INSTRUCTION AND OPERATING MANUAL

FOR

Type RV23

VACUUM-TUBE VOLTMETER

SPECIFICATIONS

Voltage ranges:	1-3-10-30-100-300 or 1000 volts positive or negative d-c; 1-3-10-30-100 or 300 volts a-c for full scale deflection.
Frequency range:	20 cps - 100 Mc/s
Input impedance:	60 MΩ at d-c. With 2 MΩ test probe: 60 MΩ ≠ about 1 pF. When measuring on resonant circuits: About 5 MΩ at audio frequencies; about 3 MΩ at 1 Mc; about 0.3 MΩ at 10 Mc. Input capacity of diode probe: about 6 pF. With the probe mounted in the instrument: about 8 pF.
Resistance ranges:	7 ranges, 0.5 Ω - 500 MΩ.
Accuracy:	a-c: 30 cycles to 50 megacycles: 5% of full scale deflection. 100 megacycles: 10%. d-c: 3% of full deflection. Resistance: about 5% from 3Ω to 30 MΩ.
Power supply:	110-127-150-200-220 or 240 volts, 50-60 cycles a-c. Consumption: about 17 watts.
Tube complement:	2 type ECC81 or 12AT7 1 - EAA91 or 6AL5
Battery:	Hellesen type VII-34 ALL STEEL, 1.5 volts, 33 ϕ x 61 mm.
Dimensions:	Height: 290 mm Width: 200 - Depth: 165 -
Weight:	6 kilos
Standard accessories:	2 MΩ test probe with lead. 2 leads with alligator clips which can be screwed on to the diode probe or the 30 kV probe.
Extra accessory:	30 kV probe type PB2

DESCRIPTION

The vacuum-tube voltmeter consists of a diode rectifier followed by a symmetrical 2-stage d-c amplifier with heavy negative feedback, which provides for less dependence on line voltage and tube aging. The built-in power supply operates with an only slightly loaded selenium rectifier with an expected useful life of more than 50 000 hours and without electrolytic condensers. Furthermore the tubes are so conservatively rated that a long troublefree service may be expected. The instrument can measure positive and negative voltages referred to chassis, and a-c voltages and resistance.

DC MEASUREMENTS are made without using the diode rectifier. The voltage is passed through an R-C filter to a voltage divider. In the positions 1-3 and 10 volts the total voltage is carried on to the grid of the input tube - in the positions 30 and 100 volts 1/10 is carried on, and in the positions 300 and 1000 volts only 1/100.

The d-c voltage may be superimposed by an a-c voltage which is 0.1 f·V, where f is the frequency in cycles per second, and V is the d-c voltage. The a-c voltage must not exceed 300 volts.

The input tube is one system of a double triode whose other system operates as the symmetrical tube of the balanced amplifier. The zero setting is accomplished by varying the grid bias of the balancing tube. The second double triode operates as a cathode follower with the meter and its series resistor connected directly to the cathodes. The series resistor is the same on the 1000-100 and 10 volt ranges and also the same on the 300-30 and 3 volt ranges, while the 1 volt range has its own series resistor.

Thus the amplifier only operates with maximum amplification on the 1 volt range, and therefore the inevitable zero drift on all the other ranges is 3 or 10 times less than on the 1 volt range.

The vacuum-tube voltmeter can be operated with zero at the center of the scale. This is achieved by injecting a stabilized voltage in the cathode circuit of the input tube, and this voltage is changed with the measuring range. The measuring ranges will be: ±0.5 V, ±1.5 V, ±5 V, ±15 V, ±150 V and ±500 V.

At d-c measurements the dB scales of the vacuum-tube voltmeter indicate the voltage directly in dB over 1 volt, if the readings on the switch and the meter dial are added up.

