

72A FREQUENCY METER  
 (J64072A)

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1. GENERAL . . . . .	1	1.01 This section describes the mechanical, electrical, and operational features of the 72A Frequency Meter (J64072A).
2. DESCRIPTION . . . . .	2	1.02 The 72A Frequency Meter is a portable test set which is designed to measure the frequencies in connection with the maintenance of signaling equipment, particularly single frequency signaling, and the alarm and control systems used with TD-2 Radio. It may also be used for carrier supply and miscellaneous tests such as frequency calibration of test oscillators. The normal measuring range is from 100 to 4000 cycles but this may be extended to a range of 10 cycles to 40 kilocycles.
(A) General . . . . .	2	1.03 The set consists essentially of a variable frequency oscillator and cathode-ray oscilloscope. An unknown frequency is measured by adjusting the frequency of the oscillator to obtain a stationary pattern on the screen of the oscilloscope. Numbers above the frequency controls indicate the frequency directly.
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(C) Output Amplifier . . . . .	6	1.05 To insure accuracy a reference frequency standard consisting of a 4000-cycle crystal oscillator is provided.
(D) Oscilloscope . . . . .	6	1.06 A separate amplifier permits the output of the oscillator to be used externally.
(E) Crystal Standard . . . . .	7	1.07 The 72A Frequency Meter is contained in a metal case approximately 12" wide, 12" long and 9-3/4" deep over-all and weighs 25 pounds. Connections to external circuits are made by means of pairs of 223A Jacks which are mounted on the front panel and into which may be inserted 241 Type Plugs.
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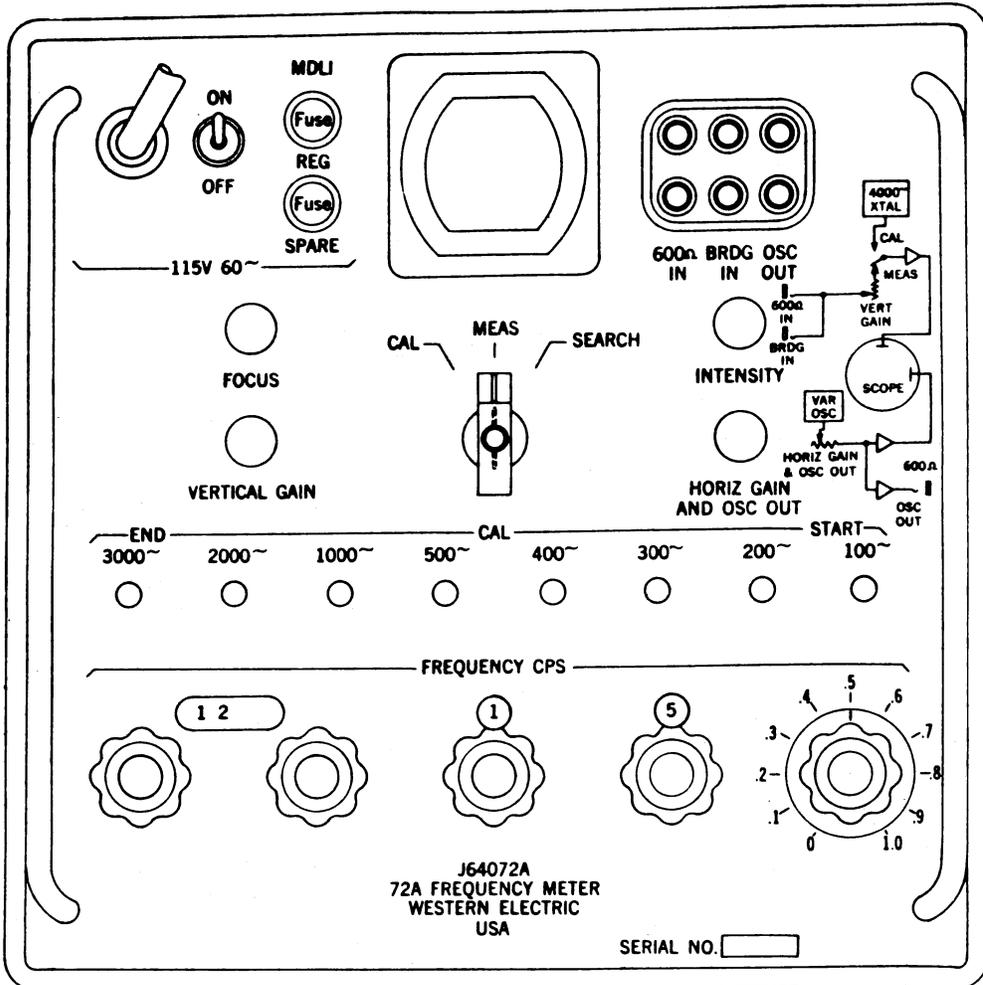


Fig. 1 - Face View - 72A Frequency Meter

**2. DESCRIPTION**

**(A) General**

2.01 The face view of the 72A Frequency Meter is shown in Fig. 1 and the block diagram of the circuit in Fig. 2. As shown in Fig. 1 all controls required for operation appear on the top panel and include frequency and gain controls, a CAL-MEAS-SEARCH switch, the ON-OFF switch and the focus and brightness controls for the oscilloscope. As shown on Fig. 2, the circuit consists of six sections which are interconnected in accordance with the setting of the CAL-MEAS-SEARCH switch. In the CAL position the crystal standard and oscillator frequencies are compared by connecting to the vertical and horizontal oscilloscope plates respectively. In the MEAS position the unknown

and oscillator frequencies are compared by connecting the unknown in place of the crystal standard. In the SEARCH position the connections to the oscilloscope remain as for MEAS but the oscillator is converted to a tunable amplifier. Additional information on these operating functions and a description of each follow.

**(B) Oscillator**

2.02 A simplified circuit of the oscillator is shown in Fig. 3. This oscillator is a Wien Bridge type consisting of an amplifier with its input and output interconnected through a bridge network. Oscillations are generated by energy circulating through the amplifier to its output, through the bridge and back into the amplifier input.

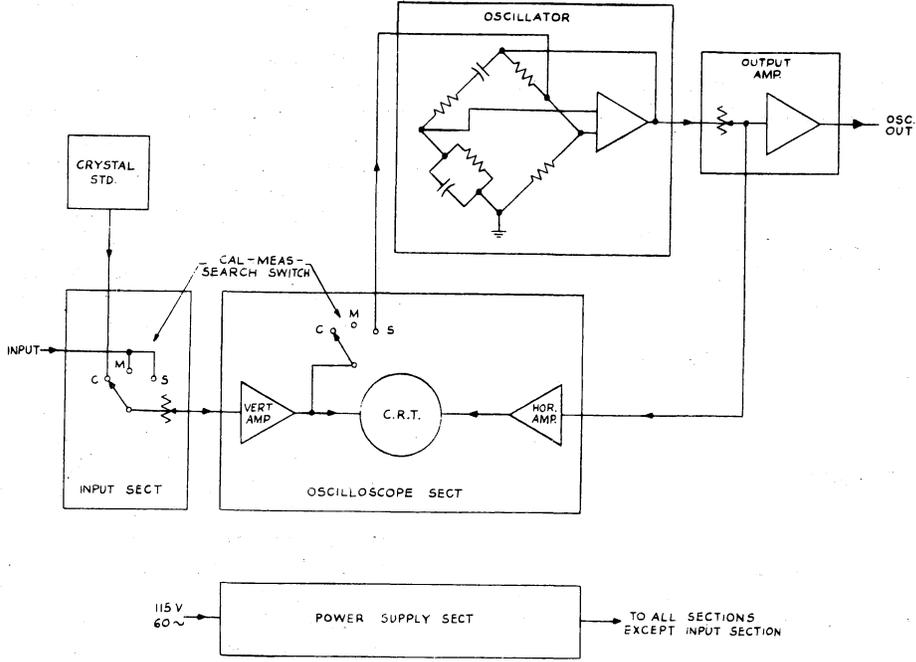


Fig. 2 - Block Diagram

2.03 The first and second stages of the amplifier are connected by a resistance-capacitance network. This network is conventional except that negative feedback from the oscillator output is applied through resistor R76 to the grid of the second stage. The direct coupling between the second and third stages simplifies the problem of stabilizing the oscillator by eliminating the coupling condenser and its inherent phase shift. The output of the third stage is connected as a cathode

follower. The low output impedance of the cathode follower minimizes phase shift between the amplifier and bridge. The inductor at the output is used to prevent d-c leakage through capacitor C10 changing the bias on the first electron tube.

2.04 In the bridge network the two left-hand arms composed of  $C_a$ ,  $R_a$ ,  $R_b$  and  $C_b$  determine the oscillator frequency and the two

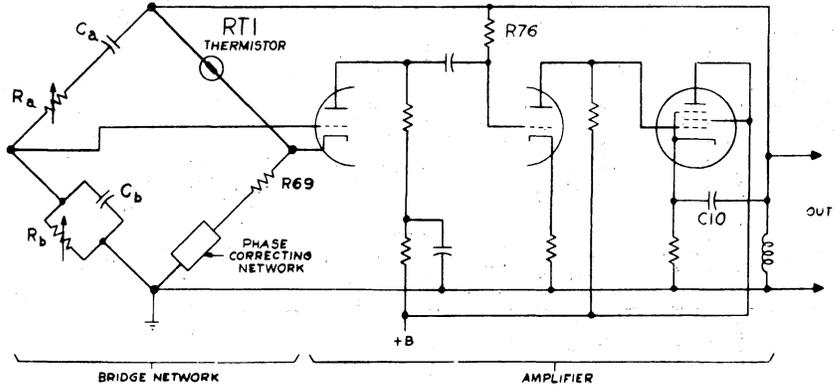


Fig. 3 - Simplified Circuit of Oscillator

right-hand arms composed of the thermistor R69 and the phase correcting network control the amplitude of the oscillations.

