INSTRUCTION AND OPERATING MANUAL
FOR

TYPE AFM1b
AM-FM MODULATION METER

CONTENTS

INTRODUCTION

The AM-FM Modulation Meter, type AFM1, meets a demand for accurate measurement of the modulation percentage of amplitude-modulated signals, and of the peak deviation of frequency-modulated signals. It is a unique feature of this instrument that both types of modulation can be measured accurately.

The basic carrier-frequency range is from 3 to 320 Mc, when less than 10 millivolts are required for satisfactory operation, but the Modulation Meter can be used to over 1000 Mc on harmonics.

The measuring range is very wide. Readings can be made from 0.1% to 100% on AM and from ±100 cps to ±300 kc on FM. The range can be extended further downwards with an external indicator, such as a vacuum-tube voltmeter. With 1 dB drop-off at 30 cps and 25 kc, the Modulation Meter can be used to check the performance of high-fidelity systems. The instrument has been designed so that it is possible to measure amplitude modulation on frequency-modulated signals, and vice versa.

The Modulation Meter has provisions for a crystal-controlled local or external oscillator, which reduces the spurious FM to about ±10 cps. a convenience when measuring residual FM in oscillators.

The intermediate-frequency and audio-frequency signals can be supplied to external monitors from terminals on the front panel.

SECTION 1
SPECIFICATIONS

FREQUENCY RANGE

3 to 320 Mc.

Operation to over 1000 Mc is possible on harmonics. The following data are valid at frequencies up to 320 Mc, but most of them apply equally well at higher frequencies.

INPUT LEVEL

Minimum: 10 millivolts, usually around 5 mV.

Maximum: 1 volts on AM for a 100% modulated signal to avoid distortion. Higher levels permitted for signals with less than 100% modulation.
10 volts on FM.

To obtain minimum residual readings, the input level must be 20 dB above the minimum level.

INPUT IMPEDANCE

75 ohms nominal

AMPLITUDE MODULATION

Ranges

3, 10, 30, and 100% AM full scale.
Measurement of positive and negative peaks of modulation.

Accuracy

3% of full scale to over 95% modulation.

Frequency response

30 cps to 25 kc (−1 dB limits referred to 1 kc)

Residual reading

Less than 0.1% AM

Distortion

Less than 0.5% to 95% AM

FREQUENCY MODULATION

Ranges

±3, ±10, ±30, ±100, and ±300 kc deviation full scale.
Measurement of positive and negative peaks of deviation.

Accuracy

3% of full scale

Frequency response

30 cps to 25 kc (—1 dB limits referred to 1 kc)

Residual reading

Varies from about 10 cps at low carrier frequencies to about 60 cps at high frequencies.

Distortion

Less than 0.5% up to ±300 kc.

AF OUTPUT

Audio-frequency signal (AM or FM) of 1 volt open-circuit at full scale from a source of 1.6 kilohms. The frequency response is within ±1 dB in the range 30 cps to 25 kc.

IF OUTPUT

1 Mc intermediate-frequency signal of approximately 0.5 volt open-circuit at full scale from a source of 250 ohms.

TERMINALS

RF input to BNC type UG-290/U coaxial sockets.
IF and AF output from standard 4 mm banana jacks.

POWER SUPPLY

Voltages: 110, 115, 127, 200, 220, 240 volts.
Line frequencies: 50 to 60 cps.
Consumption: 80 watts

TUBES

2 EAA91 (6AL5)
2 ECC81 (12AT7)
1 ECC88 (6DJ8)
2 EF86 (6267)
2 85A2 (5651)
1 6AL5
1 EC81 (6R4)
1 ECC82 (12AU7)
1 EF80 (6BX6)
4 EF91 (6AM6)
1 150B2

MOUNTING AND FINISH

Steel cabinet finished in grey enamel

DIMENSIONS AND WEIGHT

Height	Width	Depth	
290	565	270	mm
11 1/2	22 1/2	10 1/2	inches

20 kilos net (44 lbs.)

ACCESSORIES SUPPLIED

1 type 6D6 coaxial cable (75 ohms) with type UG-88/ BNC plugs

1 type 12G19 - 1.5 power cord

SECTION 2
GENERAL DESCRIPTION

The Modulation Meter is a high-quality instrument designed for stable and dependable operation. It consists of the same basic elements as a radio receiver — mixer, IF amplifier, AM and FM detectors, and AF amplifier — plus a meter for accurate indication of the modulation data. (See the simplified block diagram, figure 1, at the back of the manual.) Input signals to one of the two 75-ohm coaxial sockets are either fed directly to a diode mixer — low input levels — or through an attenuator — high input levels. The mixer has been designed for high linearity to avoid distortion of amplitude-modulated signals. It is coupled to the local oscillator, which covers the frequency range from 3.5 to 320 Mc in seven bands. If the mixer mixer is operated on oscillator harmonics, measurements can be made to over 1000 Mc.

The four-stage intermediate-frequency (IF) amplifier has a center frequency of 1 Mc and is essentially flat over a 400-kc band, flatness being essential to make accurate measurements of AM on frequency-modulated signals. The IF signal is fed either to the AM unit or to the FM unit, but it is also available from terminals on the front panel. The AM detector has two uses: first, its d-c output is used to standardize the IF signal level, second, it demodulates the IF signal and applies it to a divider network which is controlled by the meter switch (3 - 10 - 30 - 100 - 300).

