INSTRUCTION MANUAL

B1558

Modulation Meter
Type AFM2b

From serial No. 166201

RADIOMETER

ELECTRONIC MEASURING INSTRUMENTS
FOR SCIENTIFIC AND INDUSTRIAL USE

This instruction manual is valid for the Modulation Meter, type AFM2, but applies also for the type AFM2S6 when the following specification changes and additions are borne in mind:

1) On page B5 read for AFM2S6

AM distortion:

Carrier frequencies within the range 5 - 300 MHz:	0.3% distortion at 30% AM and at modulation frequencies within 20 Hz - 15 kHz. 1.5% distortion at 90% AM and at modulation frequencies within 10 Hz - 50 kHz.
Carrier frequencies within the range 300 - 1002 MHz:	1.5% distortion at 30% AM and at modulation frequencies within 10 Hz - 50 kHz.

2) Signal-to-noise ratio for each stereo channel measured with a psophometer: Typically 66 dB at ±40 kHz frequency deviation and RF < 200 MHz. These data apply only when the level of the RF signal is in the 30 - 100 mV range.

Furthermore, it applies to the Modulation Meter, type AFM2S4S5, when the following corrections are made on pages B6, B7, D6, E2, and E4:

1) AF Output	Nominally 0 dBm (0.775 V rms into 600Ω) when meter reads 3/4 of full-scale deflection, e.g., at ±75 kHz deviation in the ±100 kHz deviation range.
2) AF Output Terminals	3-pole standard, type ZNA 333874/1

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Modulation Meter
Type AFM2

Section A. Introduction

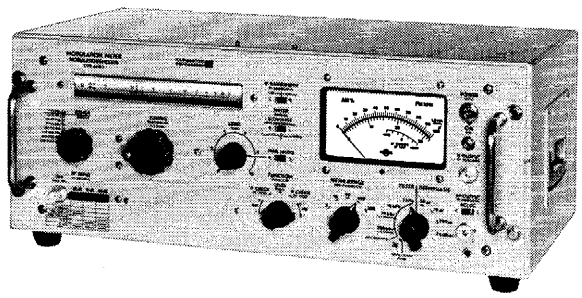


Fig.A1. The Modulation Meter, type AFM2.

The Modulation Meter, type AFM2, is a solid-state, line- or battery-operated precision measuring instrument for accurate measurement of the modulation depth of AM signals and the peak deviation of FM signals in the carrier frequency range from 5 to 1002 MHz. The Modulation Meter is designed for accepting telemetric signals with a modulation frequency up to 200 kHz, and stereo signals for which it features an L/R-separation of 46 dB.

The indicating meter has full-scale deflection for 3, 10, 30, and 100% AM, and ±3, ±10, ±30, ±100, and ±300 kHz FM, peak value. Due to the very small amount of residual modulation generated in the Modulation Meter proper, it is possible to measure residual FM and AM in oscillators, spurious AM on FM signals, and vice versa. Accurate measurements on distorted signals are rendered easy by a switch that enables the positive and the negative peak value to be measured separately. If increased resolution is desired, an external indicator, such as a voltmeter, can be employed to extend the measuring ranges downwards.

The input signal level necessary for full accuracy is 3 mV in the carrier frequency range 5 to 200 MHz, 20 mV in the range 200 to 600 MHz, and 30 mV in the range 600 to 1002 MHz. The maximum operating input voltage is 10 V. Besides a manual level control, the Modulation Meter features an automatic level control with a regulating range of 40 dB.

To increase the versatility of the Modulation Meter for measurements on narrow-band equipment, it is provided with two IF bandwidths of ±20 and ±400 kHz, just as three standard deemphasis networks of 50, 75, and 750 µs, one non-standard of 6 dB/octave (ref.1 kHz), four low-pass filters with frequencies of 3, 15, 75, and 200 kHz, and one band-pass filter with 3 dB points at 50 Hz and 15 kHz, ensure optimal measuring conditions for a wide range of applications.

A plug-in Crystal Oscillator Unit, code 900-252, and a plug-in External-Oscillator Amplifier, code 900-253, are available. See SECTION C.

Section B. Specifications

FREQUENCY RANGE OF INPUT SIGNAL	5 - 1002 MHz
FREQUENCY RANGE OF VARIABLE OSCILLATOR	7 - 1000 MHz
Fundamental ranges:	7-12, 12-21, 21-37, 37-65, 65-110, and 110-200 MHz
Harmonic ranges:	200-330, 330-600, and 600-1000 MHz
CALIBRATION ACCURACY	3%
CRYSTAL OPERATION	An optional Crystal Oscillator Unit, code 900-252, that accepts up to four switch-selected crystals, ensures low residual FM. Specification changes due to crystal operation: See SECTION C - ACCESSORIES.
INPUT LEVEL	One input socket in connection with a 3-step input attenuator (10 + 10 + 20 dB) adapts the AFM2 to input levels from 3 mV to 10 V.

Carrier frequency ranges:	5-200 MHz	200-600 MHz	600-1000 MHz
Attenuation 0 dB[+]:	3-100 mV	20-100 mV	30-100 mV
Attenuation 10 dB:	(10)[++]-100-300 mV	(60)-100-300 mV	100-300 mV
Attenuation 20 dB:	(30)-300-1000 mV	(200)-300-1000 mV	300-1000 mV
Attenuation 30 dB:	(0.1)-1-3 V	(0.6)-1-3 V	1-3 V
Attenuation 40 dB:	(0.3)-3-10 V	(2)-3-10 V	3-10 V

[+] Basic sensitivity range, BSR

[++] Values in parentheses are derived from minimum level of BSR and from lower limit of overlapping ranges.

Max. safe input level: 10 V

Input level for residual FM and AM measurements:

Min. input level	RF attenuation inserted (dB)
10 mV	0
30 mV	10
100 mV	20
300 mV	30
1 V	40

INPUT IMPEDANCE

50 Ω nominal

LEVEL SETTING

Manual level setting:

Continuous within a range of min. 40 dB.

Automatic level setting:

The AGC system keeps the level setting within 0.5% for input level variations within the specified input level ranges, inclusive of the overlapping ranges.

Fine adjustment of the automatic level setting is possible.

FREQUENCY MODULATION

Deviation ranges:

±3, ±10, ±30, ±100, and ±300 kHz f.s.d. (peak deviation).

Positive and negative deviation peaks can be measured separately.

Accuracy:

±75 kHz deviation:

2% of reading + 1% of full scale at modulation frequencies within 20 Hz - 53 kHz

4% of reading + 1% of full scale at modulation frequencies within 10 Hz - 75 kHz.

±300 kHz deviation:

2% of reading + 1% of full scale at modulation frequencies within 20 Hz - 15 kHz.

7% of reading + 1% of full scale at modulation frequencies within 10 Hz - 125 kHz.

15% of reading +1% of full scale at modulation frequencies within 125 kHz - 200 kHz.

Notes:

1. To obtain specified accuracy, the upper frequency limit of the built-in low-pass filter should be switched as follows:

Deviation range	upper frequency limit
±3 kHz	3 kHz
±10 kHz	15 kHz
±30 kHz	15 kHz
±100 kHz	75 kHz
±300 kHz	200 kHz

(see Bandwidths)

2. The specified accuracies are valid only with the METER switch set to SLOW. In position FAST, the lower frequency limit is 160 Hz.

Distortion

±75 kHz deviation:

0.1% distortion at modulation frequencies within 10 Hz - 15 kHz.

0.2% distortion at modulation frequencies within 20 Hz - 53 kHz.

0.3% distortion at modulation frequencies within 10 Hz - 75 kHz.

±300 kHz deviation:

0.5% distortion at modulation frequencies within 20 Hz - 15 kHz.

1.5% distortion at modulation frequencies within 10 Hz - 50 kHz.

3% distortion at modulation frequencies within 10 Hz - 125 kHz.

5% distortion at modulation frequencies within 125 kHz - 200 kHz.

LR-separation of FM stereo signals: For an ideal FM stereo signal (FCC and EBU-standard), the LR-separation at modulation frequencies within 40 Hz - 15 kHz is greater than 46 dB.

AF output and meter response (FM):

AF output:

Within 40 Hz - 15 kHz, the LR-separation is greater than 46 dB (see above). This corresponds to a departure from a linear phase response of less than 0.5° and a frequency response within +0.25% and -1.5% (40 Hz - 53 kHz).

Note: The built-in 200 kHz low-pass filter is to be used.

Meter response:

Within 40 Hz - 53 kHz, the frequency response of the meter is within +0.25% and -1.5%.

Notes:

1. The built-in 200 kHz low-pass filter is to be used.

2. The specified response is valid only with the METER switch set to SLOW. In position FAST, the lower frequency limit is 160 Hz.

Residual FM:

On condition of a quiet test room (noise level < 60 dB rel. 2×10^{-4} µbar.):
Less than 25 Hz FM (r.m.s.) within the frequency range 5-250 MHz; typically 15 Hz (r.m.s.).

Less than 100 Hz FM (r.m.s.) up to 1002 MHz, typically 50 Hz FM (r.m.s.).

Notes:

1. 0.1% of full deviation range is to be added.

2. Minimum RF input level: See Input Level.

3. The built-in band-pass filter (50 Hz - 15 kHz) or one of the deemphases (50 µs or 75 µs) is to be used.

FM due to AM: Additional residual FM error due to AM is typically less than 50 Hz (r.m.s.) at 50% AM, when the band-pass filter (50 Hz - 15 kHz) is used.

Deemphases:

Standard deemphases: 50, 75, and 750 µs, switchable.

Deemphasis: 6dB/oct. (ref. 1 kHz). For frequency response of filter, see Fig. B1.
The deemphasis can be switched off.