2.05 To understand the operation of the bridge note that the frequency is determined by the formula:

$$f = \frac{1}{2\pi\sqrt{C_a C_b R_a R_b}} \quad (1)$$

By making  $C_a = C_b = C$  and  $R_a = R_b = R^*$  the formula reduces to

$$f = \frac{1}{2\pi CR} \quad (2)$$

\*The capacity of  $C_a$  is made slightly larger than  $C_b$  to allow for adding resistance trimmers to  $R_b$ .

In accordance with formula (2) if  $C_a$  and  $C_b$  are fixed, the frequency varies as  $1/R$  which is the conductance of each resistor in the  $R_a R_b$  pair. When resistors are connected in parallel their conductances add directly. Therefore, if one pair of resistors connected in the bridge causes the oscillator to generate 100 cycles and another pair alone, 1000 cycles, the frequency resulting when the two pairs are

connected into the bridge together would be  $100 + 1000$  or 1100 cycles. Also, if a 2000-cycle combination resistance pair were to be paralleled to the above combination the resulting frequency would be  $1100 + 2000$  or 3100 cycles. By extending this addition principle farther, it is possible to provide pairs of resistors to produce frequencies of 100, 200, 300 and 400 cycles and by using combinations derive frequencies of 500, 600, 700, 800, 900 and 1000 cycles. Thus, four pairs of resistors can be made to generate ten frequencies and by using several such combinations a relatively small number of resistors can be used to obtain a large number of frequencies.

2.06 In the 72A Frequency Meter the above principle is employed. A functional schematic of the bridge network is shown on Fig. 4. In this circuit switches (S1) to (S4) perform functions similar to those described above. The single switches grouped together and designated S1, S2 and S3 do not operate independently as indicated, but are parts of a rotary step switch and open and close in a sequence which is arranged to obtain a decade system. In this system one rotary switch S1, changes the frequency in 1000-cycle steps, another S2 in 100-cycle steps, another S3 in 10-cycle steps. Switch S4 controlling the 1-cycle steps operates differently as explained below. The switch dials are then numbered and positioned so that by starting from the left and reading one number from each dial the frequency is obtained directly.

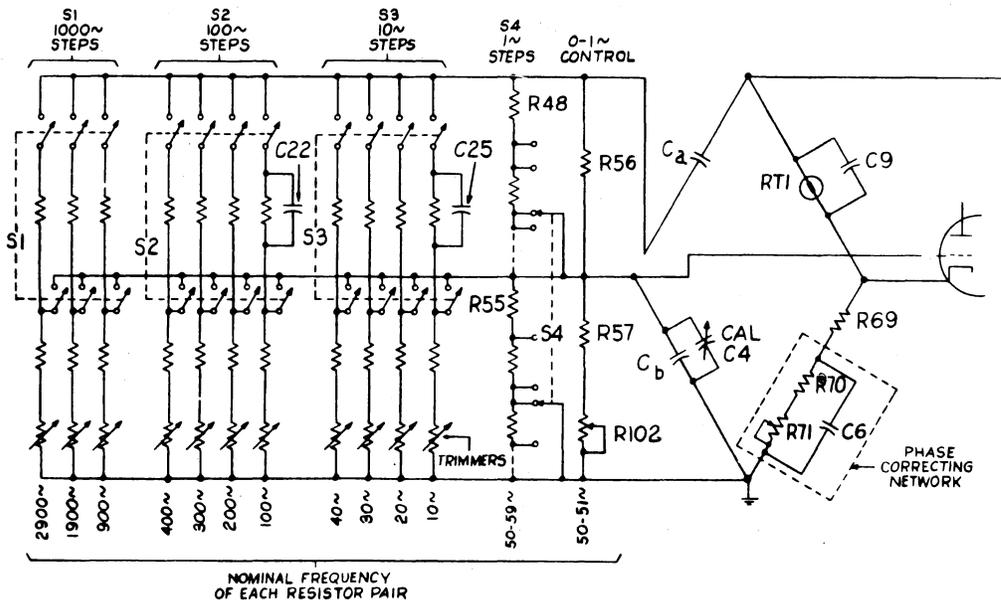


Fig. 4 - Functional Schematic of Bridge Network

2.07 Switch S1, the 1000-cycle step switch, has 4 positions and switches three pairs of resistors. Because, as will be apparent later, two 50-cycle pairs of resistors (equivalent to 100 cycles) are permanently connected in the bridge, the three pairs actually change the frequency in steps of 900, 1900 and 2900 cycles. The resulting frequencies are, nevertheless, 1000, 2000 and 3000 cycles. This procedure slightly complicates the dials. The complication is taken care of by making the 100's dial double-scaled. One scale is used for frequencies below 1000 cycles and the other for frequencies above. The proper scale is automatically selected by a movable window which is positioned by switch S1.

2.08 Switch S2, the 100-cycle step switch, is a 10-position switch which switches four pairs of resistors which, as indicated, generate 100, 200, 300 and 400 cycles. To generate frequencies above 400 cycles the following combinations are used.

400 + 100 = 500 cycles  
 400 + 200 = 600 cycles  
 400 + 300 = 700 cycles  
 400 + 300 + 100 = 800 cycles  
 400 + 300 + 200 = 900 cycles

Because of the two 50-cycle pairs of resistors R48 to R55, R57 and R102 which are always in the bridge, the lowest frequency to which the oscillator can be set is 100 cycles. Therefore, when all other frequency controls are set to minimum, the frequency obtained for each setting of switch S2 is 100 cycles more than the values listed above. Also, when the frequency is 100 cycles, none of the pairs of resistors listed is used.

2.09 Switch S3, the 10-cycle step switch, is similar to the 100 cycle step switch except that the associated 4 pairs of resistors are ten times higher in value.

2.10 Switch S4, the one-cycle step switch, is a ten-position switch which modifies the permanently connected 50-cycle resistance network formed by resistors R48 to R55. The modification is such as to increase its frequency in steps of one cycle from 50 to 59 cycles. The frequency range of this switch with all other frequency controls set to minimum is 100

to 109 cycles. Because a small degree of unbalance within a pair will not appreciably affect the frequency, the switch alternately modifies each half of the pair. This reduces by nine the number of resistors required.

2.11 Potentiometer R102 is a control which smoothly varies frequency over a range of slightly more than one cycle. This potentiometer is placed in the lower half of one of the permanently connected 50-cycle resistance networks. Because the range of this control is small, there is little error introduced by the precalibrated scale which is used with this control.

2.12 Except for the two 50-cycle resistor networks just described, trimmer potentiometers and resistors which may be strapped in or out are associated with all resistor pairs. A trimmer capacitor and capacitors which may be strapped in or out are also associated with capacitors C<sub>a</sub> and C<sub>b</sub>. These components are used for calibrating the oscillator against the crystal standard. Altogether, there are 12 trimmers provided, only eight can be adjusted externally. The four internally adjusted trimmers are associated with the resistors of switch S3 and need be but rarely adjusted.

2.13 The adjustment of the eight externally available trimmers consists of setting the oscillator dials successively to frequencies of 100, 200, 300, 400, 500, 1000, 2000 and 3000 cycles and at each frequency adjusting the correspondingly marked trimmer. Because the trimmer capacitor associated with C<sub>a</sub> affects the settings of all other trimmers, it is essential that this trimmer be adjusted first. This trimmer is marked 100 and is made at the 100-cycle setting. All other trimmers affect only the resistor pair with which they are associated.

2.14 By use of the above adjustments the accuracy at each calibration point can be made to approach the accuracy of the crystal. Also, by using highly stabilized resistors and capacitors, this accuracy can be maintained over an appreciable length of time. However, at frequency settings which are not calibration points, there is the possibility of introducing addition errors. An addition error, as explained above, occurs when the change in frequency produced by any dial setting depends upon the settings of the other dials. Capacitors

C22, C25, C9 and C6 are used to correct addition errors. In the case of capacitor C6, which is in the phase correcting network, the amount of correction is controlled by the setting of resistor R71. This resistor is factory adjusted so that a change of 100 cycles at a low frequency is equal to a change of 100 cycles at a high frequency. The action of any of the compensating capacitors is effectively to make the phase shift through the amplifier the same at all frequencies and thus make the frequency controlling arms of the bridge determine the frequency.

2.15 As mentioned above, the two right-hand arms of the bridge control the oscillator output level and do not appreciably affect frequency. In the upper right-hand bridge arm is thermistor RT1. When no power is applied to the oscillator the thermistor is at ambient temperature and has a high resistance; the bridge is unbalanced and there is a relatively small transmission loss through it. When power is applied, the amplifier gain increases above the bridge loss and the circuit starts oscillating. Energy flowing into the bridge heats the thermistor. As its temperature increases, its resistance decreases tending to balance the bridge. As a bridge balance is approached a stable condition is reached, where the loss through the bridge equals the amplifier gain. Under this condition, the thermistor reaches a value very close to twice that of  $R69 + R70 + R71$ .

