INSTRUCTION MANUAL

Type RV13
VACUUM-TUBE VOLTMETER

RADIOMETER

ELECTRONIC MEASURING INSTRUMENTS
FOR SCIENTIFIC AND INDUSTRIAL USE

INSTRUCTION AND OPERATING MANUAL

FOR

Type RV13
VACUUM-TUBE VOLTMETER

These instrcutions apply
to model RV13 only

I N D E X

Type RV13

VACUUM-TUBE VOLTMETER

The type RV13 Vacuum-Tube Voltmeter is primarily intended for measurements of a-c voltages, but it is equally suitable for d-c measurements.

The most outstanding features of this instrument are the wide frequency range which extends from 20 cycles to 500 megacycles, and the low input capacity of about 2.3 pF. The measuring diode is mounted in a small shielded probe and connected to the instrument by means of a 1 meter long shielded cable.

Another feature is the use of a built-in diode for measurements at frequencies lower than 5 Mc.

Measurements of d-c voltages can be made in the range from 0.02 volts to 30,000 volts. The high input impedance of 111 megohms (or 1200 megohms with a high-voltage probe) is maintained when switching over from measurement of positive voltages to negative voltages.

Description:

The type RV13 vacuum-tube voltmeter consists of a balanced d-c amplifier with a very strong negative feed-back, a built-in double diode, a diode of special design mounted in a probe, and a regulated power supply.

The amplifier consists of 2 penthodes followed by a double triode with separate cathodes. The triodes operate as cathode followers and the meter is connected to the cathodes. The penthodes operate with low anode current and also with reduced heater current providing for a very low grid current of the input tube.

The amplifier has an amplification of about 2 times and a negative feed-back of more than 100 times, which makes the amplifier almost independent of tube ageing and line voltage variations.

The amplifier proper provides for full deflection on the meter for 1-3 or 10 volts positive or negative referred to chassis. Voltages higher than 10 volts are attenuated 10 or 100 times by means of an input attenuator with a resistance of 111 megohms. The ranges obtained in this way are 1-3-10-30-100-300 and 1000 volts. A high-voltage probe extends the range to 30,000 volts and increases the input resistance to 1200 Mo. An R-C filter allows for superimposed a-c voltages of at least the same magnitude as that of the d-c voltage.

The accuracy is 2% of full scale on all ranges.

The zero adjustment is independent of the settings of the range switch.

The meter is protected against over-voltages on any range by the current limiting action of the tubes.

The high-ohmic high stability resistors of the input attenuator are protected against humidity and atmospheric influence by a wax-embedding.

The a-c ranges are 1-3-10-30-100 and 300 volts, full scale. The positive peak is measured, but the meter reads the rms of a sinusoidal voltage.

The diode mounted in the probe is of a special design with a very low anode-capacity and an anode-cathode clearance of only about 0.05 mm. The input condenser of the diode is mounted in the probe head which is made of Rexolite. The total input capacity amounts to only about 2.3 pF and the high diode resistor in connection with the low -loss material used, provides for an equivalent parallel resistance of about 30 megohms at low frequencies when connecting the diode to a circuit. This value decreases with increasing frequency (to about 3 megohms at 1 Mc and about 30 ko at 100 Mc) but it is always high in comparison with the circuit impedance obtainable.

The accuracy is ±3% of full scale on all ranges in the frequency range from 2 kc to 200 Mc. At higher frequencies the response is somewhat dependent on the voltage because the drop in indication due to the transit time effect of the diode is diminished to some degree at low voltages by the rise due

to resonance of the input circuit which provides for a response of about 1 dB up to 500 Mc at voltages of about 1 volt. At higher voltages the resonance effect predominates and gives a maximum rise at 500 Mc of about 3 dB.

The contact potential of the measuring diode is balanced by one diode of a built-in twin-diode. The d-c voltage obtained by rectifying the input voltage is attenuated by 3 dB thus rendering it possible to use the same meter resistors and scales as used for the corresponding d-c ranges except on the 3 lowest ranges, where the separate a-c scales must be used.

Voltages in the frequency range 20 cycles to about 5 Mc are most conveniently measured by means of the built-in diode, and voltages in the range from 20 cycles to 2 kc can only be measured in this way, because the diode mounted in the probe is not intended for use at frequencies lower than 2 kc. The upper frequency limit is dependent on the length of the leads used. The disconnection of the probe causes a rise of about 5% in the voltages from the power supply and is of no importance.

The stability of the zero setting is almost as good as that of the d-c ranges and a resetting is seldom required after the warming-up period has elapsed.

