7V 5% 400 MW	
A2CR7	1019–0016	Diode-germanium	
A2CR8	1910–0016	Diode-germanium	
A2Q5	1850–0607	Transistor-OC29	
A2Q6 Thru			
A2Q8	1850–0603	Transistor-2S703	
A2Q9	1850–0606	Transistor-2S302	
A2Q10	1850–0604	Transistor-2N743	
A2Q11	1850–0602	Transistor-2N1308	
A2Q12	1850–0062	Transistor-germanium PNP	

* See list of abbreviations in introduction to this section

Table 6–1 Reference Designation Index (cont'd)

Reference Designation	ⓗ Part No.	Description*	Note
A2R12	0758–0003	R: fxd. met. flm. 1000 ohms 5% ½W	
A2R13	0758–0006	R: fxd. met. flm. 10K ohm 5% ½W	
A2R14	0758–0009	R: fxd. met. flm. 6.8K ohm 5% ½W	
A2R15	0758–0057	R: fxd. met. flm. 5600 ohms 5% ½W	
A2R16	0758–0003	R: fxd. met. flm. 1000 ohms 5% ½W	
A2R17	0761–0021	R: fxd. met. flm. 1000 ohms 5% 1W	
A2R18	0761–0005	R: fxd. met. flm. 2200 ohms 5% 1W	
A2R19	0758–0001	R: fxd. met. flm. 3.3K ohm 1% ½W	
A2R20	0758–0029	R: fxd. met. flm. 270 ohm 5% ½W	
A2R21	0758–0029	R: fxd. met. flm. 470 ohm 5% ½W	
A2R22		Not assigned	
A2R23	0758–0003	R: fxd. met. flm. 1000 ohms 5% ½W	
A2R24	0758–0003	R: fxd. met. flm. 1000 ohms 5% ½W	
A2R25	0758–0020	R: fxd. met. flm. 22K ohm 5% ½W	
A2R26	0758–0029	R: fxd. met. flm. 470 ohms 5% ½W	
A2R27	0758–0006	R: fxd. met. flm. 10K ohm 5% ½W	
A2R28	0757–0079	R: fxd. met. flm. 2700 ohms 2% ½W	
A2R29	0757–0601	R: fxd. met. flm. 56K ohm 2% ½W	
A2R30	0757–0603	R: fxd. met. flm. 10K ohm 2%	
A2VR3	2100–0605	R: var. WW 1K ohm	
A2VR8	2100–0607	R: var. WW 100 ohm	
A3	05090–603	Oscillator Assembly	
	05090-203	Board, Blank printed circuit	
A3C31	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A3C32	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A3C33	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A3C35	0180–0606	C: fxd. elect. 100 μf —20%+100% 25 vdcw	
A3C36 Thru A3C39	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A3C40	0140–0149	C: fxd. mica 470 pf 5% 300 vdcw	
A3C41	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A3C42	0140–0156	C: fxd. mica 1500 pf 2% 300 vdcw	
A3C46	0140–0149	C: fxd. mica 470 pf 5% 30 vdcw	
A3C48	0180–0607	C: fxd. elect. 100 μf —20%+100% 10 vdcw	
A3C49	0180–0607	C: fxd. elect. 100 μf —20%+100% 10 vdcw	
A3C50 Thru A3C52	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A3C54 Thru A3C58	0150–0121	C: fxd. cer. 0.1 μf +80%—20% 50 vdcw	
A3C60	0180–0605	C: fxd. elect. 20 μf —20%+100% 50 vdcw	
A3C61	0180–0603	C: fxd. elect. 8 μf —20%+50% 12 vdcw	
A3CR11	1901–0602	Diode-varicap	
A3C12	1901–0602	Diode-varicap	
A3CR13	1910–0011	Diode-germanium 60PIV 5MA	
A3C14	1901–0096	Diode-silicon	
A3CR15	1901–0096	Diode-silicon	
A3L1	9140–0052	Coil-fxd. RF 3.3 MH	
A3L2	9140–0053	Coil-fxd. RF 1 MH	
A3Q13	1850–0601	Transistor-2G403S	
A3Q14	1850–0601	Transistor-2G403S	
A3Q15	1850–0603	Transistor-2S703	
A3Q16	1850–0606	Transistor-2S302	
A3Q17	1850–0603	Transistor-2S703	

* See list of abbreviations in introduction to this section

Table 6-1 Reference Designation Index (cont'd)

