# INSTRUCTION MANUAL

# MODEL 2.5 FREQUENCY STANDARD

SULZER LABORATORIES, INC.

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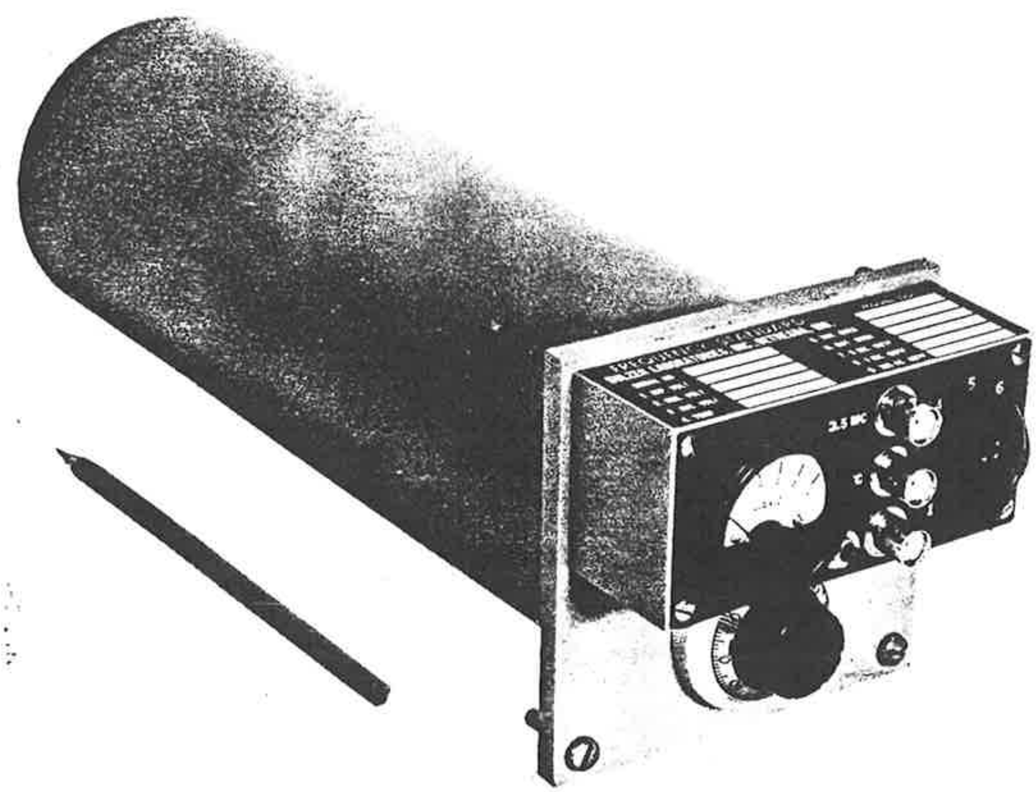
SERIAL NO. /

SULZER LABORATORIES, INC.

621 LOFSTRAND LANE

ROCKVILLE, MD.

# SULZER LABORATORIES
# Model 2.5
# FREQUENCY STANDARD



A compact, rugged, but highly stable quartz crystal oscillator is being produced by Sulzer Laboratories, Inc. This all-silicon, solid-state unit, which has been designed for use as a laboratory frequency standard, is also suitable for use in timing and synchronous communication systems.

The outputs (1 volt to 50 ohms) at frequencies of 2.5 Mc, 1 Mc, and 100 Kc, are guaranteed stable to $1 \times 10^{-10}$ or better over a period of 24 hours, with moderate ambient-temperature variations, with power-supply variations from 22 to 32 volts (at $\frac{1}{3}$ ampere), and for any moderate load variations. The short term stability is better than $8 \times 10^{-11}$ over 1 second and $8 \times 10^{-10}$ over 0.1 second. The output frequency is adjustable over a range of $100 \times 10^{-9}$ with a front panel control, which has a constant sensitivity of $5 \times 10^{-11}$ per division. A companion power supply with standby battery, and rack mount are also available. See other side for more complete details.

# MODEL 2.5 FREQUENCY STANDARD

The frequency standard employs silicon transistors and diodes. All components, which are of the highest quality, have been selected to meet military standards whenever practicable. The crystal unit is the 2.5 megacycle military type designed by Warner of Bell Telephone Labs, which will withstand a shock of 30G with a frequency change after shock of less than $1 \times 10^{-7}$. The crystal unit is mounted in a double, proportionally-controlled oven.

The frequency dividers, which are of the regenerative fail-safe type, are started manually by a front-panel push button.

The equipment has been designed for easy access to all important components with no sacrifice in strength or rigidity.

**OUTPUT**

1 volt $-20\% +50\%$ to 50 ohm loads at 2.5 Mc, 1 Mc, and 100 Kc simultaneously, available at front panel connectors and through a connector at rear of front panel.

**STABILITY**

(maximum $\Delta f/f$ for condition or change noted)

| | |
|---|---|
| (a) Input 27VDC changed $\pm 5$V: | $\pm 1 \times 10^{-10}$ |
| (b) Load 50 ohms changed $\pm 20\%$: | $\pm 1 \times 10^{-10}$ |
| (c) Ambient temp. 20°C changed $\pm 15$°C: | $\pm 2 \times 10^{-10}$ |
| (d) Time, 24 hours (after 1 month of operation) | $\pm 1 \times 10^{-10}$ |
| (e) Time, 24 hours, (at time of shipment) | $\pm 3 \times 10^{-10}$ |
| (f) Time, 0.1 sec.: | $8 \times 10^{-10}$ RMS |
| (g) Time, 1 sec.: | $8 \times 10^{-11}$ RMS |

**INPUT**

22-32 VDC at approximately 0.33

**FREQUENCY ADJUST**

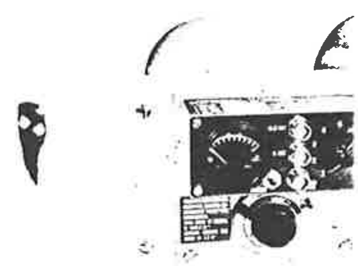
$100 \times 10^{-9}$ from front panel, appro. division. Internal adjustment approxi

**SIZE**

4½ inches square at front panel, wh extends 11¾ inches behind front pa 4 inches. The clearance required in f is 2¼ inches, excluding connectors. mounted from the bottom, or can be b A rack mount with 5¼ inch by 19 inch for one or more standards alone, or ards with choice of various power batteries.

**WEIGHT**

Approximately 6½ pounds.



Frequency Standard with 5¼ inch by 19 inch Rack

# MODEL 5P POWER SUPPLY

The power supply employs silicon transistors and diodes, and sealed nickel-cadmium cells. All components, which are of the highest quality, have been chosen to meet military standards whenever practicable.

**OUTPUT**

27 volts at a maximum of 500 ma. When charging the self-contained battery from a 60-cycle source the ripple will not exceed 20 millivolts.

**INPUT**

105-125 volts, 48-400 cps. The unit will withstand inputs as high as 135 volts without damage, but sustained operation at such a high voltage is not recommended without changing the transformer-secondary taps.

**BATTERY CAPACITY**

3 ampere-hours minimum at a 500-ma. battery. An external battery of grea used if desired. A voltage-sensitive c protect the battery from cell reversal i tended power failure. The batteries charge at 50 ma; however, a higher by means of a front-panel switch if a quired.

**AMBIENT-TEMPERATURE R**

$-28°$ to $+65$°C.

**SIZE**

4½ inches square at front panel, which extends 11¾ inches behind front panel 4¼ inches. The clearance required in fr is 2¼ inches. The power supply can be the bottom, or it can be bolted through

**WEIGHT**

Approximately 12 pounds.

**SULZER LABORATORIES INC.**
621 Lofstrand Lane,
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# SECTION 1

## GENERAL DESCRIPTION, INSTALLATION

### General Description

The Model 2.5 frequency standard generates highly stable output frequencies of 2.5 Mc, 1 Mc, and 100 Kc. Each of these outputs has excellent waveform and spectral purity. The instrument employs a high-quality, ruggedized 2.5-Mc quartz crystal unit which, with special oscillator circuitry, is mounted in a double, proportional oven. A highly stabilized feedback amplifier is used in connection with a suitably designed AVC system to maintain the crystal power at the low, constant value that is necessary to attain high frequency stability.

The equipment utilizes high-quality silicon transistors and diodes throughout. Other component parts have been chosen for reliability and long life. To facilitate servicing, the structure has been designed for easy access to all important components.

The mechanism associated with the 10-turn frequency-control dial has been machined with great care to permit the frequency to be set or reset to a few parts in $10^{11}$ while placing little or no mechanical stress upon the glass piston capacitor.

This frequency standard is an excellent frequency source for laboratory measurements, for primary frequency and time-standard systems, and for mi rowave spectroscopy. Its output, 1 v RMS to a 50-ohm load, is sufficient to drive most other commercial clocks, multipliers and frequency dividers.

Various types of companion rack mounts and power supplies are available from Sulzer Laboratories, Inc. to meet a wide range of requirements.

### Inspection

The frequency standard was tested and inspected before shipment. A copy of the test results will be found on the page following the specif cations. After the standard is unpacked, it should be inspected for damage. If damage is apparent, a claim should be filed with the carrier. A report should be obtained from the claim agent and forwarded to us. We will then notify you regarding the return of the equipment.

Installation

If the standard alone is to be mounted by the customer, it can be shelf mounted by means of the 8-32 holes tapped in the bottom of the front panel and rear clamp, or it can be fastened through a bulkhead with the aid of the studs that appear at the rear of the front panel. In either case, adequate support must be provided for the rear of the container, particularly if the equipment is to be subjected to shock or vibration during operation or shipment. This support is normally provided by the clamp mentioned above. If a bulkhead mount is contemplated, the clamp must be fastened against the bulkhead using the side plates that are assembled to the clamp. The rear clamp and side plates are not normally supplied for laboratory use.

The equipment should be mounted in a suitable rack or cabinet. If the enclosure is to contain other equipment as well, adequate ventilation should be provided to prevent the temperature from exceeding 35° C.

The frequency standard requires a dc power supply, which need not be well regulated. It should be able to deliver a minimum of 24 volts at a maximum current of 1/2 ampere. The ripple should be less than 100 mv RMS. Power is applied at the rear of the front panel with the connector and cable supplied with the equipment. The red lead is positive, violet negative, and the shields connect to the chassis ground. There are no power-supply grounds within the standard, so that either power-supply lead can be grounded, but polarity must be observed. The three output frequencies are available through this cable, and also, at the front panel. The dc output of the power supply must be fused for 1 ampere, using a fast-acting fuse.

If the standard is ordered with a power supply, the plug on the end of the power-supply cable will mate directly with the receptacle on the rear of the standard.

SECTION 2

OPERATING INSTRUCTIONS

Controls

The frequency standard contains but two external controls; a frequency dial, and a meter switch. The frequency dial is of the multi-turn type, with approximately 2000 useful divisions in approximately 20 turns. The tuning range is $1 \times 10^{-7}$, producing a frequency change of approximately $5 \times 10^{-11}$ per division. The standard is shipped with its frequency adjusted to that of WWV within $1 \times 10^{-10}$. Since the crystal will age upward in frequency, the dial is set toward the upper part of its range so that a maximum amount of negative compensation can be applied. The dial setting will then have to be decreased as the crystal unit ages. Eventually the control may reach the end of its range. It will then be necessary to remove the frequency standard from its enclosure to permit adjustment of the internal coarse frequency control, as discussed below.

If the frequency standard has been permitted to cool during shipment, a frequency offset as great as $2 \times 10^{-8}$ may occur, which will require readjustment of the oscillator frequency control.

The meter switch, in connection with the meter is used to monitor the various principal parts of the standard. On the INPUT VOLTS position the power-supply voltage is measured. Midscale corresponds to 25 volts. REG. V. indicates the output of the voltage regulator, which is normally 16 to 18 volts on a 25-volt scale. AVC indicates, on an arbitrary scale, the voltage developed by the AVC system in the oscillator. Readings here are relative, and should only be compared with those mentioned below. In the TEMP position the meter is connected to a thermistor bridge that monitors the inner oven. The normal indication here is zero, when the inner oven has attained its final temperature. When switched to the INNER OVEN, the meter reads the voltage across the inner-oven heater, with a full-scale value of 15 volts. In the OUTER OVEN position, the outer-oven voltage is monitored with 25 volts full scale. The presence of an output at each of the three frequencies is indicated by the three remaining meter-switch positions. The readings tabulated are those obtained with 50-ohm loads on the outputs. The indications will vary inversely with loading because the meter rectifiers are connected at an intermediate point in the output filters. The meter reading may actually be zero with no load.