The FM unit has three limiter stages — for the suppression of AM in a frequency-modulated signal — followed by a level stabilizer stage and a discriminator. Influence from power-line fluctuations and temperature is eliminated by the level stabilizer stage, which together with the low-distortion counter-type discriminator contribute to the performance of this unit.

Either the AM or the FM signal is taken to a three-stage audio-amplifier with strong negative feedback, which is followed by a peak-detector and a meter. Depending on the position of the polarity switch, the positive or the negative peak of modulation is measured.

The AF signal, which is available from terminals on the front panel, can be used for measurement of distortion or it can be applied to external monitors with desired characteristics, such as an oscilloscope or a

vacuum-tube voltmeter. Loading of the AF output does not interfere with the internal measurement.

In the design, simple operation has been emphasized. For example, the scale to be read on the frequency dial is marked by a light-spot which is controlled by the RANGE switch. Further, the meter has a separate scale where the IF is read, a convenience in correct tuning.

It is possible to measure shifts in carrier frequency and level due to modulation.

Printed wiring circuits are used extensively in the Modulation Meter, giving a dependable, readily accessible, rugged, and uncluttered construction.

METHOD OF MEASUREMENT

AM: The positive and negative peaks of modulation are measured from the average signal level. When the modulated signal is distorted, the two readings (+ and —) are different, which discloses the distortion. No accepted standard exists for the measurement of AM when the signal is distorted, but measurement of both peaks provides accurate and satisfactory information. If average- or rms-readings are desired, an external meter can be used.

FM: The positive and negative peaks of frequency deviation are measured from the mean frequency. This measurement is in accordance with I.R.E. standards.

SECTION 3
OPERATING INSTRUCTIONS

3.1 CONNECTING THE INSTRUMENT

Before connecting the instrument to the power line, make sure that the line voltage selector, S6, is set to the voltage of the power line. The voltage selector is always set to 220 volts when the instrument leaves the factory.

To change to another voltage, loosen the center screw on the voltage selector and set the selector to the desired voltage. The selector is accessible at the back of the cabinet. If the voltage is changed, it may also be necessary to change the fuse, located in the selector.

At 200, 220, and 240 volts a 0.5 amp, and at 110, 115, and 127 volts a 1 amp slow-blow fuse should be used.

The power input terminals are located at the back of the cabinet. Allow two minutes for warm-up, and the instrument is ready for use.

3.2 CONTROLS, DIALS, METER, AND TERMINALS

All controls are located on the front panel.

(1) Power switch (OFF) and pilot lamp
Located at the lower right on the front panel.
Pilot lamp: 6.3 V, 0.3 amp.

(2) RANGE knob

Selects the desired frequency range. On the frequency dial, the scale to be read is marked with a light spot.

(3) TUNING knob and frequency dial

The frequency dial is set to the signal frequency $\pm$ 1 Mc.

(4) FUNCTION SELECTOR switch
In position:

LEVEL - the signal is picked out and standardized to the appropriate level.

IF CHECK - the exact frequency of the converted signal is measured.

AM - amplitude modulation percentage is measured.

FM - deviation of frequency modulation is measured.

(5) RF LEVEL knob

With the FUNCTION SELECTOR in position LEVEL, the attenuator marked RF LEVEL is used for standardizing the intermediate-frequency signal for full deflection on the meter.

(6) METER switch

Selects the measuring range:

AM: 3 - 10 - 30 - 100%
FM: 3 - 10 - 30 - 100 - 300 kc.

(7) MODULATION PEAK switch

Selects the positive or the negative peak of the detected audio-frequency signal.

(8) IF SENSITIVITY switch

Inserts 20 dB attenuation in the IF amplifier.

(9) RF INPUT connectors

Two type BNC connectors are located at the lower left on the front panel.

The left one, LOW, is used for input voltages up to

100 mV for AM
1 volt for FM

On the right-hand connector, HIGH, the input voltage must not exceed

1 volts for AM
10 volts for FM

Input impedance: 75 ohms

(10) IF OUTPUT terminals

The IF signal for external monitoring can be drawn from two banana jacks. Loading of the IF OUTPUT does not affect the internal measurement.

Carrier output level: approx. 0.5 V rms for a standardized intermediate -frequency signal.

Carrier frequency: 1 Mc

Output impedance: approx. 250 ohms

(11) AF OUTPUT terminals

The detected audio-frequency signal for external monitoring can be drawn from two banana jacks. Loading of the AF OUTPUT does not affect the internal measurement.

Output level: 1.0 volt rms, full-scale deflection

Output impedance: approx. 1.5 kΩ

(12) Power input terminals

Located at the back of the cabinet. Should be connected to the power line with the type 12G19-1.5 power cord that is supplied with the instrument.

3.3 MEASURING AMPLITUDE MODULATION PRECENTAGE (AM%)

3.31 Modulation precentage of AM signals

(1) Connect the instrument under test to one of the RF INPUT terminals according to item 3.2 (9) or the text on the front panel.

(2) Set the RANGE knob to the desired frequency range.

(3) Set the FUNCTION SELECTOR to position LEVEL.

(4) Set the TUNING knob so that the frequency dial indicates the signal frequency ±1 Mc and then tune to maximum deflection.

