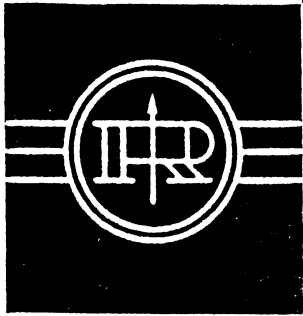


# INSTRUCTION MANUAL

FM-AM Standard  
Signal Generator  
Type MS27e



# RADIOMETER

ELECTRONIC MEASURING INSTRUMENTS  
FOR SCIENTIFIC AND INDUSTRIAL USE

**Instruction Manual  
for**

**FM-AM Standard  
Signal Generator  
Type MS27e**

## Table of Contents

	page
SECTION A - INTRODUCTION	A1
SECTION B - SPECIFICATIONS	B1
SECTION C - ACCESSORIES	C1
1. The Balancing Transformer, type UBT3	C1
2. The Attenuators, type FDL2 and FDL3	C2
SECTION D - GENERAL DESCRIPTION	D1
1. General	D1
2. Controls, Dials and Terminals	D2
SECTION E - OPERATION	E1
1. Preparing the FM-AM Standard Signal Generator, type MS27	E1
2. Operating the FM-AM Standard Signal Generator, type MS27	E1
SECTION F - CIRCUIT DESCRIPTION	F1
1. The HF Unit	F1
2. Modulation Circuits	F2
3. Incremental Frequency	F3
4. Fine Tuning Control	F4
5. Power Supply	F4
SECTION G - MAINTENANCE	G1
1. General	G1
2. Removing the Instrument from the Cabinet	G1
3. Tube Replacements	G1
4. Measurement of FM, AM, and CW	G3
5. Screw-driver Adjustments and Their Functions	G3
6. Operating Voltages and Currents of the Signal Generator	G4
7. DC Voltage Measurements	G5

# FM-AM Standard Signal Generator Type MS27 e

## Section A. Introduction

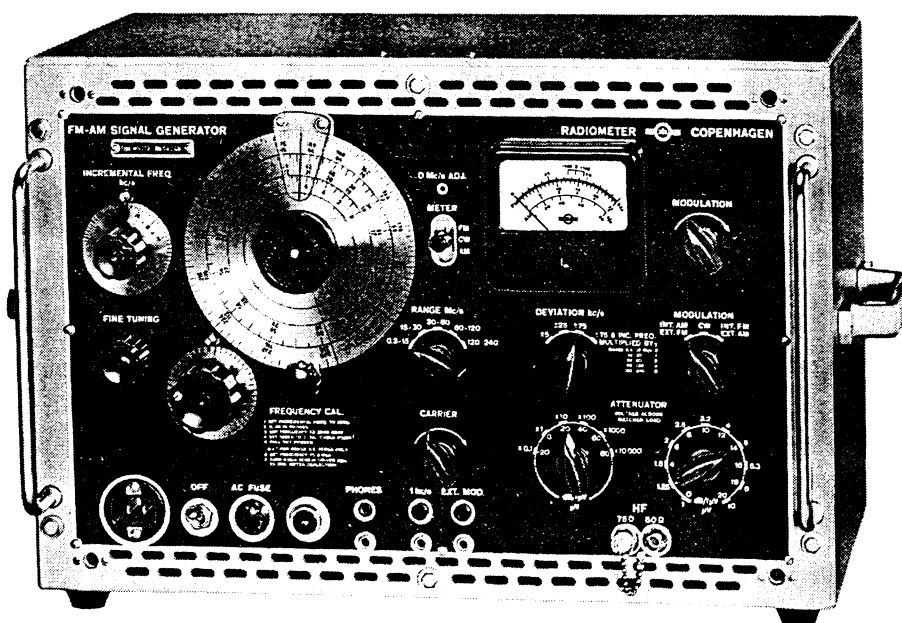


Fig.1. The FM-AM Standard-Signal Generator, type MS27

The FM-AM Standard-Signal Generator, type MS27, 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 use-

ful in many applications where otherwise an AM generator would have to be used. It furthermore accepts a stereo signal.

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.

The Standard-Signal Generator, type MS27, gives complete coverage from 0.3 to 240 MHz 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  $\pm 50$  kHz 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  $\pm 400$  kHz, the maximum value depending on the frequency range.

From two outputs with source impedances of 50 and 75  $\Omega$  respectively, voltages from 0.1 microvolt to 0.1 volt are avail-

able 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  $\Omega$  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  $\pm 5$ ,  $\pm 25$ , and  $\pm 75$  kHz 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 kHz, but if an external source is used, the frequency response referred to 1 kHz is within  $\pm 0.5$  dB from 10 Hz to 60 kHz on FM and within  $\pm 1$  dB from 50 Hz to 10 kHz 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.

## Section B. Specifications

### CARRIER FREQUENCY

<u>Range:</u>	0.3 to 240 MHz in 5 direct-reading sub-ranges, viz.: 0.3 - 15 MHz 15 - 30 MHz 30 - 60 MHz 60 - 120 MHz 120 - 240 MHz
<u>Calibration:</u>	16 crystal check points on each of the ranges above 15 MHz 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 MHz.
<u>Incremental Frequency:</u>	The dial calibration from 0 to +50 kHz with 2 kHz divisions is valid at all frequencies. With the deviation range switch at $\pm 75$ kHz & 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.
<u>Fine Tuning:</u>	Provides for about $\pm 3 \cdot 10^{-4}$ change of the carrier frequency above 15 MHz and about $\pm 15$ kHz below 15 MHz.
<u>Interpolation Dial:</u>	Gearing ratio to frequency dial 1:20. The dial carries a 0-100 scale for interpolation purposes.

