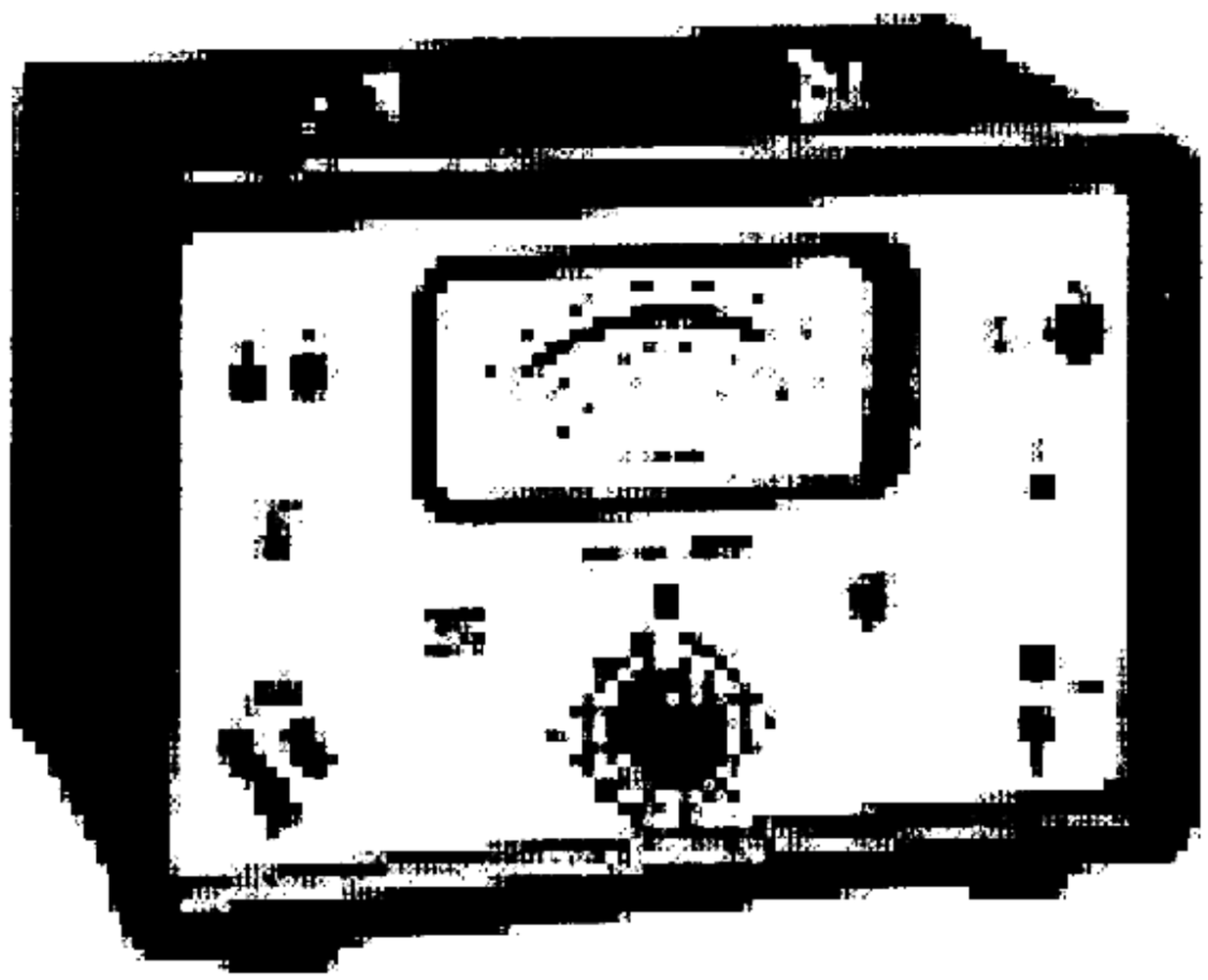
PHILIPS



Amplifier Voltmeter

PM 2520

66 403 45.1-10

20/564/01

Manual

Survey of figures

Contents

GENERAL PART

Introduction

By means of the amplifier voltmeter PM 2520 a.c. voltages of 100 μV...300 μV can be measured in a frequency range from 10 c/s to 1 **Mc/s.**

The apparatus has the following special properties:

a. Irrespective of the wave form the indication is always proportional to the r.m.s. value of the input voltage.
b. The circuit is perfectly symmetrical with respect to earth. This renders it possible to measure the voltage between two points which are at a high potential with respect to earth.

The apparatus is equipped with an accurately indicating meter having three scale divisions, viz.:

1. 0...100
2. 0...300
3. a dB-scale for direct indication of the damping factor.

For the purpose of checking the input voltage, an oscilloscope can be connected to two sockets at the front of the apparatus. These sockets can also be used as amplifier output.

The apparatus moreover has a socket for connection of a recorder, so that it is possible to record the voltage under test by means of an automatic compensator PR 2210A or PR 2400A.

II *Description of the block diagram (Fig. 1)*

In principle the apparatus consists of two amplifiers with a high input impedance and which are perfectly symmetrical with respect to earth.

The voltage under test is amplified by means of two amplifier stages (B1', 11', 2' and 12') preceded by an impedance-converting preliminary staye (B1. 11) and followed by an output amplifier (B3', 13', 4', 14'). According to the measuring range selected the voltage under test is attenuated at the input or between the amplifier stayes by the measuring-range switch. The three amplifier stages of this switch are coupled mechanically and are carried by the same shaft.

Via the Graetz rectifier the voltage is supplied to a quadratic network and indicated by the moving-coil instrument.

A calibrating-voltage generator is provided for calibrating the measuring instrument. This generator delivers constant sinusoidal voltages of 10 mV and 3 V with a frequency of 1000 c/s.

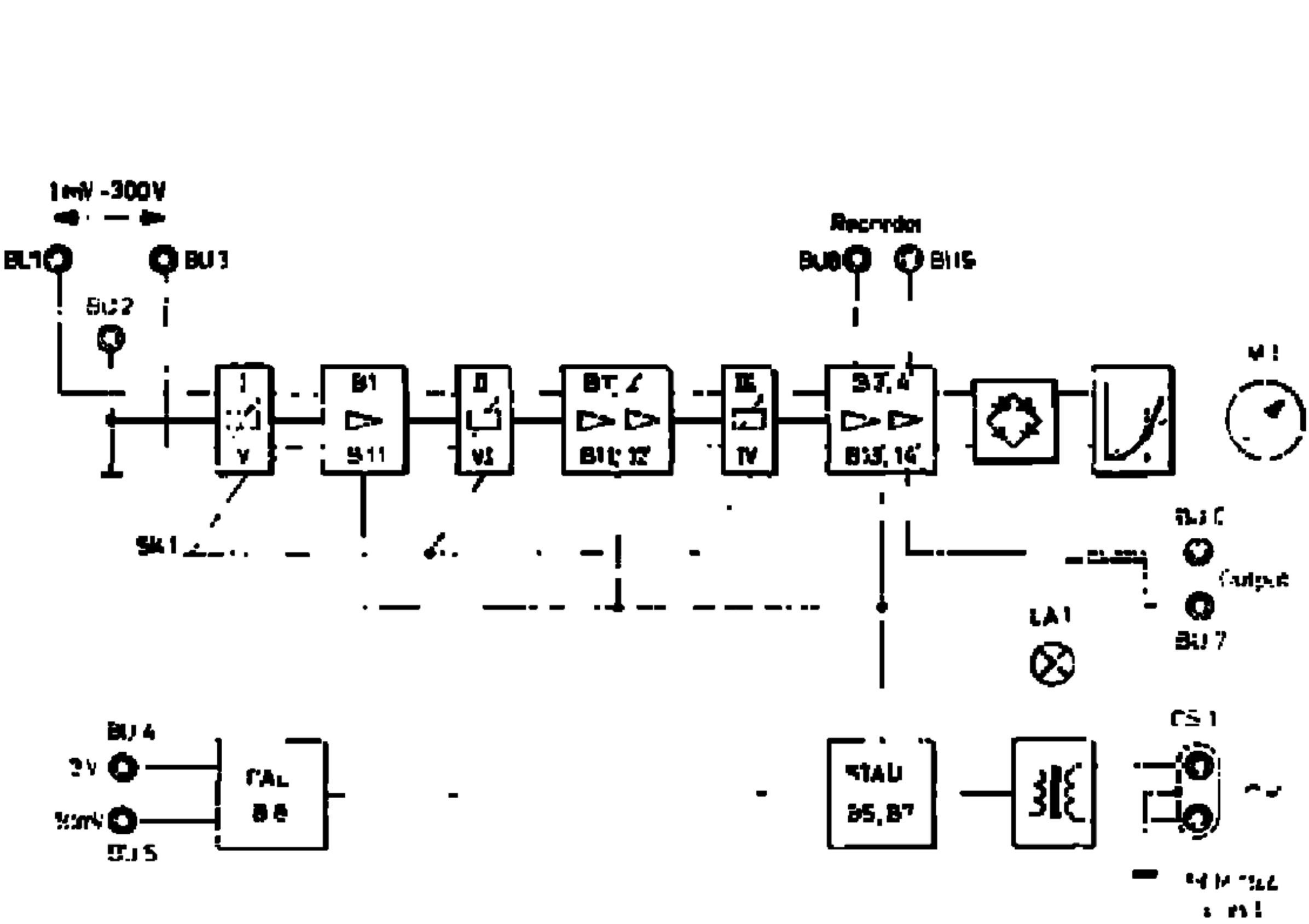


Fig. 1. Block diagram

The supply voltages for the amplifier and the calibrating-voltage generator are electronically stabilized by the valves B5...B7. The amplified input voltage is available at the sockets "OUTPUT". The sockets "RECORDER" at the rear of the instrument can be used for connecting a recorder. During the connection of a recorder the moving-coil instrument is cut out.

■■■ *Technical data*

Properties given as figures with tolerances are guaranteed by us. Numerical values without tolerances serve as a guide for the user and apply to the properties of an average instrument.
Unless stated otherwise. the numerical values refer to nominal mains voltage.

Measuring range — 100 µV...300 V subdivided in 12 ranges with max. values: 1, 3, 10, 30, 100, 300 mV and 1. 3. 10. 30. 100 and 300 V.

dB-range — –20 dB to + 20 dB
0 dB · 0.775 V across 600 Ω 1 mW.

Input impedance	*Input resistance*		*Input capacitance*	
in measuring range	symm.	asymm.	symm.	asymm.
1 mV... 1 V	8 MΩ	4 MΩ	15 pF	30 pF
3 V...300 V	20 MΩ	10 MΩ	7,5 pF	15 pF

Accuracy
After calibration for a sinewave voltage of 10 mV

(f.s.d.) and 1 Kc/s	± 1 %
Attenuation	± 1 %
Meter	± 1.5 %
Frequency response	
20 c/s - 200 Kc/s	± 1 %
10 c/s - 1 Mc/s	± 3 %

for non sinusoidal voltages following accumulative errors should be taken into account

for crest factor 1:	+ 3...4 %
for crest factor 1...5:	+ 3 %

Pre-deflection — ≤ 50 µV (in the 1 mV-range. input terminals terminated with 100 kΩ and screened).

Calibrating voltages — 10 mV and 3 V.
Frequency 100 c/s.

Proportion between peak and r.m.s.-value — $\frac{\hat{U}}{U_{r.m.s.}}$ = max. 5.

Common mode rejection I.e. the attenuation of signals which are in phase with respect to earth and applied between the input terminals and earth	60 dB for 1 V. 50 c/s.
Output for recorder	
Measuring range on sockets "RECORDER"	0 – 100 mV
Internal resistance	1 kΩ
Potential of sockets "RECORDER" with respect to earth	approx. 100 V
Max. amplification on sockets "OUTPUT"	40 ×
Internal resistance	100 Ω
Supply	By means of a voltage selector the apparatus can be adjusted to mains voltages of 110. 125. 145. 200, 220 and 245 V. frequency 40...100 c/s (frequencies < 50 c/s only at nominal mains voltage).
Measuring error at mains-voltage variations of + or –10%	± 1 %
Drift of calibrating voltage at mains-voltage variations of + or –10%	± 0.5 %
Power consumption	approx. 70 W
Dimensions and weight	height 24 cm. depth 22 cm. width 36 cm weight 9.7 kg.

IV Accessories

- Mains cable
- Manual
- Measuring cable

DIRECTIONS FOR USE

V *Installation*

A. ADJUSTING TO THE LOCAL MAINS VOLTAGE

By means of a voltage selector the apparatus can be adjusted to mains voltages of 110, 125, 145, 200, 220 and 245 V. The voltage value adjusted can be read through the round opening in the rear wall.

Adjustment to other mains voltages is effected as follows:

a. Remove the four screws C and lift the covering plate (Fig. 2).
b. Pull out the selector, turn it till the correct voltage value is up and press it back.
c. Refit the covering plate and check whether the correct voltage value is indicated.

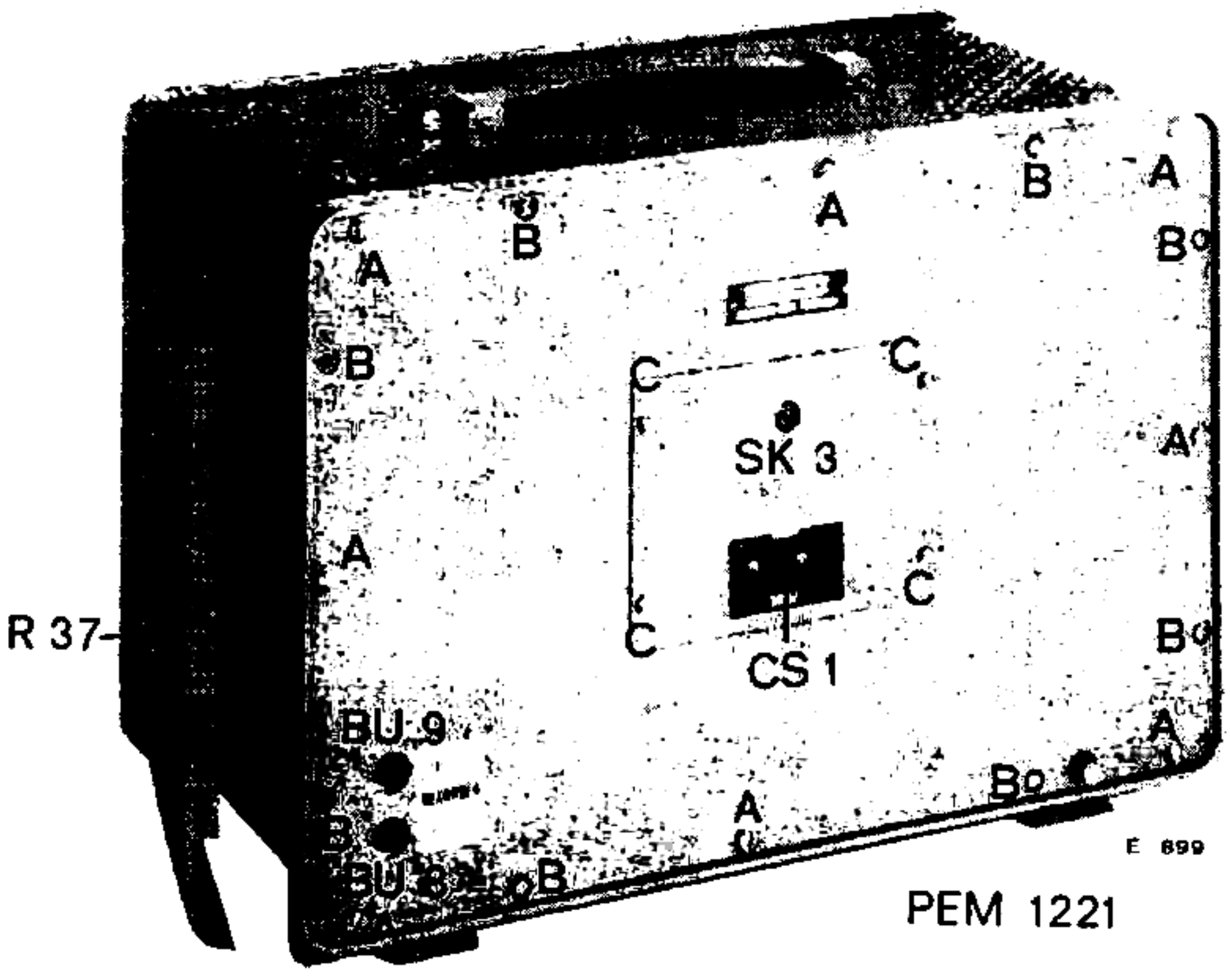


Fig. 2. Rear view

B. CONNECTIONS

Earthing

Earth the instrument according to the local safety regulations. This can be done via:

- the earth screw at the rear of the instrument
- the earth socket at the front of the instrument
  the mains cable if the instrument is equipped with a 3-core mains cable fitted with a plug with rim-earthing contacts.

Avoid double earthing; it may increase the risk of hum.

Mains cable

Proceed as follows:

a. Check whether the mains-voltage selector has been properly adjusted.
b. Earth the apparatus.
c. Set the mains switch "0 - - -" to "0".
d. Connect the mains input socket to the mains using the mains cable supplied.
e. Check whether the pointer of the meter indicates "0"; if necessary. readjust by means of the plastic screw at the front of the instrument.

VI Operation

A. SWITCHING-ON

a. Switch the instrument on by means of knob "0–∞".
b. Check whether the lamp beside the mains switch glows. After about 15 minutes the instrument has obtained the required stability.

B. CHECKING AND CALIBRATING

1. Zero adjustment and pre-deflection

The pre-deflection is adjusted as follows:

a. Short-circuit the input terminals to earth.
b. Set the measuring-range switch to position "10 mV".
c. Adjust the indication of the meter to zero by means of potentiometer "0".
d. Set the measuring-range switch to position "1 mV".
e. The meter must now indicate less than 50 μV.

2. Calibration

For calibrating purposes the front plate of the apparatus has two sockets at which stabilized calibrating voltages of 10 mV and 3 V (1000 c/s) are available.
The 10-mV voltage serves to check and calibrate the amplifier, while the 3-V voltage can be used for checking the pre-attenuator.