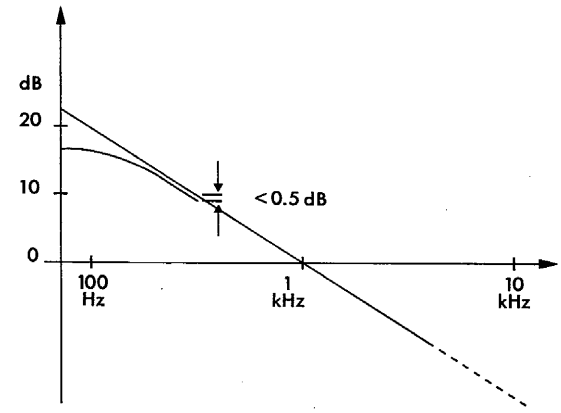


Fig. B1. Frequency response of the 6 dB/oct. filter.

AMPLITUDE MODULATION

Modulation depth range: 3, 10, 30, and 100% AM f.s.d.

Positive and negative modulation peaks can be measured separately.

Accuracy:

Manual level setting: 2% of reading + 1% of full scale at modulation frequencies within 20 Hz - 15 kHz.

5% of reading + 1% of full scale at modulation frequencies within 10 Hz - 50 kHz.

Notes:

1. To obtain specified accuracy, the upper frequency limit of the built-in low-pass filter should be switched as follows:

modulation range	upper frequency range
3%+	3 kHz
10%	15 kHz
30%	75 kHz
100%	200 kHz

+By a 10 dB increase in minimum input level, the upper frequency limit can be extended to 15 kHz.

2. The above accuracies are valid for modulation depths up to 90% AM within the carrier frequency range 15-300 MHz, and up to 30% AM within the carrier frequency range 300-1002 MHz.

Automatic level setting:

The following typical values are to be added to the above accuracies:

At a modulation frequency of 20 Hz: 6% of reading.

At a modulation frequency of 50 Hz: 1% of reading.

At modulation frequencies above 100 Hz, the additional error is negligible.

Note: The specified accuracies (manual and automatic level settings) are valid only with the METER switch set to SLOW. In position FAST, the lower frequency limit is 160 Hz.

AM distortion:

Carrier frequencies within the range 5 - 300 MHz:

0.2% distortion at 30% AM and at modulation frequencies within 20 Hz - 15 kHz.

1% distortion at 90% AM and at modulation frequencies within 10 Hz - 50 kHz.

Carrier frequencies within the range 300 - 1002 MHz:

1% distortion at 30% AM and at modulation frequencies within 10 Hz - 50 kHz

Residual AM at CW:

Less than 0.03% AM (r.m.s.) at carrier frequencies up to 200 MHz.

Less than 0.1% AM (r.m.s.) at carrier frequencies up to 500 MHz.

Less than 0.3% AM (r.m.s.) at carrier frequencies up to 1002 MHz.

Notes:

1. 0.1% of full AM range to be added.

2. Minimum RF input level: See Input Level.

3. The built-in band-pass filter (50 Hz - 15 kHz) is to be used.

AM due to FM: Additional error is less than 0.6% AM (r.m.s.) at ±50 kHz deviation.

AF output (AM)

Manual level settings: The frequency response is within ±0.5% in the range 20 Hz - 15 kHz.

Automatic level setting: The following typical error contributions are to be added to the above frequency response:

At a modulation frequency of 20 Hz: 6%

At a modulation frequency of 50 Hz: 1%

At modulation frequencies above 100 Hz, the error contribution is negligible.

INTERMEDIATE FREQUENCY CHANNEL

Frequency: 2 MHz

Bandwidths: approx. ±400 kHz/3 dB and ±25 kHz/3 dB, switch-selected.

IF check: The meter has a separate scale to facilitate correct tuning (IF = 2 MHz).

IF output: 2 MHz IF signal of 0.2 V EMF from 50 Ω source at correct frequency tuning and full scale deflection on meter.

AUDIO FREQUENCY CHANNEL

Bandwidths: four switchable low-pass filters, 3 kHz, 15 kHz, 75 kHz, and 200 kHz, to be used when measuring FM deviation and AM modulation.

3 kHz filter: for mod. freq. up to 3 kHz

15 kHz filter: for mod. freq. up to 15 kHz.

75 kHz filter: for mod. freq. up to 75 kHz and for measurements of FM stereo deviation.

200 kHz filter: for mod. freq. up to 200 kHz and for measurements of stereo L/R separation.

(bandwidth: 10 Hz (0.1 dB) - 350 kHz (3 dB))

50 Hz - 15 kHz filter: Band-pass filter, 50 Hz (3 dB) - 15 kHz (3 dB), to be used when measuring residual FM and AM.

AF output: AF signal of 1 V EMF (peak value) at full scale deflection.

Bandwidth as specified above. A switch provides for ac- or dc-coupling.

ac-coupling: Output impedance: 600 Ω in series with 10 µF.

dc-coupling: Output impedance: 600 Ω.

dc OUTPUTS

IF level:	dc-voltage of 1 V EMF from 600 Ω source at meter deflection to set level mark.
IF frequency:	dc-voltage of 1 V EMF from 600 Ω source at meter deflection to IF CHECK mark (50 mV/100 kHz).
Modulation:	dc-voltage of 1 V EMF from 600 Ω source at full scale deflection.

POWER SUPPLY

Power line:	
Voltages:	110 V and 220 V, ±10%.
Frequencies:	48 - 65 Hz.
Consumption:	about 25 VA.
	The power cord is fixed and provided with a mains plug of the Schuko type.
External dc supply:	
dc sources:	0 to +(18 to 25 V) and 0 to -(18 to 25 V).
Current drain:	approx. 400 mA from each source.

TERMINALS

RF input and IF output:	BNC
AF output:	UHF
dc output (AF):	Banana jacks
External dc supply:	Belling Lee L1436/S
Operating ambient temperature range:	0 - 50°C

DIMENSIONS AND WEIGHT

Height:	197 mm (7 3/4 in.)
Width:	485 mm (19 1/8 in.)
Depth:	245 mm (9 5/8 in.)
Weight:	13 kg (28.6 lbs)

MOUNTING AND FINISH	Steel cabinet finished in grey enamel lacquer.
ACCESSORIES SUPPLIED	1 coaxial cable (50 Ω), code 617-004, with type UG-88/U BNC plugs.
	1 battery plug, Belling & Lee, L1436/P, code 805-429.
ACCESSORIES AVAILABLE	Crystal Oscillator, code 900-252.
	External-Oscillator Amplifier, code 900-253
	1 set of dust covers (top plate and bottom plate) for rack mounting, code 884-002

Section C. Accessories

PLUG-IN CRYSTAL OSCILLATOR UNIT, CODE 900-252

General

The Plug-in Crystal Oscillator Unit, code 900-252, is preferably used within the frequency range 80 - 1000 MHz to achieve low residual FM. It is supplied without crystals.

The Crystal Oscillator Unit contains a crystal-controlled oscillator followed by a doubler stage, and it has room for up to four switch-selected crystals. The crystals are mounted inside the unit and can easily be exchanged. Initial adjustment is made by means of individual screw-driver adjustments on the front panel.

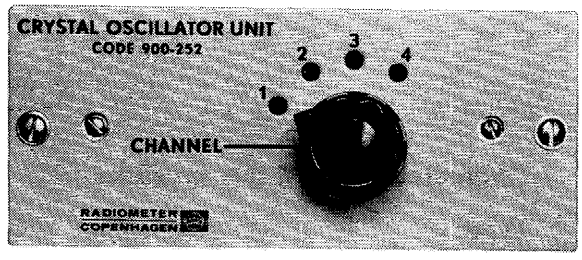


Fig. C1. The Crystal Oscillator Unit, code 900-252.

The trimmers directly cover a tuning range of 360 - 1000 MHz. In the ranges 80 - 120 MHz and 250 - 360 MHz, a fixed capacitor must be added in parallel with the trimmer.

Specifications

Number of crystals: Sockets for up to 4 crystals.

Frequency of crystals: In order to achieve the highest possible sensitivity of the modulation meter, the frequency of the crystals must be as high as possible. Overtone crystals having frequencies within the range 40 - 100 MHz are recommended. The crystal frequency f_{cr} is determined by

$$f_{cr} = \frac{f_s - 2}{2n} \text{ MHz}$$

where f_s indicates the carrier frequency and n the odd harmonic of the crystal overtone-frequency.

Initial conditions: The sensitivity specifications, item INPUT LEVEL, are based on the following combinations of carrier frequency, order of harmonic, and range of crystal frequencies.

Carrier frequency f_s	Order of harmonic n	Range of crystal frequencies f_{cr}
250 - 600 MHz	3	40 - 100 MHz
600 - 1000 MHz	5	60 - 100 MHz

Characteristics of the crystals:

Type: HC-25/U

Frequency: See above.

Frequency tolerance: 10×10^{-6} at reference temperature 25°C

Frequency tolerance over operating temperature range: 10×10^{-6}, within 0-50°C

Condition of resonance: Series

Mode of operation: 5. overtone

Max. drive level: 2 mW

Max. equivalent series resistance: 60 Ω

CHANGE IN SPECIFICATIONS OF AFM2 CAUSED BY THE CRYSTAL OSCILLATOR

Input level:

Frequency ranges:	250 - 600 MHz	600 - 1000 MHz
Attenuation 0 dB[+]:	20 - 100 mV	30 - 100 mV
Attenuation 10 dB:	(60)[++] - 100 - 300 mV	100 - 300 mV
Attenuation 20 dB	(200) - 300 - 1000 mV	300 - 1000 mV
Attenuation 30 dB:	(0.6) - 1 - 3 V	1 - 3 V
Attenuation 40 dB:	(2) - 3 - 10 V	3 - 10 V

[+]Basic sensitivity range, BSR

[++]Values in parentheses are derived from minimum level of BSR and from lower limit of overlapping ranges.