The regulated power supply operates with a "constant-current tube" which feeds the primary of the line transformer. Line voltage variations of 10% do not change the sensitivity at all and give only minor zero drift requiring resetting on the two lowest ranges only.

Operating Instructions

Before connecting the instrument to the line make sure that the correct current-regulating tube is inserted. For line voltages between 150 and 250 volts the type C8 tube must be used and the type C10 tube for voltages between 105 and 150 volts.

After switching on the instrument it should be allowed to warm up for at least some minutes because the zero setting drifts somewhat during the warm-up period.

Measurement of a-c voltages

can be made in the voltage range from about 50 millivolts to 300 volts.

Input voltages in the frequency range from 20 cps to about 5 Mc are most conveniently measured by means of the built-in diode with the diode mounted in the probe disconnected.

Set the selector switch to position " ~2" and the range switch to position "1 volt". Set the zero with the jack " ~2" connected to chassis. In most cases it is sufficient to connect the chassis to ground and leave the jack "~ 2" free. Choose the appropriate voltage range with the range switch and feed the unknown voltage to the jacks " ~2" and "chassis".

Voltages in the range up to 10 volts are read from the three separate a-c scales of the meter, and voltages between 10 volts and 300 volts from the two upper scales, which are common to a-c and d-c measurements.

Voltages of a frequency nigher than about 5 Mc have to be measured with the diode mounted in the probe, which is able to measure in the range from 2 kc to 500 Mc. Insert the probe, with the groove in the plug facing upwards , set the selector switch to position " ~1", set the meter needle to zero with the probe input short-circuited and the range switch to position "1 volt". In most cases it is sufficient to connect the chassis to ground and leave the probe input free.

The zero setting is almost independent of the range chosen.

The accuracy is ± 3% of full scale on all ranges.

The input capacity is about 2.3 pF at the probe and about 13 pF at the " ?" jack.

The load on a circuit is about 30 MΩ at low frequencies and about 3 MΩ at 1 MΩ and is almost indepent of the input used. At 10 Mc the probe has an effective input resistance of about 0.3 MΩ and at 100 MΩ of about 30 kΩ. It is thus always high in comparison with the circuit impedances obtainable in general.

Measurement of d-c voltages

Set the selector switch to one of the positions "x1" or one of the positions "x100", and set the zero with the range switch at "1 V". The input impedance is 111 MΩ at the jack "x1" and independent of the voltage range chosen. At the other jack the input impedance is about 12 MΩ and can be varied by means of the variable resistor with slotted shaft located behind the plug button inthe front plate. The latter input jack is intended for use together with the 1200 MΩ probe by means of which it is possible to measure up to 30.000 volts. The calibration of the probe is easily accomplished by first measuring a voltage (e.g. 100 volts) with the selector switch at position "x1" and then the same voltage by means of the 1200 mΩ probe with the selector switch at position "x100".

An a-c voltage of the same magnitude as the d-c voltage being measured can be allowed for because the a-c voltage is attenuated by means of an R-C filter at the input.

The accuracy is ± 2% of full scale on all ranges.

Measurement of resistance

The high input resistance of the vacuum-tube voltmeter makes it most suitable for measuring high-ohmic resistances.

The umknown resistor is connected to the "x1" jack and to a battery whose other terminal is connected to chassis.

If the battery has a voltage V and the meter reads v, the resistance is:

$$Rx = 111 \cdot \frac{V-v}{v} \text{ megohm}$$

If V = 100 volts, full deflection is obtained on the 1 volt range for Rx = 11,000 megohms.

Replacement of tubes

Tube No. 1 is a type EF94 or 6AU6 operating with only 5 volts on the filament and an anode current of only about 7 μA in order to reduce the grid current.

Make sure that (after replacement of the tube) the grid current is less than $5 \cdot 10^{-11}$ amps. This check is easily made by short-circuiting the .05 μF filter-condenser (E4 in the diagram) with the selector switch in one of the positions "x1" and the range switch in position "1V". In doing so the meter needle must not deflect more than 5 mV.

With the two switches in the positions mentioned the anode potential referred to chassis must be about 55 volts, the screen grid potential about 42 volts, and the cathode potential about 1.8 volts with no voltage at the input jacks.

Tube No. 2 is also a type EF94 or 6AU6 operating with exactly the same potentials at the electrodes. The grid leak is only about 10 MΩ and the grid current can rise to $5 \cdot 10^{-10}$ amps without disturbing the reading. The grid current is most conveniently measured by temporarily operating the tube in place of tube No. 1. Almost all specimens can be used.