When the equipment is first turned on, the meter may read full scale or higher on the TEMP, INNER OVEN, and OUTER OVEN positions. After 2 or 3 hours of operation, the normal readings should be obtained. These are tabulated on a plate mounted on the top of the control box. The outer-oven voltage will vary greatly with ambient temperature. The value above corresponds to a temperature of $25^{\circ}$ C. If the ambient temperature approaches $40^{\circ}$ C, the outer-oven current will approach zero. The meter switch must be left in the TEMP position when other readings are not being taken. Switching to OSC BIAS will produce a small frequency change, and therefore the switch should not be left in this position. It should be mentioned here that the frequency standard will require 48 hours or more to attain full frequency stability. The initial frequency setting should not be changed during this period.

## SECTION 3

## CIRCUIT DESCRIPTION

### Theory

The operating frequency of the standard is controlled by $Y_1$, which is a high-quality crystal unit. This crystal unit is designed to operate at 2.5 Mc, which is the 5th overtone of its fundamental frequency. To maintain a constant frequency, the crystal unit must be kept at a constant temperature, and must be kept in oscillation at a very low, constant power level. It is the sole purpose of the frequency standard to provide this environment for the crystal unit while furnishing the necessary output frequencies and powers.

The oscillator proper contains $Q_1$, which appears at the upper left-hand corner of the schematic diagram. It is of the modified Pierce type, with the crystal connected between base and ground through a frequency-setting network containing the coarse frequency control $C_2$, the fine frequency control $C_3$, and an inductor $L_1$, which is used to adjust the oscillator to the correct frequency and compensate for crystal-manufacturing tolerances.

To keep the crystal power sufficiently low it is necessary to use an amplitude-control system, which consists of AVC amplifier $Q_2$ - $Q_4$, and crystal diodes $CR_2$ and $CR_3$. When the crystal oscillator is first energized its amplitude of oscillation is very low. The oscillator output is amplified by $Q_2$, $Q_3$, and $Q_4$ and, when it becomes sufficiently great, crystal diodes $CR_2$ and $CR_3$ start to rectify.

The DC output of the rectifiers decreases the base current applied to transistor $Q_1$, decreasing its transconductance, and therefore tending to decrease the amplitude of oscillation. An equilibrium is reached at an acceptable value of crystal power, which is approximately 1/4 microwatt.

The output of the AVC amplifier is further amplified by buffer $Q_{18}$, and is used to drive the 2.5 Mc amplifier $Q_{30}$. The output of this amplifier is 1 volt to a 50-ohm load.

The buffer also drives $Q_{19}$ and $Q_{20}$, and $Q_{21}$ and $Q_{22}$, which comprises a regenerative frequency divider. In this circuit, $Q_{19}$ and $Q_{20}$ function as a mixer producing an output at 500 kc. Transistors $Q_{21}$ and $Q_{22}$ multiply this frequncy four times, and the resulting 2 Mc output drives the mixer, which also receives 2.5 Mc from $Q_{18}$. A transient, which is produced by pressing the start button, produces 500 kc in the collector tuned circuit of $Q_{19}$ and $Q_{20}$, initiating the regenerative process, which then continues. Division by 5 to 100 kc is accomplished by $Q_{23}$, $Q_{24}$, $Q_{25}$, and $Q_{26}$ in a similar manner. Starting transients for the two dividers are produced by relay $K_1$ which is controlled by $Q_{29}$. Once the dividers have started, $Q_{29}$ is cut off by diodes $CR_9$ and $CR_{10}$ so that the start button will have no effect. Output amplifiers are provided at 1 Mc and 100 kc. These also deliver 1 volt to a 50-ohm load. The 1 Mc signal is produced by doubling 500 kc.

The crystal temperature is maintained at a constant value by means of a two-stage oven. The inner oven, which employs the inner-oven controller $Q_5$ -$Q_7$, $Q_8$, -$Q_9$, is operated at the so-called turning point of the crystal unit, which is a minimum on the frequncy vs. temperature characteristic of the crystal. Operation here provides the minimum rate of change of frequency with temperature.

The temperature controller contains a 3-stage amplifier $Q_5$ - $Q_7$, which is tuned to a frequency approximately of 25 kc. Connected between the output and the input of the amplifier is a bridge circuit which consists of the two halves of the secondary of $T_3$, $R_{23}$ and $R_{24}$ in series, and thermistor $RT_1$. When the oven is below its operating temperature, the resistance of the thermistor is higher than its normal value, the bridge is unbalanced, and positive feedback is permitted. The amplifier will then oscillate, driving rectifiers $CR_4$ and $CR_5$. The DC output current of these rectifiers is amplified by $Q_8$ and $Q_9$, and is used to heat the oven through heater resistor $HR_1$, which is wound around the oven cylinder. As the oven heats, the termistor resistance decreases, making the bridge approach a balance. This decreases the amount of positive feedback, decreasing the amplitude of oscillation and the heater current. An equilibrium is finally reached at the point at which power supplied to the oven equals that which is needed to maintain the desired temperature. Any change in ambient temperature is largely offset by the action of the controller. As far as the inner oven is concerned, it decreases the temperature variations within the outer oven by a factor of 600. Since the outer-oven stability is better than 1 degree Centigrade, the inner-oven temperature is constant to better than 1/600 degree Centigrade, which is adequate to produce the required frequency stability.

The inner oven contains the crystal unit and the crystal oscillator itself. The outer oven contains the inner oven as well as all of the other components of the oscillator and AVC system.

The outer-oven controller is similar to the inner-oven controller, and functions in the same manner. Its temperature stability is inferior to that of the inner oven because the structure is larger and suffers from temperature gradients because of its method of mounting.

The power-supply voltage for all parts of the standard except the outer-oven heater is kept constant by a high-gain voltage regulator containing $Q_{15}$, $Q_{16}$, and $Q_{17}$. Input voltages between 22 and 32 are held constant to within $\pm$ 0.1 volt by this regulator. The circuit uses $CR_8$ as a voltage reference, which is compared with a portion of the output voltage by $Q_{17}$. The output of $Q_{17}$ is a direct current whose magnitude depends upon the difference between these two voltages. This current amplified by $Q_{16}$ and is used to actuate $Q_{15}$, which is a series-control transistor. If the output voltage is low, $Q_{17}$ tends to be cut off, increasing the base current available for $Q_{16}$, thereby increasing the base current of $Q_{15}$. This decreases the voltage drop across $Q_{15}$ which tends to increase the output voltage.

A line filter, $L_2$ - $L_5$ and associated capacitors, is provided to remove high-frequency voltages that might interfere with the operation of the standard.

The temperature of the inner oven is monitored by a thermistor $RT_3$, which is connected in a simple bridge circuit. The sensitivity of the meter indication is approximately one degree Centigrade per major division, which is sufficient only to indicate a gross malfunction of the temperature-control system. The meter reading is high if the inner-oven temperature is low, and will be below zero if the inner-oven temperature is high.

## SECTION 4

## MAINTENANCE

Maintenance of the frequency standard will consist principally of keeping its frequency adjusted to the proper value as the crystal ages. It is anticipated that the aging rate will be approximately $3 \times 10^{-10}$ per day at the time of shipment. This should decrease to $1 \times 10^{-10}$ per day after one month of operation and should eventually reach a value of $5 \times 10^{-11}$ per day. This procedure for frequency adjustment is given in the operating instructions. In any event, it must be assumed that some means of frequency comparison will be available so that the frequency of the standard can be set to the desired value.

The equipment is so designed that it will require no routine maintenance procedures. If a malfunction occurs it can be one of several different types as follows: (1), the complete disappearance of all outputs; (2), the disappearance of one output frequency only; (3), all output voltages normal, but off frequency by a small amount, such as $1 \times 10^{-7}$; (4), all output voltages normal, but off frequency by a large amount such as $1 \times 10^{-6}$ to $5 \times 10^{-6}$.

These malfunctions will be considered in detail below. It should be mentioned, however, that combinations of one or more of these may occur. The following paragraphs will cover these items in order. These must be recognized, and appropriate remedies must be applied.

(1) If all outputs disappear, a power-supply fuse may have blown. If a fuse blows again on replacement, the circuits should be checked for possible grounds, short circuits, or shorted capacitors. A fuse may also blow if the power supply has been connected in the wrong polarity. The fuse should be of the normal rather than the slow-blow type.

To check the equipment it will be necessary to disengage the power connector. The cover can be removed by taking off the four screws that hold it in place. This will expose the two large terminal boards at the front of the equipment, as well as the outer oven, which is the can projecting from the rear. This can is released by removing the four flat-head screws that go through its base. It will also be necessary to disengage the outer-oven plug $P_1$. Removal of the can will expose a smaller cylinder, which is the inner oven.

Grounds, short circuits, or shorted capacitors can be located with the aid of an ohmmeter. The inner-oven cylinder is connected to the negative line. The defective component or circuit should be traced to the proper board and isolated by removing it from the circuits. It will be helpful to note in the schematic that many connections pass through a header located on the front panel. These connections are numbered starting clockwise (as view from the front) at the bottom pin in the outer row. After completing the outer row, the inner row is numbered clockwise in the same manner.

If all outputs disappear simultaneously, it is also possible that the voltage regulator has failed.

(2) If the voltage at one output frequency only disappers, the appropriate output amplifier and its connections should be checked. It is also possible that the corresponding frequency divider may have failed. If the 500-kc divider has failed the 100-kc divider will not operate because it will have no drive.

The frequency dividers contain several tuned circuits, each of which must be adjusted to the correct frequency. Before adjustment is attempted, however, the drive or signal input to the divider should be checked. Thus, if the operation of the 500-kc divider is questioned, the voltage at the collector of the buffer, $Q_{18}$, should be measured using a vacuum-tube voltmeter, with a high-impedance (15 mmf or less) probe. If such a voltmeter is not available, an oscilloscope with a similar probe can be used for estimating the voltage. If the voltage appears normal, $T_6$ and $T_7$ should be adjusted to the proper frequencies. To adjust $T_6$, drive the base of $Q_{21}$ with approximately 1 volt RMS at 2 Mc, applied through a coupling capacitor. $T_6$ should be adjusted to produce the maximum voltage at the collector of $Q_4$. As this is accomplished, the signal-generator output should be decreased to prevent saturation of the transistor. The same procedure is used in adjusting $T_7$, except that the base of $Q_{19}$ is driven at 500 kc.

After such adjustment the divider should start when the start button is pressed. If its operation is intermittent, $T_6$ and $T_7$ should be readjusted until stable operation is obtained at the correct frequency ratio. It should be noted that the divider will stop and not restart itself if either coil is tuned outside the normal range.

The same procedure is used with the 100 kc divider, except that $T_9$ is adjusted to 100 kc; $T_8$ is adjusted to 400 kc.

If the dividers are working properly but there is no 1-Mc output, the frequency multiplier $Q_{27}$ should be checked.

The tuned circuits in the output amplifiers are adjusted for maximum output with 50-ohm loads at the output terminals.

(3) If all of the output voltages are normal, but are off frequency by a small amount, it is possible that the standard has not been adjusted to the right frequency after a long period of storage or operation. An attempt should be made to adjust to the correct frequency using the fine-frequency control. If this is impossible, and the desired frequency is definitely outside the tuning range of the standard, it is likely that the inner oven is not operating properly. This will be indicated by an abnormal reading—either above or below zero—at the TEMP position of the meter switch. If the meter reading is above zero, the inner oven is running below its normal temperature. If the inner-oven current is zero, all components in the inner oven should be checked.