Max. safe input level: 10 V

Input level for FM and AM measurements:

250 - 600 MHz:

Min. input level	RF attenuation inserted (dB)
20 mV	0
60 mV	10
200 mV	20
600 mV	30
2 V	40

600 - 1000 MHz:

Min. input level	RF attenuation inserted (dB)
30 mV	0
90 mV	10
300 mV	20
900 mV	30
3 V	40

Residual FM: Less than 20 Hz FM (r.m.s.) at carrier frequencies up to 1002 MHz; typically 15 Hz (r.m.s.).

Notes:

1. 0.1% of full deviation range is to be added.
2. Minimum RF input level: See Input Level.
3. The built-in band-pass filter (50 Hz - 15 kHz) or one of the deemphases (50 µs or 75 µs) is to be used.

Residual AM at CW: Less than 0.15% (r.m.s.) at carrier frequencies up to 1000 MHz.

Notes:

1. 0.1% of full AM range must be added.
2. Minimum RF input level: See Input Level.
3. The built-in band-pass filter (50 Hz - 15 kHz) is to be used.

EXTERNAL-OSCILLATOR AMPLIFIER, CODE 900-253

General

The Modulation Meter, type AFM2, is so designed that an optional plug-in External-Oscillator Amplifier, code 900-253, can be used if driving by means of an external oscillator, for example a synthesizer, is required. It will adapt the output of the external oscillator to the level required by the mixer of the AFM2.

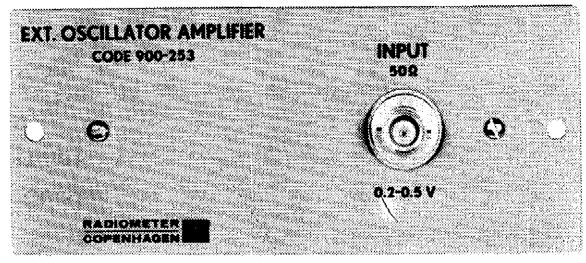


Fig. C2. The External-Oscillator Amplifier, code 900-253.

Specifications

Input Level: 0.3 to 0.5 V depending on the frequency range.

Frequency Range: 90 to 200 MHz. Up to 1 GHz on harmonics.

Input Impedance: 50 Ω (BNC connector).

Section D. General Description

DESCRIPTION

As can be seen on the simplified block-diagram shown in Fig.D1, the RF input signals to the 50 Ω coaxial connector are fed to a diode mixer via an input attenuator providing for 10, 20, 30, and 40 dB attenuation and thus accommodating RF signals from 3 mV to 10 V r.m.s. The mixer, which is balanced and highly linear, so that distortion of amplitude-modulated signals is avoided, is coupled to the local tuning oscillator. For RF input signals in the range from 5 to 200 MHz, mixing is realized with the fundamental frequency of the local oscillator, whilst it takes place with the third and fifth harmonics in the range from 200 to 1002 MHz. This results in an IF signal of 2 MHz. The mixer can also be coupled to an optional Crystal Oscillator Unit, code 900-252, which can accommodate four crystals, thereby enabling measurements at four predetermined, fixed frequencies.

The signal from the mixer is passed through an IF filter, which is a phase-linear band-pass filter with a bandwidth of ±400 kHz, a high degree of phase-linearity being necessary in order to pass a multiplex stereo signal with minimum distortion.

From the IF filter, the IF signal is fed to an IF preamplifier which acts as a buffer. At the same time, the IF preamplifier provides for amplification of the IF signal. This amplification, together with ideal coupling to the IF filter, keeps the noise level down to a minimum at all input levels.

The IF preamplifier is followed by a diode attenuator whose biasing current can be controlled by the potentiometer LEVEL, accessible on the front panel of the Modulation Meter. Level control can be performed within a range of 40 dB. Alternatively, the IF attenuator can be driven by a voltage proportional to the IF level amplified in an AGC amplifier. This provides for automatic level control within 40 dB. Fine adjustment is nevertheless also possible by means of the potentiometer LEVEL.

The IF signal from the IF attenuator is then fed to an IF amplifier which consists of two wideband amplifier stages. The IF amplifier brings the IF signal to the level required by the AM detector.

The amplified IF signal is then passed either through a band-pass filter or through a phase-compensator, according to the position of the IF BANDWIDTH control. The band-pass filter has a bandwidth of ±25 kHz and is phase-linear just as the IF filter. It is intended for use when measuring on weak signals from narrow-band equipment. The phase compensator leaves the initial bandwidth unchanged.

A buffer amplifier separates filters, AM detector and IF output amplifier. It consists of a unity-gain amplifier with low output impedance and serves to suppress any influence from the IF output which is available for external monitoring from a coaxial connector on the front panel.

The IF signal from the buffer amplifier is fed both to the AM detector and to the IF output amplifier. The AM detector is an amplifier with a mean-value detector in the feedback loop which also provides for the large amount of linearity required. The AM detector has a dc and an ac output. The first of these is coupled to the meter of the instrument via the FUNCTION selector.

In the corresponding position of the FUNCTION selector, the meter indicates the value of the AM detector's dc current - in other words: the IF level. The second output of the AM detector is coupled to the AF section (described below) via the selector FUNCTION.

As stated above, the IF signal from the buffer amplifier is also fed to the IF output amplifier which provides for amplification so that the level required for driving a following limiter is obtained.

The limiter transforms the IF signal into a square wave, the zero crossing of which is controlled by variations in the peak-to-peak value being compared with variations in the mean value. Subsequent limiting action takes place in the following limiter section. The resulting signal is fed via a buffer amplifier to the FM detector section which consists of a monostable multivibrator and an output amplifier.

The signal from the last limiter section is used to trigger a monostable multivibrator which provides for pulses of constant width. The pulses from the multivibrator are amplified in an output amplifier. The output amplifier is provided with a regulating loop consisting of a peak detector and an amplifier. This regulating loop keeps the value of the peak-to-peak voltage of the output amplifier constant. Hence, as the amplitude and the width of the pulses are constant, the mean value of the signal will vary according to the number of pulses per second. The mean value is utilized when the FUNCTION selector is in position IF CHECK for reading the value of the intermediate frequency. To ensure a high degree of accuracy and an extremely low hum level, both the multivibrator and the output amplifier are furnished with their own regulated power supply.

From the AM or FM detector, the signal is fed to a low-pass filter via a relay controlled by the FUNCTION selector. The low-pass filter features the high degree of phase-linearity required for passing stereo information without any disturbing influence on L/R separation.

The low-pass filter is followed by a two-section, 4 x 10 dB precision attenuator which determines the metering ranges. It is followed by an amplifier providing for amplification of the AF signal to the level required by the next stages.

The AF amplifier is followed by deemphasis networks providing for the standard deemphases of 50, 75, and 750 µs, and the non-standard deemphasis of 6 dB/oct. The amplified AF signal can also be passed through one of four low-pass filters with frequencies of 3, 15, 75 and 200 kHz, or through a band-pass filter with 3 dB points at 50 Hz and 15 kHz, ensuring a wide range of applications.

These networks and filters are followed by an AF amplifier. The output signal from this amplifier is available on the front panel via the AF OUTPUT connector for distortion measurements or external monitoring. Loading of the AF OUTPUT does not interfere with the meter indication. The output voltage from the first AF amplifier is also fed to another AF amplifier providing for the voltage necessary for the AF detector. The signal from the AF OUTPUT can either be dc-coupled or ac-coupled to

