

INSTRUCTION MANUAL

Type MS27
FM-AM STANDARD
SIGNAL GENERATOR



RADIOMETER

ELECTRONIC MEASURING INSTRUMENTS
FOR SCIENTIFIC AND INDUSTRIAL USE

INSTRUCTION AND OPERATING MANUAL
FOR

Type MS27
FM-AM STANDARD
SIGNAL GENERATOR

These instructions apply to
model MS27 only

INDEX

	page
Introduction	0-1
Specifications	0-4
 SECTION I - OPERATING PRINCIPLE	
1.1 The HF unit	1-1
1.2 Modulation circuits: general	1-4
1.3 Int. AM	1-4
1.4 Int. FM	1-5
1.5 Ext. mod. fidelity	1-5
1.6 Incremental frequency	1-6
1.7 Power supply	1-6
 SECTION II - OPERATING INSTRUCTIONS	
2.1 Connection	2-1
2.2 Controls, dials, and terminals	2-1
2.3 Step-by-step operation	2-4
 SECTION III - MAINTENANCE	
3.1 General	3-1
3.2 Removing the instrument from the cabinet	3-1
3.3 Tube replacement	3-1
3.4 Measurements of FM, AM, and CW	3-4
3.5 Screw driver adjustments and their functions	3-6
3.6 Operating voltages and currents	3-6
Appendix	
Circuit diagram	

INTRODUCTION

GENERAL

The type MS27 FM-AM Standard-Signal Generator is an extremely versatile instrument which features excellent electrical qualities and rugged mechanical construction.

The Signal Generator is intended primarily as an FM generator, but the amplitude modulation properties make it useful in many applications where otherwise an AM generator would have to be used.

The wide frequency range covers the RF and IF bands for AM, FM, and TV broadcasting in addition to the bands used for mobile communications equipment.

With accurate FM ranges from 5 kc to 75 kc in normal and up to 600 kc in multiplier operation demands of the most varying sorts are fulfilled.

The Signal Generator has passed tests in accordance with the British K114 Inter-Service Specifications which ensure that adverse atmospheric conditions, shocks and vibrations will not damage the instrument.

If the Signal Generator is to be used as a field instrument, a metal cover can be supplied which protects the front panel during transit and storing.

DESCRIPTION

The type MS27 Standard-Signal Generator gives complete coverage from 0.3 to 240 Mc in 5 ranges. Accurate frequency settings are obtained on the four upper ranges by means of a crystal calibrator which gives 16 check points on each range.

When working on narrow-band receivers, the inevitable backlash in the precision mechanical tuning arrangement may be bothersome. Therefore an electrical Fine Tuning has been incorporated to obtain a smooth and backlash-free control of the frequency without using the Incremental Frequency facility which is often desired for other purposes.

The Incremental Frequency settings are independent of the carrier frequency and with a dial calibration from 0 to ± 50 kc accurate readings are possible, thus making measurements of band-width convenient even at the highest frequencies. In addition, the incremental frequency can be switched to give a

calibrated detuning up to ± 400 kc, the maximum value depending on the frequency range.

From two outputs with source impedances of 50 and 75 ohms respectively, voltages from 0.1 microvolt to 0.1 volt are available in steps of 2 dB. Intermediate values are obtained by changing the attenuator input level which is monitored by a metering circuit. The attenuators are calibrated in microvolts and dB over one microvolt across a matched load, i.e. 50 or 75 ohms respectively. The corresponding open-circuit levels are 6 dB higher.

When the Modulation Switch is set to Int. FM, full scale readings are obtained for ± 5 , ± 25 , and ± 75 kc deviation depending on the setting of the Deviation range switch. The meter circuit measures the actual FM deviation which can be varied with the modulation control. Even the small deviations used in narrow-band FM systems are conveniently and accurately controlled in this instrument.

Amplitude modulation is introduced when the modulation selector is set to Int. AM. The actual AM, which is read on a 0 to 80% AM meter scale, is varied with the modulation control. The frequency of modulation is 1 kc, but if an external source is used, the frequency response is within ± 1 dB from 50 cps to 15 kc on FM and to 10 kc on AM. In case external FM is applied together with internal AM or vice versa, both modulations are monitored by means of the internal metering circuit. This property of simultaneous FM and AM is useful for instance when the amplitude suppression properties of FM receivers are investigated.

The operating principle of the type MS27 FM-AM Standard-Signal Generator is indicated in the schematic diagram and can be described as follows:

The RF signal originates from an oscillator which is tuned from 5 to 10 Mc. This oscillator feeds a series of four harmonic amplifiers, one tripler and three doublers, which produce the frequency ranges 15-30, 30-60, 60-120, and 120-240 Mc. The tuning of the oscillator and harmonic amplifier is accomplished by means of a five-gang variable capacitor with silver-plated vanes, which is carefully adjusted to ensure correct tracking of all circuits. The 0.315 Mc range is produced by mixing the output from a 36 Mc oscillator with 36-51 Mc signals from the first doubler stage.

