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ELECTRONIC MULTIMETER
PM 2401

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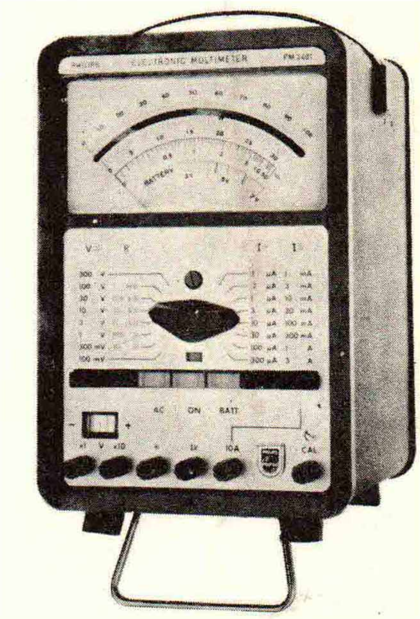
9499 470 03911

1/1068/1/03



PHILIPS

Manual

ELECTRONIC MULTIMETER
PM 2401

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IMPORTANT

In correspondence concerning this apparatus, please quote the type number and the serial number as given on the type plate at the back of the apparatus.

Contents

List of figures

GENERAL

Introduction

The Electronic Multimeter PM 2401 is a universal measuring instrument for accurate current and voltage as well as resistance measurements.

The measuring amplifier of the apparatus is fully transistorised and can be supplied by four standard batteries or four NiCd rechargeable batteries. Consequently, the Electronic Multimeter is completely independent from the mains; all disadvantages of mains supply are thus avoided.

Owing to the numerous measuring ranges and the high degree of indication sensitivity, the apparatus has a wide range of applications, for example for measurements in laboratories, service workshops, factories, out in the open, etc.

The apparatus can be used for measuring:

- D.C. and A.C. voltages in the range of 100 mV . . . 300 V full-scale deflection (f.s.d.). In the 100 V × 10 range max. 700 V D.C. can be measured
- D.C. and A.C. currents of 1 mA . . .10 A f.s.d.
- D.C. currents of 0.1 μA . . . 300 μA f.s.d. (leakage currents of diodes and transistors!)
- Resistances of 0.5 Ω . . . 50 MΩ
- D.C. high voltages of up to 30 kV, with the separately available HT probe GM 6070
- UHF voltages of up to 700 MHz, with the separately available UHF probe PM 9200 and also with T-piece PM 9250

Moreover, it can also be used as a sensitive zero-indicator in D.C. bridges.

Block diagram

II

The measuring mode is selected by depressing a push-button, by means of which the relevant input attenuator is switched on.
The three separate input attenuators are coupled with the measuring range selector. These attenuators divide the input value into an accurately defined ratio.
The third attenuator is used for resistance measurements and is connected as a stabilised-current source. The amplifier-voltmeter measures the voltage drop across the unknown resistance.
The d.c. voltage coming from the voltage divider is applied to the transistor chopper which converts it into a square-wave signal. A.C. voltages, on the other hand, are applied directly to the amplifier input via a frequency-independent voltage divider by means of the DC/AC switch.
The amplifier consists of an impedance transformer (field-effect transistor) and two negatively fed-back amplifier stages. Indicator I1 is included in the feedback circuit, so that the rectifier characteristic is made linear.
The chopper is controlled by a square-wave voltage, which is generated by a flip-flop circuit. A free-running multivibrator, producing pulses with a frequency of about 1200 Hz., controls the flip-flop circuit.
The information concerning the polarity of the d.c. input voltage is obtained by comparing the phase of the amplified signal with the control signal of the chopper. Comparison is effected by means of controlled rectification of the square-wave signal.
The amplifier and the chopper control are supplied with 12 V d.c. The latter is supplied by the d.c. converter which converts and stabilises the battery voltage (3 . . 7 V) to 12 V.
The voltmeter is calibrated by adjusting the amplifier to the battery voltage.

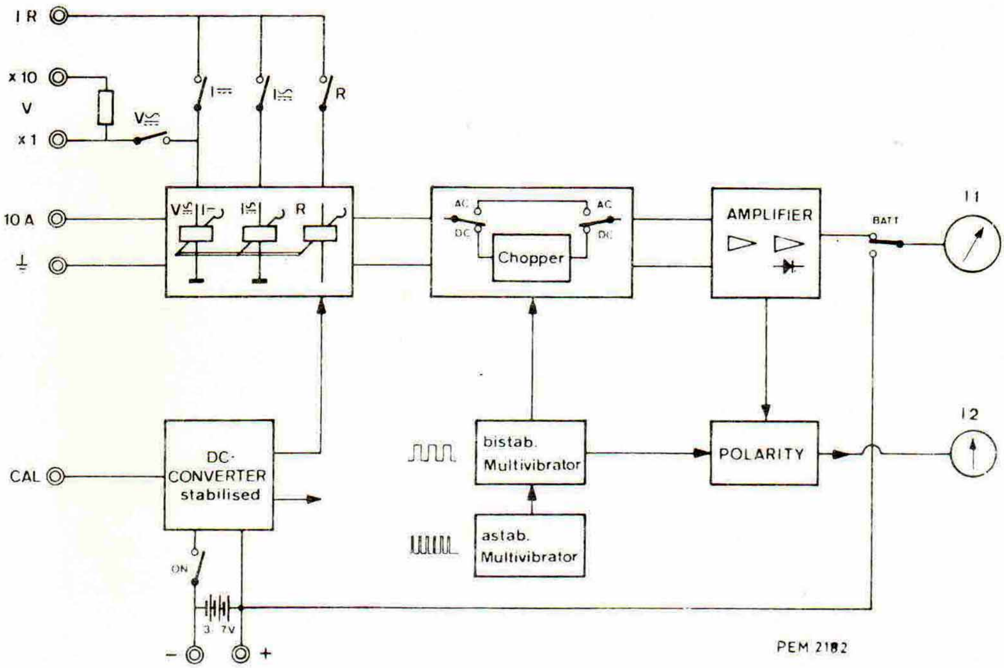


Fig. 1. Block diagram

Technical data

III

Numerical values with tolerances stated are guaranteed by us. The other values represent the properties of an average apparatus and merely serve as a guide.

Voltage measurement

D.C. and A.C.	:	5 mV . . . 300 V
Socket × 1	:	8 ranges 100 mV, 300 mV, 1 V, 3 V, 10 V, 30 V, 100 V, 300 V (f.s.d.)
Socket × 10	:	Max. permissible voltage 700 V, to be measured in the range 100 V × 10 = 1000 V (f.s.d.)
Input resistance D.C.		
Socket × 1	:	100 mV - 300 V: 1 MΩ ± 1%
Socket × 10	:	1 V - 300 V: 10 MΩ ± 1%
Input impedance A.C.		
Socket × 1	:	100 mV - 30 V: 1 MΩ ± 1%//50 pF 100 V - 300 V: 1 MΩ ± 1% (not frequency-compensated)
Socket × 10	:	1 V - 300 V: 1 MΩ ± 1% //7 pF
Max. error D.C. and A.C.	:	± 3% of f.s.d., after internal calibration
Frequency range	:	20 Hz - 200 kHz ± 1% 10 Hz - 20 Hz and 200 kHz - 1 MHz ± 3% (reference frequency 1 kHz)
Scale linearity, f.s.d.	:	± 1.5%
D.C. H.T.-measurement	:	With probe GM 6070 6 ranges (f.s.d.) 100 V 300 V 1000 V 3000 V 10,000 V 30,000 V Input resistance: 1000 MΩ ± 5% Accuracy: 8% (together with PM 2401)

H.F. measurement	:	With diode probe PM 9200 and T-piece PM 9250, UHF voltages of 30 mV - 16 V can be measured (supplied with calibration table) 6 ranges (f.s.d.): 100 mV 300 mV 1 V 3 V 10 V 30 V Frequency range: 100 kHz - 700 MHz ± 10% 1 MHz - 300 MHz ± 5%
Polarity indication	:	A sensitive moving-coil meter indicates the polarity of the input voltage of an arbitrary connection socket with respect to the earthing socket.
Calibration	:	The amplifier is calibrated with the battery voltage in the range 100 mV d.c.
Preliminary deflection	:	$<$ 1 mV ($<$ 1 scale division) with short-circuited input.
Overload protection	:	All ranges are protected up to a maximum of 300 V d.c. and 300 V_{rms} a.c. A maximum of 700 V d.c. is permitted on socket × 10.

