INSTRUCTION AND OPERATING MANUAL

FOR

MODEL 100D

LOW FREQUENCY
STANDARD

Serial 142 and Above

HEWLETT-PACKARD COMPANY
395 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U. S. A.

PRODUCTION CHANGES

Serial 142 and Above

Table of Replaceable Parts --

Change V9, V10, V11, V12, V13 to:

Tube: 6CB6, HP stock #212-6CB6

Change V17 to:

Tube: 6AV6, HP stock #212-6AV6

Change R9, R18, R27, R36 to:

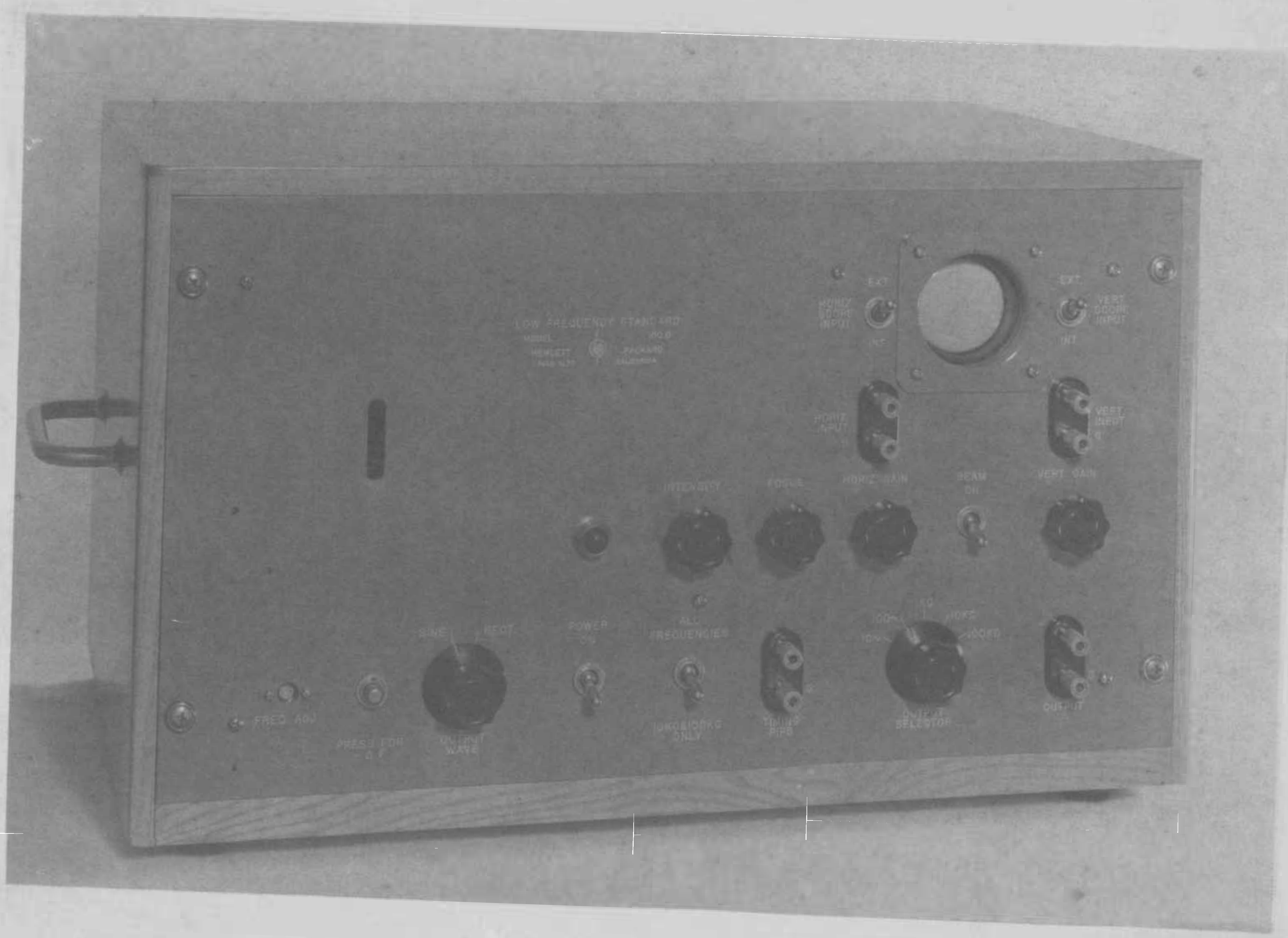
Resistor: fixed, composition, 3900 ohms, ± 10%, 1W, HP stock #24-3900, Mfr. Allen-Bradley #GB 3921

Change R5, R15, R24, R33 to:

Resistor: fixed, composition, 39,000 ohms, ± 10% HP stock #24-39K, Mfr. Allen-Bradley #GB 3931

Change R20 to:

Resistor: fixed, composition, 1.2 megohms, ± 10% HP stock #24-1.2M, Mfr. Allen-Bradley GB 1251 Electrical value adjusted at the factory


LOW FREQUENCY STANDARD
HEWLETT
PACKARD
EXT
INT
INT
VERT INPUT
HORIZ INPUT
INTENSITY
FOCUS
HORIZ GAIN
BEAM ON
VERT GAIN
SINE
RECT
POWER ON
ALL FREQUENCIES
OUTPUT WAVE
FREQ ADJ
TIMING PIPS
OUTPUT SELECTOR
OUTPUT

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LOW FREQUENCY STANDARD

MODEL 100D

C A U T I O N

READ BEFORE TURNING ON THE INSTRUMENT

The heating of the crystal oven in this instrument is regulated by a mercury-column switch. Occasionally, the mercury column is separated by jarring and vibration of the unit in shipment.

After turning the instrument on for the first time, keep a close check on the temperature of the crystal oven as indicated by the thermometer in the front panel. When the instrument has been on about 30 minutes, the crystal oven should remain automatically at a constant temperature. This condition will be indicated by a shutting off of the crystal oven indicator lamp from time to time, and by the fact that the thermometer will reach a steady reading of $65^{\circ}C \pm 2^{\circ}C$.

However, if the crystal pilot light stays on continuously, or the thermometer goes up beyond 70 degrees, the mercury column in either the thermostat or the thermometer has probably been separated in shipment. Turn the instrument off immediately and proceed as follows.

1. Remove the instrument from the cabinet and remove the crystal oven unit which plugs into tube socket adjacent to thermometer window.

2. Disconnect the thermostat wires from the terminals (#3,Fig.1). Remove the thermostat clamp by unscrewing the two screws (#4,Fig.1). Draw the thermostat out of the oven. (#5, Fig. 1)

3. Inspect the thermostat for mercury column separation and minute air bubbles in the mercury bulb.

4. If either air bubbles or separation are present, place the mercury switch bulb in ice water until mercury occupies only the bulb compartment. Tap lightly to remove any air bubbles or mercury globules left in column.

Then place the bulb in a vessel of water and heat until mercury completely fills column and a small portion of the enlargement at top of column. Then remove the thermostat and watch the mercury descent to room temperature. If there is no separation or bubbles present, the thermostat may now be put back in service. It may be necessary to repeat the above procedure more than once to unite all the mercury and remove all bubbles.

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<u>CAUTION</u>: Immerge only the bulb portion of the thermostat. If the thermostat leads get wet or any moisture collects beneath the plastic insulator covering the contact rings, remove the plastic insulator and dry tube and insulator and leads thoroughly before placing back in service. Otherwise, leakage between leads may cause heater relay to remain open.

5. Unscrew the two nuts holding the thermometer clamps (#2, Fig.1) and withdraw thermometer from the oven.

6. To unite the mercury column and remove air bubbles in the thermometer, use same procedure as that used on the thermostat.

7. Replace the thermostat and thermometer in the crystal oven; turn on the instrument and observe oven temperature and operation of the oven indicator lamp.

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INSTRUCTIONS

MODEL 100D

SECONDARY FREQUENCY STANDARD

Specifications

Output Rating --

Output Frequency	Volts into 5000 ohms load
10 cycles per second	5 minimum
100 cycles per second	5 minimum
1,000 cycles per second	5 minimum
10,000 cycles per second	5 minimum
100,000 cycles per second	5 minimum

Distortion --

4% at all frequencies with 5000 ohms load.
Internal impedance - 2000 ohms load.

Quartz Crystal --

100 kc

Quartz Crystal Oven --

Heater voltage 6.3V
Oven temperature 65° C.

Power Supply Rating --

Voltage - 105 to 125 volts

Frequency - 50 to 60 cycles

Wattage - 145 watts

Overall Dimensions --

Cabinet Model - 23-1/4" long x 12-1/4" high
x 14-7/16" deep

Overall Dimensions -- (continued)

Rack Model - 19" long x 10-1/2" high
x 14-7/16" deep
Panel - 19" long x 10-1/2" high
Depth behind panel - 13-1/4"

Weight --

Cabinet Model - 45 pounds

Rack Model - 35 pounds

Timing Pips --

Interval	Amplitude
100 microseconds	-
1000 microseconds	2 x 100 u sec amplitude
10,000 microseconds	3 x 100 u sec amplitude

Tube Complement --

Circuit Symbol	RMA Type	Function
V1	6BH6	Oscillator
V2a,b	6AL5	Rectifier (Twin Diode)
V3	6AS6	Frequency Divider
V4	6AS6	Frequency Divider
V5a,b	6AL5	Rectifier (Twin Diode)
V6	6AS6	Frequency Divider
V7	6AS6	Frequency Divider
V8	6BH6	Frequency Divider
V9	6AH6	100,000 cps Output. Cathode follower
V10	6AH6	10,000 cps Output. Cathode follower
V11	6AH6	1,000 cps Output. Cathode follower
V12	6AH6	100 cps Output. Cathode follower
V13	6AH6	10 cps Output. Cathode follower
V14	5R4GY	Rectifier
V15	6L6G	Voltage Regulator
V16	6L6G	Voltage Regulator
V17	6AQ6	Voltage Regulator
V18	OA2	Voltage Regulator
V19	2AP1A	Oscilloscope
V20	6BH6	Amplifier (V19 Horizontal Plates)
V21	6BH6	Amplifier (V19 Vertical Plates)

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Operating Instructions

Inspection --

This instrument has been thoroughly tested and inspected before being shipped and is ready for use when received.