(4) If all of the output voltages are normal but are off frequency by a moderate amount such as a few parts in $10^6$, the operation of the outer oven should be checked. If the outer oven has overheated, it will cycle on its safety thermostat, $S_1$. This will be indicated by the outer-oven voltage fluctuating regularly from zero to a high value. If the outer oven has overheated, the inner-oven current will be zero, while the thermistor will indicate below zero, showing that the inner oven has also been overheated. If the outer oven is not functioning at all, the inner oven will be cool, but will register an abnormally high voltage. In either case, the outer-oven controller should be checked. To aid this and all other tests, both direct and signal voltages are shown on the schematic diagram. Direct voltages are measured with respect to the negative line. Signal voltages are measured with respect to the negative line, which would normally be picked up only on the particular board that is being tested.

This same defect might be caused by over-heating of the inner oven, which would be detected in the TEMP position of the meter switch.

One remaining condition not listed above should be discussed in connection with the frequency standard. If, over a long period of time, a standard has drifted high in frequency outside its normal range, it will be necessary to increase the amount of capacitance in series with the crystal unit. This can be accomplished, within limits, by the use of the coarse frequency control $C_2$, which is available through the hole toward the rear of the outer-oven cylinder.

This hole is marked Frequency. The trimmer requires a small Allen wrench, which should be turned clockwise to increase the capacitance. If this capacitor has reached its clockwise stop, it will be necessary to increase the fixed capacitance which is connected across the trimmer. This can be located by removing the outer-oven cylinder, and also removing the cover cap on the end of the inner oven. This additional capacitance should be approximately 20 to 30 mmf. A Corning glass capacitor should be selected; if that type is not available, a high-quality silvered-mica unit should be used.

If $C_2$ has been readjusted radically, it may be necessary to readjust $C_5$ (marked Range) to restore the correct tuning range. Increasing the capacitance of $C_5$ will decrease the tuning range.

## SECTION 5

## PARTS LIST

The list to follow contains all electrical components plus some of the smaller mechanical parts. Although any or all of these parts could theoretically be replaced in the field, it is probable that such replacement should be limited to the transistors, resistors, capacitors, inductors, and transformers. If the crystal unit $Y_1$ is damaged, perhaps by the shock resulting from the standard being dropped on some hard surface, it is suggested that the standard be returned to the factory. Such replacement would require readjustment of the inner-oven temperature as well as $L_1$. These operations should not be attempted without the proper equipment. It might also be difficult to replace $MP_4$, which includes a hermetically-sealed header, because of the large amount of wiring that is connected to it.

Although specific manufacturers are listed here, equivalent parts from other suppliers may be used, either in the original equipment or in the spare-parts shipments.

# PARTS LIST - MODEL 2.5

| Ref. Des. | Name, | Description | Rating, | Tolerance | | Manufacturer, | Type | Locating Function |
|---|---|---|---|---|---|---|---|---|
| $R_1$ | Resistor, | composition | 1K | ± 10% | 1/4 W | A-B | CB | $Q_1$ emitter bias |
| $R_2$ | " | " | 4.7K | " | " | " | " | $Q_1$ base decoupling |
| $R_3$ | " | " | 1K | " | " | " | " | $Q_1$ collector decoupling |
| $R_4$ | " | " | " | " | " | " | " | AVC decoupling |
| $R_5$ | " | " | 4.7K | " | " | " | " | $Q_2$ base decoupling |
| $R_6$ | " | " | 1K | " | " | " | " | " collector load |
| $R_7$ | " | " | 1.5K | " | " | " | " | $CR_1$ current limiter |
| $R_8$ | " | " | 2.2K | " | " | " | " | $Q_2$ emitter bias |
| $R_9$ | " | " | 10K | " | " | " | " | feedback voltage divider |
| $R_{10}$ | " | " | 47Ω | " | " | " | " | " " " |
| $R_{11}$ | " | " | 4.7K | " | " | " | " | $Q_3$ emitter bias |
| $R_{12}$ | " | " | 1K | " | " | " | " | $Q_4$ emitter bias |
| $R_{13}$ | " | " | " | " | " | " | " | " emitter bias |
| $R_{14}$ | " | " | 470Ω | " | " | " | " | meter bypass |
| $R_{15}$ | " | " | 10K | " | " | " | " | $CR_2$-$CR_3$ load |
| $R_{16}$ | " | " | 47Ω | " | " | " | " | B+ decoupling |

| Ref. Des. | Name, | Description | Rating, | Tolerance | | Manufacturer, | Type | Locating Function |
|---|---|---|---|---|---|---|---|---|
| $R_{17}$ | Resistor, | composition | 10K | $\pm$ 10% | 1/4 W | A-B | CB | $Q_5$ collector load |
| $R_{18}$ | " | " | 6.8K | " | " | " | " | " emitter bias |
| $R_{19}$ | " | " | 10K | " | " | " | " | $Q_6$ emitter bias |
| $R_{20}$ | " | " | 470Ω | " | " | " | " | $Q_7$ " " |
| $R_{21}$ | " | " | 1K | " | " | " | " | " " " |
| $R_{22}$ | " | " | 15K | " | " | " | " | $CR_4$-$CR_5$ decoupling |
| $R_{23}$ | " | trimpot | 500Ω | | | Bourns 224L-1-501 | | inner-oven temp. adjust |
| $R_{24}$ | " | deposited carbon | value depends upon oven temp. | | " | TI | CG-1/4 | inner-oven temp. set |
| $R_{25}$ | " | composition | 22K | $\pm$ 10% | " | A-B | CB | $Q_8$ base leak |
| $R_{26}$ | " | " | 1K | " | " | " | " | $Q_8$ current limiter |
| $R_{27}$ | " | " | 47Ω | " | " | " | " | B+ decoupling |
| $R_{28}$ | " | " | 10K | " | " | " | " | $Q_{10}$ collector load |
| $R_{29}$ | " | " | 6.8K | " | " | " | " | " emitter bias |
| $R_{30}$ | " | " | 10K | " | " | " | " | $Q_{11}$ " " |
| $R_{31}$ | " | " | 470Ω | " | " | " | " | $Q_{12}$ " " |
| $R_{32}$ | " | " | 1K | " | " | " | " | " " " |

| Ref. Des. | Name, Description | Rating, Tolerance | | | Manufacturer, | Type | Locating Function |
|---|---|---|---|---|---|---|---|
| $R_{33}$ | Resistor, composition | 22K | ± 10% | 1/4 W | A-B | CB | $CR_6$-$CR_7$ decoupling |
| $R_{34}$ | " trimpot | 2K | " | " | Bourns 224L-1-202 | | Outer-oven temp. adjust |
| $R_{34}A$ | " deposited carbon | value depends upon oven temp. | | " | TI | CG-1/4 | Outer-oven temp. set |
| $R_{35}$ | " composition | 22K | ± 10% | " | A-B | CB | $Q_{13}$ base leak |
| $B_{36}$ | " " | 1K | " | " | " | " | " current limiter |
| $R_{37}$ | " " | 47Ω | " | " | " | " | B+ decoupling |
| $R_{38}$ | " " | 3.3K | " | " | " | " | $Q_{17}$ base divider |
| $R_{39}$ | " " | 4.7K | " | " | " | " | " " " |
| $R_{40}$ | " " | 470Ω | " | " | " | " | $Q_{16}$ current limiter |
| $R_{41}$ | " " | 2.2K | " | " | " | " | $CR_8$ " " |
| $R_{42}$ | " " | 10K | " | " | " | " | $Q_{17}$ collector load |
| $R_{43}$ | " " | 22.1K | ± 1% | " | TI | CG-1/4 | thermistor bridge |
| $R_{44}$ | " " | " | " | " | " | " | " " |
| $R_{45}$ | " trimpot | 2K | | | Bourns 224L-1-202 | | " " zero set |
| $R_{45}A$ | " deposited carbon | value depends upon oven temp. | | " | TI | GG-1/4 | " " padder |
| $R_{46}$ | " composition | 4.7K | ± 10% | " | A-B | CB | $Q_{18}$ base voltage divider |

| Ref. Des. | Name, | Description | Rating, | Tolerance | | Manufacturer, | Type | Locating | Function |
|---|---|---|---|---|---|---|---|---|---|
| $R_{47}$ | Resistor, | composition | 22K | $\pm$ 10% | 1/4 W | A-B | CB | $Q_{18}$ | base voltage divider |
| $R_{48}$ | " | " | 220Ω | " | " | " | " | " | collector protector |
| $R_{49}$ | " | " | 1K | " | " | " | " | " | emitter bias |
| $R_{50}$ | " | " | 1K | " | " | " | " | $Q_{19}$ | base current limiter |
| $R_{51}$ | " | " | " | " | " | " | " | $Q_{20}$ | " " " |
| $R_{52}$ | " | " | 100Ω | " | " | " | " | $Q_{19}$-$Q_{20}$ | emitter bias |
| $R_{53}$ | " | " | 470Ω | " | " | " | " | $Q_{19}$-$Q_{20}$ | collector protector |
| $R_{54}$ | " | " | 470Ω | " | " | " | " | $Q_{21}$-$Q_{22}$ | collector protector |
| $R_{55}$ | " | " | 10K | " | " | " | " | $Q_{21}$ | base bias |
| $R_{56}$ | " | " | " | " | " | " | " | $Q_{22}$ | " " |
| $R_{57}$ | " | " | 1K | " | " | " | " | $Q_{23}$ | " current limiter |
| $R_{58}$ | " | " | " | " | " | " | " | $Q_{24}$ | " " " |
| $R_{59}$ | " | " | 100Ω | " | " | " | " | $Q_{23}$-$Q_{24}$ | emitter bias |
| $R_{60}$ | " | " | 470Ω | " | " | " | " | $Q_{25}$-$Q_{26}$ | collector protector |
| $R_{61}$ | " | " | " | " | " | " | " | $Q_{23}$-$Q_{24}$ | " " |
| $R_{62}$ | " | " | 10K | " | " | " | " | $Q_{25}$ | base bias |

| Ref. Des. | Name, Description | Rating, Tolerance | | | Manufacturer, | Type | Locating Function |
|---|---|---|---|---|---|---|---|
| $R_{47}A$ | Resistor, composition | 10K | ± 10% | 1/4 W | A-B | CB | $Q_{18}$ load |
| $R_{63}$ | " " | | " | " | " | " | $Q_{26}$ base bias |
| $R_{64}$ | " " | 4.7K | " | " | " | " | $Q_{27}$ base current limiter |
| $R_{64}A$ | If used, same as $R_{64}$ | | | | | | |
| $R_{65}$ | Resistor, composition | 470Ω | " | " | " | " | $Q_{27}$ collector current " |
| $R_{66}$ | " " | 100K | " | " | " | " | $Q_{28}$ base bias |
| $R_{67}$ | " " | 47Ω | " | " | " | " | B+ decoupling |
| $R_{68}$ | " " | 2.2K | " | " | " | " | $Q_{29}$ base voltage divider |
| $R_{69}$ | " " | 15K | " | " | " | " | $Q_{29}$ " " " |
| $R_{70}$ | " " | 100Ω | " | " | " | " | " collector current limiter |
| $R_{71}$ | " " | 220Ω | " | " | " | " | " emitter bias |
| $R_{72}$ | " " | 10K | " | " | " | " | $CR_{12}$ multiplier |
| $R_{73}$ | " " | 470Ω | " | " | " | " | 2.5 Mc load |
| $R_{74}$ | " " | 2.2K | " | " | " | " | $Q_{30}$ base divider |
| $R_{75}$ | " " | 15K | " | " | " | " | " " " |
| $R_{76}$ | " " | 100Ω | " | " | " | " | $Q_{30}$ collector protector |