(5) Set the RF LEVEL knob to full-scale deflection (SET LEVEL mark).

(6) Turn the FUNCTION SELECTOR to position IF CHECI

(7) Make a fine adjustment with the TUNING knob so that the meter reads 1.0 Mc on the IF CHECK scale.

(8) Set the RF LEVEL knob to full-scale deflection (SET LEVEL mark).

(9) Set the FUNCTION SELECTOR to position AM.

(10) Set the METER switch to the proper range.

(11) Read the modulation percentage. Make sure that the reading is the same for MODULATION PEAK + and -: A difference indicates distortion on the modulation envelope.

3.32 Residual AM on FM signals

Proceed as described in item 3.31. To obtain minimum residual reading caused by the instrument itself, set IF SENSITIVITY to LOW, if the signal level permits. If dissolution somewhat better than that corresponding to the 3% AM range is wanted, a vacuum-tube voltmeter may be connected to the AF OUTPUT terminals. The external meter will read 1 volt for full deflection of the internal meter, i.e. with the METER switch set to 3, the modulation percentage read on the vacuum-tube voltmeter is 0.003% per mV.

The minimum residual AM reading caused by the instrument itself can be estimated as follows:

(1) Apply a CW signal and set the FUNCTION SELECTOI to LEVEL.

(2) Rotate the TUNING knob back and forth so that the IF is changed over the range 1.0 Mc − Δ f to 1.0 Mc + Δ f, where Δ f is the deviation of the frequency-modulated signal, whose residual AM is to be measured. (Check the frequency change with the IF CHECK scale.)

(3) Read the peak-to-peak value of the change of the LEVEL reading.

The minimum residual AM is approx. half of this percentage change.

3.4 MEASURING FREQUENCY DEVIATION (FM kc)

3.41 Frequency deviation of FM signals

(1) Connect the instrument under test to one of the RF INPUT terminals according to item 3.2 (9) or the text on the front panel.

(2) Set the RANGE knob to the desired frequency range.

(3) Set the FUNCTION SELECTOR to position LEVEL.

(4) Set the TUNING knob so that the frequency dial indicates the signal frequency ±1 Mc, and then tune to maximum meter deflection.

(5) Rotate the RF LEVEL knob to full scale deflection (not critical).

(6) Set the FUNCTION SELECTOR to position IF CHECK.

(7) Make a fine adjustment with the TUNING knob so that the meter reads 1.0 Mc on the IF CHECK scale.

(8) Set the FUNCTION SELECTOR to position FM.

(9) Set the METER switch to the proper range.

(10) Read the deviation of the frequency modulation. A difference in reading of MODULATION PEAK + and − indicates distortion.

3.42 Residual FM on CW signals and slightly modulated AM signals

Proceed as described in item 3.41. To obtain minimum residual reading caused by the instrument itself, set IF SENSITIVITY to LOW, if the signal level permits. Because of the very effective limiter in the FM detector, the residual FM caused by amplitude modulation is quite low. At the modulation percentage of 50%, the residual FM at low carrier frequencies is about 35 cps at modulation frequency 1 kc, and 100 cps at 10 kc.

If dissolution somewhat better than that corresponding to the 3-kc range is wanted, a vacuum-tube voltmeter can be connected to the AF OUTPUT terminals. The external meter will read 1 volt for full deflection of the internal meter, i.e. with the METER switch set to 3, the deviation read on the vacuum-tube voltmeter will be 3 cps per mV.

3.5 USING AN EXTERNAL OSCILLATOR

The residual FM of the local oscillator is approximately 60 cps at high oscillator frequencies, but decreases to 10 cps at low frequencies. Therefore, when measuring residual FM on a signal with a residual FM of less than approximately 100 cps, a considerable error will result.

In such a case, it is recommended that an external, crystal-controlled generator be used for injection voltage. This generator, supplying approximately 1 volt, is connected to the RF INPUT-LOW terminal, and the RANGE switch is set to EXT. OSC.

The signal under measurement is applied to the RF INPUT-HIGH terminal, or — if the level is too low — to the terminal LOW, in parallel with the external generator.

If necessary, the signal should pass through some kind of terminating and/or separating device.

The frequency of the external generator must be the signal frequency ±1 Mc or a subharmonic of this frequency.

3.6 USING AN INTERNAL CRYSTAL-CONTROLLED OSCILLATOR

If only one crystal-controlled oscillator frequency is necessary and if it is to be used quite often, it may be an advantage to modify the board which corresponds to position EXT. OSC in order to incorporate a piezoelectric crystal and an RF transformer. If the Modulation Meter is altered in this way, no additional instrument is required to obtain a crystal-controlled injection signal.

See the Appendix and figure 2 for details of the construction of this unit.

SECTION 4
CIRCUIT DESCRIPTION

4.1 THE RF INPUT CIRCUIT

Between the RF INPUT connectors J1 (LOW) and J2 (HIGH), a 20-dB (approx.) resistive attenuator is inserted to allow a higher input level without overloading the mixer. The input impedance is 75 ohms, mainly determined by R4.

4.2 THE TUNER

The local oscillator consists of a triode, V1, in a Colpitts circuit. The oscillator is tuned with the variable capacitor C8. The tuning coils and trimmers are located in a coil turret actuated by the RANGE knob.