After the instrument is unpacked, the cover should be removed (see Maintenance section) so that the instrument may be carefully inspected for damage received in transit. While the cover is off, the tubes should be checked to see that they are firmly seated in their sockets. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page at the back of this instruction book.

Initial Installation --

Before installing the Model 100D make sure that the tubes and relay are secure in their sockets.

The instrument should be situated so that there is adequate ventilation. Lack of proper ventilation may cause the ambient temperature in the instrument to rise high enough so that the oven thermostat will lose control.

Observe the "CAUTION" regarding the crystal oven, in the front of this book, before turning on the power.

After the power is on, several hours will elapse before the crystal oven temperature becomes constant. The instrument should be run continuously so that the temperature of the components reaches a steady state and constant output frequencies will be maintained. Continuous operation of the instrument will also improve the stability of the crystal.

Low capacity shielded wire should be used to distribute the output voltages to the equipment under tests as it will prevent the pick-up of extraneous voltages. The shield braid on the wire is connected to the "G" binding posts of the instrument. To maintain a minimum output voltage of 5 volts, at each frequency, a load of not less than 5000 ohms impedance may be connected across the output terminals. The following table gives the maximum capacity that can be tolerated without exceeding the above conditions.

Frequency	Capacity for Capacitive Reactance = 5000 ohms
100 kc	.0003 mf
10 kc	.003 mf
1 kc	.03 mf
100 cycles	.3 mf
10 cycles	3 mf

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Initial Installation -- (continued)

$$\frac{\text{Maximum capacity across output terminals}}{\text{Capacity (mf per foot) of wire}} = \text{Max. length of shielded wire}$$

The length of the shielded line, carrying the 100 kc may be extended by connecting a 100 kc tuned circuit across the line. This tuned circuit consists of an inductance in parallel with a variable capacitor. Tune the capacitor for maximum output.

Controls --

FREQ.ADJ.- See section on "Standardization with WWV" for the use of this control.

PRESS FOR -ΔF - Pressing this control lowers the frequency of the 100 kc oscillator approximately one cycle per second.

OUTPUT WAVE - This switch provides a choice of sine or rectangular wave shape in the output voltage at all frequencies.

POWER ON - This switch controls all power supplied to the instrument from the power line.

ALL FREQUENCIES - 10 kc & 100 kc ONLY - This switch disconnects the 225V supply from the 1000, 100, and 10 cycles frequency dividers when it is in the "10 kc and 100 kc only" position. This also removes the 1000 and 10,000 microsecond pips.

TIMING PIPS - The three types of timing pips are available simultaneously at these binding posts.

OUTPUT SELECTOR - This switch connects anyone of the five frequencies to the "OUTPUT" binding posts on the control panel, and the oscilloscope input switches.

INTENSITY - This variable resistor controls the brightness of the image on the cathode range tube screen.

FOCUS - The "FOCUS" control adjusts the focus of the electron beam on the cathode ray tube screen.

HORIZ. GAIN - This variable resistor controls the voltage admitted to the amplifier feeding the horizontal plates of the cathode ray tube.

BEAM ON - In the "BEAM ON" position this toggle switch applies voltage from the "INTENSITY" control, to the cathode ray tube and causing the electron beam to hit the

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BEAM ON - (continued)

screen. The off position applies to a higher voltage to the grid cutting off the beam.

VERT.GAIN - This variable resistor controls the voltage admitted to the amplifier feeding the vertical plates of the cathode ray tube.

HORIZ. INPUT - These binding posts are connected through the "HORIZ. SCOPE INPUT" switch, in the "Ext." position, to the oscilloscope horizontal amplifier.

VERT. INPUT - These binding posts are connected through the "VERT. SCOPE INPUT" switch, in the "Ext." position, to the oscilloscope vertical amplifier.

HORIZ. SCOPE INPUT - EXT. INT. - This switch connects the horizontal amplifier of the oscilloscope to the "OUTPUT SELECTOR" switch or to "HORIZ. INPUT" binding posts.

VERT. SCOPE INPUT - EXT. INT. - This switch connects the vertical amplifier of the oscilloscope to the "OUTPUT SELECTOR" switch or to the "VERT. INPUT" binding posts.

FUSE - The fuseholder, located on the back of the chassis, contains a 1.5 ampere cartridge fuse. The fuse may be replaced by unscrewing the fuseholder cap and inserting a new fuse.

Power Cable - The power cable consists of three conductors. Two of these conductors carry power to the instrument while the third conductor (green wire) is connected to the instrument chassis. The third wire projects from the cable near the plug end of the cable and may be connected to a ground when it is desirable to have a grounded instrument chassis.

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Output Binding Posts - The five sets of binding posts on the back of the chassis are the output terminals for the five frequencies generated by the instrument. The binding posts marked "G" are connected to the chassis.

Operation --

The positions of the Model 100D controls for typical measurements are as follows:

Standard Frequency Output (Oscilloscope Off) -

1. "OUTPUT WAVE" control set at the "SINE" or "RECT." position, depending on the type of output wave desired.

<u>Standard Frequency Output (Oscilloscope Off) - (continued)</u>

2. Connect the "OUTPUT" binding posts on the panel with the "OUTPUT SELECTOR" switch set at the frequency desired or if several frequencies are to be used simultaneously, connect to the binding posts at the rear of the instrument.

3. "BEAM ON" switch at the off position.

<u>Comparision of an Unknown Frequency with the Standard</u>

1. "OUTPUT WAVE" control set at the "SINE" position and "HORIZ. SCOPE INPUT" at "INT."

2. Connect the source of unknown frequency to the "VERT. INPUT" binding posts and the "VERT. SCOPE INPUT" switch to the "EXT." position.

3. "BEAM ON" switch at the "ON" position.

4. Rotate the "HORIZ. GAIN" and "VERT. GAIN" to their extreme counter-clockwise positions.

5. Adjust the "INTENSITY" and "FOCUS" controls for the optimum brightness and clarity of the spot on the cathode ray tube screen. Do not allow the spot to remain in one position more than five minutes, otherwise the phosphor on the cathode ray screen may be destroyed. The life of the cathode ray tube may be lengthened by keeping the "BEAM ON" switch in the "OFF" position except when making measurements.

<u>General Information</u>

The Hewlett-Packard Low Frequency Standard Model 100D is an accurate and stable secondary frequency standard. It may be standardized with the Bureau of Standards transmissions from WWV at intervals to maintain a high order of accuracy.

The Model 100D consists of a crystal-controlled oscillator operating at 100 kc which controls the stability of all frequencies generated by the instrument. The frequencies of 10 kc, 1 kc, 100 cps, and 10 cps, are produced by 10:1 cascaded frequency dividers which are driven by the 100 kc precision oscillator. Each divider operates its own isolating amplifier so that all sine and rectangular waves generated by the instrument are independently available for external use. The output voltages may also be applied to the self-contained oscilloscope to permit comparision with external unknown frequencies by means of Lissajous figures.

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General Information (continued)

The self-contained oscilloscope consists of a 2" cathode ray tube with a horizontal and a vertical amplifier. The input of the oscilloscope circuits are arranged so that standard frequencies from the isolating amplifiers may be supplied to the horizontal amplifier and either standard frequencies or external voltages may be applied to the vertical amplifier.

A regulated power supply delivers all necessary voltages to the instrument and maintains a constant voltage which contributes to the excellent stability of the instrument.

100 kc Oscillator Circuit --

The 100 kc oscillator is a modified Pierce circuit. This circuit allows the frequency to be changed ± 1 cps by changing the capacity across the crystal. A very low temperature coefficient crystal held at constant temperature controls the frequency to within 2 parts per million per week. This accuracy is attained when the crystal is operated constantly and after a thirty day run in period.

Frequency Divider Circuit --

The frequency divider circuit is composed of (see Fig. 2) tubes V2, V3 and associated components. Tube V3 is the actual frequency divider, operating as a controlled one-shot multivibrator. The time constants of the circuit are adjusted so that the circuit is triggered by every tenth cycles of the oscillator.

