KSLC

BROADCAST FREQUENCY MONITOR

TYPE 311-AB

MI-8211-C, MI-8211-F Rack Mounting Style, Black Panel
MI-8211-D, MI-8211-G Rack Mounting Style, Umber Gray Panel
MI-8211-E, MI-8211-H Rack Mounting Style, Gray Panel

F. C. C. APPROVAL No. 1462

Manufactured by

RCA Manufacturing Company, Inc.

Camden, N. J., U. S. A.

"A SERVICE OF THE RADIO CORPORATION OF AMERICA"

IB-32039

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INSTRUCTIONS

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PH-50681

Figure 1—Broadcast Frequency Monitor

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ILLUSTRATIONS

BROADCAST FREQUENCY MONITOR

TECHNICAL SUMMARY

Electrical Characteristics

Radio-Frequency Range ..... 540–2,000 kc
Frequency Deviation Ranges ..... ± 20 and ± 100 cycles
Range of Off-scale Indication ... From –100 to –500 cycles and + 100 to + 1,200 cycles, on ± 100 cycle range
R-F Input Voltage ..... 1 to 4 volts (approx. 100-ohm input)
Power Supply ..... 105-125 volts, 50-60 cycles
Power Consumption (continuous) ..... 100 watts
Additional Consumption of Oscillator Heater ..... 70 watts intermittent

Accuracy:

Oscillator Frequency Stability ..... ± 2 parts per million

Changes of ± 20% of the r-f input level will produce less than one cycle variation.

Change of oscillator frequency with a ± 5% line voltage variation and 25 degree C ambient temperature variation 0.5 parts per million (total).

Approximate maximum change of deviation indication, in the audio system, due to a ± 5% line voltage variation and a 25 degree C ambient temperature variation as follows:

1.2 cycles (total) near zero deviation.

1.7 cycles (total) at 100 cycles deviation.

Fuse Complement:

Oven ..... 2 amperes
Power ..... 2 amperes

Tube Complement

Function		Type
R-F Amplifier and Limiter	2	RCA-6SJ7
Detector	1	RCA-6H6
A-F Amplifier	1	RCA-6SJ7
A-F Amplifier	1	RCA-2A3
A.V.C. Diode	1	RCA-6H6
A-F Discriminator Diode	1	RCA-6F8-G
Voltage Regulator	1	RCA-VR-150-30
Oscillator	1	RCA-6J5
Oscillator Buffer and A.V.C.	3	RCA-6SJ7
Oven Heat Control	1	RCA-2050
Power Rectifier	1	RCA-5T4

Mechanical Specifications

Mounting ..... Standard 19-inch rack
Dimensions ..... 19 inches (length) x 15¾ inches (height)
Depth ..... 12½ inches
Weight (net) ..... 95 pounds

DESCRIPTION

The Type 311-AB Broadcast Frequency Monitor is a precision instrument which provides continuous indication of the deviation of a broadcast transmitter from its assigned frequency. It was designed to meet the specifications of the Federal Communications Commission, as set forth in Rule 3.60 and described in Section 15 of Standards of Good Engineering Practice.

The principle of operation is indicated by the block diagram of Figure 2, and is shown more completely by the simplified schematic diagram of Figure 9 and the complete schematic of Figure 8. It may be described briefly as follows:

Local oscillator signal from V-7, controlled as to amplitude by the A.V.C. bias on the oscillator amplifier (V-8, 9 and 10), is supplied to the detector (V-1) as the smaller of the two r-f components. The other component, a carrier signal obtained from a buffer stage of the transmitter, and amplitude-limited by V-13 and V-14, is adjusted to have an amplitude, at the detector (V-1), of approximately fifteen times that of the local oscillator signal. This adjustment, which involves the transmitter coupling and the "R. F. CHECK" switch, is fully explained under "Installation." The two components combine to produce a beat tone.

The function of the amplitude-limiter or "Clipper" amplifier, V-13 and V-14, is to remove any program modulation which may be present in the signal from a buffer stage and which might otherwise result in undesirable fluctuation of the indicating meter due to certain audio components disturbing the metering circuit.

The local oscillator frequency is approximately 1,000 cycles below the transmitter carrier frequency, producing a detector output with a frequency equal to this difference. This output passes through an r-f filter network to a broadly tuned 1,000-cycle-amplifier stage (V-2). This stage serves both to reduce distortion errors (due to hum modulation on the carrier, oscillator wave-form, etc.) and to feed an a-f power stage (V-3). The latter is transformer-coupled to the series R, L and C circuit of the discriminator (C-13, R-17, R-18, R-19 and L-6).

The inductive and capacitative elements of this circuit (including some series resistance), across which are connected the two discriminator diodes (V-5), are adjusted to have numerically equal impedances at a frequency very close to 1,000 cycles. It is evident that, for this audio frequency, the two diode currents will cancel in the "CYCLES" meter (M-1) and produce no deflection.

When the transmitter carrier deviates from its assigned value, producing an a-f above or below 1,000 cycles, different voltages will be supplied to the two diodes (V-5), resulting in an unbalance current in the "CYCLES" meter (M-1). The latter is a zero-center instrument, and is calibrated in cycles "HIGH" or "LOW" from assigned carrier frequency.

In order to obtain satisfactory scale spread on the "CYCLES" meter, and to hold the deviation calibration, it is necessary to maintain constant current in the R, L and C discriminator circuit. The A.V.C. circuit, obtaining voltage from the resistive elements (R-17, R-18 and R-19) of this discriminator circuit, controls the amplitude of the local oscillator signal at the detector (and thus the a-f amplitude) so as to maintain substantially constant current in the discriminator circuit over the deviation range. A manual control (R-25), in the bias circuit, is also provided for resetting this a-f level for accurate readings of deviation.

The crystal oscillator is adjusted, at the factory, to a frequency 1,000 cycles below the transmitter's assignment. After installation, however, a transmitter frequency check should be obtained and the trimmer (C-21) on the monitor oscillator adjusted so that the meter indicates the measured deviation. When the transmitter is exactly on frequency, the a-f beat tone will then be within several cycles of 1,000 cycles, and the meter will indicate zero deviation.

The crystal for the local oscillator is mounted in a special type holder which tends to minimize the effects of jar and vibration. This is mounted in a double heat box, which practically eliminates the effects of normal ambient temperature variations. The inner box is controlled by a low-differential mercury thermostat (A-2), and the relay tube V-11. The outer box, which also contains the remaining oscillator-circuit components (except the tube), is controlled by a bi-metal thermostat (A-3) of high sensitivity. A-4 and A-5 are bi-metal safety cut-outs which open the heater circuits if, for any reason, the box temperatures should exceed their normal values appreciably. These units are shown in Figure 5.

Operation of the "AUDIO CHECK" switch (S-1) places M-1 in series with the load resistor (R-16) of diode V-4, thus indicating the a-f current amplitude in R-17, 18 and 19—or in the discriminator circuit. The tap on R-19 is so adjusted, at the factory, that true off-frequency indication, on the "CYCLES" scale of M-1, will result if the "AUDIO CHECK" operation produces the specified a-f level indication, as marked on M-1.

The approximate level at which the A.V.C. holds the 1,000-cycle audio current in the discriminator circuit is adjustable by means of R-25 ("AUDIO ADJ."), which alters the amount of fixed positive bias (which is "bucked" by the negative A.V.C. bias from V-4) on the r-f amplifier. This, in turn, alters the amount of audio current required to produce (in V-4) the negative bias necessary to bring the A.V.C. circuit to equilibrium; thus serving as a control on the audio level. Since the A.V.C. action is not perfect it is necessary, in making an accurate deviation reading, to check the audio level and adjust to the proper indication on M-1.

The "DIODE CHECK" switch, S-5, is provided for occasional checks on matching of the dynamic resistances of the discriminator diodes (V-5) around their operating point. This operation makes a bridge circuit of the two diodes and their load impedances; with 60-cycle voltage across one diagonal (of proper amplitude to produce normal peak current in the diodes), and M-1 across the other diagonal. The diodes are then effectively balanced by setting R-21

("DIODE ADJ.") for zero deflection of M-1. S-5 momentarily shorts M-1 during the switching operation.

All controls and check devices which are normally used, in obtaining a deviation reading, are located on the front panel. These include the power switch (S-3), the meter range switch (S-4) (± 20 and ± 100 cycles), and three push buttons which indicate, by deflection to certain markings on M-1, the following: S-2, the existence of proper r-f input level; S-1, correct level of a-f beat signal in the discriminator circuit; and S-5, correct adjustment of the "DIODE ADJ." control (R-21) in the discriminator diode circuit. Also on the front panel are the indicating meter (M-1), a circuit-power pilot lamp (A-8), pilots A-6 and A-7 showing heater operation on the outer and inner crystal-oscillator ovens respectively, and a thermometer showing the temperature of the crystal chamber.

In order to prevent erroneous indication due to accidental disturbance of adjustment settings, the diode balance control (R-21) and the a-f level control (R-25) are placed on a sub-panel, which is accessible through a small door in the front panel. Also on this sub-panel are the r-f input control (R-1) (which is not a critical adjustment), and a telephone jack (J-1) for monitoring the audio tone. The oscillator frequency adjustment, the small trimmer capacitor C-21, is located in the outer heater oven, and can be adjusted, by means of a bakelite tuning tool, after removing a plug button in the rear cover of the oven. Figures 4 and 5 illustrate the above-mentioned parts.

The small trimmer capacitor C-25, located at the rear of the small, top chassis, is an adjustment of oscillator voltage supplied to the r-f amplifier. It is properly adjusted at the factory and, since its setting has an appreciable effect on oscillator frequency, should not be disturbed; except, perhaps, in a service operation which will be followed immediately by a check from a frequency service. This precaution also applies to all other components in the oscillator circuit.