Calibration is effected as follows:

Set the measuring-range switch to 10 mV.
Connect socket "10 mV" to one of the sockets "1 mV–300 V"; the free socket must be connected to the earth socket.

– Check whether the instrument indicates exactly 100 on the scale 0-100. If necessary, readjust potentiometer R37 (screw-driver adjustment, right-hand panel).

Checking the pre-amplifier

-- Calibrate in the above-mentioned way.
- Set the measuring-range switch to 3 V.
- Connect socket "3 V" to one of the sockets "1 mV–300 V"; the free socket must now be connected to the earth socket.

– Check whether the instrument indicates a value between 296 and 304 V on the 0-300 scale. If the meter indicates a different value, the adjustment of chapter XI E must be carried out.

3. Adjusting the common mode rejection (balance)

The instrument has a provision for symmetry adjustment, by means of which the effects of a.c. fields near the measuring arrangement can be suppressed to a maximum degree.
This adjustment is carried out in the following way by means of potentiometer "BALANCE" on the front plate:

– Connect the sockets "1 mV–300 V".
– Connect a test cable of 1 metre to these sockets; one end of this cable must lie free on the table or workbench.
– Set the measuring-range switch to position 3 mV.
– Adjust the indication to minimum by means of potentiometer "BALANCE".

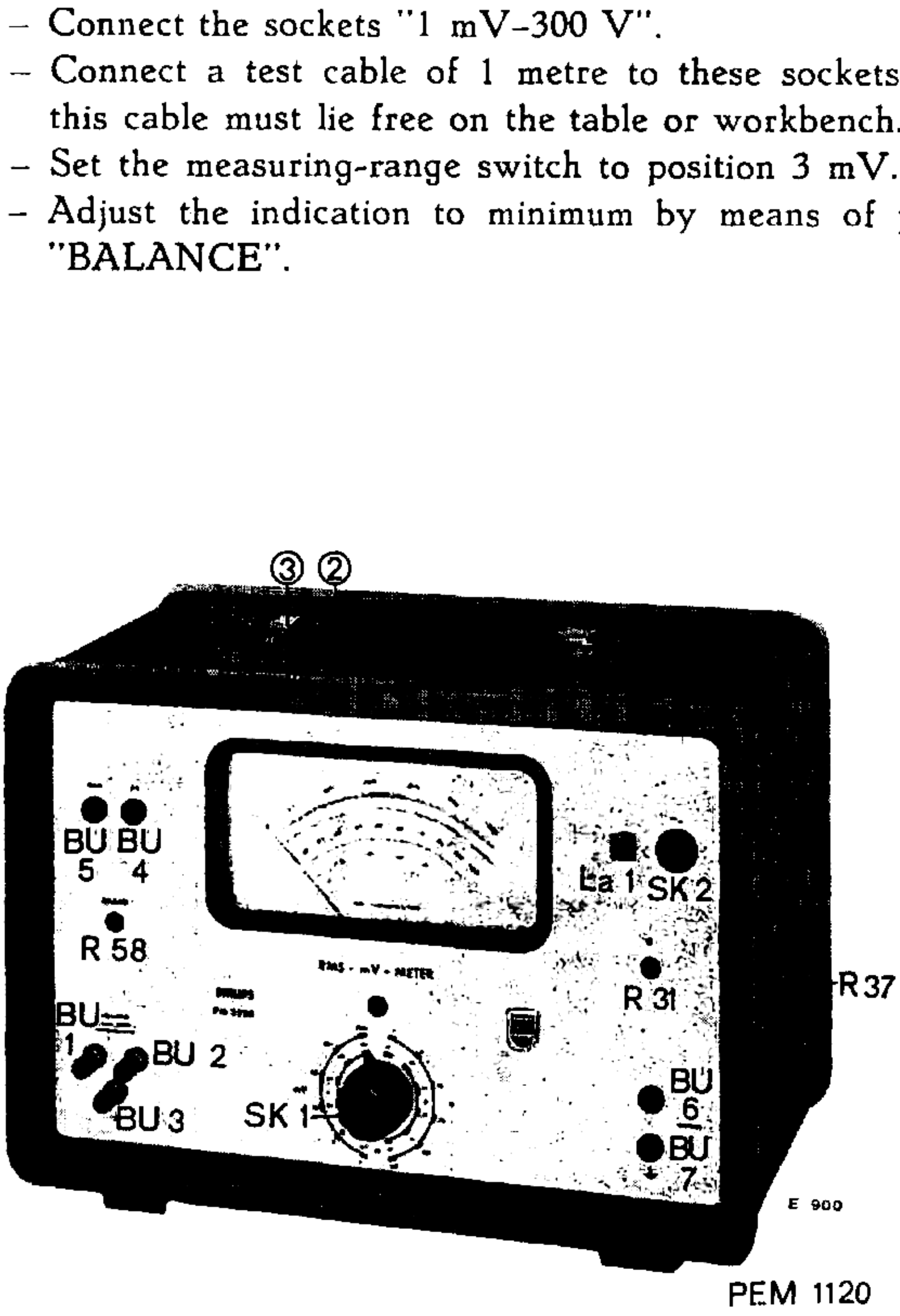


Fig. 3. Front view with controls

C. MEASURING METHODS

1. Symmetrical with respect to earth

The voltage under test is connected to the upper terminals "1 mV - 300 V" (Fig. 4a).

2. Asymmetrical with respect to earth

The voltage under test is connected to one of the upper terminals "1 mV – 300 V" and the terminal "⏚". The free terminal is connected to socket "⏚" (Fig. 4b).

3. Amplifier output

The amplifier output "OUTPUT" can be used as input both for the symmetrical and the asymmetrical methods.

4. Output for recorders

CAUTION!

A recorder must be connected free from earth, as both sockets carry a voltage of about 100 V with respect to earth.

At the rear of the instrument there are two sockets for connection of a recorder (Fig. 2).

If a plug is inserted into one of the sockets, the instrument is switched off automatically.

The output voltage is 0--100 mV (100 mV corresponds to full-scale deflection on the meter).

When connecting a recorder, the internal resistance of the measuring instrument must be taken into account.

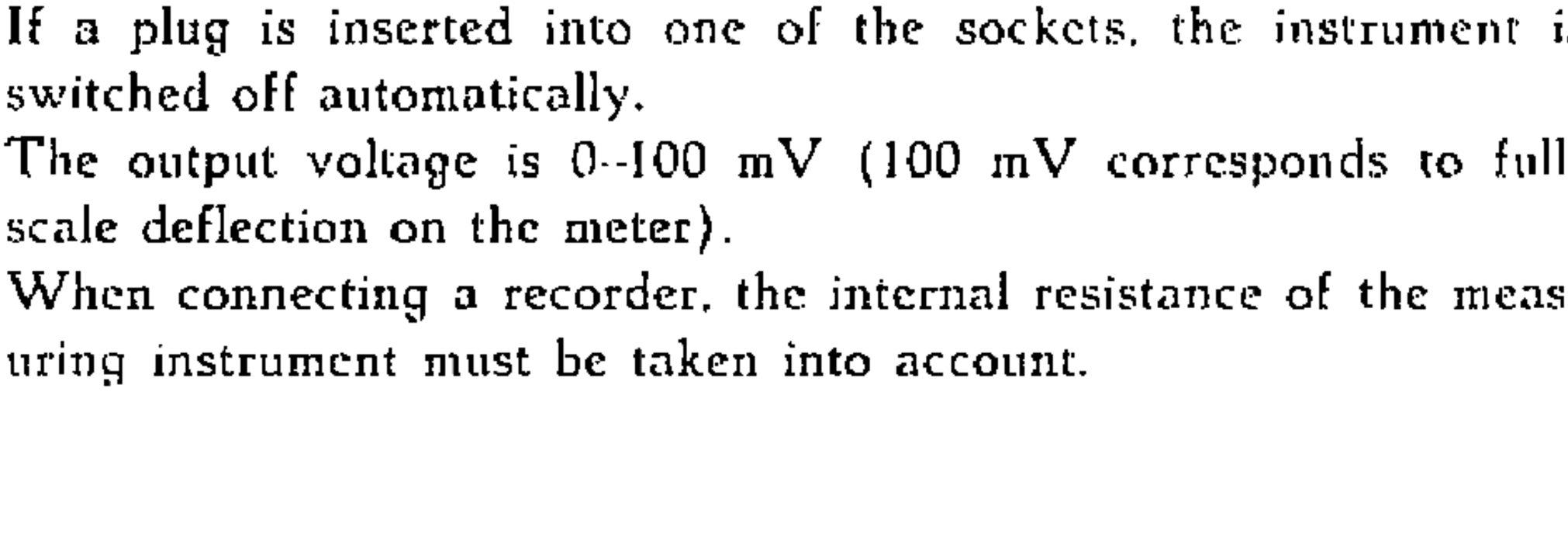


Fig. 4. Various ways of connection

SERVICE DATA

VII *Description of the mode of operation (Fig. 27)*

A. AMPLIFIER

The a.c. voltage under test is applied to the input attenuator via sockets "1 mV – 300 V".
In the measuring ranges 1 mV ·· 1 V the input signal is not attenuated. In the case of a symmetrical input the input resistance is 8 MΩ.
In the higher voltage ranges 3 V ·· 300 V the input signal is attenuated by the voltage divider R1-R3 (R101-R103), as a result of which the input resistance in these ranges is 20 MΩ with symmetrical input.

Via capacitor C32 (C132) and resistor R4 (R104) the signal is applied to the control grid of valve B1 (B11). These valves act as cathode followers and convert the high input impedance to a low impedance. Resistor R5 (R105) causes a negative feedback which increases the input impedance. Symmetry is obtained by means of potentiometer R93.

The signal now having a lower impedance is applied to the second attenuator R8-R12 (R108-R112) (Fig. 5).

Via capacitor C4 (C104) and resistor R16 (R116) the signal now reaches the control grid of valve B1′ (B11′) of the pre-amplifier and is subsequently amplified by two stages: in this case as well the output is a cathode-follower stage.

The RC network consisting of R94-C40 and R25 (R194-C140 and R125) constitutes a negative feedback to the cathode potential of valve B1′ (B11′), on account of which the frequency-response curve is corrected.
On the low side of this curve the filter represents a higher impedance than on the high side.

The common mode rejection is adjusted by means of resistors R99 and R58. The grid bias is symmetrically adjusted by means of R99, while the decoupling is adjusted by R58.

The third attenuator determines which voltage range. 3 mV or 10 mV, will be used by switching over the resistors R26 and R27 (R126 and R127).
The amplified signal is applied to the control grid of valve B3' (B13') of the output amplifier via capacitors C9 (C109) and resistors R35 (R135).
The two following stages then amplify the signal which is then given a low impedance by cathode-follower B4' (B14') and applied to the Graetz rectifier GR1...GR4.
Electrical zero adjustment is effected by adjusting the control-grid voltages of the valves B3' and B13' symmetrically by means of potentiometer R31 ("0" on the text plate).
The sensitivity of the indication and of the amplification is determined by the value of potentiometer R37 in the cathode lead of valves B3' and B13'.
The frequency-response curve is adjusted at high frequencies by means of trimmer C11 (C111).

B. QUADRATIC NETWORK

The r.m.s.-value rectification is effected by a network consisting of a special circuit of diodes and resistors (Fig. 6). The special properties of this network ensure that the current flowing through the indicating meter is proportional to the square of the voltage under test.

This quadratic function corresponds to a parabolic curve. In this way it is ensured that for indicating the r.m.s. value the scale of the meter can be calibrated almost linearly.

To explain the r.m.s.-value rectification the mode of operation of the diode circuit will first be described in detail.
Fig. 7 shows the current/voltage characteristics for average-value rectification (A), peak-value rectification (B) and r.m.s.-value rectification (C). The uninterrupted line always indicates the practical value and the dotted line the theoretical value.

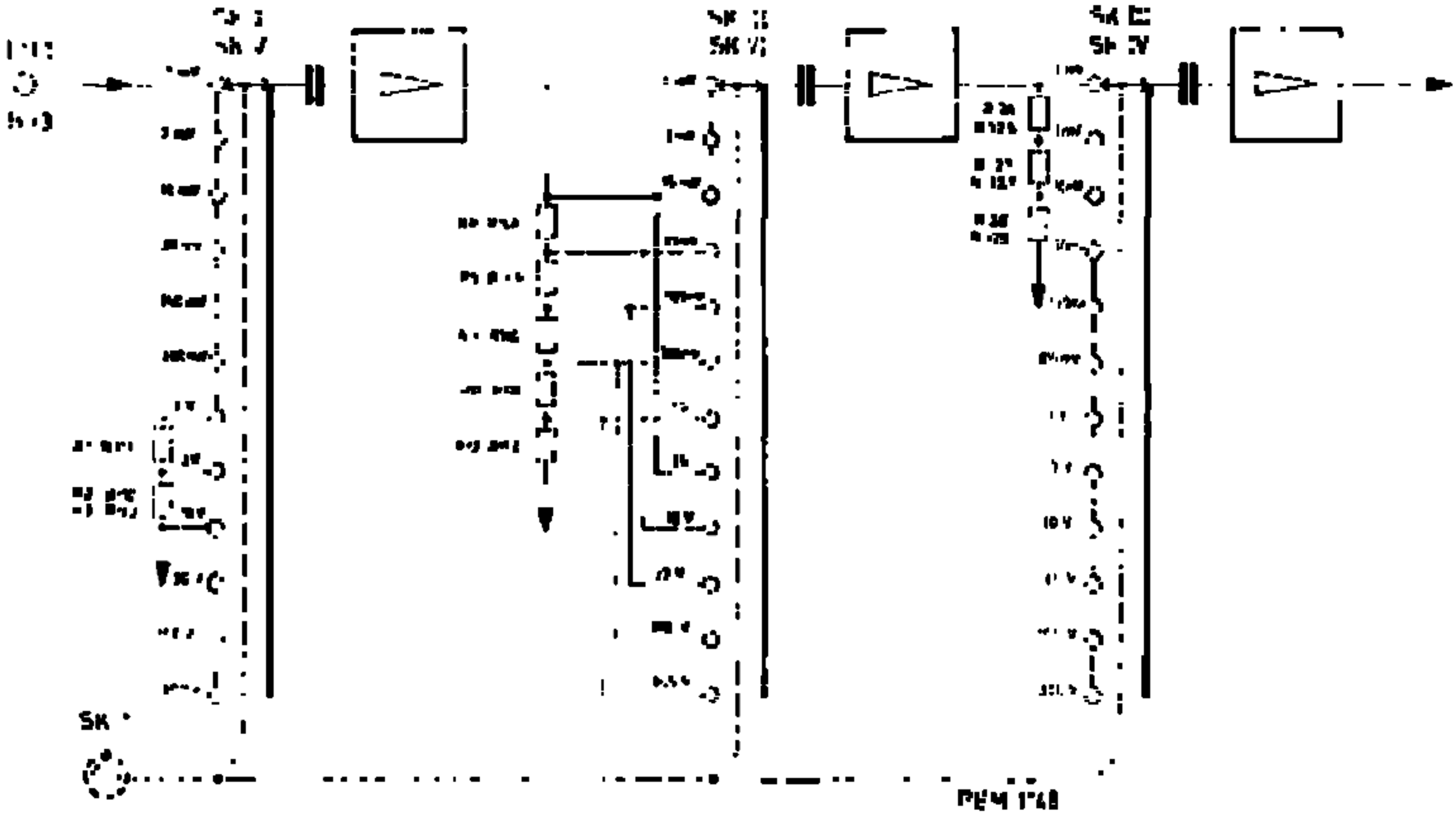


Fig. 5. Attenuator circuit

Fig. 6. Quadratic network

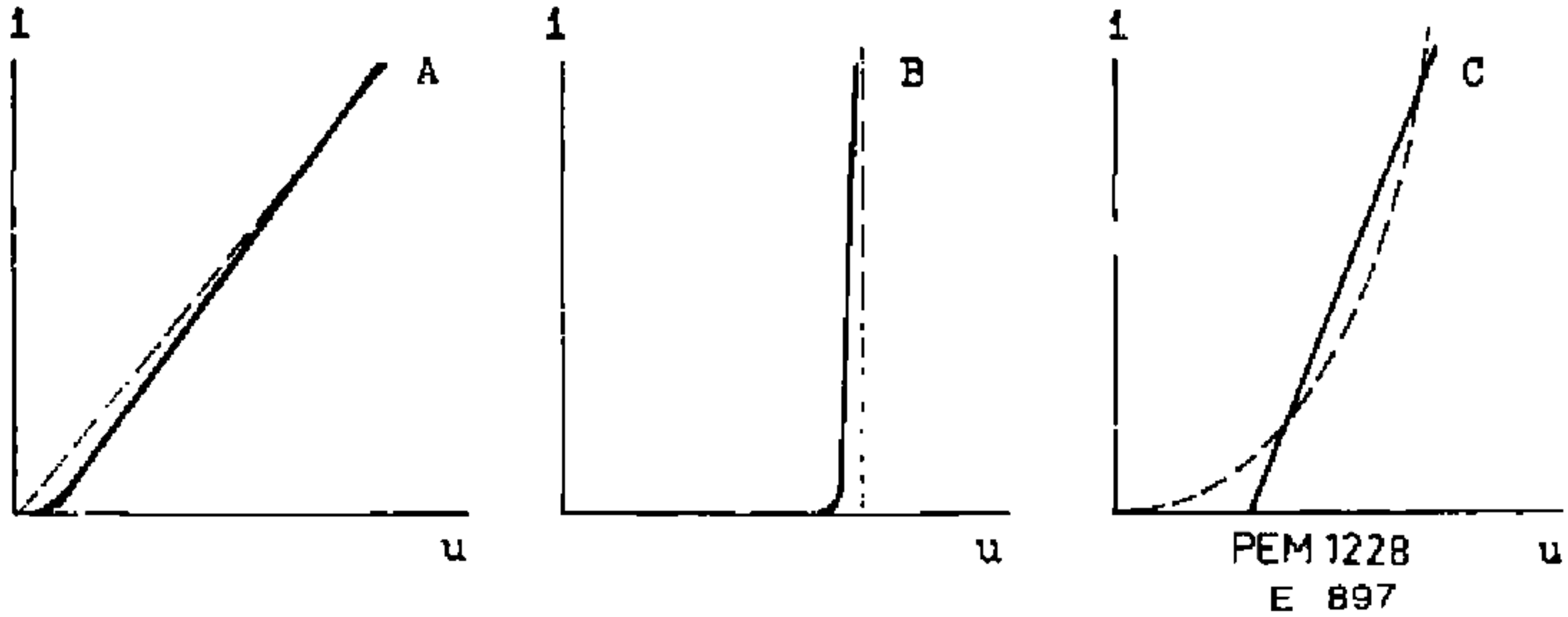


Fig. 7. Current-voltage characteristic

These figures reveal that the curve is parabolic for the r.m.s.-value rectification and represents a value between the average and peak values. As with a parabola the proportion $\frac{u}{i}$ differs in all points. r.m.s.-value rectification cannot be achieved with a linear circuit. For practical purposes the test circuit must be arranged so that the current flowing through the instrument corresponds as accurately as possible to the parabolic curve. so that it is proportional to the square of the voltage.
The circuit of the network including the diodes GR5...GR8 bends the linear characteristic (working line) in specific ratios, as a result of which the parabolic shape of the curve is approached (Fig. 8).