Assuming for a moment that the oscillator is not operating, the operation of the circuit can be described as follows: in a quiescent state tube V3 operates in such a manner that the plate is at a higher voltage than the screen grid but draws no current. This is explained by the fact that the suppressor grid is sufficiently negative with respect to the cathode to cut off the plate current. Therefore the screen grid acts a plate for the space current. The control grid is at cathode potential and is thus drawing heavy current. The cathode of the diode V2 is connected to a higher dc voltage than its plate so that V2 is an open circuit to positive voltages and to small negative voltages applied to its cathode. The negative portion of the oscillator is large enough to pass through diode V2 and trigger a multivibrator action in V3: The negative voltage is passed from the plate of V3 to the control grid through C1. The negative control grid reduces the space current, causing the screen voltage to rise and the cathode voltage to fall. This action reduces the suppressor bias with respect to the cathode sufficiently that the current passes through the suppressor grid to the

FIG. 1 BLOCK DIAGRAM OF MODEL 100D

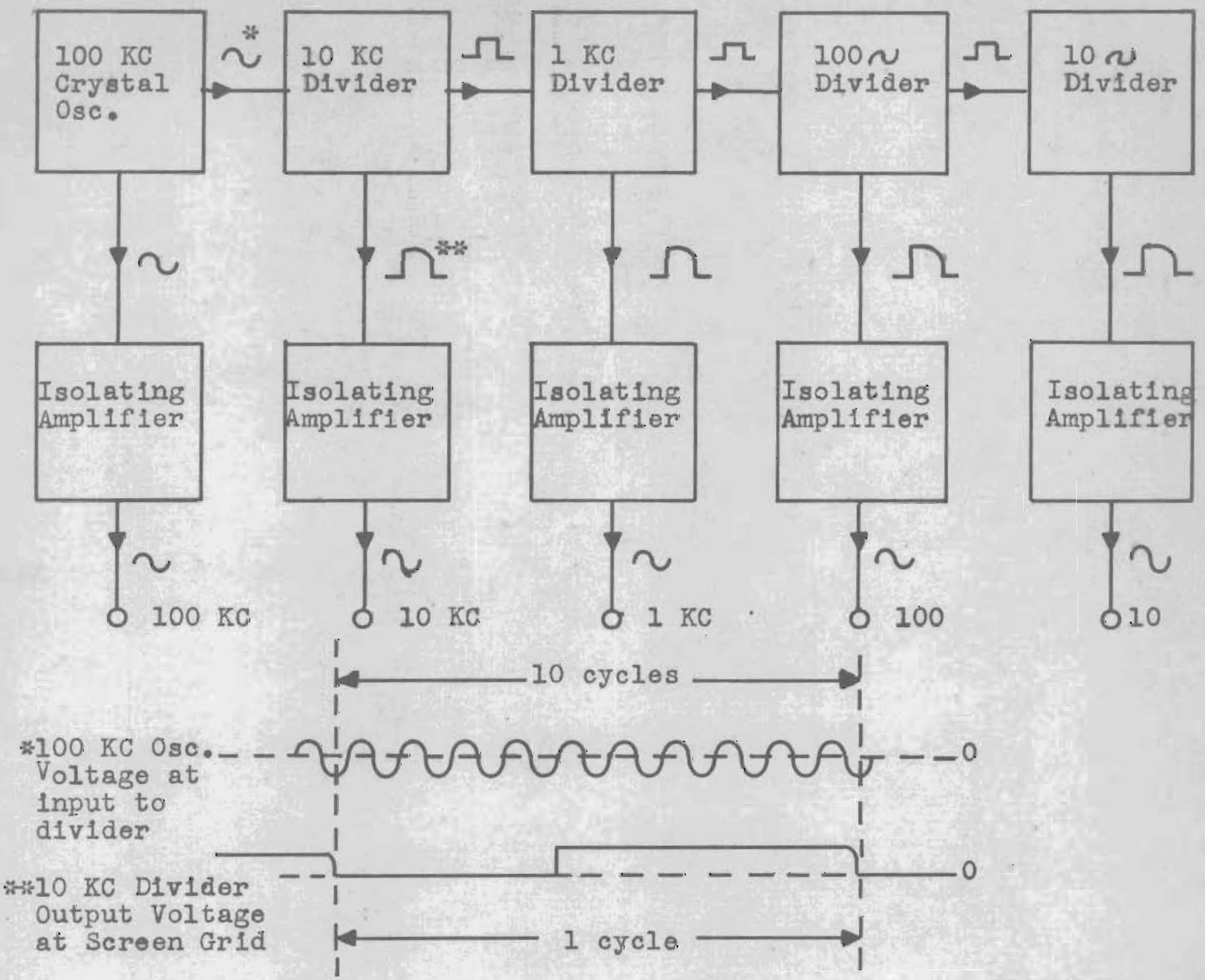

FIG. 2 BASIC CIRCUIT OF FREQUENCY DIVIDER

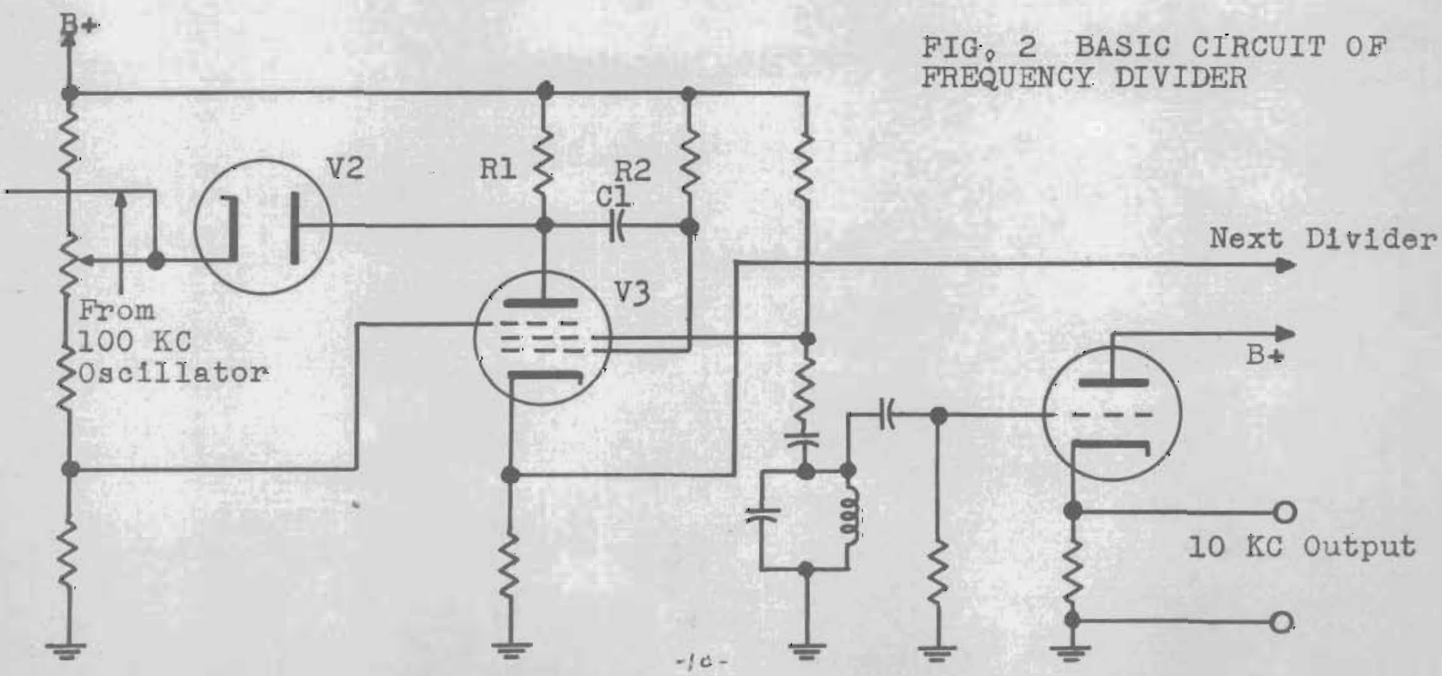

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plate. The plate voltage therefore drops rapidly, reinforcing the original negative voltage on the control grid. Because the plate voltage on V3 is now low, the plate of V2 is at a lower voltage than its cathode and no negative trigger voltages can pass through diode V2.

The circuit remains in this condition as the negative charge on the control grid leaks off through resistor R2. As the grid voltage slowly rises, the space current in the tube slowly increases, causing the plate voltage to drop somewhat more. At the same time the cathode voltage slowly rises, increasing the bias on the suppressor grid. Finally, a critical point is reached where the screen has more attraction for the space current than the plate.

When this critical point is reached, the second portion of the multivibrator action occurs: the screen voltage falls rapidly and plate current ceases. This action transfers a positive voltage to the control grid, resulting in more space current and reinforcing the crop in screen voltage. The circuit then becomes quiescent and is prepared for the next negative pulse through diode V2A. The time constants in the circuit are adjusted so that the total multivibrator action requires slightly more than nine cycles of the oscillator frequency, the circuit being again ready for triggering on the tenth cycle. Thus a frequency-dividing action has occured.

This divider circuit is highly stable and will operate for long periods of time without correction.

The sinusoidal output from the divider is obtained from a tuned circuit that is connected to the screen grid of V3 through a large isolating resistor. This sinusoidal wave is relatively harmonic-free, having less than 4% distortion.

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The sinusoidal output from the 10 cycles divider is obtained by means of a resistance capacity filter and negative feedback rather than by an inductance capacitance filter as used in the higher frequency dividers. The rectangular wave from the 10 cycles divider is applied to the grid of the tube V8.

The remaining divider circuits are connected in cascade and are driven from the cathode circuit of V3. A rectangular wave is present at the cathode and this wave, after differentiation, triggers the following divider. The remaining divider circuits operate in a manner similar to the circuit of V3, the major difference being that the time constants are adjusted to accomodate the lower repetition rates involved.

Each divider is connected to its own isolating amplifier. This amplifier isolates the divider from variable external loads and provides a low impedance output.

The rectangular wave output from the plate of the tube V8 is sent through the resistance capacitance filter and negative feedback circuit to the grid, where the components of the rectangular wave, passed by the filter, are cancelled. The 10 cycles sine wave is rejected by the filter and is applied to the isolating amplifier.

Timing pips are produced by combining the outputs of all the dividers except the 10 cycles divider and rectifying the resultant wave with a crystal rectifier.

<u>Power Supply and Voltage Regulator Circuit</u> --

The power supply consists of a transformer to supply the necessary voltages and a conventional full-wave rectifier and filter system to convert alternating current to direct current.