The transformers in the r-f input amplifier (L-10, L-11, L-12, L-13, L-14, L-1, L-2) and the oscillator-amplifier output transformer (L-3 and L-4) are provided with taps which are used, in conjunction with C-1, C-2, C-39, C-43, C-49 to cover different parts of the r-f frequency range of the monitor. The oscillator cathode coil (L-7) is provided with similar taps. The ranges of these adjustments are outlined under "Maintenance and Service," but all of these circuits are adjusted, at the factory, at the particular frequency for which each monitor is ordered.

The filter comprised of L-8, C-23 and C-24 serves to eliminate r-f noise generated in the heater-relay tube, V-11.

The two power transformers, T-2 and T-3, are each provided with two primary taps to permit operation over the line voltage ranges of 105-115 and 115-125 volts. Separate fuses, F-1 and F-2, are provided for circuit power and crystal-oven power.

INSTALLATION

It is recommended that the foregoing "Description" be read before installing or operating the monitor, and that the following procedure be observed.

The monitor is designed for mounting in a standard 19-inch rack. The dust cover is notched, near the bottom of the side edges (which fit against the panel), in order that the power cord and r-f input line may be permanently attached and passed through these notches; thus providing no interference to removal of the dust cover.

A power supply of 105 to 125 volts (preferably subject to less than several volts variation), 50-60 cycles, capable of delivering 175 watts, is required. The power transformers, T-2 and T-3, are wired at the factory, for 115-125-volt operation. If the supply voltage does not exceed 115 volts, the power input circuit should be changed to the 110-volt tap on the base of each of these transformers.

The monitor is unaffected by field strengths which would normally exist in an equipment rack. However, it is recommended that it be placed outside the immediate fields of high-power r-f stages or high-power rectifiers.

Before operation, all packing must be removed from tubes and other parts, and all tubes should be placed securely in their sockets. The crystal unit (A-1), mercury thermostat (A-2) and thermometer, which are separately packed, should not be installed until the unit is mounted in the rack and the following operations are completed.

R-F signal to the input binding posts must be obtained from an unmodulated buffer or intermediate stage which has adequate power to permit the absorption of about 0.02 watts. Inductive or capacitative feed may be employed, preferably through a 70-ohm concentric line, to the r-f input terminals on the rear apron. If a monitor terminal is not provided on the transmitter, a coil of several turns and a diameter of several inches, loosely coupled to a suitable tank circuit, should provide adequate signal strength. A high voltage capacitor of about 100 mmfd. connected to one or more turns above r-f ground on a suitable tank coil should also suffice. The concentric line preferably should not be grounded except at its ends, and should be kept away from lines carrying modulated r-f.

In adjusting the r-f input system, see that the crystal unit is not connected, remove fuse F-2 from its mounting on the rear apron of the chassis. Set the meter "RANGE" switch to ± 20, the "R. F. ADJ." to near mid-position, and turn on the "POWER" switch. Put the transmitter into operation. Modulator and final-stage power are, of course, unnecessary. Now push button "A" (S-2) under the meter, and vary the transmitter coupling or signal voltage by adjusting the pick-up coil or capacitor. Observe that the meter reading is practically constant over a wide range of input voltage, due to the action of the limiter stages. Decrease the input voltage to zero, and then increase it to a value slightly above the point at which the "R. F. CHECK" reading fails to increase appreciably with increasing input. If an r-f voltmeter is available, simply set the input between 1 and 2 volts. *In no case should the input voltage exceed 4 volts.* Now,

with button "A" again depressed, set the "R. F. ADJ." so that the meter deflects within the red "R. F. CHECK" region.

After turning off the circuit power, the crystal unit should be installed in the inner box of the heat oven. Care should be taken that the contact clips, and leads from the crystal to the outer heat box, are well spaced from each other and from the box surfaces. The "high" terminal of the crystal (the one nearest the top, or name-plate, of the unit) must be connected to the stator of trimmer C-21. See that the lid of the inner box is securely fastened by its four screws. Details are shown in Figure 5.

The mercury thermostat should now be placed in its three retaining clips, which are under, and at the left side of, the heavy, inner crystal box. The two thermostat leads must be secured to the two screw terminals near the lower right-hand corner of the inner crystal box, and the spare length pushed beneath this box. See that the oven doors are closed securely.

Remove the small "CRYSTAL TEMP." bezel from the front panel and carefully insert the thermometer, pushing the graduated leg into its slot. No appreciable force should be required.

Replace the fuse in the rear apron of the chassis (momentarily disconnecting the power cord). Put the dust cover in place—with the power cord and, if possible, the r-f input line, dressed to come out through the notches in its side edges, against the front panel. If the r-f line is a heavy concentric cable, it may be necessary to run it to the input terminals through the hole in the back of the cover; and disconnect it each time the cover is removed.

With the power switch in the "off" position, both of the heater pilots should light within 30 seconds after plugging in the power cord. Place the meter range switch on "± 100," and turn the power switch to the "on" position. The power pilot should light, and shortly the meter will deflect—probably showing nearly full scale frequency error, because of the crystal being far below its normal operating temperature. After about 10 minutes' warm-up, press button "B," turn the range switch to "± 20," and set the "DIODE ADJ." control for meter deflection to "DIODE CHECK" (mid-scale). Press button "C" (with range switch on "± 20"), and set the "AUDIO ADJ." control for meter deflection to the "AUDIO CHECK" mark.

The monitor should now be left, with all power on, for a period of at least 24 hours before any final adjustments are made. This is advisable, not only in order that the crystal and ovens may reach constant temperature, but also to allow all other parts of the equipment to reach a stable operating condition after shipment and installation. After several hours the oven heater pilots will start going out intermittently, and the thermometer column will come into view.

After this stabilization period, the oven heater power should be left on continuously, circuit power only being interrupted by the monitor power switch. Hence the monitor should be connected to an outlet from which the power cannot be cut off.

Before the monitor may be used for frequency logging it must be adjusted finally against a transmitter check from a reliable frequency service. Have the monitor power turned on for at least a half hour before the check, and see that it reads very close to zero deviation on the ± 20-cycle scale. This adjustment is made by varying the crystal trimmer capacitor in the outer crystal oven; which is reached by removing a plug button in the oven door and using a low-capacity tuning tool which will fit the small slot on the trimmer. Also make certain that the "R. F. ADJ.," "DIODE ADJ." and "AUDIO ADJ." controls are reset to give proper meter indications as previously outlined—pressing buttons "A," "B" and "C," with the "RANGE" switch on "± 20." The "DIODE CHECK" and "AUDIO CHECK" readings should be exactly on the line. Also make a record of the "crystal temperature" thermometer reading, which should remain stable hereafter.

At the pre-arranged time for the frequency measurement, take the deviation reading of the monitor, and, in order to minimize drift errors, get the check result and make final adjustment as soon as possible. Having received the measurement result, determine the monitor error; or find by how much the monitor was reading too high or too low at that time. Now re-check the three "ADJ." controls, as previously explained, for a possible new deviation reading. Then adjust the crystal trimmer capacitor, as previously explained, so as to change this reading by the proper amount and direction to correct for the measured indication error. If the change is more than a few cycles, the "AUDIO ADJ." should be rechecked as this new reading is approached.

As an example of the foregoing, assume the following conditions: At the time of the measurement, the monitor read 1 cycle high. The frequency report showed that the transmitter was 5 cycles high; which means that the monitor read 4 cycles too low. Therefore, set the crystal trimmer on the monitor for a deviation reading of 5 cycles high, thus correcting its 4-cycle error. Then adjust the transmitter for a reading of zero deviation.

The monitor will now be ready for routine operation, as described in the following section.

OPERATION

After proper installation and calibration, according to the foregoing instructions, the following operating procedure should be observed.

Turn the power switch on at least 15 minutes before the carrier is to be measured. (The frequency can be measured, of course, before power is applied to the final transmitter r-f stages.) Before taking an accurate frequency reading, the following checks should always be made: (a) see that the crystal temperature is at is stable value; (b) with the meter range switch on "±20," press buttons "A," "B" and "C" for checks on r-f level, diode balance adjustment and audio level, making any changes required on the three "ADJ." controls to give the exact meter readings. The meter will now indicate true deviation in cycles, on either frequency scale.

The "R. F. ADJ." control should require very little resetting, but should always be checked to see that the

deflection is within the red region. The "DIODE ADJ." and "AUDIO ADJ." controls may require slight readjustment at each reading.

It is recommended that the crystal oscillator of the transmitter be retrimmed, as necessary, to keep deviation indication within several cycles. If frequent, large readjustments in frequency should become necessary at any time, or if a sudden jump of more than the tolerance limit should occur, an investigation of the cause should be made at once. In such situations, there are three possible causes of the trouble: (a) the transmitter has changed frequency; (b) the monitor oscillator has changed frequency; (c) the audio indicating system of the monitor is defective. Of the first two, (a) is the more probable cause, since the monitor crystal works at a very much lower power level than the crystal in a transmitter exciter, and has received special precautions for stability. Trouble (c) is probably not present if the "DIODE" and "AUDIO" checks can be made, but it can be detected by listening to the tone from the monitor phone jack and matching it with tone from an audio oscillator which has a good frequency calibration (or by checking against any good audio reference frequency, such as a tuning fork). If the monitor tone is within a few cycles of 1,000, and the cycles meter shows deviation outside of tolerance, then the trouble is in the audio system of the monitor. (Possible causes may be found by standard test methods and reference to "Maintenance and Service Information," and the schematic and wiring diagrams herewith.) If the monitor tone appears to agree with the deviation indication, or if no external reference frequency is available, then the transmitter tuning should be changed, if possible, to give zero deviation indication (on the strength of the probability between causes (a) and (b)), and a frequency measurement should be obtained at once.

If the monitor should read within tolerance and, at the same time, it should be impossible to set the "AUDIO ADJ." control properly, the audio indicating system can again be checked by comparing the tone to a good reference frequency.

