# PHILIPS

Thanks to Henrik Ros

**INSTRUCTIONS**

Ned. Ver. v. History of the Radio



## UNIVERSAL MEASURING BRIDGE
## "PHILOSCOOP II"
## GM 4144/01

66 401 33.1-27 1/560

# CONTENT



**When correspondence about this device, always state the type number and serial number; these are on the rating plate on the rear of the device.**

# I. GENERAL PART

## PREFACE

The PHILIPS GM 4144/01 measuring bridge is suitable for measuring or comparing resistors from 1 ohm to 10 megohm and capacities from 10 pF to 100 µF. With consideration of the zero capacity, capacities of at least 1 pF can be measured. Furthermore, the device can be used for comparing self-inductors, determining conductivity of liquids, determining the loss angle (tg $\delta$), e.g. of electrolytic capacitors and checking of insulation resistances, e.g. of paper capacitors.

The measuring bridge is based on the Wheatstone bridge principle. The bridge circuit is supplied with alternating voltage from the power supply transformer or from an external voltage source and contains built-in standard resistors and capacitors. In the so-called “open-bridge” position, external comparison standards can be applied (resistors, capacitors and inductors). The device also contains a position where the deviation from the external comparison standard can be read in percent. The bridge balance is read with the aid of an electron beam indicator with two sensitivities.

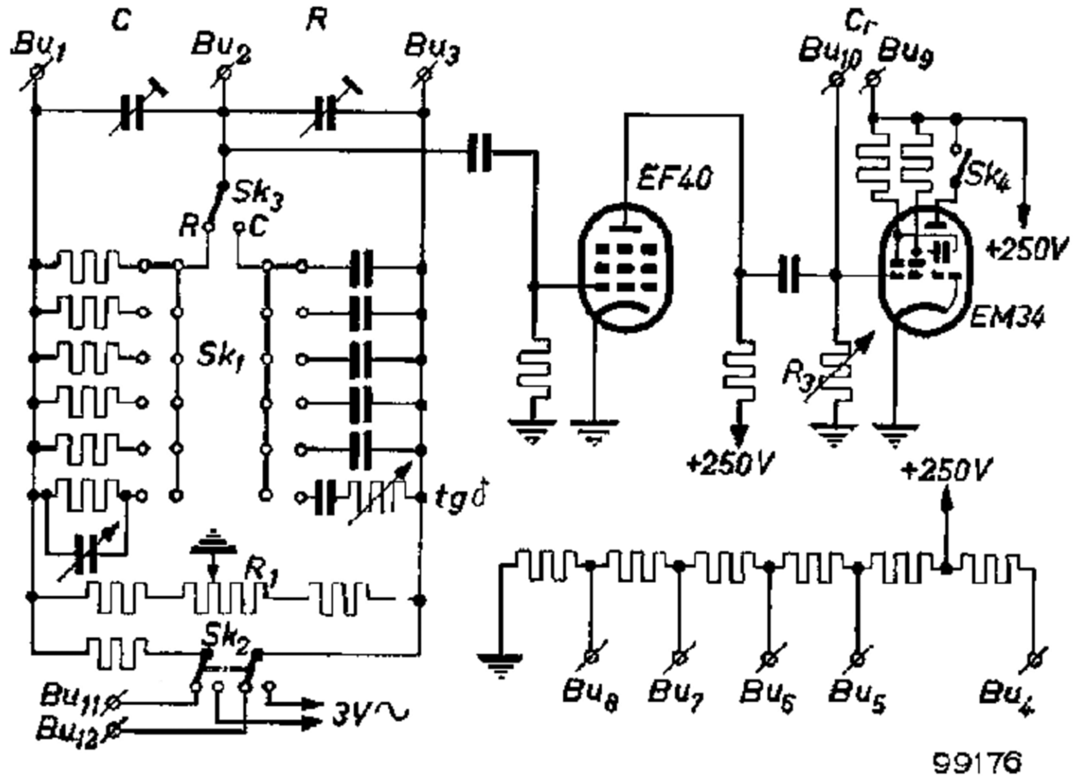


*Fig. 1. Simplified principle diagram*

## ELECTRIC DATA

**If the properties are expressed in numerical values with an indication of tolerances, these are guaranteed by us. Numerical values without tolerance are for orientation purposes only and indicate the characteristics of an average device.**

### Resistors

The total measurement range from 0.5 ohm* to 10 megohm is subdivided into six areas. Higher values can be measured using externally connected resistors. An adjustable phase correction is present for the range from 0.1 megohm to 10 megohm.