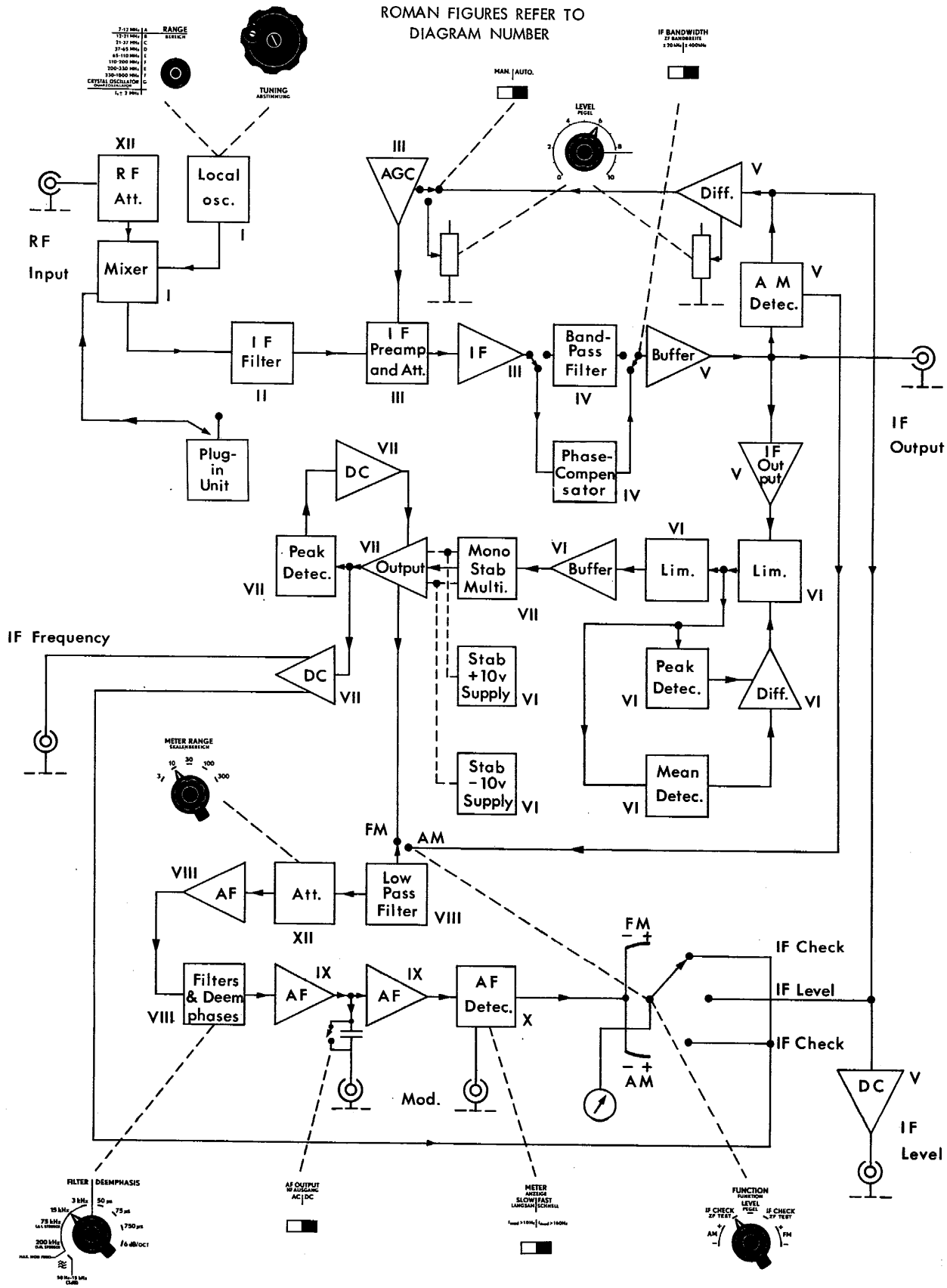


Fig. D1. Block-diagram of the Modulation Meter, type AFM2.

the AF OUTPUT connector by sliding the switch.

The AF detector gives the true peak value of any AF signal. Depending on the position of the FUNCTION selector, the positive or the negative modulation peak can be measured. The AF detector has two time constants, thereby furnishing two meter responses.

The AF detector is followed by an impedance-matching network providing for low output impedance to the meter.

CONTROLS, METER, AND TERMINALS

General

As can be seen in Fig. D2 and D4, the Modulation Meter, type AFM2, is provided with the following controls, meter, and terminals:

Controls, Meter, and Front Plate Terminals (see Fig. D2)

Power Lamp and ON switch (1)

The power switch ON is a toggle switch monitored by the lamp POWER.

RANGE Selector and Drum Scale (2)

The selector RANGE is an eight-position rotary switch. In the first six positions, the RANGE selector provides for selection of the frequency ranges according to the table printed on the front plate of the instrument. (Note that the ranges E and F each cover two frequency bands.) The next position is a rest position. In the last position, the plug-in Crystal Oscillator Unit (if any) is connected. The selector RANGE is monitored by the drum scale immediately above.

TUNING Knob (3)

The knob TUNING provides for adjustment of the local oscillator frequency at 2 MHz from the signal frequency. It is monitored by a cursor on the drum scale.

LEVEL Potentiometer (4) and MAN.-AUTO. Switch (5)

The potentiometer LEVEL has two functions according to the position of the switch MAN.-AUTO.

When the switch MAN.-AUTO. is in position MAN., the LEVEL potentiometer is used to vary the sensitivity of the instrument manually within a range of min. 40 dB.

When the switch MAN.-AUTO. is in position AUTO., the LEVEL potentiometer is used for fine-adjustment of the automatically adjusted sensitivity of the instrument.

FUNCTION Selector (6)

The selector FUNCTION is a seven-position rotary switch. The position LEVEL is used when searching the signal (i.e., tuning) and monitoring the IF level. When measuring, the positions IF CHECK are used to tune the instrument to the exact carrier frequency. (See under "Meter" below) The percentage of amplitude modulation of AM signals can be measured by placing the selector in position AM + or AM - according to the sign of the modulation peak to be measured. The frequency deviation of FM signals can be measured by placing the selector in position FM + or FM - according to the sign of the modulation peak to be measured.

METER RANGE Selector (7)

The selector METER RANGE is a five-position rotary switch. Each position corresponds to the full-scale range of the meter, viz: AM 3 - 10 - 30 - 100%, FM 3 - 10 - 30 - 100 - 300 kHz.

METER Switch (8)

The switch METER is a sliding switch. In position SLOW f_{mod} >10 Hz, the meter response is slow. This position should not be used when measuring on signals with modulating frequencies higher than 160 Hz. In position FAST f_{mod} >160 Hz, the meter response is fast.

IF BANDWIDTH (9)

The switch IF BANDWIDTH is a sliding

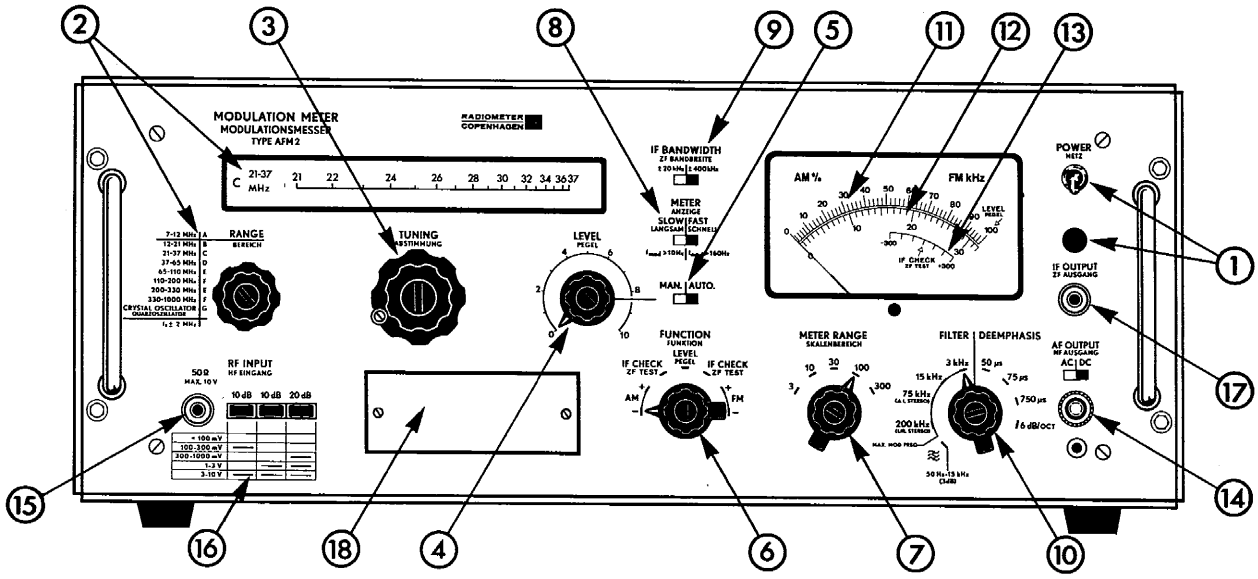


Fig.D2. Front plate of the Modulation Meter, type AFM2.

switch. It provides for switching from the band-pass filter to the phase-comparator and vice versa, i.e., from a bandwidth of ±25 kHz to one of ±400 kHz.

AF FILTER/DEEMPHASIS Selector (10)

The selector AF FILTER/DEEMPHASIS is a nine-position rotary switch. In the first position - 50 Hz—15 kHz (3 dB) - a band-pass filter is switched in. It is used when measuring residual AM and FM. In the next four positions - 200 kHz (L/R STEREO), 75 kHz (Δf, STEREO), 15 kHz, and 3 kHz - four low-pass filters are switched in. They are used when measuring FM deviation or AM modulation. The 3 kHz and 15 kHz filters are used for modulation frequencies up to 3 kHz and 15 kHz, respectively.

The 75 kHz filter is used for modulation frequencies up to 75 kHz and for measurements of FM stereo deviation. The last filter - 200 kHz - is used for modulation frequencies up to 200 kHz and for measurements of stereo L/R separation (bandwidth: 10 Hz (0.1 dB) - 350 kHz (3 dB)).

The last four positions of the AF FILTER/DEEMPHASIS selector introduce four deemphases of 50 µs, 75µs (European and American standard for stereo work), 750 µs (narrow-band equipment) and a 6 dB/oct (non-standard).

Meter

The meter of the Modulation Meter, type AFM2, is of the taut-band suspension type. It is provided with three scales.

The upper scale (11) provides for reading in the AM ranges from 0 to 10% or 0 to 100%, and in the FM ranges from 0 to 10 kHz or 0 to 100 kHz deviation, according to the positions of the FUNCTION selector and the METER RANGE selector. It is also provided with a LEVEL mark to permit setting of the IF level.

The middle scale (12) provides for reading in the AM ranges from 0 to 3% or 0 to 30%, and in the FM ranges from 0 to 3 kHz, 0 to 30 kHz, or 0 to 300 kHz deviation, according to the position of the FUNCTION and METER RANGE selectors.

The lower scale (13) is utilized when checking the frequency of the converted signal. It is graduated for ±300 kHz deviation around the 2 MHz intermediate frequency. An IF CHECK mark provides for exact tuning to the intermediate frequency.

	10 dB	10 dB	20 dB
<100 mV			
100 - 300 mV	—		
300 - 1000 mV			—
1 - 3 V		—	—
3 - 10 V	—	—	—

ATTENUATION	FREQUENCY RANGE		
	15 - 200 MHz	200 - 600 MHz	600 - 1000 MHz
0 dB	3 - 100 mV	20 - 100 mV	30 - 100 mV
10 dB	100 - 300 mV	100 - 300 mV	100 - 300 mV
20 dB	300 - 1000 mV	300 - 1000 mV	300 - 1000 mV
30 dB	1 - 3 V	1 - 3 V	1 - 3 V
40 dB	3 - 10 V	3 - 10 V	3 - 10 V

Fig.D3. Attenuation and sensitivity ranges.

