OPERATING INSTRUCTIONS

for

TYPE 1100-A FREQUENCY STANDARDS

GENERAL RADIO COMPANY

CAMBRIDGE 39 MASSACHUSETTS

NEW YORK CHICAGO LOS ANGELES

U. S. A.

TABLE OF CONTENTS

SPECIFICATIONS

Frequency Range: Standard frequencies ranging from one pulse per second to frequencies of several megacycles can be obtained from this equipment.

The output frequencies are as follows. The upper frequency limit depends upon the method used to detect and utilize the harmonics. The values here quoted are easily reached when using the Type 1106 Frequency Transfer Units.

From 100-kc multivibrator, 100 kc and its harmonics up to 50 megacycles.

From 10-kc multivibrator, 10 kc and its harmonics up to 10 megacycles.

From 1-kc multivibrator, 1 kc and its harmonics in the audio-frequency range.

From 100-cycle multivibrator, 100 cycles and its harmonics in the lower audio range.

From the syncronometer unit, one-second contactor. The time of occurrence of the contact may be phased to occur at any instant over a range of one second.

If a suitable high-frequency receiver is used to detect them, 100-kc harmonics up to 75 or more megacycles can be utilized directly. For work at higher frequencies, harmonics of an auxiliary oscillator whose fundamental is monitored against the standard at a lower frequency can be used.

Output Voltage: The harmonic outputs of the 100 and 10 kc are at low impedance (65 ohms). The r-m-s voltages, measured at the terminals of the frequency standard, across a 65-ohm load, are: at 100 kc, 0.2 volt; and 10 kc, 1.2 volts. The audio-frequency outputs are at low impedance (600 ohms). The r-m-s voltages measured at the terminal strip of the standard, across a 10,000-ohm load, are: 10 kc, 20 volts; 1 kc, 25 volts; 100 cycles, 20 volts. These voltages are representative only; they are not guaranteed values.

Frequency Adjustment: The frequency of the quartz bar in its oscillator circuit is adjusted to within 1 part in ten million of its specified frequency in terms of standard time. Slight changes in frequency may occur during shipment but a control is provided for adjusting the frequency after installation.

Accuracy: When the assembly is operated in accordance with instructions, and after an ageing period of a month, the rate of drift of the frequency will remain below 5 parts in 10^8 per day and this will decrease with time to about 0.5 part in 10^8 per day at the end of one year's operation.

Frequency Stability: The standard is designed so that ordinary changes in air pressure, ambient temperature, and line voltage have practically no effect on the frequency. The temperature coefficient of frequency of the quartz bar is less than 1 part in 10^7 per degree C. The temperature control is within ±0.01° C. The voltage coefficient of frequency of the crystal-controlled oscillator is approximately 2 parts in 10^8 for line voltage changes of 10%. The average frequency variation from this cause will be substantially less.

The fluctuations of frequency of the standard over short periods, such as those required in making frequency measurements are less than 1 part in 10^9.

Output Terminals: The various output frequencies are made available at shielded plug connections at the rear of the assembly. Since all necessary wiring, for all interconnections between units of the assembly, is provided in the form of cables, no connections need be made by the user other than power-supply connections, and a connection to the point where the standard frequencies are to be used.

Vacuum Tubes: The following tubes are required and are supplied with the assembly:

1—6AC7	
10—6SN7-GT	1—6K6-GT/G
1—5R4-GY	1—Type 2 LAP-430

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles.

Power Input: For the Type 1100-AQ Secondary Standard, the power *demand* from the supply line is approximately 155 watts; with heaters off, the power required is approximately 125 watts. For the Type 1100-AP Primary Standard, the corresponding figures are 175 and 145 watts, respectively.

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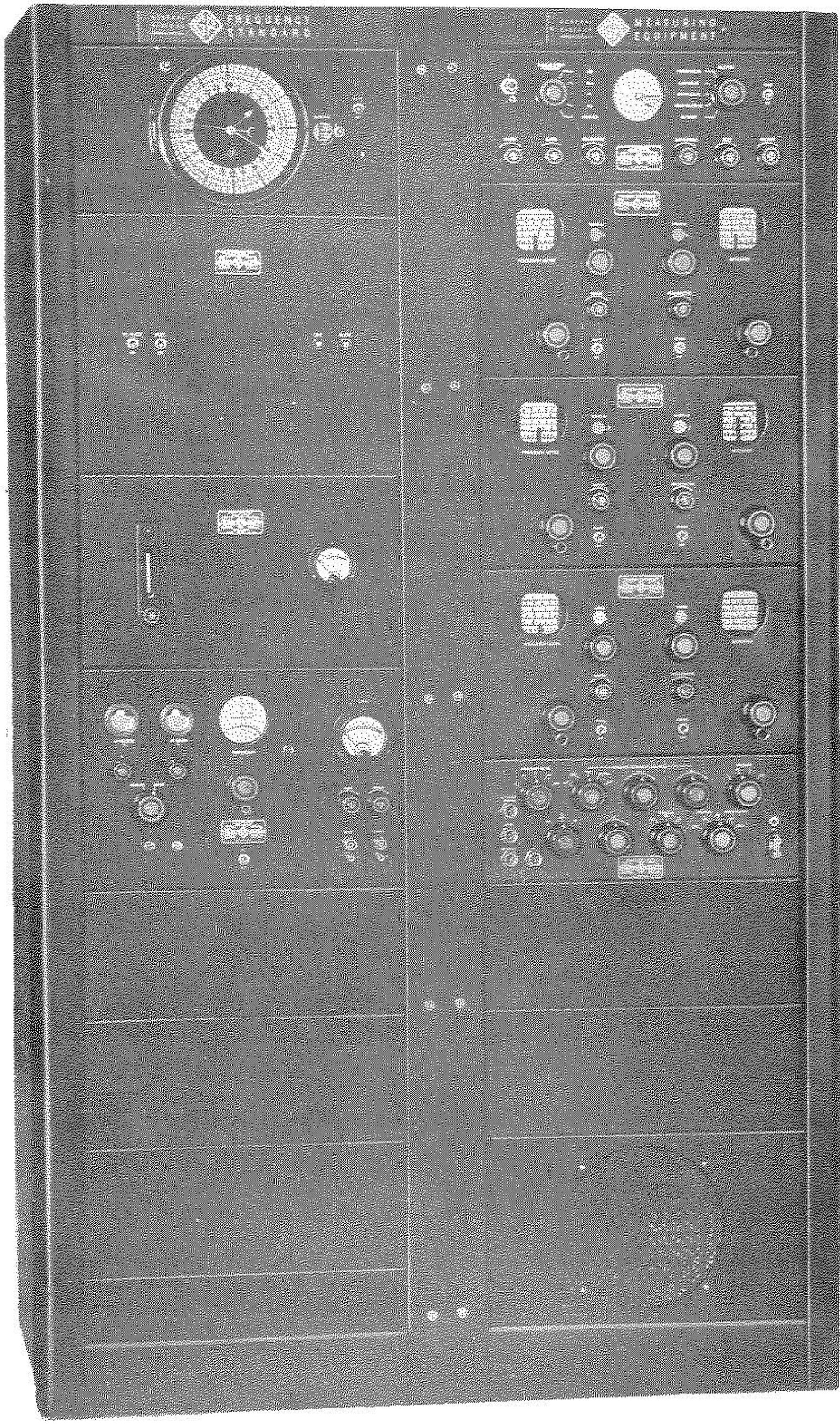


Type 1103-A Syncronometer

Type 1102-A Multivibrator and Power Supply Unit

Type 1101-A Piezo-Electric Oscillator

Type 1107-A Interpolation Oscillator

Type 1109-A Comparison Oscilloscope

Type 1106-A Frequency Transfer Unit

Type 1106-B Frequency Transfer Unit

Type 1106-C Frequency Transfer Unit

Type 1108-A Coupling Panel

Figure 1. Panel View of the Completely Assembled Type 1100-AP Frequency Standard and Type 1105-A Frequency Measuring Equipment.

TYPE 1100-A FREQUENCY STANDARDS

SECTION 1.0
INTRODUCTION

1.1 FUNDAMENTAL PRINCIPLES

The determination of frequency directly in terms of time is a fundamental measurement, since frequency is the time rate of recurrence of a cyclical phenomenon. A primary standard of frequency is, therefore, defined as one whose frequency is determined directly in terms of time. A secondary standard is one whose frequency is determined by comparison with a primary standard, or by comparison with other secondary standards, some one of which was originally compared with a primary standard.

It is to be noted that the above classifications of frequency standards have nothing to do with the accuracies of the standards. In fact the same standard is logically classed as a primary standard if checked directly against time, and as a secondary standard if checked against standard frequency transmissions (representing a distant primary standard).

In practice, the responsibility of establishing and maintaining accurate time determinations by astronomical observations is not assumed by the individuals desiring a primary standard of frequency. The time determinations are carried out by observatories especially equipped for the purpose. The results are made available to a large number of users by radio and wire transmission. In the United States, the U. S. Naval Observatory transmits high-precision time signals by radio through the facilities of the U. S. Naval Radio Service. Transmissions on several frequencies are available several times a day and can be received nearly all over the world.

The user of a primary frequency standard can then conveniently determine the frequency of the standard in terms of the standard time interval sent to him by radio. In the General Radio equipment means are provided for quickly and easily making this comparison. For the most precise results, the errors of the transmitted time signal must be taken into account. Correction data may be obtained by applying to the Superintendent, U. S. Naval Observatory, Washington, D. C.

Since the astronomical clocks now used at the Naval Observatory are piezo-electric oscillators, similar to those used in accurate frequency standards and since, through close cooperation of the U. S. Naval Observatory and the National Bureau of Standards, the piezo-electric oscillators of the latter's primary frequency standard are checked in the same way as the former's astronomical clocks, the comparison with time is, in effect, carried out by the observatory. The standard frequency transmissions sent out by the Bureau of Standards consequently represent a primary standard of high precision available to all who can receive the transmissions. Where such transmissions can be received, it is generally more convenient and much quicker to make the comparison by frequency than by time. For information and schedules of transmission of standard frequencies, apply to the Radio Division, Bureau of Standards, Department of Commerce, Washington, D. C.

Because of the vagaries of high frequency transmission, many users rely on checks against time as a reserve. They also use the primary standard as a high-precision clock for laboratory timing purposes.

As so far considered, the precision oscillator is a single-frequency device. For practical utility it is necessary to obtain from this single frequency many other frequencies, both above and below the standard frequency, for convenience in measurements. Since most of the precision oscillators operate in the region of 50 to 100 kc, it is necessary to divide the frequency to obtain a value such that an easily constructed synchronous motor can be used to count the number of cycles executed by the precision oscillator in a standard interval of time. For measurements of high radio frequencies, it is necessary to multiply the standard frequency to obtain useful frequencies in the range of the frequency being measured. Both of these operations are readily performed by a controlled relaxation oscillator, known as a multivibrator.