Reference Designation	ⓗ Part No.	Description*	Note
A3Q18	1851-0006	Transistor-germanium NPN 2N169A	
A3Q19	1850-0601	Transistor-2G403S	
A3Q20	1850-0062	Transistor-germanium PNP	
A3Q21	1850-0062	Transistor-germanium PNP	
A3Q22	1850-0062	Transistor-germanium PNP	
A3Q23	1850-0601	Transistor-2G403	
A3Q24	1850-0604	Transistor-2N743	
A3Q25	1850-0601	Transistor-2G403	
A3Q26	1850-0601	Transistor-2G403	
A3Q27	1850-0062	Transistor-germanium PNP	
A3Q28	1850-0062	Transistor-germanium PNP	
A3R41	0758-0009	R: fxd. met. flm. 6.8K ohm 5% $\frac{1}{2}$W	
A3R42	0758-0001	R: fxd. met. flm. 3.3K ohms 1% $\frac{1}{2}$W	
A3R43	0758-0017	R: fxd. met. flm. 1.5K ohm 5% $\frac{1}{2}$W	
A3R44	0758-0029	R: fxd. met. flm. 470 ohms 5% $\frac{1}{2}$W	
A3R45	0758-0007	R: fxd. met. flm. 150 ohms 5% $\frac{1}{2}$W	
A3R46	0758-0007	R: fxd. met. flm. 150 ohms 5% $\frac{1}{2}$W	
A3R47	0758-0044	R: fxd. met. flm. 2.2K ohms 5% $\frac{1}{2}$W	
A3R48	0758-0005	R: fxd. met. flm. 4.7K ohms 5% $\frac{1}{2}$W	
A3R49	0758-0006	R: fxd. met. flm. 10K ohms 5% $\frac{1}{2}$W	
A3R50	0758-0061	R: fxd. met. flm. 120K ohms 5% $\frac{1}{2}$W	
A3R51	0758-0104	R: fxd. met. flm. 180K ohms 5% $\frac{1}{2}$W	
A3R52	0761-0108	R: fxd. met. flm. 1M ohm 5% $\frac{1}{2}$W	
A3R53	0758-0006	R: fxd. met. flm. 10K ohms 5% $\frac{1}{2}$W	
A3R54	0761-0108	R: fxd. met. flm. 1M ohmn 5% 1W	
A3R55	0761-0108	R: fxd. met. flm. 1M ohm 5% 1W	
A3R56	0761-0108	R: fxd. met. flm. 1M ohm 5% 1W	
A3R57	0758-0074	R: fxd. met. ox. 27K ohms 5% $\frac{1}{2}$W	
A3R58	0758-0006	R: fxd. met. flm. 10K ohms 5% $\frac{1}{2}$W	
A3R59	0758-0020	R: fxd. met. flm. 22K ohms 5% $\frac{1}{2}$W	
A3R60	0758-0076	R: fxd. met. flm. 68K ohms 5% $\frac{1}{2}$W	
A3R61	0758-0006	R: fxd. met. flm. 10K ohms 5% $\frac{1}{2}$W	
A3R62	0758-0603	R: fxd. met. flm. 56K ohms 5% $\frac{1}{2}$W	
A3R63	0758-0070	R: fxd. met. ox. 1200 ohms 5% $\frac{1}{2}$W	
A3R64	0758-0057	R: fxd. flm. 5600 ohms 5% $\frac{1}{2}$W	
A3R65	0758-0057	R: fxd. met. flm. 5600 ohms 5% $\frac{1}{2}$W	
A3R66	0758-0601	R: fxd. met. flm. 47 ohms 5% $\frac{1}{2}$W	
A3R67	0758-0044	R: fxd. met. flm. 2200 ohms 5% $\frac{1}{2}$W	
A3R68	0686-1825	R: fxd. comp. 1.8K ohms 5% $\frac{1}{2}$W (nominal value)	
A3R69	0758-0044	R: fxd. met. flm. 2200 ohms 5% $\frac{1}{2}$W	
A3R70	0758-0006	R: fxd. met. flm. 10K ohms 5% $\frac{1}{2}$W	
A3R71	0758-0045	R: fxd. met. flm. 3900 ohms 5% $\frac{1}{2}$W	
A3R72	0758-0045	R: fxd. met. flm. 3900 ohms 5% $\frac{1}{2}$W	
A3R73	0758-0044	R: fxd. met. flm. 2200 ohms 5% $\frac{1}{2}$W	
A3R74	0758-0005	R: fxd. met. flm. 4.7K ohms 5% $\frac{1}{2}$W	
A3R75	0758-0006	R: fxd. met. flm. 10K ohms 5% $\frac{1}{2}$W	
A3R76	0758-0020	R: fxd. met. flm. 22K ohms 5% $\frac{1}{2}$W	
A3R77	0758-0006	R: fxd. met. flm. 10K ohms 5% $\frac{1}{2}$W	
A3R78	0758-0049	R: fxd. met. ox. 33K ohms 5% $\frac{1}{2}$W	
A3R79	0758-0001	R: fxd. met. flm. 3.3K ohms 1% $\frac{1}{2}$W	
A3R80	0758-0009	R: fxd. met. flm. 6.8K ohms 5% $\frac{1}{2}$W	
A3R81	0758-0003	R: fxd. met. flm. 1000 ohms 5% $\frac{1}{2}$W	
A3R82	0758-0057	R: fxd. met. flm. 5600 ohms 5% $\frac{1}{2}$W	
A3R83	0758-0001	R: fxd. met. flm. 3.3K ohms 1% $\frac{1}{2}$W	
A3R84	0758-0031	R: fxd. met. flm. 680 ohms 5% $\frac{1}{2}$W	
A3R85	0758-0057	R: fxd. met. flm. 5600 ohms 5% $\frac{1}{2}$W	

* See list of abbreviations in introduction to this section

Table 6-1 Reference Designation Index (cont'd)

Reference Designation	Part No.	Description*	Note
A3R86	0758-0001	R: fxd. met. flm. 3.3K ohms 1% ½W	
A3R87	0758-0031	R: fxd. met. flm. 680 ohms 5% ½W	
A3R88	0758-0104	R: fxd. met. flm. 180K ohms 5% ½W	
A3R89	0758-0606	R: fxd. met. ox. 22 ohms 5% ½W	
A3R90	0686-2225	R: fxd. comp. 2.2K ohms 5% ½W (nominal value)	
A3T11	5212A-9A	Transformer Oscillator	
A3VR5	2100-0603	R: var. WW 20K ohms	
A3VR6	2100-0602	R: var. WW 10K ohms	
A3VR7	2100-0606	R: var. WW 3.5K ohms	
C12	0160-0127	C: fxd. cer. 1 μf 20% 25 vdcw	
C19	0150-0121	C: fxd. cer. 0.1 μf +80%—20% 60 vdcw	
C34		Part of T4 Assy.	
C43		Part of T8 Assy.	
C44		Part of T7 Assy.	
C45		Part of T6 Assy.	
C47		Part of T5 Assy.	
C53		Part of T9 Assy.	
C59	0160-0127	C: fxd. cer. 1 μf 20% 25 vdcw	
CR16	1901-0025	Diode-silicon	
DS1	1450-0048	Light-Red Indicator	
F1	2110-0017	Fuse Cartridge 0.15 amp. 125 volt	
J1	1250-0001	Connector, RF Bulkhead Jack type BNC	
J2	1251-0148	Connector, Male 3 pin	
J3 thru J6	1250-0001	Connector, RF Bulkhead Jack Type BNC	
J7	0340-0089	Insulator, Bind Post 1 hole	
	0340-0090	Insulator, Bind Post 2 hole with Pin	
	5060-0634	Binding Post Assy. Red ¾" stud.	
	5060-0635	Binding Post Assy. Black ¾" stud.	
J8 thru J10	1250-0001	Connector RF Bulkhead Jack Type BNC	
J11	0340-0089	Insulator Bind Post 1 hole	
	0340-0090	Insulator Bind Post 2 hole with Pin	
	5060-0634	Binding Post Assy. Red ¾" stud	
	5060-0635	Binding Post Assy. Black ¾" stud.	
M1	1120-0610	Meter	
R31	0758-0049	R: fxd. met. flm. 33K ohms 5% ½W	
R32	0758-0024	R: fxd. met. flm. 100 ohms 5% ½W	
S1	3100-0610	Switch-mains DPST	
S2	3101-0033	Switch-slide DPDT	
S3	3100-0601	Switch-rotary 3 way 3 pole	
S4	2100-0346	Switch-Part of VR4	
T1	05090-0604	Transformer	
T2	05090-0605	Transformer	
T3	05090-0606	Transformer	