AF OUTPUT Switch and AF OUTPUT Connector (14)

The AF OUTPUT switch is a sliding switch used for selection of the mode of coupling of the AF signal. With the switch in the left-hand position, the AF signal is ac-coupled (600 Ω in series with 10 μF). With the switch in the right-hand position, the AF signal is dc-coupled (600 Ω). The AF signal of 1 V EMF (peak value) at full-scale deflection is delivered via a UHF connector.

RF INPUT Connector (15)

The BNC connector RF INPUT provides for connection of the RF signal to be measured on.

Input Attenuator (16)

The input attenuator is a three-step attenuator (10 + 10 + 20 dB). It is used to adapt the Modulation Meter, type AFM2, to input levels from 3 mV to 10 V. As can be seen in Fig. D3, the degree of attenuation to be selected depends on the input voltage range, and the sensitivity of the instrument on the frequency range.

IF OUTPUT (17)

The UHF connector IF OUTPUT provides for connection of the 2 MHz IF signal to, for example, external monitors. It delivers a 2 MHz IF signal of 0.2 V EMF from a 50 ohms source at correct frequency tuning and full deflection on the meter.

Plug-in Unit Receptacle (18)

The Modulation Meter, type AFM2, is so designed that two optional plug-in units, i.e., Crystal Oscillator Unit, code 900-252, and External-Oscillator Amplifier, code 900-253, can be easily plugged in. (See SECTION C - ACCESSORIES.)

Rear Terminals (see Fig.D4)

IF LEVEL (DC) (1)

The terminal IF LEVEL consists of two banana jacks (600 Ω) and delivers a dc output voltage of 1 V EMF at meter deflection to SET LEVEL mark.

IF FREQ. (DC) (2)

The terminal IF FREQ. consists of two banana jacks (600 Ω) and delivers a dc output voltage of 1 V EMF at meter deflection to IF CHECK mark.

MOD. LEVEL (DC) (3)

The terminal MOD. LEVEL (DC) consists of two banana jacks (600 Ω) and delivers a dc output voltage (meter current) of 1 V EMF at full-scale deflection.

Line Voltage Indicator (4)

The line voltage indicator shows the line voltage to which the instrument is switched: either 110 V or 220 V - 48 to 65 Hz. When the two screws (5) and (6) are loosened, the voltage indicator can be turned to the appropriate position. (For further details see SECTION E - OPERATING INSTRUCTIONS.)

Battery (7)

The terminals BATTERY are of the Belling & Lee L1436/5 type and provide for connection of the instrument to an external dc supply be means of a Belling & Lee L1436P Plug supplied with the instrument.

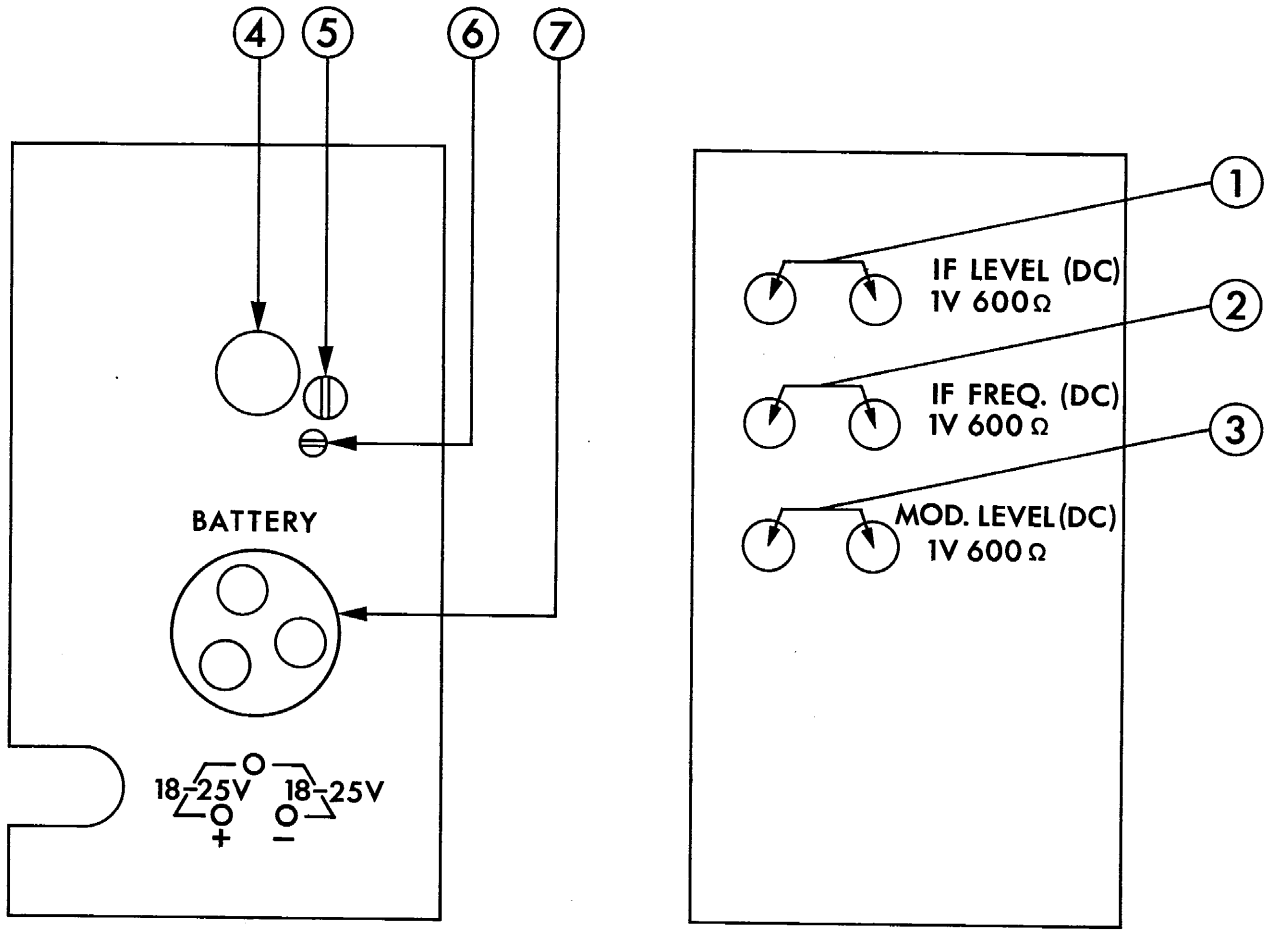


Fig. D4. Rear terminals of the Modulation Meter, type AFM2.

Section E. Operating Instructions

CONNECTING THE INSTRUMENT

Before connecting the instrument to the power line, make sure that the supply transformer and the line voltage indicator are set to the voltage of the power line.

To prepare the instrument for 110 V or 220 V line voltage operation, refer to diagram XI and proceed as follows:

1) If the instrument must be used at a line voltage of 110 V, interconnect lugs 3 and 5 and lugs 4 and 6 on the supply transformer.

2) If the instrument must be used at a line voltage of 220 V, interconnect lugs 4 and 5 on the supply transformer.

Then loosen the screws on the voltage indicator and set the indicator to the desired voltage.

MEASURING AMPLITUDE MODULATION PERCENTAGE

Modulation Percentage of AM Signals

1) Feed the signal to be measured to the RF INPUT connector. Bear in mind that the max. applicable signal is 10 V r.m.s., and that the input impedance is 50 Ω.

2) Use the RF input attenuator according to the instructions printed on the front panel, or refer to Fig.D3 in SECTION D - GENERAL DESCRIPTION.

3) Set the switch BANDWIDTH to ±400 kHz when measuring on broad-band equipment, or to ±25 kHz when measuring on narrow-band equipment.

4) Set the switch METER to SLOW if the modulation frequency of the signal is less than 160 Hz; otherwise set it to FAST.

5) Set the switch MAN.-AUTO. to MAN.

6) Set the drum scale to the desired frequency range by using the RANGE selector.

7) Set the selector FUNCTION to LEVEL.

8) Set the tuning knob so that the cursor on the drum scale indicates the signal frequency ±2 MHz, and then tune so as to obtain maximum meter deflection.

9) Turn the selector FUNCTION to IF CHECK.

10) Make a fine adjustment with the TUNING knob so that the meter reads IF CHECK.

11) Set FUNCTION to LEVEL. When using MAN.-AUTO. in position MAN. readjust to the LEVEL mark, if necessary by means of the LEVEL potentiometer. When using MAN.-AUTO. in position AUTO., fine level-adjustment can

be accomplished by means of LEVEL. It is recommended to use the MAN.-AUTO. switch in position AUTO. when performing AM measurements, as the inevitable level variations of the signal then are equalized.

12) In order to obtain the best accuracy, select the low-pass filter corresponding to the modulation frequency of the signal under test. See Fig. E1, and refer to SECTION B - SPECIFICATIONS under "AM MODULATION Accuracy".

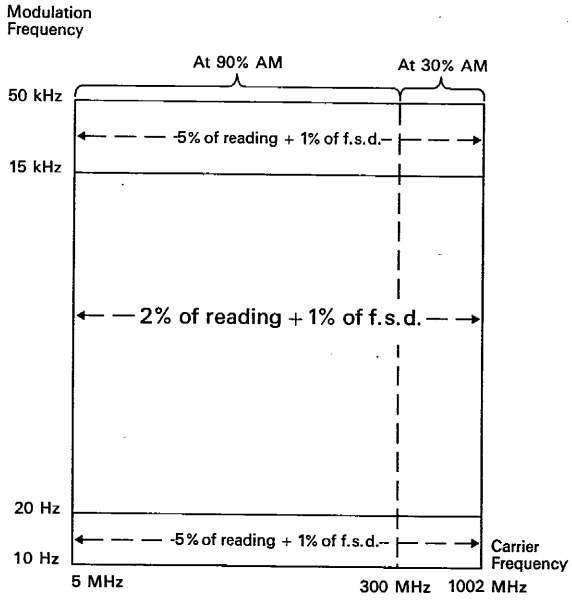


Fig. E1. Accuracy of modulation percentage measurements.