<u>Standardization with WWV</u>

The 100 kc oscillator circuit of the Model 100D is set to 100 kc at the factory and it will maintain this frequency within ± .001% (10 parts per million) on the range of normal room temperatures. This degree of accuracy is sufficient for most purposes. For a greater degree of accuracy the 100 kc oscillator should be standardized with a primary frequency standard at frequency intervals.

The most accessible primary frequency standard is the standard frequencies broadcast by the National Bureau of Standards Station WWV at Washington, D.C. This service may be utilized to check the Model 100D by employing a short wave radio receiver and a frequency multiplier.

Station WWV broadcasts standard frequencies twenty-four hours a day on the following frequencies: 2.5, 5, 10, 15, 20, 25, 30, and 35 megacycles. For the latest information on using this service, a Bureau of Standards Circular "Methods of Using Standard Frequencies Broadcast by Radio" may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. A detailed announcement of WWV broadcast services, LC886 will be provided upon request from the National Bureau of Standards, Washington 25, D.C.

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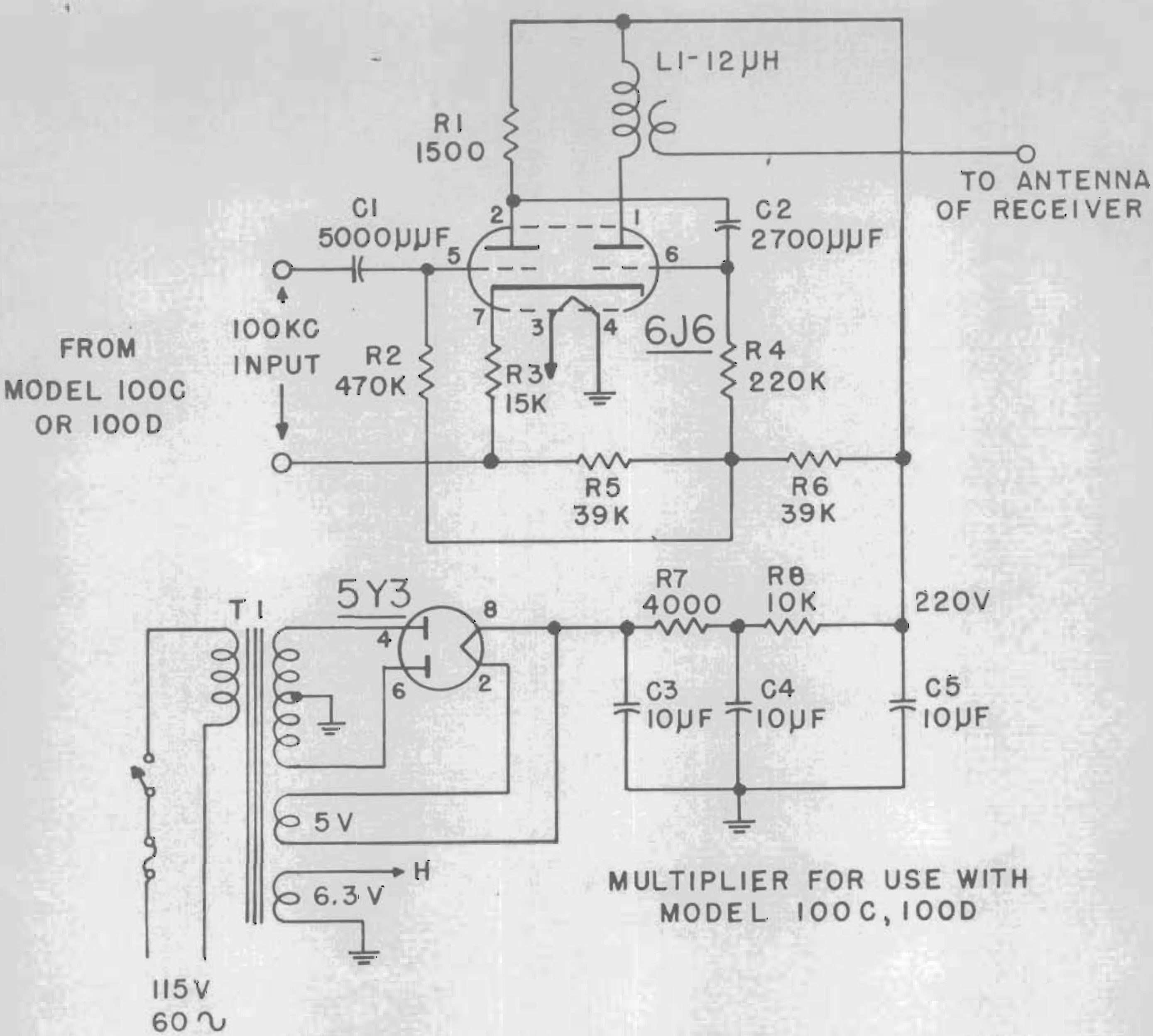

MULTIPLIER FOR USE WITH
MODEL 100C, 100D

C1	Capacitor: fixed; mica; 5000 mmf; 300 vdcw
C2	Capacitor: fixed; mica; 2700 mmf; 300 vdcw
C3, 4,5	Capacitor: fixed; electrolytic; 10 mf; 450 vdcw
R1	Resistor: fixed; composition; 1500 ohms; ±10%; 1 watt
R2	Resistor: fixed; composition; 470,000 ohms; ±10%; 1 watt
R3	Resistor: fixed; composition; 15,000 ohms; ±10%; 1 watt
R4	Resistor: fixed; composition; 220,000 ohms; ±10%; 1 watt
R5, R6	Resistor: fixed; composition; 39,000 ohms; ±10%; 2 watts
R7	Resistor: fixed; wirewound; 4000 ohms; ±10%; 20 watts
R8	Resistor: fixed; wirewound; 10,000 ohms; ±10%; 20 watts
L1	12 Microhenry coil: winding-34 turns #24 enamelled wire on 5/8" diam. bakelite form, winding 3/4" long.
T1	Power Transformer: pri. 115 v. 60 cycles; H.V. Sec. 550 V CT@ 20 MA Sec 5V @ 2A; 6.3 @1A.

Tubes:

1 5Y3GT

1 6J6

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A schematic wiring diagram for a suitable multiplier is shown in the accompanying illustration. This circuit will give multiples of 100 kc so that the signal is obtained on all the WWV transmission frequencies. A wire from the antenna terminal of the short wave receiver loosely coupled Coil L1 provides a signal to mix with the signal from WWV. This coupling should be varied until it is approximately the same strength as WWV.

The adjustment of the 100 kc oscillator in the Model 100D is performed as follows:

1. Feed the 100 kc oscillator output through the multiplier to the radio receiver tuned to the highest WWV frequency providing the best signal. The higher the WWV frequency used, the greater the accuracy obtained in calibrating the 100 kc oscillator. Headphones or loudspeaker may be used to indicate the presence of a beat between the 100 kc oscillator and WWV.

2. If a beat note is present the 100 kc oscillator has drifted from its correct frequency. Next determine whether the 100 kc oscillator has drifted to a higher or lower frequency by pressing the "PRESS FOR -ΔF" switch. If the 100 kc oscillator has drifted to a higher frequency than WWV then the "ΔF" control will lower the frequency of the beat note. If the oscillator has drifted to a lower frequency, the "ΔF" control will change the beat note to a higher pitch. To return the Model 100D oscillator to exactly 100 kc it is necessary to tune the "FREQ. ADJ." capacitor in the lower left corner of the front panel. Turn this control in the direction that produces a decrease in pitch until the zero beat point is reached and then an increase in pitch as rotation is continued. At the zero beat point the 100 kc oscillator will be standardized with WWV.

3. Should it be impossible to reach zero beat with the "FREQ. ADJ." control, then set the control to approximately one-half capacity. Next, rotate the screwdriver adjustments C2 and C4 located on the chassis in the rear of the crystal oven, together and in the same direction until the zero beat point is reached.

The accuracy of the 10 kc, 1 kc, 100 cycles, and 10 cycles outputs may be determined by comparing them with the next higher frequency by means of the built-in oscilloscope.

Application

The Low Frequency Standard is applicable to most frequency measurements from very low audio frequencies up to about twenty megacycles. It may be used as a source of constant frequency voltage to operate timing circuits and modulate radio frequency generators.

The Model 100D is most useful for the calibration of audio, supersonic and radio frequency generators. Also as a comparison device to determine the frequency stability of all kinds of radio equipment.

Low frequencies are most conveniently measured by means of Lissajous figures on an oscilloscope. However, for very complex Lissajous figures it is desirable to use a large-screen oscilloscope.

An external oscillator can be used to advantage to increase the ease of identification of the more complex patterns. For example, when measuring "inconvenient" frequencies such as 210 cps, the oscillator can be adjusted to 200 cps against the 100 cps output of the standard, resulting in a simple figure-eight pattern on the oscilloscope. By then switching the standard to 10 cps and adjusting the oscillator to the first frequency above 200 cps that results in a sinusoidal pattern, a frequency of 210 cps can be accurately obtained on the oscillator. The oscillator frequency is then compared with the unknown frequency.

High frequency measurements are best made with the aid of a suitable receiver. The transition point between low and high frequency measurements is determined by the characteristics of the equipment at hand, by the stability of unknown frequency, and by the complexity of the ratio of the unknown frequency to the standard frequency. With modern oscilloscopes and stable frequencies the transition point is above one megacycle. The relatively pure sine wave output of the Model 100D may have to be distorted to produce harmonics for some of the preceeding applications. This may be accomplished by inserting a germanium crystal in the output circuit of the Model 100D or by using an amplifier which draws grid current.