2.16 When the CAL-MEAS-SEARCH switch is changed from MEAS to SEARCH the circuit is changed from an oscillator to that of a tuned amplifier. In the SEARCH position the thermistor is removed from the bridge and a fixed resistor substituted for it. The fixed resistor has a sufficiently low value so that the bridge is what might be termed over-balanced. Under this condition, the phase shift through the bridge is 180°. This causes the oscillations to stop. Because the bridge is still near the balance point, there is only a small amount of negative feedback at the balance frequency. The amplifier gain is, therefore, high for this frequency and low at all others. A tuned amplifier is thus created. As the frequency controls are adjusted closer and closer, to the correct setting, the oscilloscope pattern first increases in width and then becomes narrower to form an oblique straight line. If at this point the circuit is returned to its original condition, the frequency controls will be found to be very near their proper setting.

(C) Output Amplifier

2.17 The circuit of the output amplifier is shown in Fig. 5. This amplifier makes the oscillator output available externally and isolates the load from the oscillating circuit. This prevents external load changes from affecting the oscillator frequency.

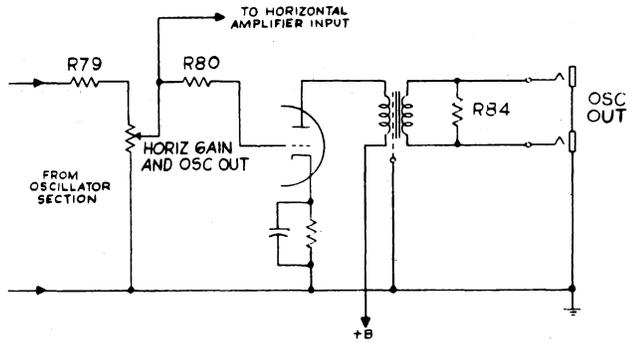


Fig. 5 - Simplified Circuit of Output Amplifier

2.18 The circuit of the output amplifier is that of a conventional single-stage amplifier with transformer output. The input is controlled by the HORIZ GAIN AND OSC OUT potentiometer. This potentiometer is also used to control the input to the horizontal amplifier. The resistor across OSC OUT jacks makes the output impedance approximately 600 ohms.

(D) Oscilloscope

2.19 The cathode-ray tube is the major component of the oscilloscope section and is used as an indicator to compare the oscillator frequency with the frequency of either the unknown or the crystal standard. This tube and its associated circuit are shown in Fig. 6. In operation 600 volts is applied to the accelerator, pin 8, and to the deflection plates, pins 6, 7, 9 and 10. This voltage is obtained from the voltage doubler in the power supply section. To permit coupling to the vertical and horizontal amplifiers, the 600-volt supply section is fed to the pins 6 and 9 through coupling resistors R96 and R100, respectively.

2.20 The electron tubes and associated resistors and capacitors to the left and right of the cathode-ray tube form the horizontal and vertical amplifiers. They are arranged to have sufficient voltage output so



The calibrating procedure, however, is not complicated because normally the frequency will be close to the calibrated value in which case it will be necessary only to adjust the trimmers until the figure, whatever it may be, becomes stationary.

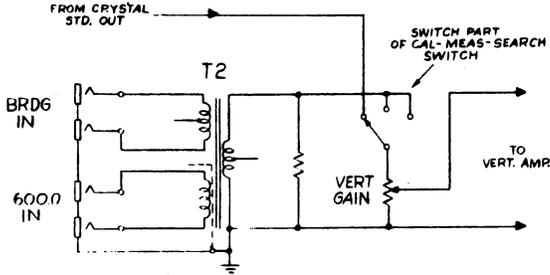


Fig. 8 - Simplified Circuit of Input Section

(F) Input Section

2.23 The input section is shown in Fig. 8. This section provides nominal input impedances of 600 ohms and 50,000 ohms. The VERTICAL GAIN potentiometer controls the level of the unknown frequency before it is applied to the vertical amplifier. Either input may be used balanced or unbalanced. In both cases, however, the balances are approximate. Only the 600-ohm input is electrostatically shielded.

(G) Power Supply

2.24 The power supply section, shown in Fig. 9, supplies 6.3 volts a-c and unregulated 300 and 600 volts d-c. Connections are made to the 60-cycle power source through a three-conductor cord; the third conductor is used to facilitate grounding. Overload protection is provided by a one-ampere slow operating type

fuse. This type permits a low fuse rating without the danger of blowing during the starting transient. The power transformer has one 740-volt winding and two 6.3-volt windings. To minimize noise pickup from the line these windings are electrostatically shielded from the primary. When the power source voltage is 115 volts the output of the high voltage winding after rectification and filtering is in the order of 300 volts, 35 milliamperes d-c. The corresponding output for the doubler section is 600 volts 70 microamperes. One 6.3-volt winding is used to operate the heater of the rectifier tube, the other, all the remaining electron tube heaters, including the cathode-ray tube.

2.25 To explain the operation of the voltage doubler, suppose that the sides of R87 and C13 shown on the drawing as connected to L1 be temporarily lifted and connected to ground. We have then a conventional half-wave rectifier (CR1, C13 and the load). This rectifier is coupled to the high voltage winding by an R-C network and under this condition would generate about 300 volts. If now we connect resistor R87 as shown in the drawing to inductor L1, a +300-volt d-c bias will be placed on the right-hand plate of C12. Since a condenser will transmit a-c independently of a d-c bias placed on one of its plates, C12 continues to transmit a-c. Thus the half-wave rectifier CR1, C13 and load continues to function and produce 300 volts d-c. This d-c voltage is, therefore, added to the 300-volt bias and produces 600 volts. Note that, except for voltage breakdown one side of C13 can be connected either to inductor L1 or to ground. Connecting C13 as shown places the same bias on both sides and thus reduces its working voltage.

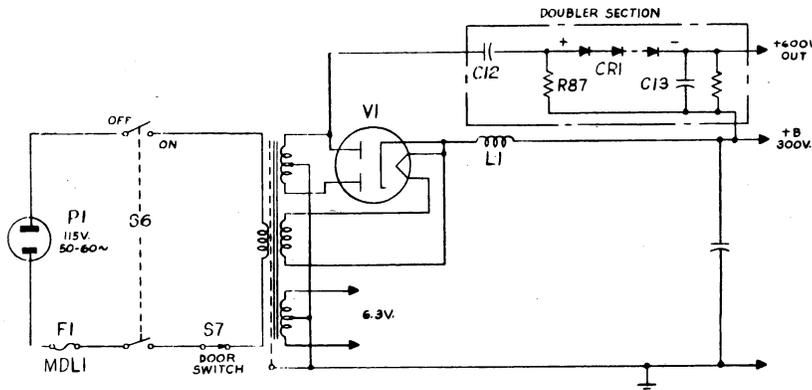


Fig. 9 - Simplified Circuit of Power Supply

### 3. PERFORMANCE

#### (A) Accuracy

3.01 The rated accuracy of the 72A Frequency Meter is  $\pm 0.5$  cycle from 100 to 500 cycles and  $\pm 0.1$  per cent. from 500 to 4000 cycles. However, if the unit is kept properly calibrated and resistor R71 is properly adjusted, accuracies in the order of  $\pm 0.2$  cycle and  $\pm 1.0$  cycle respectively, can be readily obtained. If the frequency under measurement is a simple fraction of 4000 cycles so that the crystal oscillator may be used as a direct check, accuracies in the order of .02 per cent. may be obtained.

#### (B) Frequency Measurement Range

3.02 The frequency range is nominally 100 to 4000 cycles, but by a modification of the normal operating procedure it is possible to extend this range from roughly 10 to 40,000 cycles.

#### (C) Input Sensitivity

3.03 The minimum input of a signal under measurement is .06 volt, or -22 dbm, for the 600-ohm input and 0.5 volt for the bridging input.

#### (D) Oscillator Output

3.04 The oscillator output provides frequencies from 100 to 4000 cycles. The output into a 600-ohm load is adjustable from approximately 1 to 150 milliwatts.

3.05 At 150 milliwatts the distortion of the oscillator output over the entire frequency range is approximately 12 db below fundamental. At 100 and at 10 milliwatts the distortion is 14 and 26 db below fundamental, respectively.

#### (E) Crystal Oscillator

3.06 The crystal oscillator accuracy is  $\pm .01\%$  over the ambient temperature range for normal operation.

#### (F) Ambient Temperature Range

3.07 The ambient temperature range for normal operation of this unit is 50°F. to 120°F. Outside this range the accuracy will be somewhat less than given above.

### 4. OPERATION

#### (A) General

4.01 The procedures outlined herein present step-by-step methods for operating the 72A Frequency Meter. Some of these steps require observing high ratio oscilloscope patterns. In the calibrating procedure, for example, 40/1, 20/1, 10/1, etc. patterns similar to Figs. 10A to 10H are obtained. In such

cases, it is not necessary to check the pattern by counting the peaks. The circuits and procedures are such that it is required only to observe the type of pattern and then make the adjustments specified. In making frequency measurements outside the normal 100-4000 cycle range, however, it may be desirable sometimes to count the peaks of a 10/1 pattern. See Fig. 10D. If the 10/1 pattern is stable this procedure is relatively simple and can be accomplished without difficulty.