On account of this step-wise adaptation it is possible to arrive at such an approximation of the parabolic curve that the deviations lie within fixed tolerance limits.
The resistors R50-R51. R49-R52 and R58-R53 are potential dividers delivering the intermittently occurring voltage to the relevant diode. thus determining the point of deflection.
After the input voltage has been amplified and rectified by the Graetz circuit, the diode in the relevant circuit becomes conductive when the deflection voltage is obtained, so that the resistance value of this circuit decreases.
The same process occurs in one or more diode circuits, dependent

on the voltage: every time the curve will be deflected at the moment when the relevant diode becomes conductive, so that the curve will follow a parabolic path (Fig. 8).

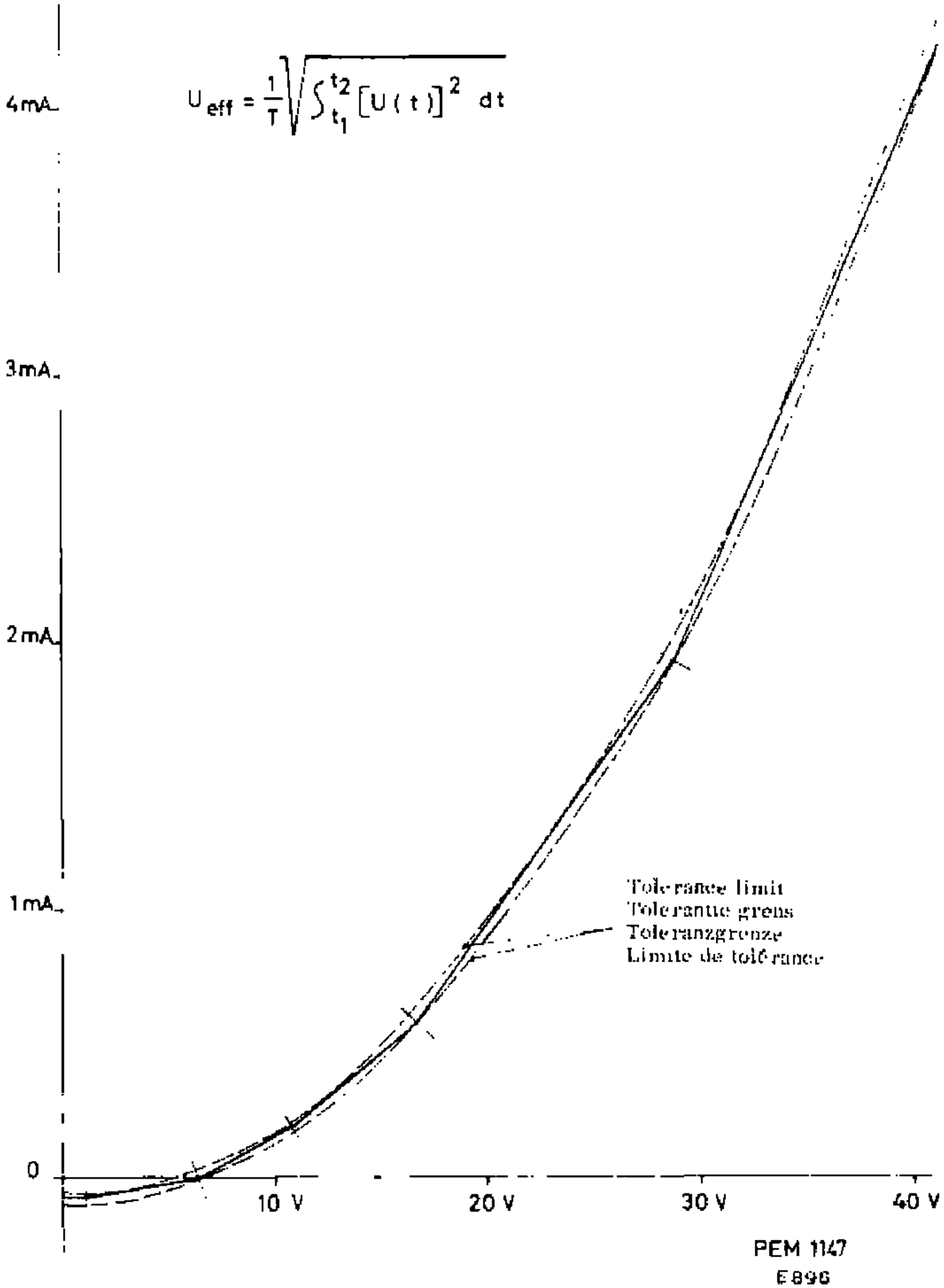


Fig. 8. Parabolic curve

Diode GR9 is provided for limiting the blocking current; but for this diode the blocking current would be a factor 4 higher.
The heating of the diodes GR5...GR8 is compensated by the diodes GR10 and GR11.

Zener diode GR17 protects the indicating meter against too high a voltage, while diode GR16 limits the meter current to about 100 μA.

C. SUPPLY UNIT

All supply units are electrically stabilised by valves B5, B6 and B7 in the classic way. The 110-V voltage is supplied by B3.

The supply transformer is protected by a thermal fuse which interrupts the mains voltage if the transformer becomes too hot.

D. CALIBRATING-VOLTAGE GENERATOR

For calibrating the instrument calibration unit U2 delivers voltages of 10 mV and 3 V; the frequency of the voltage is 1000 c/s.

The R.C. oscillator consists of pentode B8' in conjunction with the capacitors C34, C35 and C36 and the resistors R81 and R82, constituting the tuning circuit. Triode B8 is connected as a diode and serves to control the amplitude of the oscillator voltage.

The 3-V calibrating voltage is adjusted by means of resistor R84 or R87 and the 10-mV calibrating voltage by means of potentiometer R92.

E. OUTPUT FOR AN AUTOMATIC RECORDER

The output sockets "RECORDER" are provided for connection of a recorder. If a plug is inserted into one of these sockets the indicating meter is automatically cut out.

Care must be taken, however, that the sockets "RECORDER" are connected to a d.c. voltage with respect to earth. This means that the connection of the recorder must be made **free from earth.**

F. AMPLIFIER OUTPUT

At sockets "OUTPUT" the input signal (B13') amplified by channel 2 is available. This output signal is given a specific value by the cathode follower.

The output is independent of the test amplifier and the measuring procedure cannot be interfered with by external influences.

VIII *How to gain access to the parts*

1. Removing the switch knob (Fig. 9)

a. Remove cap "A" (for instance with the nails of thumb and forefinger).
b. Slacken screw "B" and tap it lightly.
c. Pull the knob from the spindle.

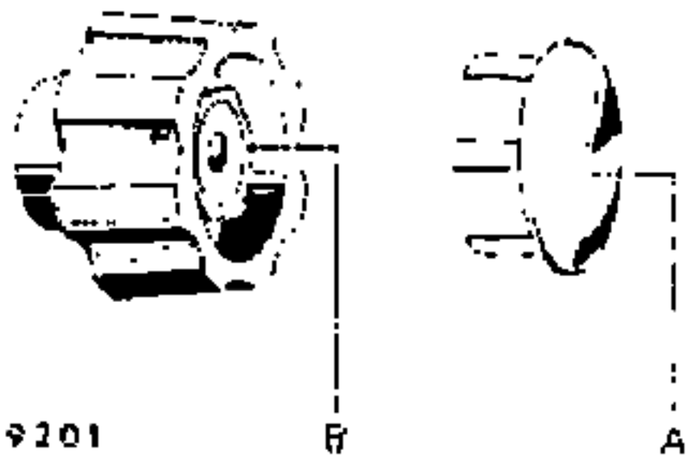


Fig. 9. Removing the knob

2. Removing the panels (Fig. 2)

The cabinet consists of a number of separate panels that can be removed one by one.

Rear wall

a. Loosen the screws "A" and the earth terminal.
b. Remove the rear wall.

Bottom plate and side panels

a. Loosen the screws "B" belonging to the plate.
b. Slide the plate forward and lift it out of the frame.

Cover

a. Remove the four screws from the grip.
b. Loosen the screws belonging to the cover.
c. Slide the cover forward and lift it out of the frame.

IX *Maintenance*

The amplifier voltmeter PM 2520 requires little maintenance. as the instrument does not contain parts that are really liable to wear. If necessary, the switch shaft can be lubricated with some thinly fluid oil (sewing-machine oil).
The switch contacts may only be treated with a special switch oil in the case of break down. (The ordering number of this oil is stated in the list of mechanical parts).
The panels are made of aluminium coated with a layer of P.V.C. and can be cleaned with water and soap after having been detached.

X *Adjusting devices and their functions*

Item to be adjusted	*Adjusting devices*	*Required auxiliary apparatus*	*Recommended PHILIPS apparatus*
Stabilised d.c. voltage	R70	Valve voltmeter	GM 6020
Electrical zero-adjustment	R31	none	
Sensitivity	R37	L.F. generator Valve-voltmeter	GM 2317 GM 6012 (calibrated)
Frequency-response curve	C11, C111	L.F. generator H.F. generator	ZV 2312 GM 2883
Pre-attenuator	R3, R103 C1, C101	L.F. generator Valve-voltmeter	GM 2317 GM 6012 (calibrated)
Calibrated-voltage generator	R84, R87 R92	L.F. generator Valve-voltmeter	GM 2317 GM 6012 (calibrated)
Common mode rejection	R58, R93 R98, R99	L.F. generator Valve-voltmeter	GM 2317 GM 6012 (calibrated)

The above sequence is completely arbitrary. The sequence stated in Chapter XI is recommended for complete adjustment.

XI *Checks and adjustments*

The tolerances stated below are factory tolerances which apply to the readjustment of the instrument. They may differ from the data stated in the "General Part" (point III).
In Chapter X all adjusting devices, selector resistors and selector capacitors are stated and their functions are described; this chapter also contains a survey of the auxiliary equipment required.

A. CHECKING THE SUPPLY UNIT

1. Mains current

- Check whether the mains-voltage selector indicates 220 V and connect the apparatus to this voltage (mains frequency 50 c/s).
- Set the mains switch to position "~". The pilot lamp must now light up.
- Measure the current consumption. This may be maximum 350 mA.

2. D.C. voltage

Adjust the mains voltage to 220 V. + or - 1 % by means of a variable transformer or a stabilizer.
- Measure the voltage with respect to earth on point 7 of unit U14. It must be 215 V. + or - 2 %. If necessary, select another value for R70.

B. ZERO ADJUSTMENT

1. Mechanical

- Set the mains switch to position "0".
- Check whether the pointer indicates zero; if necessary, readjust the pointer by means of the black plastic screw below the indicating meter.

2. Electrical

Set the mains switch to position "~".
The apparatus remains switched on during all following test measurements.
The heating-up time is at least 15 minutes.

- Short-circuit the input terminals to earth.
- Set the measuring-range switch to position "10 mV".
- Check whether the pointer indicates zero; if necessary, readjust by means of potentiometer "0" on the front plate. (Tolerance: maximum 0.5 scale division.)

C. SENSITIVITY

- Connect the left-hand socket "1 mV – 300 V" to terminal "⏚".
- Set the measuring-range switch to position "10 mV".
- Connect a voltage of 10 mV, frequency 1000 c/s between the right-hand socket "1 mV – 300 V" and earth.
- Adjust the indication of the meter to 100 by means of potentiometer R 37 (Fig. 10).
- Connect the right-hand socket "1 mV – 300 V" to terminal "⏚".
- Connect a voltage of 10 mV, frequency 1000 c/s between the left-hand socket "1 mV – 300 V" and earth.
  The meter indication must now also be 100. If necessary, check the zero adjustment.

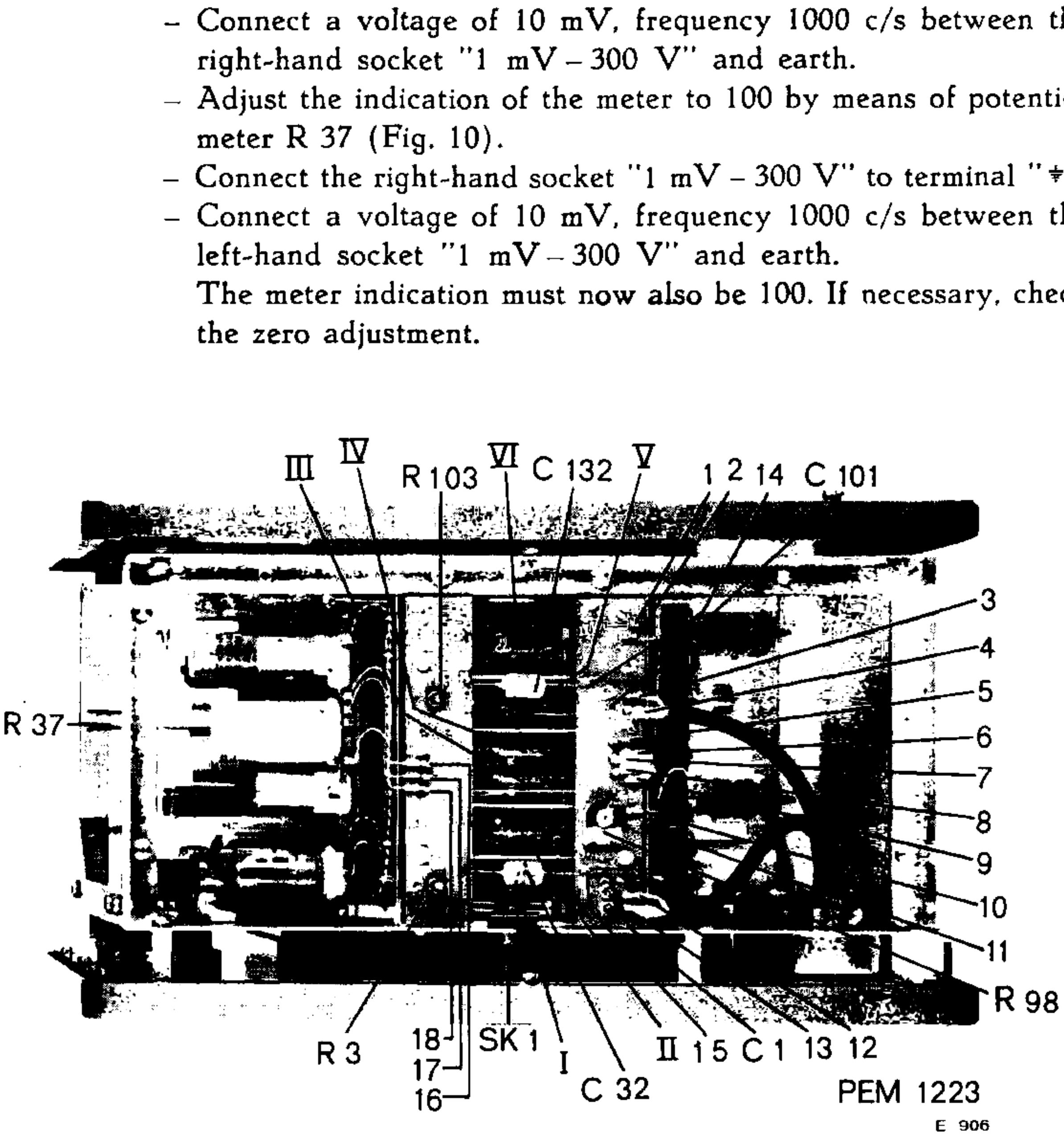


Fig. 10. Bottom view of interior

D. FREQUENCY-RESPONSE CURVE

- Connect the left-hand socket "1 mV – 300 V" to terminal "⏚".
- Set the measuring-range switch to position "10 mV".
- Connect a voltage of 10 mV, frequency 1 Mc/s between the right-hand socket "1 mV – 300 V" and earth.
- Adjust the indication of the meter to 100 by means of trimmers C11 and C111 (Fig. 11). See to it that both trimmers are given approximately the same number of turns.
- Check the other channel by reversing the connection of the left and right-hand input socket. If necessary, correct the deflection by means of the above-mentioned trimmers.
- Check the frequency response curve as follows:

frequency of input signal	*indication on the meter*
10 c/s	97...103
20 c/s	99...101
100 c/s	99...101
1 kc/s	100 reference point
10 kc/s	99...101
100 kc/s *)	99...101
200 kc/s *)	99...101
500 kc/s *)	98...102
1 Mc/s *)	97...103

*) These four ranges must also be checked in the positions, "1 mV", "3 mV", "30 mV" and "3 V" of the measuring-range switch.

E. PRE-ATTENUATOR

- Connect the right-hand input socket "1 mV – 300 V" to socket "⏚".
- Connect a voltage of exactly 3 V, frequency 70 c/s between the left-hand input socket "1 mV – 300 V" and earth.
- Adjust the deflection of the meter to 300 by means of potentiometer R3 (Fig. 10).