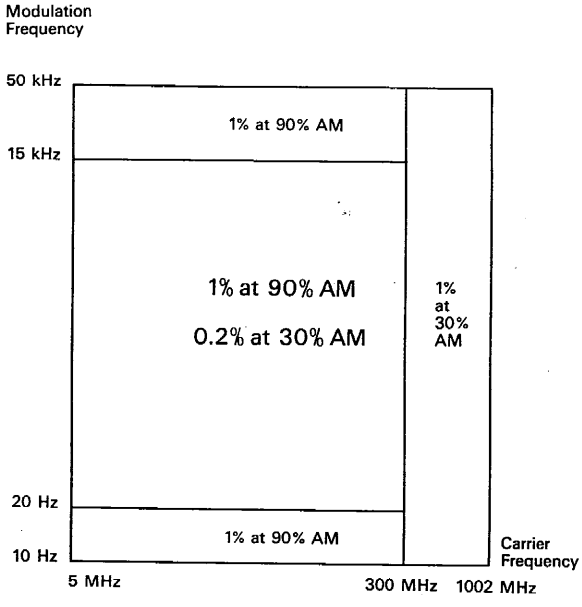


Fig. E2. Distortion for modulation percentage measurements.

13) Turn FUNCTION to AM + or AM - , depending on which peak of modulation is to be measured.

14) Rotate the selector METER RANGE until a proper deflection is obtained.

15) Read the modulation percentage. Check if the reading is the same for both peaks of modulation: a difference indicates distortion of the modulation envelope. See Fig. E2, and refer to SECTION B - SPECIFICATIONS under "AM MODULATION Distortion".

Residual AM on FM Signals

Proceed as described above. If resolution somewhat higher than that corresponding to the 3% AM range is wanted, an external meter, e.g., an electronic voltmeter, may be connected to the AF OUTPUT connector. The external meter will read 1 volt for full deflection of the internal meter, i.e., with the METER RANGE selector set to 3, the modulation percentage read on the voltmeter is 0.003% per mV.

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

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

2) Rotate the TUNING knob back and forth so that the intermediate frequency is changed over the range 2 MHz - Δ f to 2 MHz + Δf, where Δf 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 in the LEVEL reading. The minimum residual AM is approx. half of this percentage change.

MEASURING FREQUENCY DEVIATION (FM kHz)

Frequency Deviation of FM signals

1) Feed the signal to be measured to the RF INPUT connector. Bear in mind that the max. applicable signal is 10 V and that the input impedance is 50 Ω.

2) Use the RF input attenuator according to the instructions printed on the front panel, or refer to Fig. D3 in SECTION D - GENERAL DESCRIPTION.

3) Set the switch IF BANDWIDTH to ±400 kHz when measuring on broadband equipment, or to ±25 kHz when measuring on narrow-band equipment.

4) Set the switch METER to SLOW if the modulation frequency of the signal is less than 160 Hz; otherwise set it to FAST.

5) Set the switch MAN.-AUTO. to MAN.

6) Set the drum scale to the desired frequency range by using the RANGE selector.

7) Set the selector FUNCTION to LEVEL.

8) Set the TUNING knob so that the cursor on the drum scale indicates the signal frequency ±2 MHz, and then tune so as to obtain maximum meter deflection.

9) Turn the selector FUNCTION to IF CHECK.

10) Make a fine adjustment with the TUNING knob so that the meter reads IF CHECK.

11) Set the selector FUNCTION to LEVEL. When using MAN.-AUTO. in position MAN., readjust to the LEVEL mark. When using MAN.-AUTO. in position AUTO., fine level-adjustment can be accomplished by means of LEVEL.

12) In order to obtain the best accuracy, select the low-pass filter corresponding to the modulation frequency of the signal under test. See Fig. E3, and refer to SECTION B - SPECIFICATIONS under "FM MODULATION - Accuracy".

13) Turn FUNCTION to FM + or FM -, depending on which peak of modulation is to be measured.

14) Rotate the selector METER RANGE until a proper deflection is obtained.

15) Read the modulation deviation. Check if the reading is the same for

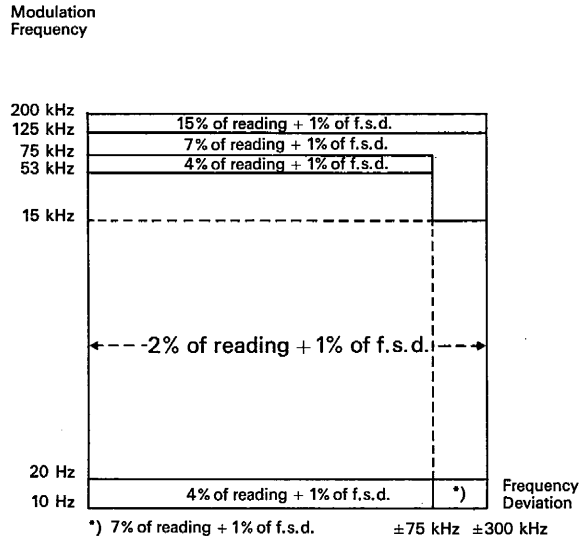


Fig. E3. Accuracy of frequency deviation measurements.

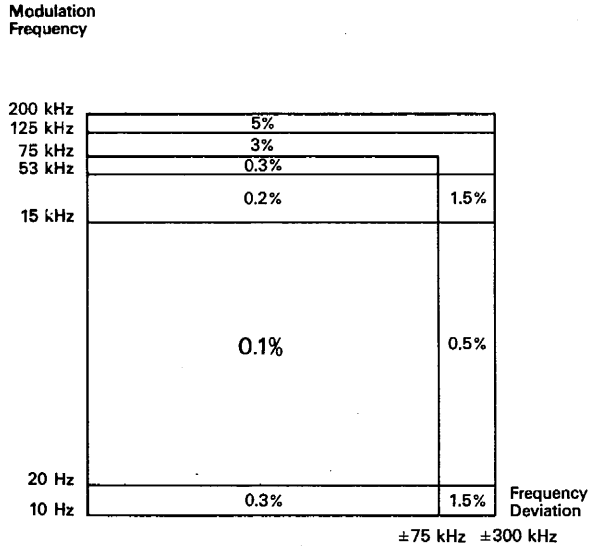


Fig. E4. Distortion for frequency deviation measurements.

both peaks of modulation: a difference indicates distortion of the modulating envelope. See Fig. E4, and refer to SECTION B - SPECIFICATIONS under "FM MODULATION - Distortion".

Residual FM on CW and AM signals

Proceed as described immediately above. Because of the very effective limiter stages in the FM detector, the residual FM caused by amplitude modulation is quite low, viz. 50 Hz (r.m.s.) at 50% AM when the band-pass filter (50 Hz - 15 kHz) is used. The residual FM at a carrier frequency within 15 - 250 MHz is less than 25 Hz FM (r.m.s.), and less than 100 Hz FM (r.m.s.) up to 1002 MHz; when measurements are performed in a room with an acoustical noise level lower than 60 dB (rel. $2\ 10^{-4}$ µbar) and the band-pass filter (50 Hz - 15 kHz) or one of the de-emphases (50 µs or 75 µs) is used. (See SECTION B - SPECIFICATIONS.)

If a resolution somewhat higher than that corresponding to the 3 kHz deviation range is wanted, an electronic 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 electronic voltmeter will be 3 Hz per mV.

USING A CRYSTAL OSCILLATOR PLUG-IN UNIT, CODE 900-252

1) Remove the two screws and the plate covering the receptacle in which the Crystal Oscillator Unit is to be placed (see Fig. E5).

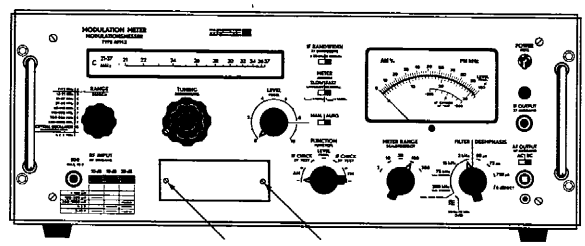


Fig. E5. The arrows show screws and plate to be removed when a plug-in unit is to be used.

2) Supply the Crystal Oscillator Unit with Crystals. Bear in mind that the crystals must have the frequency f_{cr} defined below:

$$f_{cr} = \frac{f_s - 2}{2n} \text{ MHz}$$

where f_s indicates the carrier frequency and n the odd harmonic of the crystal overtone frequency. The sensitivity specifications (see item INPUT LEVEL in SECTION C-ACCESSORIES or Fig. E6) are based on the combinations shown below of carrier frequency, order of harmonic, and range of crystal frequencies.

3) Position the Crystal Oscillator Unit in the Modulation Meter and fasten the two screws.

4) Switch the RANGE selector to position G - "CRYSTAL OSCILLATOR".

Carrier frequency	Order of harmonic	Range of crystal frequencies
f_s	n	f_{cr}
250 - 600 MHz	3	40 - 100 MHz
600 - 1000 MHz	5	60 - 100 MHz

5) Tune the Modulation Meter to the desired carrier frequency.

6) Switch the function selector to IF CHECK.

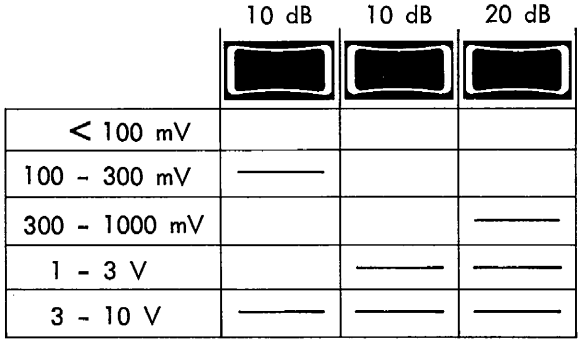
7) Switch the Crystal Oscillator Unit to the desired channel by means of the four-position selector.