A loop coupling to the tuning coil injects the oscillator signal in series with the input circuit and the diode mixer CR1.

In the ranges 3.5 - 7, 7 - 14, and 14 - 28, 28 - 56 Mc, the oscillator frequency is 3.5 - 7 and 14 - 28 Mc, respectively.

In the three high ranges the pulling between the signal and the oscillator would be too severe, if the 1st harmonic of the oscillator frequency were used. Therefore, in these ranges, the oscillator operates on half the indicated frequencies.

The scale to be read on the frequency dial is indicated by a light spot, obtained from the lamps I1 - I5.

With the RANGE switch in position EXT. OSC., the local oscillator is disconnected, and an external generator, supplying approximately 1 volt, must be connected to the RF INPUT terminal LOW, J1, to supply an injection voltage to the mixer circuit.

The signal to be measured is applied to the RF INPUT terminal HIGH, J2.

This arrangement is particularly useful when low residual FM is measured on oscillators, because it permits the use of an FM-free, crystal-controlled oscillator signal instead of the signal from the local oscillator, which inevitably has some residual FM.

4.3 IF FILTER AND RF LEVEL

From the mixer diode, the intermediate frequency of 1 Mc passes through a low-pass filter, which rejects all other mixing products.

The filter is terminated in a continuously variable attenuator, RF LEVEL, used to standardize the IF signal level.

4.4 IF AMPLIFIER

The IF AMPLIFIER contains three stagger-tuned pentode amplifiers, V2 - V3 - V4, and a cathode follower, V5.

The plate circuit of the 1st tube is tuned to 0.8 Mc, and the 2nd and 3rd amplifiers are tuned to 1.2 and 1.0 Mc. The resulting IF response is flat within 0.2 dB from 0.8 to 1.2 Mc.

Between the 1st and 2nd amplifier stage, a capacitive attenuator, IF SENSITIVITY, can be inserted providing approx. 20 dB attenuation. If the signal level permits, this attenuator should be inserted (IF SENSITIVITY in position LOW) to eliminate the noise from the front end of the instrument.

From the cathode-follower, the IF signal is fed to the terminals J3 and J4, IF OUTPUT, for external monitoring purposes. When the IF level is standardized, the output voltage is approximately 0.5 volt rms from a source impedance of approximately 250 ohms.

4.5 AM DETECTOR

The AM detector, containing a thermionic diode, V15, is continuously coupled to the cathode follower output of the IF amplifier.

With the FUNCTION SELECTOR in position LEVEL, the d-c output current from the detector is passed through the meter, M1, so that the IF level is indicated.

When the FUNCTION SELECTOR is in position AM, the detector current passes through the precision divider R89 - R90. Depending on the METER switch setting, a certain fraction of the audio-frequency voltage developed over the divider is fed to the AF amplifier through the METER switch S3.

With the FUNCTION SELECTOR in position IF CHECK or FM, a

positive d-c voltage is introduced on the cathode of the detector diode. When the IF signal exceeds this voltage, the detector current develops a negative d-c voltage, which is used as supplementary grid bias for the 1st IF amplifier tube, V2, thus providing an automatic gain control.

4.6 FM DETECTOR

4.61 Limiter

With the FUNCTION SELECTOR inposition IF CHECK or FM, the IF signal is fed from the cathode follower, V5, to the FM detector, whose first part is a limiter containing a double triode, V6, and two pentodes, V7 and V8.

The AM suppression is adjusted with the potentiometer R46, LIMITER BIAS.

4.62 Level stabilizer

The level stabilizer consists of a duodiode, V10, and a voltage reference tube, V9. The stabilizer converts the limited IF signal to square waves ("boxes") with a constant amplitude of approximately 85 volts.

4.63 Discriminator

The discriminator is a counter type, consisting of a capacitor, C54 - C55, a duodiode, V11, and loading networks, which are selected with the METER switch.

Through the left diode, the square-wave pulses charge the capacitor, C54 - C55, to the said stabilized voltage. When the square-wave voltage drops to zero, almost the whole charge of the little capacitor C54 - C55 is transferred to the much greater capacitors in the loading circuits, through the righthand diode of V11 and the silicon semiconductors CR7 - CR8.

In this way the charge and, hence, the voltage of the capacitor in the loading circuit are proportional to the number of square waves per second, i.e. to the frequency.

When the FUNCTION SELECTOR is in position FM, the discriminator is loaded by an RC network, chosen with the METER switch. When an FM signal is applied, an AF signal is developed over the RC network with an amplitude proportional to the deviation. This AF signal is fed to the AF amplifier.

The indication of the deviation is adjusted with the trimmer capacitor C55, FM ADJUST.

With the FUNCTION SELECTOR in position IF CHECK, the discriminator current passes through the meter, M1, thus measuring the intermediate frequency directly, from 0.7 to 1.3 Mc. This circuit is adjusted with the potentiometer R66, IF CHECK ADJUST.

4.7 AF AMPLIFIER

The AF amplifier contains two cascaded pentode stages, V16 and V17, and two cathode followers, the double triode V18. A strong negative, overall feedback stabilizes the amplification and reduces the distortion.

To prevent the meter needle from jerking when the METER switch is turned, the switch wafer S4 (1) grounds the capacitor C71 in the inter-positions of the METER switch while the capacitor is being charged to the changed d-c voltage over the detector load.