- Connect the left-hand input socket "1 mV – 300 V" to socket "⏚".
- Subsequently connect the input voltage between the right-hand input socket "1 mV – 300 V" and earth.
- Adjust the deflection of the meter to 300 by means of potentiometer R103.
- Increase the frequency of the input voltage to 100 kc/s.
- Adjust the deflection for both channels to 300 by means of trimmer C1 or C101.

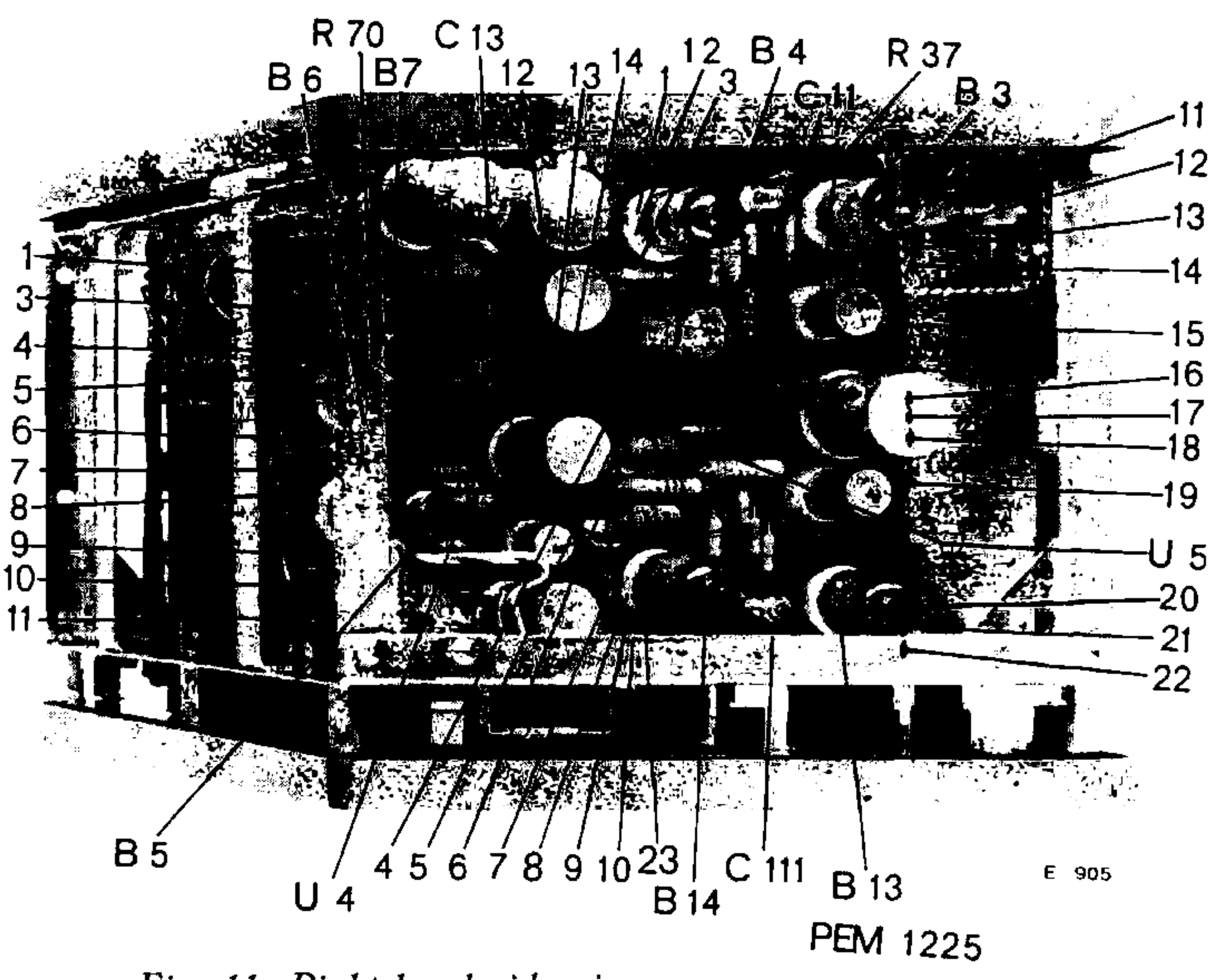


Fig. 11. Right-hand side view

F. CALIBRATING-VOLTAGE GENERATOR

-- Set the measuring-range switch to position "3 V".

- Apply an accurate calibrating voltage of 3 V, 1000 c/s and the internal 3-V calibrating voltage of the instrument to the input terminals via an external change-over switch.
  The internal or external calibrating voltage on the instrument can now be read at option, so that it is possible to compare both voltages.
- Adjust the internal calibrating voltage by means of the selector resistor R84 or R87 so that it is equal to the external voltage within 0.3 % (Fig. 12).
  Check the internal 10-mV calibrating voltage in the same way using an external calibrating voltage of 10 mV.
  The adjustment is effected by means of potentiometer R92 (Fig. 12).
- Check the oscillation frequency and the wave form by means of a calibrated oscilloscope (frequency limits 800...1200 c/s).

G. AMPLIFIER OUTPUT

Set the measuring-range switch to position "1 mV".

- Connect a voltage of 1 mV, frequency 1000 c/s, between the right-hand input socket "1 mV – 300 V" and earth.
- Measure the voltage between the output sockets "OUTPUT" "+" and "–". This voltage must be 50 mV, ± 10 %.

H. MAINS-VOLTAGE DEPENDENCE

1. Sensitivity

Set the measuring-range switch to position "10 mV".
Adjust the indication of the meter to 100 by means of an external constant voltage.
Vary the mains voltage by + and -- 10 %.
At intervals of 1 minute the deflection of the pointer must not deviate more than half a scale division.

2. Drift of the calibrating voltage

-- Connect a voltmeter to the calibration sockets.
-- Vary the mains voltage by + or - 10 %.
-- The calibrating voltage may vary maximum 0.5 %.

J. COMMON MODE REJECTION

1. D.C. voltage adjustment of the working-points of valves B1 and B11

– Adjust potentiometer R93 (Fig. 12) so that the cathode resistors of B1 and B11 (connecting points U3/13 and U3/18) are at exactly the same potential.

2. Set potentiometer R58 "BALANCE" to its central position.

3. Adjusting the differences between the amplifiers

– Connect the left-hand socket "1 mV – 300 V" to the right-hand socket.
– Connect a sinusoidal voltage of 1 V. 1000 c/s, between one of the input terminals and earth.
– Set the measuring-range switch to position "3 mV".
– Adjust the deflection of the pointer to minimum by means of potentiometer R98 (Fig. 10).

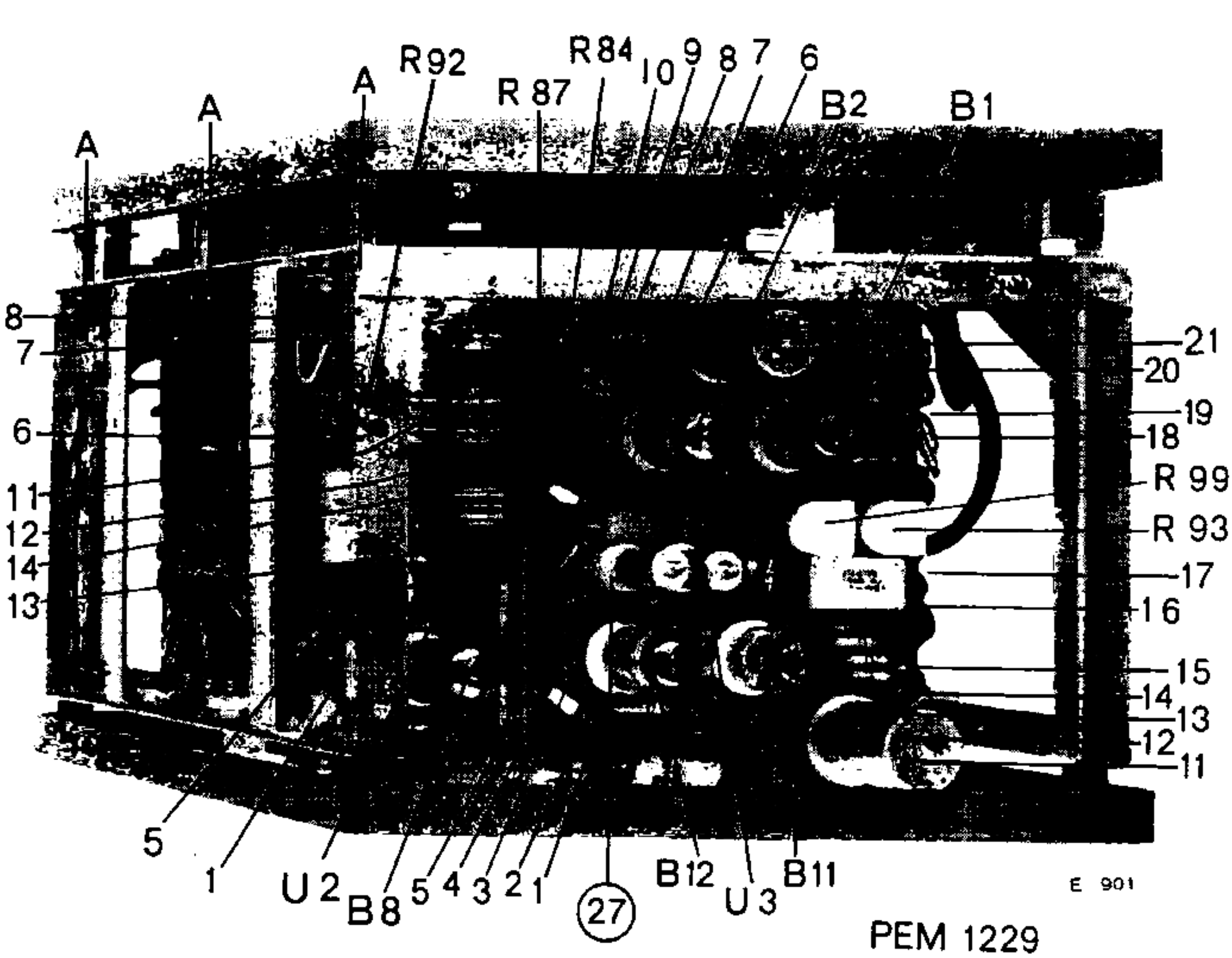


Fig. 12. Left-hand side view

4. **Phase-adjustment at low frequencies**

   - For connections, see point 3.
     Adjust the frequency of the input voltage to 50 c/s.
   - Set the measuring-range switch to position "3 mV".
   - Adjust the deflection of the pointer to minimum by means of potentiometer R99 (Fig. 12).

5. **Checking the symmetry of potentiometer R58 "BALANCE"**

   The maximum deflection in both extreme positions of the potentiometer must have approximately the same value.
   If this should not be the case, the preceding adjusting points must be checked.

6. **Fine-adjustment of the minimum deflection (see point 4) is effected by means of potentiometer R58.**

7. **The pointer must indicate less than 1 mV.**

K. R.M.S.-VALUE INDICATION

The network for indication of the r.m.s. value can be checked best by comparing this indication with the indication of a thermocouple instrument. If such an instrument is not available, it is also possible to carry out a comparative measurement with another calibrated PM 2520. Should differences be found, possible tolerance overlaps must be taken into account, however.
Apply pulses to the left-hand input socket "1 mV – 300 V" and to terminal "⏚" by means of a square-wave generator. The pulses must be so strong that full-scale deflection is obtained, while the iterative frequency must be 1000 c/s.

Select the pulse ratio $\frac{t}{T}$ as follows:

$\frac{t}{T}$:	$\frac{1}{1}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{10}$	$\frac{1}{20}$	$\frac{1}{25}$

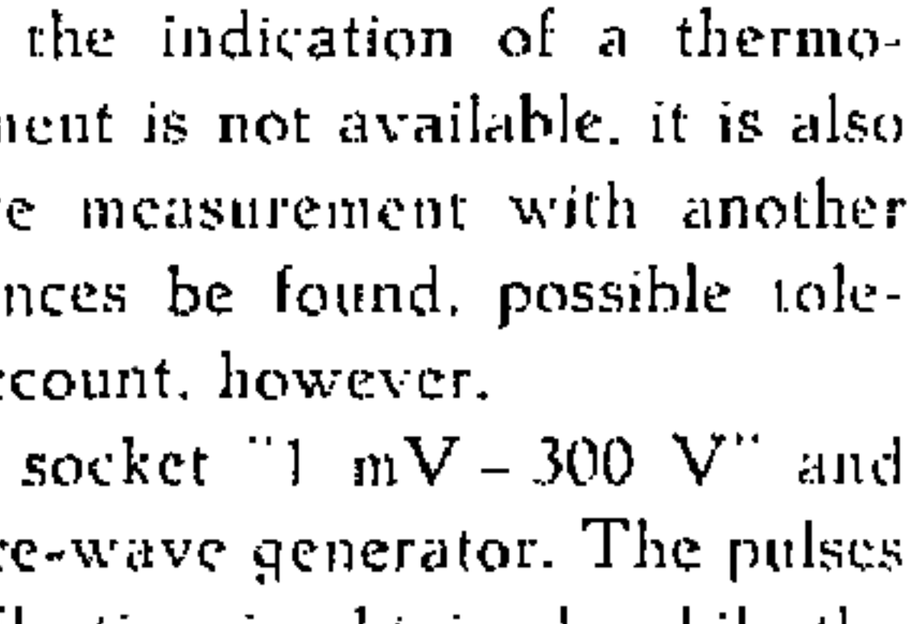


Fig. 13. Pulse shape

The deviation from the indication of a calibrated thermo-couple instrument must not exceed 4 %.
A defective diode in the network can be readily detected by measuring the blocking and forward resistances. A simple way of doing this is to use an ohmmeter; the diode need not be removed from the circuit.

L. RECORDER OUTPUT

Connect a voltage of such a value that the instrument shows full-scale deflection.
Connect a millivoltmeter with a high input impedance (Ri ≥ 100 kΩ) **free from earth** to the sockets "RECORDER" at the rear of the instrument. The indication of this instrument must lie between 95 and 105 mV d.c.

- Check whether the indicating meter is cut out when a plug is inserted into one of the sockets "RECORDER".

XII *Replacing parts*

The parts used in the manufacture of the instrument have not been specially selected or given a particular value.
When replacing electrical components the data stated in the parts list must be strictly adhered to, as otherwise the accuracy of the instrument will be affected.
For the accessibility of the parts, see Chapter II.

A. THERMAL FUSE

When this fuse blows, the cause of this blowing must be traced before replacing the fuse.

- Fitting a new thermal fuse.
  Fit the thermal fuse to the spring and pull it over the hook on the transformer. The fuse becomes accessible after removing the cover.

B. VALVES AND DIODES

Valves

In the case of replacement the valves must be aged for 100 hours. The simplest way of doing this is to leave the instrument with the new valves switched on for 100 hours.

The valves can also be aged outside the instrument, however. For this purpose the valves are connected as diodes; all grids are then connected to the anode of the relevant system. The anode voltage is selected so that at normal heater voltage a quiescent current of 1/6 × the maximum permissible cathode current flows. This quiescent current has the following values for the various types of valve:

B1/11	PCF80 = 2.3 mA	Both pentode and triode
B2/12; B3/13; B4/14	ECF80 = 2.3 mA	ditto
B8	E80CF = 3 mA	ditto
B6	EF86 = 1 mA	
B5	EL86 = 1.6 mA	
B7	85A2 = 1.6 mA	

It is recommended to carry out the following checks after replacing the following valves by aged ones:

Valve	*Chapter XI, paragraph*
B1/11, B2/12, B3/13, B4/14	= A, B, H
B5, B6, B7	= A, B
B8	= E

Diodes

For the replacement of diodes no special measures are required. In this case as well it is recommended to check the relevant part of the circuit.

C. PILOT LAMP

- Remove the lens from the text-plate.
- The lamp fitted by means of a bayonet catch can now be gripped and removed with the aid of a piece of rubber hose having an internal diameter of 5 mm.

D. INDICATING METER

- Remove the cover, the bottom plate and side panels.
  Remove the switch knob.
- Remove the mains switch (16-mm spanner).
- Unsolder the connecting wires of sockets "100 mV", "3 V" and of the two sockets "OUTPUT". If a well-fitting screwdriver is available, the threaded ring of the sockets on the text-plate can be unscrewed.
- After removal of the screws "A" (Fig. 12) lift the front panel, together with the loose edge of the cabinet, from the frame.
- Unsolder the connecting wires of the indicating meter.
- Remove the 4 fixing screws and remove the instrument from the chassis.

E. TEXT-PLATE

In principle the same method should be adopted for replacing the text-plate as the one described under D.

- Remove the 6 fixing screws at the side of the frame, the black plug sockets, the emblem and the lens.
- Take the cast-aluminium meter frame out of the old text-plate and fit it into the new one.

F. MEASURING-RANGE SWITCH U1

Remove the cover. the bottom plate and the side panels.

- Unsolder all connecting wires from the mounting plates of the switch.
- Remove the knob from the switch.
- Remove the fixing screws A (Fig. 12) from the front frame, so that it can be pulled slightly forward, together with the text-plate.
- Remove the two hexagonal screws (8-mm spanner) from the switch frame. The entire switch unit U1 can now be removed from the instrument.

G. SWITCH SEGMENTS

- Remove the measuring-range switch from the instrument according to Chapter F.
- Remove the stop of the switch and one of the fixing strips of the segments.
- Pull the shaft of the switch out of the segments.
- Replace the relevant segment.

Important

When carrying out repairs on switches always see to it that the wire forms are not displaced or deformed.
This also applies to the arrangement of the resistors fitted to the switch.
Such changes will cause capacitive variations and have a detrimental effect on the frequency-response curve of the instrument.

It is recommended in any case to check the instrument according to Chapter XI and, if necessary, to adjust it again, after the measuring-range switch has been taken apart.