4.02 In observing high ratio oscilloscope patterns the structure of the pattern will become more apparent and easier to observe if the VERTICAL GAIN and HORIZ GAIN AND OSC OUT controls are adjusted to make a long narrow pattern with the peaks located on the long side. See Fig. 10A.

4.03 In setting the FREQUENCY CPS controls it should be noted that the dials of these controls are numbered and positioned such that the frequency settings can be read directly from them. The numbers are read one from each dial and from left to right. The last dial to the right, however, indicates the fractional cycles, is smoothly adjustable and is read by noting the position of the pointer with respect to the calibration markings.

#### (B) Preparation for Service

4.04 Procedure:

(1) Set Controls as follows:

<u>Control</u>	<u>Set to</u>
CAL-MEAS-SEARCH	MEAS
HORIZ GAIN AND OSC OUT	Approx. 1/2 clockwise
INTENSITY	Max. clockwise
ON-OFF	OFF
VERTICAL GAIN	Max. counter-clockwise

(2) Apply power by connecting the power cord to a 105-125-volt 60-cycle power source, the ground connector to ground and then operate the ON-OFF switch to ON.

(3) Wait approximately one-half minute for a horizontal trace to appear on the screen of oscilloscope tube.

(4) Adjust INTENSITY and FOCUS controls so that the trace on the screen of the oscilloscope tube becomes a sharply defined line.

#### (C) Calibration

4.05 The calibrating procedure outlined below should be followed each time the unit has been placed in operation. When the maximum precision is required the calibrating procedure should be repeated after the first 15 minutes of operation and hourly thereafter. When less

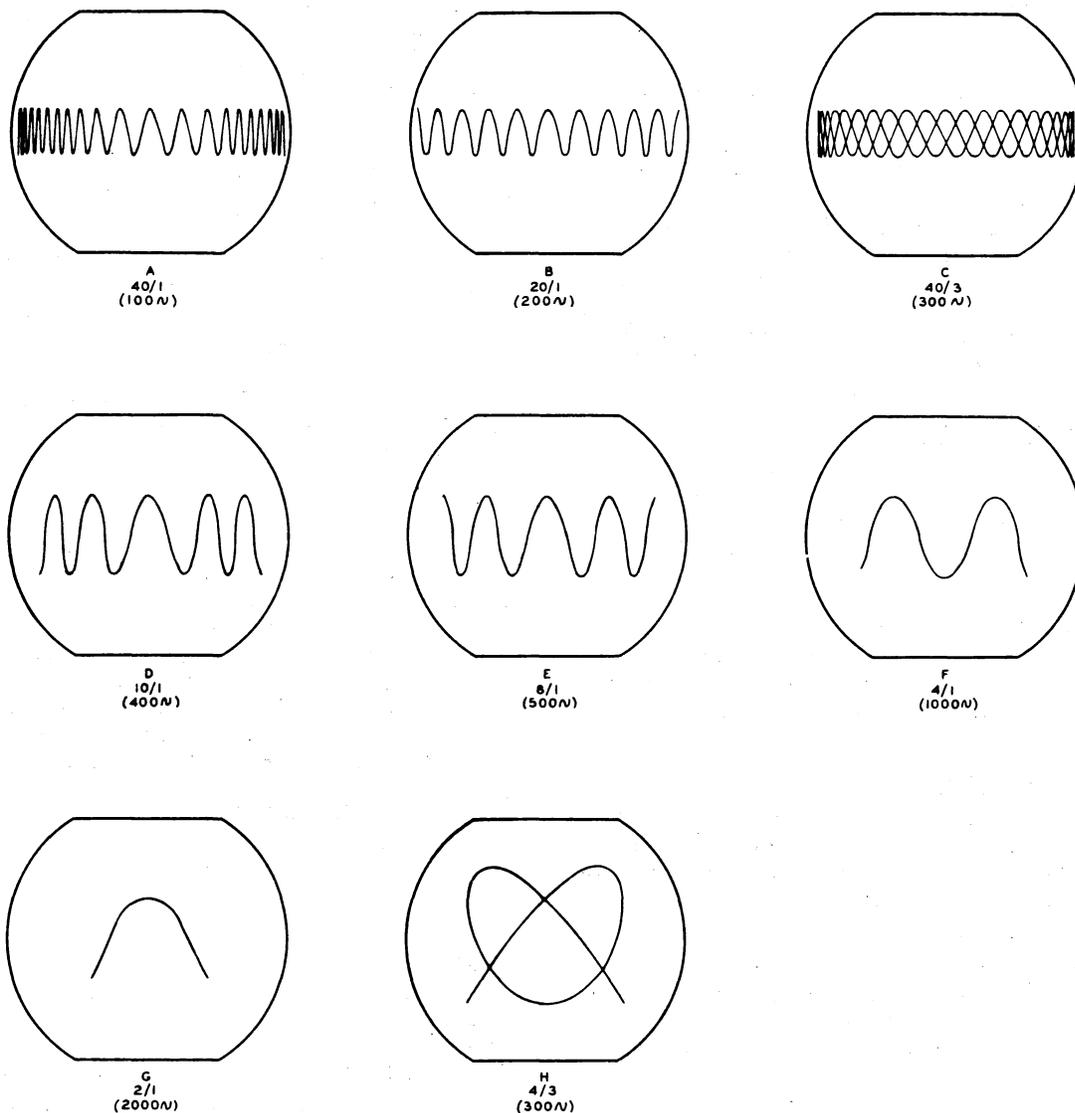


Fig. 10 - Oscilloscope Frequency Patterns (Only simplest phase shown)

precision is required the interval between successive calibration may be increased accordingly.

4.06 Procedure:

- (1) Set CAL-MEAS-SEARCH switch to CAL. This connects the output of the crystal oscillator to the vertical amplifier.
- (2) Adjust VERTICAL GAIN and HORIZ GAIN AND OSC OUT controls to obtain a pattern approximately 1/4" vertical and 1-1/4" horizontal.
- (3) Set FREQUENCY CPS dials to 100 and adjust CAL 100 control to obtain a stationary 40/1 oscilloscope pattern similar to Fig. 10A.

- (4) Set FREQUENCY CPS dials successively to 200, 300, 400, 500, 1000, 2000 and 3000 and at each setting adjust, respectively, CAL 200, 300, 400, 500, 1000, 2000 and 3000. For each adjustment obtain a stationary oscilloscope pattern similar to Figs. 10B, 10C, 10D, 10E, 10F, 10G, 10H, respectively.

Note: There are two possible ways of setting the FREQUENCY CPS dials to obtain 1000 cycles. In all cases 1000 cycles should be set by setting the thousands dial (switch S1) to 1 and the other dials to 0, rather than by setting the hundreds dial (switch S2) to 10 and the other dials to 0.

(D) Measurement of a Single Frequency in the Normal Operating Range 100-4000 Cycles

4.07 In the procedure outlined below it is assumed that the unit has been placed in operation and maintained in calibration as outlined in Parts 4(B) and 4(C).

4.08 Procedure:

(1) Connect the frequency under measurement to the 600 $\Omega$  IN or BRDG IN jacks. If the frequency source is intended to be operated into a 600-ohm load or if the available power is relatively low, the 600 $\Omega$  IN jacks should be used. If otherwise, use the BRDG IN jacks. A 241-type plug equipped with a cord will be required for making these connections.

(2) Set CAL-MEAS-SEARCH switch to MEAS. This step connects the unknown frequency into the vertical amplifier.

(3) Adjust the FOCUS, BRIGHTNESS, VERTICAL GAIN and HORIZ GAIN AND OSC OUT controls to obtain sharply defined pattern which is large enough to be readily observable but does not extend beyond the oscilloscope screen. In subsequent steps it will be assumed, unless otherwise stated, that these controls will be maintained in such adjustment.

(4) Adjust FREQUENCY CPS Controls to obtain a stationary 1/1 pattern. If the frequency under measurement is known within 10 or 20 cycles the FREQUENCY CPS dials can be readily set to obtain the required pattern. This pattern should be a stationary pattern similar to one of the patterns shown on Fig. 11. This is done by setting the FREQUENCY CPS dials in accordance with the