By means of the range switch, signals from the proper harmonic amplifier are coupled to the output stage which in turn feeds the cascaded 5 x 20 dB

and 10 x 2 dB attenuators. At the attenuator input is placed a crystal detector which monitors the level, thus standardizing the outputs which can be varied from 0.1 microvolt to 0.1 volt across a matched load.

Due to the principle of operation and the finite Qs of the circuits, spurious frequency outputs which are at least 5 Mc from the carrier are present, but their levels are so low that they rarely cause trouble.

The crystal checks are produced by beating the 5-10 Mc oscillator signal with a 0.3333 Mc crystal controlled oscillator.

Across the 5-10 Mc oscillator is connected a reactance tube which produces the frequency modulation by varying the effective inductance in the circuit. To maintain a constant deviation at all frequencies, equalizer networks have been included which are ganged to the range switch and the tuning drive. If part of this network is disconnected, the frequency deviations are multiplied in the same manner as the carrier frequencies, which means that the ± 75 kc readings are to be multiplied by 2, 1, 2, 4, or 8 according to the frequency ranges. Thus up to ± 600 kc deviation is available from 120-240 Mc.

To eliminate stray radiations all RF circuits are enclosed in a shield box with careful filtering of all output leads.

The incremental frequency circuit produces static frequency deviations in the same manner as the modulation circuits produce dynamic deviations and the properties are analog. Thus the ± 50 kc deviation is either independent of the frequency or it is multiplied by the range factors 2, 1, 2, 4, or 8.

Amplitude modulation is produced by grid modulating the output stage. This eliminates side-band cutting and ensures extremely low reaction on the 5-10 Mc oscillator which in turn means negligible incidental frequency modulation.

The AF signal is produced in an LC-type oscillator, and a metering circuit measures the frequency deviation or the modulation depth. Synchronizing voltage for an oscilloscope is available from terminals on the front panel.

A regulated power supply is incorporated to reduce the influence of line voltage variations on the Signal Generator outputs.

SPECIFICATIONS

CARRIER FREQUENCY

Range:

0.3 to 240 Mc in 5 direct-reading sub-ranges, viz.:

0.3 - 15 Mc
15 - 30 Mc
30 - 60 Mc
60 - 120 Mc
120 - 240 Mc

Calibration:

16 crystal check points on each of the ranges above 15 Mc with an accuracy better than $2 \cdot 10^{-4}$. When the frequency dial is crystal calibrated at mid-scale, the overall accuracy is better than 0.5% above 15 Mc.

Incremental Frequency:

The dial calibration from 0 to +50 kc with 2 kc divisions is valid at all frequencies. With the deviation range switch at ± 75 kc & Inc. Freq. the dial readings are multiplied by 2, 1, 2, 4, or 8 corresponding to the frequency ranges from the lowest one to the highest one.

Fine Tuning:

Provides for about $\pm 3 \cdot 10^{-4}$ change of the carrier frequency above 15 Mc and about ± 15 kc below 15 Mc.

Interpolation Dial:

Gearing ratio to frequency dial 1:20. The dial carries a 0-100 scale for interpolating purposes.

CARRIER OUTPUT

Output Level:

0.1 μ V to 0.1 V across a matched load, 0.2 μ V to 0.2 V emf. The level is adjustable in steps of 2 dB by means of the cascaded 5 x 20 dB and 10 x 2 dB attenuators. Intermediate values are obtained by use of the +1, 0, and -1 dB marks for the meter reference level.

The attenuators are calibrated in μ V and dB over 1 μ V, both measured across a matched load.

Output Impedance:

Two outputs with nominal impedances of 50 ohms and 75 ohms.

Accuracy of Output Voltage:

The total accuracy is the sum of the two accuracies stated below.

Accuracy of voltmeter:

± 1 dB to 150 Mc

+1 or -2 dB to 240 Mc

Accuracy of attenuator:

1 dB above 10 μ V

2 dB + 0.05 μ V below 10 μ V

Stray Radiation:

Negligible. Does not interfere with sensitivity measurements down to 0.1 μ V.

Terminals:

Both RF terminals are type UG-290/U BNC connectors.

FREQUENCY MODULATION**Deviation Ranges:**

0 to ± 5 kc, 0 to ± 25 kc, and 0 to ± 75 kc with direct-reading scales.

With the deviation range switch in the position ± 75 & Inc. Freq. all readings on the ± 75 kc scale are to be multiplied by 2, 1, 2, 4, or 8 corresponding to the frequency ranges from the lowest one to the highest one. Thus ± 600 kc deviation is available in the 120-240 Mc range.

Distortion:

At ± 75 kc deviation the distortion is below 2% in the 15-30 Mc range and below 1% in all other ranges, provided that the incremental and fine tuning controls are at their center-positions.

Accuracy:

7% of full scale at 1 kc.