### Capacitors

The total measuring range from 1 pF to 100 μF is subdivided into six areas. The capacity of electrolytic capacitors can also be measured in the context of 1 to 100 μF. Higher values can be measured using externally connected capacitors. DC voltages of 10, 25, 50, 100 and 250 V are available for forming electrolytic capacitors.

### Checking insulation resistances

Separate sockets are provided for checking insulation resistances (e.g. of paper capacitors). A leakage resistance of 200 megohms is still demonstrable.

### Loss angle

For capacitors from 1 to 100 μF, loss angles of tg $\delta = 0.01$ to tg $\delta = 0.6$ can be demonstrated.

### Percent scale

The percentage scale runs from –20% to + 25%.

### Accuracy

*Scale I (0.1–1)**

In the middle of the scale, the absolute measurement error (including the reading error) is ⩽ 1.5%, increasing to ⩽ 3% at the ends of the scale.

*) The 0.05–0.1 scale section is for orientation only.

When using this scale for capacitance measurements of 10 to 100 pF, the error in the middle is $\leqslant$ 2.5%, increasing to $\leqslant$ 5% at the ends of the scale.

*Scale II (0.1–10)*

With the range switch $Sk_1$ in the “$10^6$” position, the absolute measurement error at the center of the scale is $\leqslant$ 2.5%, increasing to $\leqslant$ 6% at the ends of the scale.

With $Sk_1$ in the 'open? Bridge' position, the absolute measurement error in the center of the scale is $\leqslant$ 1.5%, increasing to $\leqslant$ 5% at the ends of the scale.

*Percent scale*

The absolute measurement error in the middle of the scale is $\leqslant$ 0.3%, increasing to $\leqslant$ 0.6% at the ends of the scale. The “absolute measurement error” of the device is here understood to mean: the measurement error as a percentage of the measured impedance.

The unknown impedance ($R_x$) is determined by comparing it with an external standard impedance ($R_s$).

Example:

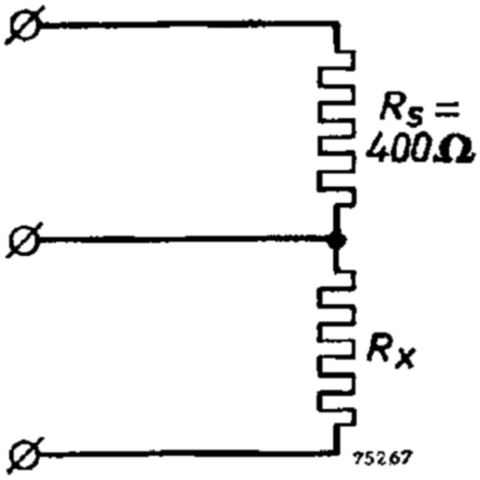


*Fig. 2*

a. For the center of the scale:

Suppose designation is 0% (tol. 3%).

The absolute error is therefore

$$\frac{3}{1000} \times 400\ \Omega = 1{,}2\ \Omega.$$

The value of the resistor Rx is therefore between 401.2 and 398.8 Ω.

b. Before the end of the scale:

Suppose the indication is –19.5% (tol. 6 ‰).

$$R_x = \frac{100 - 19{,}5}{100} \times 400\ \Omega = 322\ \Omega$$

with an error of $\leqslant$ 6%.

The value of the resistor $R_x$ is therefore between 320 and 324 Ω).

*Check position:* Deviation < 1%.

Under extremely humid conditions (e.g. in the tropics) for the higher impedances, the accuracy will not always meet the above values. The measuring bridge remains usable up to impedances of 10 megohms.

**Power supply**

The device can be set for the mains voltages 110, 125, 145, 200, 220 and 245 V by means of a rotary voltage selector. The mains frequency can be 40 – 100 Hz.

Mains voltage variations up to 10% have no influence on the accuracy of the measurement.

