# INSTRUCTION MANUAL

Type RV13
VACUUM-TUBE VOLTMETER

2nd edition

# RADIOMETER

**ELECTRONIC MEASURING INSTRUMENTS**
**FOR SCIENTIFIC AND INDUSTRIAL USE**

# INSTRUCTION AND OPERATING MANUAL
# FOR

## Type RV13
## VACUUM-TUBE VOLTMETER

2nd edition

CONTENTS

# SECTION 1
# INTRODUCTION

The type R V 1 3 Vacuum-Tube Voltmeter is primarily intended for measuring a-c voltages, but it is equally suitable for d-c measurements.

Two measuring diodes are supplied with the instrument. One is mounted in a shielded probe and connected to the instrument with a shielded cable. The other measuring diode is incorporated in the instrument.

The most outstanding features of the instrument are: The wide frequency range (from 20 cycles to 700 megacycles), the low input capacity of the probe (approx. 2pF), and the possibility of using the built-in diode at low frequencies. In this case the short leads used with the probe can be replaced by longer leads without giving any error in measurement.

D-c voltages can be measured 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 measuring positive voltages to measuring negative voltages.

# SECTION 2
# GENERAL DESCRIPTION

Type RV13 Vacuum-Tube Voltmeter incorporates a balanced d-c amplifier with an extremely strong negative feedback, a built-in double diode, a diode of special design mounted in a probe, a meter and a regulated power supply.

The amplifier incorporates 2 pentodes followed by a double triode with separate cathodes. The triodes operate as cathode followers, and the meter is connected to the cathodes. The pentodes operate with low anode current and also with reduced heater current which results in a very low grid current of the input tube.

The amplifier has an approximate gain of 2 times, and a negative feedback of more than 100 times. This feedback makes the amplifier almost independent of tube aging 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 an input attenuator with a resistance of 111 megohms. The ranges that are had 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 MΩ. The built-in R-C filter allows for a superimposed a-c voltage which is at least of 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 all ranges by the current limiting action of the tubes.

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 has a very low anode capacity. The input condenser of the diode is mounted in the probe head, which is made of Rexolite+). The total input capacity only amounts to approximately 2 pF,

+) a plastic made by Rex Corporation, 51 Landsdowne Street, Cambridge 39, Massachusetts, U. S. A.

and the high-ohmic diode resistor together with the low-loss material used gives an equivalent parallel resistance of approximately 30 megohms at low frequencies when connecting the diode to a resonance circuit. This value decreases with increasing frequency (approximately 3 megohms at 1 Mc and approximately 30 kΩ at 100 Mc) but it is always high in comparison with the circuit impedance obtainable.

The accuracy is ±3% full scale on all ranges in the frequency range from 2 kc to 200 Mc. At higher frequencies the response is partly dependent on the voltage because, the drop in indication due to the transit time effect of the diode is reduced to some degree at low voltages by the rise due to resonance of the input circuit. Thus, the response is approx. 1 dB up to 500 Mc at voltages of approx. 1 volt. At higher voltages the resonance effect predominates and gives a maximum rise at 700 Mc of approx. 2 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 making 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 from 20 cycles to about 5 Mc are easily measured with the built-in diode. Voltages in the range from 20 to 200 cycles can only be measured in this way, because the diode mounted in the probe is not intended for use at frequencies lower than 200 cycles. The upper frequency limit is dependent on the length of the leads used. The disconnection of the probe causes a rise of approx. 5% in the voltages from the power supply and is not important.

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

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

# SECTION 3
# OPERATING INSTRUCTIONS

## 3.1 CURRENT-REGULATING TUBE

Before connecting the instrument to the power line, make sure that the right current-regulating tube is mounted in the instrument. The type C8 tube is used for line voltages between 150 and 250 volts, and the type C10 tube is used for line voltages between 105 and 150 volts.

## 3.2 WARM-UP PERIOD

After turning on the instrument, allow it to warm up for a few minutes because the zero drifts some during the warm-up period.

## 3.3 MEASURING A-C VOLTAGES

A-c voltages are measured in the range from approx. 50 millivolts to 300 volts.

### 3.31 Input voltagesfrom 20 cps to approx. 5 Mc

are measured easily with the built-in diode. The diode mounted in the probe can be disconnected.

