

**OPERATING INSTRUCTIONS**  
for  
**TYPE 1170-B**  
**AND**  
**TYPE 1170-BT**  
**FREQUENCY-MODULATION**  
**MONITORS**



**GENERAL RADIO COMPANY**

**CAMBRIDGE 39**

**MASSACHUSETTS**

**NEW YORK**

**CHICAGO**

**LOS ANGELES**

**U. S. A.**







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Form 666-E  
October, 1953



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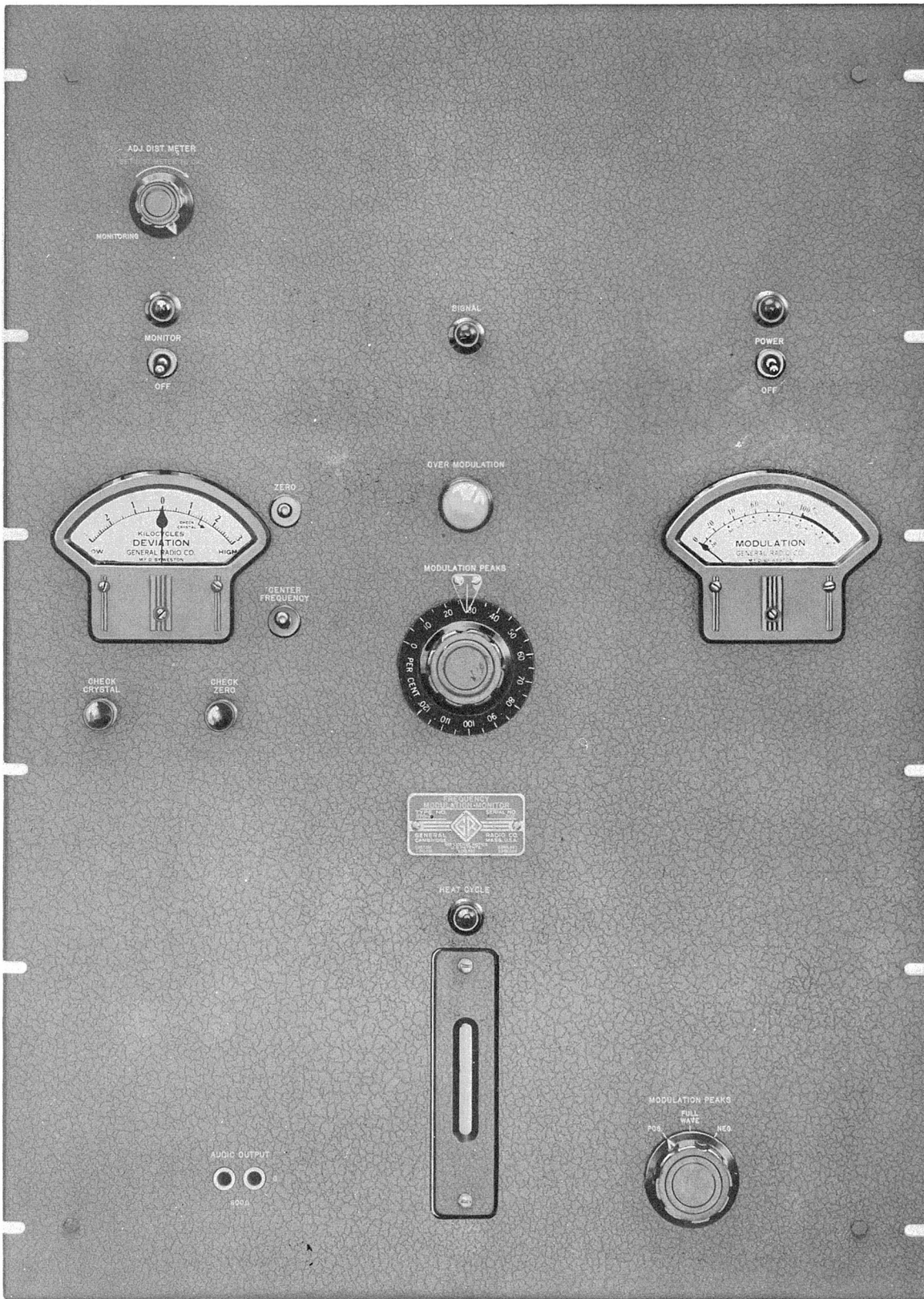


Figure 1a. Panel View of Type 1170-B Frequency-Modulation Monitor

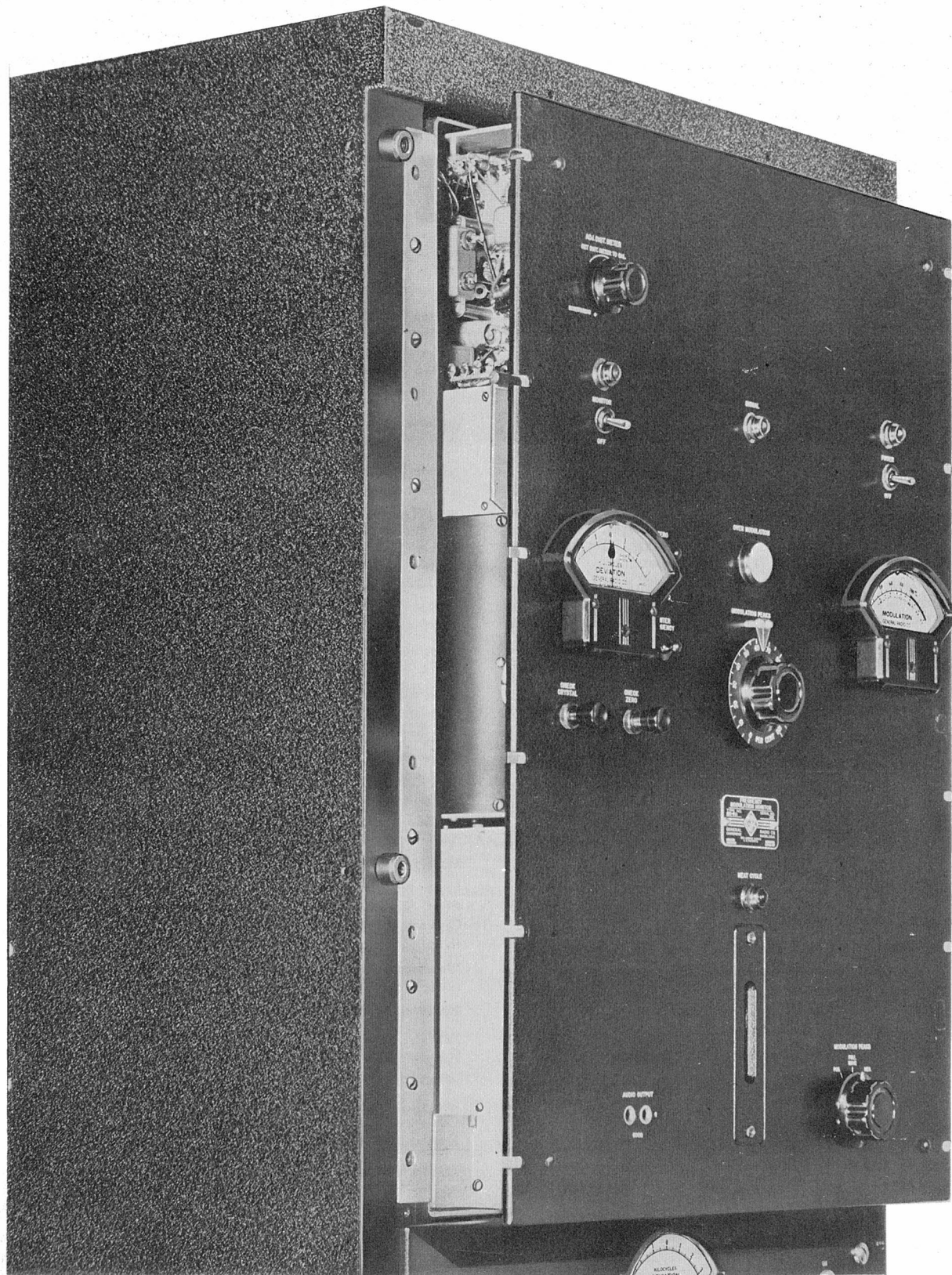


Figure 1b. Monitor is removable from front of rack, as shown, for servicing and inspection.

# SPECIFICATIONS FOR 1170-BT\*

**Transmitter Frequency Range:** Type 1170-BT1, channels 2 to 6 with Type 1170-P1 R-F Tuning Unit; Type 1170-BT2, channels 7 to 13 with Type 1170-P2 R-F Tuning Unit; Type 1170-BT3, channels 14 to 83 with Type 1170-P3 R-F Tuning Unit. The appropriate tuning unit is installed in the monitor.

**R-F Input Impedance:** High impedance, channels 2 to 13, with capacitive attenuator for adjusting the input level. Low impedance in u-h-f range with adjustable-coupling-loop input. The monitor can be used with standard RTMA transmitter monitoring output with Type 874 Coaxial Connector supplied.

**Input Sensitivity:** 1 volt, or better, on high impedance input. 500 milliwatts, or less, on low impedance input.

**Input Level Indicators:** A meter for indicating r-f input level is provided at the rear of the chassis. Signal pilot lamp and center-frequency-meter pilot glow when input level is normal and are extinguished when level drops below the usable minimum.

**Intermediate Frequency:** 150 kc for zero offset, 140 kc for -10 kc offset, 160 kc for +10 kc offset.

**Discriminator:** Pulse-counter type, linear to better than 0.1% over a range of at least  $\pm 75$  kc.

**Center Frequency:**

**Indication:** Meter is calibrated in 200-cycle divisions from -6000 to +6000 cycles per second for all TV channels. Center band of  $\pm 4$  kc (transmitter tolerance) printed in black; outer 2 kc in red. It is not necessary to check the zero for each reading, and no second crystal is required for this purpose.

**Accuracy:** Crystal frequency when monitor is received is within  $\pm 2$  parts per million (0.0002%) of specified channel frequency. Center frequency is adjustable over  $\pm 25$  parts per million (0.0025%) by controls provided in crystal circuit. Additional adjustment is provided in the metering circuit. Both adjustments are accessible from the front of the panel.

**Crystal Oscillator Stability:** After an initial aging period of approximately 60 days, the crystal oscillator will stay on frequency within  $\pm 0.5$  parts per million (0.00005%) for 10 days, and within  $\pm 1.5$  parts per million (0.00015%) for 30 days.

**Over-all Stability:**  $\pm (1.5$  parts per million +200) cycles, or better for 30 days. The 200-cycle figure represents metering circuit and meter error. Hence the 10-day stability is  $\pm (0.5$  part per million +200) cycles.

**Percentage Modulation:**

**Indication:** Meter is calibrated from 0 to 133%. Additional db scale is provided. Switch selects positive or negative peaks, or full-wave (peak-to-peak) indication. 100% modulation corresponds to 25-kc deviation. Meter ballistics meet FCC requirements.

**Accuracy:**  $\pm 5\%$  modulation.

**Overmodulation Indicator:** Lamp flashes when predetermined modulation level, as set on a dial, is exceeded. Range of dial is 0 to 120% modulation.

**Output Circuits:**

1. **Distortion and Noise Measurements:** Terminals are provided for connecting a Type 1932-A Distortion and Noise Meter, and a gain control is provided.

\*Type 1170-B specifications are identical except as follows:

**Transmitter Frequency Range:** 88 to 108 Mc with 1170-P1 Tuning Unit.

**Center-Frequency Indication:** 100-cycle divisions from -3000 to +3000 cycles.

**Residual Distortion:** Less than 0.1% for 25-kc deviation.

**Response:** 50 to 30,000 cycles per second  $\pm 1/2$  db. Standard 75 microsecond de-emphasis circuit is included.

**Maximum Output:** 1.5 volts into 100,000 ohms.

**Residual Noise Level:** -65 db or better for 25-kc deviation.

**Sensitivity:** Full output can be obtained down to 6-kc deviation. Sensitivity varies with modulation frequency in accordance with standard de-emphasis characteristic.

2. **Audio Monitoring Output:**

**Impedance:** 600 ohms, unbalanced.

**Output:** -12 dbm at 25-kc deviation.

**Response:** 50 to 15,000 cycles per second  $\pm 1/4$  db.

**Crystal Oscillator:** General Radio high-stability circuit. Crystal is temperature-controlled at approximately 60°C to  $\pm 0.15^\circ$ C or better. Temperature coefficient of crystal is 2 parts per million, or less, per degree C. Crystal oscillator output level can be read on panel meter by operating the appropriate switch.