AM or FM:

At ± 75 kc deviation the AM produced is typically below 10%.

Incidental FM:

With the generator operating in CW the incidental FM due to hum and noise is typically 0.5 parts per million, i.e. 60 dB below a ± 75 kc modulation level at 150 Mc.

External FM:

Approximately 25 volts into a min. 9 kilohm load required for maximum FM. The deviation is measured by means of the internal metering circuit, and the frequency response is within ± 1 dB from 50 cps to 15 kc.

AMPLITUDE MODULATION

Range:

0 to 80% AM

The meter scale is calibrated in % AM from 0 to 80.

Distortion:

The envelope distortion is typically 5% at 50% AM.

Accuracy:

10% of reading + 5% AM at 1 kc.

FM or AM:

At 30% AM, 1 kc, the FM produced is typically 5 parts per million.

Residual AM:

Typically below 0.2% AM due to hum and noise.

External AM:

Approximately 25 volts into a min. 13 kilohm load required for maximum AM. The modulation depth is measured by means of the internal metering circuit, and the frequency response is within ± 1 dB from 50 cps to 10 kc.

MODULATING OSCILLATOR

Frequency: 1 kc $\pm 5\%$

Distortion: Below 0.5%

1 kc Output: A synchronizing voltage of about 15 volts available from terminals on the front panel. Output impedance less than 3 kilohms.

POWER SUPPLY

Voltages: 110, 115, 127, 200, 220, 240 volts

Line Frequencies: 45 to 65 cps

Consumption: 60 watts

TUBES

8 type 5654 (6AK5) 1 type EL80F (6688)
1 type ECC81 (12AT7) 1 type EL81 (6CJ6)
1 type 90C1

OVER-ALL DIMENSIONS

Height: 370 mm (13 inches)
Width: 560 mm (22 inches)
Depth: 270 mm (10.5 inches)

The front plate is compatible with the 19" rack standard.

WEIGHT

22 kilos net

MOUNTING AND FINISH

Steel cabinet finished in grey enamel

ACCESSORIES SUPPLIED

1 type 6E6 50 ohm coaxial cable with type
UG-88/U BNC connectors
1 type 6D6 75 ohm coaxial cable with type
UG-88/U BNC connectors
1 type 12G19-1.5 power cord

EXTRA ACCESSORY

Protective Cover.

The cover is made from steel plate and fits directly on the front panel of all type MS27 Standard Signal Generators. During transit, storing, and whenever it is advisable to protect scales, knobs, etc. against damage, the cover is extremely useful. The cover has compartments for instruction manual and cables.

SECTION I

OPERATING PRINCIPLE

The drawing appended to the operating instructions shows the complete circuit diagram of the Signal Generator.

1.1 THE HF UNIT

The HF Unit is contained within a shielded box, the cover of which can be removed in case of inspection or repair.

The 5-10 Mc/s oscillator tube (No.3, type 5654) is operated as a tuned plate oscillator. The tuning is accomplished by means of the variable capacitor C_1 (location B4 of the complete circuit diagram) whose shaft is connected to the main frequency dial and the interpolation dial via a 1:20 reduction worm gear.

Across the oscillator tank circuit a reactance tube (No.2, type 5654) is connected. It acts like a variable inductance providing for frequency modulation. The resistor R_1 (loc. D3) connected to +160 V through a 50 kilohm resistor controls the bias of the reactance tube. When replacing the reactance tube, it may become necessary to adjust the said resistor to obtain minimum FM distortion.

Tube No.1, loc. B2, operates as a crystal controlled 0.3333 Mc oscillator. Through a capacitor part of the 5-10 Mc/s oscillator signal is fed to the grid of the crystal oscillator thus producing zero beats whenever the oscillator frequency is a multiple of 0.3333 Mc/s, i.e. at 5.0000, 5.3333.....10.0000 Mc/s. When connecting a set of headphones to the PHONES terminals, h.t. is applied to the crystal oscillator which makes it start. As the phones are connected across the 20 kilohm resistor (loc. F1) in the supply lead, 16 zero beats are heard when tuning from one end of a frequency range to the other. The check points indicated on the frequency dial correspond to megacycles on the 15-30 Mc/s range. The dial is calibrated by adjusting the movable index on the frequency dial. The calibration is valid for all ranges (except the 0.3-15 Mc/s range) as all signals are derived from the 5-10 Mc/s range by means of tripling and doubling operations.

To prevent that the phones are left plugged in, the meter is disconnected by means of the phone switch, pos. G2.

From the 5-10 Mc/s oscillator tank circuit, voltage is applied to the grid of tube No.4, type 5654, which operates as a class-C amplifier and buffer stage. In class-C operation the harmonic content of the anode current is high, and by tuning the anode tank circuit to the third harmonic the frequency range 15-30 Mc is produced. The tuning is accomplished by means of capacitor C_2 , which is section No.2 of a five-gang variable capacitor.