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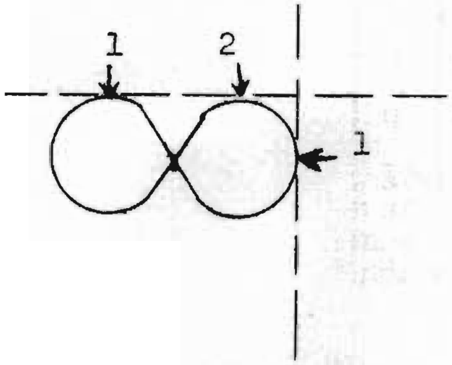
Lissajous figures are produced on the screen of cathode ray tube when an alternating current voltage is corrected to both the horizontal and vertical deflecting plates of the tube. When a standard frequency voltage is fed to one set of plates and a voltage of unknown frequency is connected to the other set, the resultant figure identifies the ratio between the standard and unknown frequencies.

TYPICAL LISSAJOUS FIGURE SHOWING POINTS OF TANGENCY



Unknown
Frequency
(connected to vertical plates
of oscilloscope)

10 KC
(Connected to horizontal plates of oscilloscope)

$$\frac{\text{No. of horizontal tangencies}}{\text{No. of vertical tangencies}} \times \text{Frequency of Standard} = \text{Unknown Frequency}$$

$$\frac{2}{1} \times 10 \text{ kc} = 20 \text{ kc}$$

Service Notes --

Periodically the Model 100D should have the dust blown from the chassis and the tubes should be checked to see that they are fimly seated in their sockets.

The following is a listing of possible symptoms and their remedies.

Symptom	Remedy
Instrument inoperative Pilot lamps and tubes do not light	1. Check for blown fuse or defective power cord. Locate and clear short circuit in the power circuits before replacing the fuse.
Low output Voltage: (100 kc output)	1. Check for too low an impedance load or a short circuit across the 100 kc output terminals.
	2. Check V1 and V9 by replacing with new tubes. Also tune C5 for peak voltage.
	3. Measure voltage from pin 8 of V16 to chassis. Should be +225V. If voltage is too low, check power circuit for short circuit.

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Service Notes -- (continued)

Symptom	Remedy
Low Output Voltage: (100 kc output normal)	1. Determine which frequencies have sub-normal output and check for too low an impedance load for a short circuit across the output terminals.
	2. Check the tubes and voltages in the divider and isolating amplifier of the highest frequency with subnormal output.
	3. Adjust the proper divider adjustment for synchronism. These adjustments are screwdriver adjustments located on the top of the chassis near the panel and are labelled: 10 kc DIVIDER, 1 kc DIVIDER, 100~ DIVIDER, and 10~ DIVIDER.
Lack of Synchronism	1. Set the "OUTPUT WAVE" switch to the "SINE" position and the "OUTPUT SELECTOR" switch to the 10 kc position. (The "OUTPUT SELECTOR" switch is so arranged that a frequency ten times the indicated frequency is connected thru the "VERT. SCOPE INPUT" switch, to the vertical amplifier of the oscilloscope. The vertical amplifier is not connected on the 100 kc position.
	2. Set the oscilloscope control as follows:

Control	Position
"Beam ON"	"ON"
"Horiz.Scope Input"	"Int."
"Vert.Scope Input"	"Int.

Adjust "INTENSITY," "FOCUS", "HORIZ.GAIN", "VERT.GAIN", for best results.

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Symptom (continued)	Remedy (continued)
Lack of Synchronism (continued)	3. Adjust R6 (10 kc DIVIDER) so that a Lissajous figure for a 10 to 1 ratio is obtained.
	4. Repeat the procedure of step 3 and change the "OUTPUT SELECTOR" to the proper frequency for 10 kc and 1 kc, 1 kc and 100 CYCLES, 100 CYCLES and 10 CYCLES. Adjust R14 (1 kc DIVIDER), R23 (100∿DIVIDER) and R32 (10∿ DIVIDER) respectively.
Crystal Oven Not Heating	1. While instrument is in operation, remove crystal oven from its socket. If relay is operating correctly, the crystal oven pilot lamp should burn. Clean relay contacts if relay is defective.
	2. If relay is correct follow procedure of CAUTION section in the front of this book.
Crystal Oven Overheating	1. See CAUTION section

Cover and Bottom Plate Removal --

The cover may be removed from the instrument without taking the instrument out of the wooden cabinet. The instrument must be removed from the cabinet when it is necessary to remove the bottom plate.

To remove the cover, unscrew the four screws holding the cover to the back of the instrument. This releases the cover so that it can be drawn out of the back of the cabinet.

The bottom plate is removed by unscrewing the four screws, one in each corner of the plates.

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Crystal Oven Disassembly --

The following is the step-by-step procedure necessary to disassemble the crystal oven to the point that the heater and socket connections are exposed. See Figure 1 for the parts numbers referred to in this procedure.

1. Remove the four wing nuts (#1), the cover, and the insulating pad.

2. Remove the four spade screws and ring on top of the oven.

3. Remove the two nuts holding the thermometer (#2) and then the thermometer.

4. Disconnect the thermostat wires at point #3.

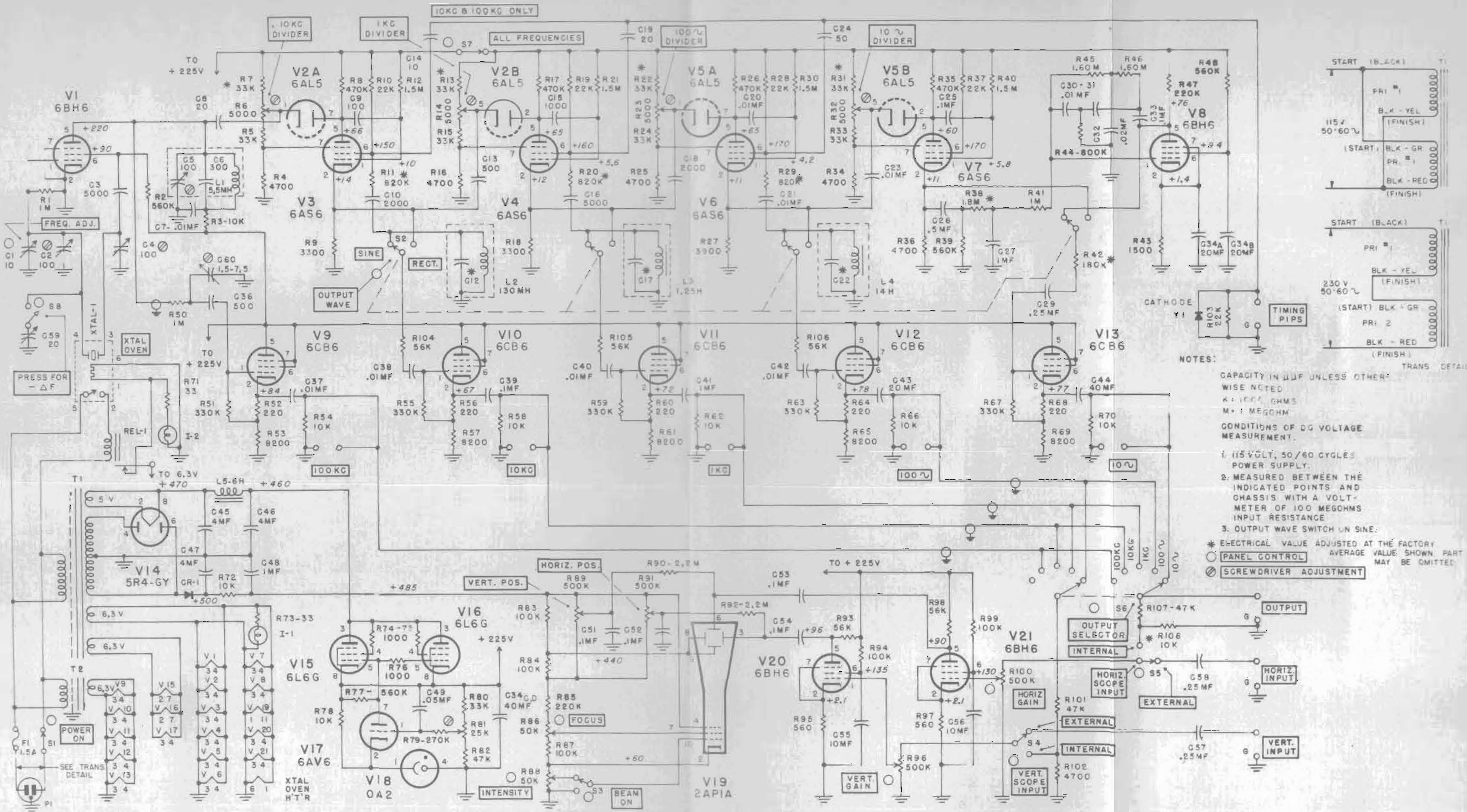
5. Remove the two screws (#4) and the thermostat guard. Draw out the thermostat.

6. Remove the four screws (#6) at the bottom edge of the oven and slide the clamp (#7) off of the housing. The housing will unwrap from around the bottom casting.

