INSTRUCTION MANUAL

Type HO12

BEAT-FREQUENCY OSCILLATOR

RADIOMETER

ELECTRONIC MEASURING INSTRUMENTS
FOR SCIENTIFIC AND INDUSTRIAL USE

INSTRUCTION AND OPERATING MANUAL

FOR

Type HO12

BEAT-FREQUENCY OSCILLATOR

These instructions apply to
model HO12 only

SECTION 1
TYPE HO12 BEAT-FREQUENCY OSCILLATOR
STANDARD DESIGN

1.1 DESCRIPTION

The Beat-Frequency oscillator operates on the heterodyne principle as the audio frequency is generated as a beat between two h-f oscillators one of which can be varied between 200,000 and 180,000 cycles while the other operates on 200,000 cycles or 220,000 cycles.

By means of the dial ZERO ADJUSTMENT the frequencies of the two h-f oscillators can be made to coincide, when the other dials are set to 0 cycle. The zero beat is watched on a cathode-ray tuning indicator tube which starts operating when the main dial is set to zero. The frequency error is less than 0.5% + 1 cycle when the zero adjustment is correct.

The frequency of the variable oscillator, and consequently the audio frequency furnished, is set on the main dial which is divided from 0 to 20,000 cycles. 20,000 cycles can be added to any scale reading by setting the switch "+0 kc, +20 kc" to position "+20 kc". The main dial is coupled to a knob on the right-hand side panel by means of a worm gear with a gear ratio of 1:62. This knob is for fine adjustment. When the knob is removed, automatic recorders or the like can be coupled instead.

By means of the dial "+c/s" up to 300 cycles can be added to any frequency between 0 and 20,000 cycles. When the switch is in position "+20 kc" the +cycle dial does not operate.

From the two h-f oscillators the two h-f voltages are fed to two buffer amplifiers and from there to a mixer tube. The h-f modulation products are filtered in the subsequent low-pass filter, and only the audio-frequency is passed on to an R-C link for correction of the frequency response. From here it is passed to the output control knobs (OUTPUT FINE and OUTPUT COARSE).

One stage of a-f amplification and a phase inverter follows the power control and finally two output pentodes in push-pull coupling.

The output terminals marked "1" and "2" can be connected to various windings of the output transformer by means of the impedance selector located to the left of them, or they can be connected to the anodes of the

output tubes through two condensers of 2 μF. By this means matching is obtained to the following load impedances: 5 ohms, 25 ohms, 150 ohms, 600 ohms, and 10 kilohms. In all positions marked "U" the output voltage is unsymmetrical, and the lower terminal 2 is connected to chassis. The secondary winding is free in positions "F", and in the positions "S" the output voltage is symmetrical referred to chassis. The frequency response depends on the output impedance chosen and also depends somewhat on the output voltage. In the frequency range 30 to 20,000 cycles it is less than ±0.2 dB in the 600 ohm position with 600 ohm ohmic load at 1 watt output.

By means of negative feedback the output impedance of the amplifier is set to the same value as that of the matching impedance. The maximum output of the amplifier in the matching resistance is about 6 watts in the frequency range 30 to 10,000 cycles. At 1 kilocycle and 600 ohm ohmic load the distortion inclusive of hum voltage is:

at	0.1	watt:	less	than	0.5%		hum	0.1%
"	1	"	"	"	0.5%		"	0.1%
"	2	"	"	"	1.0%		"	0.1%
"	4	"	"	"	2.0%		"	0.1%
"	5	"	"	"	3.0%		"	0.1%

The distortion is essentially due to the 3rd harmonics and 2nd harmonics as the higher harmonics are negligible. Typical values are found in the table below:

at	0.1	watt:	0.1%	2nd	harmonics	0.15%	3rd	harmonics	0.03%	hum	
"	1	"	0.1%	"	"	0.2%	"	"	0.06%	"	
"	4	"	0.2%	"	"	1.2%	"	"	0.07%	"	
"	5	"	0.3%	"	"	2.4%	"	"	0.08%	"	
"	6	"	1.7%	"	"	4.5%	"	"	0.08%	"	

At low frequencies the distortion increases owing to the output transformer. At 20 cycles it is about 3% at an output between 0.1 and 4 watts. At 5 watts it is about 3.5% and at 6 watts about 4%.