| Ref. Des. | Name, Description | | Rating, Tolerance | | | Manufacturer, Type | | Locating | Function |
|---|---|---|---|---|---|---|---|---|---|
| $R_{77}$ | Resistor, | composition | 220Ω | ± 10% | 1/4 W | A-B | CB | $Q_{30}$. | emitter bias |
| $R_{78}$ | " | " | 10K | " | " | " | " | $CR_{13}$ | multiplier |
| $R_{79}$ | " | " | 470Ω | " | " | " | " | 1 Mc | load |
| $R_{80}$ | " | " | 2.2K | " | " | " | " | $Q_{31}$ | base divider |
| $R_{81}$ | " | " | 15K | " | " | " | " | " | " " |
| $R_{82}$ | " | " | 100Ω | " | " | " | " | " | collector protector |
| $R_{83}$ | " | " | 200Ω | " | " | " | " | " | emitter bias |
| $R_{84}$ | " | " | 10K | " | " | " | " | $CR_{14}$ | multiplier |
| $R_{85}$ | " | " | 470Ω | " | " | " | " | 100-kc | load |
| $R_{86}$ | " | deposited carbon | 150K | ± 1% | " | TI | CG-1/4 | inner-oven | multiplier |
| $R_{87}$ | " | " " | 249K | " | " | " | " | outer-oven | " |
| $R_{88}$ | " | " " | 499K | " | " | " | " | input-voltage | " |
| $R_{89}$ | " | " " | 249K | " | " | " | " | regulator " | " |

| Ref. Des. | Name, Description | Rating, Tolerance | | | Manufacturer, Type | | Locating Function |
|---|---|---|---|---|---|---|---|
| $C_1$ | Capacitor, glass | 68mmf | ± 10% | 500v | Corning | CY10C680K | coarse-freq.-control-padder |
| $C_2$ | " " piston | 1-28mmf | | | JFD | MC 603 | coarse freq. control |
| $C_3$ | " " " | 1-18 " | | | See $MP_4$, Sulzer Lab. 25-$C_3$ | | fine " " |
| $C_4$ | " " | 68mmf | ± 10% | 500v | Corning | CY10C680K | fine-freq.-control padder |
| $C_5$ | " " piston | 1-28mmf | | | JFD | MC603 | " " " range set |
| $C_6$ | " " | 2200mmf | ± 10% | 500v | Corning | CY20C222K | $Q_1$ base feedback |
| $C_7$ | " " | 680mmf | " | " | Corning | CY10C681K | " emitter " |
| $C_8$ | " ceramic | .02mf | ± 20% | 100v | Aerovox | MC80A203AM | " " bypass |
| $C_9$ | " " | .005mf | " | " | " | MC80A502AM | +8-volt bypass |
| $C_{10}$ | " " | " | " | " | " | " | AVC " |
| $C_{11}$ | " silvered mica | .001mf | ± 5% | " | Elmenco | DM-15-102-J | $Q_2$ base coupling |
| $C_{12}$ | " ceramic | .005mf | ± 20% | " | Aerovox | MC80A502AM | $CR_1$ bypass |
| $C_{13}$ | " " | " | " | " | " | " | $Q_2$ emitter bypass |
| $C_{14}$ | " " | " | " | " | " | " | $Q_4$ " " |
| $C_{15}$ | " " | " | " | " | " | " | " voltage divider bypass |
| $C_{16}$ | " silvered mica | .001mf | ± 5% | " | Elmenco | DM-15-102-J | $CR_2$-$CR_3$ coupling |

| Ref. Des. | Name, Description | Rating, Tolerance | | | Manufacturer, Type | | Locating Function |
|---|---|---|---|---|---|---|---|
| $C_{17}$ | Capacitor, silvered mica | 470mmf | ± 5% | 300v | Elmenco | DM-15-471-J | $T_2$ tuning |
| $C_{18}$ | " ceramic | .005mf | ± 20% | 100v | Aerovox | MC80A502AM | AVC bypass |
| $C_{19}$ | " solid tant. | 4.7mf | " | 35v | Kemet | K4R7J35S | B+ " |
| $C_{20}$ | " ceramic | .005mf | " | 100v | Aerovox | MC80A502 AM | " " |
| $C_{21}$ | " solid tant. | 1mf | " | 35v | Kemet | K1J35S | $Q_5$ emitter bypass |
| $C_{22}$ | " ceramic | .02mf | " | 100v | Aerovox | MC80A203 AM | outer-oven-shell bypass |
| $C_{23}$ | " solid tant. | 1mf | " | 35v | Kemet | K1J35S | $Q_7$ emitter bypass |
| $C_{24}$ | " ceramic | .02mf | " | 100v | Aerovox | MC80A203AM | $T_3$ tuning |
| $C_{25}$ | " solid tant. | 3.3mf | " | 10v | Kemet | K3R3J10S | $Q_7$ voltage-divider bypass |
| $C_{26}$ | " ceramic | .02mf | " | 100v | Aerovox | MC80A203AM | $CR_4$-$CR_5$ coupling |
| $C_{27}$ | " solid tant. | 3.3mf | " | 10v | Kemet | K3R3J10S | $CR_4$-$CR_5$ bypass |
| $C_{28}$ | " " " | 4.7mf | " | 35v | " | K4R7J35S | B+ bypass |
| $C_{29}$ | " " " | 1mf | " | " | " | K1J35S | $Q_{10}$ emitter bypass |
| $C_{30}$ | " " " | 1mf | " | " | " | K1J35S | $Q_{12}$ " " |
| $C_{31}$ | " ceramic | .02mf | " | 100v | Aerovox | MC80A203AM | $T_4$ tuning |
| $C_{32}$ | " " | " | " | " | " | " | $CR_6$-$CR_7$ coupling |

| Ref. Des. | Name, | Description | Rating, | Tolerance | | Manufacturer, | Type | Locating | Function |
|---|---|---|---|---|---|---|---|---|---|
| $C_{33}$ | Capacitor, | solid tantalum | 3.3mf | ± 20% | 10v | Kemet | K3R3J10S | $Q_{12}$ | voltage-divider bypass |
| $C_{34}$ | " | " " | " | " | " | " | " | $CR_6$-$CR_7$ | bypass |
| $C_{35}$ | " | " " | 4.7mf | " | 35v | " | K4R7J35S | B+ | " |
| $C_{36}$ | " | " " | 1mf | " | " | " | K1J35S | $Q_{15}$ | emitter bypass |
| $C_{37}$ | " | " " | " | " | " | " | " | $Q_{17}$ | base coupling |
| $C_{38}$ | " | " " | " | " | " | " | " | $CR_8$ | bypass |
| $C_{39}$ | " | silvered mica | .001mf | ± 5% | 100v | Elmenco | DM-15-102-J | $Q_{18}$ | base coupling |
| $C_{40}$ | " | " " | 220mmf | " | 500v | " | DM-15-221-J | $T_5$ | tuning |
| $C_{41}$ | " | ceramic | .02mmf | ± 20% | 100v | Aerovox | MC80A203AM | $Q_{18}$ | emitter bypass |
| $C_{42}$ | " | silvered mica | 150mmf | ± 5% | 500v | Elmenco | DM-15-151-J | $T_6$ | tuning |
| $C_{43}$ | " | " " | 680mmf | " | " | " | DM-15-681-J | $T_7$ | tuning |
| $C_{44}$ | " | " " | .001mf | " | 100v | " | DM-15-102-J | $Q_{21}$ | base coupling |
| $C_{45}$ | " | " " | " | " | " | " | " | $Q_{22}$ | " " |
| $C_{46}$ | " | " " | " | " | " | " | " | $T_8$ | tuning |
| $C_{47}$ | " | " " | .0056mf | " | " | " | DM-19-562-J | $T_9$ | " |
| $C_{48}$ | " | ceramic | .005mf | ± 20% | " | Aerovox | MC80A502AM | $Q_{25}$ | base coupling |

| Ref. Des. | Name, | Description | Rating, | Tolerance | | Manufacturer, | Type | Locating Function |
|---|---|---|---|---|---|---|---|---|
| $C_{49}$ | Capacitor, | ceramic | .005mf | ± 2C% | 100v | Aerovox | MC80A502AM | $Q_{26}$ base coupling |
| C50 | " | " | " | " | " | " | " | $CR_9$-$CR_{10}$ " |
| $C_{51}$ | " | silvered mica | 330mmf | ± 5% | 500v | Elmenco | DM-15-331-J | $T_{10}$ tuning |
| $C_{52}$ | " | ceramic | .02mf | ± 20% | 100v | Aerovox | MC80A203AM | $CR_9$-$CR_{10}$ bypass |
| $C_{53}$ | " | " | " | " | " | " | " | $Q_{28}$ emitter " |
| $C_{54}$ | " | " | " | " | " | " | " | B+ " |
| $C_{55}$ | " | solid tantalum | 4.7mf | " | 35v | Kemet | K4R7J35S | " " |
| $C_{56}$ | " | silvered mica | 470mmf | ± 5% | 300v | Elmenco | DM-15-471-J | $T_{11}$ tuning |
| $C_{56}$A | " | " " | 330mmf | " | " | " | DM-15-331-J | $Q_{29}$ base coupling |
| $C_{57}$ | " | ceramic | .02mf | ± 20% | 100v | Aerovox | MC80A203AM | $Q_{29}$ emitter bypass |
| $C_{58}$ | " | " | .02mf | " | " | " | " | $CR_{12}$ " |
| $C_{59}$ | " | silvered mica | 470mmf | ± 5% | 300v | Elmenco | DM-15-471-J | $T_{12}$ tuning |
| $C_{60}$ | " | " " | " | " | " | " | " | $T_{13}$ " |
| $C_{61}$ | " | " " | 1000mmf | " | 100v | " | DM-15-102-J | $T_{14}$ " |
| $C_{61}$A | " | " " | 330mmf | " | 300v | " | DM-15-331-J | $Q_{30}$ base coupling |
| $C_{62}$ | " | ceramic | .02mf | ± 20% | 100v | Aerovox | MC80A203AM | $Q_{30}$ emitter bypass |
| $C_{63}$ | " | " | " | " | " | " | " | $CR_{13}$ " |

| Ref. Des. | Name | Description | Rating | Tolerance | | Manufactuerer, | Type | Locating Function |
|---|---|---|---|---|---|---|---|---|
| $C_{64}$ | Capacitor, | silvered mica | .001mf | ± 5% | 100v | Elmenco | DM-15-102-J | $T_{15}$ tuning |
| $C_{65}$ | " | " " | " | " | " | " | " | $T_{16}$ tuning |
| $C_{66}$ | " | " " | .0082mf | " | " | " | DM-20-822-J | $T_{17}$ tuning |
| $C_{66}A$ | " | " " | 1000mmf | " | " | " | DM-15-102-J | $Q_{31}$ base coupling |
| $C_{67}$ | " | solid tantalum | 1mf | ± 20% | 35v | Kemet | K1J35S | $Q_{31}$ emitter bypass |
| $C_{68}$ | " | ceramic | .02mf | " | 100v | Aerovox | MC80A203AM | $CR_{14}$ bypass |
| $C_{69}$ | " | silvered mica | .0082mf | ± 5% | " | Elmenco | DM-20-822-J | $T_{18}$ tuning |
| $C_{70}$ | " | " " | " | " | " | " | " | $T_{19}$ " |
| $C_{71}$ | " | solid tantalum | 4.7mf | ± 20% | 35v | Kemet | K4R7J35S | line filter |
| $C_{72}$ | " | " " | " | " | " | " | " | line filter |
| $C_{73}$ | " | " " | " | " | " | " | " | " " |
| $C_{74}$ | " | " " | " | " | " | " | " | " " |

| Ref. Des. | Name, Description | Rating, Tolerance | Manufacturer | Type | Locating Function |
|---|---|---|---|---|---|
| $L_1$ | inductor, toroidal | value depends upon $Y_1$ | Sulzer Labs. | 2.5-$L_1$ | $Y_1$ freq. adjust inductor |
| $L_2$,$L_3$ | " " | $L_2$,$L_3$ wound on same form | " " | 2.5-$L_2L_3$ | line filter |
| $L_4$,$L_5$ | " " | $L_4$,$L_5$ " " " | " " | 2.5-$L_4L_5$ | " " |
| $T_1$ | transformer, " | resonate at 1.75Mc with 680mmf | Sulzer Labs. | 2.5-$T_1$ | oscillator output transformer |
| $T_2$ | " " | resonate at 2.5Mc with 470mmf | " " | 2.5-$T_2$ | AVC " " |
| $T_3$ | " " | resonate at 25kc with .02mf | " " | 2.5-$T_3$ | temperature-controller bridge transformer |
| $T_4$ | " " | resonate at 25kc with .02mf | " " | 2.5-$T_4$ | temperature-controller bridge transformer |
| $T_5$ | " slug tuned | resonate at 2.5Mc with 220mmf | " " | 2.5-$T_5$ | $Q_{18}$ tank |
| $T_6$ | " " " | resonate at 2 Mc with 150mmf | " " | 2.5-$T_6$ | $Q_{21}$-$Q_{22}$ tank |
| $T_7$ | " " " | resonate at 500kc with 680mmf | " " | 2.5-$T_7$ | $Q_{19}$-$Q_{20}$ " |
| $T_8$ | " " " | resonate at 400kc with .001mf | " " | 2.5-$T_8$ | $Q_{25}$-$Q_{26}$ " |
| $T_9$ | " " " | resonate at 100kc with .0056mf | " " | 2.5-$T_9$ | $Q_{23}$-$Q_{24}$ " |