**Remote Indicators:** Circuits and terminals are provided for connecting the following indicators externally:

Center-frequency Indicator

Percentage-Modulation Meter

Overmodulation Indicator Lamp

**Vacuum Tubes:** The following tubes are used and are supplied with the monitor.

- |             |               |               |
|-------------|---------------|---------------|
| 1 — 12AU7   | 2 — 6SJ7      | 1 — 991       |
| 1 — 6AK6    | 6 — 6AL5      | 1 — 6SK7      |
| 2 — 6AG7    | 2 — 6SL7-GT   | 1 — 6AS7-G    |
| 1 — 6AC7    | 2 — 6C4       | 1 — OC3/VR105 |
| 1 — 6SN7-GT | 1 — 815       | 2 — 3-4       |
| 1 — 6AG5    | 2 — OD3/VR150 | 2 — 6SU7-GTY  |
| 2 — 2050    | 1 — 5964      |               |

**Type 1170-P1 R-F Tuning Unit:**

- |          |          |
|----------|----------|
| 1 — 6BE6 | 1 — 6AG5 |
|----------|----------|

**Type 1170-P2 R-F Tuning Unit:**

- |          |          |
|----------|----------|
| 1 — 6BE6 | 2 — 6AG5 |
|----------|----------|

**Type 1170-P3 Tuning Unit:**

- |          |         |
|----------|---------|
| 3 — 6AG5 | 1 — 6J6 |
| 1 — 9005 |         |

**Accessories Supplied:** All tubes, coaxial connector for r-f input, power line connection cord, power supply plug.

**Power Supply:** 105 to 125 volts, 50 to 60 cycles. Power-transformer-primary connections can be changed to permit operation on 210 to 250 volts. Rated power input 300 watts.

**Mounting:** 19-inch relay-rack panel. Shield box mounts on rack; monitor then slides into box.

**Panel Finish:** Standard General Radio black crackle lacquer. Certain standard grays and other finishes that can be processed in quantity can be furnished at an extra charge.

**Dimensions:** Panel, 19 x 26 $\frac{1}{4}$  inches; depth behind panel, 13 $\frac{1}{4}$  inches, over-all.

**Net Weight:** 88 pounds.

**Percentage Modulation Indication:** 100% modulation corresponds to 75-kc deviation.

**Residual Distortion:** Less than 0.2% for 100-kc deviation.

**Residual Noise Level:** -75 db or better for 75-kc deviation.

**Audio Monitoring Output:** Zero dbm at 75-kc deviation.

Manufactured and sold under United States Letters Patent:

- |                  |                  |
|------------------|------------------|
| Patent 2,069,934 | Patent 2,548,457 |
| Patent 2,362,503 | Patent 2,125,816 |

Licensed under all patents and patent applications of Dr. G. W. Pierce pertaining to piezo-electric crystals and their associated circuits.

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# OPERATING INSTRUCTIONS

for

## TYPE 1170-B

and

## TYPE 1170-BT

### FREQUENCY - MODULATION MONITORS

The General Radio Type 1170-B Frequency - Modulation Monitor has been designed for use with standard frequency-modulation broadcast transmitters, to enable them to comply with Section 3.252 and 3.253 of the Standards of Good Engineering Practice Concerning F-M Broadcast Stations, as required by the Federal Communications Commission. The monitor meets the specifications as stated in Paragraphs 14 and 15 of these standards.

The monitor can also be used in conjunction with the General Radio Type 1932-A Distortion and Noise Meter, for transmitter type-tests as required by Paragraph 13, "Requirements for Type Approval."

The Type 1170-BT model is used for monitoring the sound transmitters of television stations. The oper-

ating procedure is the same for both models, and any differences are noted in the instructions. Otherwise, reference will be made to the Type 1170-B for brevity.

When the Type 1170-BT model is used as a portion of the Type 1183-T T-V Station Monitor, it is interconnected to the Type 1171-AT Visual Transmitter Frequency Monitor to allow use of the crystal oscillator in the Type 1170-BT as a master reference oscillator for both monitors.

Before installing the monitor, read SECTION 1, INSTALLATION, and SECTION 2, OPERATION. A general review of the basic operating principles is contained in SECTION 3, CIRCUIT DESCRIPTION. SECTION 4, CIRCUIT DETAILS AND ADJUSTMENTS: is a complete discussion of the various circuits and their methods of adjustment and calibration.

#### SECTION 1.0 INSTALLATION

##### 1.1 MOUNTING

The Type 1170-B F-M Monitor will fit a standard 19-inch relay rack and has a maximum depth-behind-panel of 13-3/8 inches, including connecting plugs, to permit installation in standard sizes of cabinet racks. The panel height is 26-1/4 inches.

The Type 1170-B F-M Monitor is provided with a dust-cover and shielding case which is installed in the relay rack before the monitor is put in place. Brackets on the side of this case are pre-adjusted at the factory to fit the individual monitor. The case is installed by removing it from the monitor and bolting it in place in the 19-inch relay rack taking care not to use holes for mounting which will be required later to fasten the panel of the monitor in position. The monitor may then be installed by inserting it in the case from the front of the rack and fastening the panel in place with panel screws. Clearance holes are provided in the back of the panel to clear the screws mounting the shield case.

In case the shielding case with its brackets does not appear to fit properly on the monitor, this fit can be

checked by setting the monitor in the case on a bench with the front panel out over the edge of the bench so the weight of the monitor is not resting on the front panel. The mounting holes in the panel may then be checked with the holes in the brackets on the shield box for proper alignment. If the holes are definitely out of line, they may be re-aligned by loosening the screws holding the brackets to the box and then tightening them after re-setting the brackets on the box.

Do not mount the monitor in relay racks above power rectifiers, or other equipment generating large amounts of heat. The General Radio Company will assume no responsibility for improper operation of the monitor due to excessive heating, if the installation is made so that the temperature of the air surrounding the instrument is more than 115° F.

In those cases where a Type 1932-A Distortion and Noise Meter is to be used, this should be placed directly below the Type 1170-B F-M Monitor or in an adjacent relay rack. Serious overheating of both instruments may result if the Type 1932-A is placed above the Type 1170-B F-M Monitor.



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In all installations, the Type 1170-B F-M Monitor should be located at or near the top of the relay rack and have a minimum of six inches of panel-space clearance to any objects placed above it.

**1.2 QUARTZ PLATE**

The quartz plate is shipped in place within the temperature-controlled heater box and is ready for operation when received. The position of the quartz plate can be examined by removing the wooden cover on the rear of the heater box and opening the inner aluminum case by removing the two slotted thumb screws.

The quartz plate should not be disturbed if it is in its socket as the frequency adjustment may be affected slightly.

**1.3 THERMOMETER, THERMOSTAT, AND TUBES**

The thermometer is packed separately in the rear compartment of the instrument. This should be unpacked carefully and inserted in the hole behind the window on the front panel.

The thermostat is mounted in the wall of the inner aluminum crystal housing and is held in place by means of an internal spring clamp. Connections are made to two adjacent terminals.

All tubes and the thermostat are shipped in place and it is only necessary to make certain that they are still properly seated in their sockets.

**1.4 COUPLING TO TRANSMITTER**

The R-F INPUT terminal is the elbow connector located near the lower left corner on the rear of the instrument and will fit the GR Type 874-C Cable Jack, which is supplied. The main body of the R-F INPUT terminal is arranged to rotate and thus control the input level. The input adjustment is marked SET INPUT and, after being set, should be locked by tightening the screws.

The input circuit consists of a capacitive voltage divider in the v-h-f range, and requires an input level of approximately one volt. The input circuit in the u-h-f range is an inductive coupling loop.

Standard RMA monitoring output circuits may be used. Because of the low voltage requirements of the monitor, it is recommended that an external fixed attenuator, with a loss of about 10 db, be used between the transmitter monitoring output and the R-F INPUT terminals. This attenuator can also be used to terminate the transmitter monitoring output circuit (in its nominal impedance of 50 ohms) whenever this is considered desirable.

**1.5 POWER SUPPLY**

Power cords are supplied with the instrument for connecting it to the a-c power sources. Either 105- to

125-, or 210- to 250-volt, 50- or 60-cycle power may be used. The line voltage for which the instrument has been connected is indicated on a plate located near the power input plugs. The two power input connections are plainly marked on the rear cover plate of the shield case.

If the alternate voltage supply is to be used, the connections to TWO transformers must be changed, and the power supply nameplate removed and reversed so that it will agree with the changed line voltage.

The Wiring Diagram shows the terminal connections for both power transformers and their connection data for either 115 or 230 volt sources. Fuses should be changed in accordance with Figure 2 and are accessible from the rear of the instrument without the necessity of removing dust covers, etc.

The two power input plugs are provided to enable separate connection of the crystal oven heater circuit and of the main monitor power supply to separate a-c circuits. This feature enables the crystal heater circuit to be kept alive without requiring operation of the monitor panel switch when turning off the transmitter. The heater power input should be connected to the station stand-by power circuit.

**1.6 EXTERNAL METERS**

Provision has been made to connect remote indicating meters to the monitor. The upper Jones plug, located in the upper left corner on the rear of the instrument, is used to make the necessary connections. The connections should be made as shown in Figure 3.

Additional meters, of the type used on the instrument panel, are available from the factory. Other type meters can be used where desired, provided the general electrical characteristics are equivalent to those of the panel meter.

	115-volt SUPPLY	230-volt SUPPLY
○	3.2 amp.	1.6 amp.
MONITOR		
○	3.2 amp.	1.6 amp.
○	0.4 amp.	0.2 amp.
HEAT		
○	0.4 amp.	0.2 amp.

Figure 2. Fuse Ratings



## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

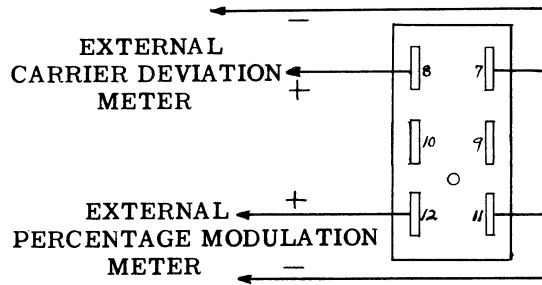


Figure 3. External Meter Connections.

General meter characteristics are as follows:

**KILOCYCLES DEVIATION - GR Type MEDS-27-3**  
(BT scale 6-0-6 kc, B scale 3-0-3 kc)

Sensitivity - 100 - 0 - 100  $\mu$ a, dc  
Resistance - 540 ohms  $\pm 20\%$   
Calibration - Linear

**MODULATION - GR Type MEDS-28**

Sensitivity - 0 - 600  $\mu$ a, dc  
Resistance - 700 ohms  $\pm 20\%$   
Calibration - Special  
Ballistics - High-speed movement,  
approx. 0.15 seconds

The General Radio Company cannot assume responsibility for calibration errors resulting from the use of external meters unless these units are supplied by the General Radio Company or fulfill the minimum requirements given above.

**CAUTION:** Whenever remote meters are not used, the dummy plug provided with the monitor must be inserted

in the Jones socket before either panel meter will operate.

### 1.7 EXTERNAL "OVER MODULATION" LAMP

A small Jones plug which is located below the power fuses on the rear of the monitor can be used to connect to a remote over-modulation warning lamp. Any standard 115-volt, 3- or 6-watt lamp may be used as a remote indicator. One side of this circuit is grounded.

### 1.8 EXTERNAL AUDIO CONNECTIONS

A program monitoring output is provided for connection to an unbalanced 600-ohm line. This may be used for local aural monitoring purposes, and is available on the front panel via standard W. E. plugs, marked AUDIO OUTPUT.

The lower Jones Plug, located near the upper left corner on the rear of the instrument, provides for permanent connection to the audio output circuits.

The 600-ohm aural monitoring output is connected to terminals #7 and #12 (Grounded) of this plug.

A second audio output circuit, intended mainly for connection directly to a Type 1932-A Distortion and Noise Meter, is connected to terminals #9 and #12 (Ground). The output cable supplied with the instrument should be used to make the connection between the Type 1170-B F-M Monitor and the Type 1932-A Distortion and Noise Meter. This is a special low-capacitance shielded cable and forms a part of the circuit capacitance. Use of substitute cables is, therefore, not recommended. This output circuit is designed to work into an impedance of approximately 100,000 ohms.

## SECTION 2.0 OPERATION

### 2.1 TEMPERATURE CONTROL

Throw the HEAT switch ON and the MONITOR switch to OFF. The red HEAT CYCLE bull's-eye should light immediately, as well as the red one at the upper right of the panel.

To test the operation of the heat-control circuit, short-circuit the thermostat terminals temporarily. The relay should open and the red HEAT CYCLE lamp go out. A fusible link is provided which melts and opens the heater circuit if the temperature becomes excessively high due to relay or thermostat failure.

The heat will remain on for about half an hour before the thermostat begins to operate. After about an hour, the thermostat will cycle so that the heat is on (indicator lamp lighted) about 50 seconds and heat off (indicator lamp out) about 160 seconds at ordinary room temperatures (70° to 80° F). A period of about

four hours is required before the inner temperature reaches its final value. When proper operating temperature has been reached, the thermometer should read  $60.0 \pm 0.3^\circ \text{C}$ .

### 2.2 RANGE OF OPERATION

One of three types of r-f mixer assemblies is supplied with the R-F Section of the monitor. The Type 1170-P1 unit covers the range between 30 - 162 megacycles, and the Type 1170-P2 unit covers the range between 160 and 220 megacycles. The Type 1170-P3 unit covers the range between 470 and 890 megacycles.

Only one unit is supplied with each monitor and has been selected to provide operation at the frequency requested and is completely tuned and adjusted when received. Changes in these adjustments are not normally required and should not be attempted without referring to SECTION 4.

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The monitor can be set up for operation anywhere within the specified range by following the procedure outlined in SECTION 4.0, CIRCUIT DETAILS AND ADJUSTMENTS.

### 2.3 CRYSTAL OSCILLATOR AND HARMONIC MULTIPLIER

Having allowed the crystal to reach normal operating temperature, turn the MONITOR switch ON and allow a few minutes for the tubes to stabilize. A time-delay relay will connect the plate supply within a period of 15 - 60 seconds. Operate the CHECK CRYSTAL button on the panel. A deflection of the meter to, or above, the red line will indicate that the crystal is oscillating with sufficient amplitude to drive the first multiplier stage.