Voltages between 1000 and 30 000 volts can be measured with a 1200 MΩ series resistor (extra accessory) which is connected to a separate jack by means of which an adjustable resistor is connected in parallel with the input voltage divider. The adjustable resistor can be set from the front plate so that it in combination with the series resistor provides a voltage division of exactly 100 times. Thus errors due to aging of the series resistor can easily be avoided.

A-C MEASUREMENTS can be made either with the diode-probe mounted in the instrument or with free probe.

With the probe in the instrument the input capacity is about 8 pF and the frequency range is limited upwards by the length of the test leads. When the probe is free, the input capacitance is about 6 pF, and the frequency range 30 cycles to 50 megacycles with a measuring accuray of ±5% of full scale deflection. The resonant frequency of the diode is between 300 and 400 megacycles with short-circuited input terminals with an increase in the sensitivity of about 1 dB at 100 megacycles, about 4 dB at 200 megacycles, and about 10 dB at 300 megacycles. The ohmic load of the diode on the voltage source is dependent on the frequency. When measuring on a resonant circuit it is about 5 megohms at low frequencies, and greater than 1 megohm at 1 megacycle (generally about 3 megohms), and at 10 megacycles about 0.3 megohm.

The diode probe is provided with a double diode. One diode operates as a peak voltage rectifier, while the other diode operates as a compensating tube for the initial voltage of the measuring diode. The rectified voltage on the measuring diode is fed through a series resistor, which can be varied by means of the potentiometer P9, to the input voltage divider. The series resistor attenuates the voltage 1.41 times so that the voltage ranges will be the same at a-c and d-c voltage. The initial voltage of the compensating diode is carried through a variable resistor, P8, to an attenuator which can attenuate the voltage 10 or 100 times. This is done synchronously with the attenuation of the voltage proper. Owing to the curvature of the

diode characteristic the rectified d-c voltage on the 1-3 and 10 volt range is too low to give full deflection on the respective ranges. Therefore the series resistor of the meter is shunted in these three ranges. This provides for true reading of the dB scales at full deflection also in the 10, 3 and 1 volt ranges for a-c voltage. At smaller deflections, however, an error will occur which at half deflection is about 0.2 dB in the 10 volt range, about 0.5 dB in the 3 volt range, and about 1 dB in the 1 volt range.

The vacuum-tube voltmeter measures the peak voltage - the positive peak - but is so calibrated that it reads the r-m-s value of a sinusoidal voltage.

Irrespective of the curve form of the voltage under test - apart from short pulses - its peak voltage is found by multiplying the reading by $\sqrt{2} = 1.41$.

The maximum voltage the diode will stand is 300 volts. The input condenser of the diode has been tested with 2000 volts d-c, but it is advisable not to work with too high positive d-c voltage superimposed on a-c voltages of 200-300 volts.

OHM MEASUREMENTS are made by connecting the unknown resistor in series with a known resistor and a 1.5 volt battery when the unknown resistor is connected to the ohm terminals of the vacuum-tube voltmeter. The voltage across the unknown resistor is measured with the vacuum-tube voltmeter after having adjusted its sensitivity so that it gives full deflection for the battery voltage. The adjustment is made with the knob "Ω∞" mounted on the potentiometer P10 which forms part of a shunt across the terminals of the meter.

The range of the ohmmeter is from 0.5 Ω to 500 MΩ, and it gives half deflection at 10 Ω - 100 Ω - 1000 Ω - 10 kΩ - 100 kΩ - 1 MΩ and 10 MΩ.

The measuring accuracy is maximum at half deflection and is about 5% from 3 Ω to 30 MΩ. On the lowest range the measuring accuracy is dependent on the internal resistance of the battery which must not exceed 1 Ω.

The line transformer has primary tags for 110-127-150-200-220-240 volts. Switching is carried out by moving a lead from one soldering tag to the soldering tag intended for the line voltage available.

OPERATING INSTRUCTIONS

GENERAL

1) Make sure that the mechanical zero of the meter is in order.