The soldered vane assembly of this five-section capacitor in connection with the silverplating ensures reliable and trouble-free service throughout the life of the instrument. All capacitors are adjusted in such a way that accurate ganging of the sections is obtained.

The 15-30 Mc tank circuit connects to the grid of tube No.5, type 5654, and from a tap to the HF section of the range switch, which in the 15-30 Mc/s position leads the signal to the grid of the output tube.

Tube No.5 operates like tube No.4, except that it is adjusted to operate as a frequency doubler thus producing signals in the range from 30-60 Mc/s. The tank circuit of this stage is connected to the grid of tube No.6 and to the HF-section of the range switch, which in turn, with the switch in the 30-60 Mc/s position is connected to the output tube.

Tubes No.6 and 7, both of type 5654, operate as frequency doublers, and output signals in the ranges 60-120 Mc/s and 120-240 Mc/s are obtained by proper setting of the range switch.

The 0.3-15 Mc/s range is produced by means of the 36 Mc/s Colpitts oscillator, 1/2 tube No.8, type ECC81, and a mixer stage, 1/2 tube No.8, which receives signals from the 36 Mc/s oscillator and via the range switch from the 30-60 Mc/s stage. The output is taken through a low-pass filter which cuts off unwanted signals. The 36 Mc/s oscillator is adjustable through a narrow frequency range by means of a 6 pF shunt capacitor which is accessible from the front panel (0 Mc/s ADJ.) by means of a screw driver. The adjustment procedure for this frequency range is also indicated on the front panel of the instrument

and it entails:

- 1) Adjustment by use of crystal calibration to 36 Mc/s.
- 2) Adjustment of the "36 Mc/s" oscillator to exactly 36 Mc/s by turning the 0 Mc/s screw driver adjustment to minimum meter deflection.

The range switch has several functions. It

- 1) makes HF-connections
- 2) connects supply voltage to the tubes in operation
- 3) connects the screen grid of the last one of the active tubes (No. 4-7) to the CARRIER adjustment potentiometer
- 4) introduces attenuation in the FM and "Incremental Frequency" leads.

The output stage, tube No. 9, type E180F, is a broadband amplifier, which by grid modulation produces AM. Via a double shielded cable the signal is fed to the 5x20 dB attenuator which is followed by the 10x2 dB attenuator and the shielded outlet box containing the type BNC output connectors.

A crystal rectifier unit is built into the 5-20 dB attenuator to provide for monitoring of the output voltage. With the METER switch in neutral position the attenuator input voltage is indicated on the meter scale, which carries three marks, 0 dB for calibrated output, +1 dB, and -1 dB for 1 dB deviations from calibrated output.

The attenuators are of the ladder-type using lumped components. All internal cables are terminated without reflexions to give the accuracy required. The 10x2 dB attenuator is connected to the 50 ohm output, and a 25 ohm resistor between the two connectors gives correct 75 ohm impedance. Only one of the outputs can be used at a time, and a cap has been attached which covers the output not used and prevents stray radiation. The output level is adjustable in steps of 2 dB from 0.2 μ V to 0.2 V open circuit voltage (0.1 μ V - 0.1 V across 50 or 75 ohms) by means of the attenuators, and in steps of 1 dB by use of the \pm dB scale marks.

All connections to the HF unit, except the output cable, are taken through the HF-filter box, thus preventing stray radiation. Leakage of HF ener-

gy at the edges of the cover is prevented by mounting a stainless steel spiral into the groove that the cover fits into, thus ensuring a multitude of contact points between the parts.

1.2 MODULATION CIRCUITS: GENERAL

The internal modulation generator, 1/2 tube No.10, type ECC81, is a 1 kc/s LC oscillator. The operating point of the oscillator is adjusted by means of the "1 kc/s" potentiometer. The oscillator anode feeds the grid of the transformer coupled cathode follower stage, 1/2 tube No.10. At the transformer secondary the voltage is approximately 14 volts and the harmonic content approximately 0.3%.

With the MODULATION switch in positions INT AM, EXT FM and INT FM, EXT FM the 1 kc/s terminals on the front panel furnishes approx. 14 volts from a source impedance of 3 kilohms, while in position CW the output is taken via the MODULATION control thus providing a voltage adjustable from a few mV to about 14 volts.

The instrument offers the following possibilities of modulation:

- INT FM and EXT AM simultaneously
- EXT FM
- INT FM
- CW
- INT AM
- EXT AM
- INT AM and EXT FM simultaneously

1.3 INT AM

The adjustable 1 kc/s voltage which is taken from the MODULATION control is via a dividing network led to the grid of the output tube, No. 9, thus producing AM by grid modulation. The bias of the tube is set, by means of the AMII control in the LF unit. The correct setting of the AMII control is one which gives the best compromise between AM envelope distortion and distortion of the carrier.

The meter circuit which operates as a diode voltmeter is connected to the AM leads when the spring-return METER switch is set to AM. The meter scale reading is set by means of the AM potentiometer in the LF unit.