In the input circuit, an active RC filter attenuates the IF signal to avoid overloading of the AF amplifier. The second pentode amplifier feeds two cathode followers, the left one supplying the feedback circuit and the AF OUTPUT terminals. The amplification of the AF amplifier is calibrated to the proper value with the potentiometer R102 in the feedback circuit. The AF OUTPUT voltage is adjusted with the potentiometer R115 to 1.0 volt emf for full-scale defdection (M1).

The righthand cathode follower supplies the AF DETECTOR.

4.8 AF DETECTOR

The silicon semiconductor diode CR5 operates as a peak-voltage rectifier. The rectifier current is measured with the meter M1,

when the FUNCTION SELECTOR is in position AM or FM.

With the MODULATION PEAK switch, the polarity of the diode and the meter is reversed, making it possible to detect a difference between the amplitude of the positive and negative modulation peak, such a difference indicating even-order harmonic distortion.

Because the output impedance of the cathode follower changes a little when the MODULATION PEAK switch is operated, a correcting network, consisting of the silicon diode CR4, the resistor R122, and the potentiometer R123, is introduced to ensure that the meter reads the same value for the positive and negative modulation peak, when a distortion-free signal is applied.

The silicon diode CR6 protects the meter against overloading.

4.9 POWER SUPPLY

The instrument can be supplied from the following nominal line voltages: 110 - 115 - 127 - 200 - 220 - 240 volts. S5 is the line switch. The slow-blow fuse F1 protects the line transformer in case of short-circuit.

All filament voltages are unregulated.

The d-c plate and screen supply consists of two bridge-coupled selenium rectifiers, CR2 and CR3, connected in parallel; LC filters, L17 - L19 and C62 - C63; and, when necessary, some means of electronic regulation.

The local oscillator and the screens of two IF amplifier stages are supplied from a voltage-stabilizing tube, V12. To prevent power-line fluctuations from affecting the meter reading, the AF amplifier and the screen grid of the last limiterstage in the FM detector are fed from a regulated power supply, consisting of the voltage referance tube V14 and the double triode V13. The output voltage is set to 200 volts with the potentiometer R82.

The less critical voltages are unregulated.

The electronic regulation of all critical voltages permits the instrument to be operated on line voltages differing $\pm$10% from the nominal value.

SECTION 5

MAINTENANCE

5.1 GENERAL

The Modulation Meter is designed to withstand some rough treatment, but careful handling and proper operation result in a long life and high reliability.

Such repairs as are necessary should only be made by skilled personnel provided with the proper equipment to ensure that the repair is correctly made.

5.2 REMOVING THE INSTRUMENT FROM THE CABINET

Remove the power cord and place the Modulation Meter with its front panel upwards. Remove the 4 fixing screws at the corners of the front panel and the 3 screws in the bottom of the cabinet. The instrument can now be lifted out of the cabinet.

5.3 TUBE REPLACEMENT

In general the tubes of the instrument should not be replaced unless they cause some kind of trouble.

5.31 V1 - V2 - V3 - V4 - V5 - V10 - V11 - V12

These tubes can be replaced without any adjustments and without compromising the properties of the instrument.

5.32 V6 - V7 - V8

Replacement of the tubes of the limiter in the FM detector may necessitate an adjustment of the AM suppression. (See item 5.47.)

5.33 V9

Generally the voltage reference tube of the discriminator will never need replacement, but if, for some extraordinary reason, it must be replaced, the FM ADJUST must be adjusted for correct indication of deviation. (See item 5.48.)

5.34 V13 -V14

When replacing the tubes in the regulated power supply, the d-c output voltage should be checked. (See item 5-42).

5.35 V15

If utmost accuracy is desired, replacement of the AM detector diode will involve an adjustment of the AM percentage indication. (See item 5.46).

5.36 V16 - V17

Replacement of the amplifier tubes of the AF amplifier may make it necessary to adjust the sensitivity of the amplifier (see item 5.44) and possibly the voltage across the AF OUTPUT terminals (see item 5.45).

5.37 V18

Replacing the cathode-follower tube may cause a difference between the indication of the positive and negative modulation peaks of an undistorted signal. Correction is made with the potentiometer R123. (See item 5.43.)

A change in the AF amplification caused by replacement of this tube is adjusted with the potentiometer R102. (See item 5.44.)

If replacement gives rise to a change in the AF OUTPUT voltage, proceed as described in item 5.45.

5.4 ADJUSTMENTS

5.41 General

Adjustments should only be made when absolutely necessary, and only by skilled personnel provided with high-precision measuring equipment.

5.42 Output voltage of regulated power supply

The output voltage is measured between ground and pin 3 (cathode) of tube V13 and should be set to 200 volts with the potentiometer R82.

5.43 MODULATION PEAK

(1) Set the FUNCTION SELECTOR to position AM and the METER switch to range 300.

(2) Supply a 1-kc voltage, approximately 7 mV rms, from a low-distortion audio-frequency generator to the AF CHECK terminals on the print board of the AF unit.

(3) Adjust the potentiometer R123, so that the same meter deflection is obtained no matter whether the MODULATION PEAK switch is in position + or −.

5.44 AMPL. ADJUST (AF amplification)

(1) Make sure that the adjustment described in item 5.43 has been made.