In the u-h-f range covered by the Type 1170-P3 unit, a test jack on the rear of the monitor is provided. This jack is across the diode load resistance, and proper functioning of the multiplier chain may be verified by plugging in a 0-10 volts d-c 1,000 ohms per volt voltmeter. This voltmeter will affect the operation of the monitor signal circuits and should not be left plugged in.

### 2.4 INPUT SIGNAL LEVEL

The small meter, located on the lower left corner of the rear of the instrument, will provide a visual indication of the transmitter input signal level to the monitor. When an r-f signal is connected to the R-F INPUT terminal, this meter will show a deflection, provided the monitoring crystal is oscillating at the correct frequency and the harmonic multipliers are properly adjusted. These adjustments have been set at the factory for operation at the specified transmitter frequency, and will not normally require alteration.

The deflection obtained on the rear meter may be varied over a considerable range by rotation between limits of the attenuator cylinder that forms the main body of the R-F INPUT jack. The meter deflection should be set to approximately 100 (10 x 10) by means of this adjustment. Two friction clamping screws maintain sufficient pressure upon the adjustment device to guard against accidental turning. The clamping screws are accessible at the rear.

When the R-F INPUT level has been set correctly, the SIGNAL pilot lamp on the panel and also the illumination lamps of the FREQUENCY DEVIATION meter, will glow with normal brilliance. These serve the purpose of continuously indicating normal operation of the monitor. Failure of either the R-F INPUT from the transmitter or the monitoring crystal oscillator will cause these SIGNAL lamps to become very dim.

### 2.5 METER READINGS

**2.51 Center-Frequency Deviation:** The monitoring crystal oscillator should be permitted to operate for a period of at least four hours following the initial installation in order that it reach final temperature and fre-

quency stability before the indications of the meter can be considered normal.

Assuming that the monitor is fully stabilized, as noted above, the meter will indicate directly the deviation from the assigned transmitter frequency, if this is within the range of +3000\* cycles. Should the frequency deviation exceed this value, the meter will deflect off scale, provided that the frequency is within 120 kc of the assigned value. If the transmitter is more than 120 kc off frequency, the meter may give false indications. It is important, therefore, to determine the exact transmitter frequency, as precisely as possible, before using the deviation meter.

Assuming that the transmitter carrier frequency has been set to give a reading on the deviation meter scale, it is possible to determine that the transmitter is on the correct (high frequency) side of zero-beat with the crystal oscillator harmonic by using the following test procedure. This procedure is recommended mainly as a check when setting up the transmitter and monitor together for the first time, as it is unlikely that the transmitter will deviate far enough to produce on-scale readings on the image frequency after an initial correct tune-up. A small capacitor of approximately 10  $\mu\mu\text{f}$  is used, preferably fitted with clips for temporary attachment to the shafts of the air capacitors in the crystal oscillator circuit (C-22, C-23). These capacitor shafts are accessible in the recess behind the lower left corner of the front panel by sliding the monitor forward in its case a few inches. When the 10  $\mu\mu\text{f}$  capacitor is connected between the exposed shafts, it is effectively bridged to ground across C-23. This will produce a change of approximately -2 parts per million in the crystal frequency. If the transmitter frequency is on the correct side of the crystal harmonic, the center-frequency meter reading will be deflected in a positive, or high, direction when the 10  $\mu\mu\text{f}$  condenser is connected. This condenser should be disconnected and removed from the vicinity of the oscillator capacitors as soon as this check is completed.

Before reading the KILOCYCLES DEVIATION meter, the "electrical" zero setting of the circuit should be checked. Operate the CHECK ZERO test switch near the lower right corner of the meter and hold it on. If the pointer fails to return to exact zero, remove the snap button located next to the upper right corner of the meter and set the screwdriver adjustment until exact zero is obtained. The movement of the meter will be sluggish under these conditions; hence, it is best to make changes in the ZERO adjustment in small increments and allow sufficient time for the meter to reach its final setting. It is important that the transmitter be on when this check is made.

Adjustments for bringing the readings of the KILOCYCLES DEVIATION meter into agreement with the results of an independent frequency check of the trans-

\*+6000 cycles for television channels.



## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

mitter are provided on the front panel. Since the adjustment procedure is different when the monitor is used for (1) f-m broadcasting or (2) t-v sound channel monitoring, a description of the two methods will be given separately below.

**2.511 F-M Broadcasting Adjustment:** The center-frequency deviation meter adjustment is accomplished by adjusting the bias on the discriminator in such a manner as to shift the operating point to a new value of intermediate frequency. The frequency of the reference crystal oscillator need not be disturbed. The control for this bias adjustment is located under the snap-button marked CENTER FREQUENCY, adjacent to the lower right corner of the meter. This adjustment has a range of  $\pm 3000$  cycles, which provides a wider range than any long-term drifts in frequency will normally require.

**2.512 T-V Sound Adjustment:** The center-frequency deviation meter adjustment is accomplished by a two-step process which requires (1) measurement of the carrier frequency of the visual transmitter and adjustment of the crystal frequency in the Type 1170-BT to provide correct indication on the meter of the Type 1176-AT Frequency Deviation Meter, and then (2) the measurement of the f-m sound transmitter carrier frequency followed by the adjustment of the bias control on the Type 1170-BT to set the KILOCYCLES DEVIATION meter to agree with the external frequency check, as set forth in 2.511 above. This two-step procedure is required because the common reference crystal oscillator for both visual transmitter and sound transmitter frequency monitors is the oscillator in the Type 1170-BT F-M monitor. The adjustments required for this procedure are carried out as follows: The crystal oscillator frequency adjustment (C-42) is located inside the crystal oven and is accessible from the front panel through a small opening located in the wooden thermometer guard to the right of the thermometer. It is necessary to remove the thermometer cover plate for access to this adjustment. Use a screwdriver with 1/8-inch diameter blade at least 3-1/2-inch long. The condenser rotor is grounded, so a metal blade is satisfactory. This adjustment is very sensitive and should not be touched unless an external frequency monitoring check is available. While the picture transmitter carrier frequency is being checked, set the frequency of the crystal oscillator in the Type 1170-BT so that the deviation meter in the Type 1176-AT Frequency Deviation Meter reads correctly. Then, while the sound transmitter carrier frequency is being checked, set the KILOCYCLES DEVIATION meter in the Type 1170-BT to agree with the check (as in 2.511 above).

Adjusting the frequency of the Type 1170-BT crystal oscillator adjusts the setting of the frequency deviation meters for both visual transmitter and sound transmitter simultaneously. Under most conditions both meters will be correct after the crystal oscillator has been adjusted to correct the reading of the Type 1176-AT Frequency Deviation Meter for the visual transmitter.

Since the adjustment of C-42 in the crystal oven removes a small amount of heat from inside the oven,

it is advisable to make as few adjustments of this control as possible. It is also possible that too long a time spent in adjusting this control may affect the frequency at which the crystal operates, due to a temporary change in the temperature of the crystal unit. This effect will usually be over in approximately 4 hours following the adjustment.

**CAUTION:** It is recommended that all of these adjustments affecting the crystal frequency and KILOCYCLES DEVIATION meters for either carrier frequency be left undisturbed for a period of at least twenty-four hours after the initial installation, in order to permit the instrument to become thoroughly stabilized.

**2.52 Modulation:** The MODULATION meter will deflect up scale when modulation is applied to the transmitter. A MODULATION PEAKS switch, located in the lower right corner of the panel permits the meter response to be set for positive, negative, or full-wave modulation peaks.

It is important that the control marked ADJ. DIST. METER be set at the Monitoring position at all times, except when distortion or noise measurements are being made. (See 2.7)

### 2.6 OVER MODULATION INDICATOR

An OVER MODULATION warning lamp, located near the center of the front panel, will flash whenever the modulation peaks exceed the setting on the MODULATION PEAKS dial. This dial may be set for any modulation level between the limits of 0 and 120 per cent.

### 2.7 DISTORTION AND NOISE MEASUREMENTS

**2.71 Noise Measurements:** The Type 1932-A Distortion and Noise Meter should be set to the CAL position, with its panel CAL control set at maximum, or full clockwise position, and the INPUT - 100 k $\Omega$  switch depressed.

Before proceeding with the tests it is advisable to check the over-all system for minimum residual noise level. First check that the residual noise level in the Type 1932-A Distortion and Noise Meter is approximately -80 db, or less. This can be done by simply removing one end of the connecting cable. Refer to Paragraph 4.4 PRECAUTIONS on Page 5 of the Type 1932-A Instruction Book.

With the connecting cable in position and the ADJ. DIST. METER control, on the panel of the Type 1170-B F-M Monitor, set at the Monitoring position, a slight increase in noise level in the order of 2 db may be noted. This may be minimized by securely grounding both instruments, reversing power plugs, etc. In all cases, the residual indicated noise level should not exceed -75 db.

To measure the transmitter noise level, apply a 400 cycle - 100% Modulation signal to the transmitter.

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By means of the ADJ. DIST. METER control, set the Type 1932-A Distortion and Noise Meter to the CAL. setting. Remove the modulation signal from the transmitter and operate the Type 1932-A in the usual manner for noise measurements. Refer to Paragraph 2.2 Noise Level Measurements, on Page 2, of the Type 1932-A Instruction Book. Noise measurements include a range of frequencies from 30 to 30,000 cycles, and the standard 75 microsecond de-emphasis frequency-weighting characteristic is included.

**2.72 Distortion Measurements:** Calibration of the Type 1932-A when used as a distortion meter is similar to the process just outlined for the noise measurement, except that measurements can be made at any fundamental frequency between 50 and 15,000 cycles and at modulation levels between 10 and 140 per cent. At the higher modulating frequencies, the available audio output signal from the monitor is reduced in accordance with the standard 75 microsecond de-emphasis weighting characteristic. This limits the percentage of modulation at which measurements can be made, at the higher modulating frequencies.

### 2.8 STAND BY OPERATION

When the transmitter is not operating, the monitor crystal oven should be left on to enable a quick return to service conditions. The separate power input connec-

tion for the crystal oven heater circuit is provided for this purpose. When connected to the station stand-by power circuit, the monitor crystal oven may be left operating while the transmitter is shut down. (See 1.5)

When the station goes back on the air, the MONITOR switch should be ON, and the monitor will then come on at the same time that the transmitter is energized if the MON. power input is connected to the transmitter a-c power source. If the monitor is not so connected, it may be returned to normal operation by throwing the MONITOR switch to ON, and allowing sufficient time for the tubes to warm up. Within a matter of minutes, all circuits will be sufficiently stabilized to operate normally, with the possible exception of the KILOCYCLES DEVIATION meter. This latter circuit may require approximately 15 minutes to approach final stability, which condition should be fully reached within an hour.

For short periods of broadcast interruption, lasting a few hours or less, it is advisable to permit the monitor to operate continuously.

A period of about four hours is required for the monitor to become stabilized from a condition of complete shut-down including the crystal oscillator temperature control system: the monitor indication should then be less than about 0.1 part per million different from the indication after a 24-hour warm-up period.

## SECTION 3.0

### CIRCUIT DESCRIPTION AND PRINCIPLES OF OPERATION

A functional block diagram of the Type 1170-B Frequency-Modulation Monitor is shown in Figure 4. The standard of frequency against which the transmitter is monitored is a crystal oscillator whose frequency, when multiplied up to the region of the transmitter, differs from the assigned channel by exactly 150 kilocycles.\* The beat-frequency produced in the mixer, between the transmitter and a harmonic of the crystal oscillator, is fed to a series of amplifiers and clippers to produce a square wave. A "pulse counter" type of discriminator is operated by the square wave to produce an output voltage which is proportional to the instantaneous fundamental frequency of the square wave. Under conditions of 100 per cent modulation, the fundamental frequency of the square wave will swing  $\pm 75^\dagger$  kilocycles about the 150 kilocycle center point, or average frequency. The average, or d-c component, of the discriminator output signal is used to operate a vacuum-tube voltmeter which indicates the deviation of the transmitter average-center-frequency from the assigned channel.

The a-c components of the discriminator output signal include the original modulation and other higher

order functions present as a result of the pulse-type waveform, etc. By means of a low-pass filter, the unwanted higher order components are eliminated.

The audio circuits are coupled to the output of the discriminator by means of a standard 75 microsecond de-emphasis circuit (which also assists in the filtering process) and a 30-kilocycle low-pass filter.

One audio amplifier operates as a low-impedance output stage to provide a local monitoring output at 600 ohms impedance for direct connection to telephone lines, etc.

A second audio amplifier is provided with a gain control and additional output filter to minimize noise and spurious signals. This circuit has been designed for very low residual noise and distortion levels and is intended for use with the Type 1932-A Distortion and Noise Meter.

A third audio system consists of a re-emphasis circuit which restores the frequency response to a uniform characteristic for the purpose of operating the modulation meter circuits. A pre-amplifier is used to operate two semi-peak diodes, and a d-c amplifier. The gain of the pre-amplifier may be changed so that the monitor may be calibrated to read 100% modulation at any value between the limits of 25 and 75 kilocycles. This permits the monitor to be calibrated for services

\*For t-v service, the intermediate frequency of the Type 1170-BT F-M Monitor may be offset by the amount of the offset in the assigned frequency.