The power consumption from the network is 20 W.

The power transformer is provided with a temperature safety (code no. 974/T 125).

**Tubes**

1 amplifier tube EF 40,

1 electron beam indicator EM 34,

1 rectifier tube EZ 40.

**Bridge voltage:** 2.7 V with an internal resistance of 5 Ω ($Bu_1$ – $Bu_3$).

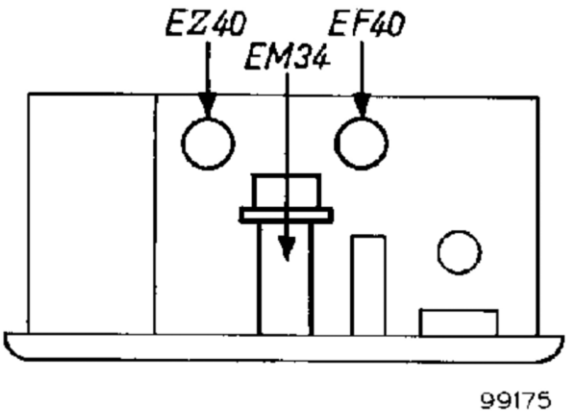


*Fig. 3. Location of the tubes*

# II. INSTRUCTIONS

## INSTALLATION

### Set for the local mains voltage

The device can be set for the local mains voltage using the voltage selector, which can be reached after removing the cover plate on the rear wall (pull the switch, turn until the correct voltage is at the top and press again).

### Connection

The earth terminal on the left side of the device must be properly grounded **before** the device is connected to the mains.

**When setting up the measuring bridge, care was taken that there were no alternating or magnetic alternating fields in the vicinity of the center bus ($Bu_2$),** as this could result in an incorrect indication or an unclear minimum when measuring high impedances.

To prevent malfunctions via the power cord, this is *shielded* while the shield is connected to the earth terminal.

## SERVICE

The name of the buttons and connection sockets is indicated in Fig. 6.

### Switch

Switching on is done by connecting the power cord to the mains.

The device is ready for use as soon as the tubes have reached their operating temperature.

### Power supply of the bridge circuit

By placing the switch $Sk_2$ in the lower ("INT.") position, power is supplied to the bridge circuit from the device itself. If an external supply voltage (alternating voltage) is to be used (for example for conductivity measurements), it can be supplied to the sockets marked "EXT.~" on the right-hand side of the device. $Sk_2$ must then be placed in the "EXT." position. The external bridge voltage may not exceed 3 V.

The external voltage source must be insulated from earth. See also under "Measuring the conductivity of liquids" (page 12).

### Check

With $Sk_1$ in the "CAL." one can check whether the indication of the indicator is correct. With the button $R_1$ you set to minimum result (maximum shadow) of the electron beam indicator. The pointer must then be at the center of the scale (point '1' on scale II).

Only *then* will the measurements errors remain within the specified tolerances.

### Sensitivity control

The sensitivity of the setting can be adjusted using $R_3$ on the left side of the device. In some cases it is recommended not to turn this knob fully clockwise (maximum sensitivity). In that case it may happen that no minimum is found when measuring capacities or inductances with a loss resistance.

With reduced sensitivity, a minimum is then found.

If you do not obtain a minimum when measuring unknown quantities, you must reduce the sensitivity of the sounder until you clearly notice or the result of the indicator decreases when turning $R_1$ to the right or left. In the first case you have to switch to a higher measuring area and in the second case to a lower measuring area.

The insensitive part of the indicator can be used for this, while the sensitive part must be used to determine the correct minimum.

**Measuring resistances**

1. The resistance to be measured is connected between $Bu_2$ and $Bu_3$, indicated on the text plate with “R”, the switch $Sk_3$ is placed in the lower position (“R”).
2. The measuring range is selected with the help of $Sk_1$ such that the probable value of the resistance lies in that measuring range.

| Measuring range | Position of switch $Sk_1$ | Read on scale | Scale reading multiply by |
|---|---|---|---|
| 1 – 10 ohm | 10 | I | 10 ohm |
| 10 – 100 ohm | $10^2$ | I | $10^2$ ohm |
| 100 – 1000 ohm | $10^3$ | I | $10^3$ ohm |
| 1000 – 10,000 ohm | $10^4$ | I | $10^4$ ohm |
| 10,000 – 100,000 ohm | $10^5$ | I | $10^5$ ohm |
| 0.1 – 10 megohm | $10^6$ | II | 1 megohm |

3. The result of the electron beam indicator is set to minimum using $R_1$. The sensitivity can be adjusted with $R_3$. If necessary, $Sk_1$ can be used in a different measuring area.