8) Insert a screwdriver in the hole corresponding to the selected channel, and adjust the corresponding trimmer until the meter indicates IF CHECK.

9) If necessary, repeat steps 6 to 9 until all four channels are trimmed.

10) The Crystal Oscillator Unit, code 900-252, is now ready for use.

Proceed as described above for AM or FM measurements, but keep in mind that certain specifications of the Modulation Meter proper cannot apply, and refer to SECTION C under "Change in Specifications of AFM2 Caused by the Crystal Oscillator Unit", and see Fig. E6.



	FREQUENCY RANGE	
ATTENUATION	250 - 600 MHz	600 - 1000 MHz
0 dB	20 - 100 mV	30 - 100 mV
10 dB	100 - 300 mV	100 - 300 mV
20 dB	300 - 1000 mV	300 - 1000 mV
30 dB	1 - 3 V	1 - 3 V
40 dB	3 - 10 V	3 - 10 V

Fig. E6. Attenuation and sensitivity ranges when the Crystal Oscillator Unit, code 900-252, is in use.

USING AN EXTERNAL-OSCILLATOR AMPLIFIER, CODE 900-253

1) Remove the two screws and the plate covering the receptacle in which the External-Oscillator Amplifier is to be placed (see Fig. E5).

2) Position the External-Oscillator Amplifier in the Modulation Meter, and fasten the two screws.

3) Switch the RANGE selector to G - "CRYSTAL OSCILLATOR".

4) Feed the signal to be measured to the RF INPUT connector.

5) Feed the signal from the external oscillator to the INPUT connector.

6) Proceed as described above for AM or FM measurements.

Section F. Technical Description

RF INPUT CIRCUIT

The RF input signal is fed to the BNC connector on the front plate of the instrument, then passed through a resistive attenuator (providing for 10 dB, 20 dB, 30 dB or 40 dB attenuation) which is inserted to avoid overloading of the mixer and to adapt the Modulation Meter to RF signals in the range 3 mV to 10 V r.m.s.

All components of the RF attenuator are numbered between 1300 and 1399.

TUNER (See diagram No.1)

The local oscillator consists of Q103 in a common-base Hartley coupling. The same circuit configuration is used in all ranges. Only the tank circuit (C_C, C_B, and L_A) and the emitter capacitor C_A are exchanged to obtain the different fundamental ranges from 7 to 200 MHz. Up to 200 MHz, the mixing takes place with the fundamental frequency of the local oscillator. Mixing with input signals which have a frequency higher than 200 MHz is accomplished with the 3rd or 5th harmonics of the local oscillator.

The intermediate frequency is chosen to be 2 MHz, and both sidebands can be used; however, only the lower sideband can be used at 5 MHz RF input signal because the lower frequency limit of the local oscillator is 7 MHz.

With the selector RANGE in position CRYSTAL OSCILLATOR, the local oscillator is disconnected, and an oscillator providing for operation at a fixed frequency, such as the Crystal Oscillator Unit, code 900-252, may be used.

The signal from the RF attenuator and that from the local oscillator or the Crystal Oscillator Unit are fed to the diodes CR101 to CR104 which form a balanced mixer and provide for good insulation between the input terminals and the local oscillator or the Crystal Oscillator Unit, and thereby reduce the influence of stray radiation. The resulting 2 MHz signal is fed to the IF filter via T102.

The tuner has its own current limiters, i.e., Q101 for +12 V, and Q102 for -12 V.

All components of the tuner are numbered between 100 and 199.

IF FILTER (See diagram No.11)

The output impedance of the mixer is matched capacitively to that of the IF filter. In this fashion, variations of the output impedance of the mixer become uncritical. From T102, the intermediate frequency signal of 2 MHz passes through a band-pass filter which rejects unwanted mixing products. It is of the phase-linear type, and it has a bandwidth of ±400

kHz around the intermediate frequency. A high degree of phase-linearity is necessary to achieve measurements on FM signals with minimum distortion, especially when the modulation frequency is high.

All components of the IF filter are numbered between 200 and 299.

IF PREAMPLIFIER AND IF ATTENUATOR (See diagram No. III)

The three-stage IF preamplifier consists of Q301, Q302, and Q303. It protects the IF filter against load impedance variations from the IF attenuator. At the same time, it provides for amplification before the signal is fed to the IF attenuator. Amplification alongside with an almost ideal connection to the IF filter results in a minimum amount of noise at all input levels. The ohmic part of the IF amplifier input is matched by means of R304, and the reactive part by means of C306. The amplified IF signal is then fed to the IF attenuator via C308.

The IF attenuator (see Fig. F1) consists of R311 and the four diodes CR310 to CR304. R311 and the four diodes form a voltage divider with one fixed resistance and the variable resistance resulting from the combination CR301 - CR302 // CR303 - CR304. Combining these four diodes ensures linear characteristic and thereby minimum distortion. The resistance value resulting from the above combination depends on the biasing current of the four diodes. This biasing current is drawn from the collector of the current generator Q310. In position MAN. of the MAN.-AUTO switch, the base of Q310 is at a potential determined by the reference voltage source Q311. The emitter current of Q310, and thereby its collector current, is controlled by means of the potentiometer R1A (LEVEL) accessible from the front of the instrument. This results in regulation of the biasing current of the diode complex CR301 to CR304, and, therefore, in regulation of the IF level. Finally, the sensitivity of the IF attenuator at a given RF input voltage can be adjusted by means of R345.

When the switch MAN.-AUTO. is in position AUTO., the base of Q310 is at a voltage delivered by the AGC amplifier. The AGC amplifier consists of a differential amplifier Q512 and Q513 followed by a unity-gain amplifier Q308 and Q309. The base of Q513 is at a potential determined by the divider consisting of R1B (LEVEL), R552, R553, and R554. The base of Q512 receives a signal proportional to the IF level from the AM detector. The difference signal (if any) is then fed to the input (base of Q308) of the unity-gain amplifier driving the exponential amplifier Q310. The emitter of Q310 is at a voltage provided by the voltage reference source Q311. The emitter basis voltage of Q310, and thereby the biasing current of the diodes CR310 to CR304, is in this case controlled by the potentiometer R1B (LEVEL) and by the AGC amplifier.

All components of the IF preamplifier and IF attenuator are numbered between 300 and 399.

IF AMPLIFIER (See diagram No. III)

The signal from the IF attenuator is then fed to the IF amplifier which consists of the two wideband amplifier stages Q304, Q305 and Q306, Q307. The IF amplifier brings the IF signal to a voltage level higher than that required by the AM detector and thus provides for compensation of the attenuation in the following band-pass filter or phase-compensator.

All components of the IF amplifier are numbered between 300 and 399.

PHASE-COMPENSATOR AND BAND-PASS FILTER (See diagram No. IV)

The amplified IF signal is then fed to a phase-compensator or to a band-pass filter, according to the position of the IF BANDWIDTH switch. When the IF BANDWIDTH is in position ±400 kHz, the phase-compensator is switched in. It provides for compensation of the phase-error that arises in the IF filter. This phase error is due to the theoretical

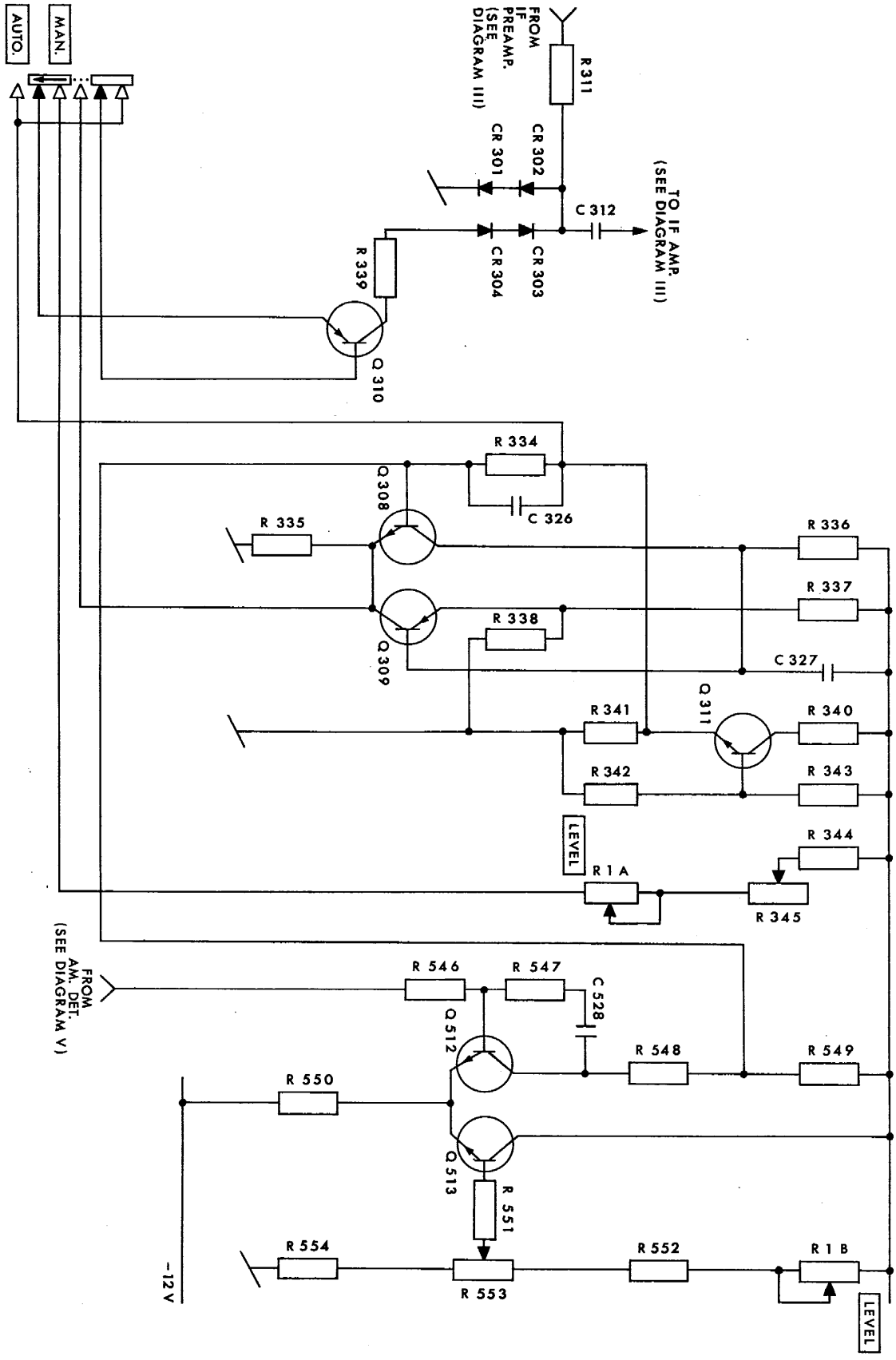


Fig. F1. IF attenuator and AGC amplifier.