An oscillator of this type is characterized by its susceptibility to control by an introduced voltage, the frequency of which lies near the fundamental, or low-order harmonic, frequency. In the controlled conditions the relaxation oscillator locks into step with the control voltage, and the frequency bears an integral relationship to the frequency of the controlling voltage.

1.2 THE TYPE 1100-A FREQUENCY STANDARDS

The Type 1100-A Frequency Standard is available in two forms, a primary standard (Type 1100-AP) and a secondary standard (Type 1100-AQ). The primary standard includes a syncronometer (synchronous motor clock) for evaluating the frequency in terms of standard time. No timing means is furnished with the secondary standard, but a very satisfactory frequency check can be obtained by comparison with the standard frequency radio transmissions from the National Bureau of Standards at Washington, D. C.

The frequency of the precision oscillator is 100 kc, which is divided successively by factors of 10 to obtain multivibrator fundamental frequencies of 10, 1, and 0.1kc. A fourth multivibrator operating at a fundamental frequency of 100 kc provides a large number of harmonics at 100-kc intervals for use at high radio frequencies. Harmonics of the 10-kc multivibrator are similarly used. In the audio-frequency and low-radio-frequency range (up to one or two hundred kc) a cathode ray oscilloscope is used to obtain hundreds of known frequencies. This is simpler than trying to make use of harmonics of the low standard frequencies.

The range of useful output frequencies obtainable from the General Radio Primary (or Secondary) Frequency Standard is indicated in Figure 4.

1.21 The Type 1100-AP Primary Frequency Standard is composed of the following instruments:

Type 1101-A Piezo-Electric Oscillator
(with temperature control unit)
Type 1190-A 100-kc Quartz Bar and Mounting
Type 1102-A Multivibrators and Power Supply
Type 1103-A Syncronometer

Brief descriptions of these instruments are given in the following pages.

1.22 The Type 1100-AQ Secondary Frequency Standard is composed of the following instruments:

Type 1101-A Piezo-Electric Oscillator
(with temperature control unit)
Type 1190-A 100-kc Quartz Bar and Mounting
Type 1102-A Multivibrators and Power Supply

1.23 Interconnections between the various units are made by means of cables and plugs supplied with the equipment. Suitable patch cords are provided for connection to the frequency-measuring equipment when the standard and Type 1105-A Frequency-Measuring Equipment are purchased together.

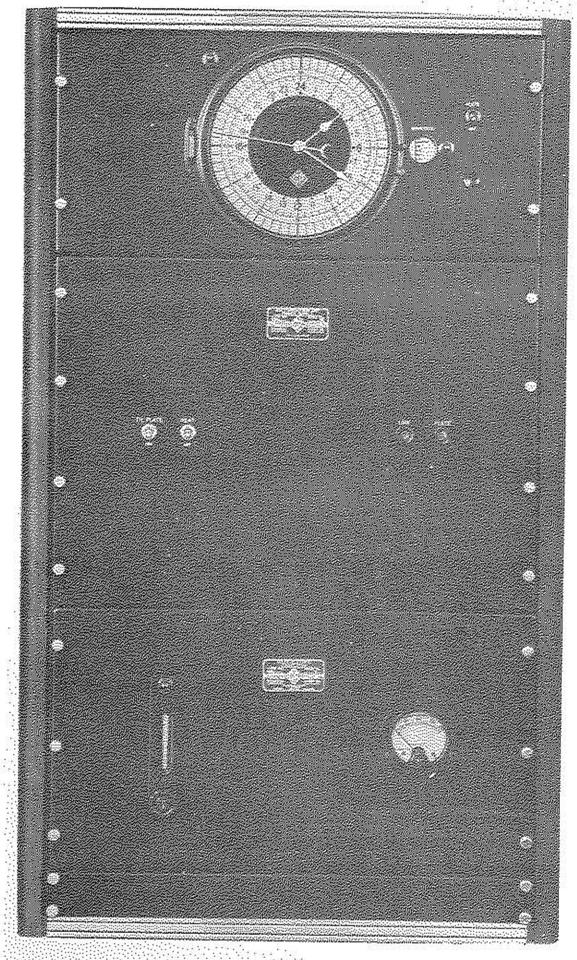


Figure 2. Type 1100-AP Primary Frequency Standard mounted in bench-type cabinet rack.

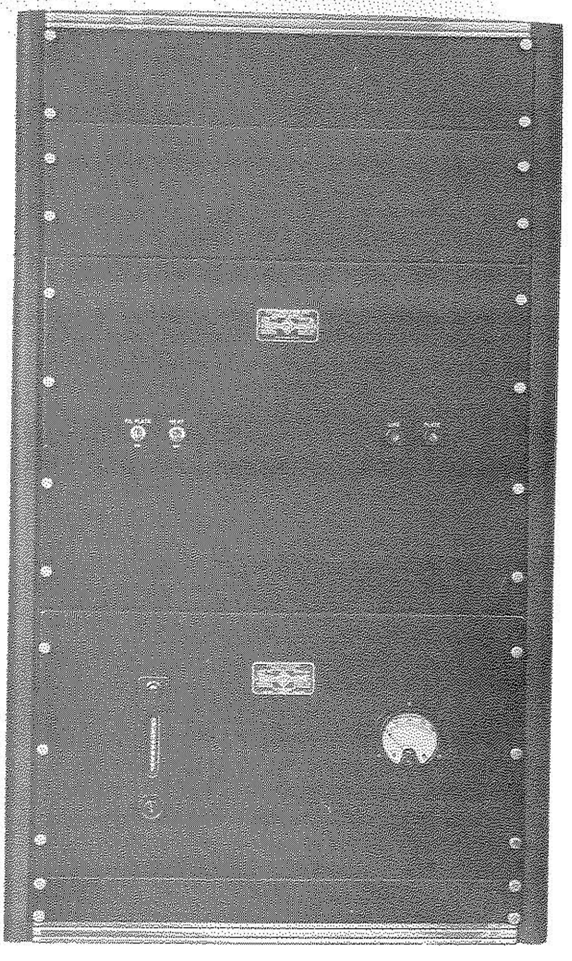


Figure 3. Type 1100-AQ Secondary Frequency Standard mounted in bench-type cabinet rack.

SECTION 2.0
INSTALLATION

2.1 RELAY RACKS

Unless otherwise specified, a bench-type cabinet rack is furnished with either standard.

In order that the interconnecting cables will fit properly, the equipment should be mounted as follows from top to bottom of the space.

Type 1103-A Syncronometer
Type 1102-A Multivibrators and Power Supply
Type 1101-A Piezo-Electric Oscillator
Blank panels are supplied to fill the remaining spaces in the rack.

2.11 IMPORTANT: Before mounting the Type 1103-A Syncronometer, remove the two clamping screws projecting through the bottom of the unit midway between the clock mountings at each end of the clock. These are used to clamp the clock firmly during shipment. On installation, the clock should be free on the aircraft-type mountings. These screws are identified by having lock terminals under the heads, on bottom of case.

2.2 Install the power cord, the crystal oscillator cable and the temperature box cable to their respective sockets in the bottom of the Type 1102-A. If a Type 1103-A Syncronometer is used, install the cable between the Type 1102-A and Type 1103-A, at the upper left rear of the Type 1102-A.

SECTION 3.0
OPERATION

3.1 Turn on power by throwing the FIL-PLATE and HEAT switches, on the panel of the Type 1102-A Multivibrators and Power Supply, to ON.

3.2 After the tubes have had time to warm up, all circuits are ready for use. The temperature control unit requires at least two to three hours to reach final temperature of 60° C. At normal room temperatures the thermostat cycle is approximately 20 seconds, the heat being on about 6 seconds, as indicated by the pilot light mounted over the thermometer on the panel of the Type 1101-A Piezo-Electric Oscillator.

3.3 On starting, the diode meter, on the panel of the Type 1101-A Piezo-Electric Oscillator, may swing to full scale momentarily. After stabilization of the bridge, the reading should be 90 ± 10 μamp. If the reading is appreciably outside this range, readjustment can be made. (See Service Notes, Paragraph 5.12.)

3.4 The control voltages and frequencies of the four multivibrators, of the Type 1102-A, can be adjusted from the rear of the equipment. These adjustments have been made at the factory and should not require resetting. See Service Notes, Paragraph 5.22, for instructions on checking and adjusting the multivibrators.

3.5 The syncronometer motor is started by pressing the starting button on the panel of the Type 1103-A Syncronometer and momentarily throwing the PLATE switch on the Type 1103-A to OFF. After the motor has started leave the PLATE switch on. When the syncronometer motor comes up to nearly synchronous speed, successive short pushes of the button are used to bring the motor into synchronism.

3.6 The syncronometer can be set, by inserting the key into the opening at the upper left of the clock face. Each "click" advances or retards the second hand by 0.5 second. If it is necessary to reset by a considerable amount, the door may be opened and the minute hand advanced or retarded. When finishing the adjustment, be sure the minute and sweep-second hands are synchronized. Final fine setting can then be done with the key.

3.7 For time signals of the type transmitted by the U. S. Naval Observatory (through the Naval Radio Service) the microdial contactor is utilized with a time signal receiver to compare accurately the time indicated

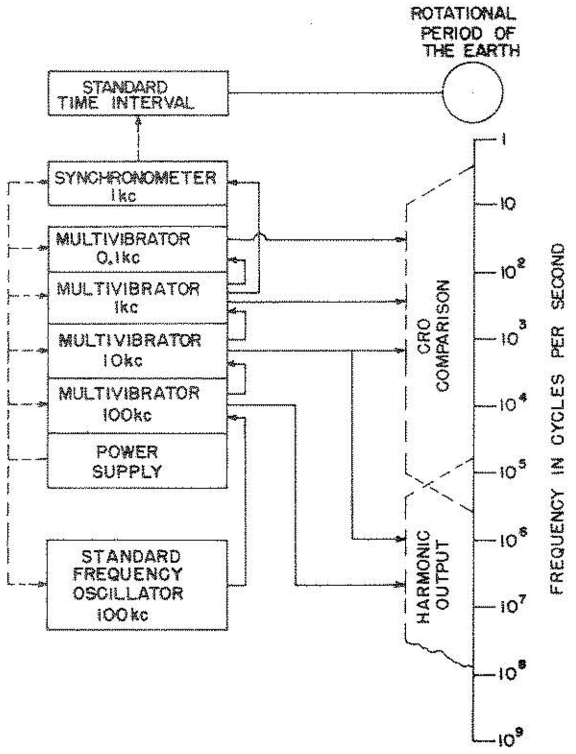


Figure 4. Functional block diagram of the frequencies obtainable from a Type 1100-A Standard.

by the syncronometer with the time signals. The contactor opens the circuit once each second for about 0.05 second. The time of the opening can be phased to occur at any instant during a second by inserting the key in the opening to the right of the microdial scale and turning the microdial housing. The microdial connections are brought out on a length of shielded cable which is a part of the cable connecting the Type 1103-A Syncronometer to the Type 1102-A Multivibrators and Power Supply. The contactor is connected across the audio-frequency output of the receiver (from which any d-c has been removed) so as to short-circuit the telephones or loud-speaker at all times except when the contact opens. In use, turn the microdial toward earlier time (lower numbers on the scale) until just the nose of the time tick is audible as a very short click. The dial is calibrated in 0.01-second intervals and comparisons can be estimated to one-half division (0.005 second) or better. In general, the limit of accuracy of the microdial settings approximates very closely the errors in the day-to-day transmissions of the time signals.