A built-in ladder attenuator is connected when the IMPEDANCE switch is set to one of the two positions "ATT.". From the jack ATTENUATOR can be furnished the voltage read on the meter multiplied by 1, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, and 10^{-5} respectively, when the unloaded attenuator is set to the corresponding positions. The output impedance of the attenuator is 0, 100, 10, 10, 10, and 10 ohms respectively and is stated on the name plate of the switch. An output impedance of zero

ohms is only had (with the attenuator in position x1) when the output voltage is kept constant even if the load varies. Otherwise the output impedance is 300 ohms. The input voltage of the attenuator is had at the output terminal 1. Terminal 2 is connected to chassis in position ATT. With the switch in position "ATT. 2" an input voltage of 50 volts is permitted. With the switch in position "1" the highest voltage available is 2 volts, but the frequency range is extended downwards to approximately 2 cycles, and the distortion at frequencies down to 30 cycles is less than 0.5%. When low voltages are required at low frequencies, use the position "ATT. 1".

The built-in copper-oxide rectifier meter has 6 measuring ranges with joint scales. It is directly connected to the terminals 1 and 2. With terminal 2 to chassis (i.e. in all positions marked "U" on the impedance selector) the accuracy in all ranges is 2%, full scale, in the frequency range 20 to 10,000 cycles, and 3% in the range 20 to 20,000 cycles.

In the position "S" the meter reads about 10% high at 20,000 cycles on the 100 volt range. On the 250 volt range (and with the impedance selector in position "10 KILOHMS S" it will read about 10% high at 10 kilocycles, about 35% high at 20 kilocycles, and about 100% at 40 kilocycles. In position "F" the error depends on the character of the external load.

The Beat-Frequency Oscillator is stabilized for line voltage fluctuations by means of a special coupling. Generally a sudden line surge of 5% will cause a momentary change in the output voltage of about 2%. After about 30 seconds the deviation from the original output voltage is about 0.5%. Line voltage variations of 10% will cause a permanent change in the output voltage amounting to about 2 or 3%.

The output voltage of the Beat-Frequency Oscillator can be varied between plus 6 dB and about minus 35 dB by feeding a negative voltage varying between about 3 to 4.5 volts to the jack REG. VOLTAGE. 0 dB equals the output without regulation. The limits of the range of regulation depend on the distortion arising when regulating upwards and the hum arising when regulating downwards. At the limits of the range mentioned neither the distortion nor the hum exceeds 2% at 1 kc.

The TONE switch provides for clickless disconnection of the output at a speed of about 600 dB per second. Measurements of reverberation

time of even heavily damped rooms will therefore be possible. With the switch in position AUTOM. the output is automatically attenuated heavily in the range from 20,000 cycles to 20 cycles.

1.2 OPERATING INSTRUCTIONS

Before connecting the instrument to the power line set the line voltage selector to the line voltage available. The line voltage selector is located behind the plate screwed on to the back panel of the instrument and it can be set to 110, 127, 150, 200, 220, 240 volts, 50-60 cycles a-c. A 3-amp, a 200-milliamp, and a 100-milliamp fuse are mounted beside the built-in line voltage selector. They protect the rectifier tubes in case of short-circuit in one of the electrolytic capacitors.

Switch on the instrument. Set all frequency controls (main dial, +c/s dial, and +0 kc, +20 kc switch) to zero and set the zero adjustment so that the cathode-ray tuning indicator tube starts flashing when turning to either side.

The output voltage is available either across the binding posts 1 and 2 (located to the upper right on the instrument) or from the attenuator jack (located to the lower right on the instrument). By means of the impedance selector the following matching impedances can be chosen: 5 ohms - 25 ohms - 150 ohms - 600 ohms - 10 kilohms. In the 10 kilohm position the matching impedance between the chassis jack and one of the binding posts 1 and 2 is 2.5 kilohms. In the positions "U" (unsymmetrical secondary) the binding post 2 is connected to chassis. In position "F" (free secondary) the secondary winding is free from chassis connections. In the positions "S" the output voltage is symmetrical referred to chassis. In position "600 Ω S" the center of the secondary winding is connected to chassis. In the positions "10 kΩ S" the anode of the output tubes are connected to the binding posts 1 and 2 through two condensers of 2 μF.