## CARRIER OUTPUT

Output Level:

0.1  $\mu\text{V}$  to 0.1 V across a matched load.  
 0.2  $\mu\text{V}$  to 0.2 V open-circuit. The level is adjustable in steps of 2 dB by means of the cascaded 5  $\times$  20 dB and 10  $\times$  2 dB attenuators. Intermediate values are obtained by use of the +1, 0, and -1 dB marks on the meter scale.

The attenuators are calibrated in  $\mu\text{V}$  and dB over 1  $\mu\text{V}$ , both measured across a matched load.

Output Impedances:

Two outputs with nominal impedances of 50  $\Omega$  and 75  $\Omega$ .

Accuracy of Output Voltage:

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

## Accuracy of voltmeter:

$\pm 1$  dB to 150 MHz

+1 or -2 dB to 240 MHz

## Accuracy of attenuator:

1 dB above 10  $\mu\text{V}$

2 dB + 0.05  $\mu\text{V}$  below 10  $\mu\text{V}$

Stray Radiation:

Negligible. Does not interfere with sensitivity measurements down to 0.1  $\mu\text{V}$ .

Terminals:

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

## FREQUENCY MODULATION

Deviation Ranges:

0 to  $\pm 5$  kHz, 0 to  $\pm 25$  kHz, and 0 to  $\pm 75$  kHz with direct-reading scales.

With the deviation range switch in the position  $\pm 75$  & Inc. Freq., all readings on the  $\pm 75$  kHz 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  $\pm 600$  kHz deviation is available in the 120-240 MHz range.

Distortion:

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

<u>Accuracy:</u>	7% of full scale at 1 kHz.
<u>AM or FM:</u>	At $\pm 75$ kHz deviation, the AM produced is typically below 10%.
<u>Incidental FM:</u>	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 $\pm 75$ kHz modulation level at 150 MHz.
<u>External FM:</u>	Approximately 3 volts into approx. a $200\text{ k}\Omega$ load required for maximum FM. The deviation is measured by means of the internal metering circuit, and the frequency response referred to 1 kHz is within $\pm 0.5$ dB from 10 Hz to 60 kHz.

## AMPLITUDE MODULATION

<u>Range:</u>	0 to 80% AM. The meter scale is calibrated in % AM from 0 to 80.
<u>Distortion:</u>	The envelope distortion is typically 5% at 50% AM.
<u>Accuracy:</u>	10% of reading $\pm 5\%$ AM at 1 kHz.
<u>FM or AM:</u>	At 30% AM, 1 kHz, the FM produced is typically 5 parts per million.
<u>Residual AM:</u>	Typically below 0.2% AM due to hum and noise.
<u>External AM:</u>	Approximately 3 volts into an approx. $200\text{ k}\Omega$ load required for maximum AM. The modulation depth is measured by means of the internal metering circuit, and the frequency response referred to 1 kHz is within $\pm 1$ dB from 50 Hz to 10 kHz.

## MODULATING OSCILLATOR

<u>Frequency:</u>	1 kHz $\pm 5\%$
<u>Distortion:</u>	Below 0.5%
<u>1 kHz Output:</u>	A synchronizing voltage of about 3 volts available from terminals on the front panel. Output impedance approx. $200\text{ k}\Omega$ .

## POWER SUPPLY

<u>Voltages:</u>	110, 115, 127, 200, 220, 240 volts.
<u>Line Frequencies:</u>	45 to 65 Hz.
<u>Consumption:</u>	60 VA:



## TUBE COMPLEMENT

8 type 5654 (6AK5)	1 type E180F (6688)
1 type ECC81 (12AT7)	1 type EL81 (6CJ6)
1 type 90C1	1 type E235L

## DIMENSIONS

<u>Height:</u>	370 mm (13 inches)
<u>Width:</u>	560 mm (22 inches)
<u>Depth:</u>	270 mm (10.5 inches)

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

## WEIGHT

22 kg net (49 lbs)

## MOUNTING AND FINISH

Steel cabinet finished in grey enamel.

## ACCESSORIES SUPPLIED

1 50  $\Omega$  coaxial cable, type 6E6, with BNC connectors, type UG-88/U.

1 75  $\Omega$  coaxial cable, type 6D6, with BNC connectors, type UG-88/U.

1 power cord, type 12K21-1.5.

## ACCESSORIES AVAILABLE

Balancing Transformer,  
type UBT3

Provides for balanced output voltages from 40 MHz to 250 MHz. Impedance ratio 75 to 300  $\Omega$ , voltage ratio 1:1. BNC input socket.

20 dB Pads, type FDL2/3

Small 20 dB attenuators terminated in male and female BNC connectors. Type FDL2. 75  $\Omega$ ; type FDL3: 50  $\Omega$ .

Protective Cover,  
type MS27/L

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

Coaxial Cable, type 3D6  
(75  $\Omega$ )

With one UHF plug, type PL-259, and one BNC plug, type UG-88/U.