1.4 INT FM

The 1 kc/s voltage from the MODULATION control is via the MODULATION switch fed to the DEVIATION switch which by means of a dividing network of precision resistors produces the different ranges. In positions " ± 5 ", " ± 25 ", and " ± 75 " the signal is fed to the attenuator network connected to the range switch in such a way that the modulating voltage is attenuated 2, 1, 2, 4 and 8 times, corresponding to the frequency ranges from the lowest one to the highest one. In this way the deviation is made independent of the setting of the range switch. To make the deviation constant over a single range the signal is further attenuated by the 2 kilohm potentiometer which is connected to the variable capacitor drive in such a way that the voltage at the lowest frequency is twice that at the highest frequency on all ranges. The potentiometer sliding contact is connected to the reactance tube grid.

With the DEVIATION switch in the " ± 75 & INC.FREQ." position no attenuation is introduced, and consequently the deviation is multiplied by the same numbers that were mentioned above for the attenuation network. In this way, maximum deviation of ± 150 , ± 75 , ± 150 , ± 300 and ± 600 kc/s are available corresponding to the frequency ranges 0.3-15 Mc, 15-30 Mc/s, 30-60 Mc/s, 60-120 Mc/s and 120-240 Mc/s.

The meter circuit is connected to the FM leads with the METER switch in position FM. The scale readings are adjusted by means of the FM potentiometer in the LF unit.

1.5 EXT MOD FIDELITY

With the MODULATION switch in position INT AM, EXT FM any voltage applied to the EXT MOD terminals produces FM. The exact amount of FM can be measured by means of the meter. The FM modulation characteristic is flat within 1 dB from 50 cps to 15 kc/s.

In position INT FM, EXT AM voltage applied to the EXT MOD terminals produces AM. The actual AM is measured by means of the meter, and the modulation characteristic is flat within 1 dB from 50 c/s to 10 kc/s.

To produce maximum modulation approx. 10 V are necessary at 1 kc/s.

If only external modulation is wanted, the MODULATION control has to be turned to the extreme left-hand position.

1.6 INCREMENTAL FREQUENCY

In the same way that an a-c voltage applied to the reactance tube grid produces a dynamic deviation (FM), a d-c voltage produces static deviation (INC.FREQ.). The d-c voltage for the INC.FREQ. is taken from a potentiometer which is part of a voltage divider connected between +160 and -90 V, thus supplying both positive and negative voltage, zero corresponding to INC.FREQ. 0 kc/s. As the d-c voltage is combined with the a-c voltage before the last section of the DEVIATION switch, the same properties are obtained for the INC.FREQ. as for the FM, i.e. a) with the DEVIATION switch in positions "+5", "+25" and "+75" kc/s the dial reading is independent of the frequency b) in position "+75 & INC.FREQ." the dial reading is multiplied by 2, 1, 2, 4 or 8 corresponding to the frequency ranges from 0.3-15 Mc/s to 120-240 Mc/s.

1.7 POWER SUPPLY

The instrument operates from a 45-65 c/s power line. The voltage selector can be set to 110, 115, 127, 200, 220, and 240 volts. A filter is introduced at the power line connection to prevent RF leakage along the power cord.

The power supply contains two rectifier units, one supplying the -90 V stabilized by means of tube No. 13, type 90C1, and the other supplying +160 V. The +160 V voltage is stabilized by means of the series tube No. 11, type EL81 and the regulator tube No. 12, type 5654, using the -90V as reference. The "+160 V" potentiometer in the LF unit permits adjustment of the +160 volts.

Filament power for all the tubes is also drawn from the power supply.

SECTION II

OPERATING INSTRUCTIONS

2.1 CONNECTION

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

When changing the voltage, remove the instrument from the cabinet. Loosen the center screw on the voltage selector mounted on the line transformer and set the selector to the desired voltage.

When the voltage is set to 110, 115, and 127 volts, the d-c fuse (located on the front panel) should be replaced by a 0.6 amp slow-blow fuse.

Switch on the instrument with the power switch and allow to warm up for some minutes.

2.2 CONTROLS, DIALS, AND TERMINALS

All controls are located on the front panel.

a) Main frequency dial

Calibrated in megacycles. The four highest ranges are combined in two scales, each with two sets of figures. Provided with 16 crystal check points for calibration. All scales have been derived from the same variable frequency oscillator.

b) Frequency tuning knob

Located to the left below the main frequency dial. Provided with a handle for fast operation and a 0-100 vernier dial for interpolation purposes.

c) Calibration knob

Friction drive knob for moving the index. The calibration procedure is printed on the front panel. The trace of the index is small enough to prevent the index from being set to a wrong check point.

d) Incremental frequency dial

Permits small deviations from the main frequency. With the DEVIATION switch in position ± 5 , ± 25 and ± 75 kc/s the calibration applies to all ranges. In the position ± 75 & INC.FREQ. the readings should be multiplied by 2, 1, 2, 4 and 8 corresponding to the ranges 0.3-15, 15-30, 30-60, 60-120, and 120-240 Mc/s.