The fraction of a second read from the microdial is to be considered a positive increment. For example, if the clock were 0.25 second slow, the reading of the microdial would be 75 divisions and the time would be read 11:59:59.75 for a time signal occurring at 12:00:00.00.

Since there are 86,400 seconds per day, one part in a million would be 0.0864 second. If readings of the microdial are taken every 24 hours and the day-to-day progressive differences are divided by 0.0864, the deviation of the frequency standard from true frequency is obtained in parts per million. If the clock is gaining, the frequency standard is high in frequency; if the clock loses, the standard is low in frequency.

SECTION 4.0
DESCRIPTIONS OF INDIVIDUAL INSTRUMENTS

4.1 TYPE 1101-A PIEZO-ELECTRIC OSCILLATOR

This unit contains the piezo-electric oscillator, output amplifier, elementary vacuum-tube voltmeter (for indication of oscillation) and temperature-control unit. It is used with the Type 1190-A 100-kc Quartz Bar which is mounted in the temperature control box. Figure 9 shows a simplified circuit; the complete circuit diagram is given in Figure 10. Components referred to below by symbol number are identified in the complete diagram.

The oscillator consists of a high-gain tuned amplifier stage (V-1) working into a phase inverter stage (V-2) which drives the bridge, composed of the quartz bar, Q-1 (with its series reactance L-2, C-8, C-9), the resistors R-8, R-9, and R-10, and the lamp, V-4. The output voltage of the bridge (top corner to ground) is impressed on the grid-cathode circuit of the amplifier, V-1.

The operation of the oscillator is briefly summarized here; for a more complete description and for an analysis of frequency stability, see the General Radio Experimenter, April and May, 1944. On starting the oscillator, the lamp, V-4, is cold and its resistance is low (tungsten filament). In consequence, the bridge is badly unbalanced; the bridge output voltage is relatively large and in the proper phase to produce oscillation. Oscillations build up rapidly, and the lamp begins to warm up. As the resistance of the lamp increases, the bridge is brought toward balance. This results in a decreased bridge output voltage, and decreases the amplitude of oscillation. Equilibrium is reached finally when the loss between input and output of the bridge is just equal to the gain from the output back to the input of the bridge through the amplifier. The frequency of oscillation is fixed entirely by the quartz bar, operating at its series resonant frequency, when there is no phase shift in the amplifier and when there is no reactance added in series with the crystal. The amplifier has been checked for zero phase shift and the adjustment locked. No appreciable phase shifts should occur over long periods of time. The point of zero reactance in series with the crystal is marked on the frequency adjustment dial (C-8).

The temperature control box (see General Radio Experimenter, August, 1944) consists of an aluminum casting, forming the inner controlled space in which the Type 1190 Quartz Bar is mounted; an asbestos board attenuating layer; an outer aluminum casting, carrying heating units over all outer surfaces; a balsa wood insulating container; and, finally, a metal housing.

The thermostat itself is a sensitive mercury-in-glass contacting thermometer, mounted in a thermostat heater, of very low heat capacity, on the top face of the outer aluminum casting. A very small amount of heat (which can be adjusted by a series resistor, R-105, accessible under the thermometer cover plate) provides for the control of the thermal position of the thermostat. Rotating R-105 clockwise raises the temperature of the controlled space. Properly adjusted, the compensated temperature control unit maintains the temperature of the controlled space independent of ambient temperature changes. Even if not perfectly adjusted, the changes in ambient temperature are reduced by a factor of the order of 500.

With the low temperature coefficient of frequency of the Type 1190-A Quartz Bar, the variations in frequency of the standard due to the possible changes in temperature are entirely negligible.

4.2 TYPE 1190-A 100-KC QUARTZ BAR

The Type 1190-A 100-kc Quartz Bar includes many features of importance in maintaining the frequency as nearly constant as possible over long periods of time.

The mounting is a spring suspension, holding the quartz bar at the corners only of the long faces, in a manner such as to introduce the least damping (see Figure 5). The spring tension maintains the mounting conditions essentially constant over long periods. Because of the mode of vibration, there are two nodal regions and supports are placed at each. The quartz bar is thus held without any tendency to twist or turn in the mounting.

The electrodes are formed directly on the surfaces of the quartz. The upper and lower electrodes are divided at the center of the bar into two sections. See Figure 6. The connections to one section are reversed with respect to the connections of the other section. In vibration, when one half is expanding, the other half is contracting. The mode of vibration is consequently the second-harmonic extensional mode.

Investigation has shown that with suitable cross-sectional dimensions, a temperature-frequency curve in the form of an inverted parabola can be obtained. See Figure 7. At the vertex, where the slope of the curve is horizontal, zero temperature coefficient is obtained. The temperature at which this point occurs can be controlled reasonably well in the production of the quartz bars. In the Type 1190-A Quartz Bar the zero temperature coefficient point comes at, or slightly below, 60°C.

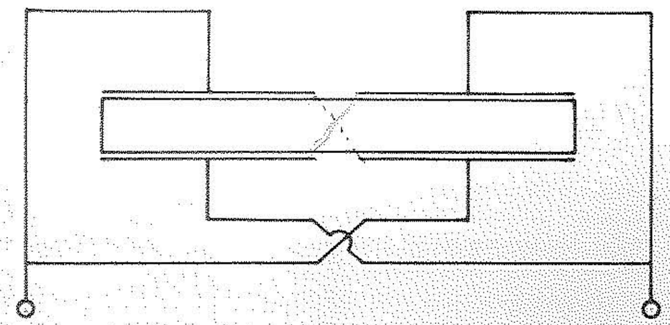


Figure 6. Diagram of the electrode system used on the Type 1100-A Quartz Bar.

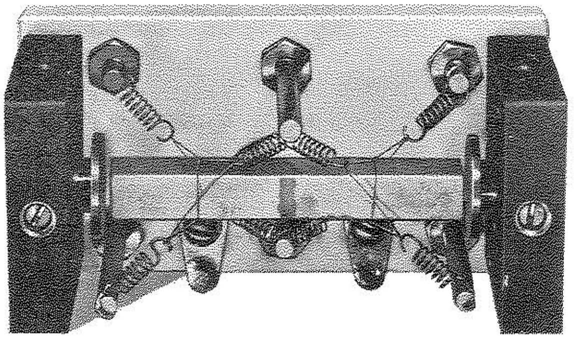


Figure 5. View of the Type 1190-A Quartz Bar with cover removed to show method of suspension.

4.3 TYPE 1102-A MULTIVIBRATORS AND POWER SUPPLY

The Type 1102-A Multivibrators and Power Supply contains four multivibrators, for 100 kc, 10 kc, 1 kc, and 100 cycles, and the power supply for the entire frequency standard. The relay circuits and heater supply transformer for the temperature-control section of the Type 1101-A Piezo-Electric Oscillator are also included.

The construction of the unit is such that the power and heater supply transformers, filters, etc., are mounted on the rear of the main panel. The multivibrator units are all mounted on the rear panel, as are the output connections from the multivibrators. All tubes are accessible and removable from the rear.

For each multivibrator two sunken screw-driver adjustments are provided, one for adjustment of the frequency and one for adjustment of the magnitude of control voltage. The latter rarely requires adjustment in the field. Instructions for checking and adjusting the multivibrator frequencies are given in the Service Notes, Section 5.2.

Two sets of output connections are provided: one pair for 100-kc and 10-kc harmonic outputs for connection to the Type 1106 Frequency Transfer Units of the

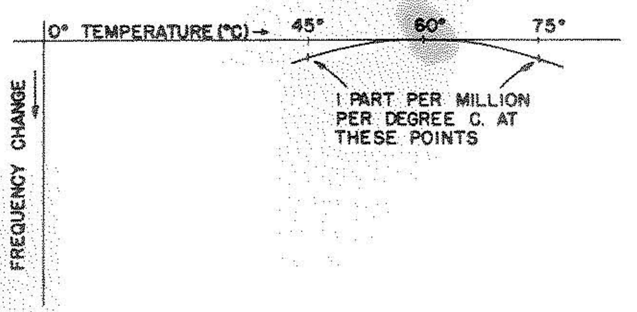


Figure 7. Temperature-frequency characteristics of the Type 1190-A Quartz Bar.

frequency measuring equipment, and one set of three for 10 kc, 1 kc, and 100 cycles for connection to the Type 1109-A Comparison Oscilloscope, or other frequency measuring equipment.

Two switches and two fuses are provided on the front panel, FIL-PLATE and HEAT switches and LINE and PLATE fuses.

The multivibrator is generally described as a "two-stage resistance-capacitance coupled amplifier with the output connected back to the input". The frequency of oscillation is determined mainly by the time constant of the R-C coupling, but also depends on the tubes, supply voltages and level of operation. The most important property, utilized in frequency standards, is that of easy synchronization with the frequency of a voltage introduced into the circuit, either at the fundamental of the multivibrator, or at any multiple of this frequency up to 12 or more. A second important property, for use in frequency standards, is that a very large number of harmonics are generated.

The synchronizing property is utilized in "frequency division", whereby the frequency of a single-frequency constant-frequency source can be reduced in successive steps, each integrally related to the source frequency, until a frequency low enough for the operation of synchronous motors is obtained. The motor then is operated as a counter to count the number of cycles which the constant frequency source executes in a given time, thereby determining the frequency of the source directly in terms of time.

The generation of harmonics is utilized in "frequency multiplication" to obtain from each divider stage a very large number of harmonics of each fundamental frequency.

In effect, for frequency measurement purposes, the combined division and multiplication generates a very large number of standard frequencies each known with the same precision as that of the constant frequency control frequency. These frequencies can be distributed over very large regions of the frequency spectrum from very low audio frequencies to very high radio frequencies.

4.4 TYPE 1103-A SYNCRONOMETER

The Type 1103-A Syncronometer contains the amplifier and circuits for operation of the syncronometer motor from a 1-kc source. Power supply is not included, this being obtained from the Type 1102-A Multivibrators and Power Supply.