2) Connect the instrument to the line voltage indicated by the plate on the back. When the vacuum-tube voltmeter leaves the factory, it is set at 220 volts. However, it can also be set to 110-127-150-200 or 240 volts by shifting the lead from tag No.6 to tag No.2-3-4-5 or 7 of the line transformer.

3) Switch on the instrument and choose the type of voltage desired with the right-hand switch.

4) Set the left-hand switch to the 1 volt range and let the instrument warm up for some minutes.

5) Set the knob ZERO so that the meter needle rests at zero and the knob "Ω ∞" so that the meter gives full deflection with the right-hand switch in position "Ω".

Now the vacuum-tube voltmeter is ready for use. The zero should be checked occasionally during the warm-up.

D-C MEASUREMENT

1) Set the right-hand switch to + or —, according as the voltage source under test has the highest impedance to chassis on its positive or negative pole.

2) Connect one of the chassis terminals of the vacuum-tube voltmeter to the pole of the voltage source with the lowest impedance to chassis, and the jack "=x1" directly to the other pole.

3) Set the left-hand switch so that the meter deflects as much as possible without hitting the stop. The vacuum-tube voltmeter will stand an input voltage of 1000 volts even on the 1 volt range.

4) Use the input jack "=x1, 2 MΩ PROBE" and the lead with the built-in 2 MΩ resistor at one end, when the capacitive loading on the voltage source must be as low as possible. This is for instance the case when measuring the negative grid voltage of an operating oscillator. The test probe loads the grid with about 1 pF. The ohmic load on the voltage source is always 60 MΩ, when one of the two input jacks "=x1" is being used.

5) Use the 1200 megohm test probe and connect it to the jack "=x100, 1200 MΩ PROBE" when measuring voltagesover 1000 volts. The lowest measuring range will be 100 volts for full deflection. The test probe can stand a voltage of 30 kV. The greatest care should be taken when measuring voltage sources that can furnish more than 10 mA at short-circuit. The 1200 MΩ test probe is not a standard accessory.

   As 1200 MΩ resistors with a stability of 1% during aging are not available, the vacuum-tube voltmeter is provided with a calibrating potentiometer

for the test probe. The adjustment is made by measuring on a voltage source of for instance about 100 volts, both with and without the 1200 MΩ test probe.

Use a screwdriver with an about 10 cm long blade for the adjustment.

6) Set the right-hand switch to position M if the polarity of the voltage under test changes during measurement. The measuring ranges will then be ±0.5 V to ±500 volts for full deflection.

A-C MEASUREMENT

Prepare the instrument as described above.

1) Connect the voltage source to the a-c jacks on the front panel, if the frequency is below about 5 megacycles, and the leads can be kept short - less than 25 cm at 5 megacycles.

2) Remove the diode probe from the instrument if the measuring frequency is higher than 5 megacycles. It is held in place by the chassis jack which must be turned to the left to release the probe. Connect the probe to the voltage source with the shortest leads possible - at frequencies above 50 megacycles preferably without leads, as the testing is made with the points of the probe.

   The probe must not be connected to a voltage source with a voltage higher than 300 volts at frequencies below 5 megacycles. At higher frequencies the maximum voltage permissible is reduced proportionally to the square root of the frequency ratio and is for instance maximum 100 volts at 50 megacycles.

3) Read the separate 1 V∿ or 3 V∿ scale when the left-hand switch is set at the corresponding positions. In all the other measuring ranges the 10 or 30 volt scale is read.

   The measuring accuracy is ±5% of full scale deflection at frequencies between 30 cycles and 50 megacycles. At 100 megacycles the error is about 5% greater.

   The dB scale gives true readings at full deflection on all measuring ranges. Owing to the curvature of the diode characteristic there is an error in the three lowest ranges at smaller deflections. At half deflection the meter reads about 0.2 dB low on the 10 volt range, about 0.5 dB low on the 3 volt range, and about 1 dB low on the 1 volt range.