   If no clear minimum is obtained in the measuring range 0.1–10 megohm ($Sk_1$ in “$10^6$” position), phase correction can be applied with the aid of $R_2C_1$ (marked “tg $\delta$”). This controls the parallel capacitance ($C_1$ in Fig. 5) of the standard resistor.

4. The value of the resistance is now found by multiplying the number indicated at the position of $Sk_1$ by the reading on the corresponding scale, as indicated in the table on page 8.

The “open-bridge” position can be used to measure resistances with a value greater than 10 MΩ, as described below.

## Measuring capacities

1. The capacitor to be measured is connected between $Bu_1$ and $Bu_2$, on the text plate indicated with “C”, and the switch $Sk_3$ is placed in the upper (“C”) position.
2. The measuring area is selected with the help of $Sk_1$ such that the probable value of the capacity lies in that measuring area.
3. The result of the electron beam indicator is set to minimum using $R_1$. The sensitivity can be adjusted with $R_3$. If necessary, you can switch to a different measuring area using $Sk_1$.
4. The value of the capacity is now found by multiplying the number indicated at the position of $Sk_1$ by 10 and by the reading on the corresponding scale, as indicated in the table below.

| Measuring range | Position of switch $Sk_1$ | Read on scale | Scale reading multiply by |
|---|---|---|---|
| 1 – 100 pF* | 10 | I | 10 pF |
| 100 – 1000 pF* | $10^2$ | I | $10^2$ pF |
| 1000 – 10,000 pF* | $10^3$ | I | $10^3$ pF |
| 0.01 – 0.1 µF | $10^4$ | I | 0.1 µF |
| 0.1 – 1 µF | $10^5$ | I | 1 µF |
| 1 – 100 µF | $10^6$ | II | 10 µF |

*) The zero capacity is measured!

The value found must be reduced by the value of the zero capacity, which can be 10 to 15 pF. The zero capacity can be determined by reading the position at which the indicator has a minimum result in the 1–100 pF measuring range. Nothing must be connected to $Bu_1$, $Bu_2$ or $Bu_3$.

Example:

Measured zero capacity 11.0 pF;

measured capacity (zero capacity plus the value of the capacity to be measured) 17.8 pF;

the value of the capacity is then 17.8 pF – 11.0 pF = 6.8 pF.

For measuring capacitors with a value greater than 100 μF, the “open-bridge” position can be used, as described below.

**Measure in the “open-bridge” position**

By placing the switch $Sk_1$ in the “open-bridge” position, marked “”, resistances, capacities and inductances can be measured using an externally applied standard. The unknown resistor ($R_x$) or capacitor ($C_x$) is normally connected in the “open-bridge” position. Self-inductors are connected such as resistors. The standards ($R_n$, $C_n$ and $L_n$) are connected to the other buses (see Figs. 4a, b and c).