## Section C. Accessories

### THE BALANCING TRANSFORMER, TYPE UBT3

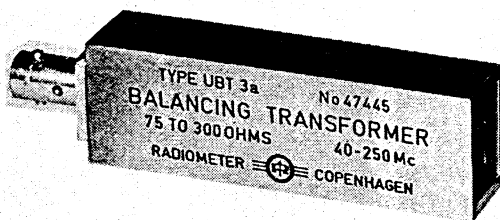


Fig.3. The Balancing Transformer, type UBT3

#### General

The Balancing Transformer, type UBT3, has been designed to produce a balanced output voltage from a signal generator. It has a voltage ratio of 1:1; i.e. the calibration of the signal generator can be used directly.

When the Balancing Transformer is connected to a 75  $\Omega$  source, the output impedance is 300  $\Omega$ . The balance of the output voltage is within a few per cent up to 200 MHz and within 5% up to 250 MHz.

The unit contains a specially designed transformer and a resistive matching network. It has a BNC input socket and output from a socket which matches a

commercially available 2-pin plug for twin-lead cable. One plug is supplied with the type UBT3.

#### Specifications

Frequency Response: Within 1 dB from 40 MHz to 250 MHz with 300  $\Omega$  load.

Voltage Ratio: 1:1.

Accuracy of Output Voltage: Within  $\pm 1$  dB of nominal value.

Output Impedance: 300  $\Omega$  when connected to a 75  $\Omega$  source.

#### Terminals:

Input: BNC socket, type UG-290/U

Output: Socket for 2-pin plug. The correct pin diameter is 3.2 mm (1/8 inch) and the spacing is 7.9 mm (5/16 inch).

#### Dimensions and Weight

Height: 25 mm (3/4 inch)

Width: 18 mm (1 inch)

Depth: 100 mm (4 inches)

Weight: 150 grams (5 1/2 oz.)

Accessories supplied: 1 type TS6217 plug (Belling Lee) for twin-lead cable.

## THE ATTENUATORS, TYPE FDL2 AND FDL3

### General

The Attenuators, type FDL, constitute a series of attenuators to be used from dc to about 300 MHz. Two types are available:

Type FDL2: 75  $\Omega$  nominal impedance, with BNC-type connectors.

Type FDL3: 50  $\Omega$  nominal impedance, with BNC-type connectors.

They are constructed as single-section pi-type resistive networks. They contain high-stability carbon resistors of the film-type, selected to close tolerances.

The attenuators are completely shielded by a metal casing, no undesired electrical coupling to the internal elements being possible.

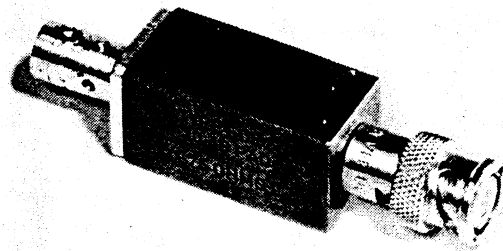


Fig.4. The Attenuator, type FDL2

### Specifications

Attenuation: 20 dB

Impedance: Type FDL2: 75  $\Omega$   
FDL3: 50  $\Omega$

Accuracy: Within  $\pm 0.2$  dB at dc  
Within  $\pm 0.5$  dB to 250 MHz.

Maximum Power Input: 0.1 VA.

Dimensions and Weight:

18 mm square  $\times$  76 mm long  
3/4 inch -  $\times$  3 inches -

Weight: 70 grams (2 1/2 oz.).

Terminals: BNC-type coaxial connectors, male and female.

## Section D. General Description

### GENERAL

The operating principle of the FM-AM Standard-Signal Generator, type MS27, is indicated in the schematic diagram shown in Fig.5 and can be described as follows:

The RF signal originates from an oscillator which is tuned from 7.5 to 15 MHz. This oscillator feeds a series of four har-

monic amplifiers which produce the frequency ranges 15-30, 30-60, 60-120, and 120-240 MHz. 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 0.3-15 MHz range is produced by mixing the output from a 36 MHz oscillator with 36.3-51 MHz signals from the second doubler stage.