OHM MEASUREMENT

Prepare the instrument as described above.

1) Connect the unknown resistor to the jack "Ω" and one of the chassis jacks.

2) Set the left-hand switch so that the meter deflection is had as near the center of the scale as possible.

   The resistance is found as the product of the reading of the meter and the switch.

The measuring accuracy is about 5% between 3 Ω and 30 MΩ.
The test voltage is 1.5 volts, and the maximum current at short-circuit is 0.15 A.

When measuring very low resistances, the zero adjustment should be made with the right-hand switch at "Ω" and with short-circuited test leads, as otherwise their resistance will affect the measuring result.

When measuring very high resistances (above 1 MΩ), one of the chassis terminals of the vacuum-tube voltmeter should be grounded to avoid errors due to induced hum voltages.

The ohm range of the vacuum-tube voltmeter can be considerably extended upwards by measuring the voltage of a d-c source both with and without the unknown as a series resistor. Use the jack "= x1" with an input impedance of 60 megohms.

If the two voltages measured are E and e, the unknown resistance is:

$$R_x = 60 \left(\frac{E}{e} - 1\right) \text{ megohms}$$

Example:

$$E = 100 \text{ and } e = 0.1 \qquad R_x \mathrel{\overset{=}{\sim}} 60{,}000 \text{ M}\Omega$$

MAINTENANCE

REPLACEMENT OF BATTERY

The battery should be replaced or at least be removed when the needle cannot bet set to the ∞ line after the zero adjustment.

The ALL STEEL type, such as Hellensen's type VII-34, is recommended, because it is more resistant to corrosion.

The battery is accessible when the rectangular plate screwed on to the inner back wall of the instrument has been removed. The clamp over the battery will have to be pressed and then pushed to the right before it can be swung aside.

The positive pole of the battery (the brass knob) must be in electrical contact with the elastic clamp.

The measuring diode inside the probe is a type EAA91 or 6AL5 double-diode, while both amplifier tubes are type ECC81 or 12AT7 double-triodes.

The diode in the probe can be replaced when the two screws in the back plate are unscrewed and the lacquered tubing is pushed up on the cable.

Almost any diode can be used. If the ratio between the initial voltage of the two diode systems in the new tube changes, it will be necessary to readjust P8, ZERO ∿. First set the zero of the amplifier in the minus 1 volt range and then ZERO ∿ in the 1 volt ∿ range. If P8 hits the stop, change one or more of the dotted connections of the two shunt resistors of the resistor chain in series with P8 (see the wiring diagram).

Very few tubes give rise to too low indication.

As the ratio between the initial voltages of the two systems of the diode may change during the life of the tube, it may become necessary to readjust the P8 potentiometer.

The amplifier tubes can be replaced when the instrument has been removed from the cabinet. (The screws along the vertical edges of the front plate must

be removed, while the three screws in the cover and the bottom of type RV23M need only be loosened).

Most tubes can be used. However, it will generally be necessary to readjust the internal zero positioning potentiometer, P2, when tube No.1 has been replaced. The adjustment should be made with the ZERO knob on the front panel in its center position.

Only very few tubes will have a disturbing grid current. The easiest way to check the grid current in tube No.1 is to connect one of the input jacks to chassis after the zero setting has been made in the 1 volt d-c range. The zero must not change more than 0.01 V when doing so. During the test the tube should be protected from strong light to avoid photoemission from the grid.

READJUSTMENT

Generally it is only necessary to readjust the potentiometers P2 and P8 when the tubes are replaced. If, however, it should prove necessary to readjust some of the other potentiometers in order to bring the errors within the limits given in the specifications, the following procedure should be followed:

1) Switch on the instrument and let it warm up for half an hour.

2) Set the right-hand switch to + and the left-hand switch to 1 V.

3) Set the knob ZERO to the center of its range and P2 so that the needle rests at 0.