| Ref. Des. | Name, Description | Rating, Tolerance | Manufacturer, Type | | Locating Function |
|---|---|---|---|---|---|
| $T_{10}$ | transformer, slug tuned | resonate at 1Mc with 330mmf | Sulzer Labs. | 2.5-$T_{10}$ | $Q_{27}$ tank |
| $T_{11}$ | " " " | resonate at 2.5Mc with 470mmf | " " | 2.5-$T_{11}$ | $Q_{29}$ " |
| $T_{12}$ | " " " | resonate at 2.5Mc with 470mmf | " " | 2.5-$T_{12}$ | 2.5Mc filter |
| $T_{13}$ | " " " | same as $T_{12}$ | " " | 2.5-$T_{13}$ | " " |
| $T_{14}$ | " " " | resonate at 1 Mc with .001mf | " " | 2.5-$T_{14}$ | $Q_{30}$ tank |
| $T_{15}$ | " " " | res. at 1Mc with .001mf | " " | 2.5-$T_{15}$ | 1 Mc filter |
| $T_{16}$ | " " " | " " " " | " " " | 2.5-$T_{16}$ | " " " |
| $T_{17}$ | " " " | resonate at 100kc with .0082mf | " " | 2.5-$T_{17}$ | $Q_{31}$ tank |
| $T_{18}$ | " " " | same as above | " " | 2.5-$T_{18}$ | 100kc filter |
| $T_{19}$ | " " " | same as above | " " | 2.5-$T_{19}$ | " " |

| Ref. Des. | Name, Description | | Rating, Tolerance | Manufacturer, Type | | Locating Function |
|---|---|---|---|---|---|---|
| $Q_1$ | transistor, | silicon | 2N917,2N957,2N916 or 2N955 | Fairchild | | 2.5-Mc oscillator |
| $Q_2$ | " | " | 2N957 or 2N916 | " | | 1st stage AVC amplifier |
| $Q_3$ | " | " | " " " | " | | 2nd stage " " |
| $Q_4$ | " | " | " " " | " | | 3rd stage " " |
| $Q_5$ | " | " | 2N697,2N333,or TI 494 | " | or TI | 1st stage,inner-oven controll |
| $Q_6$ | " | " | " " " " | " | " " | 2nd " " " " |
| $Q_7$ | " | " | " " " " | " | " " | 3rd " " " " |
| $Q_8$ | " | " | " | " | | 4th " " " " |
| $Q_9$ | " | " | " | " | | power amplifier inner-oven " |
| $Q_{10}$ | " | " | " ,2N333,or T1494 | " | or TI | 1st stage,outer-oven control |
| $Q_{11}$ | " | " | " " " " | " | " " | 2nd " " " " |
| $Q_{12}$ | " | " | " " " " | " | " " | 3rd " " " " |
| $Q_{13}$ | " | " | " | " | | 4th " " " " |
| $Q_{14}$ | " | " | 2N1485 or 2N1701 | " | | power amplifier outer-oven con. |
| $Q_{15}$ | " | " | " " " | " | | voltage regulator series control |
| $Q_{16}$ | " | " | 2N697,2N333, or T1494 | " | or TI | " " second stage |

| Ref. Des. | | | Manufacturer, Type | |
|---|---|---|---|---|
| $Q_{17}$ | transistor, silicon | 2N697, 2N333, or TI494 ECG 128 | Fairchild or TI | voltage regulator 1st stage |
| $Q_{18}$ | " " | 2N957 or 2N916 | " | 2.5Mc buffer |
| $Q_{19}$ | " " | " " " | " | 500-kc mixer |
| $Q_{20}$ | " " | " " " | " | " " " |
| $Q_{21}$ | " " | " " " | " | 2-Mc multiplier |
| $Q_{22}$ | " " | " " " | " | " " " |
| $Q_{23}$ | " " | " " " | " | 100-kc mixer |
| $Q_{24}$ | " " | " " " | " | " " " |
| $Q_{25}$ | " " | " " " | " | 400-kc multiplier |
| $Q_{26}$ | " " | " " " | " | " " " |
| $Q_{27}$ | " " | " " " | " | 1-Mc " |
| $Q_{27}$A | If used, same as $Q_{27}$ | | | |
| $Q_{28}$ | transistor, silicon | " " " | " | relay controller |
| $Q_{29}$ | " " | " " " | " | 2.5-Mc output amplifier |
| $Q_{30}$ | " " | " " " | " | 1-Mc " " |
| $Q_{31}$ | " " | " " " | " | 100-kc " " |

| Ref. Des. | Name, Description | Rating, Tolerance | Manufacturer, Type | Locating Function |
|---|---|---|---|---|
| $CR_1$ | diode, silicon | voltage regulator | TI 1N757A | +8 volt regulator |
| $CR_2$ | " " | rectifier | " 1N662 | AVC rectifier |
| $CR_3$ | " " | " | " " | " " |
| $CR_4$ | " " | " | " " | inner-oven rectifier |
| $CR_5$ | " " | " | " " | " " " |
| $CR_6$ | " " | " | " " | outer-oven " |
| $CR_7$ | " " | " | " " | " " " |
| $CR_8$ | " " | voltage regulator | " 1N757A | voltage-regulator reference |
| $CR_9$ | " " | rectifier | " 1N662 | relay-control rectifier |
| $CR_{10}$ | " " | " | " " | " " " |
| $CR_{11}$ | " " | " | " " | " transient clipper |
| $CR_{12}$ | " " | " | " " | 2.5-Mc metering rectifier |
| $CR_{13}$ | " " | " | " " | 1-Mc " " |
| $CR_{14}$ | " " | " | " " | 100-kc " " |

| Ref. Des. | Name, Description | Rating, Tolerance | Manufacturer, Type | Locating Function |
|---|---|---|---|---|
| $E_1$ | knob | control | | test-switch knob |
| $E_2$ | dial | control | Borg model 1309 or Beckman model RB | dial, fine-freq.-control |
| $J_1$ | jack | SMRE7SJ | Winchester | outer-oven jack |
| $J_2$ | " | UG1094U | Cannon | 2.5-Mc output jack |
| $J_3$ | " | " | " | 1-Mc " " |
| $J_4$ | " | " | " | 100-kc " " |
| $J_5$ | " | MRE7PJ | Winchester | power and signal jack |
| $K_1$ | relay | JSH-6D 5000Ω | Allied Control | divider starter |
| $P_1$ | plug | SMRE7PJTCH | Winchester | mates with $J_1$ |
| $P_2$ | " | MRE7SJTCH | " | " " $J_2$ |
| $M_1$ | meter | 0-100 DC UA | International Instrument Model 150-C | test meter |
| $S_1$ | switch, thermostat | 85° C. | Stevens MX-12 | outer-oven protective thermal switch |
| $S_2$ | " rotary | 2 pole 9 pos. | Grayhill 24002-9 | test circuit selector switch |
| $S_3$ | " push button | SPNO | Grayhill 30-1 | divider start switch |

| Ref. Des. | Name, Description | Rating, Tolerance | Manufacturer, Type | Locating Function |
|---|---|---|---|---|
| $Y_1$ | crystal, quartz | 2.5Mc | Bliley BG11AH-5, | 2.5Mc frequency-control crystal |
| $RT_1$ | thermistor | | Victory Engrg. 41A11 | inner-oven sensor |
| $RT_2$ | " | | " " " | outer-oven " |
| $RT_3$ | " | | " " " | bridge " |
| $HR_1$ | heater winding | 150 ohms | Sulzer Labs. 2.5-$HR_1$ | inner-oven heater |
| $HR_2$ | " " | 46 ohms | " " 2.5-$HR_2$ | outer-oven " |
| $MP_1$ | gasket, O-ring | | Parker 2-239 | outer-cover gasket |
| $MP_2$ | " " | | " 2-23 | $MP_3$ " |
| $MP_3$ | mount for $TB_1$ (includes $TB_1$) | | Sulzer labs 2.5-$MP_3$ | mount with header |
| $MP_4$ | drive for $C_1$ (includes $C_1$) | | " " 2.5-$MP_4$ | fine-frequency-control drive and capacitor |
| $MP_5$ | shaft for $MP_4$ | | " " 2.5-$MP_5$ | fine-frequency-control shaft |
| $TB_1$ | header, hermetically sealed, included with $MP_3$ | | Hermetic Seal 2785-21-SS1 | front-panel feed-through header |

SULZER LABORATORIES, INC.
621 Lofstrand Lane
Rockville, Maryland

# INSTRUCTIONS

## MODEL 5P POWER SUPPLY

The Model 5P power supply will deliver up to 500 ma at 27 volts. The self-contained standby battery has a capacity in excess of 3 ampere hours, which is sufficient to operate the Model 5 or Model 2.5 frequency standards for at least 10 hours at +25° Centigrade.

Power for the frequency standard is normally supplied through $T_1$ and bridge rectifier $CR_1$ - $CR_4$. Battery $BA_1$ is charged through $R_4$ at a 50-ma rate. This rate is stabilized by voltage regulator diode $CR_6$. The battery acts as a constant-potential source for the base of $Q_1$, which functions as an emitter-follower voltage regulator. If the AC power is interrupted, the battery is connected to the load through $CR_7$ and the base-emitter junction of $Q_1$. Thus the change-over, which is automatic, is accomplished with but a very small switching transient since the base-emitter junction of $Q_1$ is always biased in the forward direction.

If the full ampere-hour capacity of the battery is utilized, there is danger of damaging some of the cells. The lowest-capacity cells of the battery will decrease their terminal voltage first, and may actually suffer a reversal of potential if the load current continues to pass through them. Reverse charging can cause permanent damage, and must be avoided. The power supply therefore contains a battery cut-out circuit, which includes $K_1$, $CR_8$, and $Q_3$. If the battery voltage drops 6% below its normal value at 25% discharge, it is automatically disconnected from the load. The cut-out voltage is controlled by $R_6$, which is adjusted before shipment. Restoration of the AC power will automatically recharge the battery and connect it to the load.

The start button $S_3$ is included to permit the power supply to be started in the absence of AC power.

The charging-rate switch $S_2$ is normally left in the "low" position, which produces a 50-ma rate. If for any reason, such as a power failure of extended duration, it is thought that the battery has become more than 25% discharged, the battery should be given a 24-hour charge at the high rate, which is 150 ma. This should also be done shortly before a period when the full capacity of the battery will be needed, such as during a field trip when AC power is not available. If the battery has become discharged to the cut-out point, it should be given a 30-hour charge at the high rate.

The power supply has been designed to require no periodic servicing of any kind. The battery contains sealed cells, which do not require the addition of water. The line fuse ($F_1$, $\frac{1}{2}$ amp) should be of the slow-blow type. The DC fuse ($F_2$, 1 amp) should be fast acting.