(2) Set the FUNCTION SELECTOR to position AM and METER switch to range 300.

(3) Supply a 1-kc voltage, 7.40 mV rms, from a low-distortion audio-frequency generator, to the AF CHECK terminals on the printboard of the AF unit.

(4) Adjust potentiometer R102, so that the meter gives full deflection.

5.45 AF OUTPUT

(1) Make sure that the adjustments described in item 5.43 and 5.44 have been made.

(2) Set the FUNCTION SELECTOR to position AM and the METER switch to range 300.

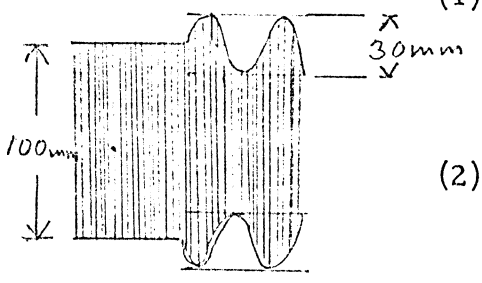
(3) Supply a 1-kc voltage, 7.40 mV rms, from a low-distortion audio-frequency generator, to the AF CHECK terminals on the print board of the AF unit, so that full-scale deflection is obtained.

(4) Connect a vacuum-tube voltmeter to the AF OUTPUT terminals.

(5) Adjust the potentiometer R115, so that the vacuum-tube voltmeter reads 1.0 volt rms.

5.46 AM ADJUST

(HP 8601)



30% AM.

(1) Use a signal generator which supplies a carrier frequency of 1 Mc modulated with a 1-kc audio-frequency to an accurately known modulation percentage, preferably 30%, with a very low distortion (less than 0.5%). Connect this generator to one of the RF INPUT terminals.

(2) Set the FUNCTION SELECTOR to position LEVEL and adjust the signal generator output voltage and/or the controls IF SENSITIVITY and RF LEVEL, so that the meter gives full deflection. If the signal level permits, the IF SENSITIVITY switch should be in position LOW.

(50% AM − 50mm).

(3) Set the FUNCTION SELECTOR to position AM and the METER switch to the proper range, preferably 30%.

(4) Set the potentiometer R88, so that the meter reads the known modulation percentage.

5.47 LIMITER BIAS

(1) Use a signal generator which supplies a carrier frequency of 1 Mc modulated with a 1-kc audio-frequency to a modulation percentage of approx. 50% and with a very low residual frequency modulation. Connect this generator to one of the RF INPUT terminals.

(2) Set the IF SENSITIVITY switch to position LOW and the FUNCTION SELECTOR to position LEVEL and adjust the signal generator output voltage and/or the control RF LEVEL so that the meter gives full deflection.

(3) Set the FUNCTION SELECTOR to position FM and the METER switch to range 3, and then connect a vacuum-tube voltmeter to the AF OUTPUT terminals.

(4) Now adjust the potentiometer R46, so that the vacuum-tube voltmeter gives minimum deflection.

5.48 FM ADJUST

(HP 8601)

(1) Use an FM signal generator that is tuned to a, preferably, not too high carrier frequency and modulated to an accurately known deviation, preferably 30 kc. Connect the generator to the proper RF INPUT terminal.

(2) Set the IF SENSITIVITY switch to position LOW, the FUNCTION SELECTOR to position LEVEL, and the RANGE switch to the proper range. Now pick out the signal by turning the TUNING knob until the meter gives maximum deflection.

(3) Make sure that the resulting intermediate frequency is close to 1.0 Mc. Either use a frequency meter (such as a counter) or proceed as follows:

(a) Disconnect the FM signal generator and connect a 1.0 Mc CW source.

(b) With the FUNCTION SELECTOR in position LEVEL, set RF LEVEL so that the meter gives full deflection.

(c) Set the FUNCTION SELECTOR in position IF CHECK and read the meter.

(d) Now, reconnect the FM signal generator, set the FUNCTION SELECTOR to position LEVEL, and turn the RF LEVEL knob until the meter gives full deflection.

(e) Then turn the selector to IF CHECK.

(f) Make a fine adjustment with the TUNING knob, so that the meter reads the same value as in item (c).

(4) Set the METER switch to the proper range (preferably 30), and the FUNCTION SELECTOR to position FM and adjust the trimmer C55 (avoid hand capacity), so that the meter reads the known deviation.

To check the deviation of the FM signal generator which is used for the calibration described above, the Crosby method ("vanishing carrier method") is useful. This method is based on the fact that the carrier frequency disappears at discrete values of the modulation index.

The modulation index B is defined as the ratio of the frequency deviation Δ F to the modulating frequency f, thus,

$$B = \frac{\Delta F}{f}$$

and consequently the frequency deviation

$$\Delta F = B \cdot f$$

The carrier will be zero at the following modulation indices:

Dev. freq	Mod. freq	Zero
3 kHz	1.248 kHz	1.
10 kHz	1.812 kHz	2.
30 kHz	2.544 kHz	4.
100 kHz	4.714 kHz	7.

2.404	1 st zero
5.520	2nd "
8.653	3rd "
11.791	4th "
14.930	5th "
18.071	6th "
21.212	7th "
etc.	