$^\dagger 25$  kc for Type 1170-BT.



## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

employing modulation levels other than the f-m broadcast standard of  $\pm 75$  kc for 100% modulation.

The semi-peak diodes are arranged to permit the selection of positive, negative, or full-wave modulation response characteristics by means of a panel switch. The modulation meter is operated by a vacuum-tube voltmeter having the required dynamic-response characteristics for modulation monitors as specified by the FCC. On transient signals, this results in the meter response having a fast upswing and slow return.

An "Over Modulation" warning lamp is provided, which will flash whenever the transient modulation peaks exceed a predetermined level as set on the MODULATION PEAKS potentiometer dial. The audio-modulation signal is applied to the grid of an amplifier tube together with a variable portion of a d-c bias voltage, as determined by the dial setting. The total potentiometer d-c voltage is made equal to the peak value of the audio signal, at 120% modulation level, which is the full range of the dial calibration. In addition, a fixed negative bias is applied in series with the grid to maintain the tube just at the cut-off point. Thus, whenever the modulation peaks exceed the dial setting, a pulse is developed in the plate circuit of the amplifier tube. This pulse is used to trigger a thyratron tube which causes the indicator lamp connected to its anode circuit to glow.

This circuit will respond to transient modulation peaks which are too short to cause the modulation meter to deflect to its final value. For this reason, coincidence of the meter readings and the lamp flashes may not occur

on all types of program material. The two will agree closely on steady-state or sine-wave modulation. The lamp operates on positive modulation peaks. This is not significant except when asymmetrical modulation is encountered. In these instances, the agreement between the flashing lamp and the meter deflections will be closest when the meter switch is set to the positive-peak position.

In general, the monitoring applications of the modulation meter and the over-modulation lamp will be identical to the well-established practices used for many years in standard a-m broadcasting. There is, however, no longer any reason to favor monitoring either one polarity of the modulation, such as exists in the a-m case\*. Operators will find the use of the full-wave modulation position (i.e. positive and negative simultaneously) an advantage since it eliminates the need for switching back and forth in order to determine the maximum modulation swing on asymmetrical program material.

When the Type 1170-BT F-M Monitor is used as a unit of the Type 1183-T T-V Station Monitor, the crystal oscillator in the Type 1170-BT is used for reference to monitor the visual transmitter carrier in the Type 1171-AT Visual Transmitter Frequency Monitor. An output connection to supply the correct crystal harmonic to the Type 1171-AT is provided. This link usually operates between 54 and 120 Mc.

\*J. L. Hathaway, "Effect of Microphone Polarity on Percentage Modulation", *ELECTRONICS*, p. 28, October 1939.

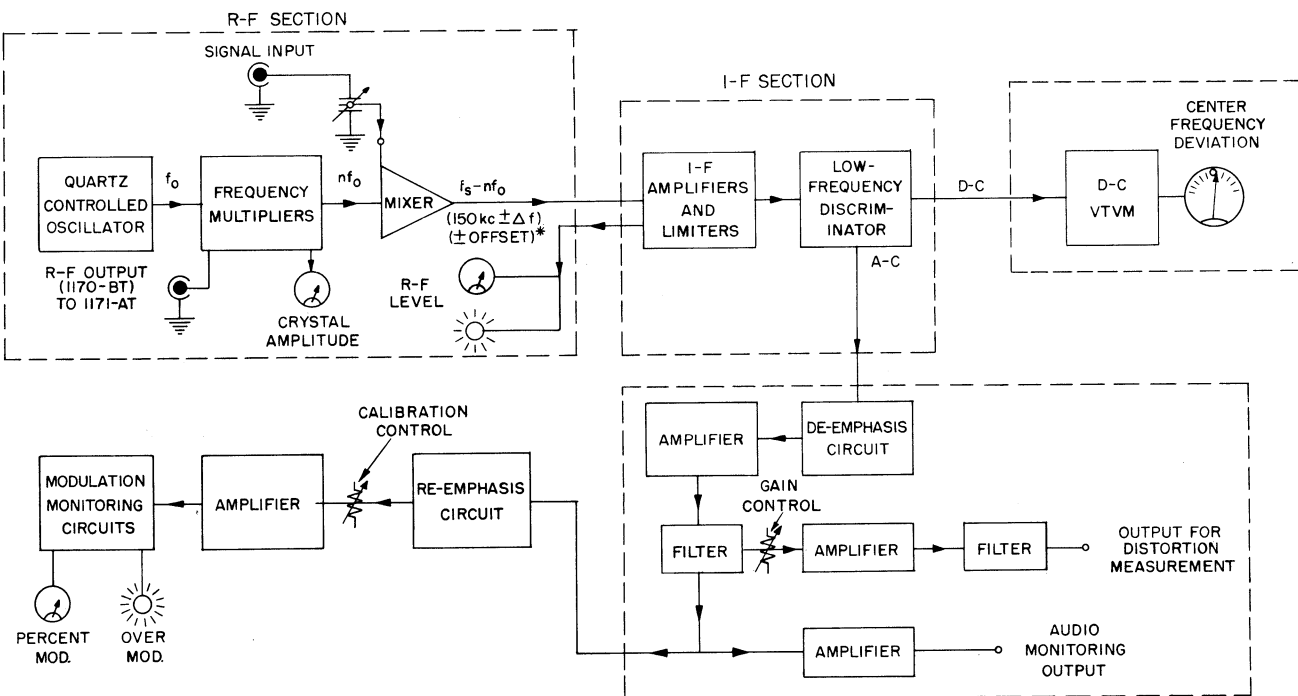


Figure 4. Functional Block Diagram of the Type 1170-B Frequency-Modulation Monitor.

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SECTION 4.0 CIRCUIT DETAILS AND ADJUSTMENTS

4.1 R-F SECTION (See Figure 5)

**4.11 Crystal Oscillator:** The temperature coefficient of the frequency monitoring crystal is less than 2 parts per million. The quartz plate is mounted in a hermetically sealed plated-electrode holder, which provides maximum stability and freedom from aging drift. This assembly is plugged into a terminal plate, and is enclosed in an aluminum casting whose temperature is controlled at 60° C.

The oscillator circuit\* is of a type developed in the General Radio laboratories for use in standard frequency oscillators. No inductance elements are employed in the frequency-determining system. Since the crystal operates very near its true resonant frequency, a high degree of stability is obtained.

Condensers C-22 and C-23 have been set at the factory for optimum conditions with the particular crystal supplied. In general, these two condensers will be set equally, and the amount of the circuit capacitance will be determined by the particular crystal frequency. Maximum stability will be obtained with these condensers set for the maximum capacitance consistent with adequate output level. These adjustments are accessible through two holes located underneath the r-f section on the lower left side of the instrument.

The main frequency adjustment is furnished by condenser C-42 which is located inside the constant-

temperature crystal oven. This adjustment has been carefully set at the factory and should only be re-set as indicated in 2.512.

The CHECK CRYSTAL switch located on the panel connects the panel meter into the grid circuit of the second multiplier stage V-2 (6AG7). By measuring the grid current at this point, the output of the crystal is indirectly determined.

**4.12 Crystal Frequency:** The operating crystal frequency will generally be within the range of 1300-5000 kilocycles. Excellent stability can be obtained with crystals operating at these relatively low frequencies.

The final selection of the exact frequency to be employed in each case is rigorously determined by several factors including:

1. 150-kilocycle beat frequency with the assigned channel frequency.\*
2. Crystal harmonic utilized.
3. Avoidance of spurious responses.

The first consideration stems from the fact that the instrument operates on a 150-kilocycle\* intermediate frequency which is obtained by heterodyning the oscillator harmonic with the transmitter carrier.

\*T-V monitors may use offset intermediate frequencies differing by the offset value from 150 Kc.

#U. S. Patent No. 2,012,497

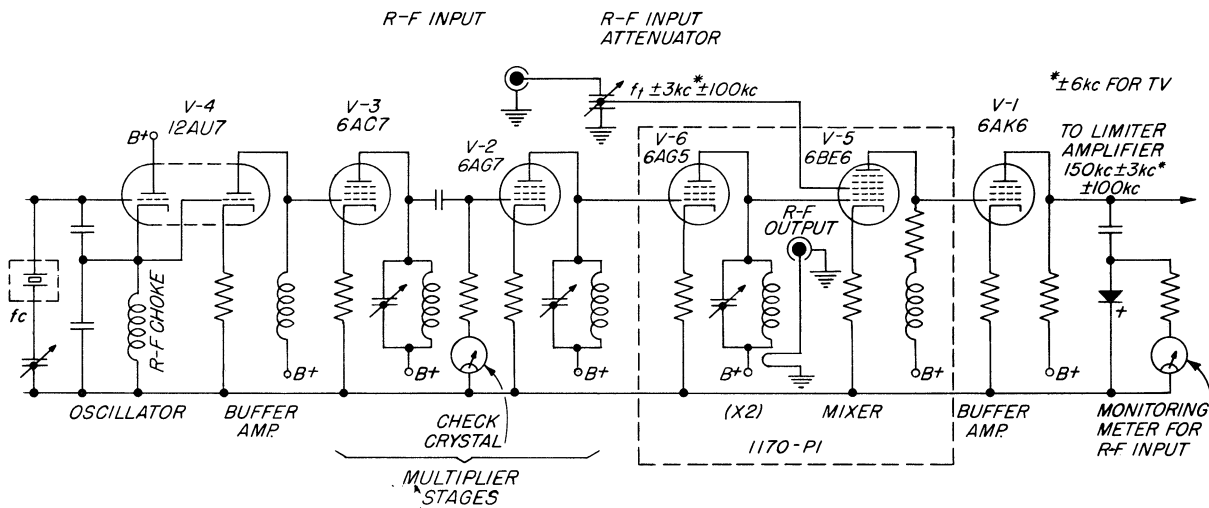


Figure 5. Elementary circuit diagram of R-F Section with Type 1170-P1 Mixer Assembly. Type 1170-P2 Mixer Assembly uses one additional tube. Type 1170-P3 U-H-F Tuning Unit uses additional multipliers and a diode mixer (complete circuit given in master circuit diagram).



## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

The second point is mainly determined by the transmitter operating frequency and is also influenced in some cases by Item 3 above. The harmonic of the crystal employed may range from the 32nd to the 128th for standard FM and TV operation in the VHF band, and up to the 432nd for UHF T-V.

The third consideration mentioned above is due to cross-modulation products which may be generated within the monitor itself. This will not be important, unless the monitor is to be used in conjunction with a distortion and noise meter. Harmonics of the intermediate frequency (150 kc)\* may cause spurious responses to exist in the detector audio-output circuit by heterodyning with the fundamental of the monitoring crystal frequency. While other cross-modulation products may exist, they will be too small to cause any interference. If these extraneous beats are produced within the "pass-band" of the audio output system (i.e., less than 30 kc) they will have the effect of raising the apparent noise level of the transmitter as indicated by a distortion and noise meter. By judicious selection of the crystal fundamental frequency, it is possible to have any spurious responses, due to this cause, occur above the audio pass-band and thus have no effect upon the noise measurements.

Table I (see end of book) contains complete data for the standard FM and TV channels and the arrangements have been selected on a basis of the conditions mentioned above.

### 4.13 Tuning R-F Circuits :

**4.131 Minor Adjustments:** When the multiplier stages require slight adjustments, such as shifting transmitter frequency to adjacent channels, etc., the procedure is quite simple and can be made by using the transmitter as a test source. It may be necessary to remove the monitor from the relay rack to make the required adjustments.

The majority of the multiplier tuning capacitance adjustments are accessible by sliding the monitor forward in the shield box. The inner shield plate on the r-f section should not be removed, since it does have a slight influence upon the tuning adjustments. It is preferable to use an insulated screw driver to make the tuning adjustments to avoid "hand-capacitance" effects, etc. If it is necessary to remove the shield plate to check resonance of the tuning adjustments the plate should be replaced before putting the finishing touches on the adjustments.

Proceed by turning C-13 through a small angle and set at the position which results in a maximum deflection of the R-F INPUT meter on the rear of the instrument. Then proceed to set C-7 and C-30, in this order, for maximum meter deflection. The R-F INPUT attenuator may be used to keep the deflection of the meter on scale, as each tuning adjustment is made. A similar procedure applies to the Type 1170-P2 and 1170-P3 tuning.

\*See footnote on page 8, column 2.

Be sure to allow sufficient time for the new monitor crystal to warm up to final temperature before attempting these adjustments.

**4.132 Major Adjustments:** When the monitor is to be set up for a markedly different transmitter frequency than that for which it was originally adjusted, the following procedure will enable the changes to be made with speed and accuracy. A test oscillator, capable of providing an output of one volt at the channel frequency, can be substituted for the transmitter, if desired. A wavemeter, covering the ranges shown in Table I, for the particular transmitter frequency desired, will be necessary, and, in addition, a standard model oscilloscope. A grid-dip oscillator is also a convenience for checking tuning adjustment.

Connect the oscilloscope to Pin #1 of the 6AL5 tube socket (V-112 located just below the 815 tube in the above Discriminator Section) by removing the tube and inserting a wire into the socket in place of the tube pin. Remove the inner shield from the R-F Section. Refer to Table I and note the operating frequencies for each multiplier.