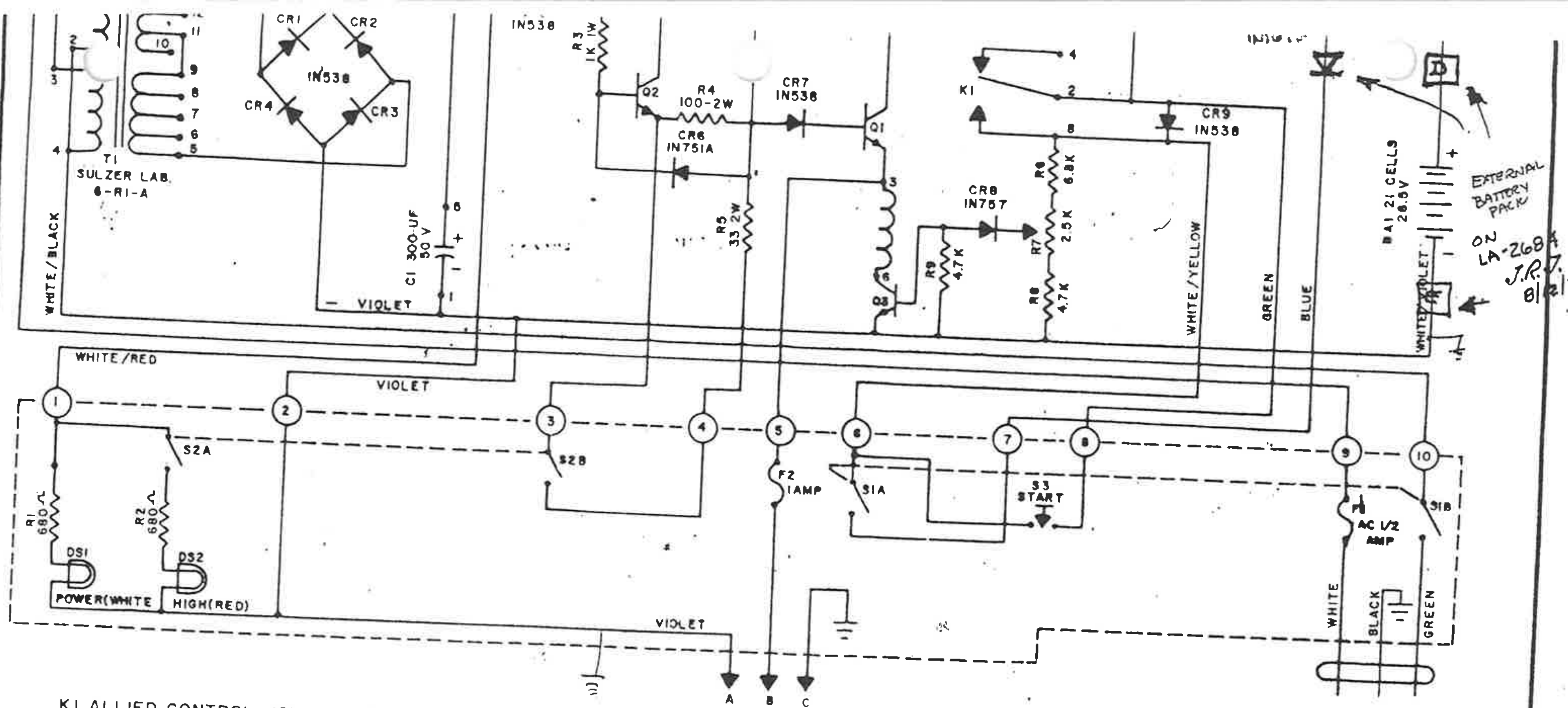
# PARTS LIST

## 5P POWER SUPPLY

| Ref. Des. | Name | Description | Rating | Manufacturer, | Type | Locating Function |
|---|---|---|---|---|---|---|
| $R_1$ | resistor, | composition | 680Ω ±10% 1W | A-B type | GB | dropping resistor for DS-1 |
| $R_2$ | " | " | " " " | " " | " | " " " DS-2 |
| $R_3$ | " | " | 1K " " | " " | " | " " " $CR_6$ |
| $R_4$ | " | " | 100Ω " 2W | " " | HB | low charging rate set |
| $R_5$ | " | " | 33Ω " " | " " | " | high " " " |
| $R_6$ | " | " | 6.8K " 1/4W | " " | CB | $CR_8$ voltage divider |
| $R_7$ | potentiometer | " | 2.5K ±20% 0.2W | Clarostat | 48M9-2500 | battery cutout adjust |
| $R_8$ | resistor | " | 3.3K ±10% 1/4W | A-B type | CB | $CR_8$ voltage divider |
| $R_9$ | " | " | 10K " " | " " | " | $Q_3$ base leak |
| $C_1$ | capacitor, | electrolytic | 300mf 50v | Aerovax | CE51C301G | B+ filter |
| $T_1$ | transformer, | rectifier | 115/42 volts at 1 amp. max. | Sulzer Labs | 6-$R_1$ | rectifier power transformer |
| $Q_1$ | transistor, | silicon | 2N1701 or 2N1485 | RCA | | emitter follower |
| $Q_2$ | " | " | " " " | " | | charger emitter follower |
| $Q_3$ | " | " | 2N697 | TI | | relay control |
| $CR_1$ | diode, | " | 1N538 | " | | bridge rectifier |
| $CR_2$ | " | " | " | " | | " " |

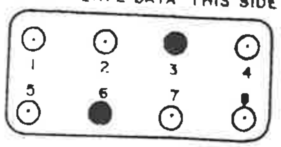
| Ref. Des. | Name | Description | Rating | Manufacturer, Type | Locating Function |
|---|---|---|---|---|---|
| $CR_3$ | diode, | silicon | 1N538 | TI | bridge rectifier |
| $CR_4$ | " | " | " | " | " " |
| $CR_5$ | " | " | " | " | dc disconnect |
| $CR_6$ | " | " | 1N751A | " | charger voltage regulator |
| $CR_7$ | " | " | 1N538 | " | battery protective diode |
| $CR_8$ | " | " | 1N757A | " | cutout regulator |
| $CR_9$ | " | " | 1N538 | " | relay contact protector |
| $K_1$ | relay, | DPDT | 5000 Ω | Allied Control JSH-6D | battery cutout |
| $BA_1$ | battery, | nickel-cadmium | Consists of 21 type S103 size D cells connected in series | Sonotone | standby battery |
| DS-1 | lamp, | pilot | 28v, 04A | Chicago Min. Lamp Works 327 | line-power pilot |
| DS-2 | " | " | " " | " " " " " | high-charge rate pilot |
| XDS-1 | lamp holder | white jewel | | Dialco 101-3830-935 | holder for DS-1 |
| XDS-2 | lamp holder | red jewel | | " 101-3830-931 | " " DS-2 |
| $F_1$ | fuse | | 1/2 amp. | Buss, slow blow | line fuse |
| $F_2$ | " | | 1 amp | " | dc line |
| $XF_1$ | fuse holder | | | Littelfuse 342004 | holder for $F_1$ |
| $XF_2$ | fuse holder | | | " " | " " $F_2$ |

| | Name | Description | Rating | Manufactur…, | Type | Locating Functio |
|---|---|---|---|---|---|---|
| 1 | switch, | toggle | DPST | ST22K | | power switch |
| $S_2$ | " | push-button | SPSTNO | Grayhill 30-1 | | start button |
| $MP_2$ | gasket, | O-ring | | Parker 2-237 | | outer-cover gasket |
| $MP_3$ | " | " | | " 2-23 | | header-mount gasket |
| $MP_4$ | mount for $TB_1$ | | | | | header-mount |
| $TB_1$ | terminal | board (header) hermetically sealed | | Hermetic Seal Corp. 2785-21-SS1 | | header |
| $XC_1$ | socket, octal | | | Elco TS 101P01 | | holder for $C_1$ |
| $S_3$ | same as $S_1$ | | | | | |




K1 ALLIED CONTROL JSH-6D, 5000~ COIL.
BA1 21 SONOTONE .S103 SIZE D CELLS.
R7 ADJUSTED TO CUT OUT AT 21 VOLTS.
Q1, Q2 2N 1485 OR 2N 1701
Q3 2N 697
CR7 MAY BE OMITTED.
FOR 230 VOLT OPERATION, CONNECT INPUT TO 1 AND 4, AND JOIN 2 TO 3.