Current measurement

D.C.	:	5 nA - 10 A, 17 ranges 100 nA, 300 nA, 1 μA, 3 μA, 10 μA, 30 μA, 100 μA, 300 μA, 1 mA, 3 mA, 10 mA, 30 mA, 100 mA, 300 mA, 1 A, 3 A, 10 A. (f.s.d.) (10-A range on separate socket.)
A.C.	:	50 μA - 10 A, 9 ranges 1 mA, 3 mA, 10 mA, 30 mA, 100 mA, 300 mA, 1 A, 3 A, 10 A. (f.s.d.) (10-A range on separate socket)
Max. error D.C. and A.C.	:	± 3% of f.s.d., after internal calibration
Frequency	:	20 Hz - 100 kHz ± 1.5%
Scale linearity, f.s.d.	:	± 1.5%
Voltage drop in all D.C. and A.C. ranges	:	100 mV

Resistance measurement

Total measuring range	:	0.5 Ω . . . 50 MΩ 6 ranges: 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ (mid-scale values)
Measuring voltage	:	max. 100 mV
Total measuring error	:	1 MΩ range (to 10 MΩ) ± 5% All other ranges ± 4%
Temperature range		15 °C to 35 °C with indicated accuracy 0 °C to 50 °C with extra measuring error of 2%
Supply		3 V - 7 V d.c. with 4 mono-cells "D" 32 diam. × 60 mm (1.5 V) or 4 NiCd batteries, e.g. type 32 A 60

Current consumption

Supply	Measuring mode	Consumption
3 V	A.C.	approx. 50 mA
	D.C.	approx. 70 mA
	Resistance	approx. 125 mA
7 V	A.C.	approx. 20 mA
	D.C.	approx. 28 mA
	Resistance	approx. 50 mA

Duration of operation per charge or per set of batteries	:	A.C. measurement: approx. 70 h D.C. measurement: approx. 50 h Resistance measurement: approx. 30 h (average value at continuous operation)
Charging	:	with charger PM 9000; charging current: 200 mA
Battery-voltage	:	can be read directly on the instrument

Mechanical data

Dimensions	:	heigt 234 mm width 157 mm depth 180 mm
Weight	:	approx. 3.4 kg.

Accessories

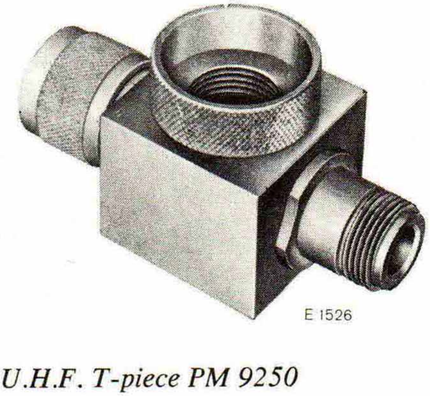
Charging cable
Manual

Separately avaible
Power pack PM 9205

H.T.-probe GM 6070

U.H.F.-probe GM 9200

Charger PM 9000



U.H.F. T-piece PM 9250

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DIRECTIONS FOR USE

Installation

V

A. SUPPLY

For the supply of the apparatus four dry-batteries, or four NiCd rechargeable batteries which may have the following dimensions, can be used:
Diameter: 30 to 34 mm
Length (without central contact cap): 54 to 59.5 mm
The lids of the battery compartments can be removed after pressing the slide lock (S in fig. 5) from the left to the right.

In the left-hand battery compartment there is an insulating disc, which should be removed.

This disc serves to protect the batteries from discharging when the apparatus is accidentally switched on during transport.
The dry cell batteries or rechargeable batteries should be positioned so, that in each holder the positive pole of the batteries (contact cap) faces inwards in the top compartment and outwards in the bottom compartment.
When the batteries are inserted incorrectly, the holders cannot be closed. Moreover, make sure that the insulating discs at the bottom of some types of batteries are removed. If the cap of the positive pole has a soldering tag, this should be cut off.

B. CHECKING THE BATTERY VOLTAGE

The battery voltage is checked as follows:

- Switch on the apparatus by depressing button "ON"
- Depress button "BATT."

With depressed button "BATT." the instrument measures the battery voltage directly, independent of the position of the measuring range selector.

Range "ACCU" on the measuring instrument indicates the admissible operation voltage for **NiCd batteries.**
The beginning of the range corresponds with the minimum operation voltage of 4.4 V and the end of the range with the maximum voltage (recharged batteries) of 5.9 V.
These voltages do not affect the function of the measuring instrument, however, they are important for checking the charging or discharging condition of NiCd batteries. Charging of the batteries is further described in Chapter IX.
The operating voltage of the instrument ranges from 3 V to 7 V, which corresponds to range "DRY CELL" with button "BATT." depressed. The measuring instrument is operative in this voltage range without affecting the tolerances stated in the technical data. Standard dry-cell batteries can therefore be used up almost completely.

C. ZERO-POINT ADJUSTMENT AND CALIBRATION

1. Place the instrument on a horizontal surface and check that the mechanical zero-point adjustment is correct. If necessary, accurately adjust to zero by means of the correction screw.

2. – Connect socket "CAL" to socket "× 1".
   - Depress button "ON".
   - Set the measuring-range selector to 100 mV.
   - Depress push-button "V".
   - Depress push-button "BATT", read the indicated value on the 0 - 100 scale and note it down.
   - Release button "BATT.", and with a screwdriver, turn setscrew "CAL" so that the pointer accurately indicates the noted voltage value.
   - Re-check by depressing button "BATT".
   - Remove connection "CAL" "× 1".

The measuring instrument is then calibrated and operational.

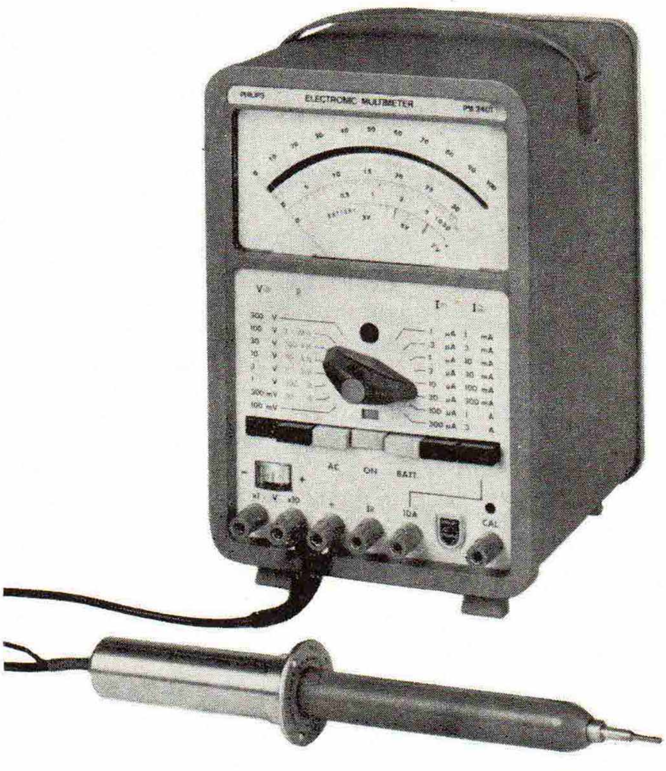
Operation

VI

A. MEASURING D.C. AND A.C. VOLTAGES

- Measuring connection: to socket "⏚" and "× 1" or "× 10".
- Depress button "ON"
- Depress button "V≅".
- For a.c. voltage measurements, depress button "AC"