asymmetry of the IF filter characteristic around the intermediate frequency. In the position ±25 kHz of the IF BANDWIDTH switch, the band-pass filter is switched on. It is of the same type as the IF filter concerning phase-linearity, but has a bandwidth of ±25 kHz, and is intended for use when measuring on signals from narrow-band equipment.

BUFFER AMPLIFIER (See diagram No.V)

The signal from the phase-compensator or the band-pass filter is fed to a buffer amplifier which separates filter, AM detector, and output amplifier. It consists of a two-stage unity-gain amplifier (Q501 and Q502) and serves to suppress any influence from the IF output. The signal from the buffer amplifier is fed both to the AM detector and to the IF output amplifier.

All components of the Buffer amplifier are numbered between 500 and 599.

AM DETECTOR (See diagram No.V)

The signal from the buffer amplifier is fed to the AM detector. It consists of a three-stage amplifier Q507, Q508, and Q509 with a mean-value detector CR505 and CR506 in the feedback loop. The feedback ensures a good linearity. A pair of output transistors, Q510 and Q511, provides for two outputs. The signal on the collector of Q511 is proportional to the IF level. This signal is fed via R546 to the differential amplifier which is part of the automatic level setting circuitry (described above), and, via R543 and R555, to a pair of complementary emitter-followers, Q514 and Q515, forming a dc output amplifier delivering voltage to the IF LEVEL (DC) output. The signal from the collector of Q511 is also fed via R544 to the indicating meter which provides for checking of the IF level.

The signal on the collector Q510 is the detected signal which is fed through a first low-pass filter section (L701, L702, C710 and C711 on diagram VII), via the network consisting of R537, R538, R539, and C530. R539 is used to calibrate the AM detector.

Note: The low-pass filter and the following AF section are described below.

All the components of the AM detector are numbered from 500 to 599.

IF OUTPUT AMPLIFIER (See diagram No.V)

The signal from the buffer amplifier is also fed to the IF output amplifier which consists of the four stages Q503, Q504, Q505, and Q506, and which provides for amplification of the IF signal to the level required by the following limiter stages. The two diodes CR502 and CR503 are used to protect the limiter input stage against too high a voltage.

All components of the IF output amplifier are numbered between 500 and 599.

LIMITER STAGES (See diagram No.VI)

General

The amplified IF signal is fed to a series of three limiters.

All components of the limiter stages are numbered from 600 to 699.

First limiter stage.

The first limiter stage consists of two emitter-coupled transistors, Q601 and Q602. Their working point is determined by the current delivered by the constant dc current generator Q607. The amplified IF signal from the IF output amplifier is fed to the base of Q601, whilst the base of Q602 is connected to ground. When a sufficient IF level is reached, Q601 and Q602 are cut-off, and the output voltage of the first limiter (at C605) is a square-wave. The peak-to-peak value of this square-wave is fixed by the constant current generator Q607. The first limiter is provided with a regulation circuit which holds the zero-crossing of the square-wave output voltage. The regulation circuit consists of a peak-dif-

ference detector, CR601 and CR602, and a differential amplifier, Q603 and Q604, where any signal from the peak-difference detector is compared with the dc component of the square-wave. The output signal of the differential amplifier (if any) is fed to the bases of Q601 and Q602 via the two emitter-followers Q605 and Q606.

Subsequent limiter stages

From C605, the square-wave signal is fed to two subsequent limiter stages Q608-Q609 and Q610-Q611 where it is again limited. The resulting signal is then fed to the FM detector via Q612.

FM DETECTOR (See diagram No.VII)

The FM detector consists of a monostable multivibrator and an output stage.

The multivibrator consists of Q701 and Q702. It is triggered by the train of positive pulses from the last limiter stage. This train of pulses is fed to the base of Q701 via C701. Transistor Q701 is cut-off when no IF signal is applied to its base whilst transistor Q702 conducts, and conversely.

The multivibrator has a time-constant determined by R707, R708 and C703, and it delivers a square-wave signal across R702. The positive pulses drive the output stage which consists of Q703 and Q704. The working points of the two transistors of the output stage are determined by the constant dc current generator Q708. The peak value of the square-wave is detected by CR704 and amplified in Q705 and Q706, which in turn drive the constant-current generator Q708 via Q707, thereby regulating amplitude variations. As the width of the pulses and their amplitude are constant, the mean value of the output voltage of the output stage will vary according to the number of pulses per second of the square-wave, i.e., according to the modulating frequency. Frequency-modulation of the IF signal will cause a variation of the output voltage of the output stage. This signal is then passed, via a low-pass filter consisting of L701, L702, C710 and C711, to the AF section described below.

A positive voltage, varying proportionally to the modulating frequency, is drawn from the collector of Q704 and, via R726 and R727, fed to a unity-gain amplifier stage consisting of the double transistor Q709 and Q710 and Q711. The amplifier signal present on the emitter of Q711 is fed via R734 to the IF FREQ. (DC) output, whilst the other part is fed via R736 to the meter when the selector FUNCTION is in IF CHECK position. R737 and R739 provide for fine adjustment of IF CHECK position and gain.

The monostable multivibrator and the output stage are provided with their own +10 V and -10 V regulated power supplies. They consist of Q613, Q614, Q615 and Q616 for +10 V, and Q617, Q618, Q619 and Q620 for -10 V. (See diagram VI)

All components of the FM detector are numbered between 700 and 799.

AF AMPLIFIERS I AND II
(See diagram VIII)

The signal from the AM detector is fed to the second low-pass filter, consisting of L801, L802, L803, L804, L805, C801, C802, C803 and C804, when the selector FUNCTION is in one of the positions AM. The signal from the FM detector is fed to the second low-pass filter when the selector FUNCTION is in one of the positions FM. The low-pass filter is characterized by its good phase-linearity and its almost flat frequency response, which are both required for passing a stereo signal with minimum distortion.

The filtered signal is then passed through the first section of a two-section resistive AF attenuator (see diagram XII) and fed to the first AF AMPLIFIER, which consists of Q801, Q802, and Q803.

The amplified signal at the collector of Q803 is passed via the second section of the AF attenuator (see diagram XII) and fed to the second AF AMPLIFIER, which consists of Q804, Q805 and Q806. It provides for the necessary amplification and for the low output impedance required for coupling to the subsequent low-pass filter.

All components of the AF AMPLIFIERS I and II are numbered from 800 to 899.

AF AMPLIFIERS III - V (See diagram IX)

The amplified signal from amplifier II is fed to the low-pass filter, which consists of L901, L902, L903, C901, and C902, and which provides for limitation of the noise bandwidth in the AF section of the instrument without deterioration of the phase-linearity and frequency-response.

The filtered signal is then passed through the third AF amplifier. It is a unity-gain amplifier, consisting of Q901 and Q902, which is part of the active filter switched in when the FILTER/DEEMPHASIS selector is in position 3 kHz, 15 kHz and 50 Hz - 15 kHz (3 dB). It acts as a buffer in the other positions of the FILTER/DEEMPHASIS selector. For filter characteristics, see SECTION B - SPECIFICATIONS. The de-emphasis networks and the 6 dB/oct filter are regular RC networks.

The following AF amplifiers IV and V, consist respectively of Q903, Q904, Q905, Q906, Q907, and Q908, Q910, Q911 and Q912. They bring the signal up to the level required by the AF detector.

The AF OUTPUT signal is drawn from the emitter of Q907 via R920 when the AF OUTPUT switch is in position DC, and via R920 and C911 when the AF OUTPUT switch is in position AC.

All the components of the AF amplifiers III - V are numbered from 900 to 999.

AF DETECTOR (See diagram X)

The signal from the emitter of Q912 is fed to the AF detector which consists of diodes CR1001 and CR1002. Diode CR1002 is used for detection of the negative peaks of modulation, whilst diode CR1001 is used for detection of the positive modulation peaks. Selection of the peak of modulation (positive or negative) is done by means of the FUNCTION selector in the positions AM or FM.

The detected signal is then fed to an impedance converter so that it can be fed to the MOD.LEVEL (DC) output and to the meter.

All the components of the AF detector are numbered from 1000 to 1099.

POWER SUPPLY (See diagram XI)

The power supply provides for the regulated dc voltages (-12 V, 0 V, +12 V) required by the different sections of the instrument. (For -10 V and +10 V supply, see FM DETECTOR.)

All the components of the power supply are numbered from 1100 to 1199.