(1) Set the selector switch to "⎓2" and the range switch to "1 volt".

(2) Connect the jack "⎓2" to chassis and set the zero.

In most cases it is sufficient to ground the chassis and leave the jack "∿2" free.

(3) Choose the appropriate voltage range with the range switch and feed the unknown voltage to the jacks "∿2" and chassis.

Voltages up to 10 volts are read from the three separate a-c scales of the meter, and voltages from 10 volts to 300 volts are read from the two upper scales (which are used for both a-c and d-c measurements).

### 3.32 Voltages of a frequency approx. above 5 Mc

are measured with the diode mounted in the probe, which can measure in the range 200 cps - 700 Mc.

(1) Insert the probe, with the groove in the plug facing upwards.

(2) Set the selector to "∿1".

(3) Set the meter needle to zero with the probe input short-circuited and the range switch to "1 volt".

In most cases it is sufficent to ground the chassis 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 pF at the probe and about 13 pF at the "⌇2" jack.

The load on a resonance circuit is approx. 30 MΩ at low frequencies and approx. 3 MΩ at 1 Mc, and it is almost independent of the input used. At 10 Mc the probe has an effective input resistance of about 0.3 MΩ, and at 100 Mc of approx. 30 kΩ. Thus it is always high in comparison with the circuit impedances which can be obtained in general.

## 3.4 MEASURING D-C VOLTAGES

(1) Set the selector switch to position "+x1" or to "-x1" when measuring without the high voltage probe.

(1a) Set the switch to position "+x100" or "-x100" when using the high voltage probe.

(2) Set the VOLTS switch to position "1V" and set the zero.

(3) Feed the unknown voltage to the input jack "x1" or "x100", depending on the setting of the selector.

(4) Set the VOLTS switch so that a readable deflection as great as possible is had, and read the voltage on one of the two upper scales.

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 the variable resistor with the slotted shaft located behind the plug button in the front plate. The latter input jack is intended to be used together with the 1200 MΩ probe with which it is possible to measure up to 30,000 volts. The calibration of the probe is accomplished easily by first measuring a voltage (e.g. 100 volts) with the selector switch at position "x1" and the same voltage by means of the 1200 MΩ probe with the selector switch in position "x100".

An a-c voltage of the same magnitude as the d-c voltage which is measured, can be tolerated if the frequency is higher than 20 cps because the a-c voltage is attenuated with an R-C filter at the input.

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

## 3.5 MEASURING RESISTANCE

The high input resistance of the vacuum-tube voltmeter makes it very adaptable to measuring high-ohmic resistances.

(1) Connect the unknown resistor to the jack "x1" and to a battery whose other terminal is connected to chassis.

(2) Compute the resistance from:

$$Rx = 111 \times \frac{V - v}{v}$$

V is the battery voltage, and v the meter reading. If V = 100 volts, full deflection is had on the 1 volt range for Rx = 11,000 megohms.

# SECTION 4
# MAINTENANCE

## 4.1 TUBE REPLACEMENT

(1) Tube No. 1

is a type EF94 or 6AU6 operating with only 5 volts on the filament and with a low anode current (approx. 7μA) in order to reduce the grid current.

When the tube has been replaced, be sure that the grid current is less than $5 \cdot 10^{-11}$ amps. This check is easily made as follows: Set the VOLTS switch to "1 V" and switch the selector switch between the two positions "+". In doing this the meter needle must not deflect more than 5 mV.

With the two switches in the positions mentioned the anode potential referred to chassis is approx. 55 volts, the screen grid potential about 42 volts, and the cathode potential approx. 1.8 volts without voltage at the input jacks.

(2) Tube No. 2

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

(3) Tube No. 3

is a type ECC81 or 12AT7 double triode. Both sections operate as cathode followers, and the meter is connected to the cathode via a resistor whose size depends on the voltage range selected. Half of the voltage drop across the cathode resistors is fed back to the input of the preceeding amplifying tubes. The negative feedback is greater than 100, and thus the amplification of the input signal is reduced to 2 times minus approx. 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 preceeding tubes.).