Actual false indication, with all adjustments being normal, is possible only when the transmitter is between 1,900 and 2,100 cycles low. This can be checked by slightly raising the transmitter frequency. If the transmitter is low by the above amount, this change will produce a deflection toward "low" deviation. For normal conditions, it should result in deflection toward "high."

Periodic checks of tubes and other maintenance precautions are recommended, as outlined in the following section. Certain precautions outlined therein with regard to changing tubes should be noted particularly, since V-3, V-4, V-5 and V-7 may have appreciable effect on deviation indication. Periodic frequency measurements, by a reliable service as required by the Federal Communications Commission, are necessary.

MAINTENANCE

Circuit adjustments, other than those described under "Operation," should not be required. The oscillator circuit should not be disturbed except in case of failure, and any readjustments should be followed by a frequency measurement.

The principles of operation of the monitor are outlined under "Description," and should be evident from the simplified and complete schematic diagrams. Checks for localizing the cause of excessive deviation indication are outlined under "Operation." If the

Voltage Data (at rated line voltage):

D.C. Voltages to Chassis

Tube	Cathode	Grid	Screen	Plate
6H6-V-1	0	—	—	−15 (at R-2, with normal r-f signal)
6SJ7-V-2	1.5	0	87	210
2A3-V-3	38	0	—	255
6H6-V-4	6	—	—	−4 (with normal r-f signal)
6F8G-V-5	KT2, 62 KT1, 6	GT2, 6 GT1, −50	— —	PT2, 6 PT1, −50 (with normal r-f signal)
VR150-V-6	0	—	—	150
6J5-V-7	0	−3	—	85 (approx. oscillating value)
6SJ7-V-8	0	−3.5 −0.5*	95 60*	170 90*
6SJ7-V-9	0	−3.5 −0.5*	95 60*	170 90*
6SJ7-V-10	0	−3.5 −0.5*	90 60*	180 90*
2050-V-11	0.5	—	—	−45 (conducting)
5T4-V-12	310	—	—	0
6SJ7-V-13	0	−0.5*	40*	120*
6SJ7-V-14	0	−0.5*	40*	120*
		KT1—KT2 GT1—GT2 PT1—PT2 } Tube Elements		

* With no r-f signal.

The above are approximate operating voltages. The use of an ordinary low-resistance voltmeter for measurements will lower some of the above values appreciably, as may be inferred from the schematic diagram.

monitor should become defective, it should be possible to locate the failing component, by standard test methods, using the accompanying tube voltage data, and wiring and schematic diagrams. Defective parts should be ordered from the accompanying "Replacement Parts" list.

For power line voltages between 105 and 115, connect to the 110-volt taps on the primaries of T-2 and T-3. For voltages between 115 and 125, connect to the 120-volt taps.

Under normal operating conditions, the following approximate values of signal voltages should occur on the circuit elements as listed:

V-1 cathode, 0.75 volt osc. signal. (With normal carrier input. Several volts with no carrier.)
V-2 grid, 0.25 volt, 1,000 cycles.
V-3 grid, 26 volts, 1,000 cycles (use tube voltmeter).
V-3 cathode, 10 volts, 1,000 cycles.
V-3 plate, 49 volts, 1,000 cycles.
Across T-1 secondary, 19.5 volts, 1,000 cycles.
V-4 plate to cathode, 8.2 volts, 1,000 cycles.
Across L-6, R-19 and R-18 (in series), 44 volts, 1,000 cycles.
Across C-13 and R-17, 47 volts, 1,000 cycles.
V-8 grid, 0.3 volt r-f (approx. for normal carrier input).
V-9 grid, 0.25 volt r-f (approx. for normal carrier input).
V-10 grid, 0.2 volt r-f (approx. for normal carrier input).

The small variable capacitor C-25 on the rear of the top chassis is set at the factory for proper oscillator voltage to the grid of V-8. Since this setting has a slight effect on oscillator frequency, *C-25 should not be disturbed except in a major servicing operation which will be followed by a frequency check.* With normal r-f input signal, proper "Audio Check" indication and normal gain in the oscillator amplifier system, proper setting of C-25 is indicated by approximately −3.5 volts d.c. on the plate of V-4 (measured with an instrument of at least 50,000 ohms resistance). This will correspond to approximately 0.3-volt oscillator signal on the grid of V-8.

It is advisable that all tubes in the monitor should be tested periodically. Changing of tubes V-3, V-4, V-5, and V-7 may have some effect on a-f indication, but the indicated frequency should not change appreciably over the useful life of a given tube or set of tubes. The possible error resulting from these changes may be outlined as follows:

Change of oscillator frequency due to changing oscillator tube, approximate maximum of 3 parts per million (total).

Approximate maximum change of deviation indication, in the audio system, due to tube changes are given as follows:

Tube	Total Cycle Variation
A-F Power Amplifier	1
A-F Discriminator Diode	3
A.V.C. Diode ..	1 cycle near zero deviation 3 cycles near 100-cycle deviation

It is therefore advisable that these four tubes particularly should be checked periodically and changed before they drop below about 80% of normal rating, and that such changes should be made immediately before obtaining a periodic frequency check. If the carrier frequency has shown very good stability, these tubes may be changed with reasonable safety by noting the change in indicated frequency resulting from the tube change, and trimming the monitor oscillator to correct for this possible change of several cycles. (Always check the settings of controls "A," "B" and "C," and allow sufficient time for warm-up.) In the event of an emergency change following failure of one of these four tubes, the same procedure can be followed by referring to the station frequency log; *provided* that the log and observations indicate that the carrier frequency has been quite stable. This, however, is not as safe as direct observation of indication change.

Capacitor C-10 and inductor L-5 are adjusted at the factory and mounted in a single unit, and cannot be replaced individually. These components resonate at approximately 1,000 cycles, and the gain of the V-2 stage is consequently peaked at this frequency. Measuring the voltage on C-11 with a tube voltmeter, the gain of this stage at 500 cycles and 2,000 cycles should be approximately 20% of that at 1,000 cycles.

Inductor L-6 and capacitors C-13 and C-13A are also adjusted at the factory to give zero indication at 1,000 cycles. In the event of trouble with any of these units, it would be necessary to return the complete instrument to the factory for readjustment, or to make the replacement according to the following procedure: If C-13A (this may be two moulded capacitors in parallel) only should fail, note the values stamped thereon and order corresponding units from the "Replacement Parts List." C-13 and L-6 are stocked in matched pairs. If either one of these should fail, both must be replaced; and a new value of C-13A will very probably be required, making it necessary to order all four of the units listed as C-13A under "Replacement Parts." After installation of L-6 and C-13, connect a source of 1,000-cycle signal (which should be accurate within about one cycle, and should contain not more than about one percent. distortion) to the grid of V-2. Adjust the amplitude of this source until the monitor meter reads on the red "Audio Check" line (with range switch on "± 20") when button "C" is pressed. Now select a value of C-13A which will make the meter indicate within one cycle of zero deviation. This may require a selected pair of the four moulded capacitors to be used in parallel. This procedure should result in an indication with an accuracy of several cycles, but an early frequency check would be advisable.

Any servicing which requires removal from the rack or handling of the monitor should be followed by a stabilizing period of about 8 hours' operation (more if the crystal oven is cold) before making a deviation adjustment against a frequency check. The complete set-up procedure and adjustments are outlined under "Installation."

The oscillator cathode coil L-7 and the r-f coils L-2, L-3, L-4, L-11, L-12 and L-13 are adjusted at the factory for the operating frequency specified on order. In the event that these adjustments should be changed or the monitor used on a new frequency, the data on tuning ranges of the various taps, given below, will be useful. The r-f tuning capacitors are located in the tops of the individual coil cans, and can be reached by means of a bakelite-rod tuning tool. L-11, L-12, and L-13 also may tuned by means of their adjustable magnetite cores. The terminals referred to appear below the chassis, on the lower ends of the coil forms. Tuning can be accomplished by means of the "R. F. Check" procedure, and adjusting for maximum indication. It is necessary to tune with reduced r-f input voltage, however, in order to prevent masking of the tuning by the A.V.C. action of the "Clipper" amplifier. With the "R. F. ADJ." at about 2/3 maximum and the meter on ± 20 range, the input voltage should be set, in each tuning operation, to produce a maximum deflection of about 4 on the ± 20 scale.

Make the connections and adjustments indicated in the chart below for the desired frequency. Remove the oscillator tube (V-7) and tune L-2 first. Then tune L-13, L-12, and L-11 in this order, reducing the input in each case as explained above. For the last two adjustments it may be necessary, in order to get sufficiently low input, to disconnect the r-f line from the monitor and use a short piece of wire as an antenna on the "R. F." terminal. Now remove all r-f input signal from the monitor, replace the oscillator tube and tune L-4 for maximum meter deflection, which may be only several scale divisions. This procedure completes tuning of the r-f amplifiers, and has no effect on oscillator frequency. The input voltage should be set as explained under "INSTALLATION." For making a change in oscillator frequency, the procedure for setting C-21 and C-25 is given earlier in this section.

Range in kc	Terminal or Jumper Connections and Tuning Ranges of R-F Coils						
	R-F Ampl. Coil		Clipper Ampl. Coils		Osc. Coupl. Coils		
	L-2		L-11, 12 and 13		L-3	L-4	
	Jumper from:	Jumper from:	Jumper from:	Core: turns "in" from max. "out" position	Jumper from:	Jumper from:	Jumper from:
540- 750	1 to A	—	C to E	7	3 to E	1 to A	—
750-1,100	1 to B	—	C to E	7	3 to H	1 to B	—
1,100-1,550	1 to C	—	C to D	4	3 to H	1 to C	—
1,550-2,000	1 to D	A to B	C to D	4	3 to E	1 to D	A to B

The oscillator cathode coil (located in the outer heat oven) is not tuned, but in order to obtain a strong crystal fundamental component, a tap is selected which is resonant within about 20% of the crystal frequency. The accompanying list of jumper connections is in the order of increasing resonant frequency, and shows approximate crystal frequencies for various connections. The lowest frequency coil which will give stable oscillation should be used. The procedure for final adjustment of C-21 and C-25 is given in an early part of this section.