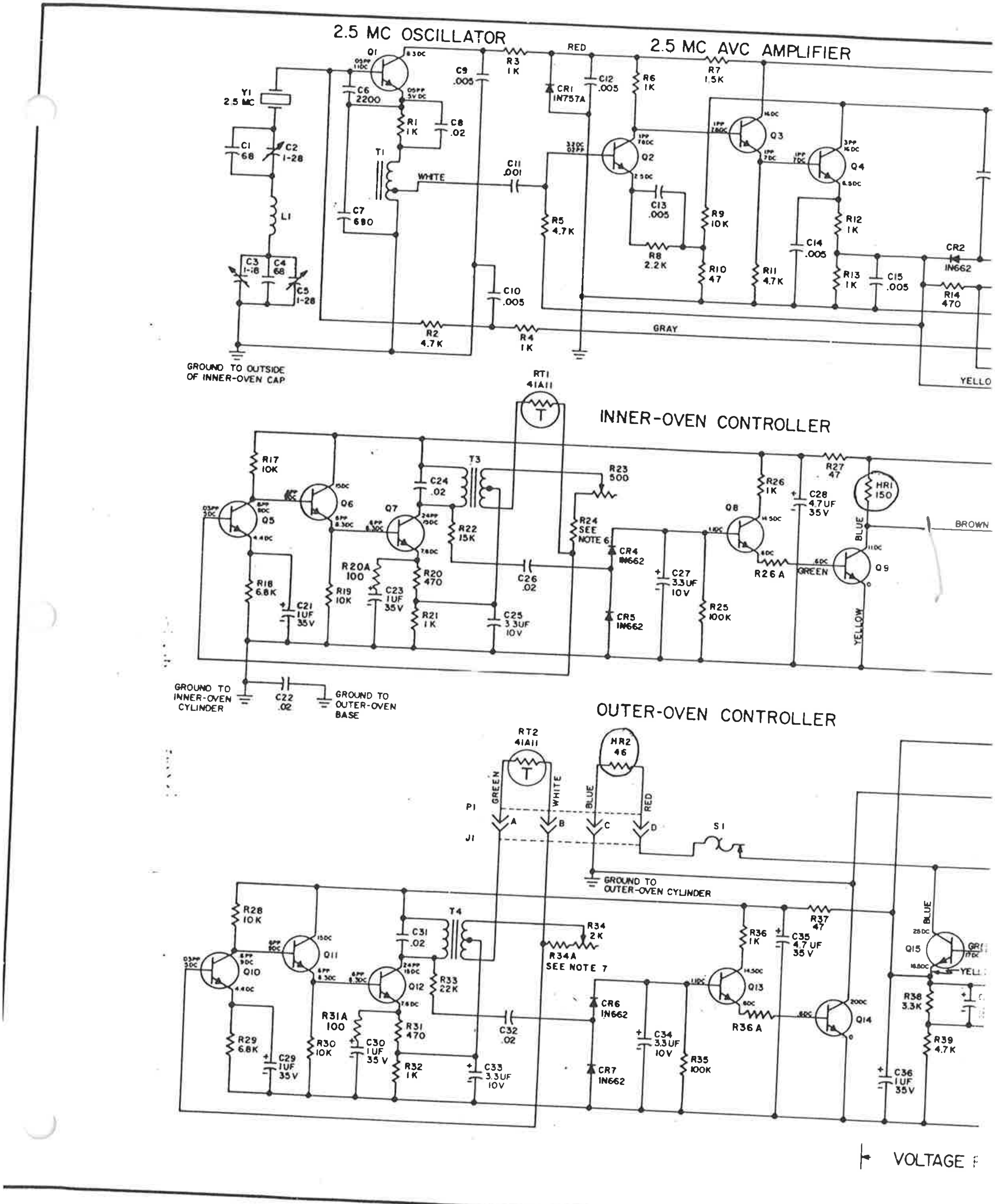
NAME PLATE DATA THIS SIDE

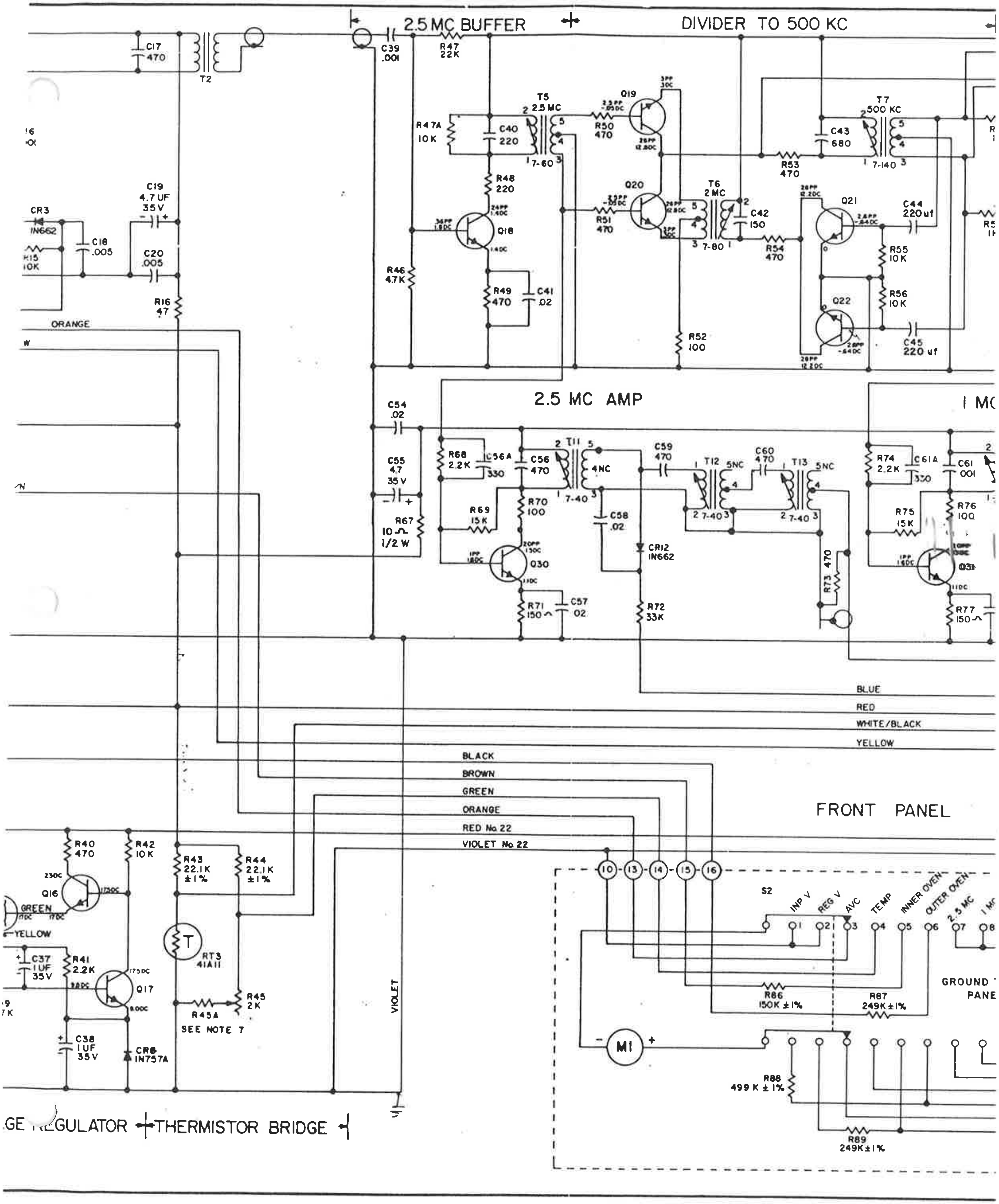


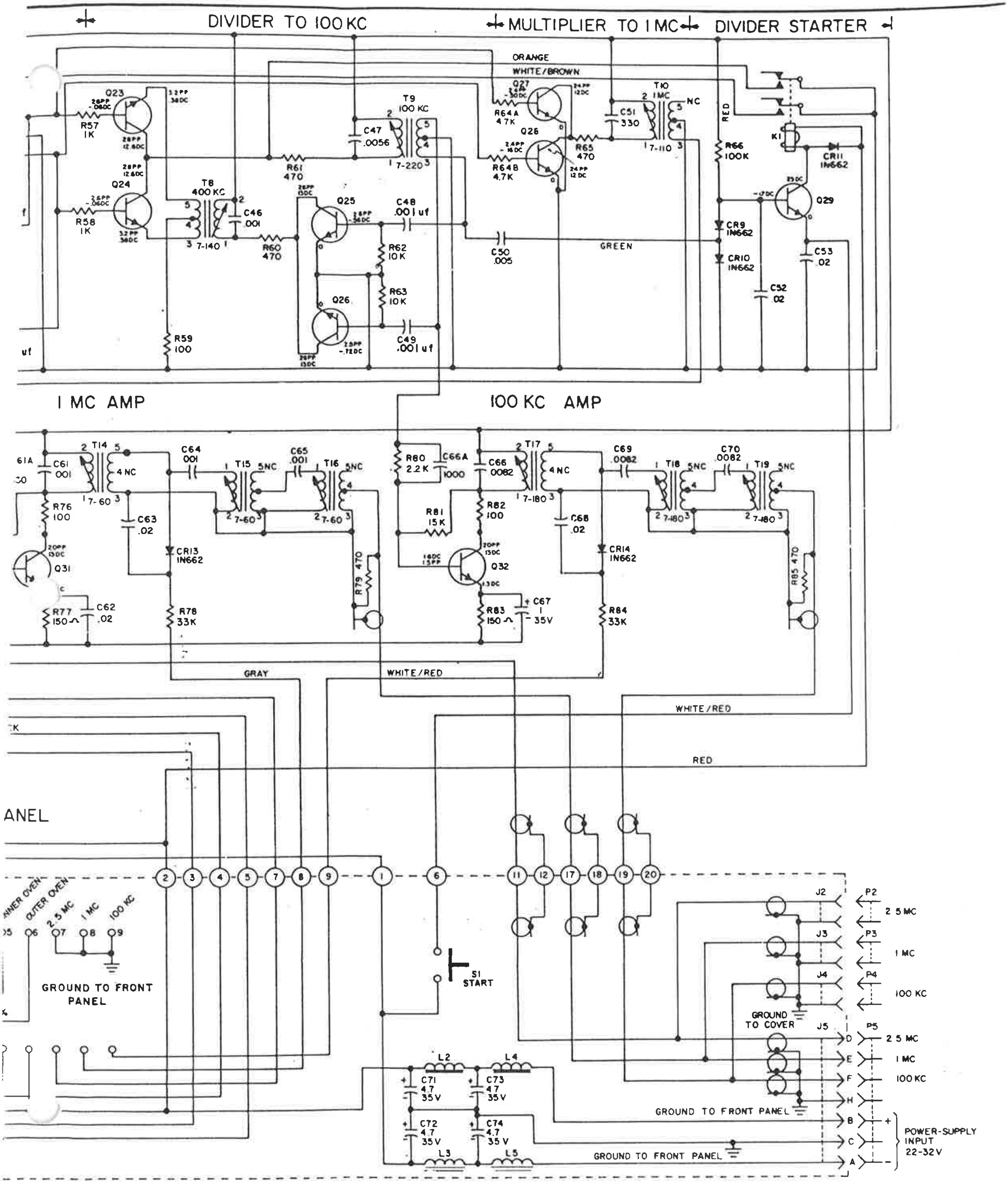

SULZER LABORATORIES INC.

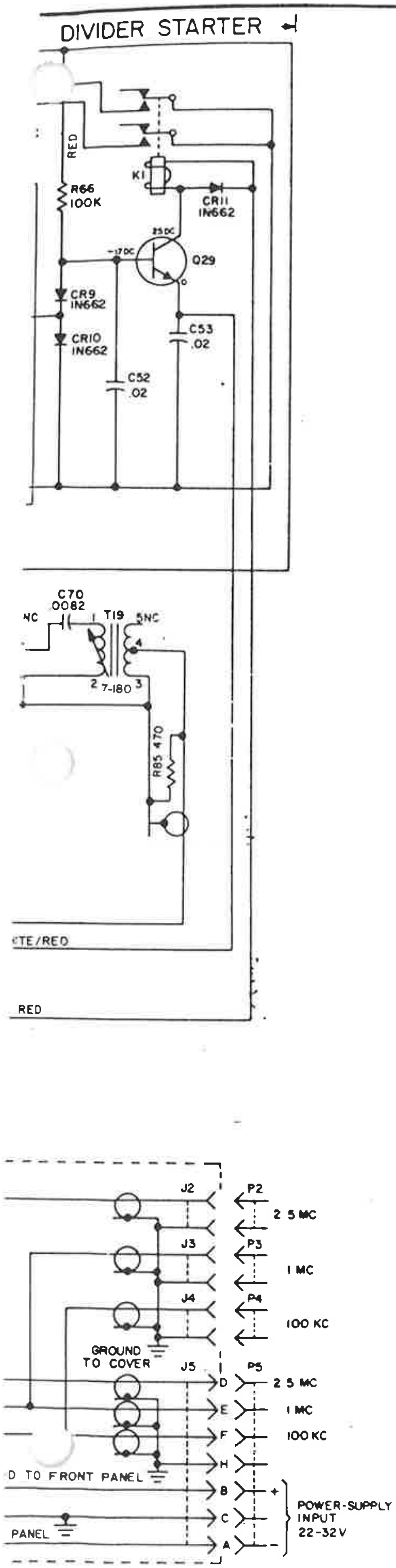
POWER SUPPLY
MODEL 5P

| DWG. NO. | DATE. | DESG. BY |
|---|---|---|


2.5 MC OSCILLATOR
2.5 MC AVC AMPLIFIER
Y1 2.5 MC
C1 68
C2 1-28
L1
C3 1-18
C4 68
C5 1-28
Q1
C6 2200
R1 1K
C8 .02
T1
C7 680
WHITE
C9 .005
R3 1K
RED
CR1 1N757A
C12 .005
R6 1K
R7 1.5K
C11 .001
Q2
Q3
Q4
R5 4.7K
C13 .005
R8 2.2K
R9 10K
R10 47
R11 4.7K
C14 .005
R12 1K
R13 1K
C15 .005
CR2 1N662
R14 470
C10 .005
R2 4.7K
R4 1K
GRAY
YELLO
GROUND TO OUTSIDE OF INNER-OVEN CAP
RT1 41A11
INNER-OVEN CONTROLLER
R17 10K
Q5
Q6
Q7
C24 .02
T3
R22 15K
R23 500
R24 SEE NOTE 6
CR4 1N662
CR5 1N662
C26 .02
C27 3.3UF 10V
R25 100K
Q8
R26 1K
C28 4.7UF 35V
R27 47
HR1 150
BLUE
BROWN
Q9
R26A
GREEN
YELLOW
R18 6.8K
C21 1UF 35V
R19 10K
R20A 100
C23 1UF 35V
R20 470
R21 1K
C25 3.3UF 10V
GROUND TO INNER-OVEN CYLINDER
C22 .02
GROUND TO OUTER-OVEN BASE
OUTER-OVEN CONTROLLER
RT2 41A11
HR2 46
GREEN
WHITE
BLUE
RED
P1
J1
A
B
C
D
S1
GROUND TO OUTER-OVEN CYLINDER
R28 10K
Q10
Q11
Q12
C31 .02
T4
R33 22K
R34 2K
R34A SEE NOTE 7
R36 1K
C35 4.7 UF 35 V
R37 47
Q13
R36A
Q14
Q15
CR6 1N662
CR7 1N662
C32 .02
C34 3.3UF 10V
R35 100K
R38 3.3K
R39 4.7K
C36 1UF 35V
R29 6.8K
C29 1UF 35V
R30 10K
R31A 100
C30 1UF 35 V
R31 470
R32 1K
C33 3.3UF 10V
VOLTAGE