When the tube has been replaced, 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 changed in order to obtain the correct sensitivity. However, this correction is only of theoretical interest as it will probably never occur because, it means means that the sensitivity of the meter proper had changed.

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

(4) Tube No. 4

is a type EAA91 or 6 AL5 double diode. One section operates as a rectifier for an input signal on the frequency range from 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 set so that the zero does not shift when the selector switch is turned from a d-c position to "∿1" or "∿2".

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

When replacing tube No. 4, it is recommended to use an aged specimen, or else the zero drift may be troublesome. If it is not possible to set the zero with the potentiometers P5 and P6 it will perhaps be necessary to change the 4 MΩ resistor of the balancing diode.

(5) Tube No. 5

is a type EA52 measuring diode which is mounted in the probe and can be replaced without further precautions.

First set the d-c zero with the ZERO knob on the front plate. Then adjust the potentiometer P5 ("Zero at ∿1") in the 1 volt range after replacement of the tube. Also make sure that P7 is set so that the deflection (due to induced hum) is minimum with the probe short circuited in the 1 volt range.

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

(6) Current-regulating tube

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

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

Check the 5 volt filament voltage, after replacing the current-regulating tube and, if necessary, adjust the voltage as explained 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. This is due to the magnetic field from the magnet of the meter being sufficiently strong in the tube to develop these oscillations.

Also check the current regulating properties of the current-regulating tube after replacement. The filament voltages should not vary by more than approx. 10% in the regulating range of the tube. Otherwise use a better tube.

Each time you have changed the input voltage wait 5 minutes before making a reading. This is necessary because of the high time-constant of the current-regulating tubes.

(7) The input voltage divider

Is made up of high-stability resistors and mounted as low as possible in order to minimize the temperature rise.

# SECTION 5
# SPECIFICATIONS

## A - C VOLTAGE

### Ranges

1, 3, 10, 30, 100 and 300 volts full scale.
First division at 50 millivolts.
Separate meter scales for 1, 3 and 10 volt range.

### Accuracy

3% of full scale at 1 Mc.

### Frequency Response

With diode-probe: 0.2 kc to 500 Mc within 1 dB, and to 700 Mc within 2 dB.
With built-in diode: 10 cps to 10 Mc within 1 dB.

### Input Impedance (loading of a resonance circuit)

With diode-probe: About 2 μμF shunted by a resistance which is 30 megohms at low frequencies. At higher frequencies the resistance decreases due to dielectric losses, thus it is approx. 3 megohms at 1 Mc and 0.3 megohms at 10 Mc.
With built-diode: Approx. 12 μμF shunted by a resistance which is 30 megohms at low frequencies.

### Superimposed d-c

The a-c peak to peak voltage plus the d-c voltage should not exceed 1000 volts at the probe or at the a-c input terminals.

## D - C VOLTAGE

### Ranges

1, 3, 10, 30, 100, 300 and 1000 volts full scale.
First division at 20 millivolts.
Up to 30,000 volts by use of 1200 Megohm Probe, type PB2.

Both positive and negative voltages (referred to chassis) can be measured with identical properties.

### Accuracy

2% of full scale reading.

### Input Resistance

111 megohms.
With type PB2 probe: 1200 MΩ.

### Superimposed a-c

At frequencies above 20 cps, superimposed a-c voltages of a level not exceeding that of the d-c will not cause any change in the reading.

## POWER SUPPLY

Voltages: 105-150 or 150-250 volts. Unless otherwise specified the instrument is supplied for operation at 150-250 volts.

Line frequency: 50 cps or as ordered.