The schematic diagram clearly indicates the operation of the oven heater circuits. The inner oven should regulate at approximately 70 degrees C, and show practically no variation. The outer oven should regulate at approximately 65 degrees C. Although it should require no attention, a screw adjustment is provided in the tubular thermostat in the outer oven.

The operation of the various switching circuits should be apparent from the schematic diagram. It should be stated, however, that the "Diode Check" switch (S-5) creates a bridge circuit of the two diodes in V-5 and their load resistors and capacitors, with a 60-cycle voltage across one diagonal and the meter across the other. This produces peak diode currents of the same order as those produced by signal, and R-21 is then adjusted for balance as indicated by the meter.

OSCILLATOR COIL CONNECTIONS

Jumper Connections		Approx. Crystal Freq.
1 to:	8 to:	
open	open	
2	open	
3	open	540
4	open	
open	7	600
5	open	
2	7	
3	7	
open	6	800
6	open	
4	7	900
2	6	
open	5	1,000
3	6	
2	5	
open	4	1,500
3	5	
2	4	
open	3	2,000

REPLACEMENT PARTS LIST

Symbol No.	Description	Stock No.
C-1	Capacitor, part of L-1, L-2	
C-2	Capacitor, part of L-3, L-4	
C-7	Capacitor, 20-10-10-10 mfd, 450 volts	18403
C-9	Capacitor, same as C-7	
C-10	Condenser, part of L-5	
C-13	Condenser, part of L- 6	
C-13A	Capacitor, 270 mmfd	12488
C-13A	Capacitor, 560 mmfd	12537
C-13A	Capacitor, 1,200 mmfd	13054
C-13A	Capacitor, 1,800 mmfd (Customer to select one from above to match capacity markings of defective capacitor.)	13580
C-17	Capacitor, 20 mfd	32400
C-18, C-19	Capacitor, 3,900 mmfd	13763
C-20	Capacitor, 220 mmfd	12694
C-22	Capacitor, 2,700 mmfd	30057
C-23, C-24	Capacitor, same as C-18	
C-25	Capacitor, variable 4-25 mmfd	17888
C-26	Capacitor, 33 mmfd	12948
C-27	Capacitor, 560 mmfd	12537
C-29	Capacitor, 47 mmfd	13141
C-30	Capacitor, 0.1 mfd	30848
C-31	Capacitor, same as C-29	
C-32, C-33	Capacitor, same as C-7	
C-34, C-35	Capacitor, 0.25 mfd	30849
C-36, C-37	Capacitor, 30-20 mfd, 450 volts	18406
C-38	Capacitor, same as C-18	
C-41	Capacitor, same as C-29	
C-42	Capacitor, 0.01 mfd	30855
C-45	Capacitor, 15 mmfd	12896
C-46, C-47	Capacitor, 15-15-5 mfd, 450 volts	19806
C-48	Capacitor, 0.01 mfd	30855
C-51	Capacitor, same as C-46	
C-52, C-53	Capacitor, 0.05 mfd	30847
F-1, F-2	Fuse, 2 amperes	3883
J-1	Jack, Assembly	30079
L-1, L-2	Transformer, R-F input	43087
L-3, L-4	Transformer, Osc. amplifier	43086
L-5	Coil, Audio reactor	43088
L-6	Coil, Discriminator reactor with capacitor	43085
L-8	Coil, R-F choke, 16 mh	2994
L-9	Reactor, 30 henries power filter	43084
L-12	Reactor	44139
M-1	Meter, Microammeter	43098
R-1	Control, 100 ohms, R-F adjustment control	43071
R-11, R-12	Resistor, 10 ohms, ½ watt	32184
R-13	Resistor, 775 ohms, wire wound, 10 watts	43077
R-16	Resistor, 150,000 ohms, wire wound	43076
R-21	Control, 500 ohms, diode adjustment control	43072
R-25	Control, 2,500 ohms, A-F adjustment control	44169
R-27	Resistor, 18,000 ohms, 1 watt	30151
R-30	Resistor, 100,000 ohms, 1 watt	3058
R-31	Resistor, 1 meg., 1 watt	2546
R-34	Resistor, 820 ohms, 1 watt	30153
R-35	Resistor, 10,000 ohms, 4.8 watts	43070
R-36	Resistor, same as R-31	
R-39	Resistor, same as R-34	
R-40	Resistor, same as R-31	
R-41	Resistor, 1,000 ohms, ½ watt	4687
R-42	Resistor, 25,000 ohms, 8 watts	43074
R-43	Resistor, same as R-41	
R-45	Resistor, same as R-31	
R-46	Resistor, 12,000 ohms, 8 watts	43075
R-47, R-48	Resistor, 68 ohms, ½ watt	32808
R-49, R-50	Resistor, same as R-41	
R-51	Resistor, 1,200 ohms, 1 watt	6134
R-52	Resistor, 30 ohms, ½ watt	34018
R-53	Resistor, 120,000 ohms, ½ watt	30180
R-54	Resistor, 100,000 ohms, ½ watt	3252
R-55	Resistor, 18,000 ohms, 2 watts	11671
R-56	Resistor, 1,200 ohms, ½ watt	30731
R-57	Resistor, same as R-54	
R-58	Resistor, same as R-53	
R-59	Resistor, same as R-56	
S-1, S-2, S-5 (mounted in one frame)	Switch, Switch for R-F, A-F, and diode check (MI-8211-F, G, H)	44519
S-1, S-2	Switch, Switch for R-F, A-F check (MI-8211-C, D, E)	44170
S-3	Switch, Power switch	18369
S-4	Switch, Meter range switch	43092
S-5	Switch, Switch for diode check (MI-8211-C, D, E)	44171
T-1	Transformer, Audio transformer	43091
T-2	Transformer, Heater transformer	43089
T-3	Transformer, Power transformer	43090
T-6, T-7	Transformer	44138
	Button, Button for diode and R-F, A-F check switch (MI-8211-F, G, H)	44520
	Connector, 2 prong male recessed	23225
	Holder, Fuse holder	32059
	Jewel, Amber lens	43739
	Jewel, Green lens	43738
	Jewel, red lens	43737
	Knob, Control and switch knobs	30075
	Lamp, Pilot lamp heater indicator	43101
	Lamp, Pilot lamp power indicator	31480
	Socket, Pilot light socket only	43734
	Socket, 4-contact wafer type tube socket	31769
	Socket, 8-contact moulded porcelain tube socket	18007
	Socket, 8-contact wafer type tube socket	33084
	Thermometer only	43103

REPLACEMENT PARTS LIST (Continued)

Symbol No.	Description	Stock No.
	HEATER BOX ASSEMBLY	
A-2	Thermostat, Mercury tube angle type	43096
A-3	Switch, Thermo. switch	43097
A-4, A-5	Thermostat, Protecting thermostat round metal type	43095
C-21	Capacitor, Variable capacitor, 3-25 mfd	43082
L-7	Coil, Oscillator coil assembly	43083
	Catch, Female heat box catch	21446
	Catch, Male heat box catch	23094
	Heater, Heater unit, small, 1,600 ohms (Pt. of R-28)	43079
	Heater, Heater unit, small, 8,800 ohms (Pt. of R-28)	43081
	Heater, Heater unit, large, 1,800 ohms (Pt. of R-29)	43078
	Heater, Heater unit, large, 3,000 ohms (Pt. of R-29)	43080
	RESISTOR BOARD ASSEMBLIES	
C-3	Capacitor, 680 mmfd	14498
C-4	Capacitor, 100 mmfd	12720
C-5	Capacitor, 1,000 mmfd	12635
C-6	Capacitor, 2,700 mmfd	30057
C-8	Capacitor, 0.25 mfd	30849
C-11	Capacitor, 0.005 mfd	30852
C-12	Capacitor, 0.05 mfd	30847
C-14	Capacitor, 0.5 mfd	30860
C-15, C-16	Capacitor, 0.5 mfd	43456
C-28	Capacitor, 1 mfd	18416
R-2	Resistor, 47,000 ohms, 1 watt	30495
R-3	Resistor, 150 ohms, 1 watt	30785
R-4	Resistor, 150,000 ohms 1 watt	31895
R-5	Resistor, 1 meg., 1 watt	2546
R-6	Resistor, 220 ohms, 1 watt	30496
R-7	Resistor, same as R-2	
R-8	Resistor, 10,000 ohms, 2 watts	43065
R-9	Resistor, 100,000 ohms, 1 watt	3058
R-10	Resistor, 470,000 ohms, 1 watt	36243
R-14	Resistor, 68,000 ohms, 1 watt	30679
R-15	Resistor, 2,700 ohms, 1 watt	14421
R-17	Resistor, 200 ohms wire wound	43059
R-18	Resistor, 35 ohms, wire wound	44168
R-19	Resistor, 75 ohms, wire wound adj. 10 watts	44167
R-20	Resistor, 240 ohms, 1 watt	43069
R-22, R-23	Resistor, 22,000 ohms, wire wound	43068
R-24	Resistor, 2,000 ohms, wire wound	43067
R-26	Resistor, 70,000 ohms, wire wound	43066
R-32	Resistor, 6 ohms, 2 watts	43063
R-33	Resistor, same as R-3	
R-37, R-38	Resistor, 18,000 ohms, 1 watt	30151
R-44	Resistor, 20,000 ohms, 2 watts	43062