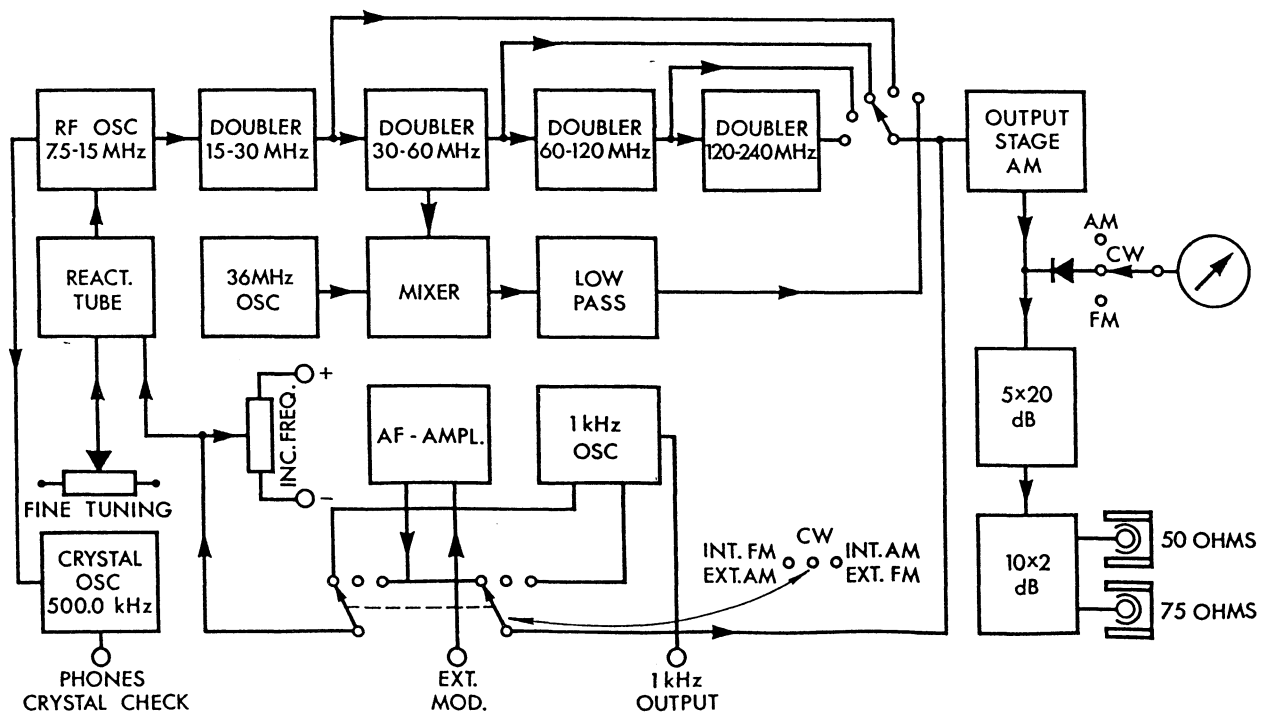


Fig.5. Simplified Block Diagram of the FM-AM Standard-Signal Generator, type MS27

By means of the range switch, signals from the proper harmonic amplifier are coupled to the output stage which in turn feeds the cascaded  $5 \times 20$  dB and  $10 \times 2$  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 Q's of the circuits, spurious frequency outputs which are at least 7.5 MHz from the carrier are present, but their levels are so low that they rarely cause trouble.

The crystal checks are produced by beating the 7.5-15 MHz oscillator signal with a 0.5000 MHz crystal-controlled oscillator.

Across the 7.5-15 MHz 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, which are ganged to the range switch and the tuning drive, have been included. If part of this network is disconnected, the frequency deviations are multiplied in the same manner as the carrier frequencies, which means that the  $\pm 75$  kHz readings are to be multiplied by 2, 1, 2, 4, or 8, according to the frequency ranges. Thus, up to  $\pm 600$  kHz deviation is available from 120-240 MHz.

To eliminate all stray radiations, all 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 analogous. Thus, the  $\pm 50$  kHz 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 elimi-

nates side-band cutting and ensures extremely low reaction on the 5-10 MHz 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.

## CONTROLS, DIALS, AND TERMINALS

As can be seen on Fig.6, all controls are located on the front panel.

### 1. Power Switch

Switches the Signal Generator on or off.

### 2. Pilot Lamp

Monitors the OFF switch.

### 3. Main Frequency Dial

Calibrated in megahertz. 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.

### 4. Frequency Tuning Knob

Provided with a handle for fast operation and a 0-100 vernier dial for interpolation purposes.