When connecting to socket "× 1", the indication corresponds to the selected V-measuring range.
When connecting to socket "× 10", the selected range should be multiplied by ten.
Permissible voltage for direct measurements: maximum 300 V (on socket × 10 : maximum 700 V).
For higher voltages, use H.T.-probe GM 6070



PEM 2078

Fig. 2. Measuring high-tension

Polarity indication when measuring d.c. voltages

The potential connected to an arbitrary socket with respect to the earthing socket, has the polarity indicated by the polarity indicator.

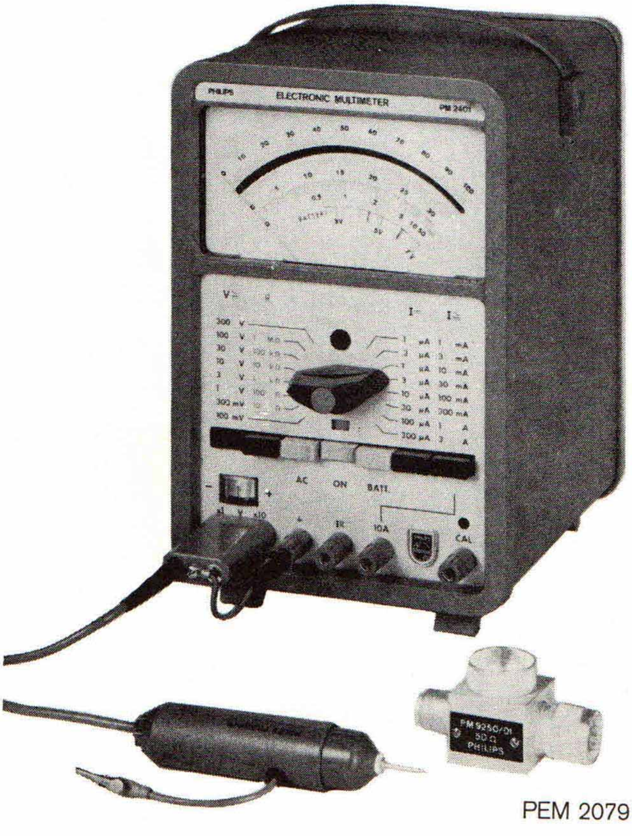
H.T. measurement of d.c. voltages up to 30 kV, with probe GM 6070

- Connect the probe to socket "× 10" and "⏚" (see Fig. 2).
- Set the measuring range selector to 30 V.
- Read on the 0 - 30 scale in kV.

Caution: When measuring, make sure that the earthing socket is connected to the chassis or to earthing potential of the measuring object.

Measuring U.H.F. voltages (with probe PM 9200 and T-piece PM 9250)

- Insert the connection plug of the probe cable into sockets "× 1" and "× 10", and connect socket "× 10" to "⏚" (Fig. 3).



PEM 2079

Fig. 3. Measuring UHFvoltage

- Set the measuring-range selector to the desired position (100 mV - 30 V).

The maximum permissible measuring voltage on the U.H.F. probe is 16 V. In case of frequencies exceeding 300 Mc/s, the correction factor on the calibration curve of the probe should be taken into account.

B. MEASURING D.C. AND A.C. CURRENTS

- Measuring connection: to sockets "⏚" and "I"
  for range 10 A: to "⏚" and socket "10 A"
- Depress button "ON".
- Depress button "I⎓" or "I≂".
- When measuring a.c. currents, depress button "AC".

Polarity indication:

The polarity indicator indicates the polarity of the potential connected to socket "IR" or "10 A".
The voltage drop in all ranges is 100 mV.

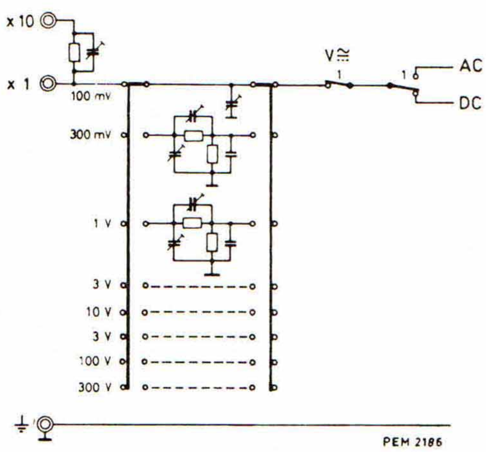
Explanation of the symbols used:

- I⎓ Measuring ranges for d.c. current and pulsating d.c. current (e.g. rectified a.c. voltage).
- I≂ Measuring ranges for a.c. current, d.c. current, and also for pulsating d.c. current.
- V≂ Measuring ranges for a.c. voltage, d.c. voltage, and also for pulsating d.c. voltage.
- R Resistance ranges in Ω, kΩ and MΩ.

C. MEASURING RESISTANCES

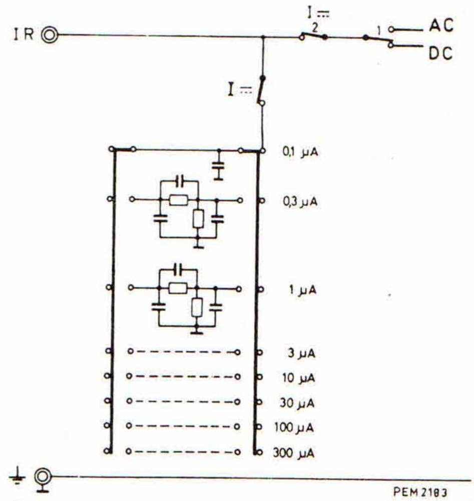
- Measuring connection: to sockets "⏚" and "R".
- Depress button "ON".
- Depress the button of measuring range "R".
- Select the desired measuring range by means of the measuring-range selector (the range indication is located in the centre of the scale, i.e. 1).
- Check whether the pointer indicates ∞ with open measuring input. If necessary, adjust with trimming potentiometers "CAL. R: 10 Ω 1 MΩ" (at the right-hand side; screwdriver adjustment).