The synchronous motor is of the impulse type operated in an amplifier circuit which is tuned for 1 kc. The rotor disc is laminated and contains a sealed mercury damping ring. The rotor has 100 teeth so the motor shaft rotates at 10 r.p.s. A worm reduction of 10:1 causes the counter shaft to turn at 1 r.p.s. This shaft carries the contactor of the microdial which is described below. The clock train is operated through a differential drive, one side of which is normally locked by a "click". On inserting the key in the opening above and to the left of the clock face, the differential can be unlocked and advanced or retarded. Each click corresponds to one-half second.

A starting motor is provided, controlled by the push-button on the panel, to bring the impulse motor up to speed. When the d-c plate current of the amplifier is flowing through the impulse motor windings, the starting motor cannot turn the wheel. Momentarily interrupting the d-c plate voltage will permit rotation. As synchronous speed is approached, short quick pushes of the button will permit a gradual increase in speed until synchronism is reached. When the impulse motor is running synchronously it will usually remain in synchronism even if the starting motor button is pushed.

The microdial is a device for comparing the time indicated by the syncronometer with time signals. It may also be used as a seconds contactor. The contactor opens the circuit for about 0.05 second each second. The time of the opening can be made to occur at any instant during the second, by rotating the housing around the counter shaft. This is done by inserting the key in the opening to the right of the clock face. A scale is observable through the window, each division corresponding to 0.01 second.

In making comparisons with time signals, the microdial contact is connected across the output of a time signal receiver (from which d-c voltages have been removed) so as to short-circuit the output except at the instants when the contactor opens. In Figure 8, the first line represents dots of the time signal sequence. The second line indicates the operation of the contactor, which occurs during spaces between the time dots so nothing would be heard. The microdial is then set by adjusting the contact opening to come at progressively earlier time, by turning the microdial toward lower scale readings. The third line represents the final setting of the microdial, where the circuit is opened before the time dot begins and closes just afterwards. Thus the leading edge or nose of the time dot is heard, as indicated in the fourth line. This adjustment can be made to about one-half division on the scale, or 0.005 second.

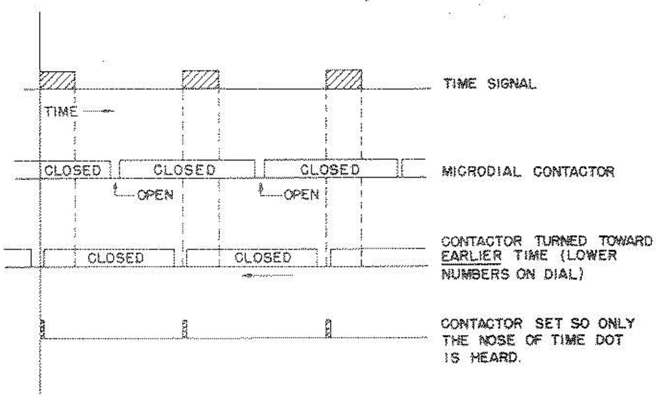


Figure 8. Diagram of time comparison using the Microdial.

SECTION 5.0
SERVICE NOTES

5.1 TYPE 1101-A PIEZO-ELECTRIC OSCILLATOR

5.11 Checking and Adjusting Frequency of Crystal Oscillator: With the crystal oscillator and 100-kc multivibrator in operation, harmonics of the multivibrator will fall at each of the standard frequency transmissions of the U. S. Bureau of Standards. (Station WWV.) Using an oscillating detector (or a receiver with a beating oscillator), adjust to obtain an audible beat tone against the standard harmonic and the standard frequency transmission, in turn. Adjust to obtain about the same strength of signal from the two sources. Then apply both sources simultaneously to the receiver. The resulting output will be the audio beat tone, waxing and waning in intensity. The rate of the waxing and waning is the difference in frequency between the crystal oscillator and the standard frequency transmission. On adjusting C-8 on the rear panel of the Type 1101-A Piezo-Electric Oscillator, the frequency of the oscillator can be set to agree with that of the standard frequency transmission by bringing the rate of waxing and waning to zero. This adjustment is facilitated by using an output voltmeter on the receiver.

Under some conditions of transmission, the standard frequency transmission will be received with rapid changes in amplitude ("fading"), in which case some care must be taken in adjusting for zero beat. Under severe fading conditions, it is sometimes necessary to off-set the crystal oscillator frequency, first on one side and then the other of zero beat, taking the point midway between the two as the zero-beat setting.

Under some transmission conditions, a Doppler change in frequency of the standard frequency transmission can take place for periods of several minutes. Such changes in frequency are only of the order of 1 in 10^8 at most and can usually be neglected.

If in making adjustment of C-8 for zero beat with the standard frequency transmissions, a series of zero-beat points is heard, it is a sign that the quartz crystal is short-circuited and that the oscillator is operating on the tuned-circuit L-2, C-8, C-9, instead of the quartz crystal, Q-1.

If in making adjustment of C-8 for zero beat with the standard frequency transmissions, beat frequencies are heard, but it is not possible to adjust for zero beat, the 100-kc multivibrator is out of control. This may be due to absence of control voltage caused by (1) crystal oscillator not oscillating, (2) poor input amplifier of the 100-kc multivibrator, or (3) faulty wiring or adjustment in control voltage circuits to 100-kc multivibrator input amplifier.

5.12 Adjusting the Amplitude of the Crystal Oscillator: When adjusted at the factory, the resistor R-9 (screw-driver adjustment on rear panel of the Type 1101-A Piezo-Electric Oscillator) is set so that the amplitude of oscillation, as indicated by the microammeter M-1 on the front panel, is 90 ± 10 μa. If, with aging or changes due to shipment, etc., the resistance of the quartz crystal changes, the amplitude of oscillation will change. If the microammeter reading is appreciably outside the range of 80 - 100 μa, R-9 should be adjusted to obtain a meter reading within the range.

When operating under the above conditions the output voltage of the crystal oscillator, as measured with a vacuum-tube voltmeter between the shielded lead connection (pin No.1) and ground at the automatic connector plug (PL-1) should be about 2.0 volts. See Section 5.2 on Type 1102-A Multivibrators for description of access to multivibrator circuits under operating conditions.

5.13 Adjustment of Temperature Control: The amount of power supplied to the compensating thermostat heater is adjusted by variation of R-105, the control being a sunken screw-driver adjustment accessible under the thermometer cover plate on the main panel of the Type 1101-A Piezo-Electric Oscillator. This adjustment is made at the factory and should not require resetting. If it is necessary to make any adjustment, R-105 should be altered in small amounts only to make the thermometer read $60.0°C \pm 0.1°C$. Turning the screw-driver adjustment of R-105 in a clockwise direction raises the operating temperature. After any adjustment of R-105, wait several hours until the temperature has fully stabilized before attempting any further adjustment.

5.14 Failure of Temperature Control: If the temperature drops, the cause is probably a burned-out pilot light, P-101. This light is mounted under the thermometer cover plate, and is readily replaced. The light signals the operation of the thermostat and control relay. At ordinary room temperatures the light lights about every 20 seconds and remains on for about 6 seconds, when the temperature control box is fully up to temperature.

5.2 TYPE 1102-A MULTIVIBRATORS AND POWER SUPPLY

5.21 Servicing of Multivibrator Circuits: Supplied with the equipment are four spacer studs and a servicing cable. If it is necessary to service the multivibrator unit proceed as follows: Remove the four wing nuts of the multivibrator rear panel. Withdraw the panel from the cabinet, breaking the connections at the automatic connector plug under the handle at the top of the panel. Attach the four spacer studs to the four corner posts. Plug in the servicing cable at the connector under the top of the case, and let servicing cable hang over one of the upper spacing studs. REVERSE the multivibrator panel so that the tube side is toward the cabinet and mount on the spacer studs using the wing nuts. Plug in the end of the service cable to the connector at top of multivibrator panel. The multivibrator circuits are now entirely exposed and can be operated in the normal manner. Point-to-point tests with ohmmeter or voltmeter are then very easily made.

5.22 Checking Adjustment of Multivibrators: The adjustment of the multivibrators can be checked with the multivibrator panel in the normal operating position. These checks should be made with all normal multivibrator output connections in place. The control voltage adjustments are normally at the maximum in the clockwise direction.

5.221 To Check the 100-kc Multivibrator: This multivibrator is located in the lower right-hand corner of the multivibrator panel as seen from the rear. Two sunken screw-driver controls are provided: (1) frequency adjustment (R-6 and R-10), marked 100 KC and located near the right edge of the panel and (2) control voltage adjustment (R-1), unmarked and located toward the center of the panel.

Using an 1106-A Frequency Transfer Unit (in Type 1105 Frequency Measuring Equipment), or a communications-type receiver which may be tuned to a harmonic of the 100-kc multivibrator, preferably the 200-kc harmonic, obtain a beat with the harmonic (200-kc) signal by using the beat frequency oscillator (or oscillating detector) of the receiver. Set to a convenient beat frequency, say 500 cycles. Operate the frequency adjustment of the 100-kc multivibrator in both directions until the beat tone suddenly becomes unsteady or jumps to another value. Note the spread between these two points on the frequency control, and take a point midway between as the final adjustment.

The open-circuit output voltage of the 100-kc multivibrator, as measured with a vacuum-tube voltmeter between the output terminal and ground, should be about 8 volts.

5.222 To Check the 10-kc Multivibrator: Using a Type 1106-A Frequency Transfer Unit, or a communications-type receiver, which can be tuned over a range of 100 kc between adjacent multiples of 100 kc, as from 300 to 400 kc, first check the receiver at these two frequencies obtained as harmonics of the 100-kc multivibrator. Next, connect the output of the 10-kc multivibrator to the receiver (replacing the 100-kc multivibrator). Setting the receiver at 310 kc, check that a steady beat tone is obtained. If the tone is unsteady, adjust the 10-kc multivibrator frequency control (located at the upper right edge of the multivibrator panel, as seen from the rear) until a steady tone is obtained. Starting at 300 kc, and calling it "zero", count the number of zero beat points passed through in adjusting the receiver through the range from 300 to 400 kc. If the number of zero beat points is 10, the multivibrator is operating at the correct frequency. Check that the 10-kc multivibrator input control (R-16) is at full clockwise position. If the frequency is not correct, the count obtained will be 9 or 11. In such cases, decrease or increase the multivibrator frequency by adjusting the frequency control (R-21, R-26) until the correct count of 10 is obtained.

When the frequency has been checked as correct, adjust the receiver to give an audible beat tone with a harmonic which is not a multiple of 100 kc, 310 kc for example. Then vary the frequency control in both directions until the beat note suddenly changes. Note the spread between these two points on the frequency control and take a point midway between them as the final adjustment.

If the Type 1105-A Frequency Measuring Equipment is available, checking of the 10-kc multivibrator is readily carried out using the Type 1109-A Comparison Oscilloscope as follows: Connect the output of the 100-kc multivibrator to the X terminals on the panel of the oscilloscope. Throw the CIRCULAR SWEEP FREQUENCY selector switch to 10 KC. Throw the SELECTOR switch to X vs STANDARD CIRCULAR SWEEP position. Adjust sweep diameter as necessary.