7. Unwrap the insulation and the heat wires and socket are exposed.

1100 32-50 Serial 7670

10-20-49 DWG. 1303-E-101D 12-10-51 SERIAL 236 TO



SCHEMATIC DIAGRAM OF -hp- MODEL 100D SECONDARY FREQUENCY STANDARD

100C 3-2-50 SER. 31 TO 100D SERIAL 26 TO

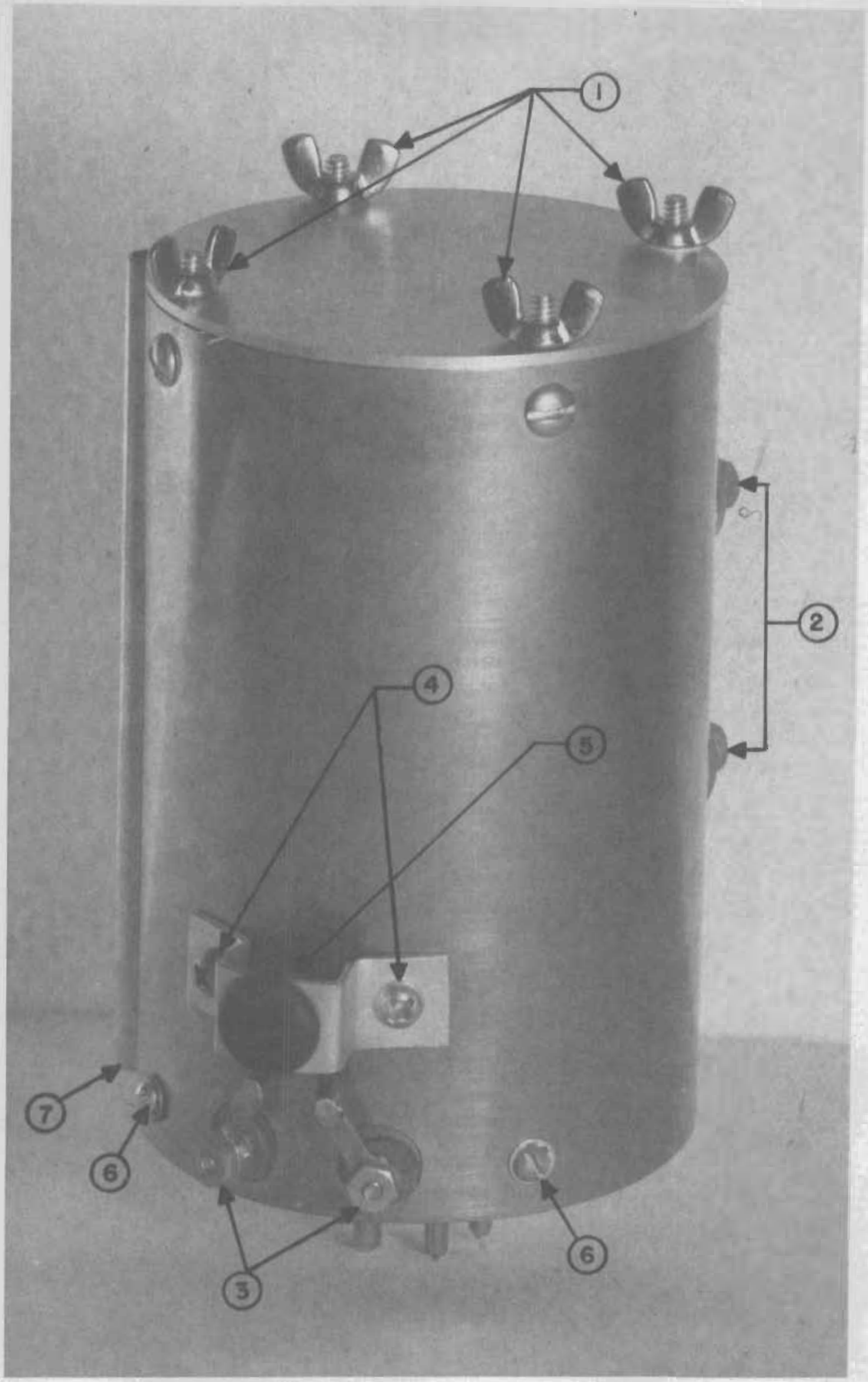


FIGURE I
MODELS 100C, 100D
CRYSTAL OVEN ASSEM.
STK.# M-69A

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
R1	Resistor: fixed, composition, 1 megohm; ± 10% 1W	24-1M	Allen-Bradley (AB) GB 1051
R2	Resistor: fixed, composition, 560,000 ohms; ± 10% 1W	24-560K	AB GB 5641
R3	Resistor: fixed, composition, 10,000 ohms; ± 10% 1W	24-10K	AB GB 1031
R4	Resistor: fixed, composition, 4700 ohms; ± 10% 1W	24-4700	AB GB 4721
R5	Resistor: fixed, composition, 33,000 ohms; ± 10% 1W	24-33K	AB GB 3331
R6	Resistor: variable, wirewound, 5,000 ohms; linear taper	210-8	Clarostat Mfr. Co. Type 58
R7	Resistor: fixed, composition, 39,000 ohms; ± 10% 1W	24-39K	AB GB 3931
R8	Resistor: fixed, composition, 470,000 ohms; ± 10% 1W	24-470K	AB GB 4741
R9	Resistor: fixed, composition, 3300 ohms; ± 10% 1W	24-3300	AB GB 3321
R10	Resistor: fixed, composition, 22,000 ohms; ± 10% 2W	25-22K	AB HB 2231
R11	Resistor: fixed, composition, 1.2 megohms; ± 10% 1W	24-1.2M	AB GB 1251
R12	Resistor: fixed, composition, 1.5 megohms; ± 10% 1W	24-1.5M	AB GB 1551
R13	Resistor: fixed, composition, 39,000 ohms; ± 10% 1W	24-39K	AB GB 3931
R14	Resistor: variable, wirewound, 5,000 ohms; linear taper	210-8	Clarostat Type 58
R15	Resistor: fixed, composition, 33,000 ohms; ± 10% 1W	24-33K	AB GB 3331
R16	Resistor: fixed, composition, 4700 ohms; ± 10% 1W	24-4700	AB GB 4721
R17	Resistor: fixed, composition, 470,000 ohms; ± 10% 1W	24-470K	AB GB 4741

1000 3-2-50 Serial 26 to

TABLE of REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
R18	Resistor: fixed, composition, 3300 ohms; ± 10% 1W	24-3300	AB GB 3321
R19	Resistor: fixed, composition, 22,000 ohms; ± 10% 2W	25-22K	AB HB 2231
R20	Resistor: fixed, composition, 750,000 ohms; ± 5% 1W FACTORY ADJUSTMENT	24-90	AB GB 7545
R21	Resistor: fixed, composition, 1.5 megohms; ± 10% 1W	24-1.5M	AB GB 1551
R22	Resistor: fixed, composition, 39,000 ohms; ± 10% 1W	24-39K	AB GB 3931
R23	Resistor: variable, wirewound, 5000 ohms; linear taper	210-8	Clarostat Type 58
R24	Resistor: fixed, composition, 33,000 ohms; ± 10% 1W	24-33K	AB GB 3331
R25	Resistor: fixed, composition, 4700 ohms; ± 10% 1W	24-4700	AB GB 4721
R26	Resistor: fixed, composition, 470,000 ohms; ± 10% 1W	24-470K	AB GB 4741
R27	Resistor: fixed, composition, 3300 ohms; ± 10% 1W	24-3300	AB GB 3321
R28	Resistor: fixed, composition, 22,000 ohms; ± 10% 2W	25-22K	AB HB 2231
R29	Resistor: fixed, composition, 1 megohm; ± 10% 1W	24-1M	AB GB 1051
R30	Resistor: fixed, composition, 1.5 megohms; ± 10% 1W	24-1.5M	AB GB 1551
R31	Resistor: fixed, composition, 39,000 ohms; ± 10% 1W	24-39K	AB GB 3931
R32	Resistor: variable, wirewound, 5000 ohms; linear taper	210-8	Clarostat Type 58
R33	Resistor: fixed, composition, 33,000 ohms; ± 10% 1W	24-33K	AB GB 3331
R34	Resistor: fixed, composition, 4700 ohms; ± 10% 1W	24-4700	AB GB 4721

100D 3-2-50 Serial 26 to

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
R35	Resistor: fixed, composition, 470,000 ohms; ± 10% 1W	24-470K	AB GB 4741
R36	Resistor: fixed, composition, 3300 ohms; ± 10% 1W	24-3300	AB GB 3321
R37	Resistor: fixed, composition, 22,000 ohms; ± 10% 2W	25-22K	AB HB 2231
R38	Resistor: fixed, composition, 1.2 megohms; ± 10% 1W	24-1.2M	AB GB 1251
R39	Resistor: fixed, composition, 560,000 ohms; ± 10% 1W	24-560K	AB GB 5641
R40	Resistor: fixed, composition, 1.5 megohms; ± 10% 1W	24-1.5M	AB GB 1551
R41	Resistor: fixed, composition, 1 megohm; ± 10% 1W	24-1M	AB GB 1051
R42	Resistor: fixed, composition, 180,000 ohms; ± 10% 1W	24-180K	AB GB 1841
R43	Resistor: fixed, composition, 1500 ohms; ± 10% 1W	24-1500	AB GB 1521
R44	Resistor: fixed, composition, 800,000 ohms; ± 1% 1W	31-800K	Wilkor Type CP-1
R45	Resistor: fixed, composition, 3.05megohm; ± 1% 1W	31-3.05M	Wilkor Type CP-1
R46	Resistor: fixed, composition, 3.28 megohms; ± 1% 1W	31-3.28M	Wilkor Type CP-1
R47	Resistor: fixed, composition, 220,000 ohms; ± 10% 1W	24-220K	AB GB 2241
R48	Resistor: fixed, composition, 560,000 ohms; ± 10% 1W	24-560K	AB GB 5641
R49	This circuit reference not assigned		
R50	Resistor: fixed, composition, 1 megohm; ± 10% 1W	24-1M	AB GB 1051
R51	Resistor: fixed, composition, 330,000 ohms; ± 10% 1W	24-330K	AB GB 3341