With the impedance selector in position "ATT. 1" or "ATT. 2" the attenuator is connected to the binding posts 1 and 2, and the jack ATTENUATOR can be furnished with the voltage read on the meter multiplied by 1, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}. The output voltage must not exceed 50 volts when the attenuator is in position 2, and 2 volts in position 1. In position 1 the distortion at low frequencies is lowered, and

the frequency range is extended downwards to about 2 cycles.

The voltmeter is always connected to the binding posts 1 and 2. It has 6 measuring ranges with a joint scale, and the accuracy is 2%, full scale on the range 20 to 10,000 cycles and about 3% on the range 20 to 20,000 cycles in all positions "U" of the impedance selector. In positions "F" and "S" the error in indication increases with the frequency and is greatest on the highest ranges (see page 1-3, third passage).

SECTION 2
TYPE HO12W BEAT-FREQUENCY OSCILLATOR
SPECIAL DESIGN WITH WOBBLER

2.1 DESCRIPTION

The fixed oscillator of this model can be frequency-modulated by means of a reactance tube. A ladder attenuator provides for adjustment of the frequency deviation to ±20, ±25, ±32....±400, each step adding about 20%. The said frequency deviations can be multiplied by 1, 0.5, or 0.2 by setting a switch accordingly. The Beat-Frequency Oscillator can operate either at a constant frequency deviation being independent of the frequency furnished, or at a frequency deviation being approximately proportional to the frequency furnished, as the detent spring of the ladder attenuator can be put out of action so that the fine adjustment knob turns both the tuning condenser and the ladder attenuator by means of two worm gears. The modulating frequency that determines how many times a second the frequency furnished oscillates about the medium value, can be adjusted to one of the following frequencies: 3.2 - 4 - 5 - 6.3 - 8 - 10 or 12.5 cycles. The modulating voltage is sinusoidal.

2.2 OPERATING INSTRUCTIONS

The built-in wobbler is started by setting the switch immediately below the main frequency dial to position "+0 kc, WOBBLER ON" and the switch MODULATING FREQUENCY to one of the seven (sinusoidal) modulation frequencies between 3.2 cycles and 12.5 cycles. Adjust to the desired frequency deviation on the ladder potentiometer "FREQUENCY DEVIATION ±c/s" and on the switch "x1, x0.5, x0.2". The frequency deviation is had as the product of the two readings. If the Beat-Frequency Oscillator is to operate with a frequency deviation independent of the audio-frequency, the detent spring of the ladder potentiometer is put in action by setting the switch CONST. VARIABLE to position CONST. If, however, the Beat-Frequency Oscillator is to operate with a frequency deviation that amounts to a certain percentage of the scale frequency, the switch is set to position VARIABLE. The potentiometer arm and the main condenser are then operated by the fine adjustment knob on the right-hand side panel of the instrument. If, for

instance, the frequency deviation is to be 5% of the scale frequency, the main dial is set to 500 cycles and the potentiometer to 25 cycles. For increasing scale frequency the frequency deviation will then be approximately 5% up to about 8000 cycles, after which it becomes constantly ±400 cycles. The frequency deviation also becomes constantly equal to ±20 cycles at frequencies below 400 cycles, as it has proved to be most expedient to operate with a constant frequency deviation at low frequencies.

SECTION 3
TYPE HO12H BEAT-FREQUENCY OSCILLATOR
SPECIAL DESIGN WITH 1-MEGACYCLE OSCILLATOR

3.1 DESCRIPTION

This model incorporates a 1-megacycle oscillator which can be modulated from 0 to 100% from the Beat-Frequency Oscillator proper when the impedance switch is set at position "600 Ω U". At 50 volts a-f the modulation is 100%. As the modulation percentage and the modulating voltage are proportional, any modulation percentage can be read directly on the scale. The distortion of the modulation is very low at low modulation percentages and is less than 2% at 95% modulation. A ladder attenuator gives off voltages of approximately 1, 10, 100, 300, or 1000 millivolts and the corresponding output load has to be higher than 100 ohms in position "1 V" so as to avoid distortion of the modulation. The frequency modulation is negligible, being only about 200 cycles at 100% modulation.

3.2 OPERATING INSTRUCTIONS

The built-in 1-megacycle oscillator is started by setting the switch OFF-ON to position ON. The output voltage is at the jack HF OUTPUT and by means of the ladder attenuator it can be adjusted to one of the following values: 1 mV - 10 mV - 100 mV - 0.3 V - 1 V.