* See list of abbreviations in introduction to this section

Table 6–1 Reference Designation Index (cont'd)

Reference Designation	ⓗ Part No.	Description*	Note
T4	05090–0607	Transformer	
T5	05090–0610	Transformer	
T6	05090–0607	Transformer	
T7	05090–0609	Transformer	
T8	05090–0608	Transformer	
T9	05090–0608	Transformer	
T10	9100–0601	Transformer-Mains	
VC1	0130–0001	C: var. cer. 7-45 pf	
VR1	2100–0601	R: var. WW 1K ohm	
VR2	2100–0604	R: var. WW 10K ohm	
VR4	2100–0346	R: var. WW 12K ohm +20% 1W	
XY1	1200–0028	Socket 2 pin crystal	
Y1	0410–0021	Crystal quartz 0.005%	
		MISCELLANEOUS	
	0340–0038	Post terminal	
	0340–0038	Insulator bushing	
	0360–0124	Terminal pin	
	0370–0113	Knob $\frac{3}{4}$" dia. Blk. $\frac{1}{4}$" shaft concentric	
	0370–0114	Knob $\frac{5}{8}$" Dia. Red. $\frac{1}{8}$" shaft with arrow	
	1400–0084	Fuseholder Post type 2 5/64" lg.	
	1410–0052	Bushing 0.43" lg. × 0.261" ID	
	1490–0031	Stand Cabinet Tilt 4-7/16" wide.	
	1520–0001	Plate capacitor mtg. 1–17/32 × 23/16 in.	
	5000–0703	Cover side 6 × 11 in. cabinet	
	5000–0703	Cover side 6 × 11 in. cabinet	
	5000–0711	Cover bottom 5 × 11 in. cabinet	
	5020–0700	Spacer 4–9/16 in. lg.	
	5020–0700	Spacer 4–9/16 in. lg.	
	5020–0700	Spacer 4–9/16 in. lg.	
	5060–0703	Frame assy. side 6 × 11 in. cabinet	
	5060–0703	Frame assy. side 6 × 11 in. cabinet	
	5060–0709	Cover top 5 × 11 in. cabinet	
	5060–0727	Foot cabinet 4–3/8 in. lg.	
	5060–0727	Foot cabinet 4–3/8 in. lg.	
	8120–0078	Cable power 7½ ft.	
	05090–001	Back panel	
	05090–002	Front panel	
	05090–003	Bracket	
	05090–003	Bracket	
	05090–004	Bracket	
	05090–005	Bracket	
	05090–204	Box-small	
	05090–205	Box-large	
	05090–206	Lid-large	
	05090–207	Lid-small	
	10502–6001	Cable (AC–16E)	