XIII *A few data for fault analysis*

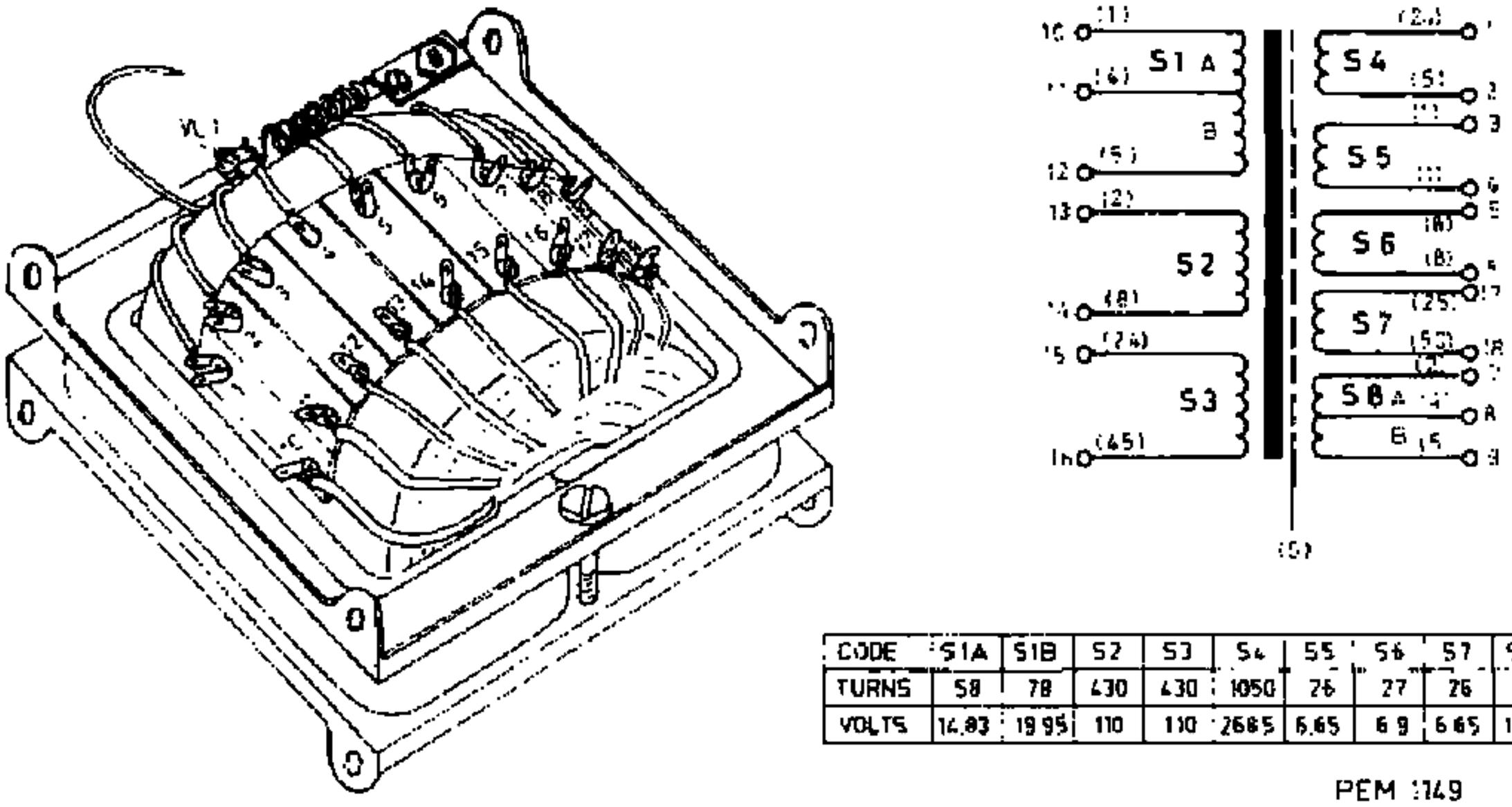
The following voltage values apply to an average apparatus and are given for your information only.

1. Supply transformer

The supply transformer and its connection diagram are shown in Fig. 14.
The voltage values in the relevant table have been measured at no load.
The numbers stated between brackets represent the wire colours according to the international resistor colour code.

2. Operating voltages

The principal operating voltages of the instrument are stated in the circuit diagram. These voltages have been measured with respect to earth or between the indicated connecting points by means of a valve-voltmeter.



CODE	S1A	S1B	S2	S3	S4	S5	S6	S7	S8A	S8B
TURNS	58	78	430	430	1050	26	27	26	67	67
VOLTS	14.83	19.95	110	110	2685	6.65	6.9	6.65	17.3	17.3

PEM 1149
E 893

Fig. 14. Mains-transformer

XIV List of parts

A. MECHANICAL

Fig.	Item	Number	Code number	Description	S	Minimum basic stock for 1	3	5	10 apparatus
15	1	1	ZD 202 84	Instruction plate	**	-	-	-	1
3	2	1	M7 076 17	Grip	**	-	-	-	1
3	3	2	E2 742 67	Bracket	**	-	-	-	2
15	4	1	P5 560 16/NB	Lens	**	-	-	-	1
16	5	2	M7 751 78	Switch socket	*	1	2	3	5
15	6	1	973/53	Knob 30 mm dia.	*	1	2	2	3
15	7	1	973/D52	Cap for knob	**	-	1	1	1
15	8	1	973/P51	Arrow head for knob	**	-	-	1	2
15	9	3	M7 694 87	Terminal	*	1	2	3	5
15	10	1	08 521 10	Mains switch	*	-	1	1	2
16	11	1	M7 415 67	Lamp holder	*	-	-	-	1
15	12	4	P5 655 14	Rubber stud	**	-	-	2	4
17	13	1	M7 737 11	Voltage selector	*	-	-	-	1
17	14	1	978/M2 19	Mains connection	*	-	-	-	1
17	15	11	976/PW9 12	Valve socket, noval	*	2	4	6	10
17	16	1	976/PW7 10	Valve socket, miniature	*	-	-	1	2
	17	1	ZD 413 40	Print U1 (left)	*				
	18	1	ZD 412 94	Print U2	*				
	19	1	ZD 412 99	Print U3	*				
	20	1	ZD 413 04	Print U4	*				
	21	1	ZD 413 26	Print U5	*				
	22	1	ZD 412 92	Print U6	*				
	23	1	ZD 413 42	Print U1 (right)	*				
17	24	109	A3 320 36	Soldering tag	**	10	10	15	25
	25	10 cc	971/71	Switch oil	**	-	-	-	10 cc
	26	1	4822 075 00261	Measuring instrument	*	-	-	1	2
12	27	2	909/V9.4	Base for C6 C106	*		-	1	1

Measuring cable (fig. 26)

Pos.	*Number*	*Code number*	*Description*	*S for*	*Minimal basic stock* 1	3	5	10 *apparatus*
1	1		Housing					
2	1	4822 216 00411	Plug pin	*	-	-	1	2
3	2	M7 343 37	Plug pin	*		1	2	3
4	1	4822 216 00407	Mounting block	**	-	-	1	2
5	1	4822 216 00409	Rubber sleeve	*	-	-	1	2
6	1.2 m	4822 128 00439	Coaxial cable		1.2	2.4	2.4	4.8 m
7	1	4822 216 00408	Rubber sleeve	*	-	-	1	2
8	2	978/1 · 4AP	Plug	*		-	1	2
9	1	978/8	Crocodile clip	*	-	-	1	2

Purpose of the column S

Components not marked

These should be present at the Service Department in the country concerned or at the customer's who is using the apparatus.
They include:
a. nearly all electrical components:
b. mechanical parts which are vulnerable, or which are subject to wear.

– *Components marked with one asterisk*

These components generally have a long or unlimited service-life, but their presence is essential for the correct working of the apparatus. Stocking up of a few of these components depends on the following factors:
a. the number of apparatus present in the country concerned:
b. the necessity of having the apparatus working continuously or not;
c. the time of delivery of the components with respect to the import restrictions in the country concerned and the duration of the transport.

– *Components marked with two asterisks*

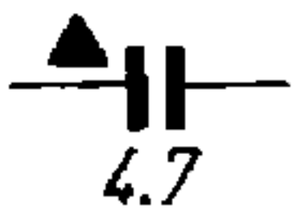
These components have a long or unlimited service-life and they are not essential for the correct working of the apparatus. Generally there is not a local stock.

B. ELECTRICAL PARTS

Explanation of the electrical parts list

Only non-standardised parts are stated in the electrical parts list. In the circuit diagram the standard components are indicated by means of identification marks, each representing a certain number. A list of marks with corresponding numbers is provided on the diagram. The order number of a certain standard part may be determined as follows:

is ordered under number 901/120K.



is ordered under number 904/4E7.

The correct values of the adjustment resistors and capacitors have been fixed during adjustment at the factory.
All resistors are vaporised carbon resistors. unless otherwise stated.

Capacitors

Item	*Unit*	*Code number*	*Value*		*Volt*	*Description*
C3	U 3	C 435 DF/H320	320	µF	64	Electrolytic
C5	U 3	909/X16	16	µF	40	Electrolytic
C6/C106	U 3	909/A400	400	µF	4	Electrolytic
C8	U 5	AC 8324/100	100	µF	150	Electrolytic
C10/C110	U 5	909/T640	640	µF	4	Electrolytic
C12	U 6	C 426 AE/G12.5	12.5	µF	25	Electrolytic
C13/C14	U 4	C 435 DF/F800	800	µF	25	Electrolytic
C15/C16	U 4	AC 8209/16 + 16	16 + 16	µF	400	Electrolytic
C17/C18	U 4	AC 8209/16 + 16	16 + 16	µF	400	Electrolytic
C21/C22	U 4	AC 8226/25 + 25	25 + 25	µF	250	Electrolytic
C23/C24	U 3	AC 8226/25 + 25	25 + 25	µF	250	Electrolytic
C41	U 4	AC 8603/25	25	µF	100	Electrolytic

Resistors

Item	*Unit*	*Codenummer*	*Value*		*Watt*	*Tol.*	*Description*
R3/R103	U 1	F 088 DG/10AO3	5	kΩ lin.	0.1	20 %	Carbon potentiometer
R8/R108	U 1	48 063 95/1K55	1550	Ω	0.4	0.5 %	Wire-wound resistor
R10/R110	U 1	48 760 95/155E	155	Ω	0.4	0.5 %	Wire-wound resistor
R11/R111	U 1	48 760 95/49E	49	Ω	0.4	0.5 %	Wire-wound resistor
R12/R112	U 1	48 760 95/22F7	22.7	Ω	0.4	0.5 %	Wire-wound resistor

Item	*Unit*	*Code number*	*Value*		*Watt*	*Tol.*	*Description*
R19/R119	U 3	B8 305 23D/190E	190	Ω	0.1	1 %	Carbon resistor
R26/R126	U 1	48 063 95/1K55	1550	Ω	0.4	0.5 %	Wire-wound resistor
R28/R128	U 1	48 760 95/227E	227	Ω	0.4	0.5 %	Wire-wound resistor
R31	-	E 199 AA/C21B1K	1	kΩ	1	10 %	Wire-wound potentiometer
R37	U 5	4822 071 005 84	5	kΩ log.	0.1	20 %	Carbon potentiometer
R39/R139	U 5	4822 070 003 21	43	kΩ	1	5 %	Carbon resistor
R44	U 5	E 003 AG/D6K2	6200	Ω	1	5 %	Carbon resistor
R45/R145	U 5	E 003 AG/D15K	7.5	kΩ	2	1 %	Carbon resistor (par.)
R46	U 6	B8 305 23D/55K	55	kΩ	0.1	1 %	Carbon resistor
R47	U 6	901/82K	41	kΩ	0.1	1 %	Carbon resistor (par.)
R48	U 6	901/36K + /2K4	38400	Ω	0.1	1 %	Carbon resistor (ser.)
R49	U 6	901/10K - /11K	21	kΩ	0.1	1 %	Carbon resistor (ser.)
R50	U 6	901/10K -2K2	12200	Ω	0.1	1 %	Carbon resistor (ser.)
R51	U 6	901/1K2 -					
		B8 305 17D/1K65	2850	Ω	0.1	1 %	Carbon resistor (ser.)
R52	U 6	B8 305 23D/21K2	10600	Ω	0.1	1 %	Carbon resistor (par.)
R53	U 6	901/100K - /82K	45	Ω	0.1	1 %	Carbon resistor (par.)
R58	U 6	916/GE20K	20	kΩ lin.	0.125	20 %	Carbon potentiometer
R70	U 4	901/33K...1M	33kΩ...1	MΩ	0.25	5 %	Adjustment resistor
R83	U 2	48 123 93/15K	15	kΩ	1.2	1 %	Wire-wound resistor
R84	U 2	901/5K...1M	5kΩ...1	MΩ	0.25	5 %	Adjustment resistor
R85	U 2	48 123 01/85K	85	kΩ	1.2	1 %	Wire-wound resistor
R86	U 2	B8 304 94D/34K	34	kΩ	1.2	1 %	Wire-wound resistor
R87	U 2	901/100K...1M	0,1...1	MΩ	0.25	5 %	Adjustment resistor
R88/R89	U 2	48 123 01/110K	110	kΩ	1.2	1 %	Wire-wound resistor
R91	U 2	48 760 95/190E	190	Ω	0.4	1 %	Wire-wound resistor
R92	U 2	901/1K...1M	1kΩ...1	MΩ	0.25	5 %	Adjustment resistor
R93	U 3	E 088 DG/10AO3	5	kΩ lin.			Carbon potentiometer
R98	U 1	4822 128 001 59	100	Ω lin.			Carbon potentiometer
R99	U 3	E 097 AD/1M	1	MΩ lin.			Carbon potentiometer

Valves and semiconductors

Item	*Unit*	*Number*	*Type*	*Description*
B1/B11	U 3	2	PCF80	Valve (noval)
B2/B12	U 3	2	ECF80	Valve (noval)
B3/B13	U 5	2	ECF80	Valve (noval)
B4/B14	U 5	2	ECF80	Valve (noval)
B5	U 4	1	EL86	Valve (noval)
B6	U 4	1	EF86	Valve (noval)
B7	U 4	1	85A2	Valve (miniature)
B8	U 2	1	E80CF	Valve (noval)

Item	*Unit*	*Number*	*Type*	*Description*
GR1	U 5	1	OA5	Diode, gold-wire
GR2	U 5	1	OA5	Diode, gold-wire
GR3	U 5	1	OA5	Diode, gold-wire
GR4	U 5	1	OA5	Diode, gold-wire
GR5	U 6	1	OA5	Diode, gold-wire
GR6	U 6	1	OA5	Diode, gold-wire
GR7	U 6	1	OA5	Diode, gold-wire
GR8	U 6	1	OA5	Diode, gold-wire
GR9	U 6	1	OA5	Diode, gold-wire
GR10	U 6	1	OA5	Diode, gold-wire
GR11	U 6	1	OA5	Diode, gold-wire
GR12	U 4	1	OA214	Silicon diode
GR13	U 4	1	OA214	Silicon diode
GR14	U 4	1	OA214	Silicon diode
GR15	U 4	1	OA214	Silicon diode
GR16	U 6	1	OA85	Germanium diode
GR17	U 6	1	OAZ213	Zener diode
GR18	U 4	1	OA210	Silicon diode
GR19	U 4	1	OA210	Silicon diode

Miscellaneous

Description	*Pos.*	*Code number*
Mains transformer	T1	ZD 601 24
Thermal fuse	VL1	974/T125
Pilot lamp	LA1	6828 (6 V 100 mA)