e) Range switch

Selects the desired frequency range.

f) Carrier control

Standardizes the attenuator calibration when the meter is set to the mark at 0 dB.

g) 0 Mc/s adjustment

Screwdriver adjustment of the converter oscillator frequency. To be adjusted in accordance with the calibrating instructions on the front panel. Use a screwdriver which is at least 130 mm long.

h) Attenuator

Indicates the output voltage when the meter reading (CW) is set to 0 dB. Calibrated in μV and dB/1 μV across 50 or 75 ohms. Can be set to values from 100 mV (100 dB) down to 0.1 μV (-20 dB). Open circuit voltage is 6 dB higher.

i) Modulation switch

Selects the type of modulation desired. In the left-hand position the Signal Generator can operate on:

- 1) Internal AM only
- 2) Simultaneous internal AM and external FM when modulation voltage is applied to the EXT MOD terminals.
- 3) External FM only. In this case the MODULATION control must be turned to the extreme left-hand position.

In the right-hand position the Signal Generator is set up for the same combinations, but with internal FM and external AM.

j) Modulation control

Located to the right of the meter. Controls the internal modulation depth. With the MODULATION switch in CW position the synchronizing voltage from the 1 kc/s terminal can be controlled from 0 to approx. 14 volts.

k) Meter switch

Connects in the neutral position the meter circuit to the attenuator input voltage, and in the two other positions to the AM and FM modulation circuits.

l) Deviation switch

Selects the FM range desired on the meter. In the three positions ± 5 , ± 25 and ± 75 kc/s the deviation reading of the meter applies to all ranges. In the right-hand position, ± 75 & INC. FREQ. the meter reading on the scale 0- ± 75 kc/s and the reading of the INCREMENTAL FREQ. dial have to be multiplied by 2, 1, 2, 4 and 8 corresponding to the ranges 0.3-15, 15-30, 30-60, 60-120 and 120-240 Mc/s.

m) Power input terminals

Located to the lower left on the front panel. Should be connected to the power line by means of the type 12H19-1.5 power cord supplied with the instrument.

n) HF output terminals

The output may be drawn from either the 50 or the 75 ohm type UG-290/U BNC connectors, but not from both of them at the same time. Put the cap on the terminal not in use to prevent stray radiation. The instrument is supplied with 50 and 75 ohm output cables, types 6E6 and 6D6, respectively.

o) EXT MOD terminals

For injecting external modulation voltage. The voltage required is approx. 10 volts at 1 kc/s.

Source impedance > 3 kilohms.

p) 1 kc/s terminals

Furnish approx. 14 volts (1 kc/s) for oscilloscope synchronisation. Source impedance < 3 kilohms. With the MODULATION switch in

position CW the voltage can be adjusted from 0 to approx. 14 volts by means of the MODULATION control.

q) Phones

Terminals for plugging-in of headphones to indicate the zero beat during the calibration procedure. When the phones are plugged in, h.t. is applied to the crystal oscillator, and the HF monitoring circuit is disconnected.

r) Meter

Monitors the HF voltage at the attenuator with the METER switch in neutral position. Provided with marks for 0 dB (normal output) and ± 1 dB for interpolation.

Monitors the modulation voltage with the METER switch in FM or AM positions.

s) Fuses

Protect the instrument against overload. The power fuse is accessible from the front panel. At 200, 220, and 240 volts a 0.3 amp, and at 110, 115, and 127 volts a 0.6 amp slow-blow fuse should be used. If ordinary quick-blow fuses are used, higher values must be chosen to prevent the fuses from burning out when switching on. However, the protection of the instrument becomes correspondingly poorer. Suitable values are 2 amps and 4 amps, respectively.

The plate voltage fuse (0.3 amp quick-blow) is mounted in the LF unit.

t) Pilot lamp

6 volts, 0.2 amp

2.3 STEP-BY-STEP OPERATION

- 1) Make sure that the voltage indicator is set at the correct voltage.
- 2) Connect the instrument to the power line, switch it on, and allow it to warm up for a few minutes.
- 3) Calibrate the instrument around the frequency desired in accordance with the instructions on the front panel.
- 4) Set the RANGE switch to the desired frequency.

- 5) Set the frequency tuning dial to the desired frequency.
- 6) Turn the CARRIER control until the meter reads 0 dB.
- 7) Throw the MODULATION switch to the desired type of modulation. In the case of FM set the DEVIATION switch to a suitable position.
- 8) With the METER switch in the modulation positions, turn the MODULATION control until the desired modulation depth is obtained.
- 9) Set the HF output by means of the ATTENUATOR. It may become necessary to reset the 0 dB level.

SECTION III

MAINTENANCE

3.1 GENERAL

The type MS27 Signal Generator has been designed to withstand a certain amount of rough treatment, but careful handling and proper operation result in longer life and higher stability.