Button V≅ depressed



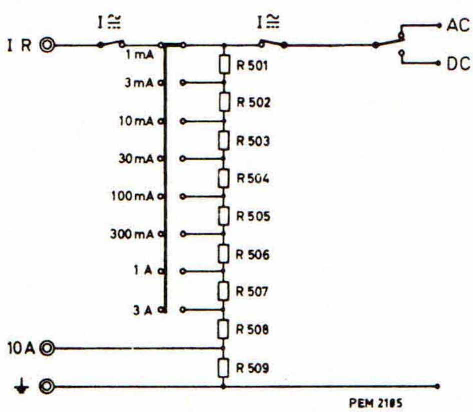
a

Button I⎓ depressed



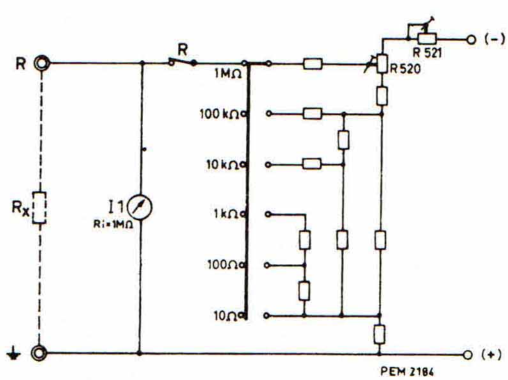
b

Button I≅ depressed



c

Button R depressed



d

Fig. 4. Attenuator systems

SERVICE DATA

Circuit description

VII

A. INPUT-VOLTAGE DIVIDER

Measuring-range selector SK1 principally consists of three independent voltage dividers which should be switched on according to the selected measuring mode. These three attenuators serve the following purpose:

1. Attenuation system SK1/I and II

Voltage division for the a.c. and d.c. mode and also for d.c. current measurements up to 300 μA (Fig. 4a).
This step-attenuator is combined for the voltage and current ranges, at which, for the voltage attenuation, each step has a frequency-independent calibrated voltage divider. When measuring d.c. currents, the resistor of this voltage divider connected to earth, serves as shunt (Fig. 4b).

2. Attenuation system SK1/IIIb

With this step switch, the measuring ranges for a.c. and d.c. from 1 mA to 3 A, are defined.
Depending on the range selected, a resistor or the series-connection of several resistors are connected in parallel to the output, thus forming a shunt (Fig. 4c).

3. Attenuation system SK1/IIIa

For measuring resistances, the stabilised 12-V supply voltage is divided into six ranges by means of an efficient resistor combination. These ranges are selected so, that with a resistance Rx, whose value corresponds to the value of the measuring range, the instrument gives a mid-scale reading (1), Fig. 4d.
With an Rx of 0 Ω, the instrument indicates 0 and when the input is open, ∞.

B. PUSH-BUTTON SWITCH

The measuring mode is selected by means of a push-button which switches on the relevant measuring circuits. Electronic as well as mechanical locks prevent operation errors and protect the apparatus against overload. The electrical working is shown in the circuit diagram (Fig. 21).

To ensure that the push-buttons are mutually locked in certain positions, there are the following mechanical locks:

- Buttons "V≅", "R", "I⎓", "I≅" mutually release each other.
- When button "R" or "I⎓" is depressed" button "AC" is blocked in the rest position.
- Buttons "AC" and "ON" can be released by re-depressing.
- Button "BATT." has no locking device and can be depressed arbitrarily.

C. AMPLIFIER

The measuring instrument has a three-stage negatively fed-back a.c. amplifier. In the input stage, a field-effect transistor (TS102) works as impedance transformer.

The d.c. working point of TS102 is fixed by GR109, R108 and R109.

The a.c. voltage across R111 drives the next stage (TS103), whose collector-emitter voltage is controlled by transistor TS104 which is connected as emitter follower. The d.c. control signal of this transistor is produced across R121 at the output stage.

The voltage produced across collector resistor R112 controls output stage TS105. The emitter side of the output stage is stabilised by TS106.

The indicator with full-wave rectifier is located in the feedback circuit from TS105 to TS103.

The current flowing in this circuit is additionally linearised by the feedback, which results in a pointer deflection proportional to the input signal.

D. CONVERSION FROM A.C. TO D.C., CHOPPER, MULTIVIBRATORS

From the input attenuator, the a.c. voltage is applied to the amplifier input via the frequency-independent attenuator (C102, R101, and C103, R103). This extra a.c. voltage divider takes into account the ratio of the average d.c. voltage value of sinusoidal- and square-wave voltages, including the efficiency of the chopper.

D.C. voltages, on the other hand, are applied to chopper transistor TS101 via the hum filter (R124, C101 and R102); the chopper transistor converts the d.c. voltages into square-wave voltages. This square-wave voltage then is applied to the amplifier input via C105.

Chopper transistor TS101 is driven by a bistable multivibrator (flip-flop), and the flip-flop circuit in turn is controlled by a free-running multivibrator. This method of connection requires very low current consumption for the chopper drive.

The bistable multivibrator consists of transistors TS206 and TS207. Diodes GR205, 206 and 207 form a diode gate for positive pulses.

During the pulse interval, GR206 discharges capacitor C208. One of the diodes GR205 or GR 207, is blocked continually by a conductive transistor while the other diode is conductive.

As a result, this diode applies the rising pulse to the base of the conductive resistor and this pulse blocks it, with the result that the switching-over is started. Whenever a negative pulse passes C208, the flip-flop reverses. The resulting square-wave voltage can be measured at connection points U 2/11 and U 2/12.

The free-running multivibrator, consisting of TS204 and TS205, produces short pulses with a duration of $\leqslant 5\ \mu s$ and has a switching frequency of about 1200 c/s.
The switching time or frequency is determined by C206, R213 and the pulse duration by C206 and r_{BB}' of TS205.

E. POLARITY INDICATION

The polarity indicator indicates the polarity of the voltage on one of the terminal sockets with respect to the earthing socket.

The indication is effected as follows:
The amplified chopper signal is applied from the amplifier output to a controlled rectifier which short-circuits the positive or negative half-wave, depending on the polarity. The pulsating direct current, flowing through instrument I2, moves the pointer out of its mid-position.
Assume that the collector emitter junction of transistor TS209 to point U 2/10 is divided; then a square-wave alternating current flows through instrument I2 and due to its delayed action I2 cannot produce a deflection.

Transistor TS209 only functions as a switch and is controlled by the same square-wave voltage as the transistor chopper.
As TS209 switches in the same rhythm of the chopper input, it short-circuits either the positive or the negative phase of the square-wave voltage. In the first case, the polarity indicator points to the right; with reversed polarity of the input voltage, the output volage is phase shifted 180° with respect to the chopper control voltage and the indicator deflects to the left.

F. SUPPLY

Function of the blocking transformer

For the supply of the measuring amplifier, a d.c. voltage transformer produces the required stabilised working voltage of about 12 V. This transformer operates as follows:
When button "ON" is depressed, a current surge arises in transformer T201. This current surge passes diode GR201 and charges capacitors C202 and C203. This current surge in T201 causes an induction voltage in its secondary winding S2, by which a current flows through the base-emitter junction of TS201 via R206 and C204. As a result, the collector-emitter junction becomes conductive so that the current through S1 of T201 rises even more to the saturation point of the transformer or to the moment that the base of TS201 blocks again on account of the decreasing induction voltage. As the C-E junction of this transistor is blocked now, the voltage increases sharply due to the self-inductance in T201; the current flows via diode GR201 and charges C202. In the same discharge-phase of T201, again an induction voltage is produced in winding S2. However, as the polarity of this voltage is reversed now, the base of TS201 is blocked so that no current can flow and thus the collector-emitter junction remains blocked. Consequently the induction current flows only via diode GR201 into the electrolytic capacitors and charges the latter. When the induction voltage decreases to less than the battery voltage again, there is another current surge from the battery after which oscillation starts again.
Diode GR201 functions as blocking valve, so that the current can flow only in charging direction; at the switching-on moment, GR202 and R204 cause fast charging of C203 to the battery voltage which is a condition to make the transistor TS201 oscillate.

Control-circuit of the stabilisation

On the output, parallel to C203, the voltage is controlled by a bridge circuit, at which the total value of the Zener voltages of GR203 and GR204 forms the reference voltage. When the output voltage across C203 exceeds the reference voltage, the collector current of TS203 decreases. Consequently, TS202 is recontrolled which effects a decrease of the average base current of TS 201. Because the oscillation frequency of TS201 at a small base current will be lower than at a larger base current, the electrolytic capacitors C202 and C203 will be charged less, so that the output voltage remains virtually the same as the reference voltage.