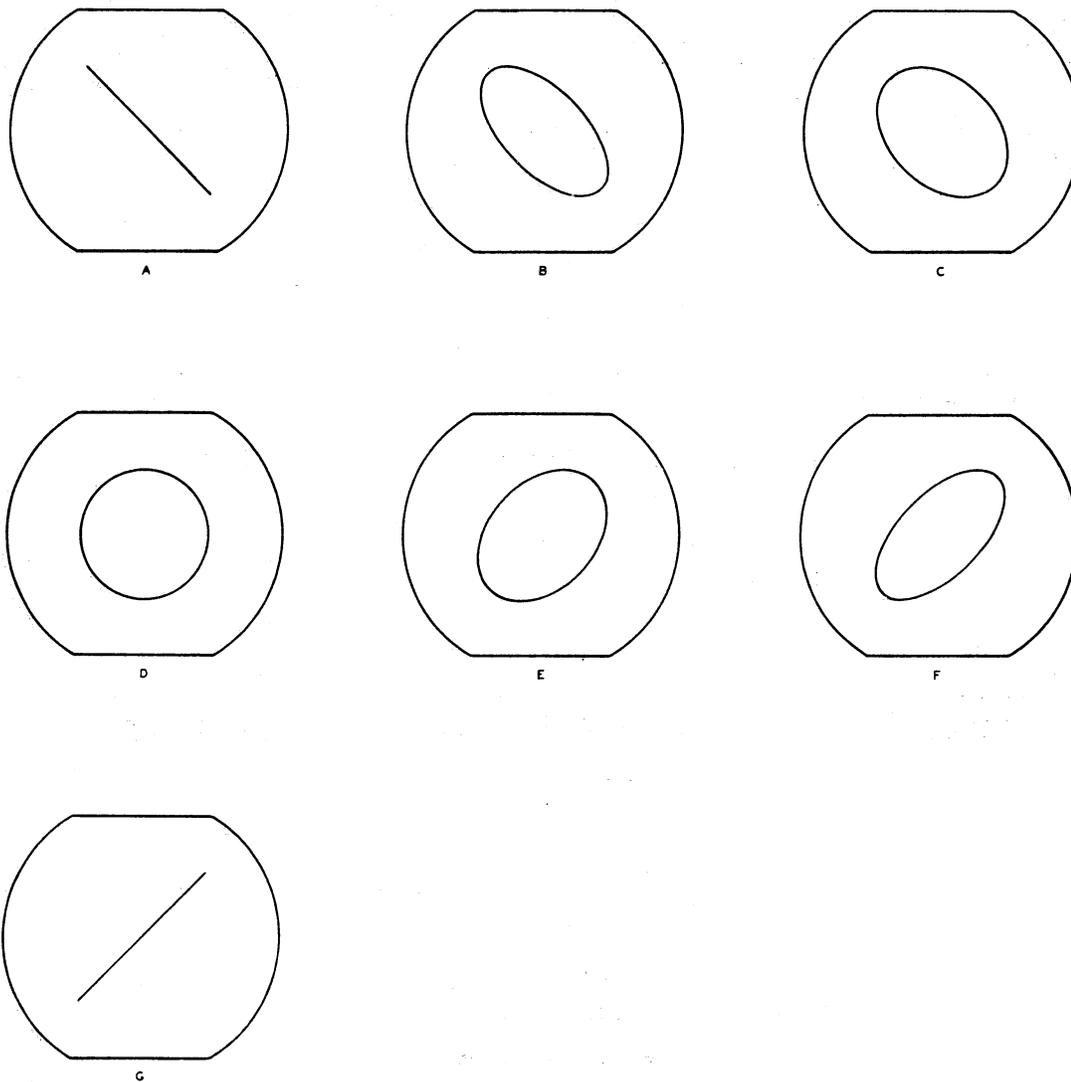


Fig. 11 - Successive Phases of a 1/1 Frequency Pattern

known information and then adjusting successively the 10-cycle dial, the 1-cycle dial and finally the 0-1-cycle dial. These dials are adjusted so as to cause the pattern to rotate at a slower and slower rate until it becomes essentially stationary.

(E) Search for Unknown Frequency

4.09 When the frequency to be measured is not known approximately, the use of the SEARCH feature may be used to facilitate the measurement. This feature converts the oscillator to a tuned amplifier and since the output is always connected to the horizontal oscilloscope plates, the horizontal dimension of the pattern is indicative of how close the frequency setting is to the unknown frequency. When the setting is remote from the unknown frequency the oscilloscope pattern will be a vertical line, as shown in Fig. 12A. As the unknown frequency is approached the pattern will expand into an ellipse with a small horizontal component,

Fig. 12B. Then the ellipse will assume a diagonal position, Figs. 12C, 12D and finally the pattern will become a diagonal straight line, Fig. 12E. Under this condition the frequency setting should be very close to the actual frequency. The frequency measurement then may be made by setting the switch back to the MEAS position, and readjusting the frequency setting slightly so as to obtain a stationary pattern. In using the search feature the presence of harmonics or other distortion will modify the pattern somewhat, but the correct pattern is easily recognizable. Two possible variations are shown in Figs. 12F and 12G.

(F) Frequency Measurements Outside Normal Operating Range

4.10 Though this unit is intended primarily for measuring frequencies from 100 to 4000 cycles, it may, by slightly modifying the operating procedure, be used to measure frequencies in the ranges from 10 to 100 cycles and 4000 to 40,000 cycles. The procedure is

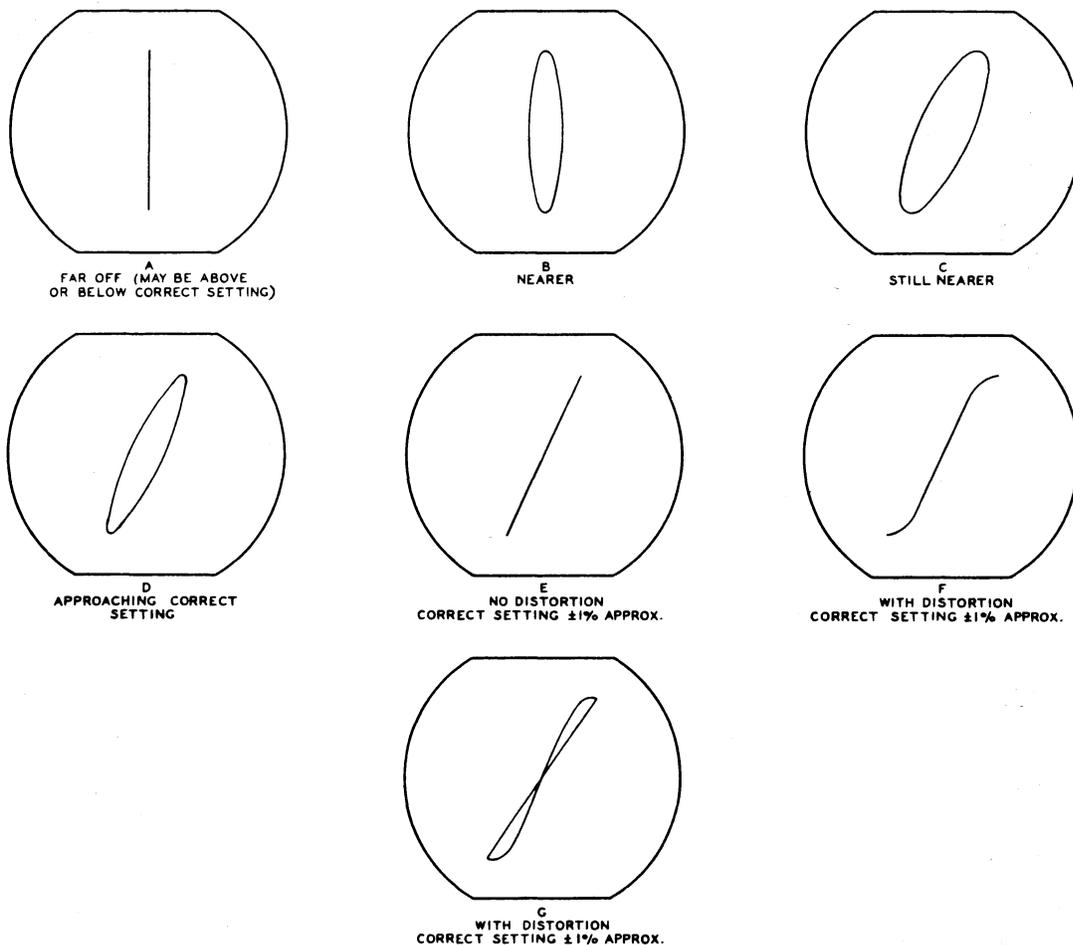


Fig. 12 - Oscilloscope Patterns Obtained When Using Search

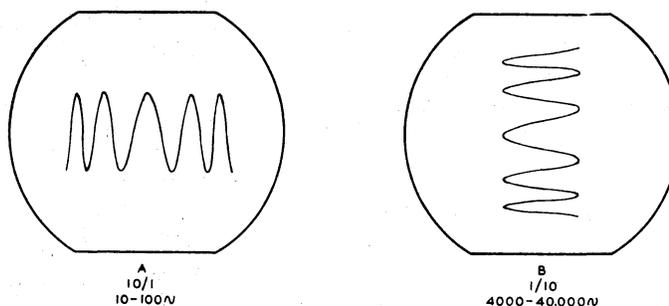


Fig. 13 - Patterns for Measuring Frequencies Outside Normal Range

based on using higher ratio oscilloscope patterns as explained in 4.01. The procedure described below uses a 10:1 ratio. Procedures based on using oscilloscope patterns such as 2/1, 3/1, etc., may be similarly used, but are slightly more complicated in that they require multiplying or dividing the dial indication by 2, 3, etc. A discussion of such a procedure is given in Section A702.667, E40.621, R70.270. This section covers the DuMont Type 304H Cathode-Ray Oscillograph.

4.11 Procedure:

- (1) Proceed as in Steps (1), (2) and (3) of Part 4(D). These steps cover connecting to the frequency under measurement and the adjustment and setting of controls. The unit is assumed to have been placed in operation and maintained in calibration.
- (2) Adjust FREQUENCY CPS dials to obtain a stationary 10/1 pattern. If the frequency under measurement is known within about 1 cycle for the low range and about 30 cycles for the high, little difficulty should be encountered in obtaining a 10/1 oscilloscope pattern as in Figs. 13A and 13B. If otherwise it will be necessary to hunt over the range of the FREQUENCY CPS dials so as to obtain the required settings. The search feature will not function outside the 100-4000-cycle range and, therefore, can not be used. If there is any possibility

that a 9/1, 11/1, etc., oscilloscope pattern has been erroneously obtained the pattern ratio should be checked by counting the peaks.