If the multivibrator frequency is locked in, a stationary pattern will be seen, appearing somewhat as a gear wheel. If the frequency is correct there will be 10 teeth on the wheel. If the pattern is not stationary, adjust the 10-kc multivibrator frequency control (R-21, R-26) to obtain a stationary pattern, and, if necessary, readjust to obtain the correct number of teeth.

Vary the frequency control in both directions until the 10-tooth pattern blurs or disappears. Note the spread between these two points on the frequency control and take a point midway between them as the final adjustment.

The open circuit output voltage of the 10-kc multivibrator, as measured with a vacuum-tube voltmeter between the output terminal (at right, as seen from the rear) and ground, should be about 60 volts.

5.223 To Check the 1-kc Multivibrator: Where Type 1105-A Frequency Measuring Equipment is available, the 1-kc multivibrator can be checked using the Type 1109-A Comparison Oscilloscope as described above (Paragraph 5.222) by connecting the output of the 10-kc multivibrator at the left rear to the X terminals on the panel of the oscilloscope. Throw the CIRCULAR SWEEP FREQUENCY selector switch to 1 KC. Throw the SELECTOR switch to X vs STANDARD CIRCULAR SWEEP position. Check that the 1-kc input control, (R-33) is in the full clockwise position. Then proceed as described above (Paragraph 5.222), adjusting the 1-kc multivibrator frequency control (R-38, R-43) as required. The frequency control is marked 1 KC and is located at the upper left hand edge of the multivibrator panel as seen from the rear.

The 1-kc multivibrator can also be checked using an audio-frequency oscillator, such as the Type 1107-A Interpolation Oscillator and an ordinary cathode-ray oscilloscope. Connect the 10-kc multivibrator output, at the left rear of the multivibrator unit, to the vertical deflection amplifier of the oscilloscope. Connect the audio-frequency oscillator to the horizontal deflection amplifier. Check that the 1-kc input control (R-33) is in full clockwise position. Adjust the oscillator to 2 kc, when a 5:1 Lissajous figure will be obtained. Adjust the oscillator carefully to make the pattern stand still, then leave the oscillator adjustment alone. Replace the 10-kc vertical deflection input by the 1-kc multivibrator output. A 2:1 stationary Lissajous figure should be obtained, if the 1-kc multivibrator is locked in and is adjusted to correct frequency.

If difficulty is experienced in interpreting the pattern because of distorted waveform connect a capacitance of 0.05 microfarad or more across the vertical deflection input.

If the pattern is not stationary, adjust the 1-kc multivibrator frequency control (R-38, R-43) to obtain a stationary pattern and readjust if necessary to get a 2:1 ratio. The 1-kc multivibrator frequency control is marked 1 KC and is located at the upper left edge of the multivibrator panel as seen from the rear.

Vary the frequency control in both directions until the 2:1 pattern blurs or disappears. Note the spread between these two points on the frequency control; take a point midway between them as the final adjustment.

The open circuit output voltage of the 1-kc multivibrator, as measured with a vacuum-tube voltmeter between the output terminal and ground, should be about 45 volts.

5.224 To Check the 100-cycle Multivibrator: Where the Type 1105-A Frequency Measuring Equipment is available, the 100-cycle multivibrator can be checked using the Type 1109-A Comparison Oscilloscope as described above (Paragraph 5.222) by connecting the output of the 1-kc multivibrator to the X terminals on the panel of the oscilloscope. Throw the CIRCULAR SWEEP FREQUENCY selector switch to 100 ~. Throw the SELECTOR switch to X vs STANDARD CIRCULAR SWEEP position. Check that the 100-cycle multivibrator input control (R-50) is in full clockwise position. Then proceed as in Paragraph 5.222 adjusting the 100-cycle multivibrator frequency control (R-55, R-60) as required. The frequency control is marked 100 ~ and is located at the lower left hand edge of the multivibrator panel as seen from the rear.

The 100-cycle multivibrator can also be checked using an audio-frequency oscillator and an ordinary cathode-ray oscilloscope. Connect the 1-kc multivibrator output to the vertical deflection amplifier of the oscilloscope. Connect the audio-frequency oscillator to the horizontal deflection amplifier. Check that the 100-cycle input control (R-50) is in full clockwise position. Adjust the oscillator to 200 cycles, when a 5:1 Lissajous figure will be obtained. Then proceed as outlined in Paragraph 5.223.

If difficulty is experienced in interpreting the pattern because of distorted waveform, connect a capacitance of 0.05 microfarad, or larger, across the vertical deflection amplifier input.

Vary the frequency control (R-55, R-60) in both directions until the 2:1 pattern blurs or disappears. Note the spread between these two points on the frequency control; take a point midway between them as the final adjustment.

The open circuit output voltage of the 100-cycle multivibrator, as measured with a vacuum-tube voltmeter between output and ground, should be about 40 volts.

5.3 TYPE 1103-A SYNCRONOMETER

The Type 1103-A Syncronometer requires little attention. The bearings are all sealed ball-bearings requiring no lubrication. A very small amount of light oil may be placed on the vertical and horizontal worm gears about once a year. Occasionally, a squeak may develop at the cam shoe of the microdial, in which case a very little light oil may be placed on the cam face.

TEST DATA

on

TYPE 1100-____ FREQUENCY STANDARD

Type 1103-A Syncronometer
Serial No. __________

Type 1102-A Multivibrators and Power Supply Unit
Serial No. __________

Type 1101-A Piezo-Electric Oscillator
Serial No. __________
Frequency Adjust __________ div.
Temperature __________ °C.
Diode Meter Reading __________ μa.

Type 1190-A Quartz Bar
Serial No. __________

TYPE 1105-A

FREQUENCY MEASURING EQUIPMENT

Type 1107-A Interpolation Oscillator
Serial No. __________

Type 1109-A Comparison Oscilloscope
Serial No. __________

Type 1106-A Frequency Transfer Unit
Serial No. __________

Type 1106-B Frequency Transfer Unit
Serial No. __________

Type 1106-C Frequency Transfer Unit
Serial No. __________

Type 1108-A Coupling Panel
Serial No. __________

DATE: __________________ No. ____ OBSERVER: __________________

COMPONENTS FOR OSCILLATOR

RESISTORS			TYPE
R-1	= 220 Ohms	±10%	REC-20BF
R-2	= 47 K Ohms	±10%	REC-20BF
R-3	= 390 Ohms	±10%	REC-20BF
R-4	= 1.0 Megohms	±10%	REC-20BF
R-5	= 560 Ohms	±10%	REC-20BF
R-6	= 2200 Ohms	±10%	REC-30BF
R-7	= 2700 Ohms	±10%	REC-30BF
R-8	= ✳ Ohms	±5%	REC-20BF
R-9	= 2000 Ohms		301-465-2
R-10	= 370 Ohms	±1%	REF-1
R-11	= 2700 Ohms	±10%	REC-30BF
R-12	= 2700 Ohms	±10%	REC-30BF
R-13	= 15 K Ohms	±10%	REC-30BF
R-14	= 4700 Ohms	±10%	REC-30BF
R-15	= 47 Ohms	±10%	REC-20BF

✳ For values of R-8 see Miscellaneous below

CONDENSERS

C-1	= 1.0 μf		COL-5
C-2	= 0.5 μf		COL-4
C-3	= 7-140 μμf		COA-51
C-4	= 0.0003 μf	±2%	COM-45C
C-5	= 0.02 μf	±10%	COM-50B
C-6	= 0.01 μf	±10%	COM-45B
C-7	= 0.5 μf		COW-3
C-8	= 13-320 μμf		COA-12
C-9	= 0.00025μf	±2%	COM-45C
C-10	= 0.5 μf		COW-3
C-11	= 0.02 μf	±10%	COM-50B
C-12	= 0.01 μf	±10%	COM-45B
C-13	= 0.01 μf	±10%	COM-35B

MISCELLANEOUS

L-1	= Inductor	379-34-2 for 50 kc	
L-2	= Inductor	379-34-2 for 50 kc	
R-8	= ✳	2700 Ω±5% for 50 kc	
L-1	= Inductor	379-39-2 for 100 kc	Standard
L-2	= Inductor	379-39-2 for 100 kc	Standard
R-8	= ✳	680 Ω ±5% for 100 kc	Standard

M-1 = Meter 0-200 μ amp. Weston 506 MED-22

PL-1 = Plug CDMP-463-6

Q-1 = Quartz Bar 1190-A (100 kc)