First make certain that the new crystal is warmed up and oscillating normally. Using the wavemeter, adjust C-13 for the correct harmonic of the crystal frequency. When this has been done, operation of the CHECK CRYSTAL switch on the panel will show a deflection to, or above, the red line on the panel meter.

Connect the R-F INPUT to the transmitter monitoring line, or the local test oscillator set at the transmitter frequency. Increase the scope gain until a deflection is observed on its screen. Should the input r-f happen to be set exactly on the desired frequency of the transmitter, the scope frequency will be 150 kc. However, it is not important that this be done precisely and the frequency observed may vary between 50 and 250 kc.

Adjust C-7 and then C-30 in that order for a maximum deflection on the oscilloscope, gradually decreasing the amplifier gain to keep the pattern within the range of the oscilloscope. Usually, it will be found that only one position for each of these capacitance adjustments will result in maximum oscilloscope deflection. When this condition has been met, the R-F INPUT meter on the rear of the instrument will be reading up scale, and it may be necessary to adjust the R-F INPUT attenuator to keep the meter deflection on scale. Remove the cylindrical shields from the tuning inductances, L-2 and L-8, and using the wavemeter, check the frequencies to be in accordance with Table I. The power in these circuits will not be sufficient to give a direct indication on most absorption-type wavemeters. However, a reaction on the oscilloscope will be noted as the wavemeter is tuned through resonance and held near the inductance. Removal of the coil shields, etc., will slightly de-tune the multipliers; hence, when it has been determined that the frequency settings have been correctly made, the final adjustment should be made with all shields in place.

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TRANSMITTER FREQ. IN MC TV CHANNELS	30-50 -	50-88 2-6	88-160 -	160-220 7-13	470-540 14-24	540-630 25-38	630-720 40-54	720-750 55-59	750-810 60-69	810-890 70-83
R-F Tuning Unit	1170-P1	1170-P1	1170-P1	1170-P2	1170-P3	1170-P3	1170-P3	1170-P3	1170-P3	1170-P3
First Multiplier	L-3, C-13	L-3, C-13	L-3, C-13	L-3, C-13	L-3, C-13	L-3, C-13	L-3, C-13	L-3, C-13	L-3, C-13	L-3, C-13
Second Multiplier	L-2, C-7 L-2=1170-205 (15-25 Mc)	L-2, C-7 L-2=1170-206 (25-44 Mc)	L-2, C-7 L-2=1170-86 (40-80 Mc)	L-2, C-7 L-2=1170-86 (40-80 Mc)	L-2, C-7 L-2=1170-86 (40-80 Mc)	L-2, C-7 L-2=1170-86 (40-80 Mc)	L-2, C-7 L-2=1170-86 (40-80 Mc)	L-2, C-7	L-2, C-7	L-2, C-7
Third Multiplier	L-8, C-30 L-8=1170-206 (22-50 Mc)	L-8, C-30 L-8=1170-86 (42-88 Mc)	L-8, C-30 L-8=1170-803 (61-163 Mc)	L-602, C-604 L-602=1170-824 (80-110 Mc)	L-702, C-704	L-702, C-704	L-702, C-704	L-702, C-704	L-702, C-704	L-702, C-704
Fourth Multiplier	None	None	None	L-604, C-608 L-605, C-611 (160-220 Mc) L-604=1170-826 L-605=1170-825	L-703, C-710 L-703=1170-P3-25-2 (76-90 Mc)	L-703, C-710 L-703=1170-P3-26 (105-120 Mc)	L-703, C-710 L-703=1170-P3-25-3 (105-120 Mc)	L-703, C-710 L-703=1170-P3-25-2 (76-90 Mc)	L-703, C-710 L-703=1170-P3-25-2 (76-90 Mc)	L-703, C-710 L-703=1170-P3-25-3 (90-105 Mc)
Fifth Multiplier	None	None	None	None	L-706, C-715 L-706=1170-P3-802 (220-270 Mc)	L-706, C-715 L-706=1170-P3-811 (270-315 Mc)	L-706, C-715 L-706=1170-P3-812 (315-360 Mc)	L-706, C-715 L-706=1170-P3-802 (220-270 Mc)	L-706, C-715 L-706=1170-P3-802 (220-270 Mc)	L-706, C-715 L-706=1170-P3-811 (270-315 Mc)
Sixth Multiplier Input Circuit	None	None	None	None	L-707, C-716	L-707, C-716	L-707, C-716	L-707, C-716	L-707, C-716	L-707, C-716
Sixth Multiplier Output Circuit	None	None	None	None	L-709, C-717	L-709, C-717 L-709=1170-P3-27 (450-775 Mc)	L-709, C-717	L-709, C-717	L-709, C-717 L-709=1170-P3-34 (750-900 Mc)	L-709, C-717 L-709=1170-P3-34 (750-900 Mc)
Mixer Stage	Untuned	Untuned	Untuned	Untuned	L-711, C-718 L-711=1170-P3-805 (450-630 Mc)	L-711, C-718 L-711=1170-P3-808 (630-750 Mc)	L-711, C-718 L-711=1170-P3-808 (630-750 Mc)	L-711, C-718 L-711=1170-P3-808 (630-750 Mc)	L-711, C-718 L-711=1170-P3-809 (750-880 Mc)	L-711, C-718 L-711=1170-P3-809 (750-880 Mc)

TUNING ADJUSTMENTS OF CRYSTAL HARMONIC MULTIPLIERS

## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

4.14 V-H-F Range Extension: The monitor has two different mixer assemblies which form a part of the R-F Section. These have overlapping ranges, and the appropriate assembly as required by the operating frequency will be supplied.

These units are mounted upon a removable plate which contains the final multiplier and mixer stages and also an additional R-F amplifier in the higher frequency unit. While it is possible to interchange these units in the field, this practice is not recommended.

4.15 U-H-F Range Extension: For operation in the u-h-f t-v band, 470-890 Mc, a third mixer-multiplier assembly is substituted for the ones used in the v-h-f range. This assembly is mounted on a removable plate, and fits into the same place on the casting housing the r-f circuits.

This u-h-f tuning unit uses one doubler stage, V-701 (6AG5), a driver and phase-inverter stage, V-702 (6AG5) and a tripler stage, V-703 (6J6). The output of the tripler is inductively coupled to the tuned input circuit of a harmonic generator using crystal diode (D-701, 702) frequency multipliers to double or triple to the output frequency of the multiplier chain. When used as doublers, the diodes are connected as a full-wave rectifier, or in push-push. When used as triplers, a push-pull or balanced connection is used. These diodes generate their own self-biasing potential by rectifying the radio-frequency power supplied by the tripler. The radio-frequency output of this crystal-diode stage is supplied to the mixer through a coaxial line with a loop to couple to the mixer tuned circuit. A diode mixer is used, a thermionic diode being chosen to avoid burn-outs under momentary overloads. A beat amplifier is added to make up for lack of conversion gain in the diode mixer.

A test jack is provided for connecting a voltmeter directly across the load resistance of the diode mixer. By plugging in a d-c voltmeter of 1000 ohms-per-volt (or higher) sensitivity, it is possible to check mixer voltage developed across the diode load. This check may be used to line up the frequency multiplier chain, or, by

shutting off the crystal oscillator, to check tuning of the mixer input tuned circuit to the transmitter frequency. This jack also provides the connection for use in measuring incidental a-m noise in the u-h-f t-v transmitter. A suitable calibration and de-emphasis circuit is provided in the Type 1932-P1 A-M Detector Unit which is intended for use with this detector in the u-h-f t-v band. The patch cord supplied with the Type 1932-P1 should be used in this application.

4.16 R-F Output Connection: Each of the r-f tuning units is supplied with an r-f output connection (GR Type 874-P) located on the rear of the instrument. This connection is not used for f-m monitoring; however, it is essential for monitoring the t-v visual transmitter carrier frequency when the Type 1170-BT is used as a unit of the Type 1183-T T-V Station Monitor. A Type 874-R20 patch cord will enable interconnection of this point with the Type 1171-AT Visual Transmitter Frequency Monitor, as described in the instruction book covering the t-v station monitor including the Type 1171-AT. Although the attachment or removal of this patch cord does affect the tuning of the multiplier slightly, its effect is readily corrected by the multiplier stage tuning adjustment.

### 4.2 DISCRIMINATOR SECTION (See Figures 6-10)

4.21 I-F Limiter Amplifiers: The output of the previous R-F Section is passed on to the input full-wave diode clipper tube V-112 (6AL5), is then amplified by V-114 (6SK7), and again clipped by the full-wave diode clipper V-115 (6AL5). Each of the two diodes has a fixed bias applied to alternate plates and cathodes. (See 4.45). This fixes the cut-off point of the diodes and assists in reducing the effect of tube characteristics upon the waveform and amplitude of the square wave.

The resultant square wave is further amplified and limited by V-109 (6AG7) and finally by V-108 (815). At this point, the square wave has a high degree of amplitude stability and maintains essentially constant waveform over the entire frequency swing from 50 to 250 kc.

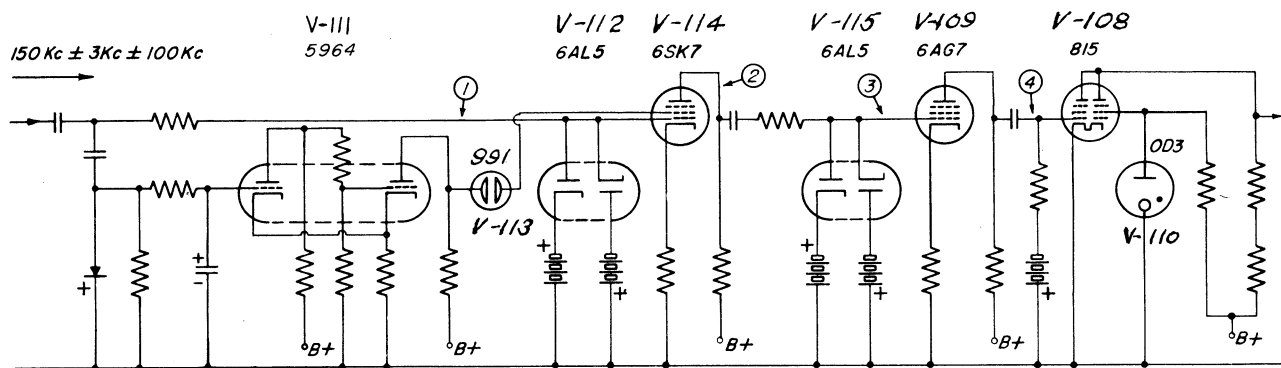


Figure 6. Elementary Schematic Diagram of I-F Limiter Amplifier



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4.22 Signal Monitoring Circuits: (See Figure 7) With square-wave circuits, it is possible to obtain an output signal with a relatively low amplitude of input signal, such as might be obtained with one or more of the clippers and limiters operating below saturation. This would then result in an erratic behavior of an indicating device which is normally intended to operate from a constant-amplitude square wave. To avoid this effect, a control is introduced which reduces the gain of the i-f amplifier until sufficient signal amplitude is present to maintain the minimum required for proper operation. It is also advantageous to have a monitoring circuit to indicate continuously the minimum signal level. Both of these functions are obtained from a single control circuit.

Part of the incoming signal from the previous r-f section is passed to a crystal diode rectifier (D-103). Since the signal level at this point is proportional to the R-F INPUT level, the rectified output of the crystal diode is an indirect measure of the R-F INPUT level. The microammeter which responds to this crystal diode current is the small meter placed on the rear of the instrument under the caption ADJ. R. F. INPUT TO 100.

The d-c voltage developed by the crystal diode (D-103) is filtered and applied to the grid of one section of an unbalanced "flip-flop" tube V-111 (5964 or 6J6). This tube controls the gain of the i-f amplifier tube V-114 (6SK7) by cutting off its screen-grid potential and simultaneously controls the action of the SIGNAL thyatron by cutting off the source of positive grid potential nor-

mally applied to its control grid. A relay in the thyatron anode circuit controls the plate and screen supply for the i-f amplifier tubes V-108 and V-109, also the signal pilot, and meter lamps in M-401. The a-c plate supply for the thyatron is taken from the crystal oven HEAT circuit transformer, and hence prevents operation of the monitor without the crystal heater in operation. This arrangement provides some protection against off-frequency operation due to a cold crystal oven.

With no signal present and the diode potential at zero, the right side of the twin-triode tube V-111 (6J6) is conducting, by virtue of its positive grid potential. This is developed by the resistances R-167 and R-166. Due to the cathode current flowing in R-165, a voltage is developed across this resistance which is sufficient to bias the left side of the twin triode beyond cutoff. The plate current of the right-hand triode causes a potential drop through R-172, which is in series with the plate supply. The voltage appearing across the neon glow lamp V-113 (991) is not sufficient to cause conduction; hence, no current can flow through it. This results in an essentially open circuit in series with the screen-grid supply of the amplifier V-114 (6SK7).