At a higher consumption current or at a lower battery voltage, the oscillating frequency is higher than at a small load current or with good batteries.

By means of this circuit, a very good stabilisation of the supply voltage is obtained. Moreover, it permits optimum use of the battery capacity with a minimum of influence on the measuring accuracy.

Dismantling the apparatus

VIII

1. **Removing the cabinet**

   – Remove the rear plate by removing the four screws in the corners.
   – The cabinet can then be removed by sliding it off to the rear.

2. **Removing the rearmost mounting plate** (Fig. 5)

   – Remove the four screws "A"
   – Loosen both screws "B" (these are accessible from the bottom between the print plate and the rearmost mounting plate).
   – Remove screw "C", which secures the print plate to the side.
   – The rearmost mounting plate together with the battery holders can then be pulled out towards the rear.

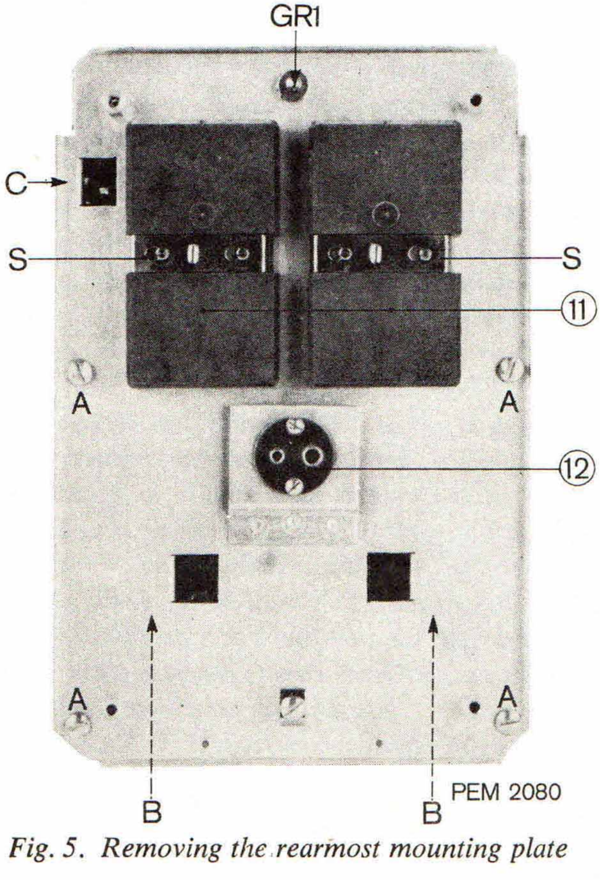


Fig. 5. Removing the rearmost mounting plate

3. Removing the control knob

- Pull out the centre cap.
- Loosen the nut from the clamping cone and remove the knob. In case the knob is still tight after the nut has been loosened, slightly tap the nut.

4. Removing the printed wiring boards

a. Printed wiring board U1 (Fig. 6)

This is the printed wiring board on which the push-button unit is located.
The printed wiring board can be removed easily by proceeding as follows:

- Remove the rearmost mounting plate (see under point 2).
- Remove the two screws "D" and "G" (Fig. 10) at the side of the push-button unit.
- Remove the control knob.
- Unscrew the two screws "F" and remove the two screws "B".
- Unsolder the three connections to the attenuator.
- Printed wiring board U1 together with push-button unit and supporting-plate with locking mechanism can now be hinged out sideways.

b. Printed wiring board U2 (Fig. 11)

This board is located at the bottom of the apparatus and can be hinged out when on one side both screws "E" are removed.

c. Printed wiring board U3 and U4

These boards are located at both sides of the attenuator switch and can be removed only after detaching the attenuator unit.

d. Printed wiring board U5 (Fig. 13)

This is the printed wiring board at the side of the apparatus. The board can be hinged out if screw "C" is removed.