Such repairs as may become necessary should only be made by skilled personnel provided with sufficient equipment to ensure that the repair is properly made.

Unnecessary repair or attempts to improve the accuracy should not be made.

When the instrument is not in use, the power switch should be turned off.

The Signal Generator is able to stand elevated temperatures and moisture, but it is advisable not to expose the instrument to extreme temperatures, moisture, and dust unless necessary.

If the type MS27 Signal Generator is treated carefully, long life and troublefree service may be expected.

3.2 REMOVING THE INSTRUMENT FROM THE CABINET

The Signal Generator can be removed from the cabinet when the six fixing screws along the edge of the front panel have been removed.

3.3 TUBE REPLACEMENT

In general the tubes of the type MS27 Signal Generator require no replacement until they cause some kind of trouble. The troubles generally originating from faulty tubes are: insufficient power output, faulty internal modulation, etc.

The LF unit:

Replacement of any tube of the voltage regulator (tubes No. 11, 12 and 13) may cause a change in magnitude of the regulated voltage. Therefore, when changing a tube of the regulator circuit, it is advisable to

measure the value of the regulated voltage (terminal No.11 at the LF unit output). This voltage should be approximately 160 volts, and it can be adjusted to the proper value by means of the "+160 V" screw driver adjustment. It should be noted, however, that any change in the -90 volt or +160 volt supplies affects the calibration of the Incremental Frequency dial. Consequently a value differing slightly from 160 volts may be the correct one.

When the 1 kc/s oscillator tube (No.10) is replaced, it may become necessary to set the "1 kc/s" adjustment. In position CW the 1 kc/s output should be approx. 15 volts with a distortion of about 0.3%.

The HF unit:

The HF unit is contained within a shielded box, the cover of which can be removed by undoing the two screws and pulling the black cover away. When replacing the cover, make sure that the edges of the cover are properly inserted in the groove, as otherwise stray radiation will result.

The tubes of the HF unit should only be replaced if absolutely necessary.

Calibrating oscillator (tube No.1):

This stage requires no adjustment after the replacement. If, by chance, the oscillator does not function properly, the core of coil L_1 , loc. A2 may be adjusted.

Reactance tube (tube No.2):

When replacing this tube, the FM calibration and the Incremental Frequency calibration may be affected. To make this circuit operate correctly it is necessary first to select the resistance R_1 (loc. D3) so that minimum FM distortion is achieved. Next the meter sensitivity should be set by means of the FM screw driver adjustment in the LF unit to make the meter reading correct in position FM. The adjustment should be made in such a way that the kc/s FM are correct when the meter switch is released. Finally the "+50 kc/s" adjustment must be set to give correct Inc. Freq. readings.

A method of measuring the FM is described below.

Oscillator (tube No.3):

Replacement of the oscillator tube may affect the frequency dial calibration by narrowing or widening the frequency range. This is examined by means of the calibration oscillator. If the adjustable index is set to give correct frequency reading at say 15 Mc/s, the reading at 30 Mc/s may be incorrect. The limits of the frequency range can be moved by adjusting the 11 pF trimmer mounted on the variable capacitor, loc. B4, and as outlined above, correct calibration may be ensured by successive measurements.

Tripler stage (tube No.4):

With the frequency range switch in the 120-240 Mc/s position the 11 pF trimmer mounted on section No.2 of the ganged variable capacitor is adjusted to give maximum output at 240 Mc/s. Replacement of this tube will generally not involve any adjustment of the tank coil L_5 , loc. B6.

Doubler stages (tubes No.5, 6 and 7):

The adjustment procedure for tube No.4 may be followed.

In case the tube replacement and subsequent adjustment of the 11 pF capacitors does not give satisfactory performance on one of the ranges, adjustment of the coil of that stage may be tried. The frequency range is set to 120-240 Mc/s as before, and the trimmer is adjusted to give maximum output at 240 Mc/s. Then the coil is adjusted to give maximum output at 120 Mc/s (by turning the dust core or by changing the spacing of the coil turns). This affects the trimmer which must be readjusted. At successive adjustment optimum performance may be obtained.

36 Mc/s oscillator and converter (tube No.8):

When this tube has been replaced, only the oscillator frequency will have to be adjusted as described on the front panel. If the "0 Mc/s Adj." does not give sufficient change of frequency, the spacing of the turns of the oscillator coil L_{11} , loc. B11, may give the required frequency setting.

Output stage (tube No.9):

Replacement of this tube affects the AM setting. By means of a screw driver adjustment (AM II in the LF unit) the grid bias is adjusted to a value giving about 4% envelope distortion at 50% AM. With some tubes a lower value of distortion may be obtained, but this may affect the waveform of the carrier output. When the bias has been set to the correct value, the AM adjustment in the LF unit must be set in order to give correct AM meter reading.

Replacement of silicon rectifier:

The silicon rectifier used in the CW metering circuit is subject to damage from electrical or mechanical shocks.