* See list of abbreviations in introduction to this section

Table 6—2 Replaceable Parts

ⓗ Part No.	Description	Mfr.	Mfr. Part No.	T.Q.	
0130–0001	C: var. 7—45 pf cer. N500 500 vdcw	72982	50300D2PO	1	
0140–0099	C: fxd. 1000 pf ±1% 500 vdcw	28480	0140–0099	1	
0140–0149	C: fxd. mica 470 pf 5% 300 vdcw	04062	DM15F471J	2	
0140–0156	C: fxd. mica 1500 pf 2% 300 vdcw	04062	DM19F152G	1	
0150–0121	C: fxd. cer. 0.1 µf +80%—20% 50 vdcw	56289	5C50A	14	
0160–0127	C: fxd. cer. 1 µf 20% 25 vdcw	56289	5C13	2	
0160–0602	C: fxd. polystyrene 0.1 µf +10% 200 vdcw	28480	0160–0602	1	
0160–0603	C: fxd. polystyrene 4700 pf ±1% 100 vdcw	28480	0160–0603	3	
0160–0604	C: fxd. polystyrene 680 pf ±1% 125 vdcw	28480	0160–0604	1	
0160–0606	C: fxd. polystyrene 4700 pf ±1% 125 vdcw	28480	0160–0606	1	
0180–0047	C: fxd. elect. 500 µf 75 vdcw	56289	D32443	1	
0180–0051	C: fxd. elect. 47 µf 35 vdcw	28480	0180–0051	1	
0180–0603	C: fxd. elect. 8 µf —20%+50% 12 vdcw	28480	0180–0603	1	
0180–0605	C: fxd. elect. 20 µf —20%+100% 50 vdcw	28480	0180–0605	1	
0180–0606	C: fxd. elect. 100 µf —20%+100% 25 vdcw	28480	0180–0606	1	
0180–0607	C: fxd. elect. 100 µf —20%+100% 10 vdcw	28480	0180–0607	2	
0340–0038	Post terminal	28480	0340–0038	16	
0340–0039	Insulator bushing	28480	0340–0039	16	
0340–0089	Insulator bind post 1 hole	28480	0340–0089	4	
0340–0090	Insulator bind post 2 hole with pin	28480	0340–0090	2	
0360–0124	Terminal pin	28480	0360–0124	1	
0370–0113	Knob ¾" dis. Blk. ¼" shaft concentric	28480	0370–0113	1	
0370–0114	Knob ⅝" dia. Red ⅛" shaft with arrow	28480	0370–0114	1	
0410–0021	Crystal quartz 100Kc 0.005%	00815	NE13N	1	
0686–1825	R: fxd. comp. 1.8K ohms 5% ½W (nominal value)	28480	0686–1825	1	
0686–2225	R: fxd. comp. 2.2K ohms 5% ½W (nominal value)	01121	EB2225	1	
0757–0079	R: fxd. met. flm. 2700 ohms 2% ½W	28480	0757–0079	1	
0757–0601	R: fxd. met. flm. 56K ohms 2% ½W	28480	0757–0601	1	
0757–0603	R: fxd. met. flm. 10K ohms 2% ½W	28480	0757–0603	1	
0758–0001	R: fxd. met. flm. 3.3K ohms 1% ½W	28480	0758–0001	5	
0758–0003	R: fxd. met. flm. 1000 ohms 5% ½W	28480	0758–0003	6	
0758–0005	R: fxd. met. flm. 4.7K ohms 5% ½W	28480	0758–0005	2	
0758–0006	R: fxd. met. flm. 10K ohms 5% ½W	28480	0758–0006	10	
0758–0007	R: fxd. met. flm. 150 ohms 5% ½W	28480	0758–0007	2	
0758–0009	R: fxd. met. flm. 6.8K ohms 5% ½W	28480	0758–0009	4	
0758–0017	R: fxd. met. flm. 1.5K ohms 5% ½W	28480	0758–0017	1	
0758–0018	R: fxd. met. flm. 15K ohms 5% ½W	28480	0758–0018	3	
0758–0020	R: fxd. met. flm. 22K ohms 5% ½W	28480	0758–0020	3	
0758–0024	R: fxd. met. flm. 100 ohms 5% ½W	28480	0758–0024	1	
0758–0029	R: fxd. met. flm. 270 ohms 5% ½W	28480	0758–0029	4	
0758–0031	R: fxd. met. flm. 680 ohms 5% ½W	28480	0758–0031	2	
0758–0044	R: fxd. met. flm. 2.2K ohms 5% ½W	28480	0758–0044	4	
0758–0045	R: fxd. met. flm. 3900 ohms 5% ½W	28480	0758–0045	2	
0758–0049	R: fxd. met. ox. 33K ohms 5% ½W	28480	0758–0049	6	
0758–0057	R: fxd. met. flm. 5600 ohms 5% ½W	28480	0758–0057	5	
0758–0061	R: fxd. met. flm. 120K ohms 5% ½W	28480	0758–0061	1	
0758–0070	R: fxd. met. ox. 1200 ohms 5% ½W	28480	0758–0070	1	
0758–0074	R: fxd. met. ox. 27K ohms 5% ½W	28480	0758–0074	1	
0758–0076	R: fxd. met. flm. 68K ohms 5% ½W	28480	0758–0076	1	
0758–0104	R: fxd. met. flm. 180K ohms 5% ½W	28480	0758–0104	2	
0758–0601	R: fxd. met. flm. 47 ohms 5% ½W	28480	0758–0601	1	
0758–0603	R: fxd. met. flm. 56K ohms 5% ½W	28480	0758–0603	1	
0758–0606	R: fxd. met. ox. 22 ohms 5% ½W	28480	0758–0606	1	
0761–0005	R: fxd. met. flm. 2200 ohms 5% 1W	28480	0761–0005	1	
0761–0021	R: fxd. met. flm. 1000 ohms 5% 1W	28480	0761–0021	1	

Table 6—2 Replaceable Parts (Cont'd)

ⓗ Part No.	Description	Mfr.	Mfr. Part No.	T.Q.
0761–0108	R: fxd. met. flm. 1M ohm 5% 1W	28480	0761–0108	4
1120–0610	Meter	28480	1120–0610	1
1200–0028	Socket 2 pin crystal	91662	430BC	1
1250–0001	Connector RF Bulkhead Jack type BNC	91737	5126	9
1251-0148	Connector, Male 3-pin	18480	1251-0148	1
1400–0084	Fuseholder post type 2 5/64" lg.	75915	342014	1
1410–0052	Bushing 0.438" lg. × 0.261" ID	28480	1410–0052	1
1450–0048	Light red indicator	28480	1450–0048	1
1490–0031	Stand cabinet tilt 4–7/16" wide	28480	1490–0031	1
1520–0001	Plate capacitor mtg. 1–17/32" × 23/16"	28480	1520–0001	1
1850–0062	Transistor-germanium PNP	28480	1850–0062	6
1850–0601	Transistor-2G403	28480	1850–0601	6
1850–0602	Transistor-2N1308	28480	1850–0602	1
1850–0603	Transistor-2S703	28480	1850–0603	3
1850–0604	Transistor–2N743	28480	1850–0604	1
1850–0606	Transistor–2S302	28480	1850–0606	2
1850–0609	Transistor–OC29	28480	1850–0609	2
1851–0006	Transistor-germanium NPN 2N169A	03508	2N169A	1
1901–0025	Diode-silicon	28480	1901–0025	1
1901–0026	Diode-silicon	14099	SA–783	2
1901–0096	Diode-silicon	28480	1901–0096	2
1901–0602	Diode-varicap	28480	1901–0602	2
1902–0031	Diode-breakdown 12.7V 5% 400MW	28480	1902–0031	2
1902–0601	Diode-zener 3.3V 250MW	28480	1902–0601	1
1902–0610	Diode-zener 6.8V	28480	1902–0610	1
1910–0011	Diode-germanium 60PIV 5MA	28480	1910–0011	1
1910–0016	Diode-germanium	93332	D2361	2
2100–0346	R: var. comp. 12K ohms +20% 1W	28480	2100–0346	2
2100–0601	R: var. comp. 1K ohm	28480	2100–0601	1
2100–0602	R: var. 10K ohm WW	28480	2100–0602	2
2100–0603	R: var. comp. 20K ohm WW	28480	2100–0603	2
2100–0604	R: var. comp. 10K ohm	28480	2100–0604	1
2100–0605	R: var. comp. 1K ohm WW	28480	2100–0605	2
2100–0606	R: var. comp. 3.5K ohm	28480	2100–0606	2
2100–0607	R: var. comp. 100 ohm ¼W	28480	2100–0607	2
2110–0017	Fuse cartridge 0.15 amp 125 volt	28480	2110–0017	1
3100–0601	Switch-oak	28480	3100–0601	1
3100–0610	Switch-mains DPST	28480	3100–0610	1
3101–0033	Switch-slide DPDT	28480	3101–0033	1
5000–0011	Cover-bottom 5 × 11 in cabinet	28480	5000–0011	1
5000–0703	Cover-side 6 × 11 in. cabinet	28480	5000–0703	2
5000–0711	Cover bottom 5 × 11 in. cabinet	28480	5000–0711	1
5020–0700	Spacer 4–9/16 in. lg.	28480	5020–0700	3
5060-0634	Binding Post Assy. Red 3/4" stud	28480	5060-0634	2
5060-0635	Binding Post Assy. Black 3/4" stud	28480	5060-0635	2
5060–0703	Frame assy. side 6 × 11 in. cabinet	28480	5060–0703	2
5060–0709	Cover top 5 × 11 in. cabinet	28480	5060–0709	1
5060–0727	Foot cabinet 4–3/8 in. lg.	28480	5060–0727	2
8120–0078	Cable power 7½ft.	70903	KH4147	1
9100–0601	Transformer-main	28480	9100–0601	1
9140–0052	Coil-fxd. RF 3.3MH	28480	9140–0052	1
9140–0053	Coil-fxd. RF 1MH	28480	9140–0053	1
9140–0601	Choke	28480	9140–0601	1
5212A–9A	Transformer oscillator	28480	5212A–9A	1
05090–001	Back panel	28480	05090–001	1