4) Connect a +10 volt source between the chassis and the jack "=x1". Set the left-hand switch to the 10 volt position, and set P3 so that the meter reads 10 volts.

5) Set the left-hand switch to the 1 V position and adjust P4 at an input voltage of exactly 1 volt.

6) Once more adjust the P3 as described under item 4, and then P4. Repeat the adjustments until the vacuum-tube voltmeter gives true reading at both 1 volt and 10 volts.

7) Make sure that the error is less than 1% at full scale deflection on the 3 volt range. Is this not the case, it is due to the fact that the high stability resistors of 6.33 kilohms and 20 kilohms (position B7 in the wiring diagram) deviate more than 0.5% proportionally from each other.

8) Set P5 so that the indication is true with an input voltage of 100 volts, and P6 so that the reading is true at 300 volts.

9) Set P7 so that the needle rests at M when the switches are at position "M" and 1 volt. Check the zero with the right-hand switch at position + or —. If the center deflection in position "M" moves more than 2% of full deflection when switching to one of the other measuring ranges, the error may be in the resistor chain consisting of the high stability resistors 31.6 kilohms, 10 kilohms and 4.62 kilohms (position D9).

10) Set the zero in the plus or minus 1 volt range with the knob ZERO and then to the 1 volt a-c range with P8. The measuring diode must be short-circuited.

11) Set P9 to an input voltage of 100 volts or 30 volts at e.g. 1 kilocycle. The distortion factor must be less than 0.5% as the error with a peak voltage rectifier may amount to as high a percentage as the distortion.

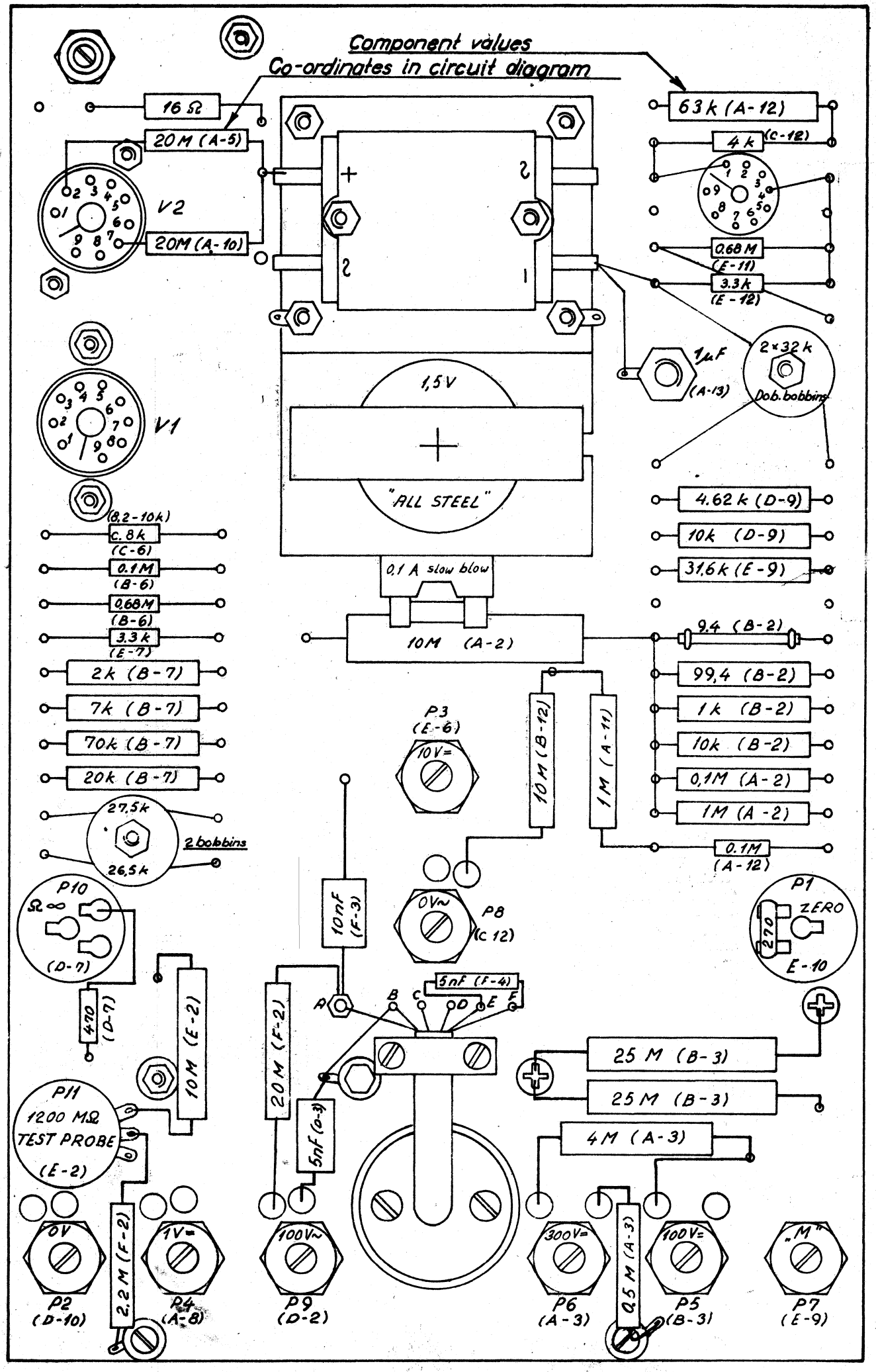
All the internal potentiometers are accessible when the corresponding cover plates are removed.