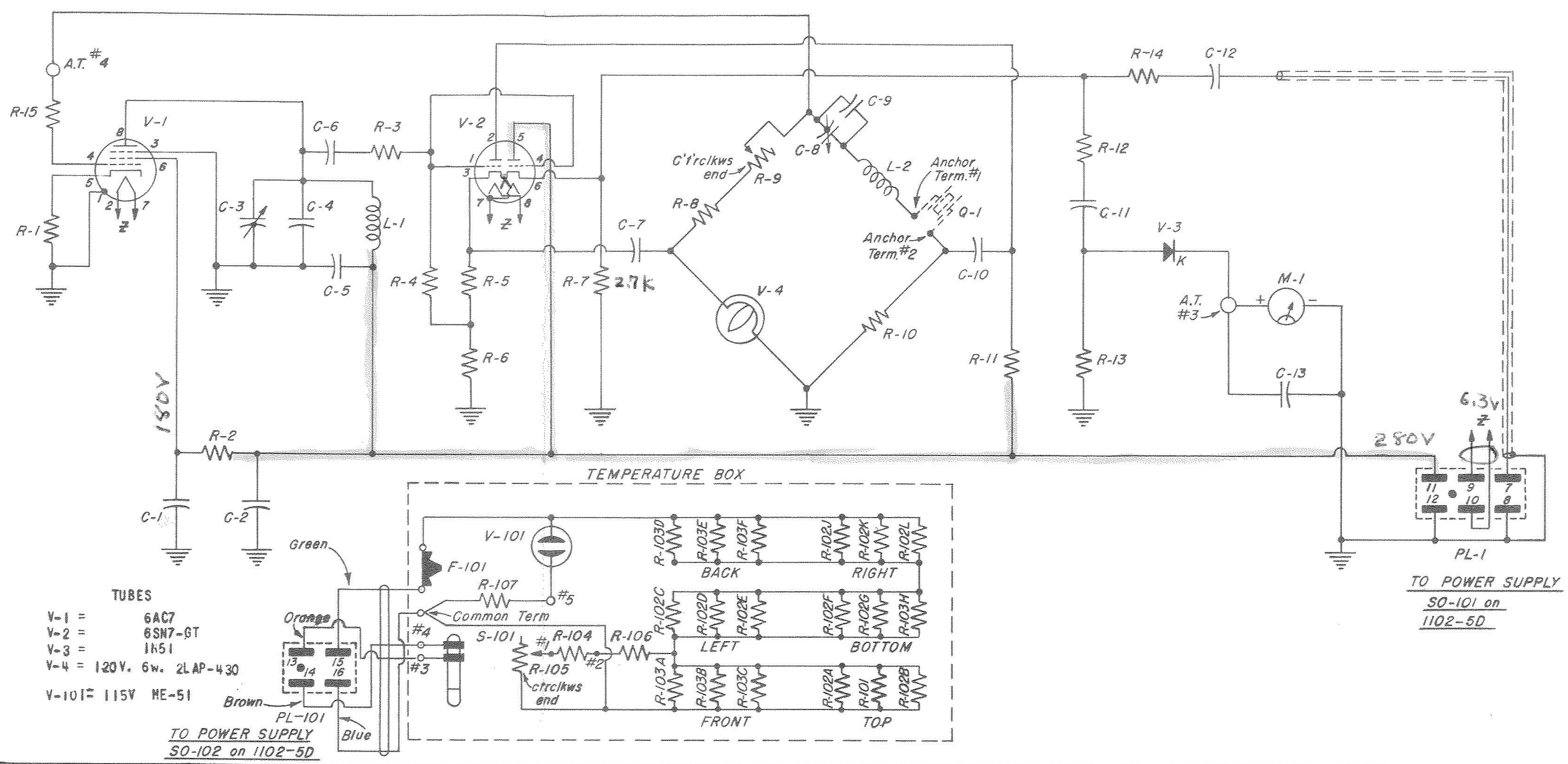
COMPONENTS FOR TEMPERATURE BOX

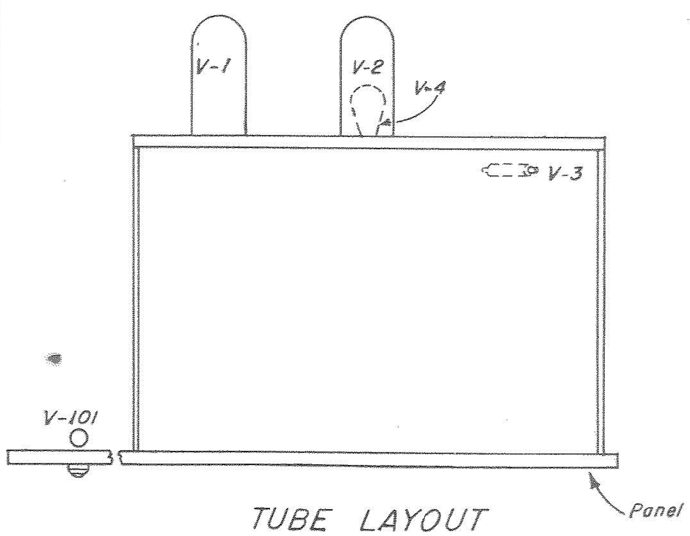
R-101	= REPO-4, 1 Req.	18, 1000 Ω 3 sets of 6 resistors in parallel. Three sets in series.	
R-102A-L	= REPO-6, 11 Req.		
R-103A-F	= REPO-7, 6 Req.		
R-104	= 260 Ohms	±5%	1101-26
R-105	= 2000 Ohms		POSW-3
R-106	= 1000 Ohms	±10% IRC	TYPE BW-1/2
R-107	= 82 kΩ	±10%	REC-20 BF
F-101	= Fusible Link		547-50

S-101 = Thermostat TH-503. 60

PL-101 = Plug CDMP-465-4

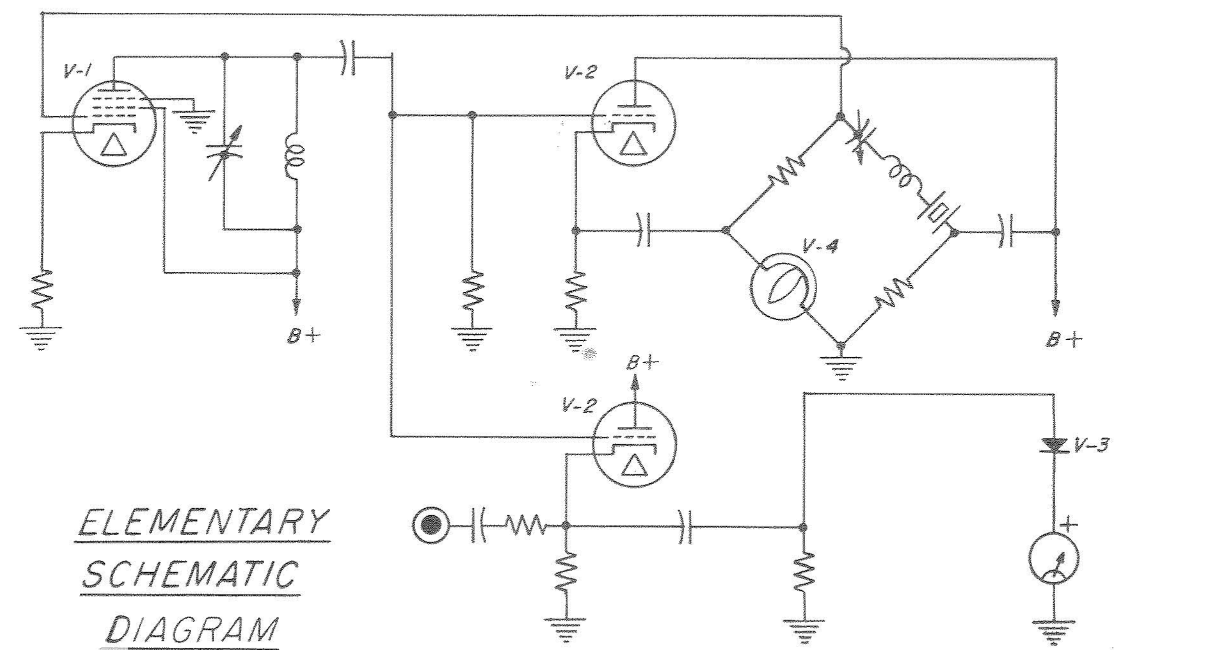
WIRING DIAGRAM FOR 1101A PIEZO ELECTRIC OSCILLATOR





TUBE LAYOUT

TOP VIEW OF INSTRUMENT



ELEMENTARY SCHEMATIC DIAGRAM

DWG. NO. 1102-5D

RESISTORS

R-101 = 1800 Ohms ±10% IRC TYPE BW-1
R-102 = 100 Ohms ±10% IRC TYPE BW-1/2
R-103 = 1 Megohm ±10% IRC TYPE BTA

CONDENSERS

C-101 = 16 µf COE-4
C-102 = 0.1 µf COL-2
C-103 = 0.01 µf ±10% CD Type 3L
C-104 = 0.01 µf ±10% CD Type 3L
C-105 = 4.0 µf ±10% COL-8
C-106 = 4.0 µf ±10% COL-8
C-107 = 4.0 µf ±10% COL-8

SWITCHES

S-101 = DPST SWT-333
S-102 = DPST SWT-333
S-103 = RELAY SRE-5

TRANSFORMERS

T-101 = 565-407
T-102 = 485-462

INDUCTORS

L-101 = 485-476
L-102 = 1102-26

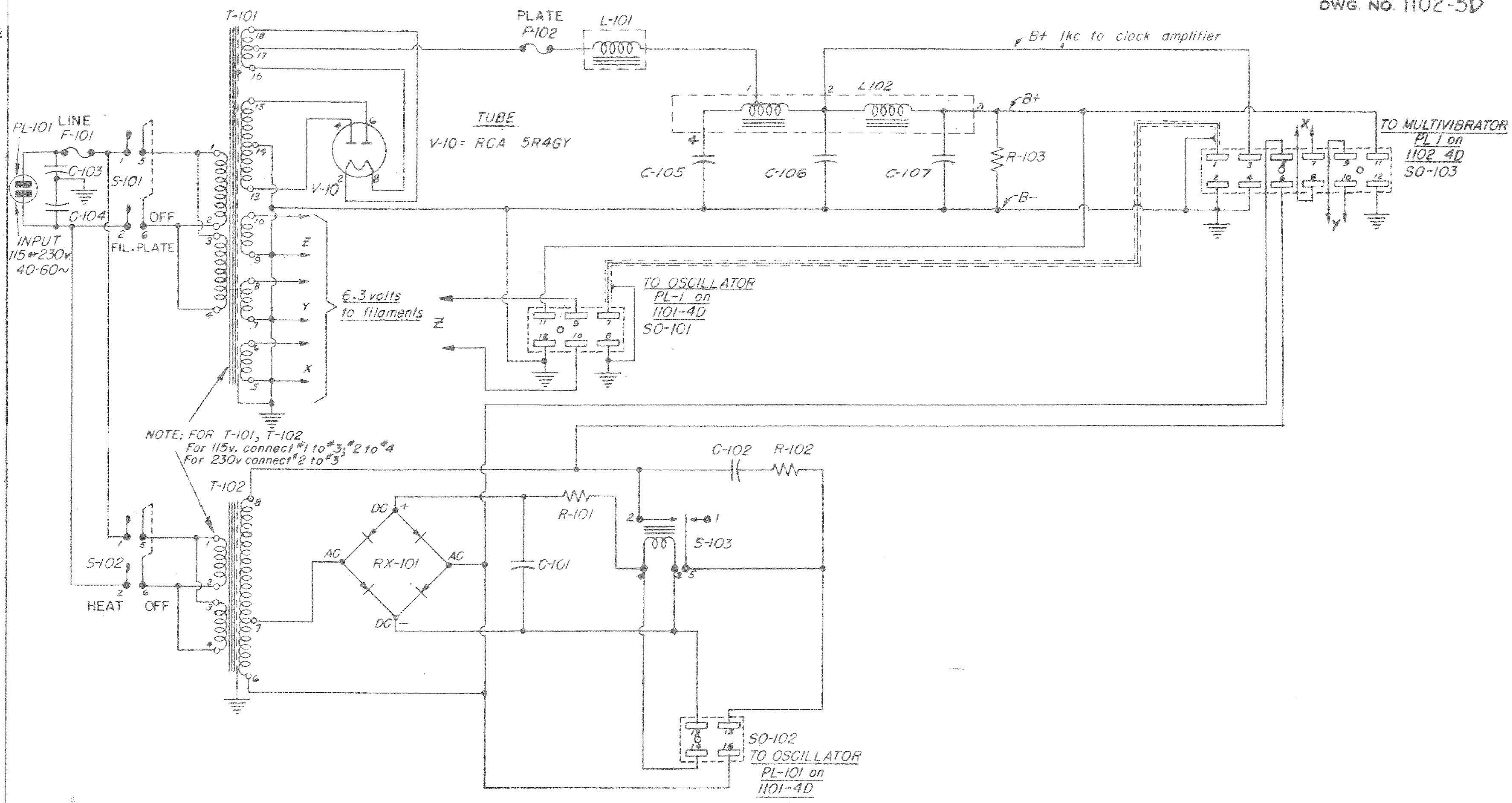
FUSES

For 115v. 50-60∿ input:
F-101 = 2 amp. Slow Blow 3AG GR FUF-1
For 230v. 50-60∿ input:
F-101 = 1 amp. Slow Blow 3AG GR FUF-1
For 115v. 40∿ input:
F-101 = 3.2 amp. Slow Blow 3AG GR FUF-1
For 230v. 40∿ input:
F-101 = 1.6 amp. Slow Blow 3AG GR FUF-1