The output impedance is about 25 ohms in the "0.3 V" position and about 10 ohms in the other positions.

In the "1 V" position the load impedance should be high in proportion to the attenuator impedance so as not to introduce modulation distortion. The 1-megacycle generator is modulated directly from the Beat-Frequency Oscillator when the impedance selector is set to "600 Ω U". At a 50 volt output voltage the modulation is 100%, and it decreases in proportion to the output voltage. The modulation distortion is about 2% at 95% modulation with 1000 cycles.

SECTION 4
TUBE REPLACEMENT

Tube No. 1

is a type EF40 which operates as a variable oscillator. The h-f voltage on the grid point of the coil should be about 2.2 volts. Generally this tube can be replaced right away, but some tubes may give rise to too much hum (as the h-f voltage proper may be modulated with 50 cycles) or to unstable frequency.

Tube No. 2

is a type EF40 which operates as a buffer amplifier for the variable oscillator and furnishes an h-f voltage of about 10 volts to the third grid of the mixer tube. It can be replaced right away. Only very few tubes give too much hum.

Tube No. 3

is a type EF40 which operates as a fixed h-f generator. The h-f voltage at the grid point of the coil should be about 2.2 volts. A poor tube may produce hum and also cause small jumps in the oscillator frequency.

Tube No. 4

is a type EF40 which operates as a buffer amplifier for the fixed oscillator. The amplification of the tube, and consequently the output of the Beat-Frequency Oscillator can be altered by altering the negative voltage to the first grid of the tube. This voltage can either be an external voltage fed to the jack REG. VOLTAGE or an internal voltage developed across a dropping resistor placed in the minus lead of the d-c power supply and named "Compensation of line voltage variation" in the diagram because the output of the Beat-Frequency Oscillator is almost independent of line voltage variations of maximum ±10% if this resistor has the correct value.

Tube No. 5

is a type ECH42 which operates a a mixer tube. Check distortion and hum when the tube has been replaced. By varying the screen grid voltage the distortion is brought to a minimum. The potentiometer for adjustment of the

screen grid voltage is mounted on the shelf below the main condenser. The 50 cycle hum of the output has to be brought to a minimum by means of the potentiometer named "Min. of 50 c/s hum" in the diagram. The potentiometer is located just beside the tube No. 1. If this hum cannot be decreased to 0.05% at 25 volts output, use another tube.

Tube No. 6

is a type EF40 which operates as an l-f amplifier. It can be replaced right away. Only a few tubes cause too much hum.

Tube No. 7

is a type EF40 which operates as a phase inverter. In most cases it can be replaced right away. Only very few tubes cause hum.

Tubes No. 8 and 9

are type EBL21 tubes which operate as output pentodes. They should have the same characteristic to avoid 2nd harmonics. When the tubes have been replaced, connect two milliammeters between the jacks located at the tubes, and adjust the anode current plus screen grid current of the two tubes to the same value by means of the potentiometer between the tubes.

Tube No. 10

is a type EM34 which operates as a null indicator. Generally it can be replaced right away. The highest sensitivity is obtained by matching the cathode resistor.

Tubes No. 11 and 12

are type EZ40 rectifier tubes and can be replaced right away. Tube No. 12 should be replaced if the current through tube No. 14 is less than about 10 milliamps at a line voltage that is 10% below the nominal value. Tube No. 11 should be replaced if the anode voltage measured directly on the type EBL21 tube is less than 235 volts at nominal line voltage, as otherwise the distortion will increase heavily at high outputs.

Tubes No. 13 and 14

are type 90C1 glow-discharge voltage regulator tubes for stabilizing the anode voltage. They should be replaced if their voltage drop changes more than 1 to 2% when the line voltage varies 10%. The tubes should also be replaced when they start burning irregularly, as this irregularity may give rise to small jerky changes of the output frequency (1 cycle or less), which may be inconvenient at bridge measurements.