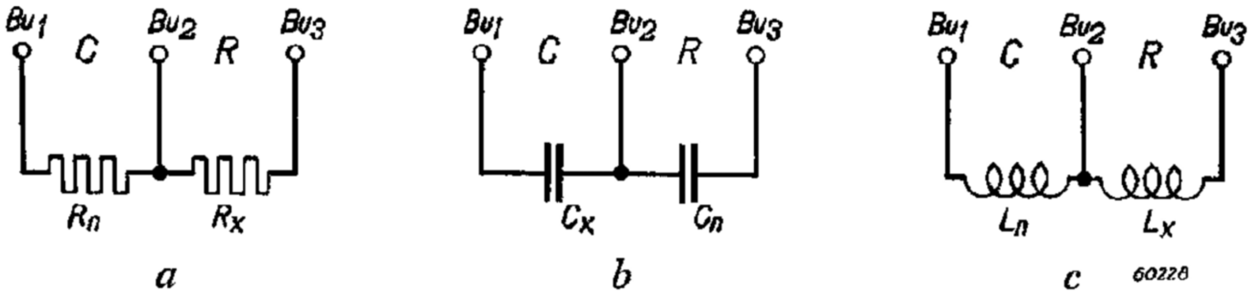


*Fig. 4*

The indicator is set to minimum with the help of $R_1$, while the sensitivity is also adjusted with the aid of $R_3$. If an unclear minimum is obtained when comparing self-inductors, this can be caused by the resistance of the two self-inductors not having the correct ratio. It is therefore desirable to correct the minimum with the help of a variable resistor in series with the standard inductance.

In the “open-bridge” position one always finds the value of the unknown by multiplying the value of the standard by the reading on scale II. One can also determine the value of the loss resistance in this way.

This scale has a distribution of 0.1 to 10, so that it can be used to measure resistances, capacities and inductances with a value of 0.1 to 10 times the standard used.

The zero capacity of the bridge must be taken into account when using the “open-bridge” position. This is 10-15 pF and can influence the measurements with high impedances.

For comparative measurements with very low impedances, the series resistance must be taken into account.

## Measuring in the “%” position

The switch $Sk_1$ is set to the “%” position. The circuit and the measurement are also carried out in the same way as with the “open-bridge” position, except for the reading, which is now taking place on the inner scale.

On this one can now read the percentage deviation (from –20 to + 25%) of a resistor, a capacitor or an inductor with respect to the externally applied standard.

Here too it may be necessary to obtain an induction when measuring self-inductors. Clear minimum to compensate for any phase differences using a variable resistor in series with the self-inductor to be measured or with the standard self-inductor.

If the bridge branches are open in the “%” position, the pointer need not be set to “0” with a minimum of the indicator.

## Measuring the loss angle (tg $\delta$)

When measuring capacitors in the range of 1–100 µF ($Sk_1$ in “$10^6$” position), the quality can be checked using $R_2C_1$, marked “tg $\delta$” on the text plate. This controls the series resistance ($R_2$ in Fig. 5) of the built-in standard capacitor.

First a minimum is set in the normal way with the aid of $R_1$ and then this is adjusted with the aid of $R_2C_1$. Both actions are possibly repeated. If the extreme minimum is reached with maximum sensitivity, the position of $R_2C_1$ indicates the value of tg $\delta$ of the measured capacitor. The value of the capacity is normally read on scale II.

The “open-bridge” position must be used to determine tg $\delta$ in other measurement areas.

## Checking insulation resistances

This can be done as follows:

1. $Sk_1$ is set to "CAL."
2. $R_3$ is turned completely clockwise so that maximum sensitivity is achieved.
3. The result of the indicator is set with $R_1$ such that the **sensitive** sector has ¾ of the maximum light coverage.
4. The object to be measured is connected between $Bu_9$ and $Bu_{10}$, marked "$C_R$" on the text plate.

   At a resistance value of 200 megohms, the shadow sector will then already change perceptibly, while the light coverage of the sensitive sector will disappear completely at a resistance value of 40 megohms.

## Forming and measuring electrolytic capacitors

Positive voltages (relative to earth terminal) of 10, 25, 50, 100 and 250 V are available on the right-hand side of the device on the correspondingly marked buses.

Electrolytic capacitors can be formed with the aid of these voltages.

The capacity of an electrolytic capacitor can be measured while it is live. The positive side is then connected to $Bu_2$ and the negative side to $Bu_1$ (indicated by "C"). The desired voltage is taken from the corresponding bus and applied to the bus $Bu_2$. The measurement is furthermore carried out in the normal manner.

## Measuring the conductivity of liquids

When measuring the resistance of electrolytes and other liquids, it is recommended (to prevent electrolysis or polarization) to use a voltage source with a frequency higher than the mains frequency for the bridge circuit power supply (e.g. 1000 Hz, 3 V).

Furthermore, for this measurement the PHILIPS measuring cells GM 4221, PR 9512 or GM 4227 (for flowing liquids) must be used.