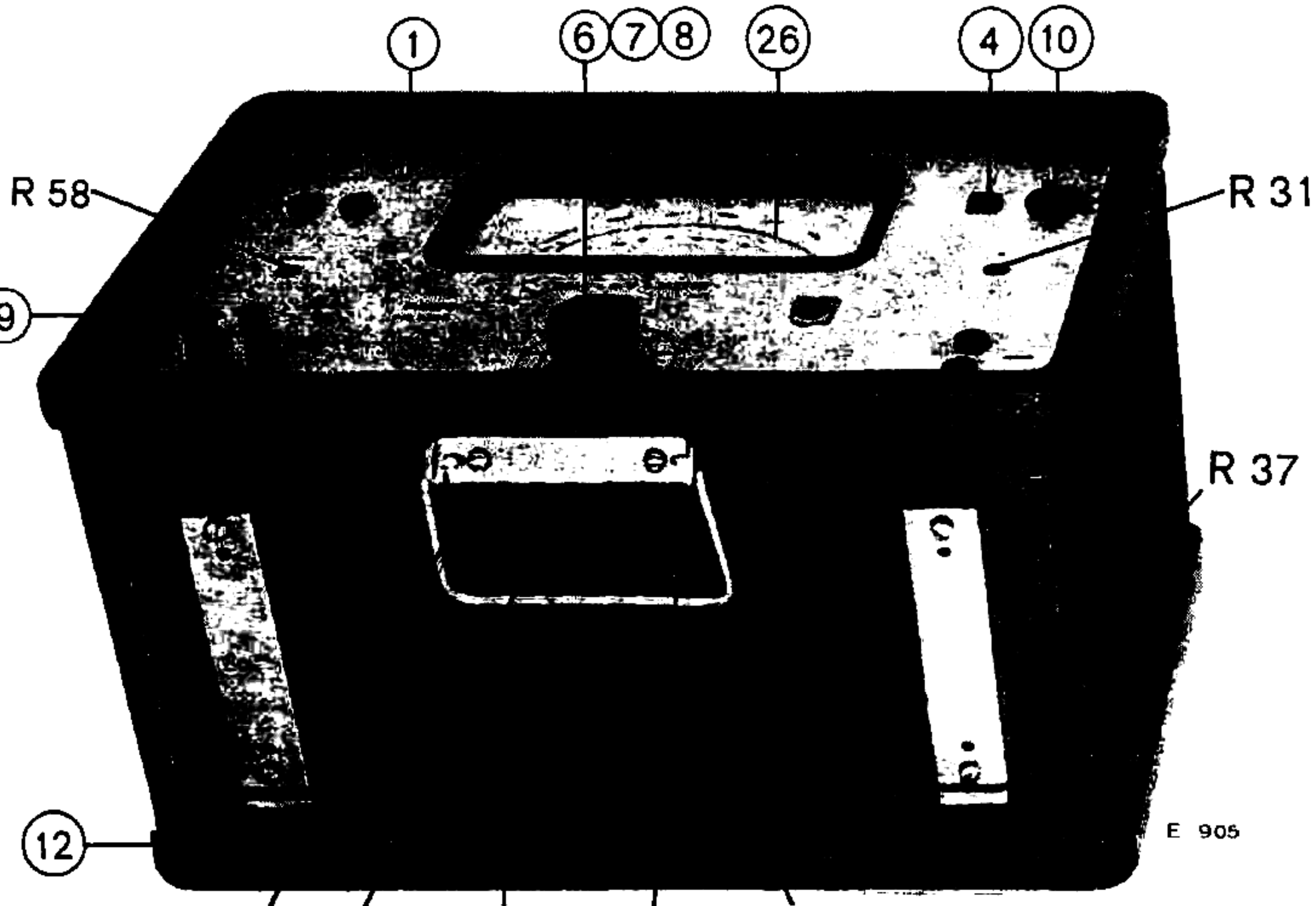


Fig. 15. Bottom view of exterior

Fig. 16. Top view

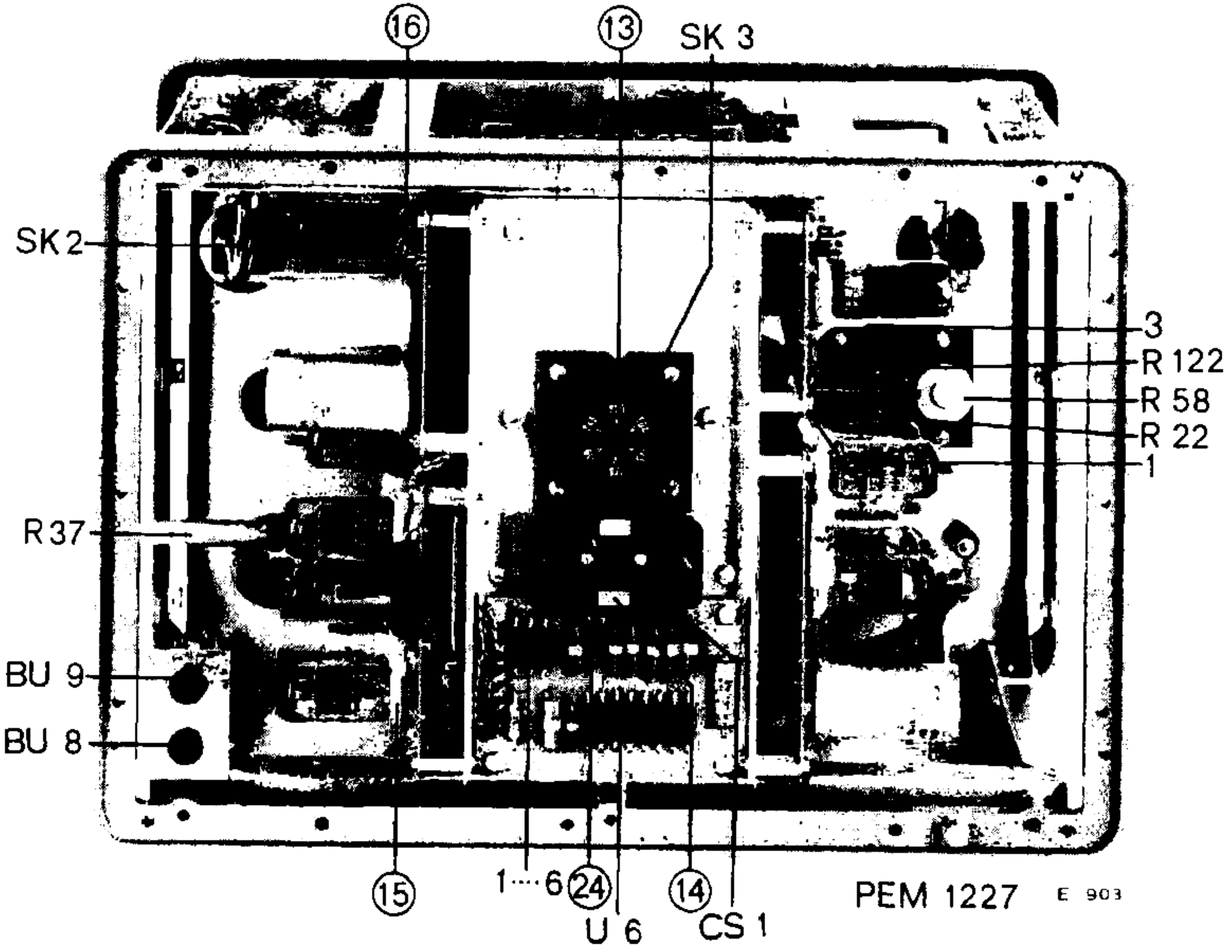
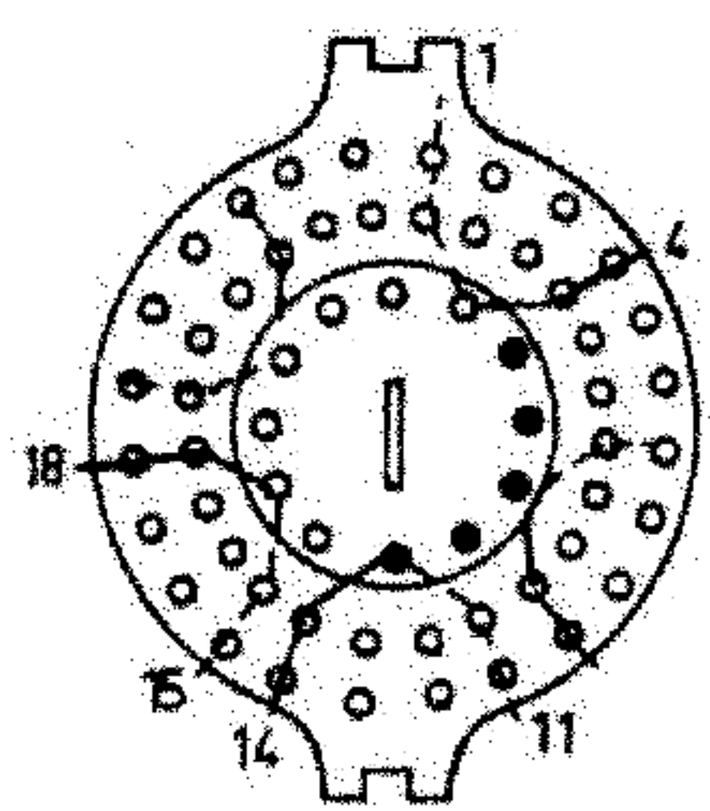
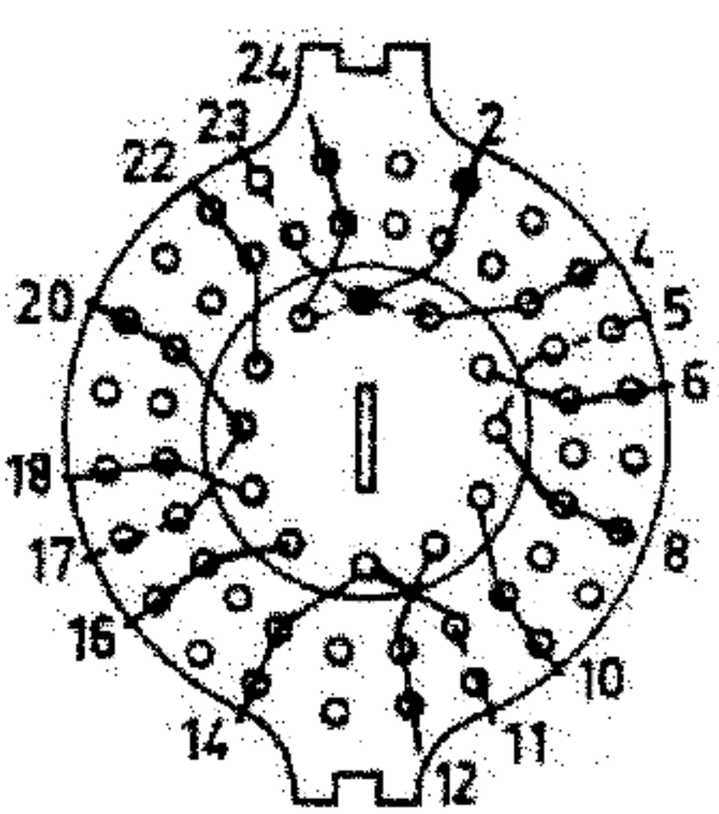