Table 6—2 Replaceable Parts (Cont'd)

Part No.	Description	Mfr.	Mfr. Part No.	T.Q.	
05090-002	Front panel	28480	05090-002	1	
05090-003	Bracket	28480	05090-003	2	
05090-004	Bracket	28480	05090-004	1	
05090-005	Bracket	28480	05090-005	1	
05090-204	Box-small	28480	05090-204	1	
05090-205	Box-large	28480	05090-205	1	
05090-206	Lid-large	28480	05090-206	1	
05090-207	Lid-small	28480	05090-207	1	
05090-604	Transformer	28480	05090-604	1	
05090-605	Transformer	28480	05090-605	1	
05090-606	Transformer	28480	05090-606	1	
05090-607	Transformer	28480	05090-607	2	
05090-608	Transformer	28480	05090-608	2	
05090-609	Transformer	28480	05090-609	1	
05090-610	Transformer	28480	05090-610	1	
05090-611	Transformer	28480	05090-611	1	
05090-612	Transformer	28480	05090-612	1	
10502-6001	Cable (AC-16E)	28480	10502-6001	1	

Table 6-3

CODE LIST OF MANUFACTURERS

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

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

Galley 3 - Hewlett Packard Code List

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

Revised: HP Ltd. August 1965

Table 6-3 (Cont'd)

CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
81349	Military Specification	....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
[illegible] 145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcest.r, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

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

Code No.	Manufacturer	Address
J000C	Winchester Electronics, Inc.	Santa Monica Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

E 0001 Texas Instruments Ltd., Bedford.

E 0002 Mullard Ltd., London

E 0003 A. F. Bulgin & Co. Ltd., Barking

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

00015-39
Revised : HP Ltd. August 1965

APPENDIX I—AREA OF USE

Propagation of a radio signal at 200-kc follows the normal pattern of a ground-wave which passes from transmitter to receiver without any ionospheric reflections, and a sky-wave which comprises signals which are reflected by ionospheric layers.

The results of theoretical calculations of signal strength are shown in Figure 1A-1. The results for the ground-wave are presented separately from those for day and night-time sky-wave propagation. If it could be assumed that the ground-wave and sky-wave were mutually phase coherent (i.e. if at any geographical location the phase difference between the received ground-wave and the received sky-wave was a constant) and of constant relative amplitude, then the effect of interference between sky-wave and ground-wave would be to produce a resultant signal of constant phase with respect to the transmitted signal. Thus the service area of the transmitter for first-grade frequency standard purposes would be very extensive, as the actual figures of signal strength show. However, the reflectivity of an ionospheric layer is not constant with time, and the amplitude of the reflected wave will vary to some extent. In addition, the phase stability of the sky-wave is degraded by Doppler-type effects. Apart from phase shifts which might occur from vertical movements of the ionosphere, it has been shown that the ionospheric layer can be regarded as having an irregular lower surface and moving horizontally. This imparts to the reflected signal additional phase shifts which are indistinguishable from those due to true vertical movements.

In contrast, the ground-wave is regarded as being very phase stable, and investigations are proceeding to find out just how stable it is. In the absence of further information at the present time, it will be assumed in the following discussion that the ground-wave does not contribute any phase disturbances to the received signal.

It will readily be appreciated from Figure 1A-1 that there are regions in which ground and sky-wave amplitudes are sufficiently comparable for interference between them to have a noticeable effect on the phase of the resultant signal. If the reasonable assumption is made that the relative phase of the two signals is always changing, then the effect on the resultant signal is illustrated by the vector diagrams of Figure 1A-2. In this figure E_G represents the ground-wave signal, E_S represents the sky-wave signal, and E_R represents the resultant signal. All the diagrams show phase with respect to E_G which, as stated earlier, is assumed to incorporate no phase disturbances. Figure 1A-2a illustrates the case $|E_G| > |E_S|$. It can be shown by inspection that the phase disturbances of E_R (i.e. $d\phi/dt$) is at a maximum when E_S directly opposes E_G. When $|E_S|$ is equal to $|E_G|$ the $d\phi/dt$ can become infinite (Figure 1A-2b), while increasing distance from the transmitter leads to Figure 1A-2c where $|E_G| < |E_S|$. It can be deduced from Figure 1A-1 that the two amplitudes are equal at about 1100 Km during the day and 550 Km during the night.

Development of the above reasoning, assuming uniform speed of the apparent vertical shifts of the ionosphere, gives rise to the curves shown in Figures 1A-3a and 1A-3b. Here the short-term frequency stability of the received signal with respect to the ground-wave (and hence to the transmitter) is shown as a function of distance over a sea-path for both day and night. Transmission over a land-path modifies both these diagrams by causing more rapid attenuation of the ground-wave with increasing distance. It will be seen that the region of most severe disturbance (where $|E_G| \simeq |E_S|$) is comparatively narrow, and due to the vagaries of the sky-wave would not fall consistently in one place. Large associated fluctuations of signal level as indicated on the receiver meter would warn the user that he was in this region at a particular time.