### 5. FREQUENCY CALIBRATION Knob

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

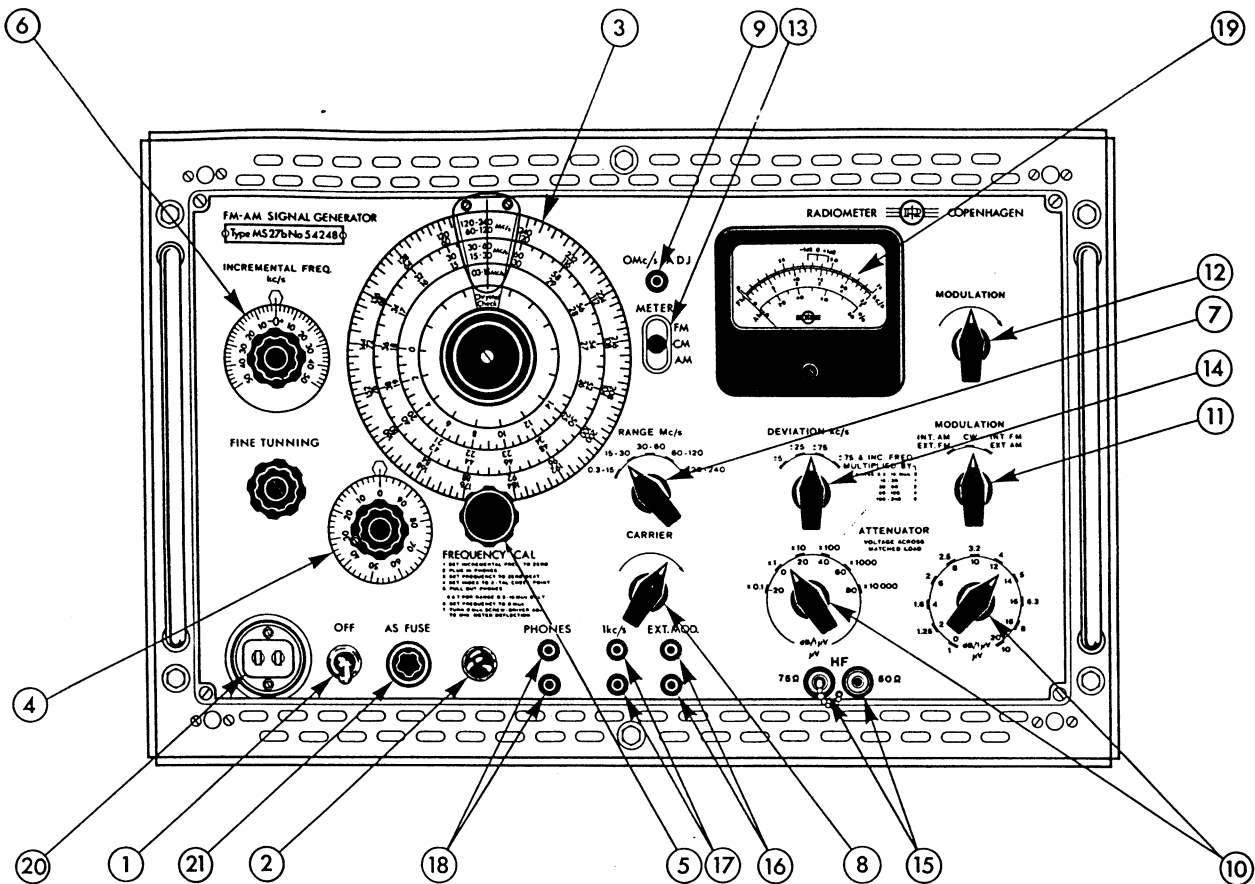


Fig.6. Front Plate of the FM-AM Standard-Signal Generator, type MS27

#### 6. INCREMENTAL FREQUENCY dial

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

#### 7. RANGE switch

Selects the desired frequency range.

#### 8. CARRIER control

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

#### 9. 0 MHz 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.

#### 10. ATTENUATOR control

Indicates the output voltage when the meter reading (CW) is set to 0 dB. Calibrated in  $\mu\text{V}$  and dB/ $\mu\text{V}$  across 50 or 75  $\Omega$ . Can be set to values from 100 mV (100 dB) down to 0.1  $\mu\text{V}$  (-20 dB). Open circuit voltage is 6 dB higher.

#### 11. MODULATION switch

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

Internal AM only

Simultaneous internal AM and external FM when modulation voltage is applied to the **EXT.MOD.** terminals.

### 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.

### 12. MODULATION control

Controls the internal modulation depth.

### 13. METER switch

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

### 14. DEVIATION switch

Selects the FM range desired on the meter. In the three positions  $\pm 5$ ,  $\pm 25$  and  $\pm 75$  kHz, the deviation reading of the meter applies to all ranges. In the right-hand positions,  $\pm 75$  & INC.FREQ., the meter reading on the scale 0- $\pm 75$  kHz 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 MHz.

### 15. HF Output Terminals

The output may be drawn from either the 50 or the 75  $\Omega$  connectors, type UG-290/U BNC, 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  $\Omega$  output cables, types 6E6 and 6D6, respectively.

### 16. EXT. MOD. terminals

For injecting external modulation voltage. The voltage required is approx. 3 volts at 1 kHz.

Source impedance approx. 200 k $\Omega$ .

### 17. 1 kHz terminals

Furnish approx. 3 volts (1 kHz) for oscilloscope synchronization.

Source impedance approx. 200 k $\Omega$ .

### 18. 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.

### 19. Meter

Monitors the HF voltage at the attenuator with the METER switch in neutral position. It is provided with marks for 0 dB (normal output) and  $\pm 1$  dB for interpolation. It also monitors the modulation voltage with the METER switch in FM or AM positions. The two upper scales are used when measuring FM, and are calibrated from 0 to 75 kHz and from 0 to 25 kHz. The lower scale is used when measuring AM, and is calibrated from 0 to 80%.

### 20. Line Voltage Receptacle

Allows for connection to the power line by means of the power cord, type 12G19-1.5, supplied with the instrument.

### 21. AC Fuse

The FM-AM Standard Signal Generator, type MS27, is set to a line voltage of 220 V when leaving the factory, and it is therefore provided with two 0.4 A slow-blow fuses for 200-240 V operation.

### 22. Line Voltage Selector

Is located on the rear of the instrument and permits operation from line voltages of 110, 115, 127, 200, 220, and 240 V.



## Section E. Operation

### PREPARING THE FM-AM STANDARD SIGNAL GENERATOR, TYPE MS27

Check that the instrument is switched to the value of the voltage to be employed. When leaving the factory, the instrument is switched to 220 V. If used on another line voltage, remember to reconnect the leads to other supply transformer tags and change the fuse, if necessary. A 0.8 A slow-blow fuse should be used for 110 - 127 V operation, and a 0.4 A slow-blow fuse for 200 - 240 V operation.

### OPERATING THE FM-AM STANDARD SIGNAL GENERATOR, TYPE MS27

- 1) Prepare the instrument as above.
- 2) Set the INCREMENTAL FREQ. dial to zero.
- 3) Plug in phones.
- 4) Set frequency to zero beat by means of FINE TUNING knob.
- 5) Set the index of the frequency dial to CRYSTAL CHECK point by using the knob below the aforementioned frequency dial.
- 6) Pull out the phones.
- 7) When using the 0.3 - 15 MHz range only, set the frequency to 0 MHz, and then turn the 0 MHz ADJ. screw-driver adjustment so as to obtain minimum meter deflection.
- 8) Set the RANGE switch to the desired frequency range.
- 9) Turn the CARRIER potentiometer until the meter reads 0 dB on the uppermost scale.
- 10) Throw the MODULATION switch to the desired type of modulation. In the case of FM, set the DEVIATION switch to a suitable position.
- 11) With the METER switch in a position corresponding to the chosen type of modulation, turn the MODULATION control until the desired modulation depth is obtained.
- 12) Set the HF output by means of the ATTENUATOR. It may become necessary to reset the 0 dB level. This is done by means of the CARRIER potentiometer.