(HP 8553 Spectrum analyzer)

A selective communication receiver tuned to the output frequency of the signal generator can be used to determine the point at which the carrier disappears.

For instance, if the modulating frequency is 30 kc/11.791 ≒ 2.544 kc, and a frequency deviation of 30 kc is desired, the modulating voltage should be increased until the 4th zero occurs.

5.49 IF CHECK ADJUST

(1) Make sure that the adjustment described in item 5.48 has been made.

(2) Connect a 1.0 Mc CW source to the RF INPUT.

(3) With the FUNCTION SELECTOR in position LEVEL, set RF LEVEL, so that the meters gives full deflection.

(4) Set the FUNCTION SELECTOR to position IF CHECK and adjust the potentiometer R66, so that the meter reads 1.0 Mc on the IF CHECK scale.

5.5 OPERATING VOLTAGES

Voltages referred to chassis.

Point A	280 V
" B	300 V
" C	150 V

Tube	Pin	Voltage
V1	1	−3 V
	8	110 V
V2	2+6	1.1 V
	5	100 V
	7	130 V
V3	2+6	1.1 V
	5	120 V
	7	130 V
V4	2+6	1.8 V
	5	220 V
	7	220 V
V5	1+6	280 V
	3+8	75 V
V6	1	280 V
	2	55 V
	3+8	57 V
	6	260 V
	7	55 V
V7	2	2.7 V
	5	240 V
	7	230 V
V8	1+3+9+6	2.5 V
	7	200 V
	8	190 V
V9	1	83 V
V12	1	150 V
V13	1	300 V
	2+6	198 V
	3	200 V
	7	80 V
	8	84 V
V14	1	84 V
V16	1	60 V
	2+3+7	1.5 V
	6	85 V

Tube	Pin	Voltage
V17	1	70 V
	2+3+7	1.7 V
	6	60 V
V18	1+6	200 V
	3	55 V
	8	60 V

The instrument consumes 360 mA at 220 V.

APPENDIX

MODIFICATION FOR INTERNAL CRYSTAL-CONTROLLED OSCILLATOR

(1) First, remove the empty board in the coil turret that corresponds to position EXT. OSC. of the RANGE knob and remove the connection between the two contact pins.

(2) Mount a piezoelectric crystal X and an RF transformer T on the board as shown in the diagram, figure 2.

(3) Reinsert the board in the coil turret.

When using this unit, set the RANGE knob to EXT. OSC. and turn the TUNING knob to the extreme right.

Crystal X:

The resonance frequency should be between 3 - 20 Mc.
The resonance frequency must be equal to the frequency of the signal to be examined ±1 Mc or to a subharmonic of this frequency.

RF transformer T:

To obtain a tight coupling between the two windings, a ferrite core should be used. The number of turns should be found by the "cut-and-try" method. The ratio between the primary and secondary winding should be approx. 2:1, the best value being determined by experiment.

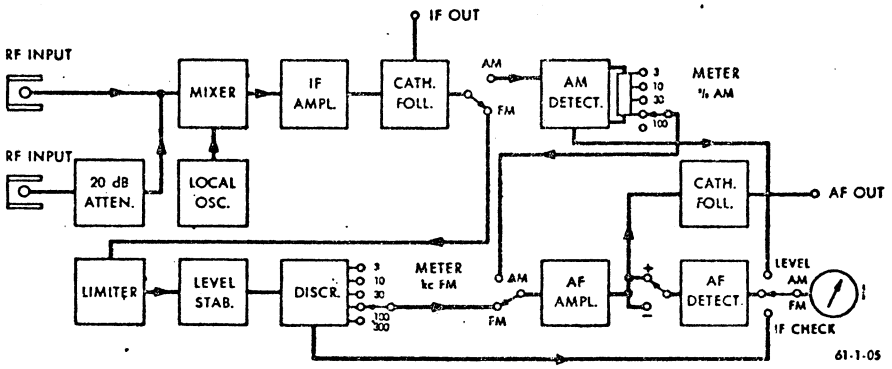


Fig. 1. Simplified block diagram.