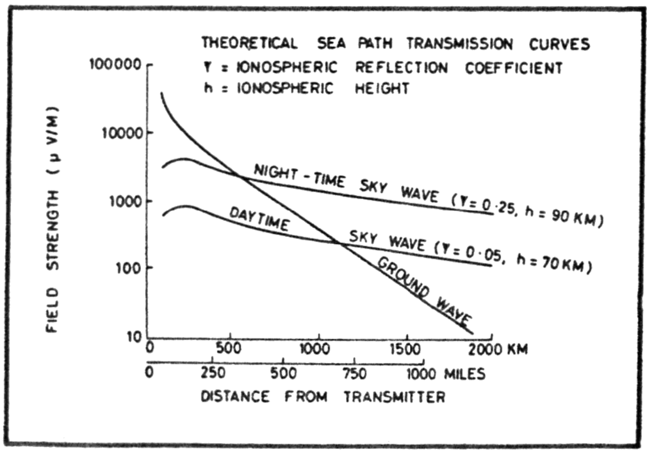


Figure IA–1 Variations of Field Strength with Distance

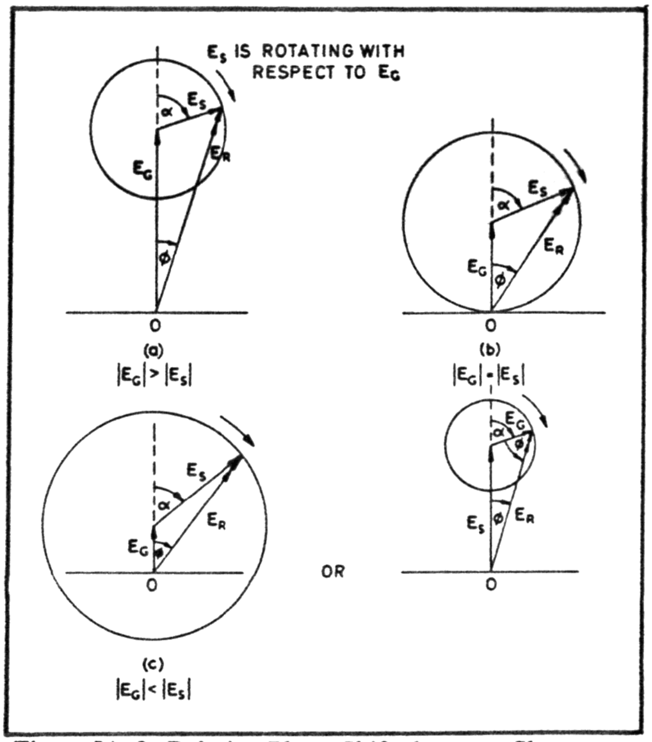


Figure IA–2 Relative Phase-Shifts between Sky-wave and Ground-wave

Both parts of Figure 1A-3 follow the same pattern. Moving away from the transmitter one leaves the region of pure ground-wave control and enters a region in which the sky-wave has an increasing influence. Moving further, one passes through the region of most severe disturbance, after which the short-term frequency stability assymptotically approaches that of the sky-wave alone. A moderate ionospheric disturbance would result in apparent vertical movements at speeds of about 10 metres/sec., and would give rise to short-term stabilities of the order given in the first set of figures in the diagram (Figures 1A-3B and 1A-3D The bracketed figures correspond to good ionospheric conditions (apparent vertical speeds of 1 metre/sec.). If Figure 1A-3A is taken to represent the conditions which hold during a normal working day for most people, it can be seen that the service area of the transmitter falls into two regions—a primary area under predominantly ground-wave control and a secondary area under predominantly sky-wave control. In the primary service area the receiver could be used as a stable frequency-source as well as an accurate frequency-comparator, while the above figures indicate that even in the secondary service area very accurate comparisons should be possible when carried out over long integration times. The transitional periods of sunset and sunrise are to be avoided in the secondary service area. The British Isles and parts of Europe fall within the primary service area as shown in Figure IA-4

It must be emphasized that the above reasoning is theoretical, but the field work so far carried out has provided some confirmation of its usefulness.

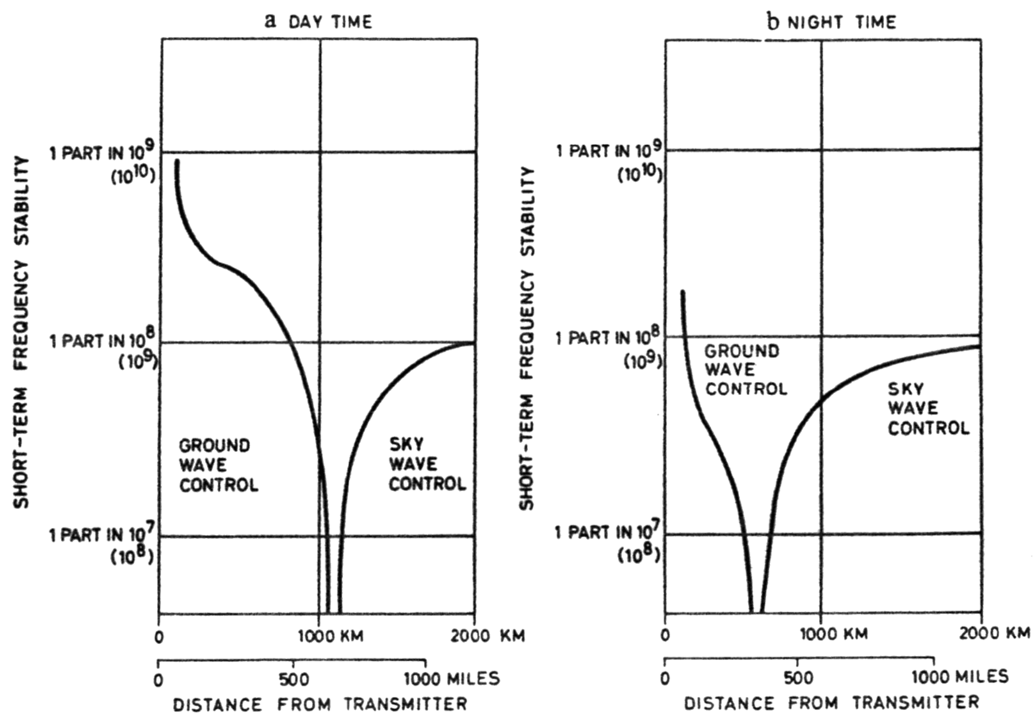


Figure IA–3 Effect of Ionospheric Propagation on Short-term Frequency Stability

Figure IA-4 Service Area of Droitwich Transmitter

APPENDIX II —FREQUENCY & TIME STANDARDS

1. TIME SCALES.

A number of slightly difference time scales are in use for various purposes. The three most commonly used time systems are Universal Time (UT), Ephemeris Time (ET), and Atomic Time (AT). These systems are discussed fully in Hewlett-Packard Application Note No. 52, "Frequency and Time Standards", but briefly are as follows:

A. UNIVERSAL TIME. Universal Time (UT) or Greenwich Mean Time (GMT), or Greenwich Civil Time (GCT) is a system of mean solar time based on the rotation of the earth about its axis relative to the position of the sun. Several UT scales are in use: Uncorrected astronomical observations used in determining mean solar time are denoted UTO; the UTP time scale corrected for the earth's polar variation is denoted UT1; the UT1 time scale corrected for annual variation in the rotation of the earth is denoted UT2. However, although UT2 is widely used, it must be recognized that UT2 is non-uniform because of changes in the speed of the earth's rotation. Time signals transmitted by standard frequency stations are generally based on the UT2 time scale.

B. EPHEMERIS TIME. Scientific measurement of precise time intervals requires a uniform time scale. The fundamental standard of constant time is defined by the orbital motion of the earth about the sun, and is called Ephemeris Time (ET). ET is determined from lunar observations, and the ET second is defined (International Committee of Weights and Measures, 1956) as "the fraction 1/31,556,925.9747 of the tropical year for 12^h ET of January 0, 1900". (Jan. 0, 1900 = December 31, 1899).

C. ATOMIC TIME. Molecular and atomic resonance characteristics can be used to provide time scales which are apparently equivalent, or nearly equivalent, to ET. The designation A1 has been given to the time scale derived from the zero-field (4,0)⟷(3,0) resonance of caesium, with one second equal to 9,192,631,770 periods of oscillation.

2. DROITWICH TRANSMISSION.

Although broadcast transmission by most standard frequency stations are based on the UT2 time scale, it will be appreciated that the UT scales are not invariant. While UT2 is freed of periodic variations, it is still affected by irregular and secular variations and is subject to annual adjustment with respect to the Ephemeris time scales. The Ephemeris second (defined in paragraph 1B) is invariant, and the current difference between UT2 and ET is 150 parts in 10^{10}.

For practical purposes the Ephemeris second is derived from the frequency of a caesium beam oscillator, and this is the basis for the correction figures published by the National Physical Laboratory for various standard frequency transmissions. The Droitwich 200-kc transmission is unique in that its nominal frequency is based on the Ephemeris second and not the UT2 second. Consequently, measurements made with respect to this transmission may be compared directly with future Ephemeris-based measurements without further correction. However, the user who takes advantage of this more-satisfactory system must bear in mind the possibility of confusion when comparisons are made with a transmission based on the variable UT2 second.

3. ADJUSTMENT OF TIMING SYSTEMS.

Optimum performance from a timing system or clock driven by a precision oscillator will not be obtained merely by periodically restoring the oscillator to its nominal frequency. Such oscillators typically exhibit a uniform drift rate for considerable periods of time. Improved performance of the timing system can be obtained if account is taken of the anticipated drift rate in setting up the oscillator. Figure IIA-1 demonstrates

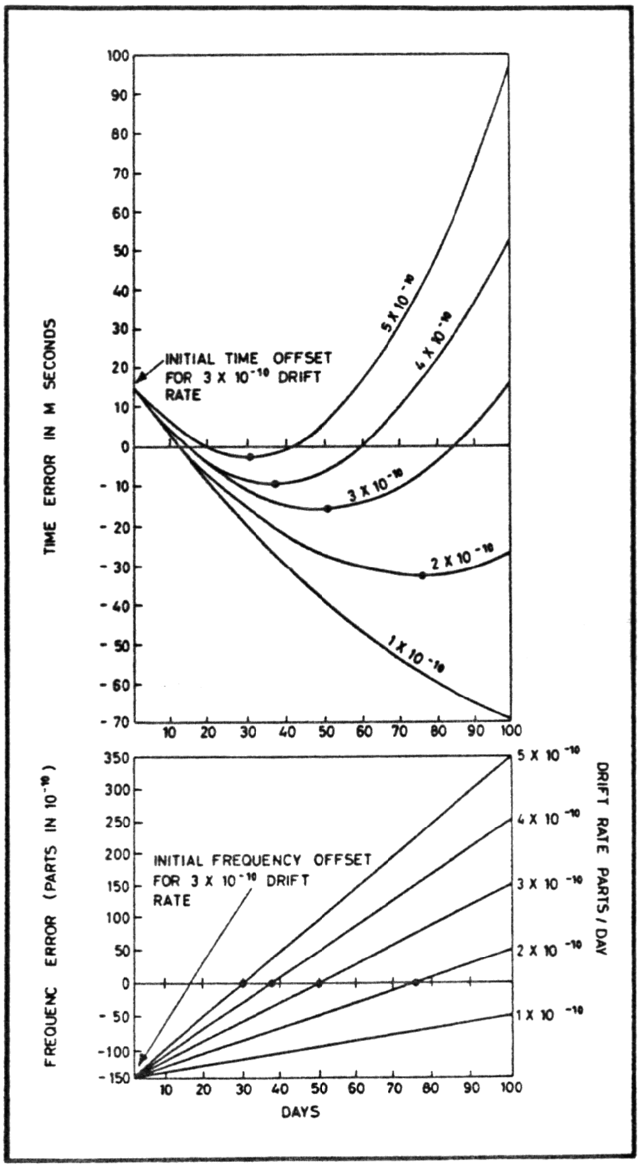


Figure IIA-1 Oscillator Drift Rate

coincident error plots of Time and Frequency over 100 day period for a predicted drift rate of 3 parts in 10^{10}/day (heavy lines). Initial frequency and time offsets shown are values for minimising clock error at the assumed drift rate over the time period

It should be noted, however, that once a clock has been offset to anticipate a given drift rate, then any change in the drift rate—even a reduction—will result in increased time errors. A more-detailed description of this important technique is given in Hewlett-Packard Application Note 52—"Frequency and Time Standards".