## Section F. Circuit Description

### 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.

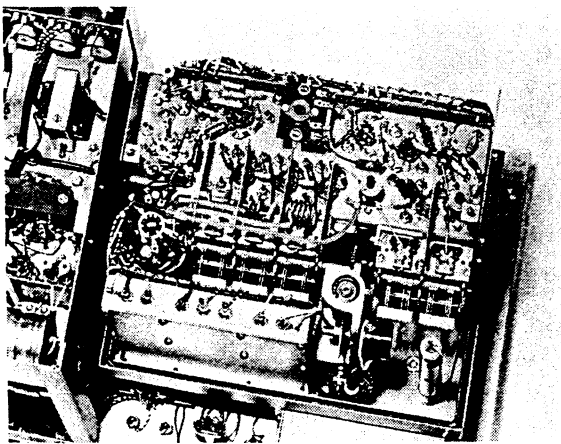


Fig.7. The HF unit viewed from the rear with the cover removed

The 7.5-15 MHz oscillator tube No.3 is operated as a tuned plate oscillator. The tuning is accomplished by means of the variable capacitor C8A (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 re-

actance tube No.2 is connected. It acts as a variable inductance providing for frequency modulation. The resistors R16 and R80 (loc.D3) are connected to +160 V and control the bias of the reactance tube. When replacing the reactance tube, it may become necessary to adjust resistor 15 to obtain minimum FM distortion.

Tube No.1 (loc.B2) operates as a crystal-controlled 0.5000 MHz oscillator. Through a capacitor, part of the 7.5-15 MHz oscillator signal is fed to the grid of the crystal oscillator, thus producing zero beats whenever the oscillator frequency is a multiple of 0.5000 MHz, i.e. at 7.5000, 8.000.....15.000 MHz. 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 resistor R77 (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 megahertz on the 15-30 MHz 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 MHz range), as all signals are derived from the 7.5-15 MHz range by means of doubling operations.

As a reminder that the phones are plugged in, the meter is disconnected by means of the phone switch (loc.G2).

From the 7.5-15 MHz oscillator tank circuit, voltage is applied to the grid of tube No.4 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 second harmonic, the frequency range 15-30 MHz is produced. The tuning is accomplished by means of capacitor C8B which is section No.2 of a five-gang variable capacitor.

The soldered vane assembly of this five-section capacitor in connection with the silver plating 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 MHz tank circuit connects to the grid of tube No.5 and from a tap to the HF section of the range switch, which in the 15-30 MHz position leads the signal to the grid of the output tube.

Tube No.5 operates like tube No.4, i.e. it is adjusted to operate as a frequency doubler, thus producing signals in the range from 30-60 MHz. 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 MHz position, is connected to the output tube.

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

The 0.3-15 MHz range is produced by means of the 36 MHz Colpitts oscillator, 1/2 tube No.8, and a mixer stage, 1/2 tube No.8, which receives signals from the 36 MHz oscillator and via the range switch from the 30-60 MHz stage. The output is taken through a low-pass filter

which cuts off unwanted signals. The 36 MHz oscillator is adjustable through a narrow frequency range by means of a 6 pF shunt capacitor which is accessible from the front panel (0 MHz ADJ.) by means of a screw-driver.

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

A crystal rectifier unit is built into the 5x20 dB attenuator to provide for monitoring of the output voltage. With the switch METER in neutral position, the attenuator input voltage is indicated on the meter scale.

The attenuators are of the ladder-type using lumped components. All internal cables are terminated without reflections to give the accuracy required. The 10x2 dB attenuator is connected to the 50  $\Omega$  output, and a 25  $\Omega$  resistor between the two connectors gives correct 75  $\Omega$  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.

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

## MODULATION CIRCUITS

### General

The internal modulation generator, 1/2 tube No.10, is a 1 kHz LC oscillator.

The operating point of the oscillator is adjusted by means of the 1 kHz potentiometer R107. 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 switch MODULATION in positions INT.AM, EXT.FM and INT.FM, EXT.AM, the 1 kHz terminals on the front panel furnish approx. 3 volts from a source impedance of 200 k $\Omega$ , while in position CW, the 1 kHz LC oscillator is disconnected.

#### Internal AM Modulation

The adjustable 1 kHz 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 AMI control in the LF unit. The correct setting of the AMI control is the 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.

#### Internal FM Modulation

The 1 kHz voltage from the MODULATION control is via the switch MODULATION fed to the switch DEVIATION which by means of a dividing network of precision resistors produces the different ranges. In positions  $\pm 5$ ,  $\pm 25$ , and  $\pm 75$ , 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 potentiometer R13 which is connected to the variable capacitor drive in such

a way that the voltage at the lowest frequency is twice the voltage at the highest frequency on all ranges. The potentiometer sliding contact is connected to the reactance tube grid.