The potentiometer P3 is accessible when the rectangular cover plate on the internal back panel is removed.

The potentiometer P8 is mounted behind the circular cover plate designated "ZERO ∿".

The remaining potentiometers can be adjusted through the six holes at the bottom of the back plate. The holes are uncovered by loosening the two lower screws and pushing the cover plates of the holes aside.

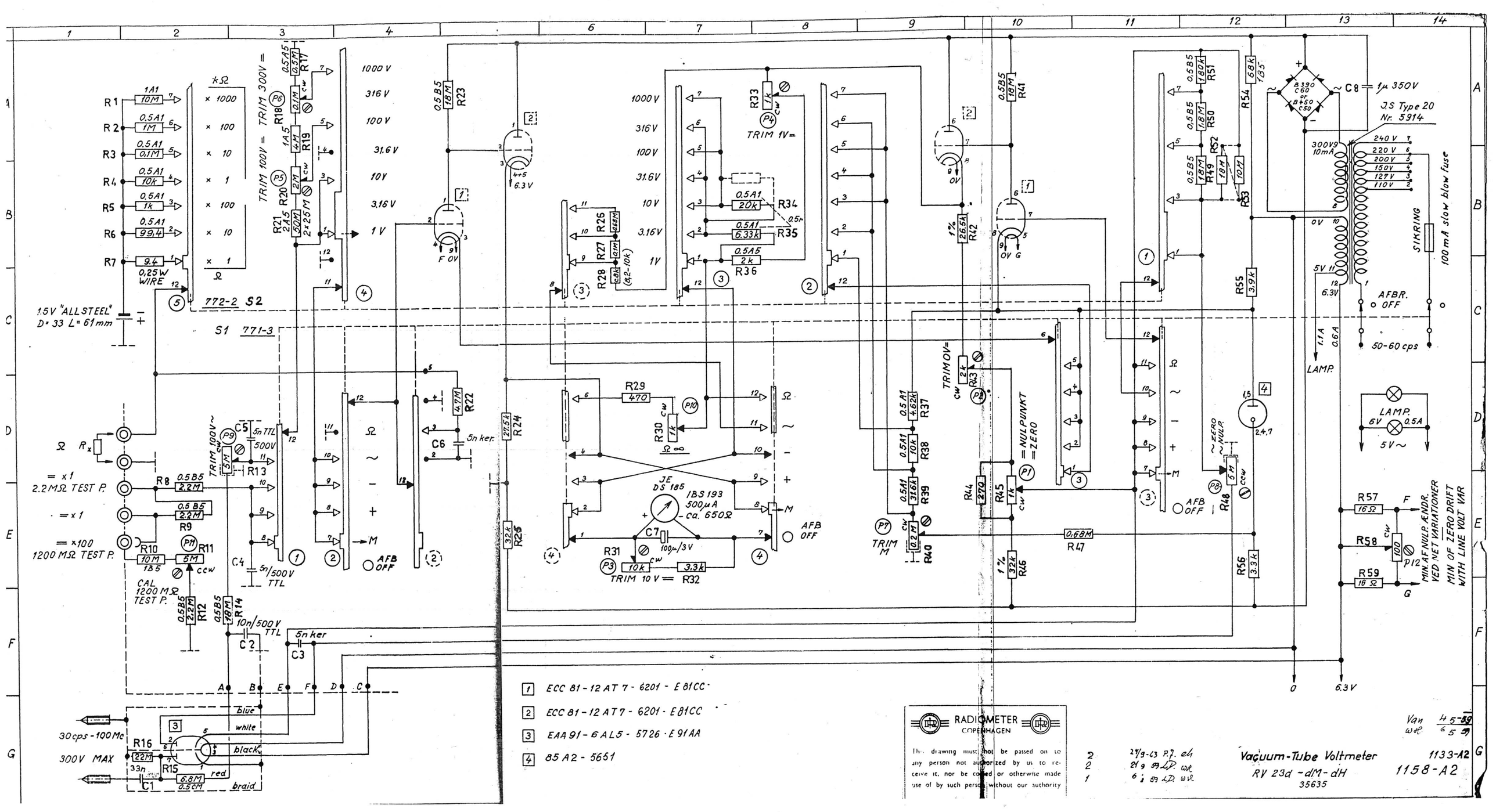
The drawing shows the positioning of the potentiometers and the components, and the co-ordinates refer to the wiring diagram.



Vacuum-Tube Voltmeter, type RV23

A.2 9/12-62
St.nr 1. 1/6-69

1548-A4


1.5V "ALL STEEL" D=33 L=61mm
772-2 S2
S1 771-3
TRIM 100V = TRIM 300V =
TRIM 1V=