F-102 = 0.5 amp. 3AG GR FUF-2

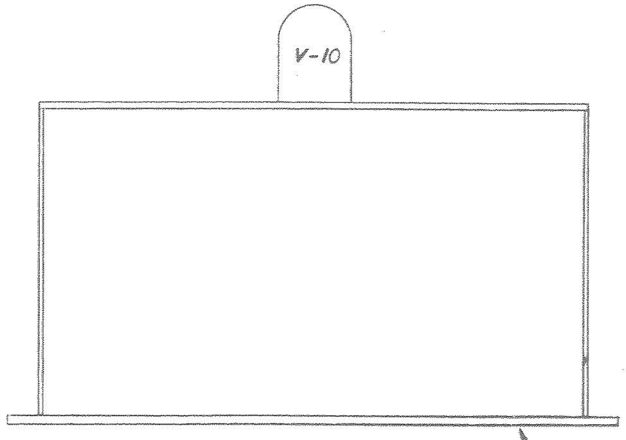
RECTIFIER

RX-101 = 2RE-1400-3



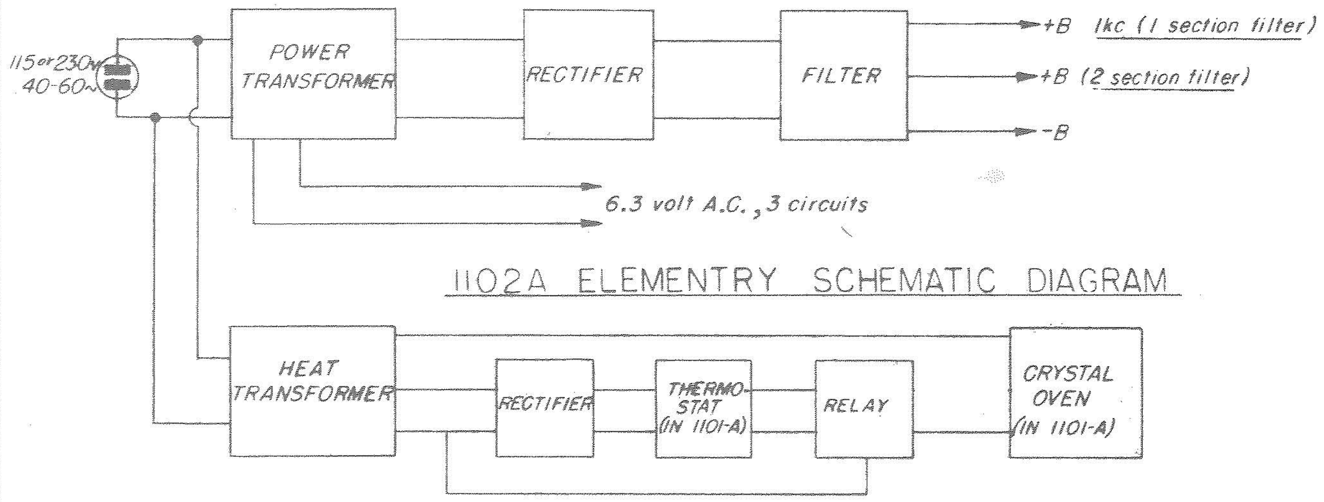
WIRING DIAGRAM FOR 1102A MULTIVIBRATORS & POWER SUPPLY

(POWER SUPPLY SECTION, FOR MULTIVIBRATOR SEE DWG 1102-4D)



TUBE LAYOUT

TOP VIEW OF INSTRUMENT



1102A ELEMENTRY SCHEMATIC DIAGRAM

RESISTORS

R-1 =	50 K Ohms		301-466
R-2 =	1 Megohm	±10%	REC-30BF
R-3 =	470 Ohms	±10%	REC-20BF
R-4 =	2700 Ohms	±10%	REC-30BF
R-5 =	2500 Ohms	±1%	REPR-16
R-6 =	2 K Ohms		Part of 1102-305
R-7 =	5 K Ohms	±1%	REPR-16
R-8 =	20 K Ohms	±1%	REPR-16
R-9 =	2500 Ohms	±1%	REPR-16
R-10 =	2 K Ohms		Part of 1102-305
R-11 =	20 K Ohms	±1%	REPR-16
R-12 =	1 Megohm	±10%	REC-30BF
R-13 =	1 K Ohm	±10%	REC-30BF
R-14 =	2 K Ohms	±5%	REPO-16
R-15 =	47 K Ohms	±10%	REC-30BF
R-16 =	50 K Ohms		301-465
R-17 =	1 Megohm	±10%	REC-30BF
R-18 =	470 Ohms	±10%	REC-20BF
R-19 =	2700 Ohms	±10%	REC-30BF
R-20 =	10 K Ohms	±1%	REPR-16
R-21 =	5 K Ohms		Part of 1102-306
R-22 =	5 K Ohms	±1%	REPR-16
R-23 =	20 K Ohms	±1%	REPR-16
R-24 =	20 K Ohms	±1%	REPR-16
R-25 =	10 K Ohms	±1%	REPR-16
R-26 =	5 K Ohms		Part of 1102-306
R-27 =	20 K Ohms	±1%	REPR-16
R-28 =	20 K Ohms	±1%	REPR-16
R-29 =	1 Megohm	±10%	REC-30BF
R-30 =	470 Ohms	±10%	REC-30BF
R-31 =	2 K Ohms	±5%	REPO-16
R-32 =	47 K Ohms	±10%	REC-30BF
R-33 =	20 K Ohms		301-465
R-34 =	1 Megohm	±10%	REC-30BF
R-35 =	470 Ohms	±10%	REC-20BF
R-36 =	2700 Ohms	±10%	REC;30BF
R-37 =	30 K Ohms	±1%	REPR-16
R-38 =	20 K Ohms		Part of 1102-307
R-39 =	5 K Ohms	±1%	REPR-16
R-40 =	10 K Ohms	±1%	REPR-16
R-41 =	30 K Ohms	±1%	REPR-16
R-42 =	30 K Ohms	±1%	REPR-16
R-43 =	20 K Ohms		Part of 1102-307
R-44 =	10 K Ohms	±1%	REPR-16
R-45 =	30 K Ohms	±1%	REPR-16
R-46 =	1 Megohm	±10%	REC-30BF
R-47 =	10 K Ohms	±10%	REC;30BF
R-48 =	2 K Ohms	±5%	REPO-16
R-49 =	47 K Ohms	±10%	REC-30BF
R-50 =	20 K Ohms		301-465
R-51 =	1 Megohm	±10%	REC-30BF
R-52 =	470 Ohms	±10%	REC-20BF
R-53 =	2700 Ohms	±10%	REC-30BF
R-54 =	30 K Ohms	±1%	REPR-16
R-55 =	20 K Ohms		Part of 1102-307
R-56 =	5 K Ohms	±1%	REPR-16
R-57 =	10 K Ohms	±1%	REPR-16
R-58 =	30 K Ohms	±1%	REPR-16
R-59 =	30 K Ohms	±1%	REPR-16
R-60 =	20 K Ohms		Part of 1102-30
R-61 =	10 K Ohms	±1%	REPR-16
R-62 =	30 K Ohms	±1%	REPR-16
R-63 =	1 Megohm	±10%	REC-30BF
R-64 =	10 K Ohms	±10%	REC-30BF
R-65 =	10 K Ohms	±10%	REC-30BF
→ R-66 =	2 K Ohms	±5%	REPO-16
R-67 =	10 K Ohms	±10%	REC-30BF
R-68 =	33 K Ohms	±10%	REC-30BF
R-69 =	47 K Ohms	±10%	REC-30BF
R-70 =	1.0 Megohm	±10%	REC-30BF
R-71 =	100 K Ohms	±10%	REC-20BF