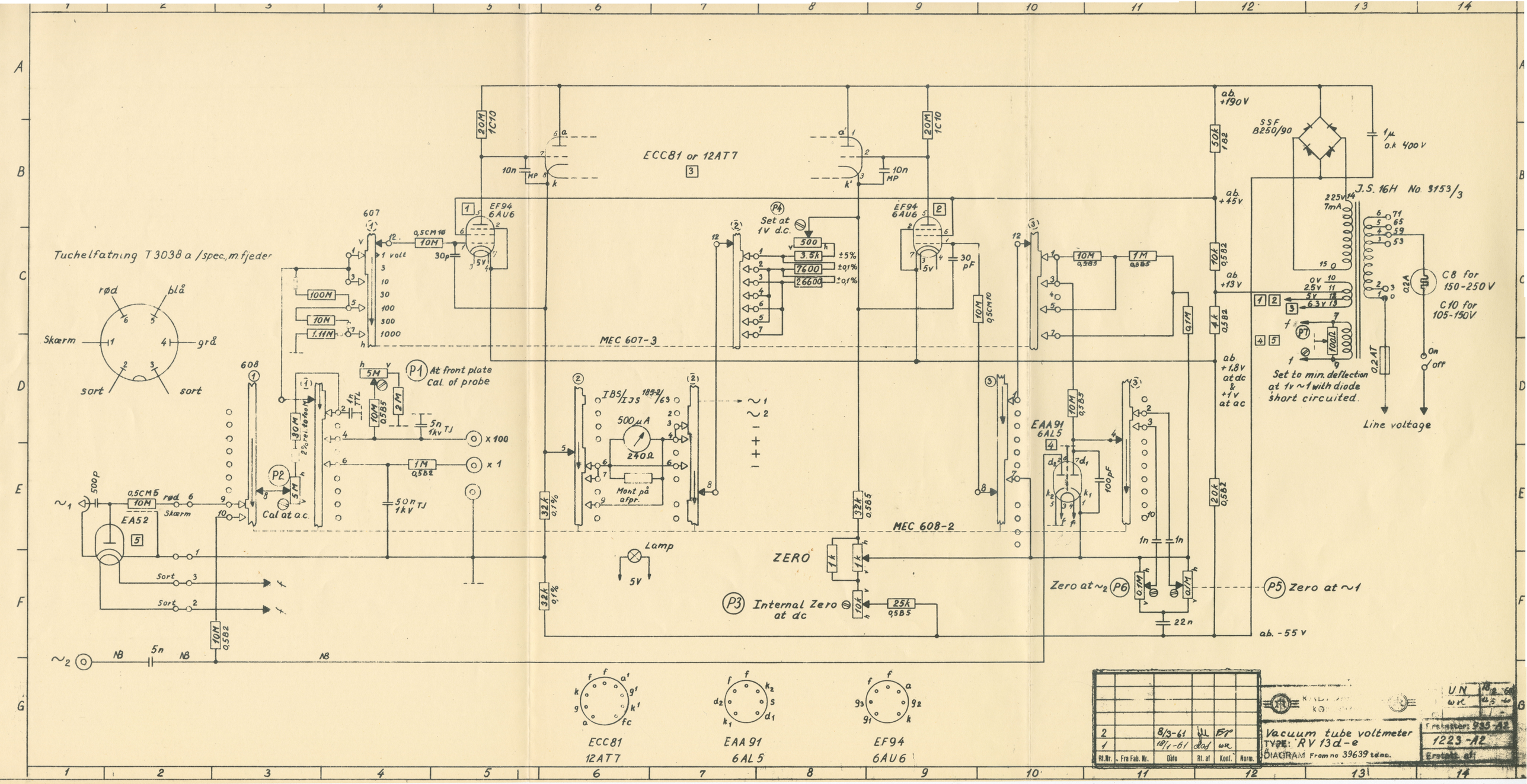
Consumption: 0.2 amp.

## DIMENSIONS AND WEIGHT

HxWxD = 275x205x180 mm
10 3/4x8x7 inches
6 kilos net (13 lbs.)

## ACCESSORIES SUPPLIED

1 type PB2 1200 Megohm Probe for max. 30,000 volts. When used with the type RV13, a 100:1 reduction of the voltage is produced.
1 type RV13L1 test lead with alligator clip and threaded terminal.
1 type RV13L2 test lead with alligator clip.
1 type 12G13-1.5 power cord.




| Rf.Nr. | Fra Fab. Nr. | Dato | Rf. af | Kont. | Norm. |
|---|---|---|---|---|---|
| 2 | | 8/3-61 | JL | FJ° | |
| 1 | | 18/1-61 | dod | wr | |

Vacuum tube voltmeter
TYPE: RV 13d-e
DIAGRAM From no 39639 tdnc.

Fremstillet: 935-A2
1223-A2
Erstatter: 611