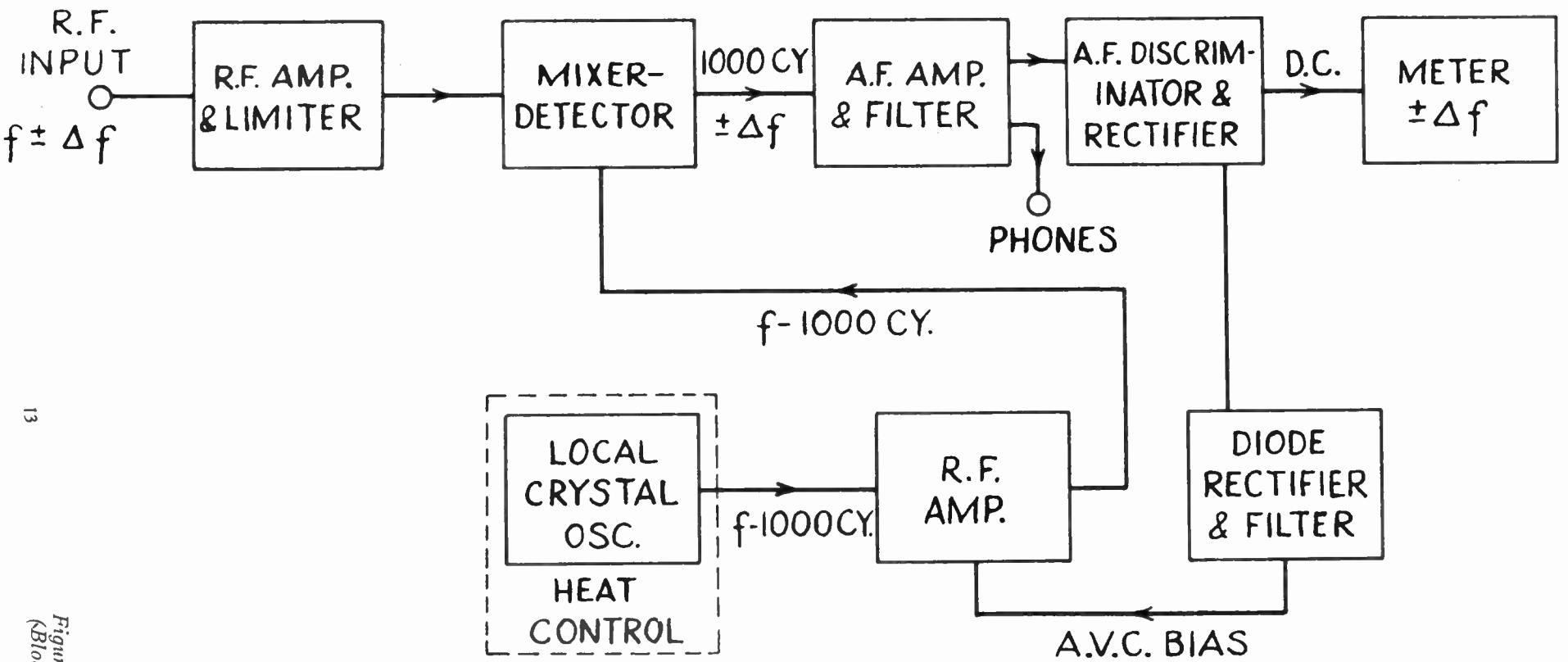


Figure 2—Frequency Monitor (Block Diagram MX-244373)

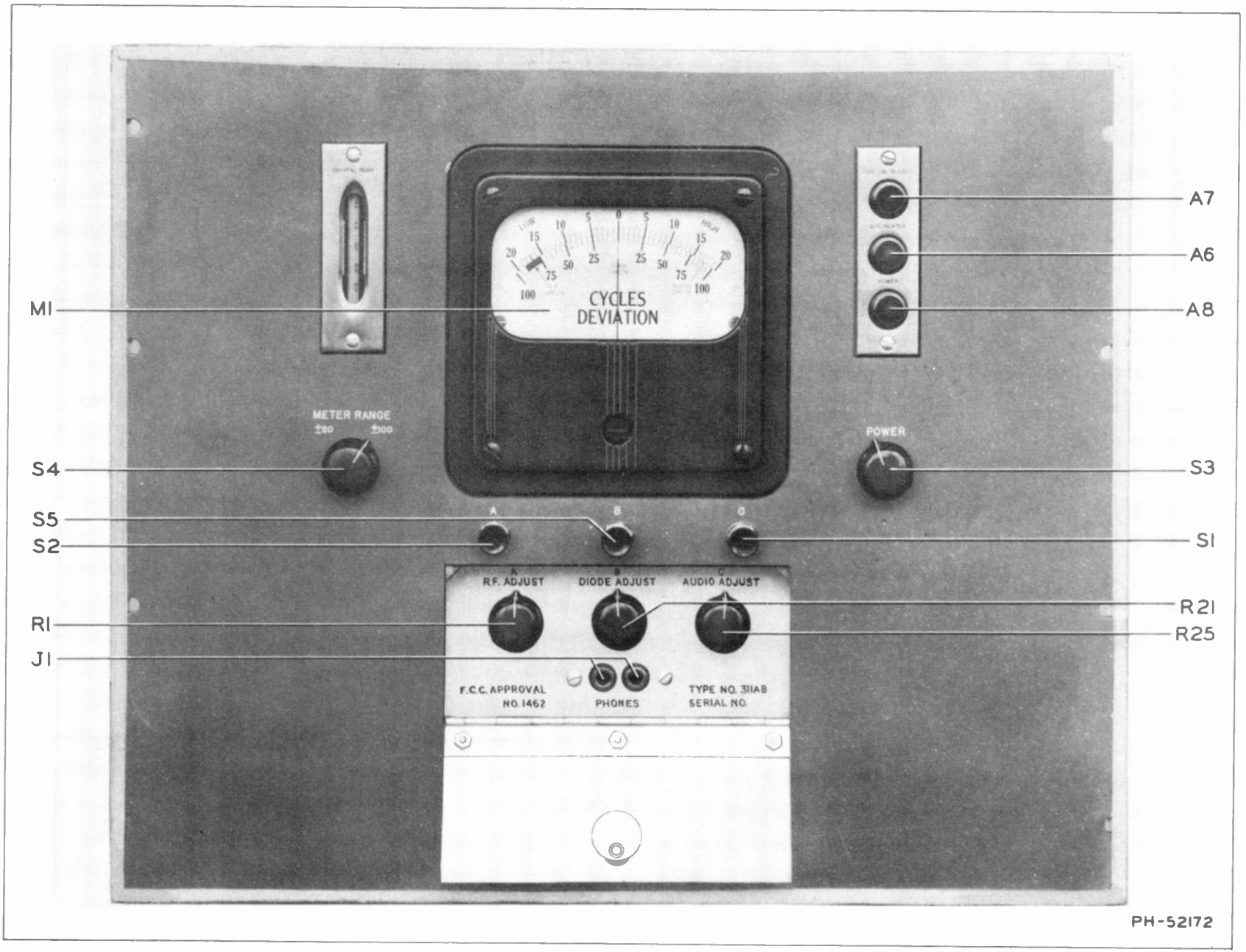


Figure 3—Control Panel (Door Open)

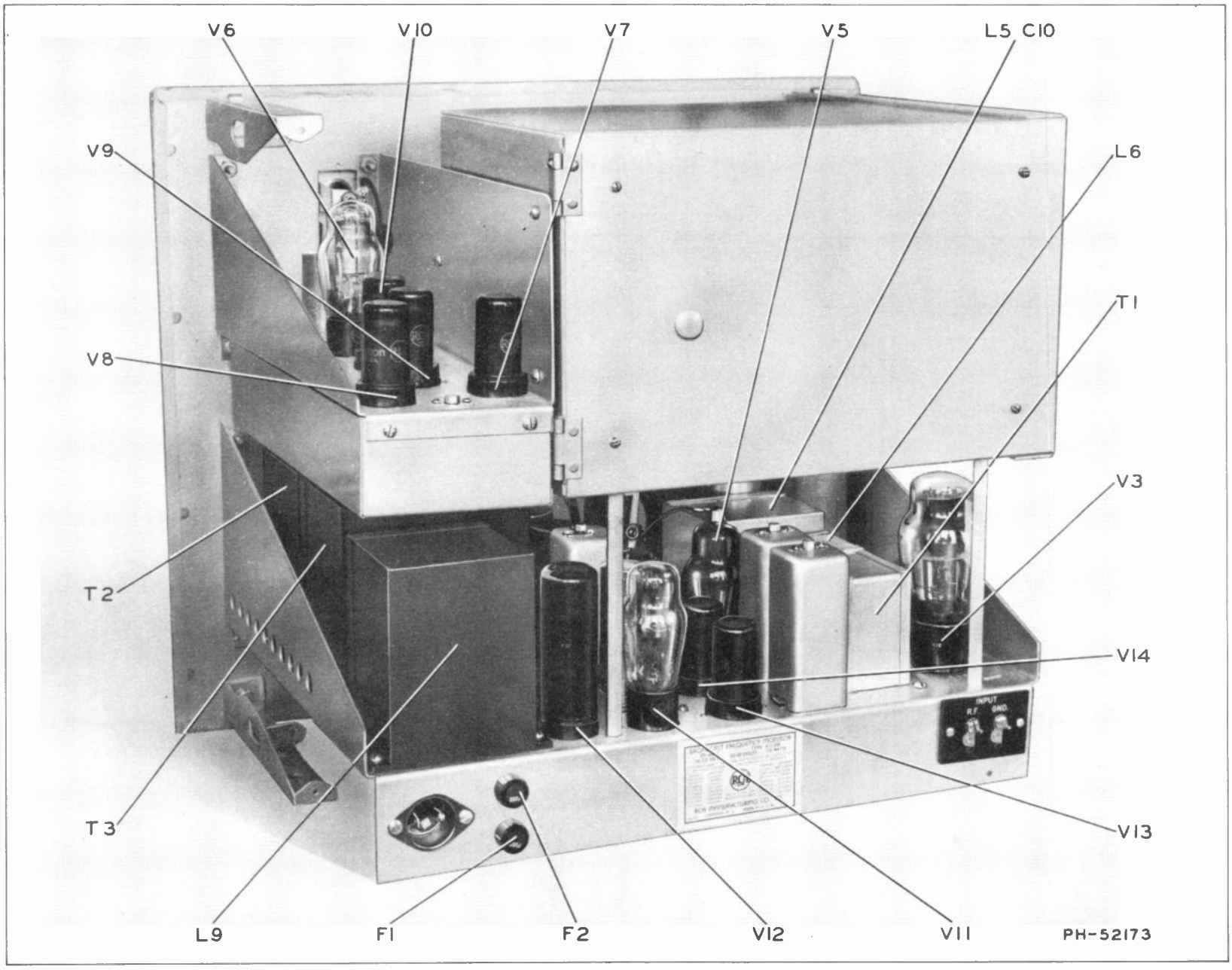


Figure 4—Frequency Monitor (Rear View)