- (3) Read FREQUENCY CPS dials, then for 10-100-cycle range, divide by 10 and for 4000-40,000 cycle range multiply by 10. With a pattern similar to Fig. 13A divide by 10 and similar to 13B multiply by 10. Since in all cases the frequency under measurement will be roughly known there will be little ambiguity as to whether to divide or multiply the reading of the FREQUENCY CPS dials by 10.

(G) Measurement of Two Frequencies

4.12 The 72A Frequency Meter may be used to measure the frequency of each of two simultaneous frequencies provided (1) the magnitude and frequency of each component are within the normal operating limits of the unit and (2) the difference in amplitude between the two components does not exceed 20 db. The procedure outlined assumes that the unit has been placed in operation and maintained in calibration.

4.13 Procedure:

- (1) Proceed as in Steps (1), (2) and (3) of Part 4(D).
- (2) Adjust the FREQUENCY CPS dials to obtain a pattern with a stationary envelope. This is one frequency. A pattern with a stationary envelope is one in which the general shape of the pattern is stationary, but may be uniformly shaded or composed of

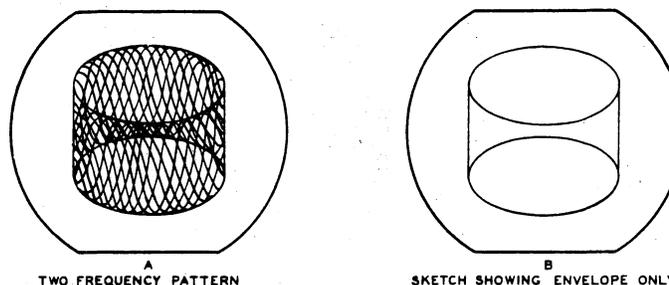


Fig. 14 - Patterns for Measuring Signals Composed of Two Frequencies

many moving lines. The patterns are illustrated in Figs. 14A and 14B, for non-harmonically related frequencies. If the frequencies are approximately known little difficulty should be encountered.

- (3) Repeat the above steps for the other frequency.

(H) Search for Two Frequencies

4.14 Procedure:

- (1) Set CAL-MEAS-SEARCH switch to SEARCH.  
 (2) Adjust VERTICAL GAIN and HORIZ GAIN AND OSC OUT to obtain a pattern with roughly same height and width.

- (3) Adjust FREQUENCY CPS dials to obtain a diamond shaped pattern similar to Fig. 15E or 15H. This is done most easily by starting with the left-most FREQUENCY CPS dials and observing the effect on the pattern after each dial change. Successive patterns are illustrated, see Fig. 15. With a small amount of practice little difficulty should be encountered.

- (4) Reset CAL-MEAS-SEARCH switch to MEAS and proceed as in Part 4(G).

(J) Use as an Oscillator

4.15 The 72A Frequency Meter may be used as an oscillator by connecting to the jacks marked OSC OUT. The output level can be controlled by the HORIZ GAIN AND OSC OUT control and the frequency set by means of the FREQUENCY CPS dials. The CAL-MEAS-SEARCH switch may be set to either CAL or MEAS.

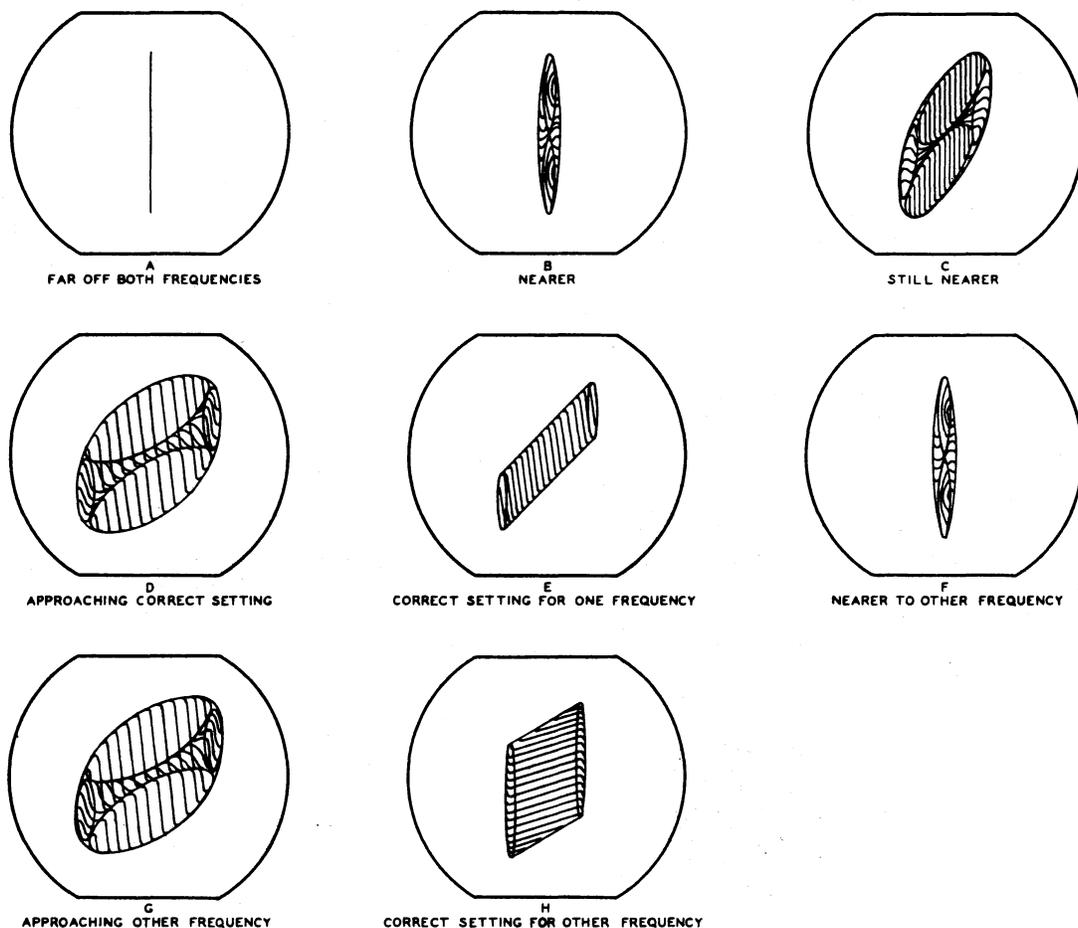


Fig. 15 - Search Patterns for Signals Composed of Two Frequencies

(K) To Obtain Increased Accuracy at Specific Frequencies

4.16 By using the information in Table I, accuracies equivalent to that of the crystal standard may be obtained for the frequencies listed. This table shows all frequencies from 100 to 4000 cycles which with 4000 cycles form 1/1 to 1/40 stationary single-line patterns and stationary multi-line patterns up to 20/19. To use the table proceed as follows:

4.17 Procedure:

- (1) Calibrate as in Part 4(C).
- (2) Set FREQUENCY CPS dials to frequency selected from table and CAL-MEAS-SEARCH switch to CAL.
- (3) Adjust FREQUENCY CPS dials not more than  $\pm 1$  cycle and obtain the stationary pattern listed. In general only one pattern will be obtainable within the  $\pm 1$  cycle range. If within this range more than one is noted, use pattern with fewest number of lines. Because of the accuracy of the unit it is not necessary to count lines or analyze pattern to insure it is the correct one. In cases of doubt a check may be made at the adjacent frequencies listed.

5. MAINTENANCE

(A) General

5.01 This Part contains (1) an operating check, (2) a trouble chart and (3) procedures for isolating and eliminating troubles. The operating check should be followed whenever a trouble condition is suspected or when it is desired to check the instrument to insure it is in a proper operating condition. Since the unit is essentially self-checking

the procedure consists of placing the instrument in operation, calibrating, measuring a frequency and then checking a series of selected frequency settings.

5.02 The trouble chart is based on the results of the operating check and indicates the procedures to be followed when a trouble condition is encountered.

(B) Operating Check

5.03 Proceed as in Part 4(B) Preparation for Service and Part 4(C) Calibration. Then proceed as outlined in 5.04. The CAL-MEAS-SEARCH switch remains on CAL.

5.04 In following this procedure it is not required to check the pattern by counting the peaks, it is only necessary to adjust the FREQUENCY CPS dials within the range indicated so that the pattern, whatever it may be, becomes stationary. In the third column below where reference is given to a figure, the pattern shown in this figure will be similar in type only but not necessarily in the exact number of peaks.