Add 3-2-50 Serial C 26 R

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
R52	Resistor: fixed, composition, 220 ohms; ± 10% 1W	24-220	AB GB 2211
R53	Resistor: fixed, composition, 8200 ohms; ± 10% 2W	25-8200	AB HB 8221
R54	Resistor: fixed, composition, 10,000 ohms; ± 10% 1/2W	23-10K	AB EB 1031
R55	Resistor: fixed, composition, 330,000 ohms; ± 10% 1W	24-330K	AB GB 3341
R56	Resistor: fixed, composition, 220 ohms; ± 10% 1W	24-220	AB GB 2211
R57	Resistor: fixed, composition, 8200 ohms; ± 10% 2W	25-8200	AB HB 8221
R58	Resistor: fixed, composition, 10,000 ohms; ± 10% 1W	24-10K	AB GB 1031
R59	Resistor: fixed, composition, 330,000 ohms; ± 10% 1W	24-330K	AB GB 3341
R60	Resistor: fixed, composition, 220 ohms; ± 10% 1W	24-220	AB GB 2211
R61	Resistor: fixed, composition, 8200 ohms; ± 10% 2W	25-8200	AB HB 8221
R62	Resistor: fixed, composition, 10,000 ohms; ± 10% 1/2W	23-10K	AB EB 1031
R63	Resistor: fixed, composition, 330,000 ohms; ± 10% 1W	24-330K	AB GB 3341
R64	Resistor: fixed, composition, 220 ohms; ± 10% 1W	24-220	AB GB 2211
R65	Resistor: fixed, composition, 8200 ohms; ± 10% 2W	25-8200	AB HB 8221
R66	Resistor: fixed, composition, 10,000 ohms; ± 10% 1/2W	23-10K	AB EB 1031
R67	Resistor: fixed, composition, 330,000 ohms; ± 10% 1W	24-330K	AB GB 3341
R68	Resistor: fixed, composition, 220 ohms; ± 10% 1W	24-220	AB GB 2211

100D 2-2-50 Curic 26 to

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
R69	Resistor: fixed, composition, 8200 ohms; ± 10% 2W	25-8200	AB HB 8221
R70	Resistor: fixed, composition, 10,000 ohms; ± 10% 1/2W	23-10K	AB EB 1031
R71	Resistor: fixed, composition, 33 ohms; ± 10% 1W	24-33	AB GB 3301
R72	Resistor: fixed, composition, 10,000 ohms; ± 10% 1W	24-10K	AB GB 1031
R73	Resistor: fixed, composition, 33 ohms; ± 10% 1W	24-33	AB GB 3301
R74	Resistor: fixed, composition, 1000 ohms; ± 10% 1/2W	23-1000	AB EB 1021
R75	Resistor: fixed, composition, 1000 ohms; ± 10% 1/2W	23-1000	AB EB 1021
R76	Resistor: fixed, composition, 1000 ohms; ± 10% 1/2W	23-1000	AB EB 1021
R77	Resistor: fixed, composition, 560,000 ohms; ± 10% 1W	24-560K	AB GB 5641
R78	Resistor: fixed, composition, 10,000 ohms; ± 10% 1W	24-10K	AB GB 1031
R79	Resistor: fixed, composition, 270,000 ohms; ± 10% 1W	24-270K	AB GB 2741
R80	Resistor: fixed, composition, 33,000 ohms; ± 10% 1W	24-33K	AB GB 3331
R81	Resistor: variable, composition, 25,000 ohms; linear taper	210-11	Centralab BA1-010-1990
R82	Resistor: fixed, composition, 47,000 ohms; ± 10% 1W	24-47K	AB GB 4731
R83	Resistor: fixed, composition, 100,000 ohms; ± 10% 1W	24-100K	AB GB 1041
R84	Resistor: fixed, composition, 100,000 ohms; ± 10% 1W	24-100K	AB GB 1041
R85	Resistor: fixed, composition, 220,000 ohms; ± 10% 1W	24-220K	AB GB 2241

MCD 3.2.50 Serial 26 to

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
R86	Resistor: variable, composition, 50,000 ohms; linear taper	210-8	Centralab 33-010-176
R87	Resistor: fixed, composition, 100,000 ohms; ± 10% 1W	24-100K	AB GB 1031
R88	Resistor: variable, composition, 50,000 ohms; linear taper	210-18	Centralab 33-010-176
R89	Resistor: variable, composition, 500,000 ohms; linear taper	210-20	Centralab 33-010-255
R90	Resistor: fixed, composition, 2.2 megohms; ± 10% 1W	24-2.2M	AB GB 2251
R91	Resistor: variable, composition, 500,000 ohms; linear taper	210-20	Centralab 33-010-255
R92	Resistor: fixed, composition, 2.2 megohms; ± 10% 1W	24-2.2M	AB GB 2251
R93	Resistor: fixed, composition, 56,000 ohms; ± 10% 1W	24-56K	AB GB 5631
R94	Resistor: fixed, composition, 100,000 ohms; ± 10% 1W	24-100K	AB GB 1041
R95	Resistor: fixed, composition, 560 ohms; ± 10% 1W	24-560	AB GB 5611
R96	Resistor: variable, composition, 500,000 ohms; linear taper	210-20	Centralab 33-010-255
R97	Resistor: fixed, composition, 560 ohms; ± 10% 1W	24-560	AB GB 5611
R98	Resistor: fixed, composition, 56,000 ohms; ± 10% 1W	24-56K	AB GB 5631
R99	Resistor: fixed, composition, 100,000 ohms; ± 10% 1W	24-100K	AB GB 1041
R100	Resistor: variable, composition, 500,000 ohms; linear taper	210-20	Centralab 33-010-255
R101	Resistor: fixed, composition, 47,000 ohms; ± 10% 1W	24-47K	AB GB 4731
R102	Resistor: fixed, composition, 4700 ohms; ± 10% 1W	24-4700	AB GB 4721

Add 22-56 Serial 2670

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
R103	Resistor: fixed, composition, 22,000 ohms; ± 10% 1/2W	23-22K	AB EB 2231
R104	Resistor: fixed, composition, 56,000 ohms ± 10% 1/2W	23-56K	AB EB 5631
R105	Resistor: fixed, composition, 56,000 ohms; ± 10% 1/2W	23-56K	AB EB 5631
R106	Resistor: fixed, composition, 56,000 ohms; ± 10% 1/2W	23-56K	AB EB 5631
R107	Resistor: fixed, composition, 47,000 ohms; ± 10% 1W	24-47K	AB GB 4731
R108	Resistor: fixed, composition, 10,000 ohms; ± 10% 1W	24-10K	AB GB 1031
C1	Capacitor: variable, air, 25 mmf	12-9	Hewlett-Packard
C2	Capacitor: variable, air, 100 mmf	12-17	Sarkes-Tarzian J-103 #2Term
C3	Capacitor: fixed, mica, 5000 mmf; ± 10% 300 vdcw	14-14	Micamold Radio Corp. Type W
C4	Capacitor: variable, air, 100 mmf	12-17	Sarkes-Tarzian J-103 #2Term
C5	Capacitor: variable, air, 100 mmf	12-11	Sarkes-Tarzian A-103L #2Ter
C6	Capacitor: fixed, mica, 400 mmf; ± 10% 500 vdcw	14-400	Micamold Type OXM
C7	Capacitor: fixed, paper, .01 mf; ±20% 600 vdcw	16-41	Solar Mfg. ST-6-0
C8	Capacitor: fixed, mica, 20 mmf; ± 10% 500 vdcw	14-20	Micamold Type OXM
C9	Capacitor: fixed, mica, 100 mmf; ± 10% 500 vdcw	14-100	Micamold Type OXM
C10	Capacitor: fixed, mica, 2000 mmf; ± 10% 500 vdcw	14-13	Micamold Type W

1000 3-2-50 Serial 26[illegible]

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
C11	This circuit reference not assigned		
C12	Part of Tuned Circuit Assembly		
C13	Capacitor: fixed, mica, 500 mmf; ± 10% 500 vdcw	14-500	Micamold Type OXM
C14	Capacitor: fixed, mica, 10 mmf; ± 10% 500 vdcw	14-10	Micamold Type OXM
C15	Capacitor: fixed, mica, 1000 mmf; ± 10% 500 vdcw	14-11	Micamold Type W
C16	Capacitor: fixed, mica, 5000 mmf; ± 10% 300 vdcw	14-14	Micamold Type W
C17	Part of Tuned Circuit Assembly		
C18	Capacitor: fixed, mica, 1000 mmf; ± 10% 500 vdcw	14-11	Micamold Type W
C19	Capacitor: fixed, mica, 10 mmf; ± 10% 500 vdcw	14-10	Micamold Type OXM
C20	Capacitor: fixed, mica, .01 mf; ± 10% 300 vdcw	14-23	Micamold Type W
C21	Capacitor: fixed, mica, .01 mf; ± 10% 300 vdcw	14-23	Micamold Type W
C22	Part of Tuned Circuit Assembly		
C23	Capacitor: fixed, paper, .01 mmf; -10% +30%	16-11	Aerovox Type 684
C24	Capacitor: fixed, mica, 10 mmf; 500 vdcw	14-10	Micamold Type OXM
C25	Capacitor: fixed, paper, .1 mf; -10% +20% 600 vdcw	16-1	Aerovox Type 684
C26	Capacitor: fixed, paper, .5 mf; 200 vdcw	16-37	Sprague Elect. Co. 68P25
C27	Capacitor: fixed, paper, 1 mf; ± 10% 600 vdcw	17-12	Gen.Elect.Co 23F467G103
C28	This circuit reference not assigned		