With the switch DEVIATION in position  $\pm 75$  and INC.FREQ., 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  $\pm 150$ ,  $\pm 75$ ,  $\pm 150$ ,  $\pm 300$  and  $\pm 600$  kHz is available, corresponding to the frequency ranges 0.3-15 MHz, 15-30 MHz, 30-60 MHz, 60-120 MHz and 120-240 MHz.

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

#### External Modulation Fidelity

With the switch MODULATION 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 referred to 1 kHz is flat within  $\pm 0.5$  dB from 10 Hz to 60 kHz.

In position INT.FM, EXT.AM, voltage applied to the EXT.MOD. terminals produces AM. The actual amount of AM is measured by means of the meter, and the modulation characteristic referred to 1 kHz is flat within  $\pm 1$  dB from 50 Hz to 10 kHz.

To produce maximum modulation, approx. 3 V are necessary at 1 kHz. If only external modulation is wanted, the MODULATION control has to be turned to the extreme left-hand position.

#### INCREMENTAL FREQUENCY

In the same way as an ac voltage applied to the reactance tube grid produces

a dynamic deviation (FM), a dc voltage produces static deviation (INC.FREQ.). The dc 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 kHz. As the dc voltage is combined with the ac 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  $\pm 5$ ,  $\pm 25$ , and  $\pm 75$  kHz, the dial reading is independent of the frequency; b) in position  $\pm 75$  and INC.FREQ., the dial reading is multiplied by 2, 1, 2, 4 or 8, corresponding to the frequency ranges from 0.3-15 MHz to 120-240 MHz.

#### FINE TUNING CONTROL

In addition to the INCREMENTAL FREQ. dial, the instrument has been provided with a FINE TUNING control.

The FINE TUNING dial is uncalibrated and provides for a frequency deviation

of approximately  $3 \times 10^{-4}$  of the carrier frequency above 15 MHz, and about  $\pm 15$  kHz below 15 MHz.

The control does not affect the INCREMENTAL FREQ. dial.

#### POWER SUPPLY

The instrument operates from a 45-65 Hz 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 -90V stabilized by means of tube No.13, type 90C1, and the other supplying +160V. The +160 V voltage is stabilized by means of the series tube No.11, and the regulator tube No.12, using the -90 V as reference. The +160 V potentiometer in the LF unit permits adjustment of the +160 volts.

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

## Section G. Maintenance

### GENERAL

The Signal Generator, type MS27, 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 be undertaken only by skilled personnel provided with sufficient equipment to ensure that the repairs are properly made.

Unnecessary repairs 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, when avoidable.

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

### 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 are unscrewed.

### TUBE REPLACEMENT

#### General

As a rule, the tubes of the 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 kHz oscillator tube (No.10) is replaced, it may become necessary to set the 1 kHz adjustment. The 1 kHz output should be approx. 3 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 grooves, as otherwise stray radiation will result.

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

### 1. 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.

### 2. 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  $R_{15}$  (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 give correct meter reading in position FM. The adjustment should be made in such a way that the kHz FM are correct when the meter switch is released. Finally the  $\pm 50$  kHz adjustment must be set to give correct Inc. Freq. readings.

A method of measuring the FM is described below.

### 3. 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 adjustment index is set to give correct frequency reading at, say, 15 MHz, then the reading at 30 MHz may be wrong. The limits of the frequency range can be moved by adjusting the trimmer  $C_7$  mounted on the variable capacitor, (loc.B4), and as outlined above, correct

calibration may be ensured by successive measurements.

### 4. Doubler stages (tubes No.4,5,6 and 7):

In case the tube replacement and subsequent adjustment of the trimmers  $C_{13}$ ,  $C_{16}$ ,  $C_{19}$ , and  $C_{22}$ , do not give satisfactory performance on one of the ranges, adjustment of the coil of the corresponding stage may be tried. The frequency range is set to 120-240 MHz as before, and the trimmer is adjusted to give maximum output at 240 MHz. Then the coil is adjusted to give maximum output at 120 MHz (by turning the dust core or by changing the spacing of the coil turns). This affects the trimmer setting which must be readjusted. By alternate adjustment, optimum performance may be obtained.

### 5. 36 MHz 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 MHz 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.

### 6. Output stage (tube No.9):

Replacement of this tube affects the AM setting. By means of a screw-driver adjustment (AMII 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 can 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.

### 7. 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 5 x 20 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  $\Omega$ , the cartridge should be discarded. The measurement should be performed at a voltage not exceeding 1.5 volts.

## 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:  $\Delta F$ , 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.

### Continuous Waves

The CW reading can be checked either with a selective voltmeter or with a broad-band voltmeter at e.g. 1 MHz. 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.

## SCREW-DRIVER ADJUSTMENTS AND THEIR FUNCTIONS

In the LF unit:

"1 kHz" Adjustment of 1 kHz 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.