When a carrier signal is applied to the R-F input jack, a d-c potential is developed across capacitor C-137 by the rectifying action of the crystal diode D-103, proportional to the level of the input signal. The polarity of this potential is such as to decrease the net negative bias applied to the left triode section of V-111, and as a result this section begins to conduct, causing a voltage drop across R-173, and consequently a decrease in the

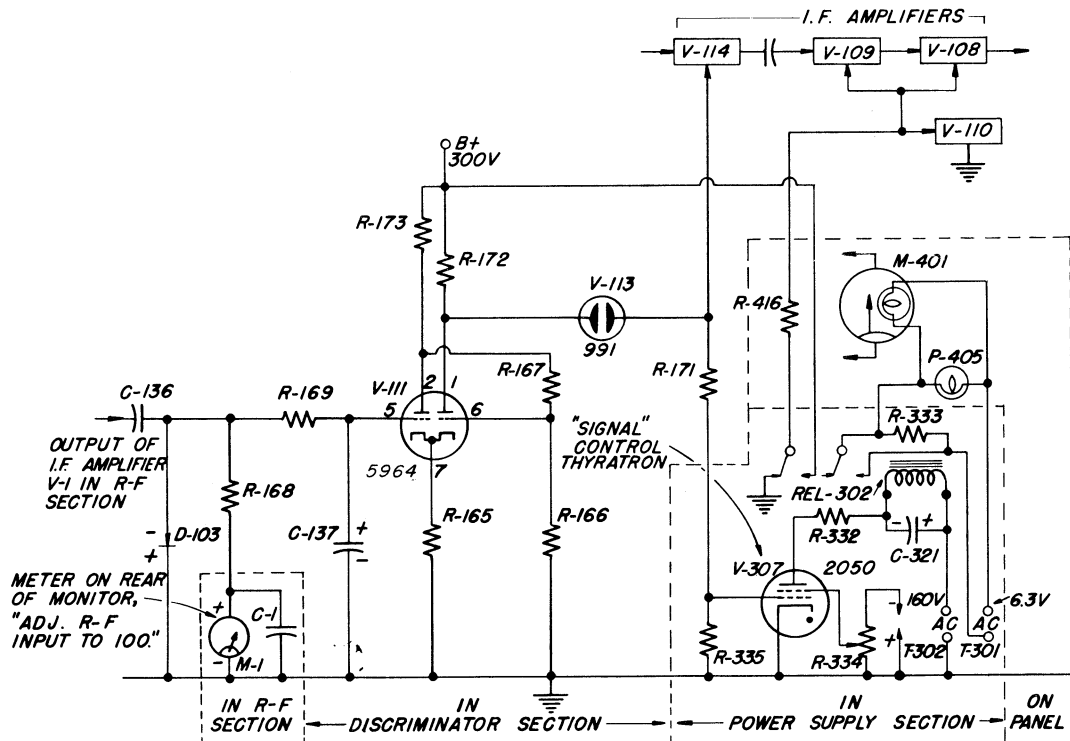


Figure 7. Signal Monitoring Circuits

## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

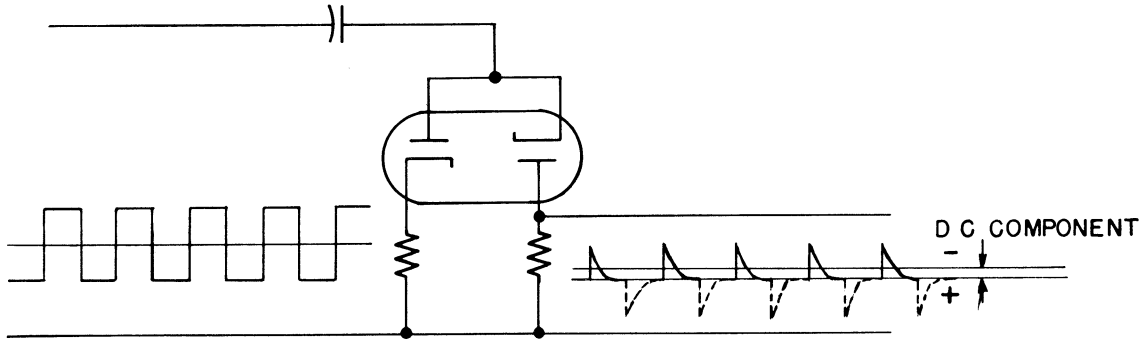


Figure 8. Schematic Diagram Showing Discriminator Circuit Operation

positive bias applied to the right triode. Because of the common cathode resistor R-165 this action is cumulative, so that at a critical level of input signal the right triode is biased beyond cut-off.

When this happens, the voltage drop across R-172 momentarily disappears, thus applying sufficient potential from the plate supply to cause V-113 (991) to become conducting. A positive potential is now applied to the screen grid of V-114 (6SK7) and this amplifier tube functions with normal gain. Simultaneously, a positive voltage is applied to the grid of the SIGNAL thyatron-control tube via R-171 and R-335. The relay REL-302 then lights the SIGNAL pilot and meter lamps, and connects the plate and screen supply to V-108 and V-109. R-333 permits the SIGNAL lamps to glow very dimly in the absence of signal voltage for the purpose of indicating circuit continuity.

**4.23 Discriminator Circuit Operation:** The discriminator circuit used in the monitor is a pulse-counter type. It consists essentially of a series capacitance and shunt resistance, as shown in the elementary schematic diagram of Figure 8. The RC time constant is quite small compared to a half cycle of the square wave. When a square wave is applied to such a circuit, the capacitance will be charged to the peak value of the square on alternate half cycles.

By the addition of two diodes, the capacitance may be made to charge through one and discharge through the other, and thus result in unidirectional voltage pulses appearing across the resistance at the rate of one per cycle of the square wave. A bias is applied in series with the diodes to eliminate the residual diode current which would otherwise flow through the resistances.

**4.24 Discriminator Circuit Details:** The basic discriminator circuit includes the duo-diode tube V-107 (6AL5), the series capacitor C-120, and the shunt impedance element R-140 and L-102. The capacitor is adjusted at the factory for output level and maximum linearity of the discriminator characteristic. It is intended for use in adjusting for manufacturing tolerances only and should never be changed in any way.

A bias voltage is developed across the resistance R-141 for the purpose of limiting the initial diode current produced by the tube V-107 (6AL5). This minimizes the effects of the tube characteristics upon the

calibration. The voltage is derived from the regulated plate supply and is filtered by the R-C combination of R-143 and C-121.

Additional stabilization is provided through the use of a series constant-current ballast-tube of the Amperite 3-4 type, V-304, to regulate the heater current to V-107.

**4.25 Operation of Center-Frequency Indicator:** An elementary diagram of the center-frequency indicator circuit is shown in Figure 9.

With the transmitter unmodulated and operating on its assigned channel frequency the output of the discriminator will consist of a series of identical, uniformly spaced, unidirectional pulses, occurring at a rate of 150 kc. By integrating these pulses, a d-c voltage is developed which is used to operate a balanced d-c vacuum-tube voltmeter.

When frequency modulation is applied to the transmitter the above conditions are changed. With the transmitter operating on its assigned channel frequency, the average recurrence rate of the discriminator output pulses is still 150 kc, but the instantaneous rate depends upon the instantaneous transmitter frequency as determined by the modulation wave.

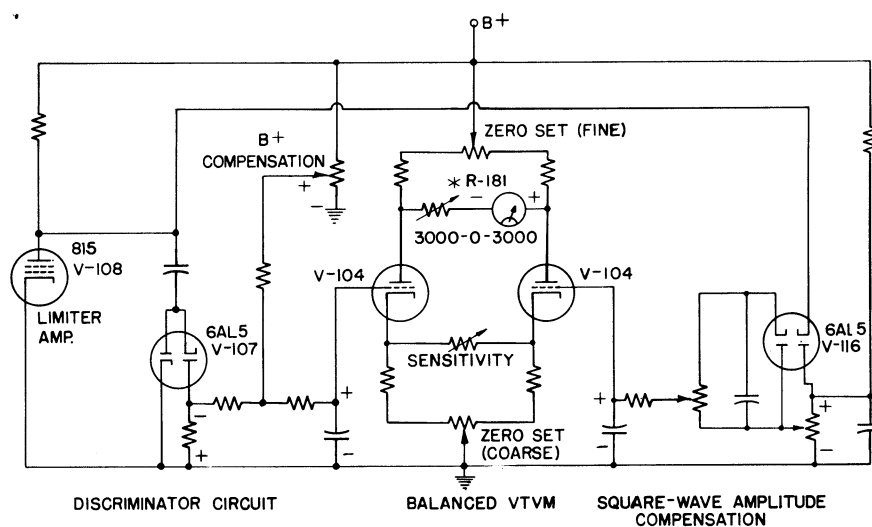
If the frequency of the transmitter departs from its assigned channel frequency, the frequency of the square wave changes in the same manner. Since the number of pulses generated by the discriminator per unit time has changed, the d-c voltage developed will also change in magnitude and thus cause a shift in the vacuum-tube voltmeter. This is the basis of operation of the KILOCYCLES DEVIATION or center-frequency meter.

Changes in both amplitude and frequency of the square wave will affect the discriminator output voltage. Since it is desired to have the discriminator respond only to frequency, the square wave amplitude must be precisely regulated. This is achieved for the most part

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\*or the offset intermediate frequency if used for t-v monitor (140 or 160 Kc).

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\* Used to Change Meter to 6.0-6 Kc Scale Range

Figure 9. Elementary Schematic Diagram of Center-Frequency Indicator

in the i-f limiter-amplifier circuits, but it is impractical to attempt to reduce the amplitude changes to the degree required for operation of the center frequency indicator. Accordingly, compensation circuits are included in the center-frequency indicator which reduce the effects of minor amplitude changes to a negligible value.

The discriminator d-c output voltage is applied to one side of a balanced d-c vacuum tube voltmeter, as shown in Figure 9. A peak-response diode is used as an amplitude compensation device and develops a d-c voltage which is applied to the opposite side of the balanced d-c vacuum-tube voltmeter.

The center-frequency indicator is a zero-center device. To adjust the d-c vacuum-tube voltmeter to zero, a positive voltage is obtained from the regulated plate supply. This voltage is set to give a zero reading on the meter, when the i-f is exactly 150 kc.\* Since this control determines the calibration of the meter with respect to the i-f, it is also used to adjust for frequency drifts in the crystal oscillator, and is available on the panel under a snap-button captioned CENTER FREQUENCY.

It is important to note that the final i-f limiter amplifier V-108 (815) is operated between the limits of plate-current cutoff, and plate current saturation. The resultant square wave is thus limited in positive amplitude by the regulated plate supply, and in negative amplitude by the voltage drop across the tube. Compensation for minor changes in the positive amplitude of the square wave are thus obtainable directly from the plate supply. This is accomplished automatically by the center frequency adjustment circuit. Compensation for minor changes in the negative square wave ampli-

tude is effected by means of the half-wave diode. The other half of the duo-diode tube V-116 (6AL5) is used to balance out the contact potential of the diode as well as changes in the emission current of the limiter tube V-108 (815) with heater supply voltage.

**4.26 Circuit Details of Center-Frequency Indicator:** The square-wave amplifier output is fed to the discriminator diodes V-107 and the amplitude compensation diode circuit, V-116. The resultant d-c voltages are applied to opposite grids of the two balanced vacuum-tube voltmeter tubes V-104 and V-105 (6SL7-GT).

By slight adjustment of a compensating d-c voltage derived from the plate supply, the center-frequency position of the KILOCYCLES DEVIATION meter can be shifted over a limited range. Under the original calibrating conditions, the total amount of compensating d-c voltage is made equal to the d-c voltage output of the discriminator when the fundamental frequency of the square wave is 150 kc\*, to result in a zero center reading of the meter. There are two adjustments which control this d-c compensating voltage. The first, which is located behind the monitor nameplate on the front panel, is identified by the engraving CENTER FREQ. and is only used for initial factory adjustment. A second control is accessible beneath a snap-button on the panel, adjacent to the lower right corner of the KILOCYCLES DEVIATION meter and is engraved CENTER FREQUENCY. This control is intended for use in adjusting the monitor to agree with the results obtained from independent transmitter frequency measuring services. This calibration adjustment should not be disturbed unless an accurate frequency check indicates that the monitor readings are in error. The useful range of adjustment is +3 kilocycles. Should the required correction exceed this limit, the monitor crystal will probably be found off frequency. The potentiometers R-156 and R-160 are factory adjusted and should not be disturbed.

\* or the offset intermediate frequency if used for t-v monitor (140 or 160 kc).



## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

R-181 is inserted to change the meter scale range to 6-0-6 kc, which is normally supplied for television transmitters (1170-BT).

The balanced d-c vacuum-tube voltmeter, which is used to operate the KILOCYCLES DEVIATION meter, is a zero-center device and will deflect to full scale in either direction ( $\pm 3000$  cycles) when a nominal potential of  $\pm 0.30^{\dagger}$  volt is applied. The effects of power-supply voltage variations have been reduced to a minimum through the use of a balanced circuit, regulated plate voltage supply, and regulation of the tube heater current. The latter is achieved through the use of a series connection, employing a constant-current ballast tube of the Amperite 3-4 type, V-306.

If the crystal oscillator has drifted slightly, necessitating a change in the setting of the CENTER FREQUENCY adjustment, the intermediate frequency will no longer be 150 kc\* for a zero meter reading. It will differ from 150 kc\* by an amount equal to the shift in the control.

An independent check of the electrical zero# of the KILOCYCLES DEVIATION meter is provided on the instrument panel. When the panel CHECK ZERO switch is depressed, the signal is removed from the balanced d-c vacuum-tube voltmeter. The meter should

\*See footnote on page 14.

$\dagger \pm 0.60$  volts for the  $\pm 6$  kc range.