1000 2-1-50 Serial 26 to

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
C29	Capacitor: fixed, paper, .25 mf 200 vdcw	16-36	Sprague 68P
C30	Capacitor: fixed, mica, .01 mf; ± 1% 300 vdcw	15-41	Aerovox Type 1464X
C31	Capacitor: fixed, mica, .01 mf; ± 1% 300 vdcw	15-41	Aerovox Type 1464X
C32	Capacitor: fixed, mica, .01 mf; ± 1% 300 vdcw	15-41	Aerovox Type 1464X
C33	Capacitor: fixed, paper, .1 mf; -10% +20% 600 vdcw	16-1	Aerovox Type 684
C34 abc	Capacitor: fixed, electrolytic, 20 mf; 450 vdcw	18-42	PR Mallory FPQ-444
C35	This circuit reference not assigned		
C36	Capacitor: fixed, mica, 500 mmf; ± 10% 500 vdcw	14-500	Micamold Type OXM
C37	Capacitor: fixed, paper, .01 mf; -10% +30% 600 vdcw	16-11	Aerovox Type 684
C38	Capacitor: fixed, paper, .01 mf; -10% +30% 600 vdcw	16-11	Aerovox Type 684
C39	Capacitor: fixed, paper, 1 mf; -10% +20% 600 vdcw	16-1	Aerovox Type 684
C40	Capacitor: fixed, paper, .01 mf; -10% +30% 600 vdcw	16-11	Aerovox Type 684
C41	Capacitor: fixed, paper, 1 mf; ± 10% 600 vdcw	17-12	Gen. Elect. Co 23F467G103
C42	Capacitor: fixed, paper, .01 mf; -10% +30% 600 vdcw	16-11	Aerovox Type 684
C43	Capacitor: fixed, electrolytic, 20 mf; 450 vdcw	18-20	PR Mallory FPS-144
C44	Capacitor: fixed, electrolytic, 40 mf; 450 vdcw	18-40	PR Mallory FPS-144
C45	Capacitor: fixed, paper, 4 mf; ± 10% 600 vdcw	17-10	Cornell-Dubilier TLA-6040

1000 3-2-50 Serial 26 ☆

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
C46	Capacitor: fixed, paper, 4 mf; ± 10% 600 vdcw	17-10	Cornell-Dubilier TLA-6040
C47	Capacitor: fixed, paper, 4 mf; ± 10% 600 vdcw	17-10	Cornell-Dubilier TLA-6040
C48	Capacitor: fixed, paper, 1 mf; ± 10% 600 vdcw	17-12	Gen.Elect.CO 23F467G103
C49	Capacitor: fixed, paper, .05 mf; ± 10% 600 vdcw	16-15	Aerovox P688
C50	This circuit reference not assigned		
C51	Capacitor: fixed, paper, 1 mf; -10% +20% 600 vdcw	16-1	Aerovox Type 684
C52	Capacitor: fixed, paper, 1 mf; -10% +20% 600 vdcw	16-1	Aerovox Type 684
C53	Capacitor: fixed, paper, 1 mf; -10% +20% 600 vdcw	16-1	Aerovox Type 684
C54	Capacitor: fixed, paper, 1 mf; -10% +20% 600 vdcw	16-1	Aerovox Type 684
C55	Capacitor: fixed, electrolytic, 10 mf; ± 50% 450 vdcw	18-10	PR Mallory WB-72
C56	Capacitor: fixed, electrolytic, 10 mf; ± 50% 450 vdcw	18-10	PR Mallory WB-72
C57	Capacitor: fixed, paper, .25 mf; 600 vdcw	16-42	Sprague Elec. #68P37
C58	Capacitor: fixed, paper, .25 mf; 600 vdcw	16-42	Sprague Elec. #68P37
C59	Capacitor: variable, ceramic, 7-20 mmf.	13-20	Erie Resist. Co. TS2A
C60	Capacitor: variable, $1\frac{1}{2}$ - 7 mmf	13-7	Erie Resist. Co. TS2A-NPO
	Binding Post:	312-3	Hewlett-Packard

1000 3-2-50 Serial 260

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Description
CR1	Rectifier:	212-57	Bradley Lab. SE8L28H
	Crystal Oven: (less crystal)	M-69A	Hewlett-Packard
	Replaceable Parts in Crystal Oven:		
	Crystal, Quartz: 100 kc	41-13	Jas.Knight H18-55
	Thermometer: contact	41-5	Precision Inst. Co. 40
	Thermometer:	41-6	Jensen Inst. Co. S.F.
F1	Fuse: 1.5 amp; 3AG type	211-15	Bussman Mfg. MDL1.6
	Fuseholder:	312-8	Littelfuse 342001
I1	Lamp:	211-47	GE Supply #47
	Knob: 1-1/8" diam.	37-9	Hewlett-Packard
	Knob: 1-1/2" diam.	37-11	Hewlett-Packard
	Power Cable:	812-56	Hewlett-Packard
T1	Power Transformer:	910-43	Hewlett-Packard
T2	Power Transformer: filament	910-16	Hewlett-Packard
L1	Coil, R.F.: 5.5 mh	48-3	Maguire Ind. 19-4551
L2,L3, L4,C12, C17,C22	Tuned Circuit Assembly:	911-22	Hewlett-Packard
L5	Reactor: 6H @ .125 ma; 240 ohms	911-12	Hewlett-Packard

1100 3-2-50 Serial 26 to

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
REL -1	Relay: SPST normally closed	49-6	Sigma Inst. Co. Type 41R07 - 10,000-5
S1	Toggle Switch: SPST	310-11	Arrow-Hart & Hegeman 20994-HW
S2	Rotary Switch:	310-73	Hewlett-Packard
S3	Toggle Switch: SPDT	310-12	Arrow-Hart & Hegeman 21350
S4	Toggle Switch: SPDT	310-12	Arrow-Hart & Hegeman 21350
S5	Toggle Switch: SPDT	310-12	Arrow-Hart & Hegeman 21350
S6	Rotary Switch:	310-39	Hewlett-Packard
S7	Toggle Switch:	310-11	Arrow-Hart & Hegeman 20994-HW
S8	Pushbutton Switch:	310-75	Arrow-Hart & Hegeman 3391E
V1	Tube: Type 6BH6	212-6BH6	
V2A, V2B	Tube: Type 6AL5	212-6AL5	
V3	Tube: Type 6AS6	212-6AS6	Western Electric Co
V4	Tube: Type 6AS6	212-6AS6	Western Electric Co
V5A, V5B	Tube: Type 6AL5	212-6AL5	
V6	Tube: Type 6AS6	212-6AS6	Western Electric Co

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. & Mfrs. Designation
V7	Tube: Type 6AS6	212-6AS6	Western Electric Co
V8	Tube: Type 6BH6	212-6BH6	
V9	Tube: Type 6AH6	212-6AH6	
V10	Tube: Type 6AH6	212-6AH6	
V11	Tube: Type 6AH6	212-6AH6	
V12	Tube: Type 6AH6	212-6AH6	
V13	Tube: Type 6AH6	212-6AH6	
V14	Tube: Type 5R4GY	212-5R4GY	
V15	Tube: Type 6L6G	212-6L6G	
V16	Tube: Type 6L6G	212-6L6G	
V17	Tube: Type 6AQ6	212-6AQ6	
V18	Tube: Type OA2	212-OA2	
V19	Tube: Type 2AP1A	212-2AP1A	
V20	Tube: Type 6BH6	212-6BH6	
V21	Tube: Type 6BH6	212-6BH6	
	NOTE: Any tube with RMA standard characteristics may be used except as listed for V3, V4, V6, and V7.		
Y1	Crystal rectifier: 1N34	212-34	Sylvania 1N34

LIST OF MANUFACTURERS CODE LETTERS FOR REPLACEABLE PARTS TABLE

Code Letter	Manufacturer
A	Aerovox Corp.
B	Allen-Bradley Co.
C	Amperite Co.
D	Arrow, Hart and Hegeman
E	Bussman Manufacturing Co.
F	Carborundum Co.
G	Centralab
H	Cinch Manufacturing Co.
I	Clarostat Manufacturing Co.
J	Cornell Dubilier Electric Co.
K	Electrical Reactance Co.
L	Erie Resistor Corp.
M	Federal Telephone and Radio Corp.
N	General Electric Co.
O	General Electric Supply Corp.
P	Girard-Hopkins
HP	Hewlett-Packard
Q	Industrial Products Co.
R	International Resistance Co.
S	Lectrohm, Inc.
T	Littelfuse, Inc.
U	Maguire Industries, Inc.
V	Micamold Radio Corp.
W	Oak Mfg. Co.
X	P. R. Mallory Co., Inc.
Y	Radio Corp. of America
Z	Sangamo Electric Co.
AA	Sarkes Tarzian
BB	Signal Indicator Co.
CC	Sprague Electric Co.
DD	Stackpole Carbon Co.
EE	Sylvania Electric Products, Inc.
FF	Western Electric Co.
GG	Wilkor Products, Inc.
HH	Amphenol
II	Dial Light Co. of America
JJ	Leecraft Manufacturing Co.
ZZ	Any tube having RMA standard characteristics

CLAIM FOR DAMAGE IN SHIPMENT

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

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof (except tubes, fuses and batteries). This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number, type number and serial number. On receipt of this information, we will give you service instructions or shipping data.

2. On receipt of shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Railway Express. The instruments should be packed in a wooden box and surrounded by two to three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY
Laboratory Instruments for Speed and Accuracy
395 PAGE MILL ROAD PALO ALTO, CALIF.