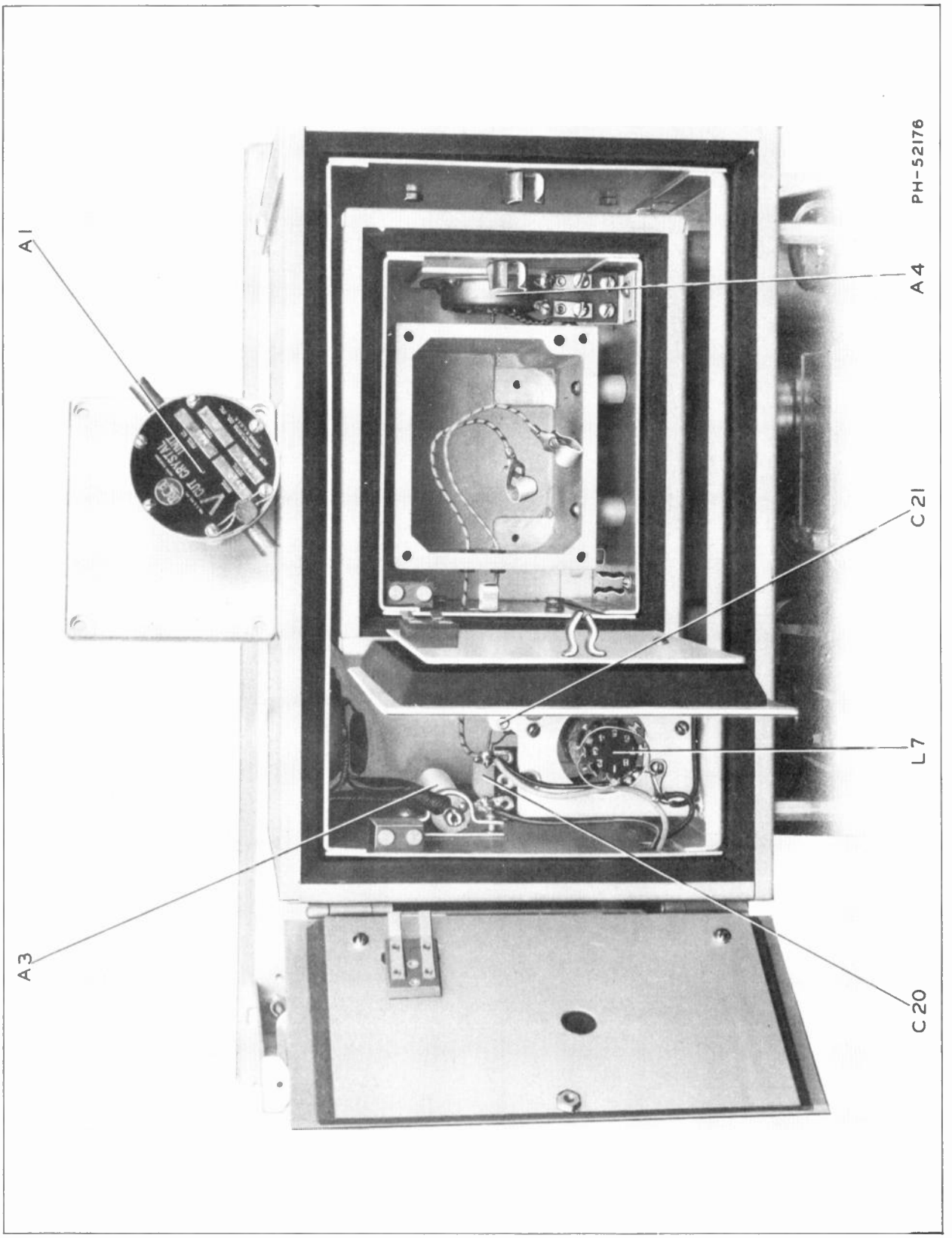


Figure 5—Crystal Oven (Doors Open)

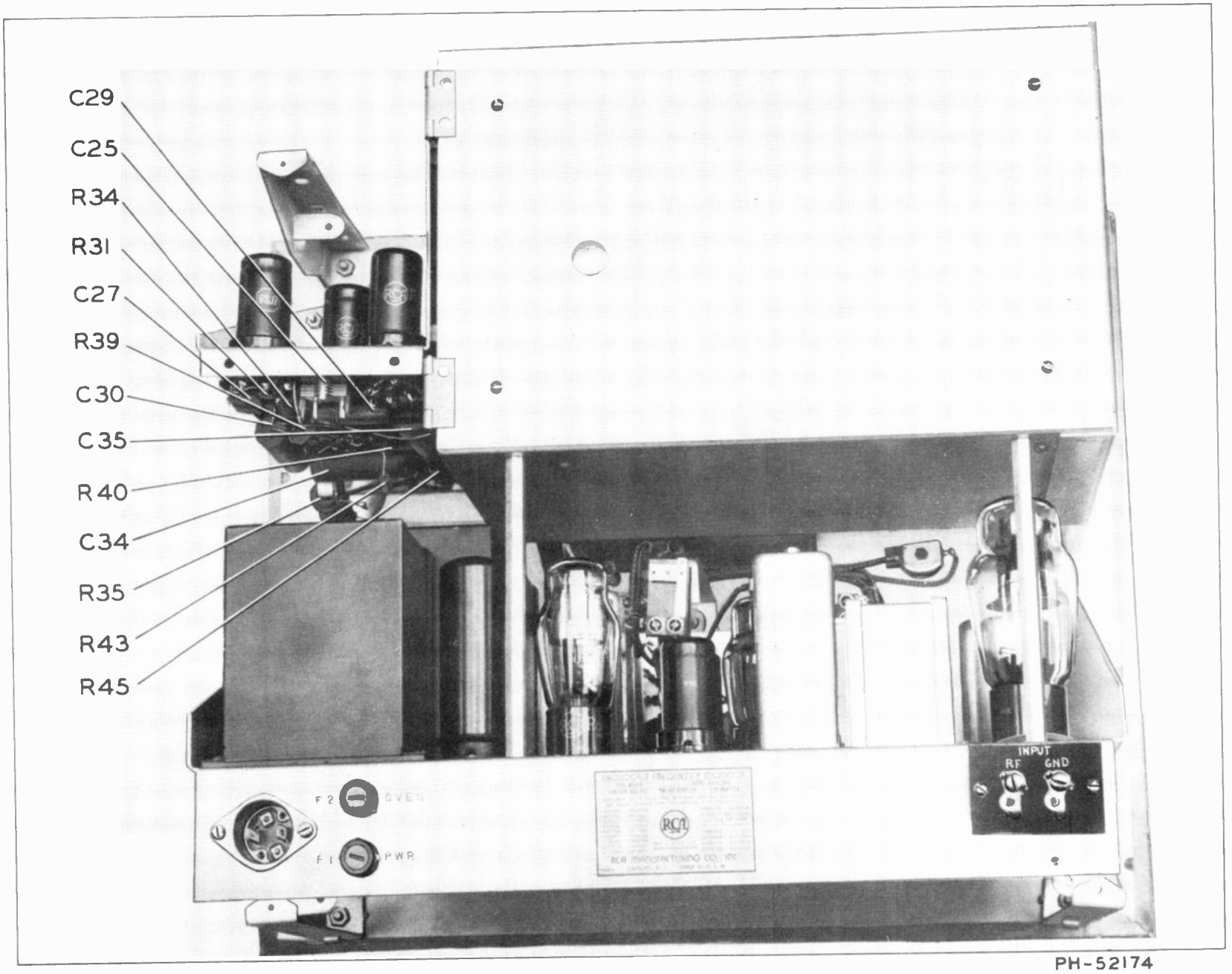


Figure 6—Oscillator Chassis (Sub-chassis View)