The contacts of the measuring cell are connected to the buses $Bu_2$ and $Bu_3$ marked "R", of the GM 4144/01. The output buses of the L.F. generator are connected to the buses, marked "EXT. ~", on the right-hand side of the GM 4144/01. The switch $Sk_2$ of the measuring bridge must then be placed in the "EXT." position. The measurement is entirely the same as with the measurement of resistances. For the use of the measuring cells and other auxiliary devices, see the relevant operating instructions. In the instructions for use of the measuring cells, the calculation of the specific conductivity from the resistance value read is also stated. For a comparative measurement at the mains frequency, it is only necessary to place the switch $Sk_2$ of the GM 4144/01 in the "INT." position.

If *only* measurements of the conductivity of liquids are to be made, it is recommended to use the PR 9500 conductivity measuring bridge.

COMMENTS

1. If annoying own hum occurs in the device, it can be set to minimum with the aid of the hum potentiometer $R_4$, which can be reached through an opening in the rear wall. $Sk_1$ is placed in "$10^6$" position and $Sk_2$ in "EXT." position. The $R_4$ button is now turned in such a way that the result of the indicator becomes minimal.

2. **The device must be kept clear of interference during all measurements.**

3. Buses $Bu_1$, $Bu_2$ and $Bu_3$ should not normally be grounded; the only place where the circuit is normally connected to ground is the *terminal on the left side of the device*. If impedances are to be measured that are grounded on one side, *this side must be connected to one of the buses $Bu_1$ or $Bu_3$*. In order to obtain correct measurement results, the measuring bridge must be set up in isolation (for example on a glass plate). The circuit is then only earthed via $Bu_1$ or $Bu_3$.

## III. LIST OF RESISTORS AND CONDENSERS

(subject to change)

**Condensers**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 100 | pF | C18 | 9.5 | µF | R10 | 100 | Ω | R29 | 1 | MΩ |
| C2 | 1 | µF | *(C18//C20* | *10* | *µF)* | R11 | 10 | Ω | R30 | 1.2 | MΩ |
| *(C2//C3* | *1* | *µF)* | C19 | 68 | pF | R12 | 100 | Ω | R31 | 10 | MΩ |
| C3 * | 10,000 – | | C20 * | 0.1 – 0.68 | µF | R13 | 1 | kΩ | R32 | 5 | Ω |
| | 68,000 | pF | C21 | 1000 | pF | R14 | 10 | kΩ | R33 | 220 | kΩ |
| C4 | 2 × | | C22 * | 3900 – | | R15 | 100 | kΩ | R34 | 1,000 | MΩ |
| | 47,000 | pF | | 8200 | pF | R16 | 1 | MΩ | R36 * | 3.6 – 10 | kΩ |
| *(C4//C22* | *0.1* | *µF)* | C23 | 1000 | pF | R17 | 4,500 | Ω | R36′ * | 10 – 270 | kΩ |
| C5 | 10,000 | pF | C24 | 2.5 | pF | R18 | 1 | kΩ | R37 | 21 | Ω |
| C6 | 980 | pF | C25 | 1.8 | pF | R19 | 1,500 | Ω | R38 * | 330 – 620 | Ω |
| C8 | 25 | pF | | | | R20 | 2,400 | Ω | R39 * | 10 – 1,000 | kΩ |
| C9 | 10 | pF | **Resistors** | | | R21 | 5 | kΩ | R40 * | 10 – 1,000 | kΩ |
| C10 | 220 | pF | R1 | 1 | kΩ | R22 | 15 | kΩ | | | |
| C11 | 10 | pF | R2 | 200 | Ω | R23 | 8,200 | Ω | | | |
| C12 | 2,000 | pF | R3 | 1 | MΩ (log.) | R24 * | 3.6 – 10 | kΩ | | | |
| C13 | 12.5 | µF | R4 | 50 | Ω | R24′ * | 10 – 270 | kΩ | | | |
| C14 | 12.5 | µF | R5 | 70 | Ω | R25 | 2.2 | MΩ | | | |
| C15 | 22,000 | pF | R6 | 70 | Ω | R26 | 820 | kΩ | | | |
| C16 | 220,000 | pF | R8 | 1,050 | Ω | R27 | 220 | kΩ | | | |
| C17 | 22,000 | pF | R9 | 100 | Ω | R28 | 1 | MΩ | | | |