Tube No. 3 is a type E80CC or 12AT7 double triode. Both sections operate as cathode followers and the meter is connected to the cathodes via a resistor whose size depends on the voltage range chosen. Half of the voltage drop across the cathode resistors is fed back to the input of the preceding amplifying tubes. The negative feed-back is greater than 100 and the amplification of the input signal is thus reduced to 2 times minus about 1%.

The voltages at the cathodes of the tube are about 2 volts higher than the voltages at the grids of the tube (and the anodes of the preceding tubes).

When replacing the tube, check the sensitivity of the 1 volt d-c range, and if the deflection is not correct, use the internal potentiometer P4. If the sensitivity on the 10 volt d-c range is not correct and the wirewound resistors have

their correct values, the resistor in parallel with the meter must be altered in order to obtain the correct sensitivity. However, this correction is only of theoretical interest as it will probably never occur, because it means that the sensitivity of the meter proper has changed.

If the zero knob on the front plate does not operate in the vicinity of its mid-position, this position can be obtained by means of the "Internal Zero at d-c" potentiometer P3.

Tube No. 4 is a type EB91 or 6AL5 double diode. One section operates as a rectifier for an input signal on the frequency range 20 cps to 5 Mc and the other as a balancing diode, which also operates together with the diode mounted in the probe when the selector switch is set to position "~1".

The negative voltage which is fed to the grid of tube No. 2 from the balancing diode can be controlled by the two potentiometers P5 - "Zero at ~1" and P6 - "Zero at ~2". P5 and P6 are so set that the zero does not shift when the selector switch is turned from a d-c position to "~1" or "~2". The zero on the 30 volt a-c range is set with the potentiometer P7.

The settings of the potentiometers P5, P6, and P7 must not be made before the instrument has been operating for at least 15 minutes.

When replacing tube No. 4 it is advisable to use an aged specimen, as otherwise the zero drift may be inconveniently heavy. If it is not possible to set the zero by means of the potentiometers P5 and P6, it will perhaps be necessary to change the 4 Mo resistor of the balancing diode.

Tube No. 5 is a type SA100 measuring diode made by "Telefunken". The diode has a pin-head anode placed at a distance of only 0.05 mm from the cathode. The diode is mounted in the probe and can be replaced right away.

First set the d-c zero by means of the knob on the front plate. Then adjust the potentiometer P5 "Zero at ~1" in the 1 volt range after replacement of the tube.

Check the sensitivity with a 10 volt input. Minor deviations can be eliminated by means of the potentiometer P2 if the sensitivity in the 10 volt d-c range is correct.

The type C8 current-regulating tube provides for line voltages from 150 volts to 250 volts, 50 to 60 cps, and the type C10 for voltages between 105 and 150 volts.

The tubes operate with a current of 0.2 amp. Deviations from this value can be corrected by using the appropriate soldering tag at the primary of the line transformer.

Check the 5 volt filament voltage after replacement of the tube and, if necessary, adjust the voltage as indicated above. The probe with the diode must be connected to the instrument when making this check. Do not forget to mount the iron tube surrounding the current regulating tube. Otherwise there is a risk that the filament of the tube will break because parts of it can oscillate with the frequency of the line voltage due to the fact that the magnetic field from the meter is sufficiently strong at the tube to develop these oscillations.

Also check the current regulating properties of the tube after replacement. The filament voltages should not vary more than about 10% in the regulating range of the tube. Before making any reading, the high time-constant of the regulating tube makes it necessary to wait at least 5 minutes each time the input voltage is altered.

The input voltage divider consists of high-stability resistors embedded in wax in a small box which is placed as low as possible in the cabinet in order to minimize the temperature rise.

The embedding provides for maximum stability and independence of atmospheric influence.

Placed above the box containing the resistors is a Perspex strip with soldering tags for the mounting of "trimming resistors" in order to obtain the correct attenuation. The resistors are indicated with dotted lines in the diagram, and minor changes in the embedded resistors with time can be eliminated by replacing the "trimming resistors". If the accuracy of the attenuator drops more than a few per cent, it is advisable to return the instrument or the resistor box for repair.

S p e c i f i c a t i o n s

Voltage range:

a-c: 1-3-10-30-100 and 300 full scale
d-c: 1-3-10-30-100-300 and 1000 volts full scale
d-c: with 1200 Mω test prod 100-300-1000-3000-10,000 and 30,000 volts

Both positive and negative voltages referred to chassis can be measured.