<u>Requirement for Setting of Frequency</u> <u>CPS Dials</u>	<u>Stationary Pattern</u>	<u>See Fig.</u>
105.0 to 105.5	38/1	10A
110.9 to 111.3	36/1	10A
117.4 to 117.9	34/1	10A
121.0 to 121.4	33/1	10A
133.1 to 133.6	30/1	10A
142.6 to 143.1	28/1	10A
153.6 to 154.1	26/1	10B
181.5 to 182.1	22/1	10B
190.2 to 190.7	21/1	10B
1332.8 to 1333.8	3/1	10F
1713.3 to 1714.8	7/3	16A
2285.0 to 2286.4	7/4	16B
2856.4 to 2857.7	7/5	16C

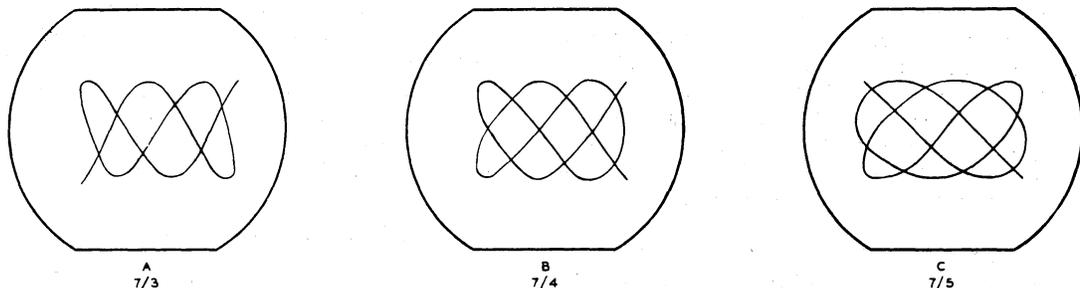


Fig. 16 - Oscilloscope Frequency Patterns (Only Simplest Phase Shown)

(C) Trouble Chart

5.05 If a trouble condition is encountered in 5.03 or 5.04 above, reference should be made to the table below. This table lists possible trouble conditions as well as references to procedures for isolating and eliminating the trouble.

Trouble Chart

<u>Trouble Condition Noted</u>	<u>Check</u>
No light appears on oscilloscope screen.	Power Supply Oscilloscope Section
A light spot appears but no horizontal trace.	Oscillator Horiz. Amp.
Trace will not focus or lacks brilliance.	Oscilloscope Power Supply
Insufficient vertical deflection.	Vacuum Tubes Vertical Amp. Crystal Osc. Input Sect.
Oscilloscope pattern does not become stationary.	Oscillator
Required pattern not obtainable.	Oscillator

(D) Procedures for Isolating and Eliminating Trouble

5.06 This equipment contains high voltages which are dangerous. All tests, therefore, should be made with the unit inside of the carrying case. Voltage measurements should be made by connecting the meter to the terminals as required, replacing the chassis in the case so as to allow the voltmeter leads to come out between the chassis and the panel and then applying power. To remove the chassis from the case disconnect the power cord from the power source, loosen the four captive screws located near the corners of the panel and lift the chassis from the case. Before any component, terminal or wire inside the unit is touched with any part of the body or an uninsulated tool, condensers C13 and C14 should be completely discharged by short-circuiting them.

5.07 As a further precaution the ground clip at the end of the power cord should be connected to ground at all times. When comparing the results of a voltage measurement with

the nominal voltage values given in the text, discrepancies of as much as +20% may be observed. Such discrepancies can result from differences in line voltage, individual components, and the voltmeter used. These possibilities should be taken into account when isolating and eliminating troubles.

5.08 In attempting to locate a trouble it is assumed that the equipment will be examined visually and the wiring checked to insure that there are no breaks, badly soldered joints, or short circuits. Examining the wiring of a suspected component is particularly important. To facilitate this procedure the subchassis containing switches S1 to S4 and associated components is removable. To remove this section remove the associated panel knobs and then the four screws fastening the section to the main chassis. Rotate condenser C4 to the closed position and remove the section by withdrawing it from the panel.

5.09 The following test equipment or its equivalent is required to make the test outlined below:

- 1 - 716B Telephone Receiver equipped with a suitable cord terminating in a 241A plug
- 1 - 106A resistor 5000 ohms
- 2 - 241A plugs equipped with suitable cords to facilitate making connections
- 1 - Test frequency source at 1000 + 100 cycles
- 1 - Leeds and Northrup type 5410 Testing Set
- 1 - Stop-watch to measure 5 to 125 seconds
- 1 - M9B Meter (Portable Volt-Ohm-Milliammeter)
- 1 - Condenser 600 volt 0.1 MF, Mallory TP
- 1 - Voltmeter to measure up to 400 volts d-c and a-c  
 A Weston 779, Simpson 260 or Triplett 630 volt-ohm-milliammeter may be used

Power Supply - A-C Section

5.10 Remove electron tube V1, apply power to unit and measure the a-c power supply voltages as covered in Table II Voltage Measurements. If trouble is indicated, check the components. To check T1, disconnect it from the circuit and apply 115V a-c to terminals 1-2. The voltages measured should then be approximately as given for the a-c power supply voltages in Table II Voltage Measurements.

Power Supply - D-C Section

5.11 Apply power to the unit and measure the d-c power supply voltages as in Table II Voltage Measurements. If trouble is unlocated

check the components. To check CR1, use the M9B Meter and a 45V "B" battery. Using the 30V scale on the M9B Meter, measure the battery voltage through varistor CR1 connected in series with the battery and meter. The voltage indicated by the meter with the red end of CR1 connected to the negative pole of the battery should be above IOV. The indicated voltage with the red end of CR1 connected to the positive pole of the battery should be essentially 0.

#### Oscilloscope Section

5.12 Apply power to the unit, set the FOCUS and INTENSITY controls to maximum clockwise, and measure the oscilloscope voltages as in Table II Voltage Measurements. If voltages are approximately as shown in Table II but trouble condition is still present, replace tube V6 with a new one. To replace tube V6, loosen clamp at the base and pull the socket from the tube. Remove the front bezel by prying carefully on the edges near the panel. Replace the new tube by following the reverse procedure. If the trouble appears to be cleared, apply a trace on the screen of tube V6, as in 4.04. If the trace is not horizontal, temporarily release the tube clamp and rotate tube V6 so that a horizontal trace is obtained. If, after replacing tube V6, the trouble still persists it is probable elsewhere, so check the remaining components.

#### Oscillator-Amplifier Section

5.13 Using the M9B Meter to measure voltages, apply 0.5V a-c, 1000 + 100 cycles to jacks J1 and J2. With the unit in operation, the CAL-MEAS-SEARCH switch set to SEARCH and the VERTICAL GAIN set to maximum clockwise, adjust FREQUENCY CPS dials for maximum voltage across coil L2. This voltage should be approximately 5.0V. If otherwise, check the input section, the CAL-MEAS-SEARCH switch S5 and electron tubes V2 and V4 as outlined in 5.19, 5.20 and 5.21 respectively. If this procedure fails to locate the trouble the section should be further checked by measuring the oscillator amplifier voltages as in Table II Voltage Measurements.

#### Oscillator - Frequency Network Section

##### 5.14 Operating Check

(1) Check for operation at 100 cycles if the circuit fails to oscillate. Check the amplifier section as in 5.13 above and if the trouble is not located proceed as follows: Remove power from the circuit. Set the CAL-MEAS-SEARCH switch to MEAS, at resistor R69 disconnect the lead from R69 to terminal V2-3. Using a Wheatstone bridge measure the resistance of R69 + R70 + R71. The resistance as measured should be

from 2000 to 2100 ohms. Using the M9B Meter and with R17 disconnected from the circuit, measure the resistance from terminal 1 of C10 to terminal V2-3. This resistance should be approximately 25,000 ohms as measured on the RX1000 scale of the M9B Meter. Heat one terminal of RT1 with a soldering iron and the resistance should decrease to about 15,000 ohms or lower. Restore the circuit to normal and set the FREQUENCY CPS dials to 100 cycles. Using a Wheatstone bridge measure the resistance across condenser C5. This resistance should be 124,000 + 1000 ohms. Similarly measure the resistance across the terminals of R56. This resistance should be 120,000 + 1000 ohms. If this procedure does not locate the trouble check condensers C1 to C5.

(2) Check for operation at 100 cycles if the circuit oscillates but cannot be calibrated at 100 cycles, condenser C2 or C5 may have aged so as to change the factory adjustment. In this case attempt to calibrate the circuit with C1 or C3 connected in or out of the circuit. Failing to clear the trouble, proceed as in (1) above.

(3) If the circuit operates satisfactorily at 100 cycles but does not oscillate at one or more of the other frequencies proceed as follows: Check the individual resistance associated with each switch (S1 to S4) which is not set to zero when the trouble condition is noted. Examine the contacts of switches S1 to S4 and check in accordance with the sequences of operation given in SD-59373-01 and particularly check to insure there are no short circuits to ground.

(4) If the circuit operates satisfactorily but cannot be calibrated because of insufficient range of adjustment connect or disconnect the resistors associated with the particular calibrating adjustment so as to extend the calibrating range. See SD-59373-01.

(5) To adjust, R65 to R68 and R39 to R42, proceed as follows: Place unit in operation and calibrate as in 4.04 to 4.06 above and adjust the resistors in accordance with the following table:

Set FREQUENCY CPS to	Adjust	Obtain Stationary Pattern
111.11	R68, R42	36/1
121.21	R67, R41	33/1
133.33	R66, R40	30/1
148.15	R65, R39	27/1

(6) To check other frequencies, the patterns of Table I may be used. These patterns are satisfactory for checking small errors only. Large errors are detected by the procedures given above. These patterns are obtained with the CAL-MEAS-SEARCH set to CAL. This list is given as an aid and it is not intended that the entire list be investigated but rather to provide a sufficiently wide distribution of frequencies so that one or two can be selected at or near a particular frequency which may be in question.

(7) If in testing the unit as in 5.04 the frequency is outside of limits at the high frequencies, the adjustment of resistor R71 may be out. To adjust resistor R71, measure the frequencies as in 5.04 and if the settings are, in general, above the limits, slightly increase the resistance of R71, if below, reduce it. After each re-adjustment recalibrate the unit and recheck as per 5.04.