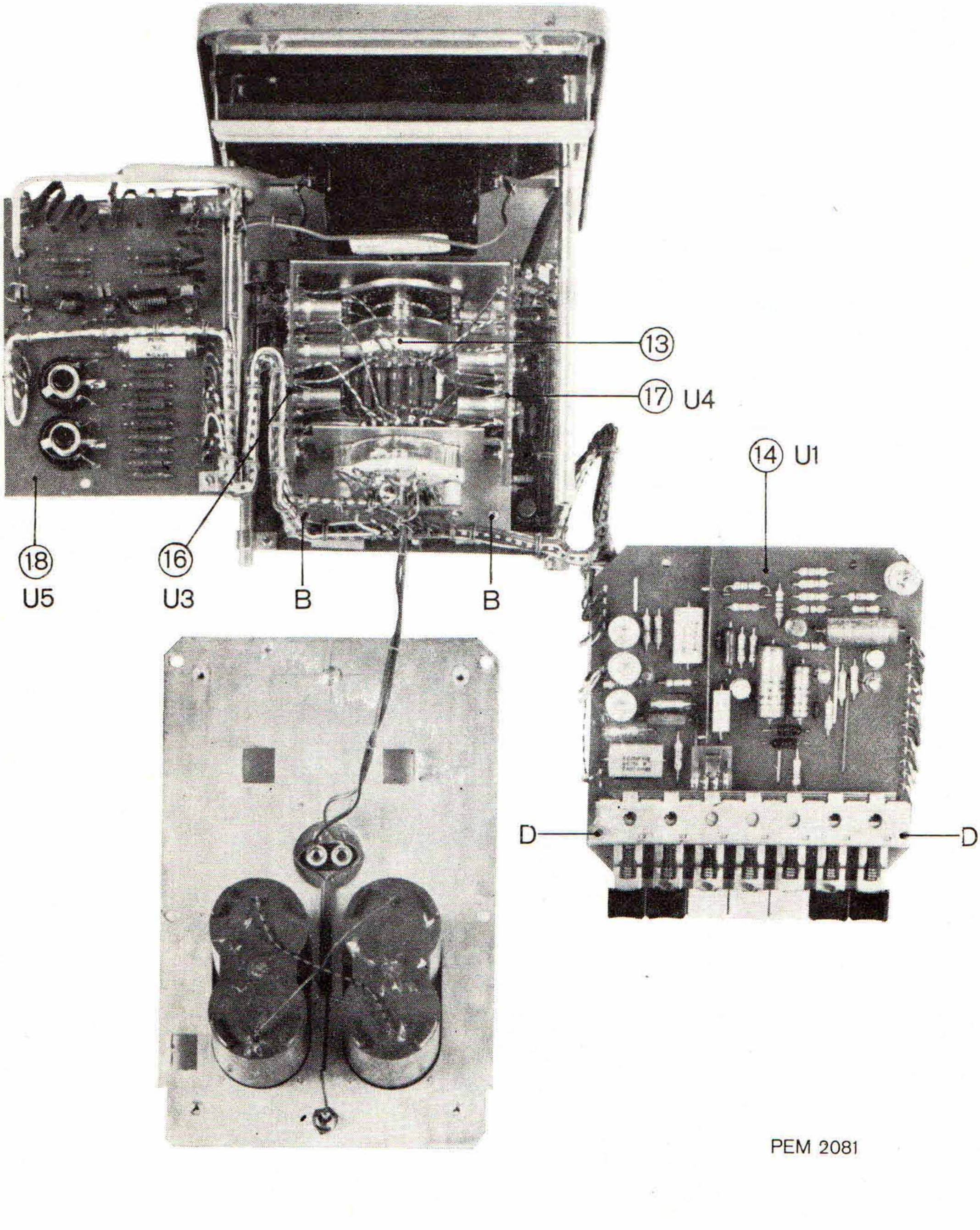


Fig. 6. Removing printed wiring board U1

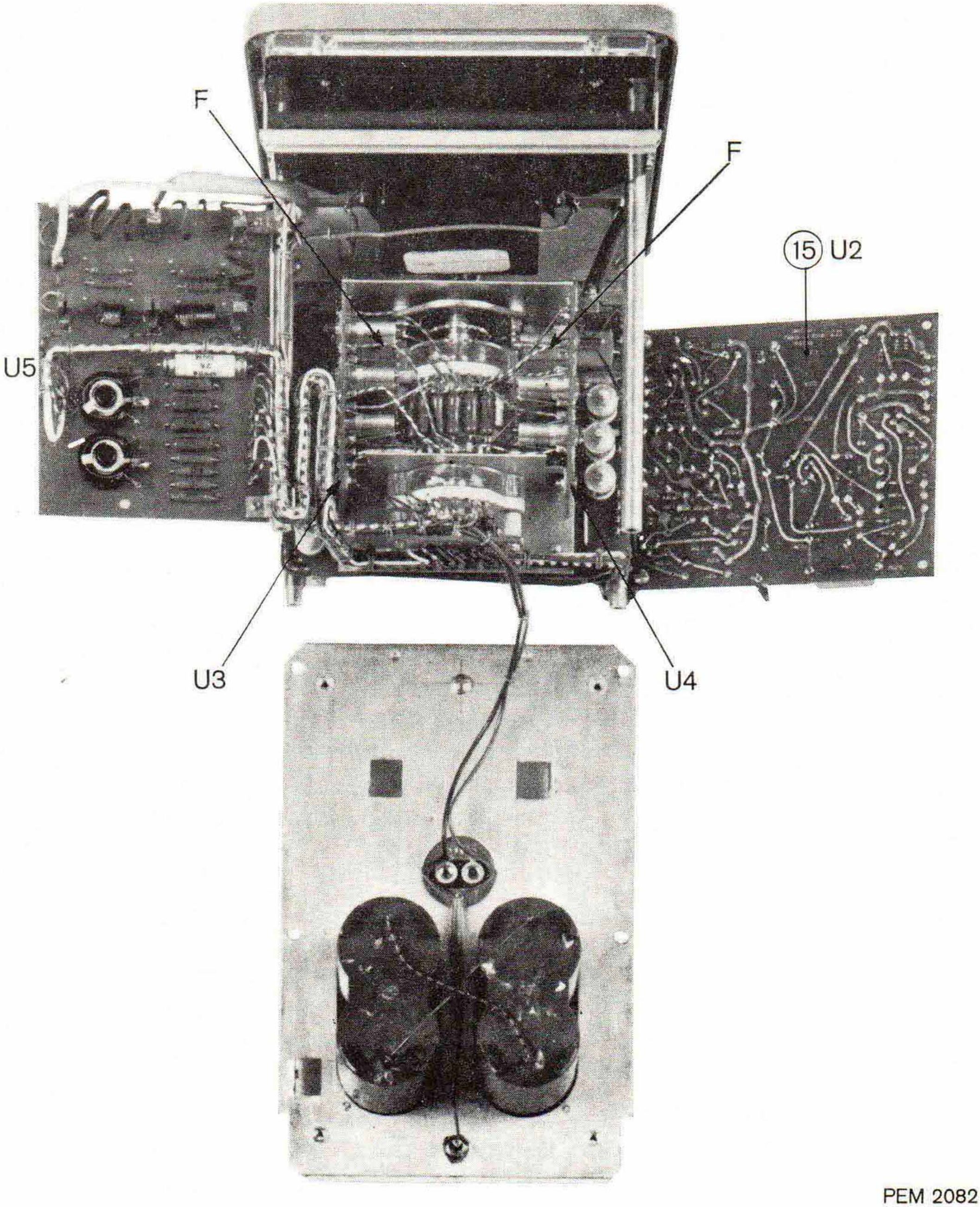


Fig. 7. Removing the attenuator

5. Removing the attenuator unit (Fig. 7)

- Remove the control knob (see point 3).
- Remove the cabinet (see point 1).
- Remove the rearmost mounting plate (point 2).
- Unsolder the four leads.
- Loosen both screws "F".
- The complete unit can then be pulled out to the rear.

6. Replacing the text plate

- Remove the control knob (point 3).
- Remove the cabinet (point 1).
- Detach all connection sockets.
- The text plate can then be removed.
- The new plate should be glued to the upper part (e.g. with rubber cement).

7. Replacing the measuring instrument

- Remove the cabinet (point 1).
- Unsolder both connection leads to the measuring instrument.
- Hinge out the print-plate at the side (remove screw "C").
- Disconnect the profile and remove the instrument.

8. Replacing the push-button unit

- Remove print-plate U1 (point 4.a.).
- With a vacuum-soldering iron, the solder on all soldering points of the push-button unit should be removed.
- The push-button unit can be removed from the print-plate by unsoldering the various soldering points.

REMARK

In case of breakdowns one can always apply to the world-wide PHILIPS Service Organisation.

Whenever it is desired to send the apparatus to a PHILIPS Service Centre for repair, the following points should be observed:

- tie on a label, bearing full name and address of the sender.
- indicate as complete as possible the symptom(s) of the fault(s).
- carefully pack the apparatus in the original packing, or, if no longer available, in a wooden crate.
- send the apparatus to the address provided by your local PHILIPS representative.

Maintenance

IX

In general, the Electronic Multimeter does not require any maintenance as the apparatus does not contain any parts subject to actual wear.
However, for a dependable performance, the apparatus should not be exposed to extreme heat or excessive moisture.
In case of extensive intervals between operation, the batteries should be removed from the holders.

a. Push-button unit

In case there is excessive friction when operating, the push-button unit without actual defects in the working, the vulnerable parts, such as the bolts, should be greased lightly with Moly-cote grease. Sliding surfaces are lubricated best with a thin oil (e.g. sewing machine oil).

b. measuring-range selector

If necessary, the ratchet of the measuring-range selector can be lubricated with a thin oil.

c. Switch contacts

In case of contact troubles, the contacts should only be treated with a special switch oil (see the list of mechanical parts for the order number).

Charging the rechargeable batteries

For recharging the NiCd-rechargeable batteries, charger PM 9000 can be used.
For this, the bi-pole plug of the charging cable should be connected to the sockets at the rear of the apparatus. On the charger, switch "200 mA/45 mA" should be set to position 200 mA; the charging current then is about 200 mA.
Connect the charger to the a.c. mains. The operating condition is indicated by the signal lamp in the charger. During charging, the apparatus may be used or be switched off.
The rechargeable batteries should be recharged, if, when checking the batteries, the pointer is at the beginning of the range and they

should be recharged until the end of range "BATT". For measuring the battery voltage, the charger should be switched off, as otherwise the charging voltage is indicated.
The charging time for charging from 4.4 V to 5.9 V is about 17 hours.

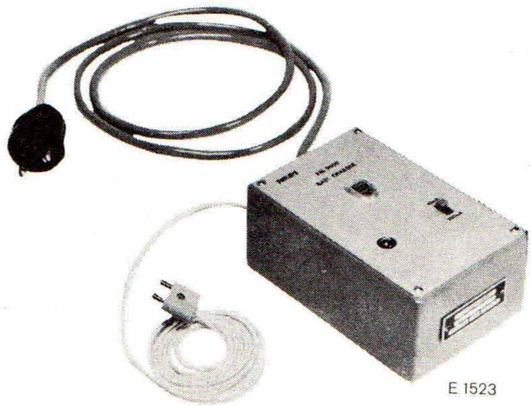


Fig. 8. Battery charger PM 9000

Survey of the adjustments

X

Checking and adjusting is effected in accordance with the data in chapter XI "Checking and adjusting".