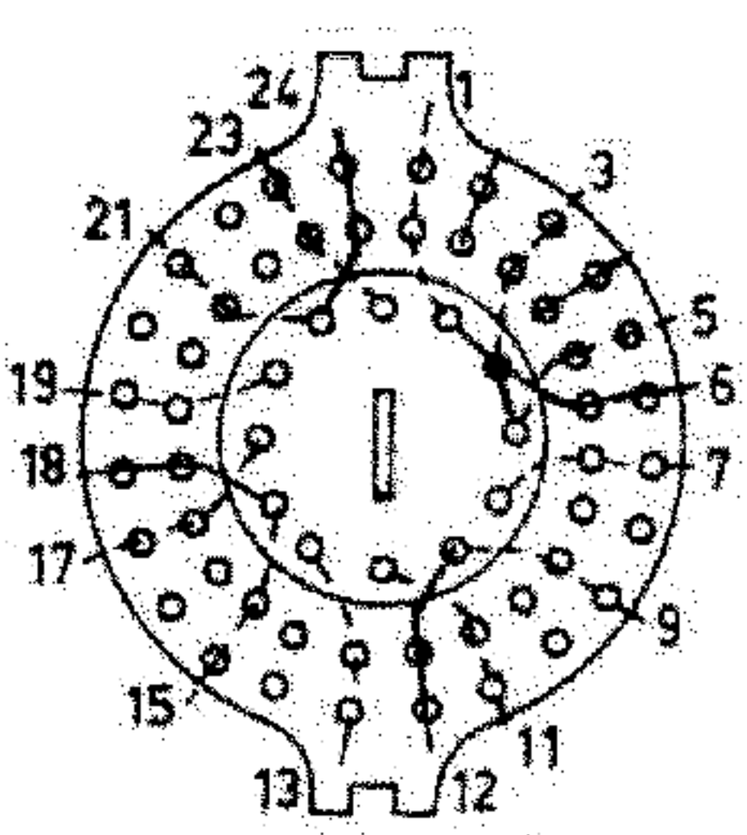
Fig. 17. Rear view without rear plate



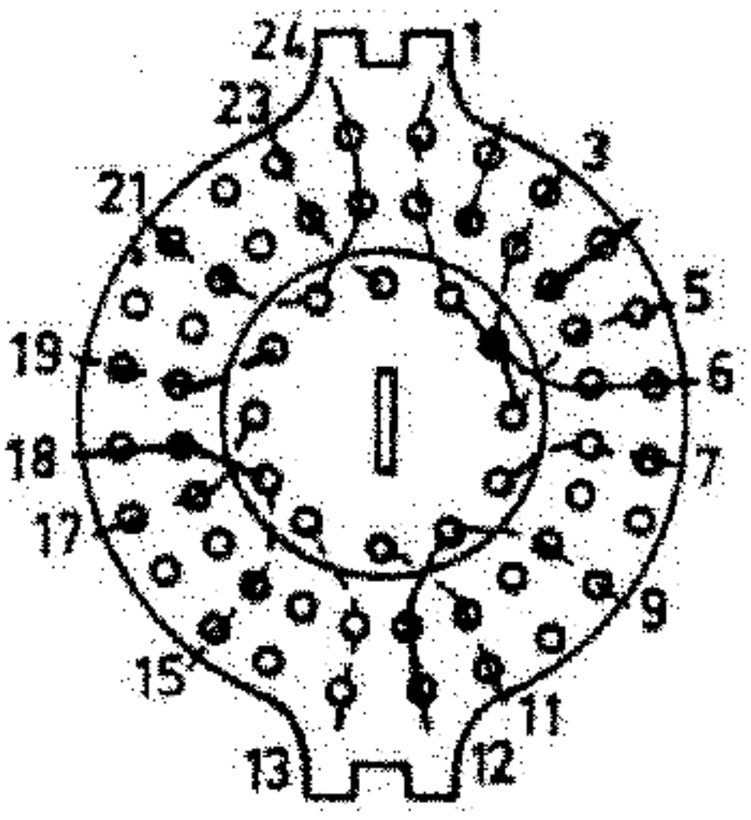
SK1 I



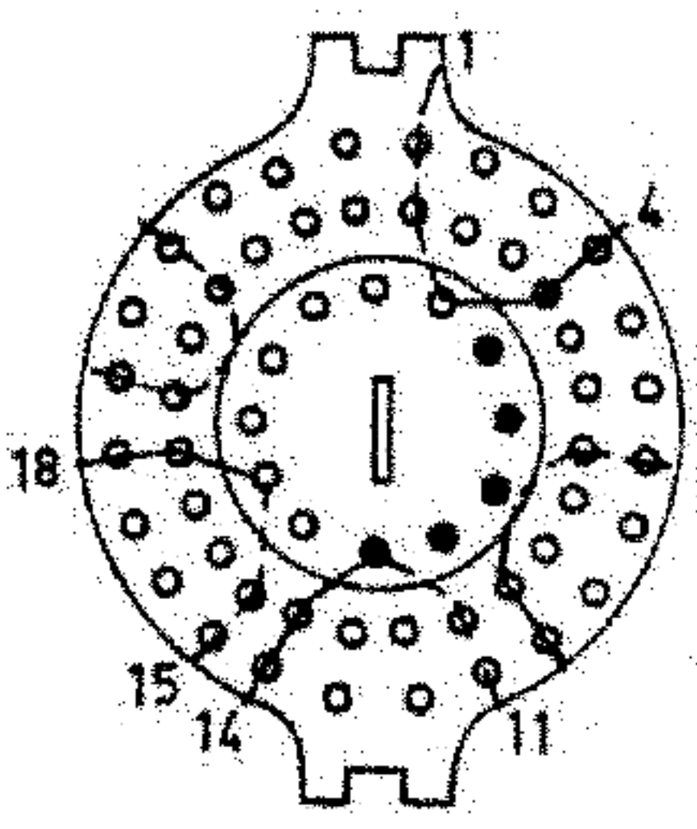
SK1 II



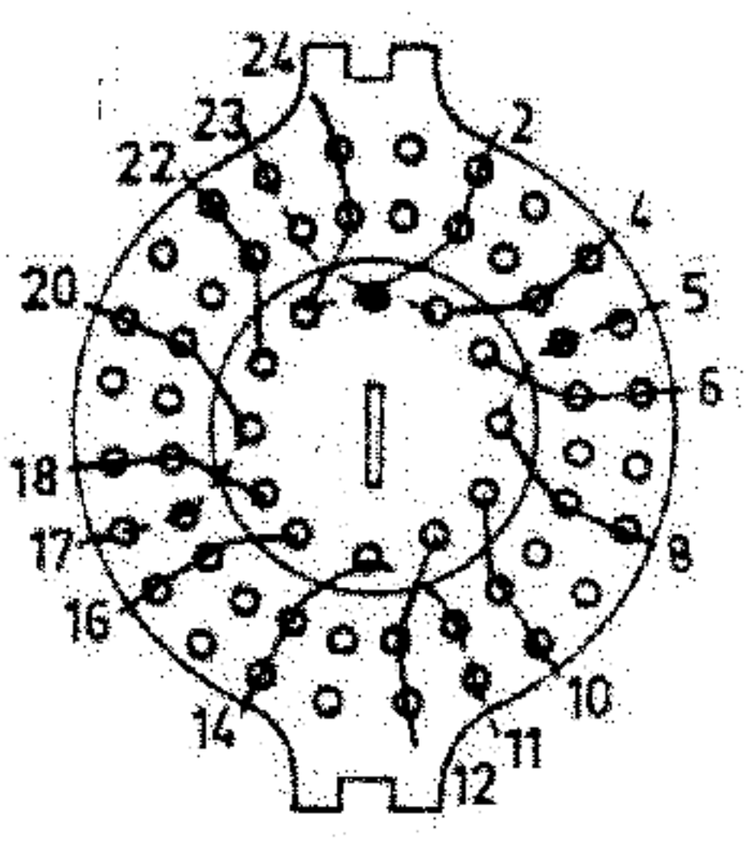
SK1 III



SK1 IV



SK1 V

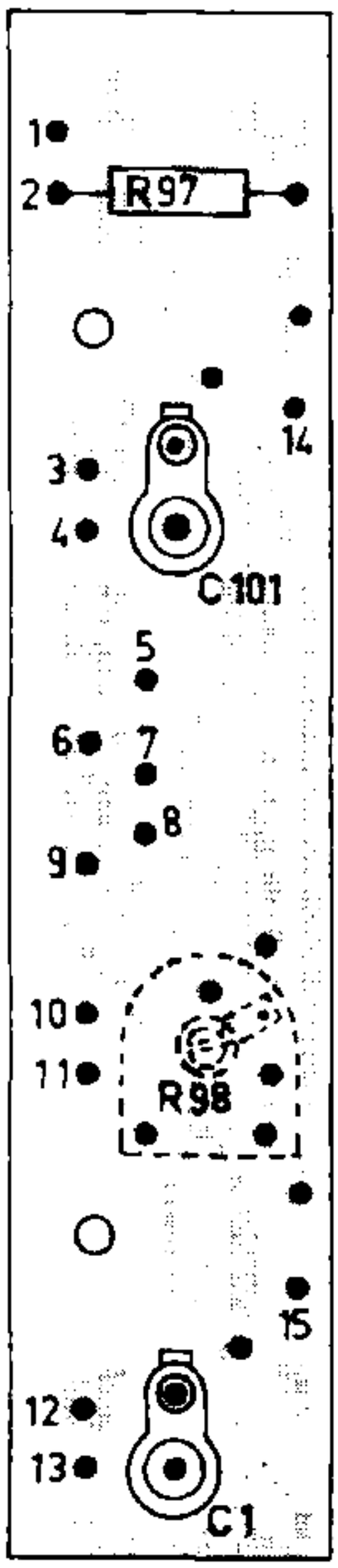


SK1 VI

PEM 1150

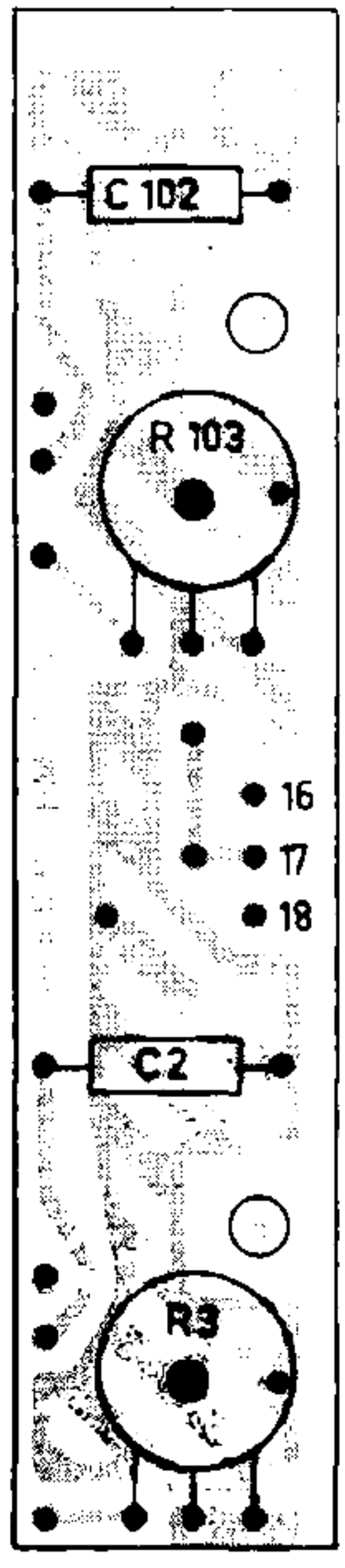
E 907

Fig. 18. Switch segments



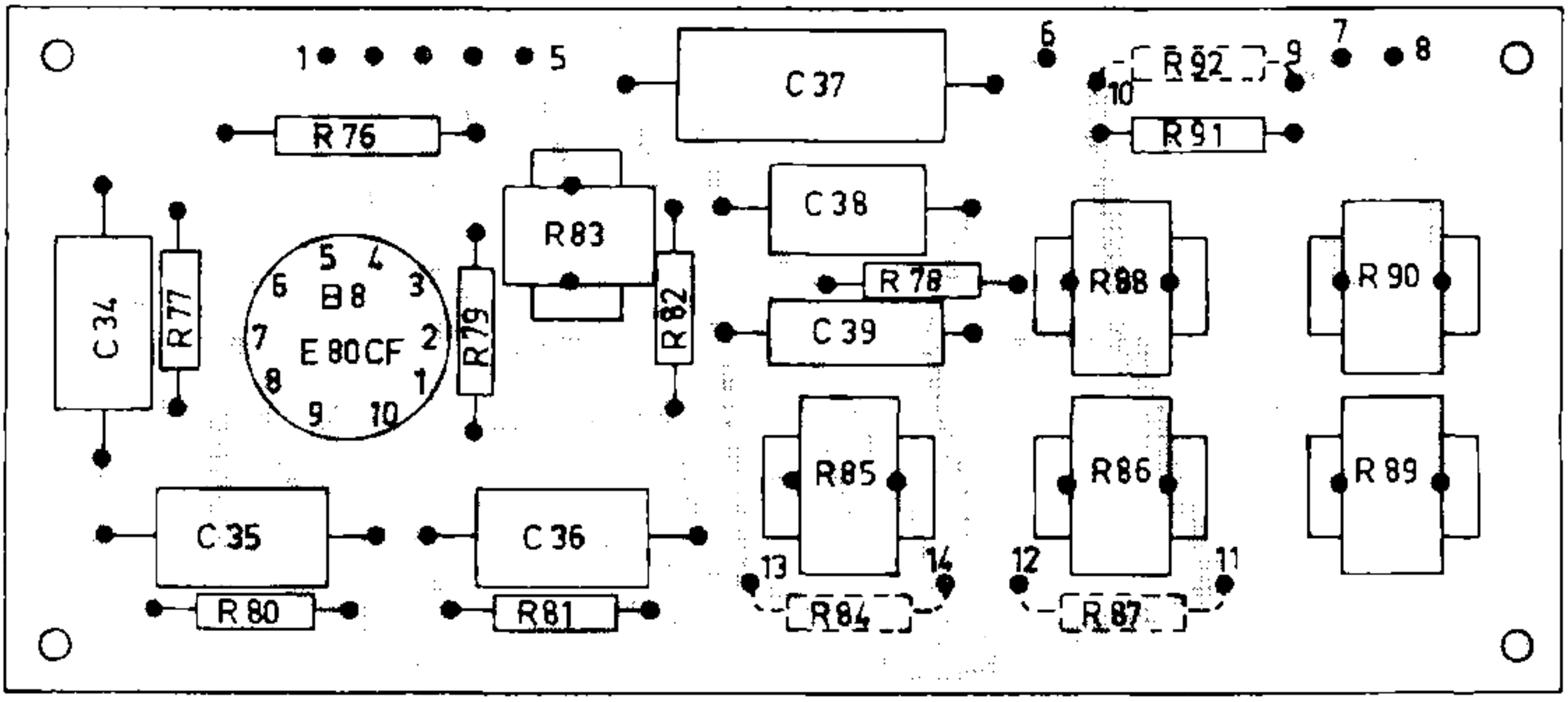
PEM 1152
E 912

Fig. 19. Unit U1. (left). switch plate



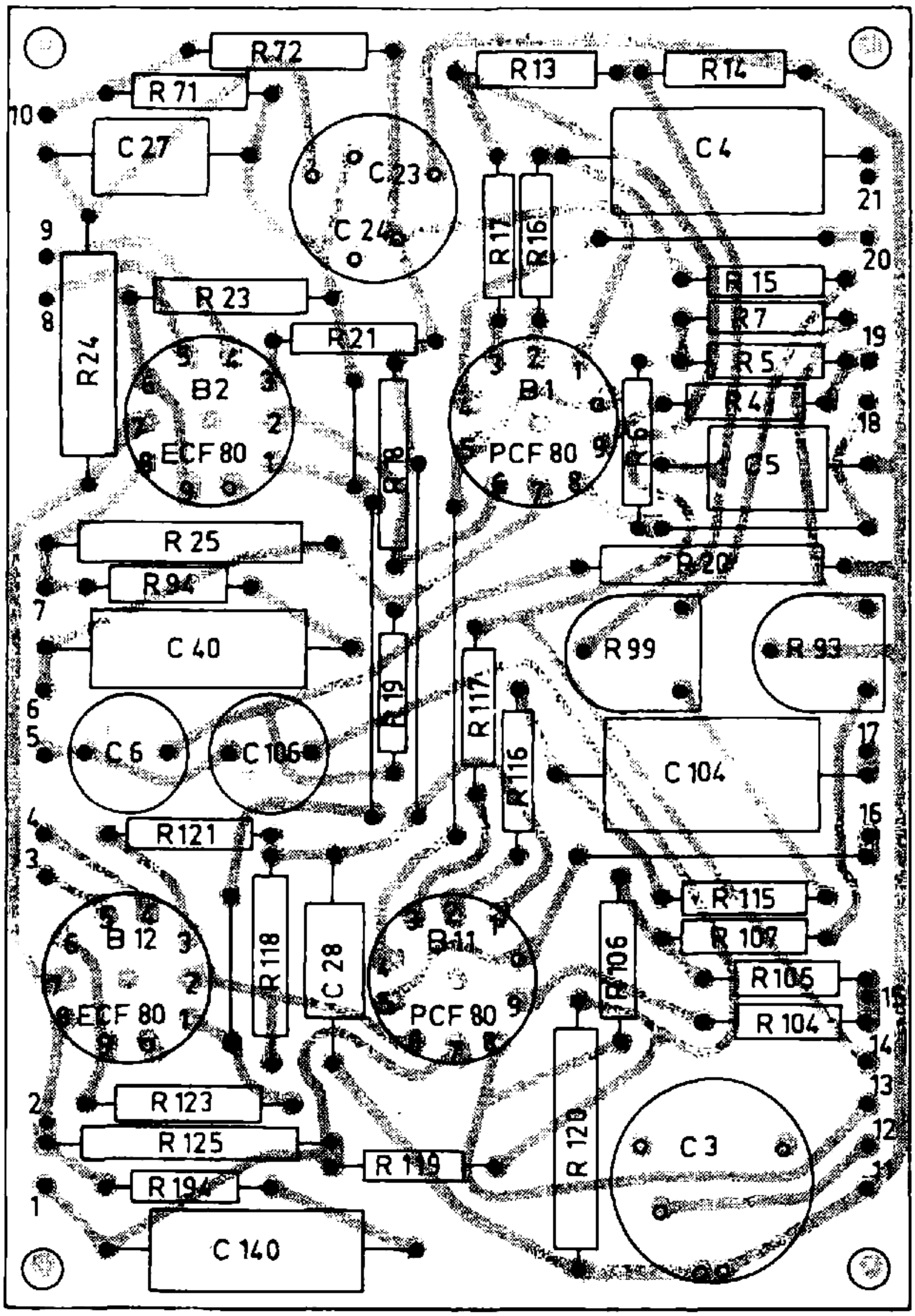
PEM 1151
E 909

Fig. 20. Unit U1, (right). switch plate



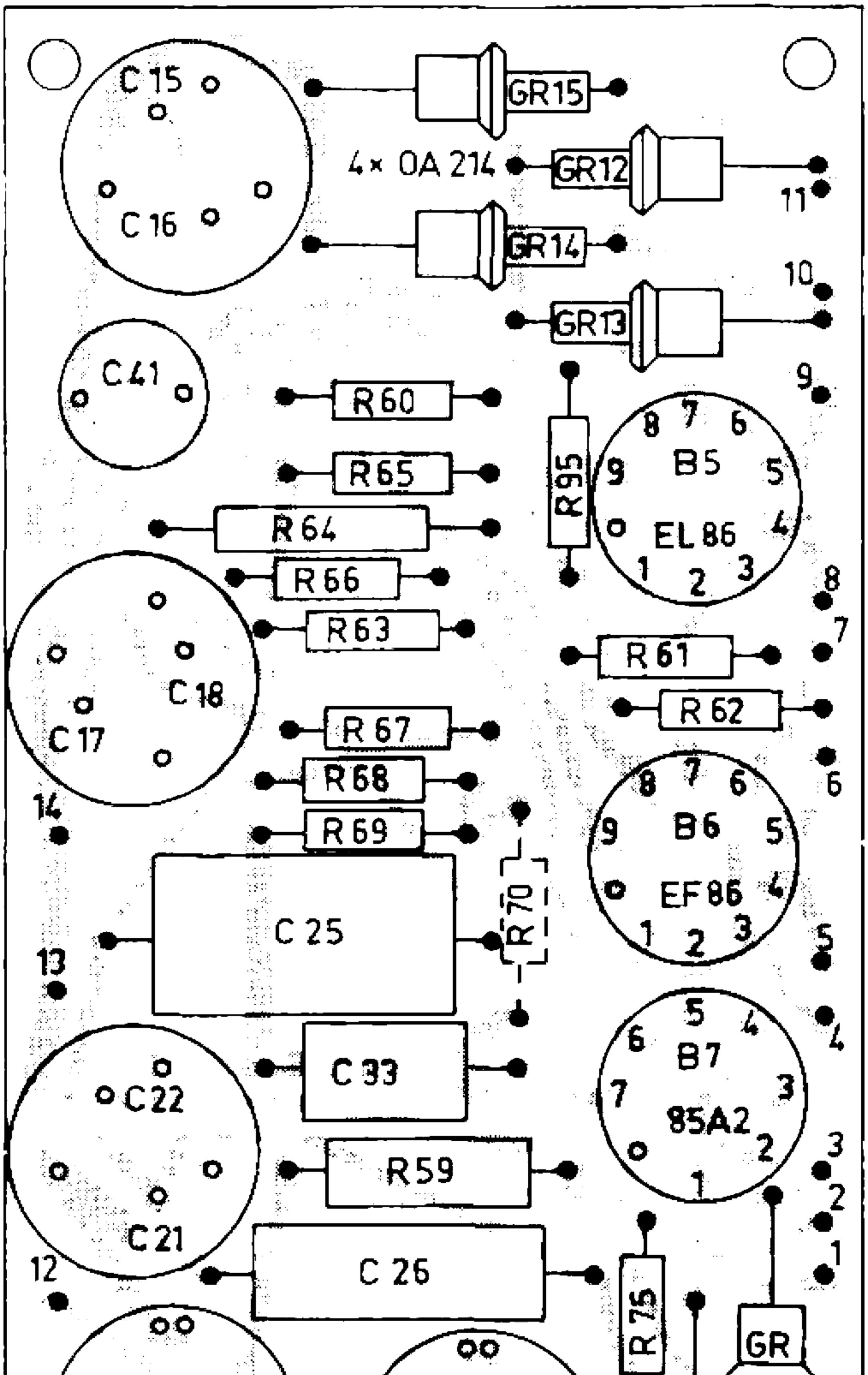
PEM 1153
E 908

Fig. 21. Unit U2, calibration voltage generator



PEM 1154
E 913

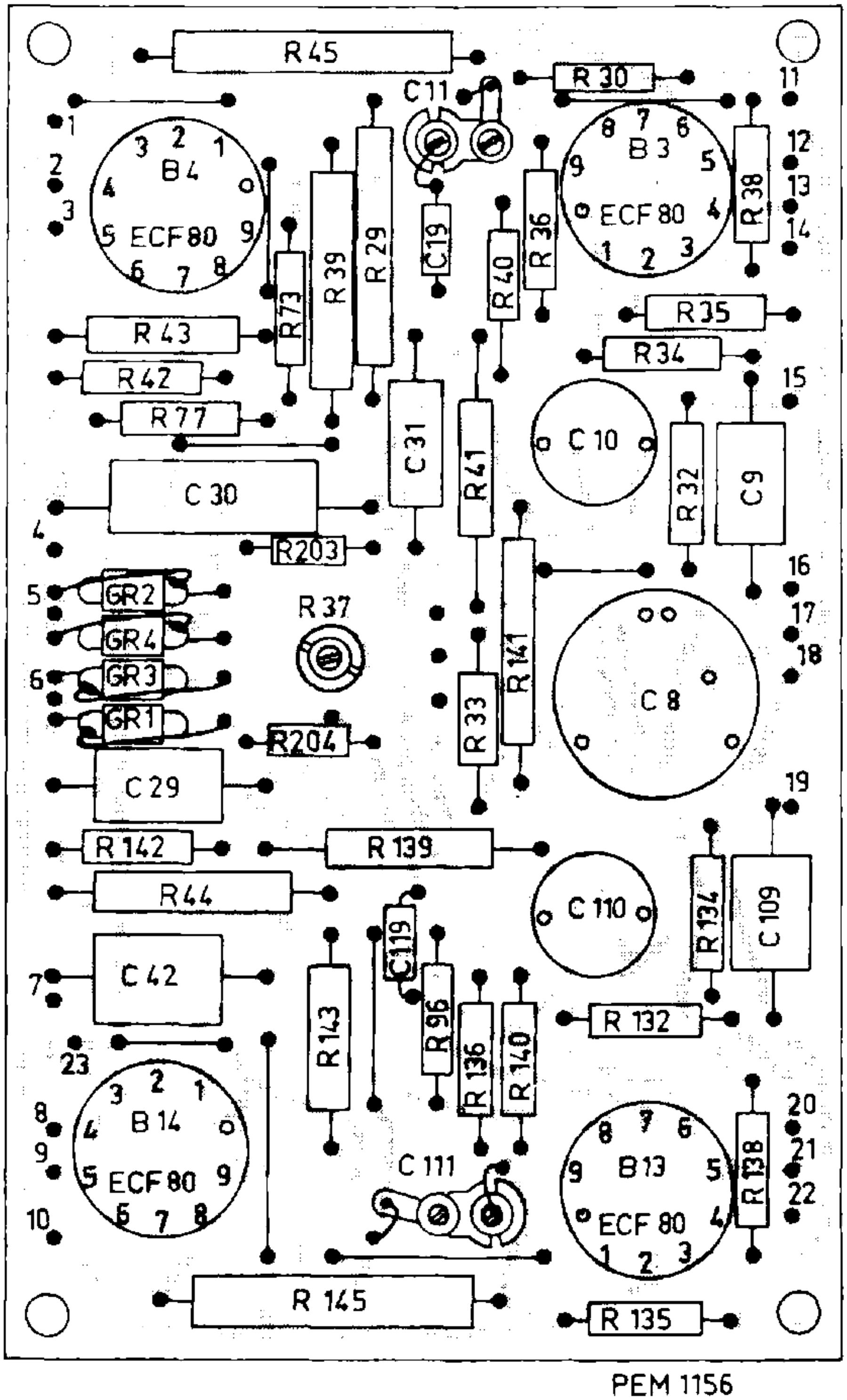
Fig. 22. Unit U3, pre-amplifier



PEM 1155

E 914

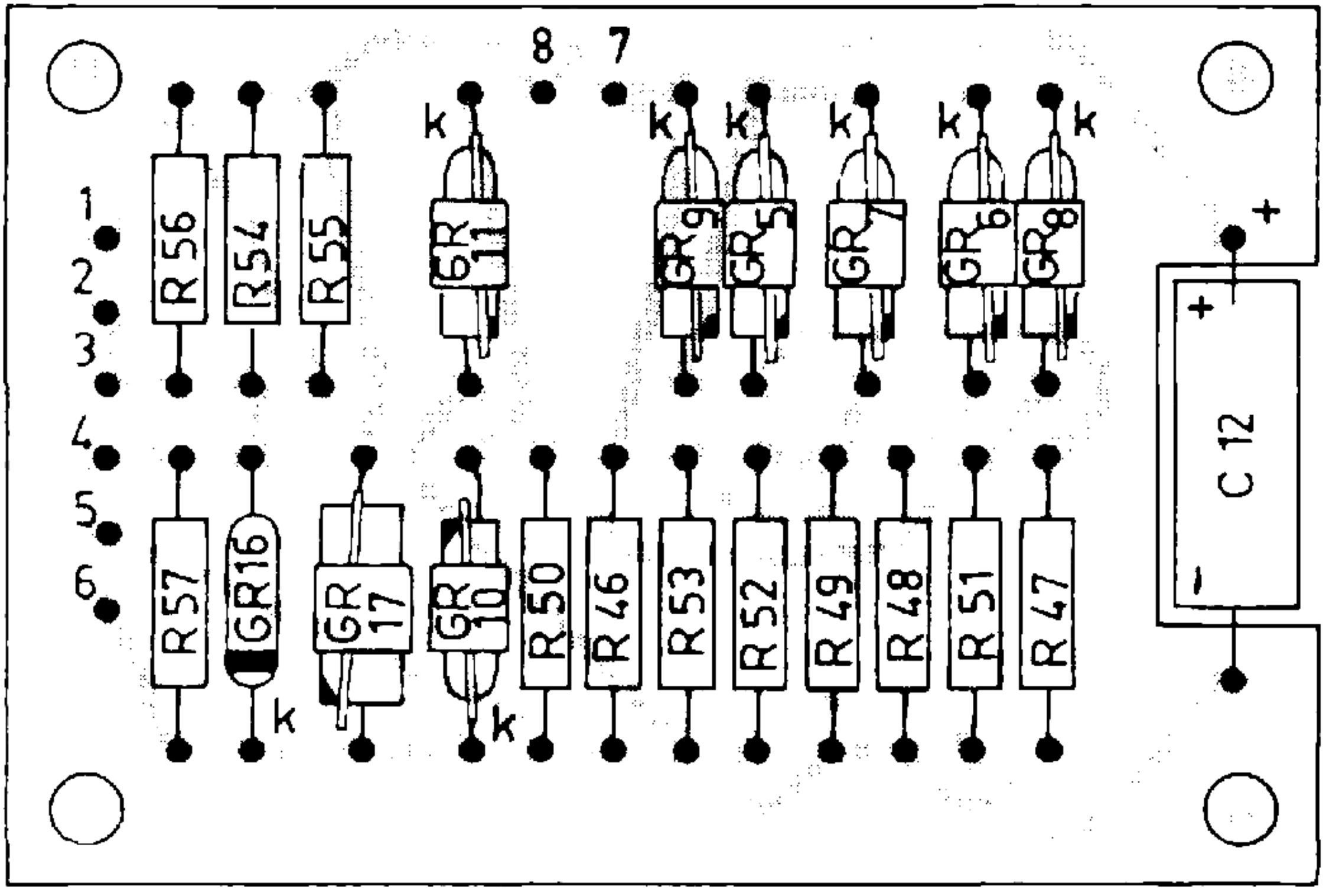
Fig. 23. Unit U4, supply unit



PEM 1156

E 915

Fig. 24. Unit U5, output stage



PEM 1157
E 911

Fig. 25. Unit U6. quadratic network

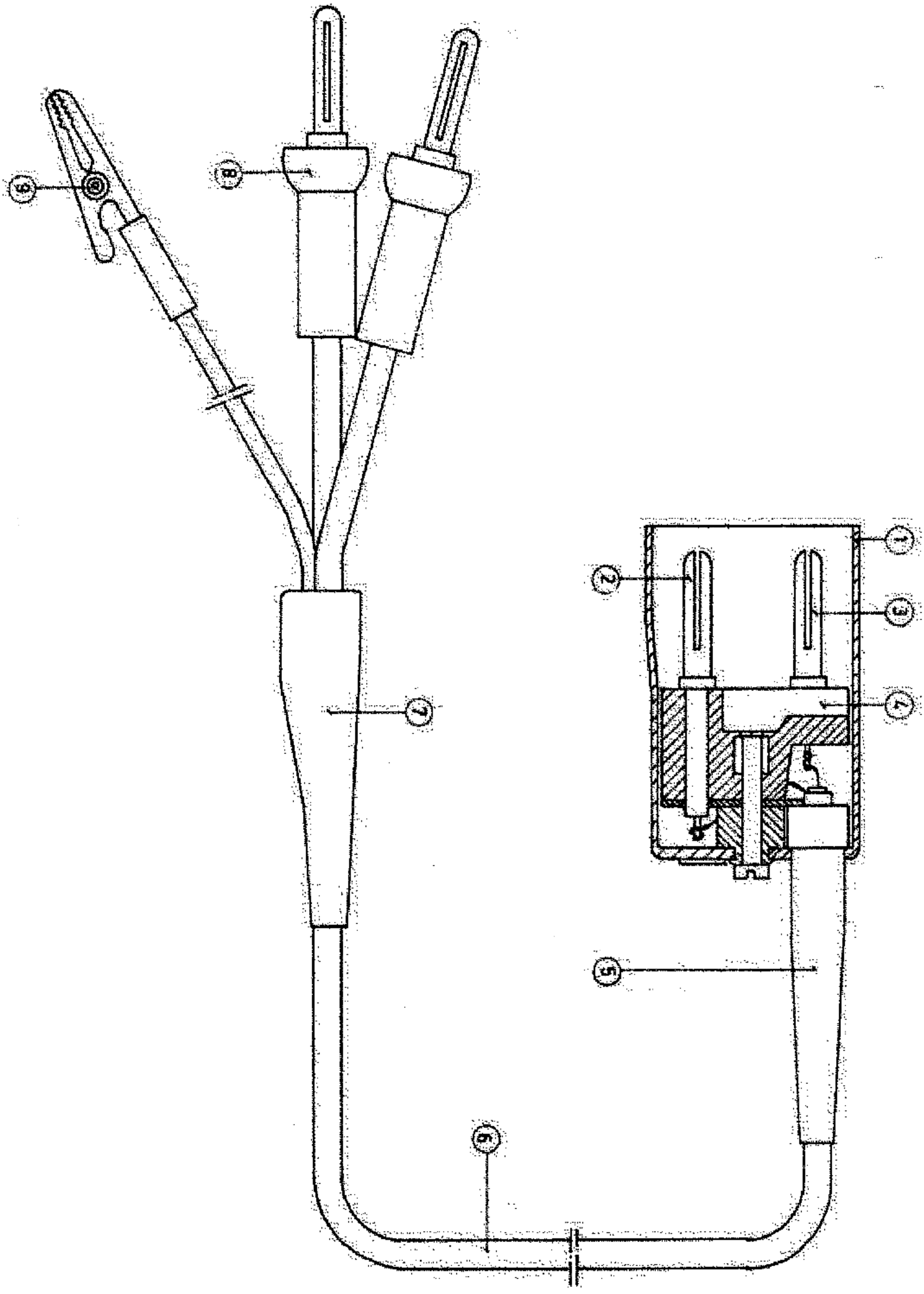


Fig. 26. Measuring cable

U1 U3 U1 U3 U7

B1 PCF 80 B1' PCF 80 B2' ECF 80 B11 PCF 80 B11' PCF 80 B12' ECF 80 B12 ECF 80

SK1 I SK1 II SK1 III SK1 IV SK1 V SK1 VI

BU1 BU2 BU3

C1 1-6 C2 1K5 C101 1-6 C102 1K5 C132 47K C32 47K C4 1µF C3 320µF C104 1µF C140 390K C40 390K C5 16µF C6 400µF C106 400µF

R1 10M R2 20K R3 5K R101 10M R102 20K R103 5K R4 390 R5 1K5 R6 2K7 R7 15K R93 5K R105 1K5 R106 2K7 R107 15K R104 390 R98 100 R9 1K55 R9 390 R10 155 R11 47 R12 22K R112 33K R111 47 R110 155 R109 390 R108 1K35 R97 151 R13 R17 100 R18 R21 220 R23 22K R94 47K R16 390 R15 1M R99 1M R14 56K R19 180 R20 2K9 R24 10K R115 1M R120 2K9 R119 180 R116 330 R117 100 R118 422 R121 422 R123 22K R122 17K9 R58 20K

60V 28V 85V 110V 185V