## 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.

## DC VOLTAGE MEASUREMENTS

All voltages measured to chassis

tube No. 1	pin No. 1	$\sim -0.5$	-8 V
	5-6	$\approx 50$	65 V
tube No. 2	pin No. 2-7	$\sim -3.7$	4.7 V
	5-7	$\downarrow$	160 V
tube No. 3	pin No. 1	$\sim -2.4$	-4.8 to -6.4 V
	5	$\downarrow$	160 V
	6	$\downarrow$	100 V
tube No. 4	pin No. 1	$\sim -4.5$	-16 to -20 V
	5	158	150 V
	6	74	140 V
tube No. 5	pin No. 1	$-0.8$	-26 to -35 V
	5	125	115 V
	6	150	135 V
tube No. 6	pin No. 1		-18 to -23 V
	5	160	150 V
	6	150	135 V
tube No. 7	pin No. 1		-12 to -17 V
	5	165	150 V
	6	148	135 V
tube No. 8	pin No. 1	$\downarrow$	150 V
	2		-1.6 V
	3	116	1.5 V
	6	$\downarrow$	115 V
	7	$\downarrow$	-3.5 V
tube No. 9	pin No. 2	$\downarrow$	-1.8 V
	7	140	145 V
	9	150	150 V
tube No. 10	pin No. 1	155	158 V
	3	175	14 V
	6	280	300 V
	8	5	6 V
tube No. 11	pin No. 2	0	141 V
	3-4-5	280	160 V 150
	6-9	0	300 V
	8		300 V
	top		300 V-170
tube No. 12	pin No. 1	$-4.2$	-4.6 V
	5	152	141 V
	6	165	160 V
tube No. 13	pin No. 7	$\downarrow$	-88 V

## CURRENT MEASUREMENTS

Total primary consumption at 220 volts line voltage: 300 mA

CRYSTAL OSC. Q500MHz REACTANCE TUBE OSCILLATOR

1' DOUBLER (15-30MHz)

2' DOUBLER (30-60MHz)

3' DOUBLER (60-120MHz)

4 DOUBLER (120-240MHz)

CONVERTER OSC. (36MHz)

OUTPUT STAGE

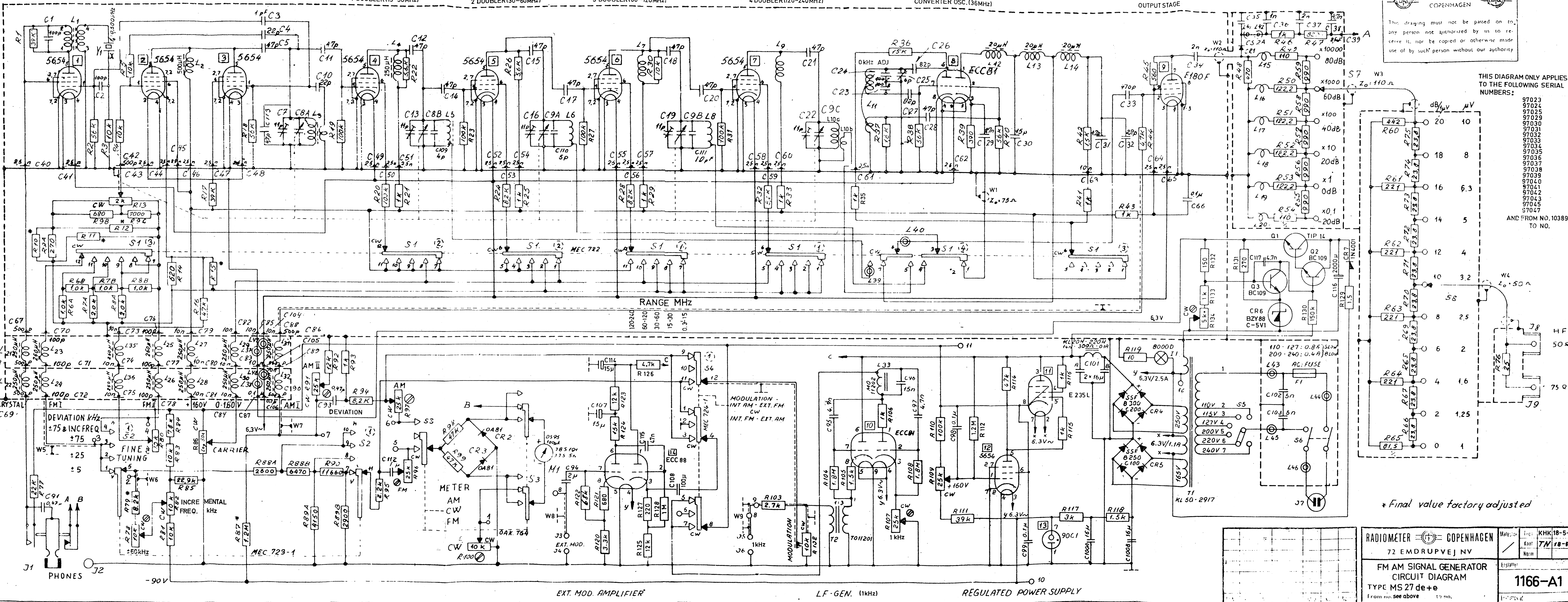


This drawing must not be passed on to, any person not authorized by us to receive it, nor be copied or otherwise made use of by such person without our authority

THIS DIAGRAM ONLY APPLIES TO THE FOLLOWING SERIAL NUMBERS:

97023  
97024  
97025  
97029  
97030  
97031  
97032  
97033  
97034  
97035  
97036  
97037  
97038  
97039  
97040  
97041  
97042  
97043  
97045  
97047

AND FROM NO. 103894 TO NO.



\* Final value factory adjusted

RADIOMETER COPENHAGEN		Model	KHK 18-5-67
72 EMDRUPVEJ NV		Serial	7M 18-5-67
FM AM SIGNAL GENERATOR		Assembled	
CIRCUIT DIAGRAM			
TYPE MS 27 de+e			
From no. see above			
1166-A1			