*) The correct value is chosen when manufacturing the device

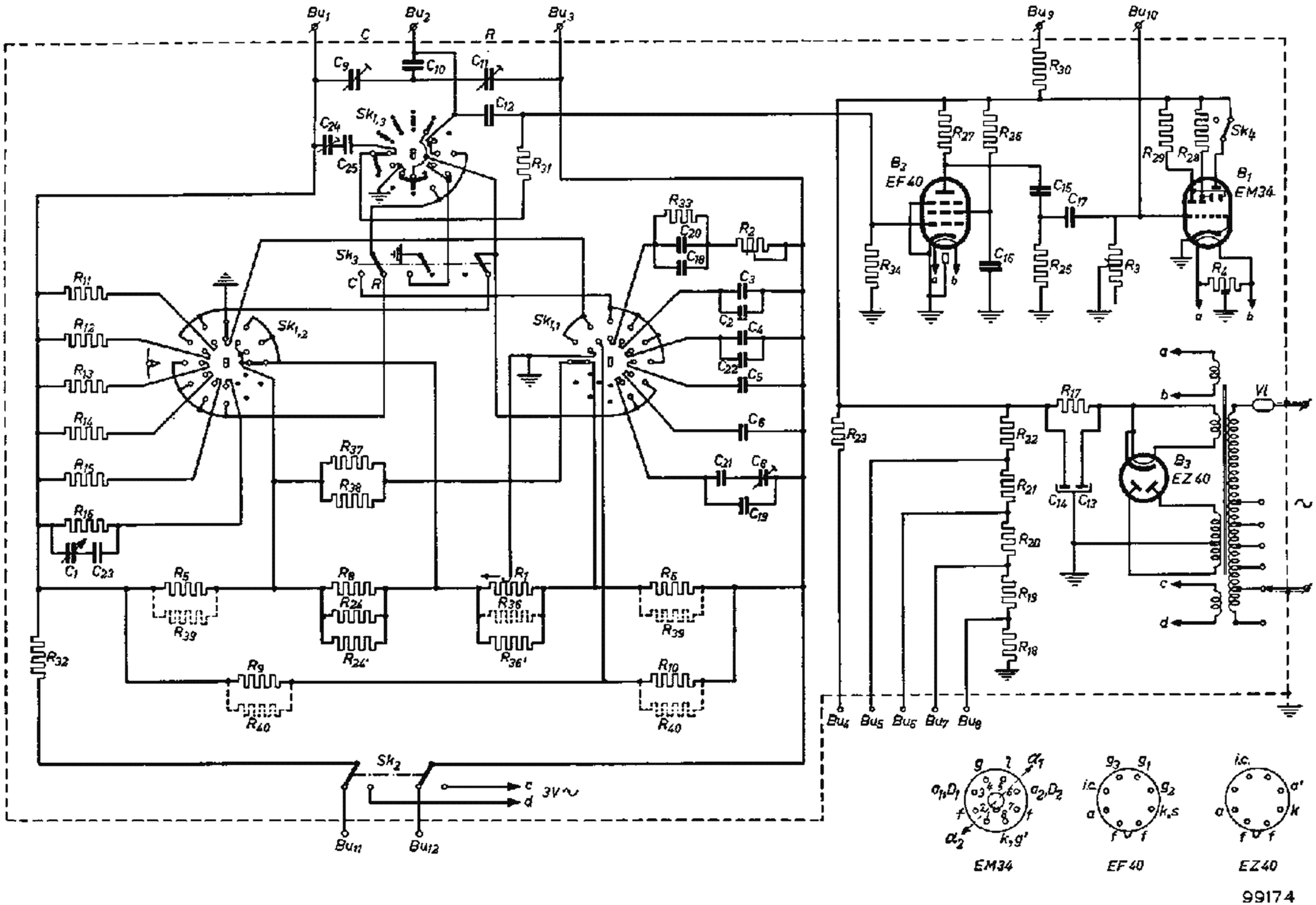


*Fig. 5. Diagram of the Universal Measurement Bridge GM 4144/01 (subject to change)*