Accuracy:

Within 3% of full scale on all a-c ranges and within 2% of full scale on all d-c ranges.

Frequency response:

With probe: Within 3% of full scale from 2 kc to 200 Mc, about 3 dB to 500 Mc.

With built-in diode: Within 3% of full scale from 20 cps to about 5 Mc (depending on the length of leads).

Input impedance:

With diode mounted in probe: about 2.3 pF in parallel with about 30 megohms at 10 kc and about 30 kΩ at 100 Mc.

With built-in diode: about 13 pF in parallel with about 30 megohms at low frequencies and about 1.5 megohm at 1 Mc.

Power supply:

110 to 150 volts or 150 to 240 volts, 50-60 cps, depending on the regulating tube used.
Consumption: 0.2 amp

Mounting:

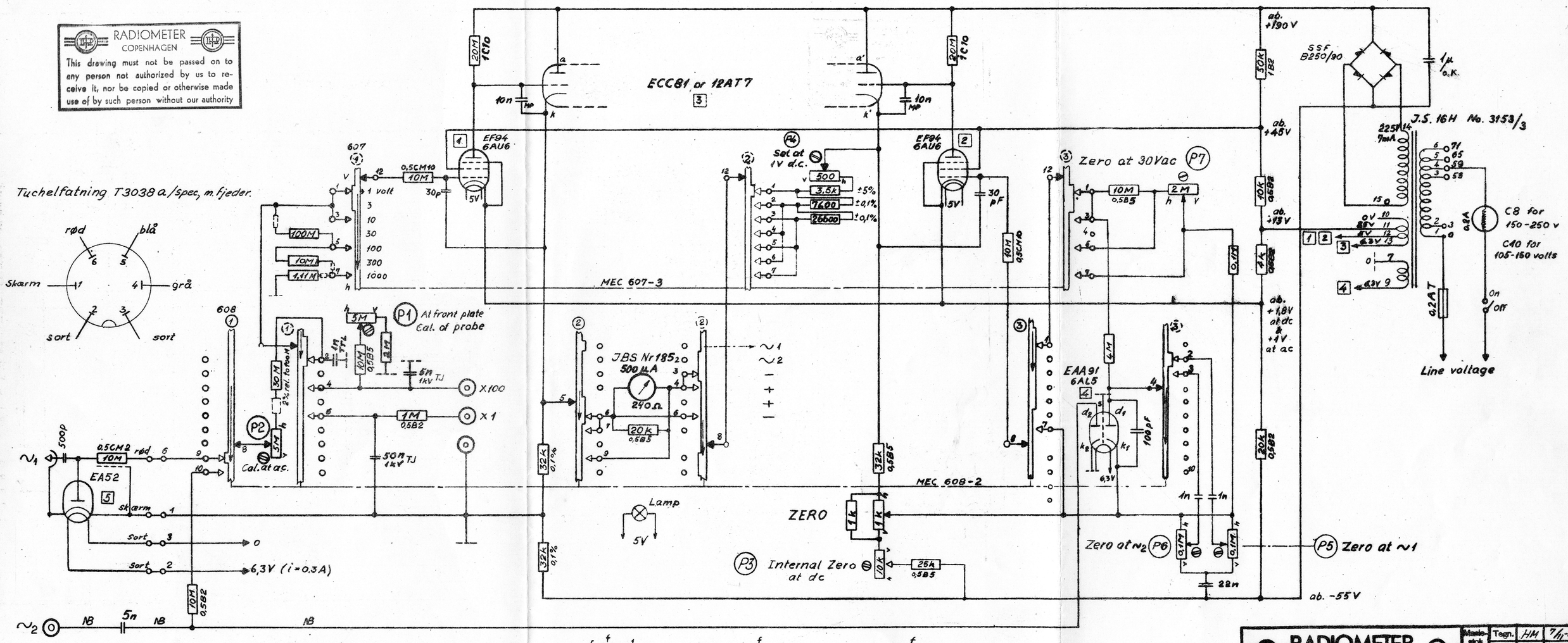
Metal case finished in grey enamel

Over-all dimensions:

H: 270 mm W: 200 mm D: 165 mm

Weight:

5.8 kilos



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RADIOMETER
KØBENHAVN

Vacuum tube voltmeter
Type RV 13 c

diagram from nr. 24242 to no 39638

Maalestok ~	Tegn. HM	7/11-56
	Konf.	/
	Normprøve	/

Erstatter: 709-A2

935-A2

Erstattet af: 1223-A2