#It is important to note that this is the actual zero setting of the balanced d-c vacuum-tube voltmeter alone, and is entirely independent of the center frequency adjustment. Errors in setting of this zero adjustment are addition to the readings of center frequency, however, hence this checking system is provided.

slowly return to zero in this case. In the event that a zero drift is found, the zero adjustment (R-404) (located to the right of the meter and under a snap-button) can be changed. Do not make this check unless the monitor is operating with a signal from the transmitter.

The initial calibration of this vacuum-tube voltmeter circuit has been made by means of the two concealed adjustments located under the panel nameplate. These are engraved CAL (R-403) and ZERO (R-405) and are factory adjusted and should not be disturbed.

There are two cylindrical shields placed over the two vacuum-tube voltmeter tubes V-104 and V-105 (6SU7-GTY) for the purpose of removing electrostatic charges which may build up on the glass envelopes of the tubes and cause erratic behavior of the indicating meter. A spring clip grounds each shield.

**4.27 Discriminator Audio-Output System Operation:**  
An elementary schematic is shown in Figure 10. The pulse rate in the discriminator output varies linearly with the original modulation wave applied to the transmitter. Due to the unidirectional pulse-type waveform, the discriminator output contains a d-c component and also a-c components which are a result of the modulation wave, the pulse fundamental frequency, and many high-frequency harmonics. The d-c component is eliminated by a series capacitor, and the unwanted higher frequencies, by a low-pass audio filter. The remaining components are essentially those of the original transmitter-modulation frequency.

To minimize the reactive load placed across the discriminator output, the de-emphasis network is introduced as the coupling link between the discriminator.

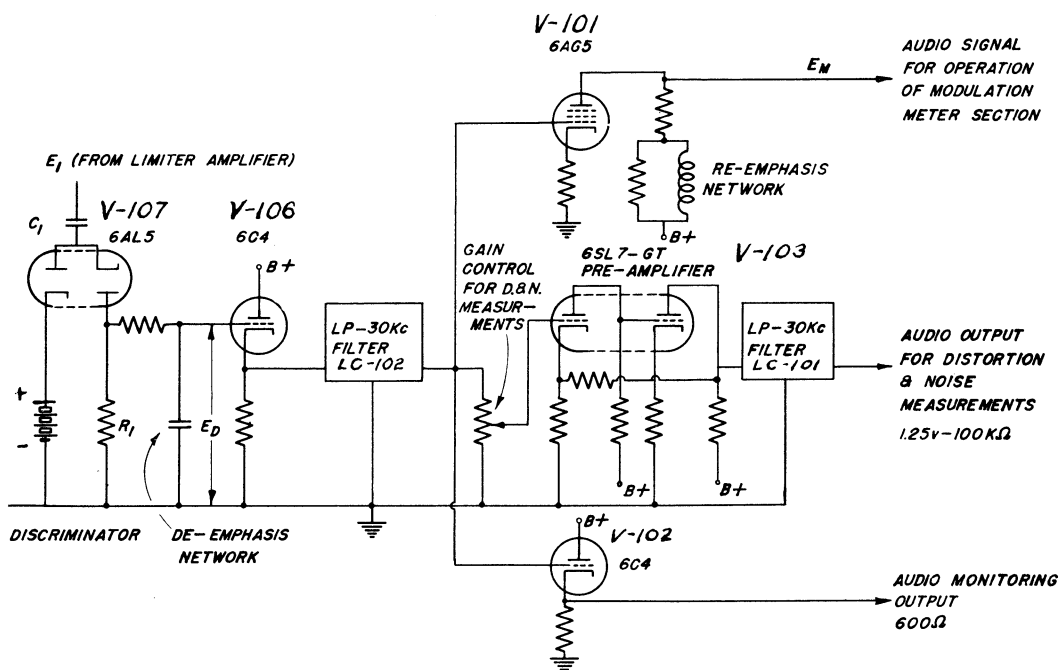


Figure 10. Discriminator Audio-Output System

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and the associated audio circuits. An additional advantage is also realized in that this network is essentially a low-pass filter and thus assists in attenuating the unwanted high frequency components present in the pulse wave. Added filtering follows, and the resultant audio signal is passed on to three independent circuits. One of these provides a 600-ohm output for local aural monitoring; a second is used as a pre-amplifier for distortion and noise measurements; and a third includes a re-emphasis network to restore the over-all response to a flat frequency characteristic, for operation of the modulation meter section of the instrument.

**4.28 Circuit Details of Discriminator Audio-Output System:** The de-emphasis network consists of the series resistance R-145, and the shunt capacitance C-116. The latter is adjustable, and is intended for manufacturing use only to calibrate the frequency-response characteristic.

A cathode follower tube, V-106 (6C4), is employed to couple this high-impedance circuit into a 30-kc low-pass filter, LC-102. At this point in the circuit, the signal is essentially a replica of the original modulation wave.

V-102 (6C4) provides an audio output signal at a 600-ohm level and is intended for local aural monitoring.

The audio signal is connected to a potentiometer (R-116) located on the panel and engraved ADJ. DIST. METER (SET DIST. METER TO CAL.). This controls the audio input level to the pre-amplifier which is used to operate the external Type 1932-A Distortion and Noise Meter. In order to minimize the residual distortion within this amplifier, it is operated at essentially a constant level by means of the potentiometer. There is a possibility of overloading the amplifier at high modulation levels (i. e., maximum audio signal) if this control is turned full on. For this reason, the OFF position is engraved MONITORING and the control should be left in this position at all times, except when in use. When distortion or noise-level measurements are made, the fixed sensitivity of the external Type 1932-A Distortion and Noise Meter will automatically determine the correct setting of this control. If a distortion and noise meter of a different type is used, its sensitivity must be such that it will operate with an input signal not greater than 1.25 volts. Its gain control should be left full ON, and the calibration effected via the potentiometer control (R-116) on the monitor panel.

In order to provide for noise measurements approaching a limit of 80 db below 100% modulation, additional filtering is added in this circuit and consists of a second 30-kc low-pass filter, LC-101. Both of the low-pass filters have adjustments which are intended only for manufacturing use and should not be altered in any way.

### 4.3 MODULATION METER SECTION (See Figure 11)

**4.31 Pre-Amplifier (See Figure 11):** The audio signal is applied to the modulation meter section through the

shielded cable lead which is plugged into the receptacle PL-202, located on the inside surface of the shelf just above the crystal oven.

A pre-amplifier V-203 (6SN7-GT) has an adjustable gain control (R-220) which can be used to change the over-all calibration of the modulation meter and the MODULATION PEAKS dial. The instrument is normally calibrated for 100% modulation equal to a modulation swing of +75 kc, for all standard FM broadcast transmitters in the 88 - 108 Mc band.

Television aural FM transmitters employ a calibration level of 100% modulation equal to a modulation swing of +25 kc. The adjustment R-220 is intended for changing the pre-amplifier gain to set this calibration. The control is continuously variable so that it is possible, therefore, to set the monitor to 100% modulation level for any value of modulation swing between the limits of +25 to +75 kc. The arrangement of this control makes it possible to shift the entire audio circuit calibration by means of one adjustment.

**4.32 Modulation Meter Circuits:** A duo-diode tube V-204 (6AL5) is arranged in a semi-peak response circuit so that either diode alone, or both in parallel, may be operated. The panel selector switch MODULATION PEAKS (S-201) connects these diodes so that positive, negative, or full-wave response will be indicated by the MODULATION meter.

The d-c voltage developed by the diodes is applied to a d-c vacuum-tube voltmeter through R-C coupling networks. These networks, in conjunction with a high-speed meter produce the required response characteristics for FM modulation monitors as specified by the FCC\*. The over-all characteristic results in a rapid rise of the modulation indicating meter in response to a modulation peak, followed by a slow return toward zero.

The d-c vacuum-tube voltmeter consists of two paralleled triodes, each of which is controlled by its separate diode. When full-wave operation is used, both triodes are operating simultaneously; hence, the sensitivity of the indicating meter is halved by a shunt resistance (R-203) CAL-FULL WAVE. A calibration control is provided for setting the meter sensitivity (R-233) CAL-POS. NEG.; and the electrical zero setting is made by means of (R-205) ZERO-SET. These three adjustments are accessible from the rear of the instrument, on the lower right corner. An internal adjustment R-231 is a balance control and is used to equalize the positive and negative readings on sine-wave modulation. This is intended for manufacturing use only and will not normally require re-setting. Adjustments C-201, C-206, C-207 are frequency-characteristic compensation capacitors and should not be disturbed.

**4.33 Over-Modulation Lamp Circuits:** The pre-amplifier audio output signal is coupled to the grid of V-202 (6SJ7). A fixed bias is introduced in the grid circuit which is sufficient to maintain the tube at plate current cut-off, in the absence of an audio signal on its

\* FCC Standards of Good Engineering Practice.

## TYPE 1170-B AND 1170-BT FREQUENCY-MODULATION MONITORS

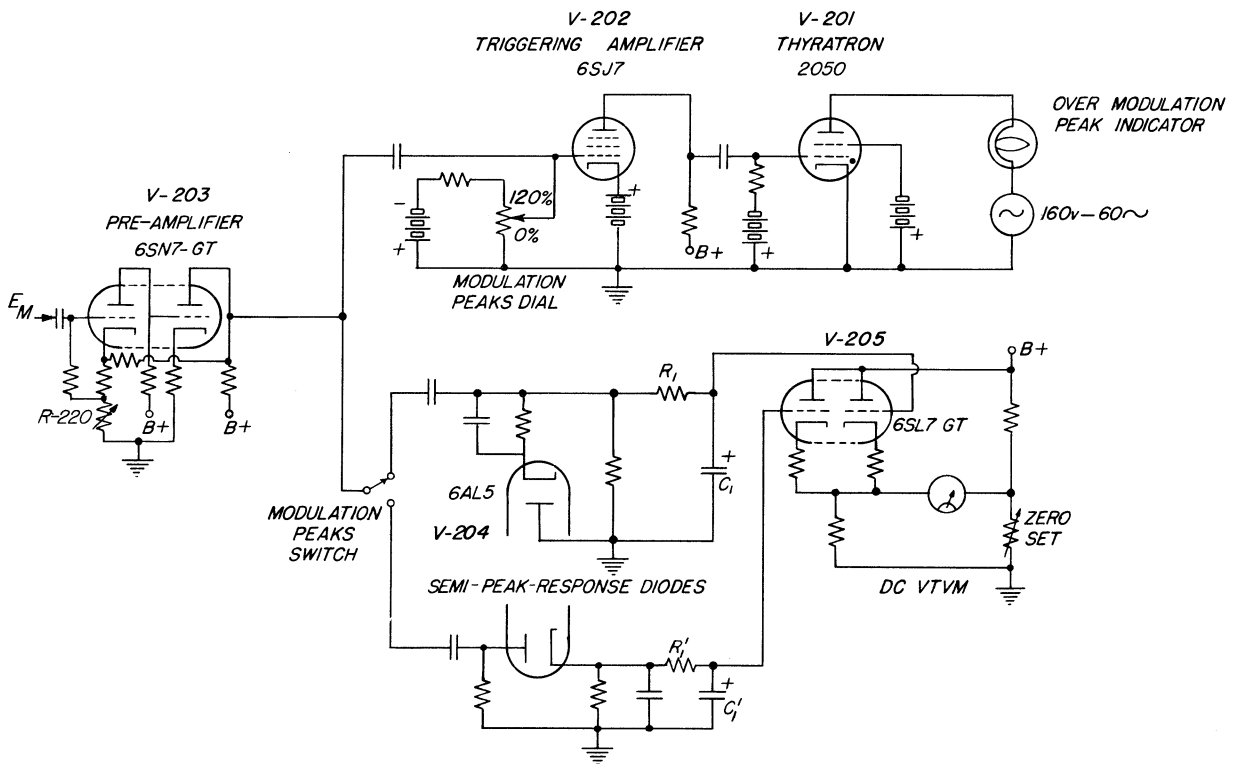


Figure 11. Elementary Schematic Diagram of Modulation Metering Section

grid. Whenever an audio signal appears on the grid, this bias is exceeded and, provided the MODULATION PEAKS dial is set at zero, a pulse of plate current is developed by the amplifier tube. This fixed bias is adjusted by means of R-214 so that the lamp remains extinguished in the absence of modulation, with the MODULATION PEAKS dial set at zero.

The MODULATION PEAKS dial (R-401) controls an additional negative bias in the grid circuit of V-202. The range of the control is equivalent to 0 to 120% modulation; hence, the audio-signal peak amplitude at 120% modulation level is adjusted (via R-216) to be equal to the total d-c potential across the potentiometer R-401. Thus, whenever the peak value of the modulation signal exceeds the grid bias as set by the MODULATION PEAKS dial, the amplifier tube V-202 develops a plate current pulse.

The bias voltages for operation of this circuit are obtained from the voltage-regulated bias rectifier system within the power-supply section.

The plate voltage pulse developed by V-202 is used to trigger a thyatron tube V-201. The OVER MODULATION lamp (P-406) is connected in the anode circuit of the thyatron and hence will flash whenever the thyatron conducts. Fixed negative potentials are applied to both grids of the thyatron tube, whose anode circuit is operated from a winding on the main power transformer T-301. Because of this condition, the thyatron becomes non-conducting during each negative

half-cycle of the power-line frequency. This characteristic may result in a "beat" indication of the OVER MODULATION lamp whenever steady sine-wave modulation is employed on the transmitter. With normal program modulation, this effect is not noticeable.