*The circuit is connected to the cabinet at points "⏚".*

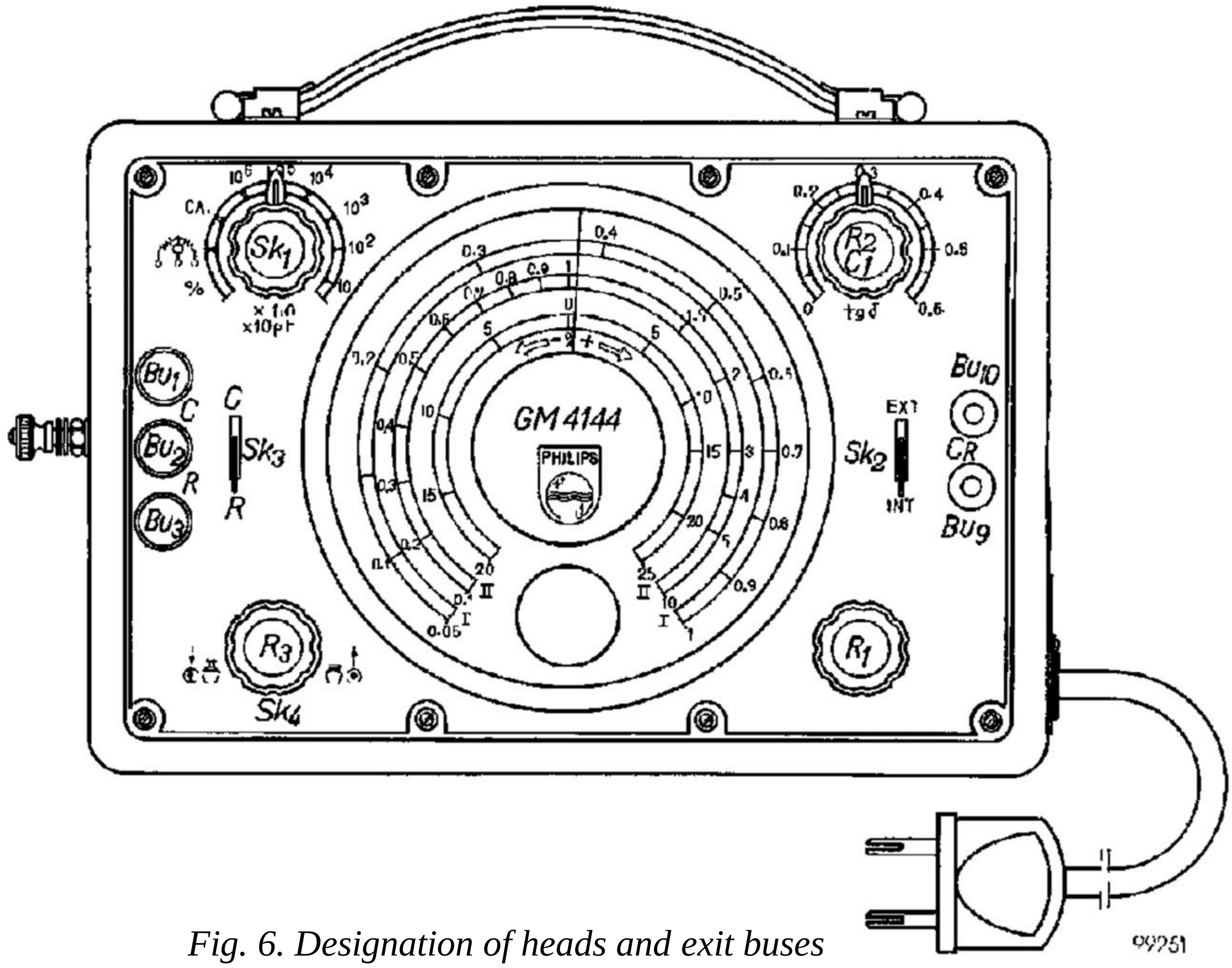


*Fig. 6. Designation of heads and exit buses*

To extend the life of the electron beam indicator EM 34, a pull / push switch ($Sk_4$) is provided, with which the anode voltage can be switched off. For this purpose, this switch, which is coupled to the potentiometer $R_3$, must be pressed.