Control element	*Fig.*	*Adjusting point*	*Required measuring instruments or choice resistors*	*Adjustment according to chapter XI*
R108	14	Working point of TS102	Choice resistors of 0 - 500 kΩ, 5%	1.a.
C106 C108	10+14	Min. preliminary deflection		2
R1	9+13	Amplification "CAL"	DC compensator 100 mV ± 0.2%	3
		Range AC-V × 1:		
C103	10+14	Range 100 mV		
C403	10+17	Range 300 mV		
C404	10+17	Range 1 V	L.F. generator	
C304	13+16	Range 3 V	100 kc/s, 1 Mc/s	
C305	13+16	Range 10 V	1 - 30 V, 0.5%	6
C306	13+16	Range 30 V	L.F. millivolt-meter	
C109	13+14	AC-V range		
		Range AC-V × 10:		
C303	13+16	Range 30 V		
C701	10+11	Range 30 V × 10	Resistor 1 MΩ 1%	
C302	13+16	Range 10 V	Capacitor 50 pF 1%	
C301	13+16	Range 3 V	L.F. generator 100 kc/s	7
C402	10+17	Range 1 V	1 V - 300 V ± 0.5 %	
C401	10+17	Range 300 mV	L.F. milli-voltmeter	
C405	10+17	Range 100 mV		
R520	13+18	Ohm-range 1 MΩ	Resistance box	9
R521	13+18	Ohm-range 10 Ω	10 Ω - 1 MΩ, 1%	
		Attenuator switch	Precision attenuator	4
R225	15	Internal calibration		11

For complete or extensive adjustment or checking of the apparatus, it is preferable to follow the sequence given in chapter XI.

Checking and adjusting

XI

The numerical values given in this chapter with tolerances stated, are factory data and apply only when the apparatus is re-adjusted. These may differ from the data given in chapter III, "Technical Data".

1. Working point adjustments

a. Unit U1

- The voltage measured between points 5 (—) and 17 (+) should be 11.5 V ± 2%.
- To adjust the working point of TS102, for R108 a resistor with such a value that the voltage at point 21 with respect to point 17 is 5.2 V ± 0.1 V should be fitted.
- Measure the voltage at point 8 with respect to point 17.
  This should be —6.0 V ± 0.2 V.

b. Unit U2

- Supply the apparatus with a d.c. voltage of 5 V ± 5%.
- The voltage measured at point 1 (—) and point 2 (+) should be 10.9 V . . . 12.4 V.
- Vary the supply voltage between 3 V and 7 V.
  The voltage variation between points 1 and 2 should be max. 0.2 V.
- With an oscilloscope, measure — at a voltage of 11.5 V ± 2% between points 13 (—) and 9 (+)—, the square-wave voltage on the following points:
  Point 12 with respect to 9 = 8 $V_{p\text{-}p}$ ± 10%
  Point 11 with respect to 9 = 7.8 $V_{p\text{-}p}$ ± 10%
  Pulse duration $\frac{T}{2}$ = 0.8 ms ± 15%
  Frequency = 625 c/s ± 15%

2. Electrical zero point, preliminary deflection

- Depress buttons "ON" and "V"
- Set the measuring-range selector to 100 mV
- Sockets "× 1" and "× 10" open

- Turn trimmer C108 half-way in, and adjust the deflection of the instrument to minimum by means of C106 (polarity indicator in mid-position)
- Connect socket "× 1" to "⏚"
- Check whether the polarity indicator shows the same deflection as with open input. If not, cancel the connection between "× 1" and "⏚" and adjust to the same deflection by means of C108.
- The preliminary deflection of the instrument should be max. 1 scale division.

3. Amplification and polarity indicator

- Depress buttons "ON" and "V"
- Set the measuring-range selector to 100 mV
- Apply a negative voltage of 100 mV ± 0.2% to socket "× 1". The polarity indicator should deflect to the left.
- Adjust to 100 scale divisions by means of R1 (CAL)
- Reverse the polarity of the voltage connected
- The polarity indicator should deflect to the right
- Permissible deviation of the instrument: max. 0.5% of the former deflection
- Set the measuring-range selector to 1 V
- The polarity indicator should clearly deflect to the right

4. Attenuator check (sockets "x1" and "x10")

Check the inaccuracy of the attenuator in each range by means of an accurate external attenuator and proper d.c. voltages.
Permissible deviation ± 1%.

5. Scale linearity

Check the scale linearity at 100%, 80%, 60%, 40% and 30% by means of a precision attenuator and a constant voltage source (battery).
Permissible deviation from full-scale value: ± 1%.

6. A.C. voltage ranges (socket "x1")

- Depress buttons "ON", "AC" and "V".
- Connect an external, accurate voltage with a frequency of 100 kc/s between sockets "× 1" and "⏚" and adjust to scale deflection 100 and 30 respectively at the following voltage values by means of the corresponding trimmers:

Range selector in position	*External voltage 1 kc/s*)*	*Adjustment to nominal value with R1 (in all ranges)*	*External voltage 100 kc/s*)*	*Adjust to mominal value with:*
100 mV	100 mV ± 0.2%	100	100 mV ± 0.5%	C103
300 mV	300 mV ± 0.2%	30	300 mV ± 0.5%	C403
1 V	1 V ± 0.2%	100	1 V ± 0.5%	C404
3 V	3 V ± 0.2%	30	3 V ± 0.5%	C304
10 V	10 V ± 0.2%	100	10 V ± 0.5%	C305
30 V	30 V ± 0.2%	30	30 V ± 0.5%	C306

For and exact adjustment it is therefore necessary to effect an accurate calibration in each range with the aid of R1 and a precise external voltage with a frequency of 1 kc/s, before adjusting a trimmer.

- Set the range selector to 3 V.
- Connect a voltage of 1 V ± 0.5%, 1 Mc/s, between sockets "× 1" and "⏚".
- Adjust the meter reading to 30 by means of C109.

7. A.C. voltage ranges (socket "x10")

- Depress buttons "ON", "AC" and "V".
- Set the measuring range selector to 30 V.
- Externally connect a resistor of 1 MΩ (± 1%) in series with a voltage of 60 V ± 0.5%, 100 c/s between sockets "×1" and "⏚". Also, a 50-pF (1%) capacitor should be connected in parallel to the 1-MΩ resistor.
- Adjust the meter reading to 30 with trimmer C303
- Connect a voltage of 300 V ± 0.5%, 100 kc/s,between sockets "× 10" and "⏚" (no series resistor).
- Adjust the meter reading to 30 by means of C702.

Remaining adjustments

Position of the measuring range selector	*External voltage at 100 kc/s*	*Adjust with*	*Scale value*
10 V	100 V ± 0.5%	C302	100
3 V	30 V ± 0.5%	C301	30
1 V	10 V ± 0.5%	C402	100
300 mV	3 V ± 0.5%	C401	30
100 mV	1 V ± 0.5%	C405	100

*) The non linear distortion of the generator should not exeed 0.5%.