When the lid of the 5x20 dB attenuator and the small contact piece inside have been removed, the rectifier cartridge can be pulled out. If the backward to forward ratio resistance is less than 10:1, or if the forward resistance is higher than about 300 ohms, the cartridge should be discarded. The measurement should be performed at a voltage not exceeding 1.5 volts.

3.4 MEASUREMENT OF FM, AM AND CW

Frequency modulation:

If it is desired to check the frequency modulation, this may be done either with special instruments or by the "Vanishing Carrier Method" outlined below.

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: ΔF to the modulating frequency: f, i.e.

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

and consequently the frequency deviation

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

The carrier will be zero at the following modulation indices:

2.404
5.520
8.653
11.791
14.930
19.071
21.212
etc.

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

The FM meter reading can be adjusted by means of the FM potentiometer in the LF unit.

Amplitude modulation:

The AM reading can be checked either by means of a selective modulation meter, and this is the method to be preferred, or by displaying the output from one of the lower ranges on an oscilloscope screen. The latter method does not offer a high degree of accuracy, but it may be adequate for many applications.

The AM meter reading can be adjusted by means of the AM potentiometer in the LF unit.

CW :

The CW reading can be checked either with a selective voltmeter or with a broadband voltmeter at e.g. 1 Mc/s. The first method is to be preferred as the influence of harmonics is avoided.

The CW meter reading can be adjusted by means of the CW potentiometer in the LF unit.

3.5 SCREW DRIVER ADJUSTMENTS AND THEIR FUNCTIONS

In the LF unit:

"1 kc/s"	Adjustment of 1 kc/s oscillator feedback. Used for setting the oscillator to operate at a point of low distortion and suitable output (approx. 15 volts in position CW).
"CW"	Adjustment of meter sensitivity with meter switch in position CW.
"AM"	Adjustment of meter sensitivity with meter switch in position AM.
"FM"	Adjustment of meter sensitivity with meter switch in position FM.
"+160 V"	Adjustment of regulated +160 V supply. This voltage affects the Incremental Frequency calibration.
"AM II"	Adjustment of grid bias of the output stage, tube No. 9. This adjustment influences AM distortion and calibration.

3.6 OPERATING VOLTAGES AND CURRENTS OF THE SIGNAL GENERATOR

The voltages and currents listed on the following pages can be used when servicing the signal generator. These values are mean values from a series of measurements, and deviations up to 20% may usually be neglected.

The voltmeter used should have a negligible consumption (vacuum-tube voltmeter) and should for all measurements on HF grid circuits be equipped with a low capacitance probe.

D-C VOLTAGE MEASUREMENT

All voltages measured to chassis

tube No. 1	pin No. 1	-8 V
	5-6	65 V
tube No. 2	pin No. 2-7	4.7 V
	5-7	160 V
tube No. 3	pin No. 1	-4.8 to -6.4 V
	5	160 V
	6	100 V
tube No. 4	pin No. 1	-16 to -20 V
	5	150 V
	6	140 V
tube No. 5	pin No. 1	-26 to -35 V
	5	115 V
	6	135 V
tube No. 6	pin No. 1	-18 to -23 V
	5	150 V
	6	135 V
tube No. 7	pin No. 1	-12 to -17 V
	5	150 V
	6	135 V
tube No. 8	pin No. 1	150 V
	2	-1.6 V
	3	1.5 V
	6	115 V
	7	-3.5 V
tube No. 9	pin No. 2	-1.8 V
	7	145 V
	9	150 V
tube No. 10	pin No. 1	158 V
	3	14 V
	6	300 V
	8	6 V
tube No. 11	pin No. 2	141 V
	3-4-5	160 V
	6-9	300 V
	8	300 V
	top	300 V
tube No. 12	pin No. 1	-4.6 V
	5	141 V
	6	160 V
tube No. 13	pin No. 7	-88 V

CURRENT MEASUREMENTS

Total primary consumption at 220 volt line voltage 300 mA

APPENDIX

1) FINE TUNING CONTROL

In addition to the INCREMENTAL FREQ. dial the instrument has been provided with a FINE TUNING control which is located just below the INCREMENTAL FREQ. dial.

The FINE TUNING dial is uncalibrated and gives a frequency deviation of approximately 3×10^{-4} of the main frequency. When the white dot on the knob points upwards, the control is in its neutral position.

The control does not affect the INCREMENTAL FREQ. dial.

2) AF SYNCHRONIZATION VOLTAGE FROM THE TERMINAL 1 kc/s

To avoid spurious FM in the CW position of the MODULATION switch the AF modulation oscillator is switched off in this position so that no AF output is available from the terminal 1 kc/s in the CW position. In the two other positions (INT.FM, EXT.AM and vice versa) the conditions are unchanged.

3) EXT. MODULATION

The voltage required for full modulation is approximately 25 volts, and the input impedance has been increased to at least 6 kilohms.