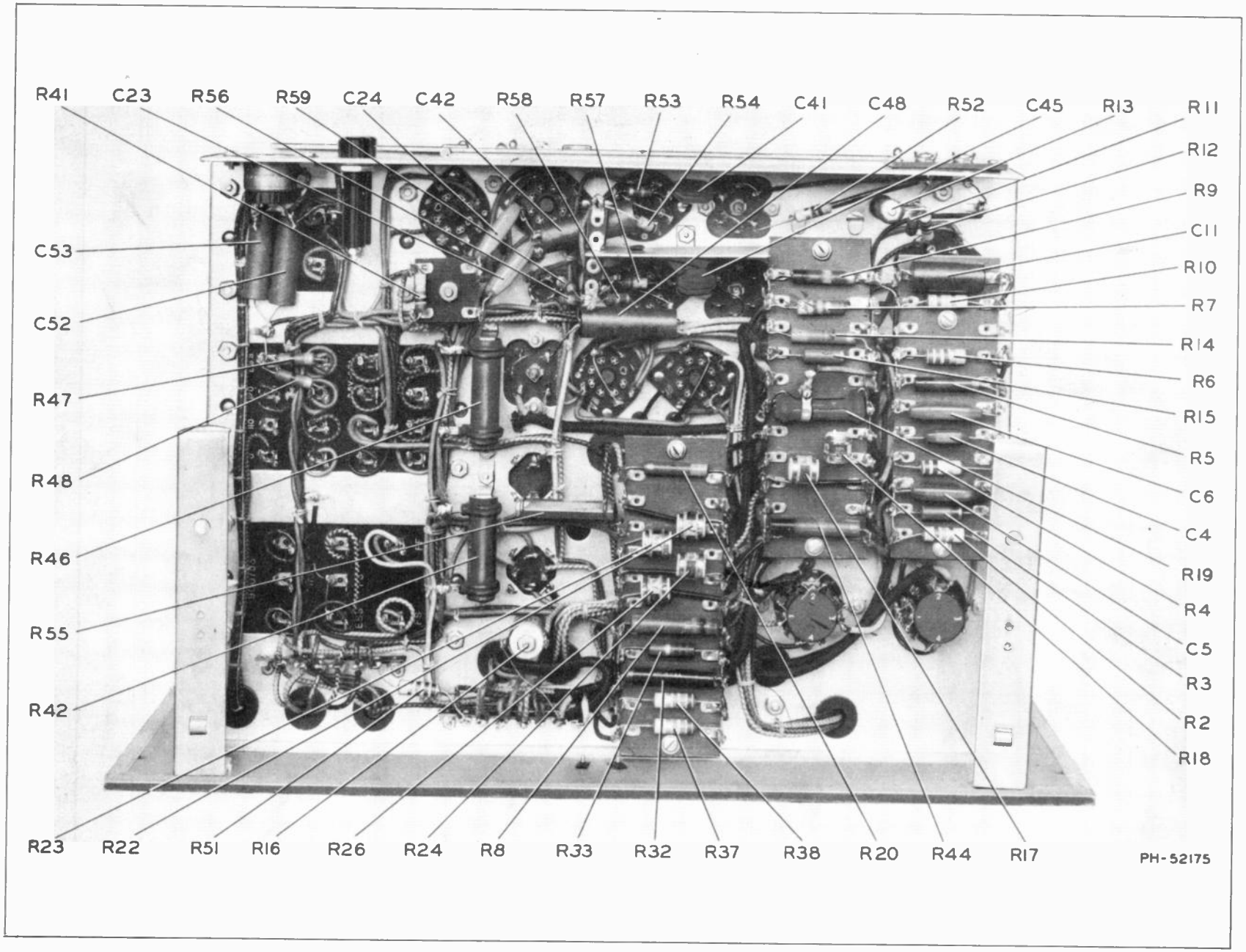


Figure 7—Main Chassis (Bottom View)

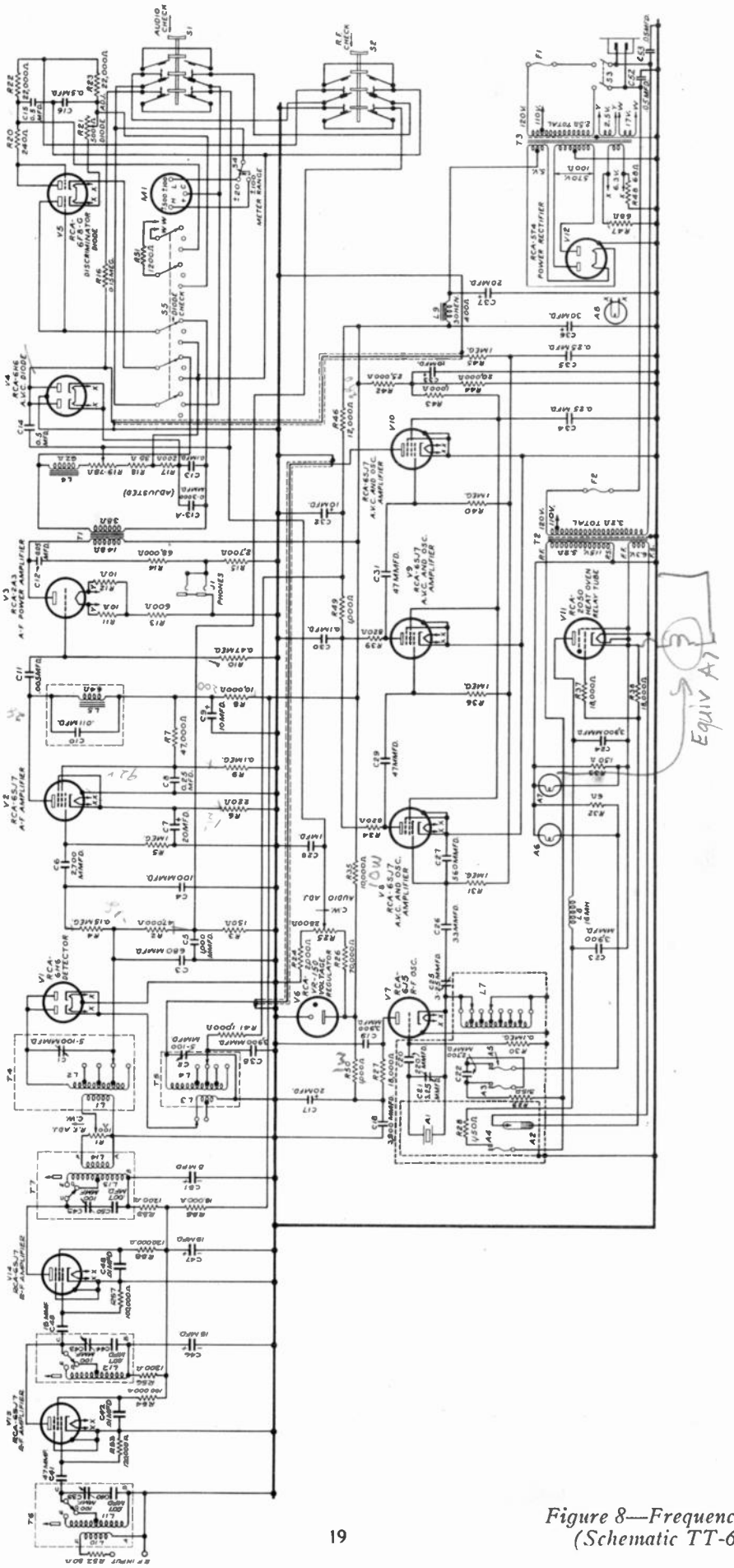


Figure 8—Frequency Monitor (Schematic TT-617076)

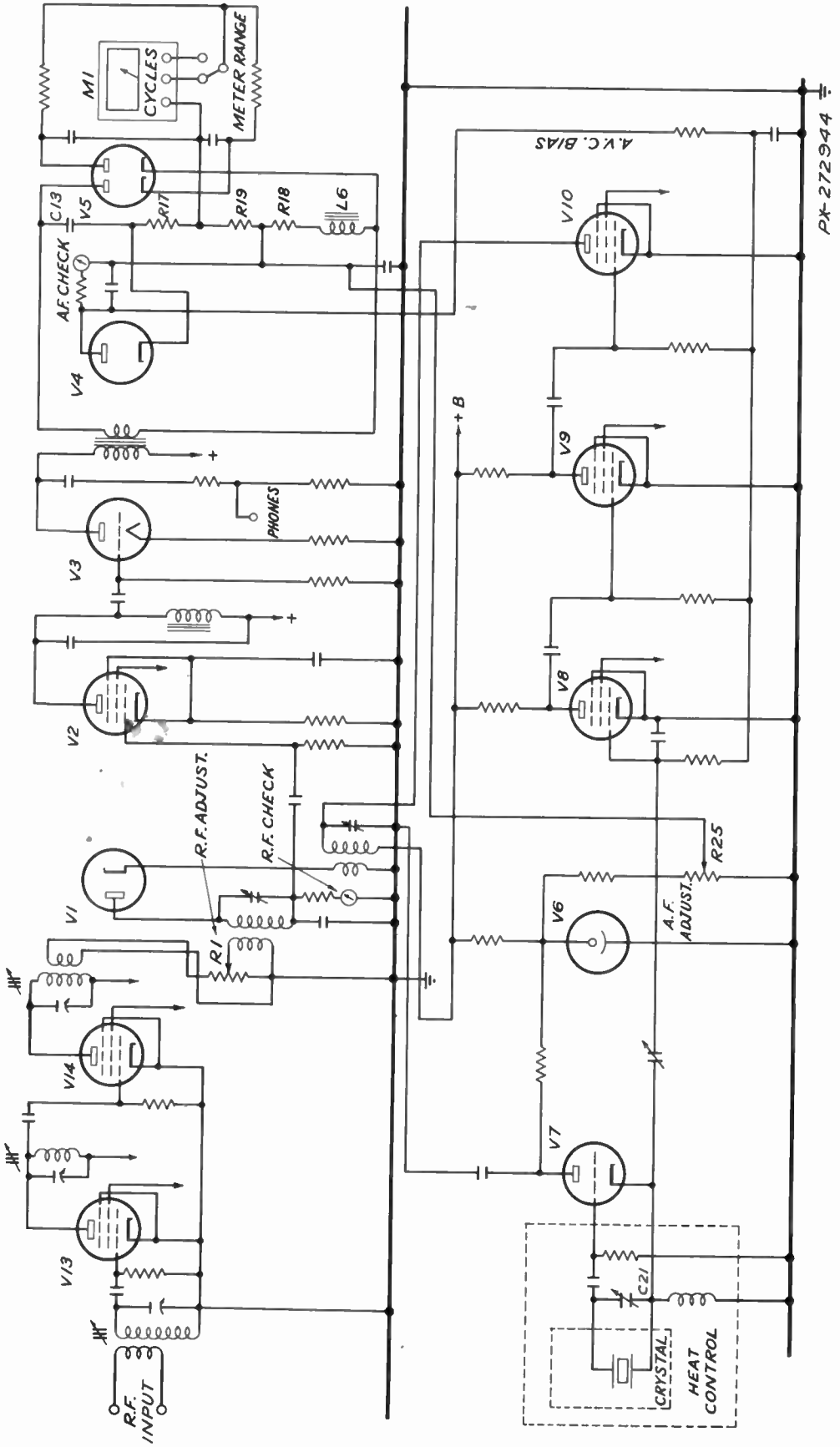


Figure 9—Frequency Monitor (Simplified Schematic PX-272944)