CONDENSERS

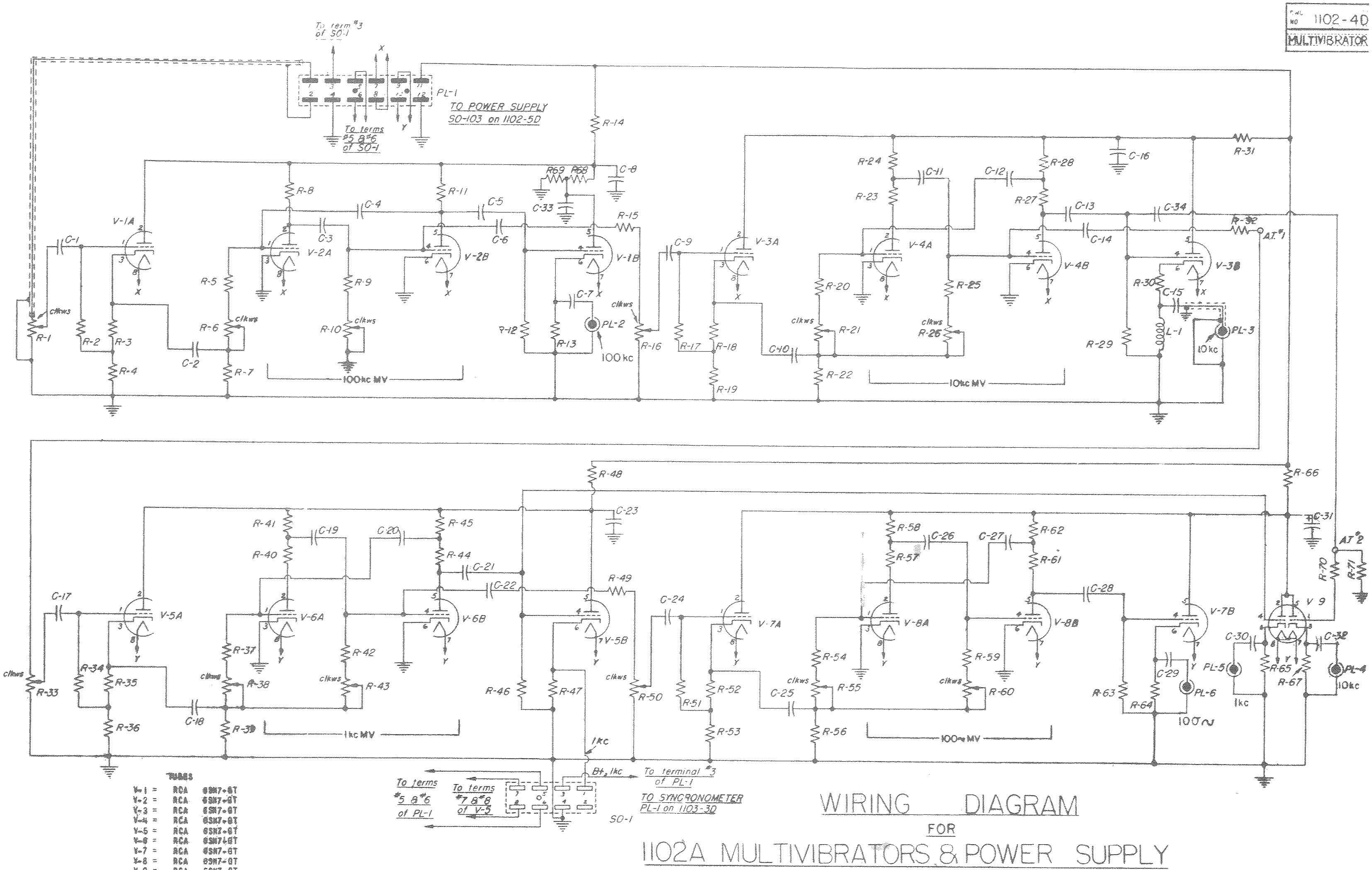
C-1 =	0.001 µf	±10%	COM-45B
C-2 =	0.002 µf	±10%	COM-45B
C-3 =	0.000325 µf	±2%	COM-45B*
C-4 =	0.000325 µf	±2%	COM-45B*
C-5 =	0.000100 µf	±10%	COM-45B
C-6 =	0.000020 µf	±10%	COM-45B
C-7 =	0.004 µf	±10%	COM-45B
C-8 =	1.0 µf		COL-5
C-9 =	0.001 µf	±10%	COM-45B
C-10 =	0.01 µf	±10%	COM-50B
C-11 =	0.001520 µf	±2%	COM-45B*
C-12 =	0.001520 µf	±2%	COM-4
C-13 =	0.000500 µf	±10%	COM-45B
C-14 =	0.000200 µf	±10%	COM-45B
C-15 =	0.004 µf	±10%	COM-45B
C-16 =	2.0 µf		COL-6
C-17 =	0.001 µf	±10%	COM-45B
C-18 =	0.02 µf	±10%	COM-50B
C-19 =	0.005115 µf	±2%	COM-45B*
C-20 =	0.005115 µf	±2%	COM-45B*
C-21 =	0.01 µf	±10%	COM-45B
C-22 =	0.002 µf	±10%	COM-45B
C-23 =	4.0 µf (2, 2.0 µf in //)		COL-6
C-24 =	0.002 µf	±10%	COM-45B
C-25 =	0.025 µf	±10%	COM-50B
C-26 =	0.0627 µf	±2%	COM-45B*
C-27 =	0.0627 µf	±2%	COM-45B*
C-28 =	0.025 µf	±10%	COM-50B
C-29 =	0.5 µf		COL-4
C-30 =	0.5 µf		COL-4
C-31 =	20.0 µf		COE-5
C-32 =	0.03 µf	±10%	COM-50B
C-33 =	1 µf		COL-5
C-34 =	0.0002µf	±10%	COM-45B

*Tolerance on sum of these condensers equals ±2 although tolerance on individual condensers each group may be ±10%.

INDUCTOR

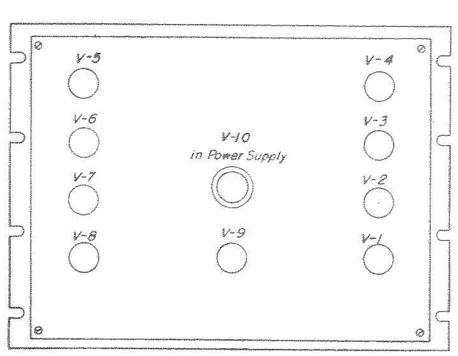
L-1 =	379-35-2

DWG NO 1102-4D
MULTIVIBRATOR

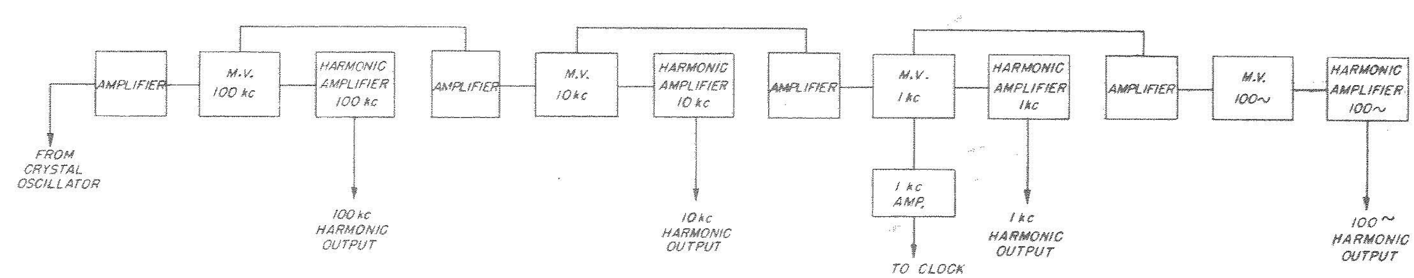


WIRING DIAGRAM
FOR
1102A MULTIVIBRATORS & POWER SUPPLY
(MULTIVIBRATOR SECTION, FOR POWER SUPPLY SEE DWG 1102-5D)

TUBE LAYOUT



REAR VIEW OF INSTRUMENT



1102A ELEMENTARY SCHEMATIC DIAGRAM

RESISTORS		TYPE
R-1 =	50 K Ohms	301-469
R-2 =	25 K Ohms ±10% IRC	REC-30 BF
R-4 =	1 K Ohms ±10% IRC	REW-4C
R-5 =	0.1 Megohm ±10% IRC	REC-30BF

CONDENSERS		TYPE
C-1 = 0.05 µf	±10%	COM-50B
C-2 = 2 µf	±10%	COL-6
C-3 = 0.025 µf (1200V. DCWV)	±10% (2 X 0.0125 in //)	COM-50B
C-4 = 1 µf	±10%	COL-5

TRANSFORMERS

T-1 = 345-H
T-2 = 693-30

SWITCHES

S-1 = SWT-323 N.B. (S.P.S.T.)
S-2 = SWP-809 (S.P.S.T.)

PILOT LAMP

P-1 =
P-2 =
P-3 =
P-4 =
} 2LAP -939 (6.3V.) Mazda #44)

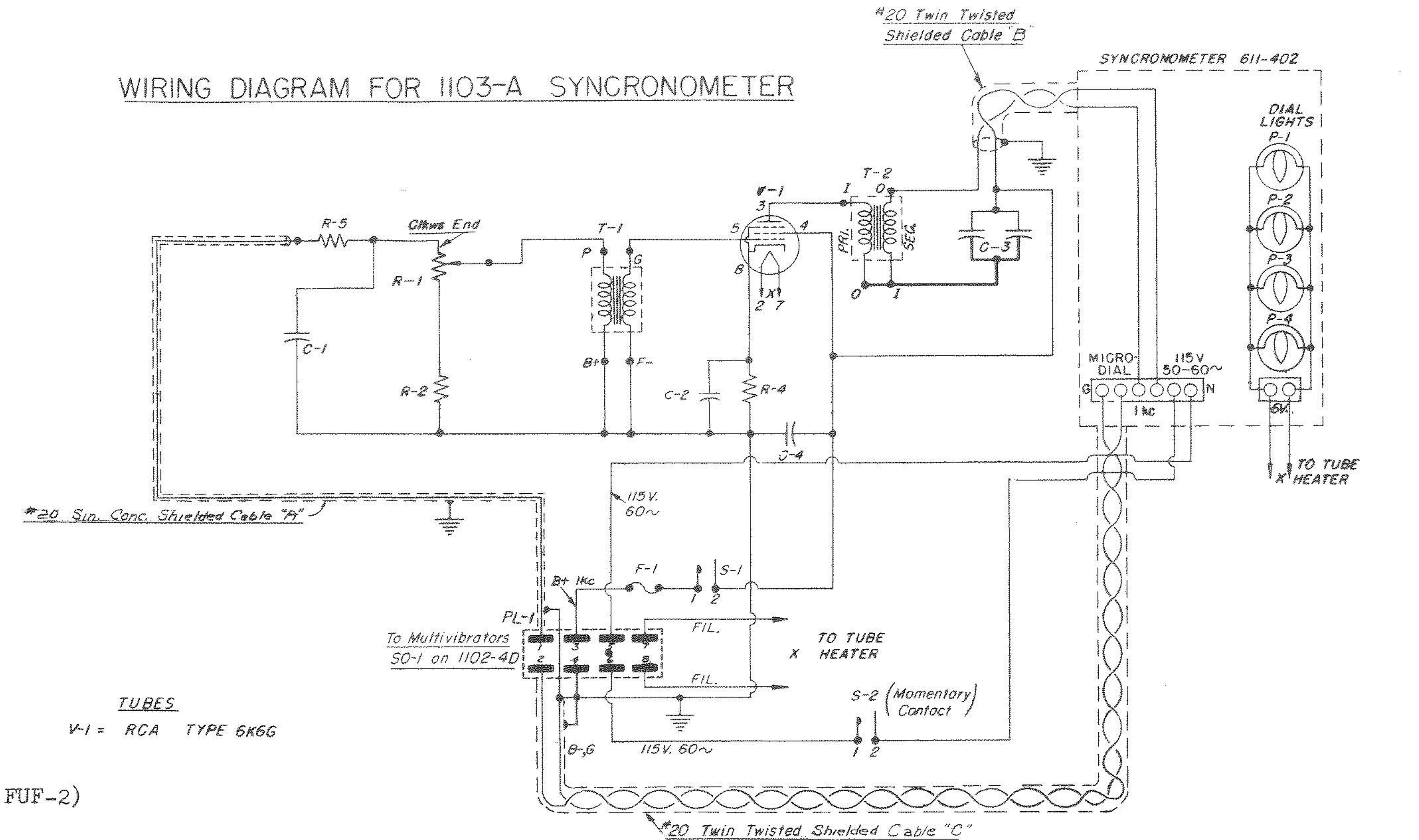
TUBES

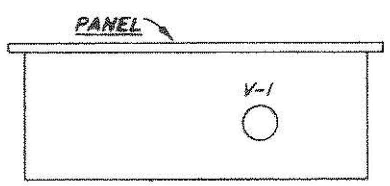
V-1 = RCA TYPE 6K6G

FUSES

F-1 = 0.2 Amp. Bussmann Type 3AG (GR FUF-2)

WIRING DIAGRAM FOR 1103-A SYNCRONOMETER





TUBE LAYOUT
PLAN VIEW

ELEMENTARY SCHEMATIC DIAGRAM