TRIM 10V =
TRIM 100V~
TRIM 0V=
TRIM M
= NULPUNKT = ZERO
AFB OFF
JE DS 185
IBS 193 500µA - ca. 650Ω
Ω Rx
= x1 2.2MΩ TEST P.
= x1
= x100 1200MΩ TEST P.
CAL 1200MΩ TEST P.
30cps - 100Mc
300V MAX
blue
white
black
red
braid
JS Type 20 Nr. 5914
300V 9 10mA
100 mA slow blow fuse
SIKRING
AFBR. OFF
50-60 cps
LAMP.
LAMP. 6V 0.5A 5V~
MIN. AF NULP. ÆNDR. VED NET VARIATIONER
MIN OF ZERO DRIFT WITH LINE VOLT VAR
0
6.3V
1 ECC 81 - 12AT7 - 6201 - E81CC
2 ECC 81 - 12AT7 - 6201 - E81CC
3 EAA 91 - 6AL5 - 5726 - E91AA
4 85A2 - 5651
RADIOMETER COPENHAGEN
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
2 24/9-63 P.J. eh
2 24 9 59 LD. wk
1 6 i 59 LD. wk
Vaçuum-Tube Voltmeter
RV 23d - dM - dH
35635
1133-A2
1158-A2
Van wk 4 5-59 6 5 59