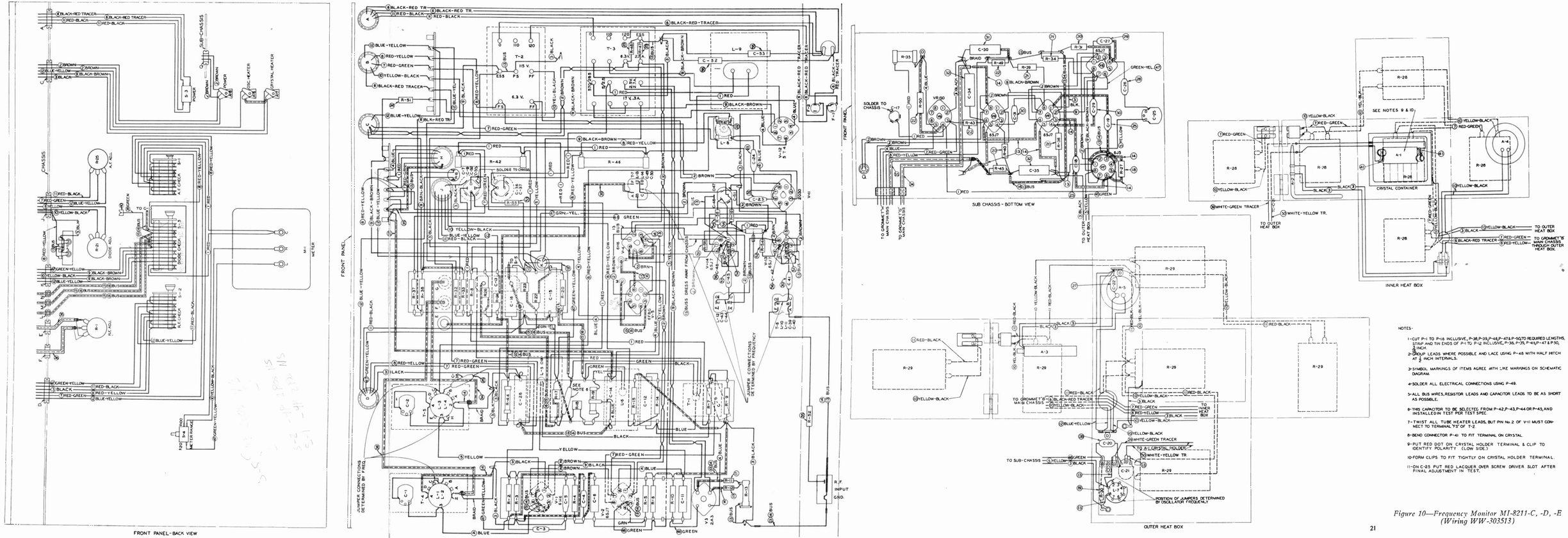
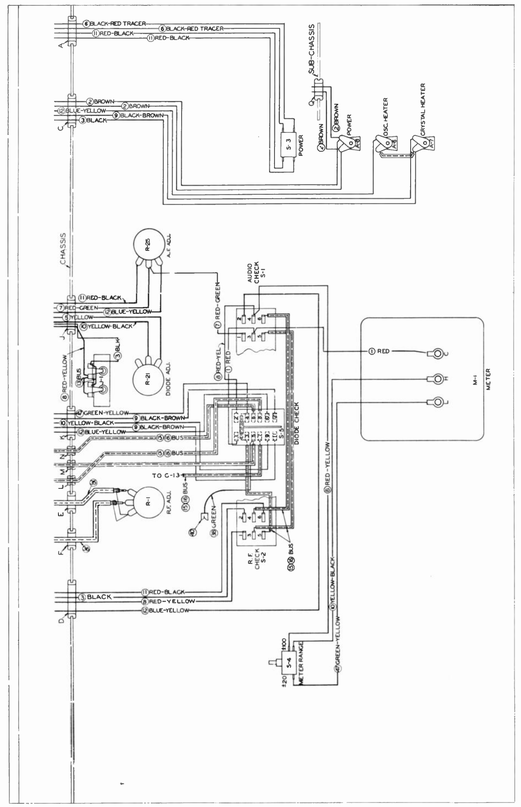
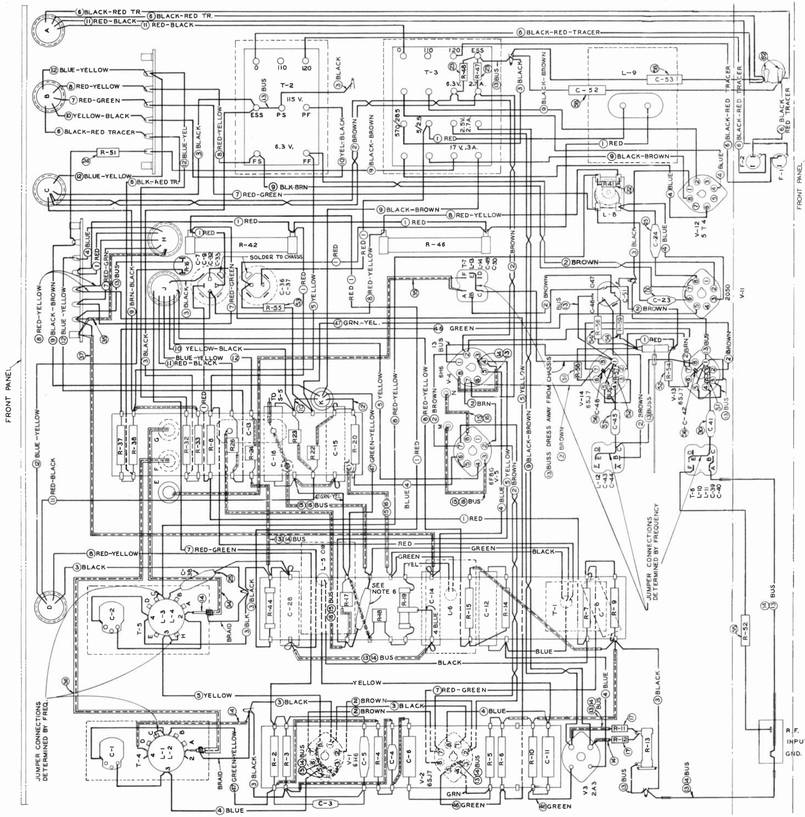
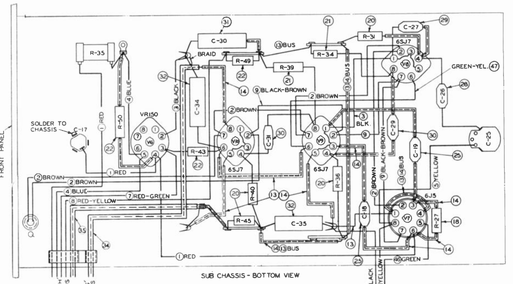
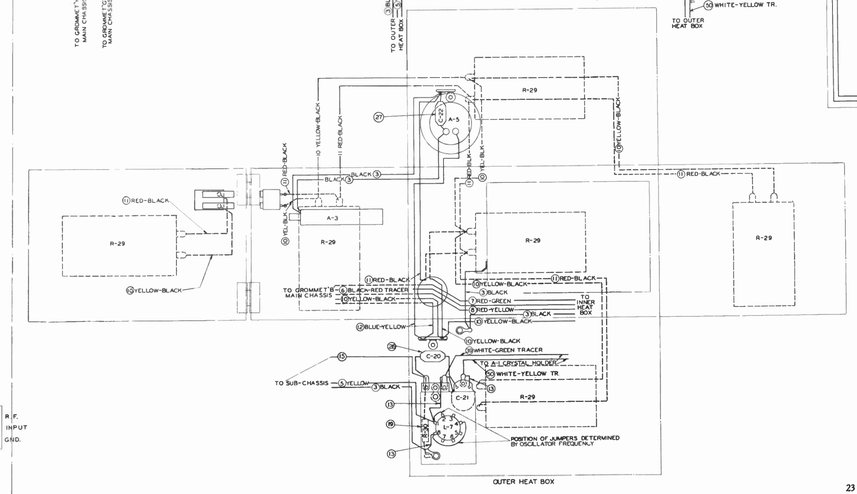


Figure 10—Frequency Monitor MI-8211-C, -D, -E (Wiring WW-303513)









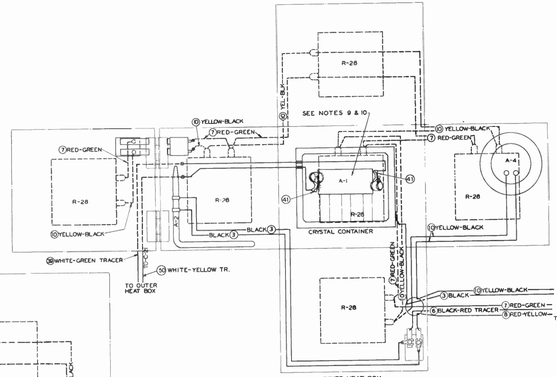


Figure 11—Frequency Monitor MI-8211-F, -G, -H (Wiring WW-303543)