U2

B8 E80CF B8' E80CF

R88 110K R89 110K R90 56K R91 180 R92 R86 32K R87 R85 2K R84 R83 115K R79 560K R76 22K R77 11K R78 11K R82 470K R81 R80 100K C38 47K C34 510 C36 510 C35 510 C39 47K C37 470K

BU4 BU5

U5

B3 ECF 80

R73 4K7 R29 2K2 C31 47K C30 1µF R74 560K C29 47K

U3 U1 U3 U1 U5

K1 I

B1 PCF 80 — R4 330 — 60V — R5 1M5 — R6 22K7 — R7 15K — R93 5K — C 32 47K

SK1 II — R98 100 — R8 1K55 — R9 430 — R10 155 — R11 47 — R12 22?

SK1 VI — R112 33? — R111 47 — R110 155 — R109 390 — R108 1K55 — R97 15?

B11 PCF 80 — 60V — R104 390 — C132 47K — R105 1M5 — R106 22K7 — R107 15K

B1' PCF 80 — R13 680K — R17 100 — R18 109K — R21 220 — R16 390 — 28V — R15 1M — R14 56K — R99 1M — C5 16µF — C4 1µF — C3 320µF — R115 1M — R120 2K9 — C106 400µF — R119 190 — 28V — C6 400µF — R19 190 — R20 2K9 — 85V — R24 10K

B2 ECF 80 — R23 22K — B2' ECF 80 — R94 82K — R25 136K — 135V — C40 390 K

U7 — R22 11K8 — R58 20K — R122 11K8

B11' PCF80 — B12' ECF80 — C104 1µF — R116 390 — C140 390 K — R194 82K — R125 136K — B12 ECF 80 — R117 100 — R118 91K — R121 220 — R123 22K — 135V

SK1 III — R201 150K — R26 1K55 — R27 39G — R28 22? — R128 22? — R127 390 — R126 1K55 — R202 150K

SK1 IV

C8 100µF — C109 150 K

SK1 V — R86 — R87 — C39 27K — R85 — R84 — R83 15K

B8 E80CF — B8' E80CF — C38 47K — R76 33K — C34 510 — R79 150K — R77 1K — 185 V — R78 1K — C36 510 — C35 510 — R82 100K — C37 470 K — R81 100K — R80 100K

B3 ECF 80 — 110V — C31 47K — C30 1µF — R73 150K — R29 22K2 — C29 47K — R74 150K

U5 — U3 — U4

R72 11K5 — R71 11K2 — C28 47K — C24 25µF — C27 47K — C23 25µF

C22 25µF — 215 V — C26 100 K

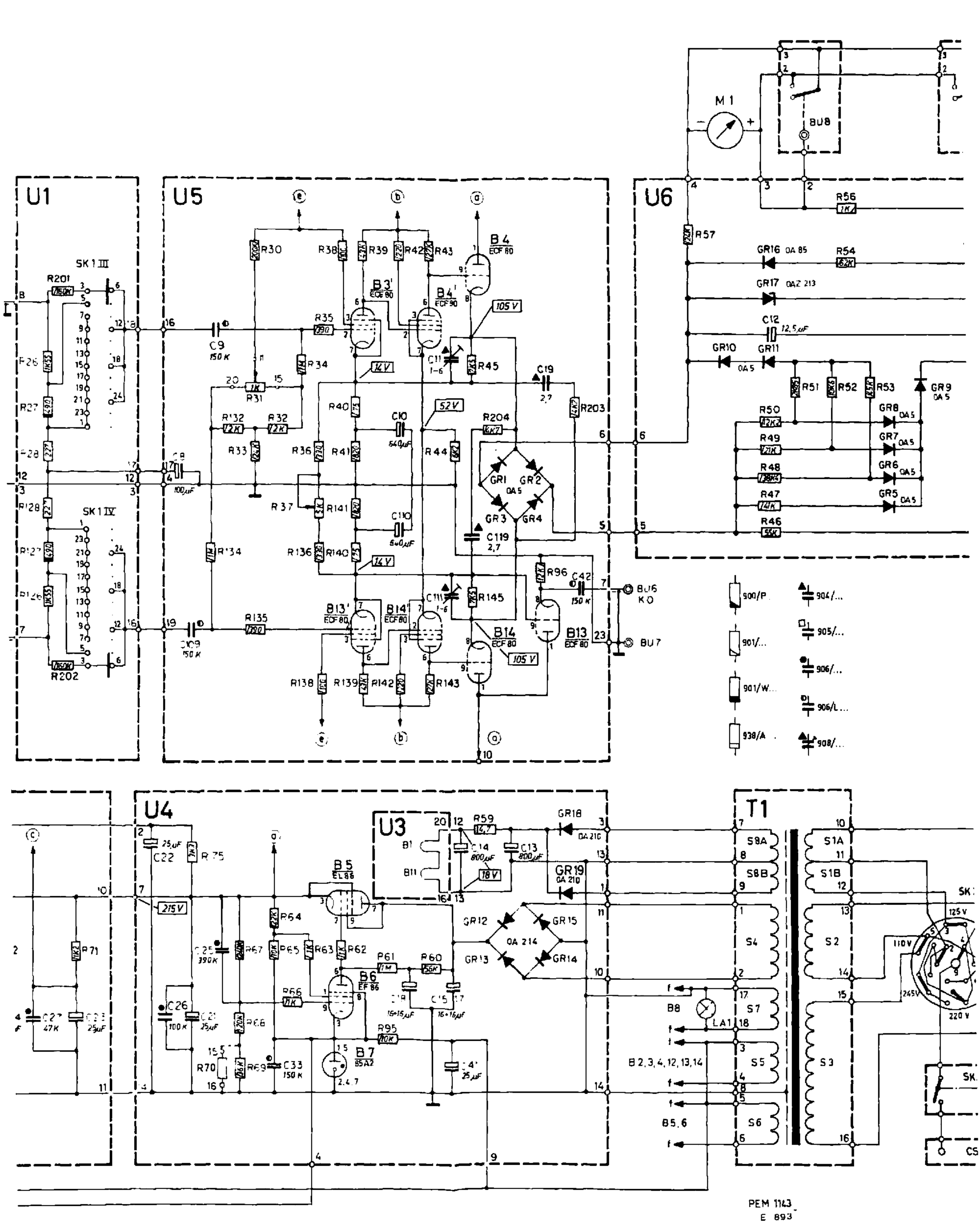


Fig. 27. Circuit diagram PM 2520

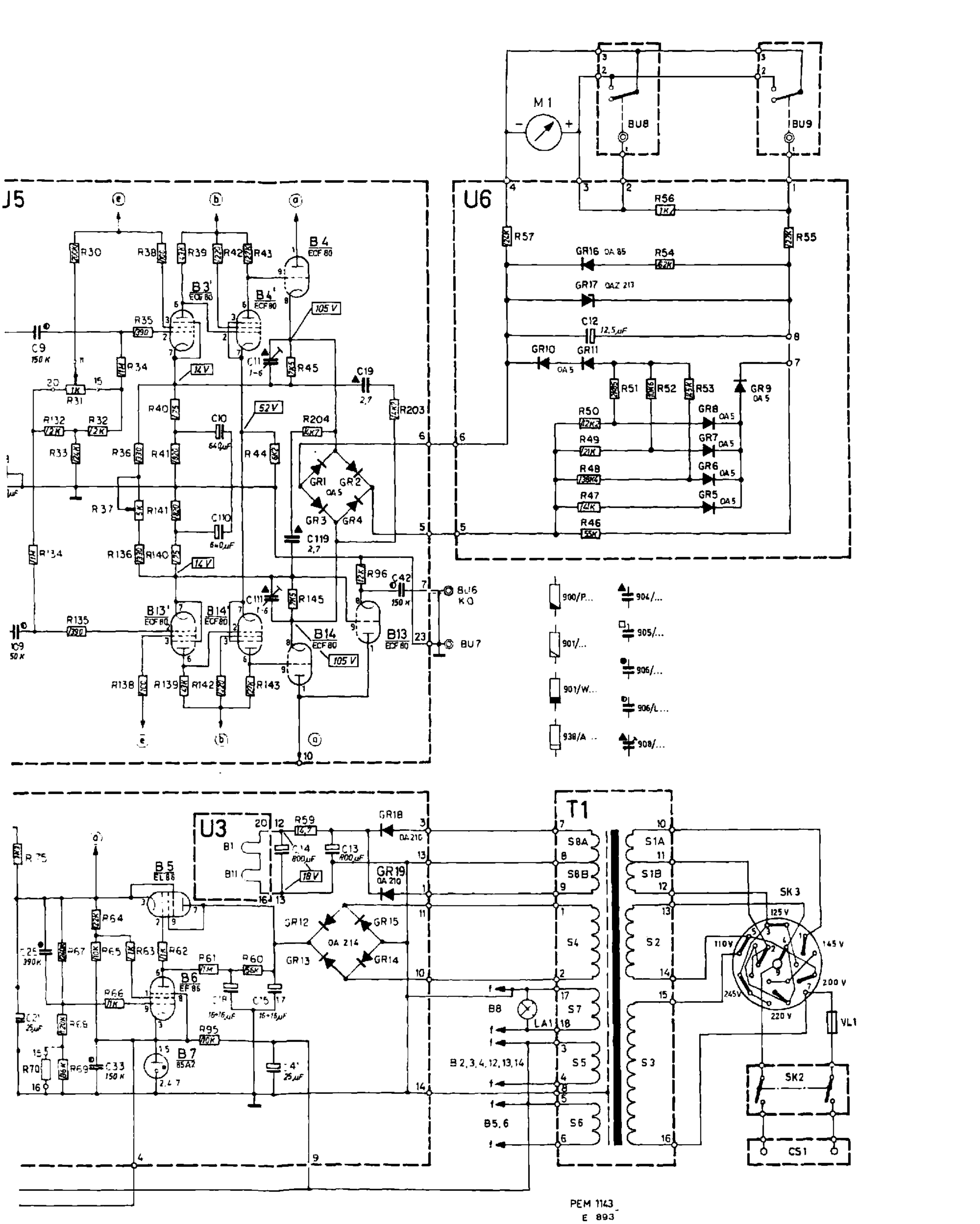


Fig. 27. Circuit diagram PM 2520