References:

1. Steele: "Standard frequency transmission", Journ. Brit. I.R.E. Vol. 26 p. 78, July 1963.
2. Williams: "Low frequency radio wave propagation by the ionosphere, with particular reference to long distance navigation". Proc. Inst. Elec. Engrs. Vol. 98, III, March 1951.
3. McNicol and Thomas: "Measurements of changes in the phase path of radio waves reflected from the ionosphere at normal incidence: Australian J. Physics, Vol. 13, No. 2. pp. 120-131.
4. Eburt: "Ionospheric propagation on long and medium waves". European Broadcasting Union—Document TECH 3081, 1962.
5. Crichlow, Smith, Morton and Corliss: "Worldwide radio noise levels expected in the frequency band 10 kc/s to 100 Mc/s" N.B.S. Circular No. 557, 1955.

Acknowledgement:

The information given in Appendix I was first published in the July 1964 issue of "British Communication & Electronics" magazine and is reproduced here by courtesy of the publishers.

APPENDIX III — MANUAL CHANGES

This manual applies directly to the 5090A Standard Frequency Receiver having serial number prefix E538. This manual with the following changes also applies to 5090A Standard Frequency Receiver having serial prefix numbers: E530, E525, E512, E447, E414, E402.

To adapt this manual to instruments with serial number prefixes other than E538 make changes as follows:

Instrument Serial No. Prefix	Change No.
E530	1
E525	1, 2
E512	1, 2, 3
E447	1, 2, 3, 4
E402	1 thru 5

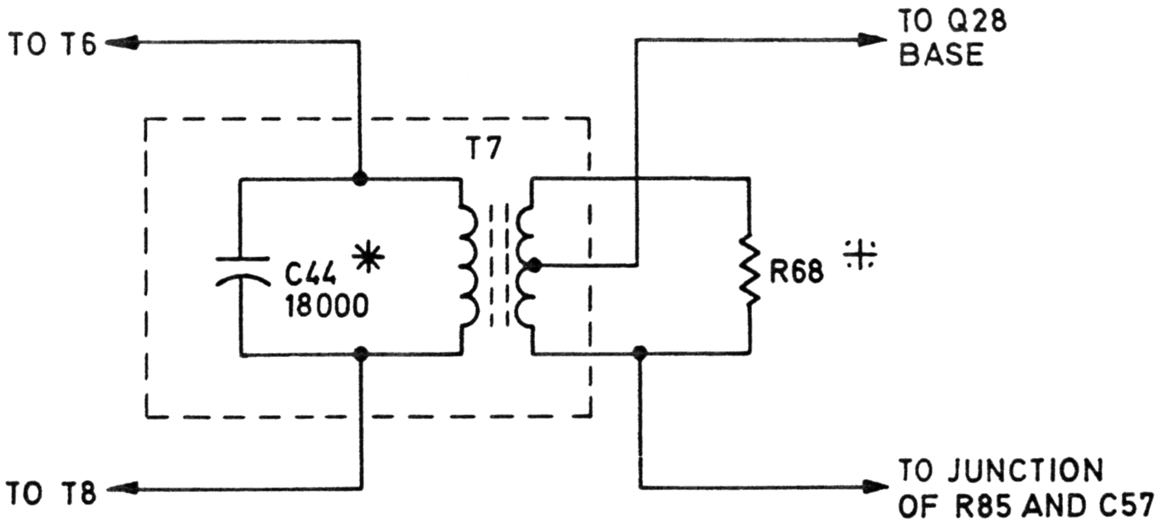
CHANGE 1: Figures 5-6, 5-10 Table 6-1
Delete A1R92 Resistor Fixed 150 ohm Part No. 0686-1515

CHANGE 2: Figures 5-7, 5-10 Table 6-1
Change A2R18 from 2200 ohms to 1500 ohms Part No. 0761-0015
Figures 5-8, 5-10 Table 6-1
Change A3R76 from 22k ohms to 47k ohms, Part No. 0758-0040
Figures 5-10 Table 6-1
Change F1 from 0.15 amp slow blow to 1 amp Part No. 2110-0001

CHANGE 3: Figures 5-8, 5-10 Table 6-1
Delete A3R91 Resistor fixed 15k ohms Part No. 0758-0018
Figures 5-7, 5-10 Table 6-1
Change A2C20 from 47µf to 20µt Part No. 0180-0608
Figures 5-8, 5-10 Table 6-1
Change A3R52 from 1M ohm to 470k ohms Part No. 0758-0087
Figures 5-8, 5-10, Table 6-1
Delete A3R90 Resistor selected value.
Change circuit of A3T7 with partial schematic Figure IIIA-1

CHANGE 4: Figures 5-6, 5-7, 5-8 Table 6-1
Change the following etched circuit boards from
Part No. 05090-201 to 05090-65A-1
Part No. 05090-202 to 05090-65B-1
Part No. 05090-203 to 05090-65C-1

CHANGE 5: Table 6-1
Change A2C18 from 100µf to 100µf Part No. 0180-0607
Figures 5-7, 5-10 Table 6-1
Change A2VR8 from 100 ohms resistor variable to A2R22 resistor fixed selected value.
Figures 5-8, 5-10 Table 6-1
Change A3Q19 from 2G403S to 2G404 Part No. 1850-0062
Figures 5-6, 5-10 Table 6-1
Delete A1 L1 choke 3.3 mH Part No. 9140-0601
Figures 5-8, 5-10 Table 6-1
Change A3R84, R87 from 680 ohms to 1000 ohms Part No. 0758-0003
Figures 5-8, 5-10 Table 6-1
Delete CR16 Part No. 1901-0025
Figures 5-7, 5-10 Table 6-1
Change A2R27 from 10k ohms to 22k ohms Part No. 0758-0020.



⁜ FACTORY SELECTED

* DO NOT ATTEMPT TO REPLACE THIS CAPACITOR WITHOUT REFERENCE TO SECTION V PARA 5-4

Figure III A-1 Modification to Figure 5-8