Tubes No. 15 and 16

are type EF42 and EF40 tubes respectively, and are only mounted in model HO12H with built-in 1 Mc oscillator. The type EF42 operates as a 500 kc oscillator by means of the grid and the screen grid. In the anode of the tube there is a 1 Mc circuit feeding the grid of the EF40 operating as a triode. In the anode of the EF40 there is another 1 Mc circuit feeding the attenuator. The d-c anode voltage of the EF40 is fed from a potentiometer with slotted shaft located beside tube No. 15. When replacing one of the tubes No. 13, 14, 15, or 16, an adjustment will generally be necessary. The potentiometer is so set that the modulation is 100% when the output voltage of the Beat-Frequency Oscillator is 50 V with the impedance switch in position "600 Ω U". After replacement of tubes No. 15 and 16 check the negative voltage at the grids of the tubes. They should be about minus 6 and minus 5 volts respectively. Also check the frequency of the 500 kc oscillator. The frequency can be trimmed through the middle one of the three holes in the bottom of the unit. The 1 Mc pentode circuit has to be adjusted so that the negative voltage at the grid of the EF40 tube is maximum (about 5 volts). Trimming is made through the farthest hole in the bottom of the unit as reckoned from the front plate.

Finally the compensating trimmer and the iron core of the 1-Mc triode circuit are adjusted so that the distortion of the modulation is minimum at 100% modulation at which the modulation trapezium has to be a triangle with straight lines. This provides a coarse control.

SECTION 5
MISCELLANEOUS

5.1 CONVERSION

All Beat-Frequency Oscillators supplied can be provided with wobbler and/or 1-megacycle oscillator when they are sent to the factory, and any type of HO12 Beat-Frequency Oscillator can be mounted with a type NS3 Logarithmic Frequency Response Recorder in a joint cabinet. Both instruments can be mounted on a 19" relay rack.