### 4.4 POWER SUPPLY SECTION

The power supply for the monitor is located on the upper right shelf assembly. Two power transformers are used; one to supply the requirements of stand-by operation which includes the crystal-oven heaters, etc., and a second to provide for the majority of the monitor tube circuits. Each is separately fused and has its own power input connector.

**4.41 Adjustments:** There are only three adjustments provided. These are set at the factory and will not normally require adjustment after the monitor is placed in service. The voltage of the main regulated plate supply has been set to 300 volts by means of R-317; and the power-supply ripple voltage set for a minimum via R-315. The third adjustment controls the negative bias applied to the screen grid of a thyatron tube, which in turn controls the SIGNAL and KILOCYCLES DEVIATION meter pilot lamps. This bias voltage is sufficient to maintain the tube at cut-off until it is triggered by a positive voltage applied to its control grid. Unless a markedly different thyatron tube is placed in the V-307 position (adjacent to R-334) this control will not require resetting. To check its setting, it is merely necessary to remove the 6BE6 mixer tube (R-F Section) and note that the SIGNAL pilot goes out, or becomes very dim.



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**4.42 Plate Voltage Supply:** The plate voltage supply employs selenium rectifiers (RX-304, 305, etc.) connected in a full-wave voltage doubler circuit. An unregulated source of d-c voltage is derived from the rectifier output and employs an R-C ripple filter. The main portion of the rectifier output is passed through an L-C ripple filter and a series-type electronic regulator which maintains a close control of the voltage level.

**4.43 Regulated Tube-Heater Supply for Vacuum-Tube Voltmeter:** The tubes used in the vacuum-tube voltmeter circuit for the KILOCYCLES DEVIATION meter are supplied from a constant current a-c source, and have their heater circuits connected in series (V-104 and V-105). A series ballast tube, V-306, is used as the control device. This tube is located toward the rear of the power-supply shelf assembly and is nearest to the MONITOR fuses.

A similar regulator tube, V-304, is used to control the heater of the diode rectifier (V-107) employed in the discriminator circuit. This tube is located toward the rear of the power supply shelf and is immediately below the main rectifier unit.

By employing this regulation on the vacuum-tube voltmeter tube heater, a high degree of stability is achieved and the effects of line-voltage variation do not interfere with the normal operation of the circuits used to indicate the transmitter center frequency (i.e., KILOCYCLES DEVIATION meter).

If either of these ballast tubes should fail, an emergency substitution of a fixed resistor may be made, in order to restore the monitor to operating condition until a replacement can be obtained. The resistance should consist of a 2 watt, 3.3 ohm  $\pm 10\%$  resistor and be connected between terminals #2 and #7 of the tube socket. It must be noted, however, that substitution of either a fixed resistor or of another 3-4 tube for V-306 may change the calibration of the KILOCYCLES DEVIATION meter by 500 cycles in the worst case.

**4.44 D-C Tube Heater Supply:** Two separate rectifier supplies, employing full-wave bridge-connected selenium rectifiers, are used to provide a source of d-c for the heaters of low-level audio amplifier tubes and also for the discriminator drive tube. Owing to the extremely low values of hum level required for operation of these circuits, their heaters are operated from well filtered d-c sources.

The first rectifier system (RX-301) is used to supply heater power to the audio amplifier (V-103) and also the cathode follower stage which is used as an impedance coupling device at the input to the low-pass filter (LC-102). Owing to the necessity of limiting

heater-cathode potentials to their rated value, this supply is operated above ground potential.

A second rectifier (RX-302) is used to supply heater power to the discriminator input tube, V-108 (815). The negative side of this supply is grounded.

**4.45 Bias Supply:** A diode rectifier tube V-308 (6AL5) is used to supply bias voltages at five different levels. This system is controlled by use of an OC3/VR105 voltage regulator tube (V-305). Biasing potentials are developed across a voltage divider (R-322 to R-326 inc.) and are used to supply the following circuits: (1) positive and negative bias potentials for the diode clipper tubes V-112 and V-115; (2) negative bias potentials for the control and screen grids of the thyatron tube V-201 which controls the OVER MODULATION warning lamp; and, (3) a negative bias potential which is applied to the grid of V-202, the thyatron triggering amplifier, through the MODULATION PEAKS potentiometer.

A second negative bias voltage, applied to the control grids of the discriminator driver tube V-108 (815), is obtained from the selenium rectifier system RX-303. This rectifier is operated from the auxiliary power transformer and also connects to other circuits.

**4.46 Auxiliary Transformer Supply:** When the monitor is operated under stand-by conditions, the small power transformer T-302 is used to supply the power for the crystal oven heaters. This heat circuit is controlled by a d-c relay, which derives its source of power from the selenium rectifier system RX-303. A d-c relay control system is employed to avoid the chatter and uncertain contact difficulties that are apt to result from the use of sensitive a-c operated relays. The mercury-column thermostat (S-405-51) is arranged so that it will short-circuit the relay energizing coil, when the temperature reaches a critical point. Opening of the relay disconnects the heater circuit. The panel HEAT CYCLE pilot lamp is in series with a part of the heater circuit and thus indicates normal functioning of the system.

**4.47 "Signal" Thyatron Control:** The SIGNAL pilot and meter lamps are controlled by the anode-circuit relay REL-302 of the thyatron tube V-307 (2050). With an a-c potential supplied from the main power transformer heater winding connected in the relay circuit, the SIGNAL pilot (and meter illumination lamps of the center-frequency indicating meter) will glow whenever the relay is actuated by the thyatron. To keep the thyatron from conducting under conditions of zero control grid potential, a negative d-c voltage is applied to the screen grid via R-334. This voltage is derived from the same rectifier source, RX-303, used to supply the relay, REL-301.

TABLE I

CRYSTAL FREQUENCIES  
AND  
R-F TUNING ADJUSTMENTS  
FOR STANDARD FM BROADCAST BAND--88-108 Mc

CRYSTAL FREQUENCY IN KILOCYCLES	FIRST MULTIPLIER		SECOND MULTIPLIER		THIRD MULTIPLIER		TOTAL MULT.	TRANSMITTER CHANNEL	
	Ratio	Approx. Tuning in Mc	Ratio	Approx. Tuning in Mc	Ratio	Approx. Tuning in Mc	Ratio	Freq. Mc	Number
1570.536	x4	6.282	x7	43.97	x2	87.95	x56	88.1	1
1574.107	"	6.296	"	44.07	"	88.15	"	88.3	2
1577.679	"	6.311	"	44.18	"	88.35	"	88.5	3
1581.250	"	6.325	"	44.28	"	88.55	"	88.7	4
1584.821	"	6.339	"	44.37	"	88.75	"	88.9	5
1588.393	"	6.354	"	44.48	"	88.95	"	89.1	6
1591.964	"	6.368	"	44.58	"	89.15	"	89.3	7
1595.536	"	6.382	"	44.67	"	89.35	"	89.5	8
1599.107	"	6.396	"	44.77	"	89.55	"	89.7	9
1402.344	"	5.609	x8	44.87	"	89.75	x64	89.9	10
1405.469	"	5.622	"	44.97	"	89.95	"	90.1	11
1408.594	"	5.634	"	45.07	"	90.15	"	90.3	12
1411.719	"	5.647	"	45.18	"	90.35	"	90.5	13
1414.844	"	5.659	"	45.27	"	90.55	"	90.7	14
1417.969	"	5.672	"	45.37	"	90.75	"	90.9	15
1421.094	"	5.684	"	45.47	"	90.95	"	91.1	16
1424.219	"	5.697	"	45.58	"	91.15	"	91.3	17
1427.344	"	5.709	"	45.67	"	91.35	"	91.5	18
1430.469	"	5.722	"	45.78	"	91.55	"	91.7	19
1433.594	"	5.734	"	45.87	"	91.75	"	91.9	20
1436.719	"	5.747	"	45.98	"	91.95	"	92.1	21
1439.844	"	5.759	"	46.07	"	92.15	"	92.3	22
1442.969	"	5.772	"	46.17	"	92.35	"	92.5	23
1446.094	"	5.784	"	46.27	"	92.55	"	92.7	24
1545.833	x5	7.729	x6	46.37	"	92.75	x60	92.9	25
1549.167	"	7.746	"	46.48	"	92.95	"	93.1	26
1552.500	"	7.763	"	46.58	"	93.15	"	93.3	27
1555.833	"	7.779	"	46.67	"	93.35	"	93.5	28
1559.167	"	7.796	"	46.78	"	93.55	"	93.7	29
1562.500	"	7.813	"	46.88	"	93.75	"	93.9	30
1565.833	"	7.829	"	46.97	"	93.95	"	94.1	31
1569.167	"	7.846	"	47.08	"	94.15	"	94.3	32
1572.500	"	7.863	"	47.18	"	94.35	"	94.5	33
1575.833	"	7.879	"	47.27	"	94.55	"	94.7	34
1579.167	"	7.896	"	47.37	"	94.75	"	94.9	35
1582.500	"	7.913	"	47.48	"	94.95	"	95.1	36
1585.833	"	7.929	"	47.57	"	95.15	"	95.3	37
1589.167	"	7.946	"	47.68	"	95.35	"	95.5	38
1592.500	"	7.963	"	47.78	"	95.55	"	95.7	39
1709.821	x4	6.839	x7	47.87	"	95.75	x56	95.9	40
1713.393	"	6.854	"	47.98	"	95.95	"	96.1	41
1716.964	"	6.869	"	48.08	"	96.15	"	96.3	42
1720.536	"	6.882	"	48.17	"	96.35	"	96.5	43
1724.107	"	6.896	"	48.27	"	96.55	"	96.7	44
1727.679	"	6.911	"	48.37	"	96.75	"	96.9	45

Channel	FM Sound Freq. (Mc)	1170-BT Mult. Freq. (Mc)	Crystal Freq. (Kc)	Frequency Multipliers												Total Mult. Ratio
				#1		#2		#3		#4		#5		#6		
				Ratio	Freq.	Ratio	Freq.	Ratio	Freq.	Ratio	Freq.	Ratio	Freq.	Ratio	Freq.	
56	727.75	727.6	2021.111	4	8.08	5	40.42	2	80.8	This stage is used as an amplifier. (XI)	3	242.5	3	727.6	360	
57	733.75	733.6	3396.296	3	10.18	4	40.76	2	81.5		3	244.5	3	733.6	216	
58	739.75	739.6	4108.889	2	8.22	5	41.09	2	82.2		3	246.5	3	739.6	180	
59	745.75	745.6	2761.481	3	8.28	5	41.42	2	82.8		3	248.5	3	745.6	270	
60	751.75	751.6	2319.753	3	6.96	6	41.76	2	83.5		3	250.5	3	751.6	324	
61	757.75	757.6	2338.272	3	7.01	6	42.09	2	84.2		3	252.5	3	757.6	324	
62	763.75	763.6	4242.222	2	8.48	5	42.42	2	84.8	3	254.5	3	763.6	180		
63	769.75	769.6	3562.963	3	10.69	4	42.75	2	85.5	3	256.5	3	769.6	216		
64	775.75	775.6	2154.444	4	8.62	5	43.09	2	86.2	3	258.5	3	775.6	350		
65	781.75	781.6	2171.111	4	8.68	5	43.42	2	86.8	3	260.5	3	781.6	360		
66	787.75	787.6	2430.864	3	7.29	6	43.75	2	87.5	3	262.5	3	787.6	324		
67	793.75	793.6	2449.383	3	7.35	6	44.09	2	88.2	3	264.5	3	793.6	324		
68	799.75	799.6	2467.901	3	7.40	6	44.42	2	88.8	3	266.5	3	799.6	324		
69	805.75	805.6	2486.420	3	7.46	6	44.75	2	89.5	3	268.5	3	805.6	324		
70	811.75	811.6	1878.704	4	7.51	6	45.09	2	90.2	3	270.5	3	811.6	432		
71	817.75	817.6	2162.963	3	6.49	7	45.42	2	90.8	3	272.5	3	817.6	378		
72	823.75	823.6	2287.777	4	9.15	5	45.75	2	91.5	3	274.5	3	823.6	360		
73	829.75	829.6	2304.444	4	9.22	5	46.09	2	92.2	3	276.5	3	829.6	360		
74	835.75	835.6	2321.111	4	9.28	5	46.42	2	92.8	3	278.5	3	835.6	360		
75	841.75	841.6	3117.037	3	9.35	5	46.75	2	93.5	3	280.5	3	841.6	270		
76	847.75	847.6	2616.049	3	7.85	6	47.09	2	94.2	3	282.5	3	847.6	324		
77	853.75	853.6	3387.302	2	6.77	7	47.42	2	94.8	3	284.5	3	853.6	252		
78	859.75	859.6	3411.111	2	6.82	7	47.75	2	95.5	3	286.5	3	859.6	252		
79	865.75	865.6	2003.704	4	8.01	6	48.09	2	96.2	3	288.5	3	865.6	432		
80	871.75	871.6	2305.820	3	6.92	7	48.42	2	96.8	3	290.5	3	871.6	378		
81	877.75	877.6	3250.370	3	9.75	5	48.75	2	97.5	3	292.5	3	877.6	270		
82	883.75	883.6	2454.444	4	9.82	5	49.09	2	98.2	3	294.5	3	883.6	360		
83	889.75	889.6	2471.111	4	9.88	5	49.42	2	98.8	3	296.5	3	889.6	360		