#### Horizontal Amplifier

5.15 Set the FREQUENCY CPS dials to 1000 and the CAL-MEAS-SEARCH switch to MEAS. Using the M9B Meter, measure the a-c voltage between terminal 3 of R83 and chassis and adjust the HORIZ GAIN AND OSC OUT control so as to make this voltage 1.0V a-c. With a 0.1 mf condenser connected in series with the meter, measure the voltage between terminal 6 of tube V5 and ground. This voltage should be approximately 26 volts a-c. If this voltage is appreciably different from the above, check the components.

#### Vertical Amplifier

5.16 Set the FREQUENCY CPS dials to 1000, the CAL-MEAS-SEARCH switch to MEAS and the HORIZ GAIN AND OSC OUT control to approximately the middle of its range. Using the patching cord connect the OSC OUT to the BRDG IN, then by means of the M9B Meter, measure the a-c voltage between terminal 3 of R86 and ground and adjust the VERTICAL GAIN control so as to make this voltage 1.0V. Using a 0.1 mf condenser in series with the M9B Meter measure the voltage between terminal 8 of tube V3 and ground. This voltage should be approximately 26 volts a-c. If this voltage is appreciably different from the above, check the components.

#### Crystal Oscillator

5.17 The operation of the crystal can be checked roughly by listening to the 4000 cycle tone which is usually emitted by the vibrating crystal. Hearing the tone indicates

that the crystal is oscillating. As a further check, the voltage across resistor R89 may be measured. Measure this voltage by means of the M9B Meter connected in series with the 0.1 mf condenser. This voltage should be approximately 0.1V a-c. If trouble is indicated check the components. The crystal can be checked by removing the wire to terminal 2T of varistor CR2. This procedure will allow more energy to be sent into the crystal and if the crystal is in difficulty, it may sometimes be found to oscillate under this condition, but not with the normal connections. A crystal which will operate only with the connection to varistor CR2 opened is probably defective and should be replaced. If the crystal oscillator still does not oscillate, the remaining components should be checked including the crystal oscillator voltages as in Table II Voltage Measurements.

#### Oscillator Output Amplifier

5.18 Set the FREQUENCY CPS dials to 1000 and the CAL-MEAS-SEARCH switch to MEAS. Using the M9B Meter, measure the voltage between terminal 3 of R83 and ground and adjust the HORIZ GAIN AND OSC OUT control so as to make this voltage 1.0V. Measure the output voltage at the OSC OUT jacks J5 and J6. This voltage should be approximately 8V a-c. If this voltage is appreciably different from the above check the components.

#### Input Circuit

5.19 Set the CAL-MEAS-SEARCH switch to MEAS. With 1.0V, 1000 cycles across the 600Ω IN jacks J3 and J4, and the VERTICAL GAIN control set to maximum counter-clockwise, measure the a-c voltage across resistor R86. This voltage should be 10.0V a-c. Repeat the above procedure with 1.0V, 1000 cycles across the BRDG IN jacks J1 and J2. This voltage should be 0.5V a-c. If trouble is still indicated, check the components.

#### Electron Tubes V1 to V5

5.20 The electron tubes may be tested in the KS-5727 Hickok Tube Tester or equivalent in accordance with the information covering the set such as Section A702.664, E40.554, R70.340. In removing any tubes for testing, care should be taken so that all tubes found to be good are replaced in the same socket from which they were removed. This procedure will minimize the possibility of readjustments.

#### (E) Checking Components

5.21 When checking a component, measure directly across its terminals. When a component appears defective remove it from the circuit and recheck to make sure a false indication

was not caused by some other component. Unless otherwise stated it will be assumed that any component removed for checking will be replaced before proceeding with additional tests.

5.22 Condensers above 0.1 mf may be roughly checked for capacity by means of an ohmmeter. This can be done using the method outlined in Section E40.581 M9B Meter. An ohmmeter test is not satisfactory for roughly checking the capacity of low capacity condensers. The ohmmeter may, however, be used to insure that these condensers do not have high resistance leaks but will not indicate if they are open.

Attached:  
Tables I and II.

If a condenser is suspected of being open and cannot be checked by means of a capacity bridge check by substituting an equivalent unit. Values of capacity can be obtained from SD-59373-01.

#### 6. DRAWINGS

6.01 The following drawings are listed for reference only and are not attached to this section.

ED-63630-01 Equipment  
SD-59373-01 Circuit

TABLE I

PATTERNS - FREQUENCY CPS VS. 4000 CPS

FREQUENCY CPS	Oscilloscope Pattern	FREQUENCY CPS	Oscilloscope Pattern	FREQUENCY CPS	Oscilloscope Pattern	FREQUENCY CPS	Oscilloscope Pattern
100	40/1	571.43	7/1	1684.21	19/8	2823.53	17/12
102.56	39/1	600.00	20/3	1714.29	7/3	2857.15	7/5
105.26	38/1	615.38	13/2	1750.00	16/7	2888.88	18/13
108.11	37/1	631.58	19/3	1777.78	9/4	2909.09	11/8
111.11	36/1	666.67	6/1	1800.00	20/9	2933.33	15/11
114.28	35/1	705.88	17/3	1818.18	11/5	2947.36	19/14
117.65	34/1	727.27	11/2	1846.15	13/6	3000.00	4/3
121.21	33/1	750.00	16/3	1866.66	15/7	3058.82	17/13
125.00	32/1	800.00	5/1	1882.35	17/8	3076.92	13/10
129.03	31/1	842.10	19/4	1894.73	19/9	3111.11	9/7
133.33	30/1	857.14	14/3	2000.00	2/1	3142.85	5/4
137.93	29/1	888.89	9/2	2105.26	19/10	3157.89	19/15
142.86	28/1	923.08	13/3	2117.65	17/9	3200.00	5/4
148.15	27/1	941.17	17/4	2133.33	15/8	3250.00	16/13
153.85	26/1	1000.00	4/1	2153.85	13/7	3272.73	11/9
160.00	25/1	1052.63	19/5	2181.82	11/5	3294.12	17/14
167.67	24/1	1066.66	15/4	2200.00	20/11	3333.33	6/5
173.91	23/1	1090.91	11/3	2222.22	9/5	3368.41	19/16
181.88	22/1	1111.11	18/5	2250.00	16/9	3384.61	13/11
190.48	21/1	1142.86	7/2	2285.72	7/4	3400.00	20/17
200.00	20/1	1176.47	17/5	2315.79	19/11	3428.58	7/6
210.53	19/1	1200.00	10/3	2333.33	12/7	3466.66	15/13
222.22	18/1	1230.77	13/4	2352.94	17/10	3500.00	8/7
235.30	17/1	1250.00	16/5	2400.00	5/3	3529.44	17/15
250.00	16/1	1263.16	19/6	2444.44	18/11	3555.55	9/8
266.67	15/1	1333.33	3/1	2461.54	13/8	3578.94	19/17
285.71	14/1	1400.00	20/7	2500.00	8/5	3600.00	10/9
300.00	40/3	1411.76	17/6	2526.31	19/12	3636.36	11/10
307.69	13/1	1428.57	14/5	2545.45	11/7	3666.66	12/11
333.33	12/1	1454.55	11/4	2571.43	14/9	3692.30	13/12
363.63	11/1	1473.68	19/7	2588.23	17/11	3714.28	14/13
400.00	10/1	1500.00	8/3	2600.00	20/13	3733.33	15/14
421.05	19/2	1538.46	13/5	2666.67	3/2	3750.00	16/15
444.44	9/1	1555.55	18/7	2736.83	19/13	3764.71	17/16
470.59	17/2	1600.00	5/2	2750.00	16/11	3777.77	18/17
500.00	8/1	1647.06	17/7	2769.23	13/9	3789.47	19/18
533.33	15/2	1666.66	12/5	2800.00	10/7	3800.00	20/19
						4000.00	1/1

TABLE II  
VOLTAGE MEASUREMENTS

Unless Otherwise Stated Use M9B Meter For All Measurements

Section	Apparatus	Terminals	Nominal Voltage	Remarks
Power Supply	T1	1 2	115V a-c	With V1 Removed
		3 4	370V a-c	" " "
		4 5	370V a-c	" " "
		6 8	6.3V a-c	" " "
		9 10	6.3V a-c	" " "
	V1	8(+) Gnd	315V d-c	V1 Replaced
	C14	2(+) Gnd	315V d-c	" "
Power Supply	CR1	Red(+)		
	C14	2	240V d-c	" "
Oscilloscope	V6	1 12	6.3V a-c	
	V6	7(+)		
	C14	2	Above 250V d-c	See Note (1)
	C14	2(+) Gnd	Above 250V d-c	" " "
	V6	4(+) Gnd	155V d-c	" " "
	V6	2(+) Gnd	135V d-c	" " "
Oscillator Amplifier	V2	1(+) Gnd	164V d-c	Use 300V Scale
		3(+) Gnd	0.8V d-c	
		6(+) Gnd	137V d-c	Use 300V Scale
	V2	8(+) Gnd	0.6V d-c	
	V4	5(+) Gnd	Above 250V d-c	Use 300V Scale
	V4	6(+) Gnd	Above 250V d-c	Use 300V Scale
	V4	2(+) Gnd	150V d-c	Use 300V Scale
Crystal Oscillator	V3	8 Gnd	1.7V d-c	
	V3	6 Gnd	230V d-c	

Note:

- (1) Set FOCUS and INTENSITY controls to maximum clockwise.