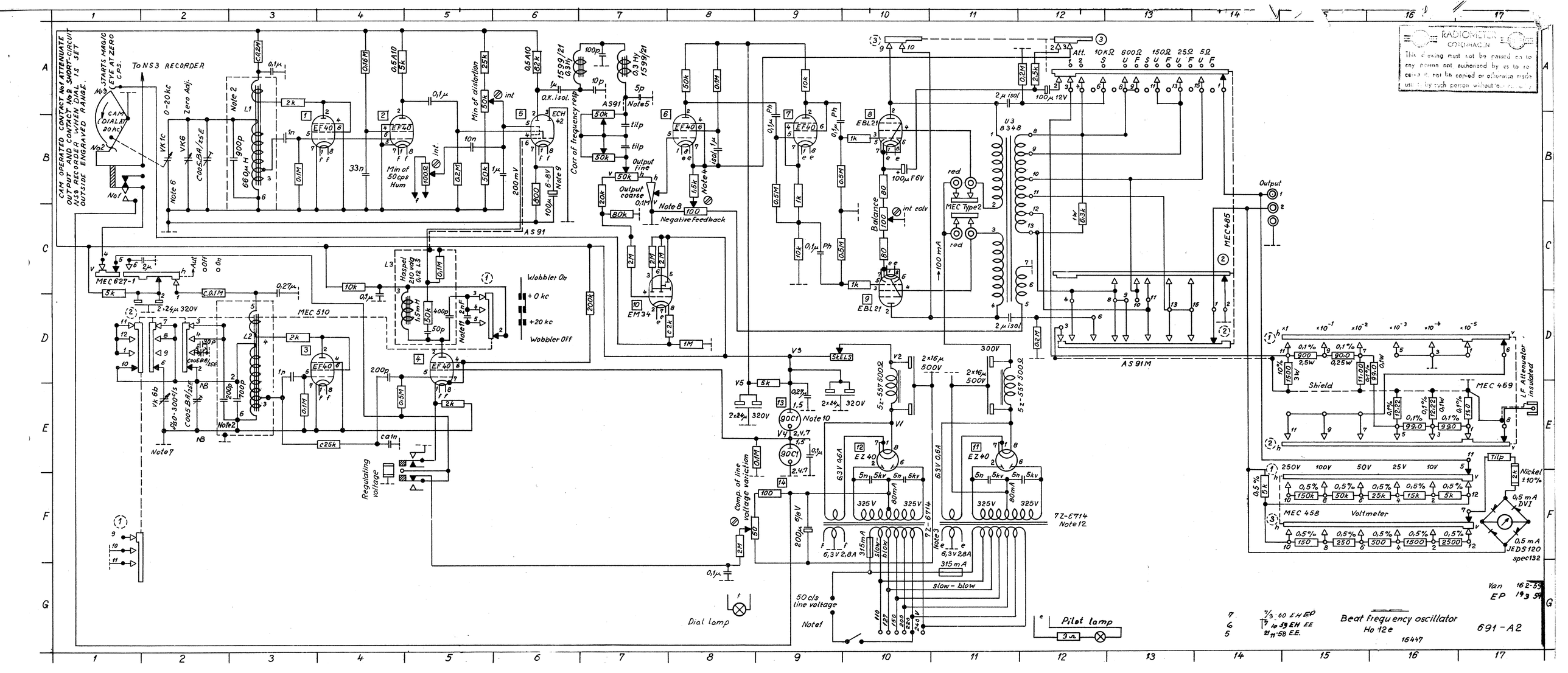
5.2 ADJUSTING THE SILENT RANGE

The main tuning condenser carries an adjustable disk at the rear end of its shaft. The disk actuates a micro-switch by pressing a flexible lever. When the micro-switch is actuated, a voltage of about minus 6 volts is fed to the regulating tube (No. 4) providing for a very high attenuation of the output if the TONE switch is set to position AUTOM. The operating range of the micro-switch can be adjusted by adjusting the opening angle of the disk.

The type HO12 Beat-Frequency Oscillators supplied together with type NS3 Logarithmic Recorders carry an additional micro-switch fixed with the same screws as the first mentioned micro-switch. The second switch provides for switching off the motor of the Logarithmic Recorder after the completion of each recording in order to secure a minimum wear of the Teflon disks. The micro-switch is actuated by an adjustable clamp at the end of the peg protruding from the adjustable disk. The lever of the first mentioned micro-switch is connected to a part of the grid leak of the first output tube (No. 6) of the Logarithmic Recorder. When the lever is connected to chassis by means of the adjustable disk, the pen of the Recorder moves to the left-hand stop. The frequency at which this happens can be chosen at will within certain limits by loosening the adjustable disk and fixing it in the proper position. The adjustment is generally so made that the Recorder is inoperative when the dial of the Beat-Frequency Oscillator is turned beyond the 20 kc line. However, the Recorder is released again at 20 cps.

If the NS3/HO12 is to be used in a Microphone Measuring Equipment, the limits are set at 16 kc and 20 cps because the condenser microphone

supplied with the equipment does not operate properly at frequencies higher than 16 kc. In order not to overload the loudspeaker used at microphone response recordings the adjustable disk is provided with an adjustable clamp of insulating material by means of which it is possible to keep the output attenuating micro-switch depressed until the bass resonance frequency of the loudspeaker has been passed. The output of the HO12 Beat-Frequency Oscillator, however, is only attenuated when the TONE switch is at position AUTOM.


CAM OPERATED CONTACT No1 ATTENUATE OUTPUT AND CONTACT No2 SHORT-CIRCUIT VARIABLE CONDENSER WHEN DIAL IS SET OUTSIDE ENGRAVED RANGE.
CAM (DIAL) 20 kc
No1
No2
No3 STARTS MAGIC EYE AT ZERO CPS.
To NS3 RECORDER
0-20 kc
Zero Adj.
Note 6
Note 2
L1
660 µH
Min of 50 cps Hum
int.
Min of distortion
O.K. isol.
Corr of frequency resp
Output fine
Output coarse
Negative Feedback
Note 8
Note 4
Note 5
AS 91
200 mV
Haspel 210 vdg 0/12 L3
Wobbler On
+ 0 kc
+ 20 kc
Wobbler Off
MEC 627-1
MEC 510
Note 7
Regulating voltage
Dial lamp
50 c/s line voltage
Note 1
Comp. of line voltage variation
Note 10
Note 11
Note 12
Note 3
7Z-6714
EZ 40
EBL 21
EM 34
MEC Type 2
MEC 485
AS 91 M
MEC 459
Shield
LF Attenuator insulated
MEC 458
Voltmeter
Nickel ±10%
0,5 mA DVI
0,5 mA JEDS 120 spec132
Output
Att. 10KΩ 600Ω 150Ω 25Ω 5Ω
Pilot lamp
Beat frequency oscillator
Ho 12e
691 - A2
16447
EP 193 58
Van 162-58
RADIOMETER COPENHAGEN
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