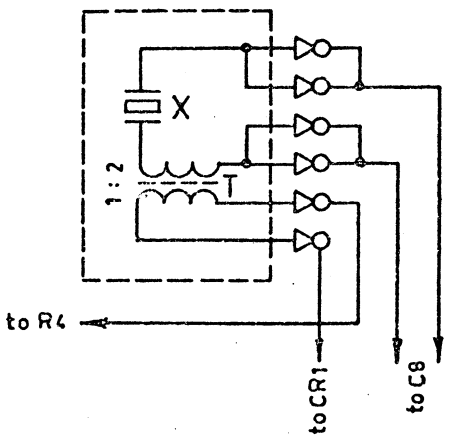
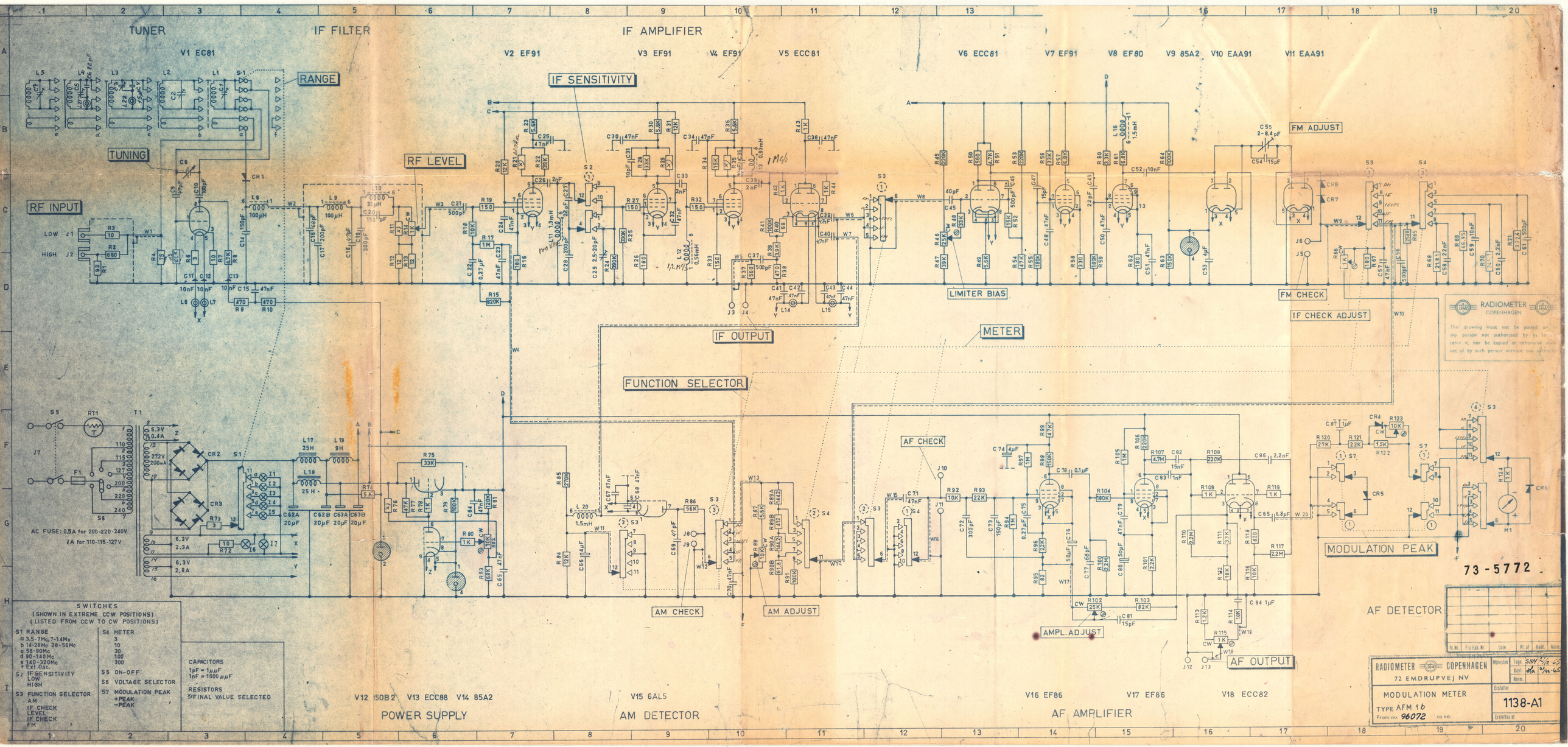


Fig.2 Crystal circuit.


TUNER
IF FILTER
IF AMPLIFIER
V1 EC81
V2 EF91
V3 EF91
V4 EF91
V5 ECC81
V6 ECC81
V7 EF91
V8 EF80
V9 85A2
V10 EAA91
V11 EAA91
RANGE
IF SENSITIVITY
TUNING
RF LEVEL
RF INPUT
FM ADJUST
LIMITER BIAS
FM CHECK
IF CHECK ADJUST
IF OUTPUT
METER
FUNCTION SELECTOR
AF CHECK
AM CHECK
AM ADJUST
AMPL. ADJUST
MODULATION PEAK
AF OUTPUT
AC FUSE: 0.5A for 200-220-240V
1A for 110-115-127V
V12 150B2
V13 ECC88
V14 85A2
POWER SUPPLY
V15 6AL5
AM DETECTOR
V16 EF86
V17 EF86
V18 ECC82
AF AMPLIFIER
AF DETECTOR
SWITCHES
(SHOWN IN EXTREME CCW POSITIONS)
(LISTED FROM CCW TO CW POSITIONS)
S1 RANGE
a 3.5-7Mc 7-14Mc
b 14-28Mc 28-56Mc
c 56-90Mc
d 90-140Mc
e 140-320Mc
f Ext. Osc.
S2 IF-SENSITIVITY
LOW
HIGH
S3 FUNCTION SELECTOR
AM
IF CHECK
LEVEL
IF CHECK
FM
S4 METER
3
10
30
100
300
S5 ON-OFF
S6 VOLTAGE SELECTOR
S7 MODULATION PEAK
+PEAK
-PEAK
CAPACITORS
1pF = 1µµF
1nF = 1000 µµF
RESISTORS
5% FINAL VALUE SELECTED
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This drawing must not be passed on to any person not authorized by us to receive it, nor be copied or otherwise made use of by such person without our permission.
73-5772
RADIOMETER COPENHAGEN
72 EMDRUPVEJ NV
MODULATION METER
TYPE AFM 1b
From no. 96072 to no.
Erstatter
1138-A1
Erstattes af