2.5 MC BUFFER
DIVIDER TO 500 KC
2.5 MC AMP
I MC
FRONT PANEL
GE REGULATOR
THERMISTOR BRIDGE
C17 470
T2
C39 .001
R47 22K
T5 2.5 MC
Q19
R47A 10K
C40 220
R50 470
7-60
R48 220
Q20
R51 470
T6 2 MC
7-80
C42 150
Q18
R46 4.7K
R49 470
C41 .02
R52 100
T7 500 KC
C43 680
R53 470
7-140
Q21
C44 220uf
R54 470
R55 10K
R56 10K
Q22
C45 220 uf
C19 4.7 UF 35V
CR3 IN662
C18 .005
R15 10K
C20 .005
R16 47
ORANGE
C54 .02
C55 47 35 V
R67 10 Ω 1/2 W
R68 2.2K
C56A 330
C56 470
T11
4NC
7-40
C59 470
T12 5NC
C60 470
T13 5NC
R69 15K
R70 100
C58 .02
CR12 IN662
Q30
R71 150 Ω
C57 .02
R72 33K
R73 470
R74 2.2K
C61A 330
C61 .001
R75 15K
R76 100
R77 150 Ω
BLUE
RED
WHITE/BLACK
YELLOW
BLACK
BROWN
GREEN
ORANGE
RED No.22
VIOLET No.22
R40 470
R42 10K
Q16
GREEN
YELLOW
R43 22.1K ±1%
R44 22.1K ±1%
T
RT3 41A11
C37 1UF 35V
R41 2.2K
Q17
R45 2K
R45A
SEE NOTE 7
VIOLET
C38 1UF 35V
CR8 IN757A
S2
INP V
REG V
AVC
TEMP
INNER OVEN
OUTER OVEN
2.5 MC
R86 150K ±1%
R87 249K ±1%
GROUND PANE
M1
R88 499 K ± 1%
R89 249K±1%


DIVIDER TO 100 KC
MULTIPLIER TO 1 MC
DIVIDER STARTER
ORANGE
WHITE/BROWN
Q23
Q24
R57 1K
R58 1K
T8 400 KC 7-140
C46 .001
R59 100
R60 470
R61 470
T9 100 KC 7-220
C47 .0056
Q25
Q26
C48 .001 uf
C49 .001 uf
R62 10K
R63 10K
Q27
R64A 4.7K
R64B 4.7K
Q28
R65 470
T10 1 MC 7-110
C51 330
C50 .005
GREEN
RED
R66 100K
K1
CR11 1N662
Q29
CR9 1N662
CR10 1N662
C52 .02
C53 .02
1 MC AMP
100 KC AMP
T14 7-60
C61 .001
C64 .001
C65 .001
T15 7-60
T16 7-60
R76 100
Q31
C63 .02
CR13 1N662
R77 150
C62 .02
R78 33K
R79 470
R80 2.2K
C66A 1000
C66 .0082
T17 7-180
C69 .0082
C70 .0082
T18 7-180
T19 7-180
R81 15K
R82 100
Q32
C68 .02
CR14 1N662
R83 150
C67 1 35V
R84 33K
R85 470
GRAY
WHITE/RED
WHITE/RED
RED
ANEL
INNER OVEN
OUTER OVEN
2.5 MC
1 MC
100 KC
GROUND TO FRONT PANEL
S1 START
J2
P2
2.5 MC
J3
P3
1 MC
J4
P4
100 KC
GROUND TO COVER
J5
P5
2.5 MC
1 MC
100 KC
L2
L4
C71 4.7 35V
C73 4.7 35V
C72 4.7 35V
C74 4.7 35V
L3
L5
GROUND TO FRONT PANEL
GROUND TO FRONT PANEL
POWER-SUPPLY INPUT 22-32V




| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | LTR | DESCRIPTION | DATE | APPROVAL |
| | | | | |

NOTES:

1. TRANSISTOR TYPES AS FOLLOWS: Q1 = 2N957, 2N2221 OR 2N917; Q2-Q4 & Q18-Q32 = 2N957 OR 2N2221; Q5-Q13, Q16, Q17 = 2N697; Q14, Q15 = 2N1701 OR 2N1485.
2. ALL RESISTANCES ARE IN OHMS, ± 20% TOLERANCE, OTHERWISE STATED.
3. ALL RESISTORS 1/4 WATT RATING UNLESS OTHERWISE STATED.
4. CAPACITANCE 1 OR GREATER ARE IN UUF UNLESS OTHERWISE STATED.
5. L1 IS USED TO SET FREQUENCY. A CAPACITOR MAY BE USED IN SOME UNITS.
6. THE VALUE OF R24 IS CHOSEN DURING TEST.
7. R34A & R45A MAY BE OMITTED.
8. K1 IS ALLIED CONTROL JSH-6D, 5000 OHM COIL.
9. VALUES OF C1, C4, C56A, C61A AND C66A ARE SELECTED DURING TEST.
10. AC AND DC VOLTAGE ARE MEASURED WITH RESPECT TO COMMON NEGATIVE LINE.
11. THE VALUES OF R26A, R36A, R38, R39, R49, R52, R53, R59, R61, R71, R77 & R83 ARE SELECTED DURING TEST.
12. R47A MAY BE OMITTED.

| | | |
|---|---|---|
| DESIGNED | | |
| DRAWN | F.A. WALCOTT | 11-27-61 |
| CHECKED | | |
| APPROVED | | |
| APPROVED | | |

SULZER LABORATORIES INC

TITLE

FREQUENCY STANDARD
MODEL 2.5

NEXT ASSEMBLY ~ | SCALE ~ | DRAWING NO

## Bead Thermistors

| Bead Diameter | 0.005 | 0.010 | 0.013 | 0.043 |
|---|---|---|---|---|
| Dissipation Constant (δ) Mw/°C | 0.045 | 0.09 | 0.10 | 0.35 |
| Time Constant (τ) (seconds) Still Air @ 25°C | 0.12 | 0.5 | 1.0 | 6.0 |

VECO™'s bead thermistors utilize metallic oxide semiconductor material sintered on platinum-iridium alloy lead wires and feature a hermetic seal via a controlled glass coating for excellent stability under continuous exposure to conductive, corrosive, and other hostile environments. Fast response times and high power sensitivities in a mini size make them ideal for applications involving measuring and controlling the temperature of liquid or gas flow. Specific applications are gas chromatography and thermal conductivity gas analysis. They are available in a complete range of resistance values, resistance-temperature characteristics, and with any desired calibration accuracy of temperature or resistance. Complete product information is contained in Bulletin MB012.

**Maximum Operating and Storage Temperatures**

**Continuous Operation: 325°C (617°F)**

**Intermittent Operation: 550°C (1,022°F)**

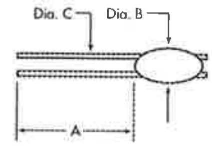



**Figure 1**

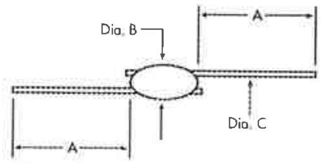



**Figure 2**

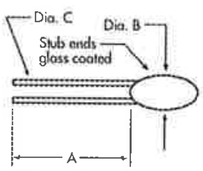
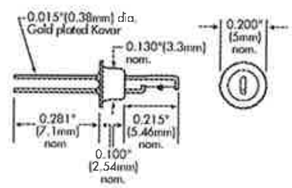
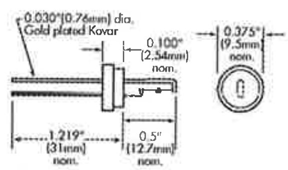



**Figure 3**

| VECO Part Number | Zero Power Resistance Ro @ 25°C (ohms) | Temperature Coefficient α @ 25°C (%/°C) | Ratio | | Dimensions | | |
|---|---|---|---|---|---|---|---|
| | | | Ro @ 0°C / Ro @ 50°C | Ro @ 25°C / Ro @ 125°C | A | B | C |
| **Micro-Beads (Figure 1 or 2)** | | | | | | | |
| 32A402A | 2,000 ± 25% | -3.3 | 5.2 | 13.2 | 0.25 | 0.005 | 0.0007 |
| 41A401A | 10,000 ± 25% | -3.6 | 6.0 | 16.1 | 0.25 | 0.005 | 0.0007 |
| 43A401A | 30,000 ± 25% | -3.9 | 7.1 | 20.6 | 0.25 | 0.005 | 0.0007 |
| 51A401A | 100,000 ± 25% | -4.0 | 7.4 | 21.8 | 0.25 | 0.005 | 0.0007 |
| 61A401A | 1 Meg ± 25% | -4.6 | 10.3 | 35.8 | 0.25 | 0.005 | 0.0007 |
| **Ultra Small and Small Beads (Figure 1, 2, or 3)** | | | | | | | |
| 31A7 | 1,000 ± 25% | -3.3 | 5.2 | 13.2 | 0.3125 | 0.010 | 0.001 |
| 32A50 | 2,000 ± 25% | -3.4 | 5.6 | 14.6 | 0.3125 | 0.010 | 0.001 |
| 32A48 | 2,000 ± 25% | -3.4 | 5.6 | 14.6 | 0.3750 | 0.013 | 0.001 |
| 41A5 | 10,000 ± 25% | -3.9 | 7.1 | 20.6 | 0.3125 | 0.010 | 0.001 |
| 51A22 | 100,000 ± 25% | -4.4 | 9.2 | 30.1 | 0.3125 | 0.010 | 0.001 |
| **Medium Beads (Figure 1, 2, or 3)** | | | | | | | |
| 32A12 | 2,000 ± 20% | -3.9 | 7.1 | 20.6 | 0.3125 | 0.043 | 0.004 |
| 35A1 | 5,000 ± 20% | -4.0 | 7.4 | 21.8 | 0.3125 | 0.043 | 0.004 |
| 51A2 | 100,000 ± 15% | -4.6 | 10.3 | 35.8 | 0.3125 | 0.043 | 0.004 |
| 61A2 | 1 Meg ± 20% | -5.0 | 12.6 | 51.9 | 0.3125 | 0.043 | 0.004 |



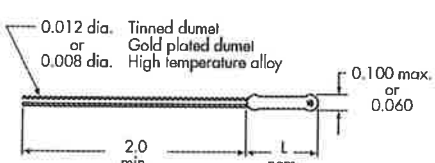

**Mounting Option 1**




**Mounting Option 2**

## Bead-In-Glass Probes

VECO™ Bead-In-Glass Probes consist of bead thermistors with sintered-in platinum-iridium leads embedded in solid glass. Hermetically sealed, they have excellent stability over long periods of time under continuous exposure to harsh environments. They retain excellent stability at temperatures to 325°C (617°F) for storage or continuous operation, and to 550°C (1,022°F) for intermittent operation. For complete product information request VECO™ Bulletin MGR061.




| VECO Part Number | Zero Power Resistance Ro @ 25°C (ohms) | Temperature Coefficient α @ 25°C (%/°C) | Ratio | |
|---|---|---|---|---|
| | | | Ro @ 0°C / Ro @ 50°C | Ro @ 25°C / Ro @ 125°C |
| **0.100 Probes — 0.5" Long** | | | | |
| 31A11 | 1,000 ± 20% | −3.8 | 6.9 | 19.7 |
| 32A11 | 2,000 ± 20% | −3.9 | 7.1 | 20.6 |
| 35A11 | 5,000 ± 20% | −4.0 | 7.4 | 21.8 |
| 41A11 | 10,000 ± 20% | −4.4 | 9.1 | 29.7 |
| 45A11 | 50,000 ± 20% | −4.5 | 9.5 | 31.5 |
| 51A11 | 100,000 ± 15% | −4.6 | 10.3 | 35.8 |
| 55A11 | 500,000 ± 20% | −5.0 | 12.3 | 49.6 |
| 61A11 | 1Meg ± 20% | −5.0 | 12.6 | 51.9 |
| **0.060 Probes — 0.25" and 0.5" Long (Leads 0.008 Dia.)** | | | | |
| 31A52 | 1,000 ± 20% | −3.8 | 6.9 | 19.7 |
| 32A129 | 2,000 ± 20% | −3.9 | 7.1 | 20.6 |
| 35A36 | 5,000 ± 20% | −4.0 | 7.4 | 21.8 |
| 41A28 | 100,000 ± 20% | −4.4 | 9.1 | 29.7 |

**Typical Time and Dissipation Constants**

| Type of Probe | Time Constant* (seconds) | | | Dissipation Constant* (Mw/(C) | | |
|---|---|---|---|---|---|---|
| | Still Air | Still Oil | Still Water | Still Air | Still Oil | Still Water |
| 0.100" | 22.0 | 2.00 | 1.00 | 1.0 | 3.5 | 5.0 |
| 0.060" | 6.0 | 0.50 | 0.25 | 0.6 | 2.0 | 3.0 |

*Units supported by their lead in indicated ambient at 25°C.