8. Current ranges

- Depress buttons "ON" and "I≃".
- Supply sockets "IR" and "⏚" with an a.c. current source (50 c/s) having the following constant current values:

Constant-current value	*Position of the measuring range selector*	*Indicator (scale divisions)*
1 mA ± 0.5%	1 mA	100
1 mA ± 0.5%	3 mA	31.6
1 mA ± 0.5%	10 mA	10
30 mA ± 0.5%	30 mA	100
30 mA ± 0.5%	100 mA	31.6
30 mA ± 0.5%	300 mA	10
1 A ± 0.5%	1 A	100
1 A ± 0.5%	3 A	31.6
1 A ± 0.5%	socket 10 A	10

9. Resistance ranges

a. – Depress buttons "ON" and "R".
- Set the measuring-range selector to 10 Ω.
- Adjust to 100 scale divisions by means of R521.
- Switch the measuring-range selector to 100 kΩ. In every range, the indication should be 100 scale divisions, ± 0.5 scale division.
- Set the measuring-range selector to 1 MΩ.
- With R520, adjust the meter reading to 100 scale divisions.
- The polarity indicator should deflect to the left.

b. Connect a resistance box with an accuracy of 1% to sockets "IR" and "⏚" and check the indication at the following values:

Resistance value to be adjusted	*Position of the measuring range selector*	*Meter reading (scale 0 - 100) in scale divisions*
1 MΩ	1 MΩ	50 ± 1 scale division
100 kΩ	100 kΩ	50 ± 1 scale division
10 kΩ	10 kΩ	50 ± 1 scale division
1 kΩ	1 kΩ	50 ± 1 scale division
100 Ω	100 Ω	50 ± 1 scale division
10 Ω	10 Ω	50 ± 1 scale division

10. Battery check

- Depres buttons "ON" and "BATT".
- Supply the apparatus with the following external supply voltages on the charging sockets (remove the batteries or remove 1 battery-compartment lid):

Supply voltage	*Meter reading*
7 V ± 1%	7 V ± 5%
5 V ± 1%	5 V ± 5%
3 V ± 1%	3 V ± 5%

11. Internal calibration

- Supply the apparatus with a d.c. voltage of 5 V.
- Set the measuring-range selector to 100 mV.
- Interconnect socket "CAL" and socket × 1.
- Whether or not button "BATT" is depressed, the pointer deflection(s) should be the same. Permissible deviation ± 1% of full scale.
- Adjust with choice resistor R225.
  Permissible deviation ± 1%.

Parts lists

XII

A. MECHANICAL

Item	*Fig.*	*Qty.*	*Ordering number*	*Description*
1	9	1	4822 498 40004	Grip
2	9	2	4822 693 70019	Cap
3	9	1	4822 347 50019	Measuring instrument 100 μA, 1%, 1380 Ω
4	9	1	4822 535 40015	Correction screw
5	9	1	4822 411 20028	Knob
6	9	1	4822 276 70016	Push-button unit
7	9	4	4822 462 40006	Foot
8	9	6	4822 290 40011	Socket 4 mm
9	9	1	4822 347 10006	Polarity indicator
10	9	1	4822 455 90165	Text plate
11	5	1	4822 256 60042	Battery compartment
12	5	1	4822 267 30029	Sockets
13	6	1	4822 273 60039	Switch
14	6	1	4822 216 70025	Printed wiring board U1
15	7	1	4822 216 70026	Printed wiring board U2
16	6	1	4822 216 70027	Printed wiring board U3
17	6	1	4822 216 70028	Printed wiring boarl U4
18	6	1	4822 216 70029	Printed wiring board U5
19	–	1	4822 264 30022	Charging cable plug
20	–	1.5 m	4822 323 30002	Cable for charging cable
21	–	30 cc	4822 390 10007	Switch oil

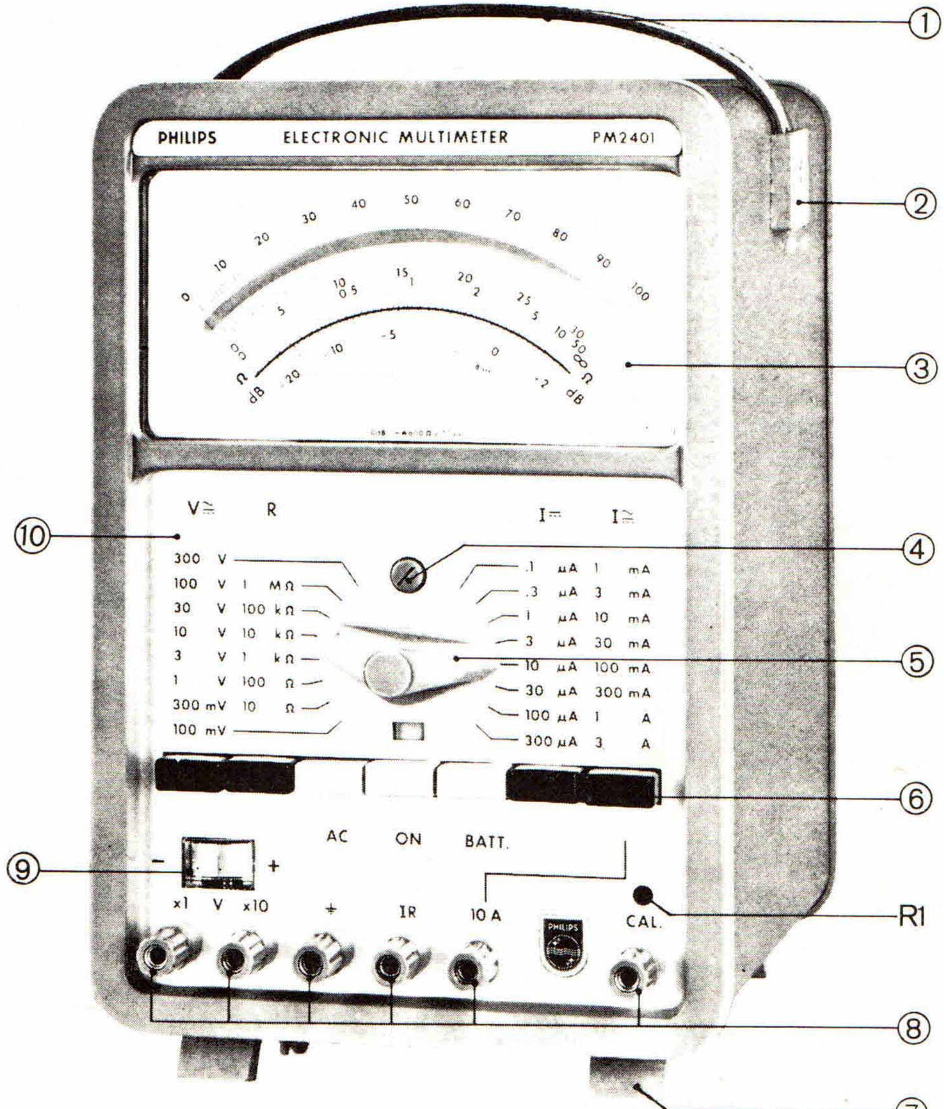


Fig. 9. Front view with item numbers

B. ELECTRICAL — ELEKTRISCH — ELEKTRISCH — ELECTRIQUE — ELECTRICOS

This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

Diese Ersatzteilliste enthält keine Universal- und Standard-Teile. Diese sind im jeweiligen Prinzipschaltbild mit Kennzeichnungen versehen. Die Spezifikation kann aus nachstehender Übersicht abgeleitet werden.

In deze stuklijst zijn geen universele en standaardonderdelen opgenomen. Deze componenten zijn in het principeschema met een merkteken aangegeven. De specificatie van deze merktekens is hieronder vermeld.

La présente liste ne contient pas des pièces universelles et standard. Celles-ci ont été repérées dans le schéma de principe. Leurs specifications sont indiquées ci-dessous.

Esta lista de componentes no comprende componentes universales ni standard. Estos componentes están provistos en el esquema de principio de una marca. El significado de estas marcas se indica a continuación.

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
— 0,125 W 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 0,25 W ≦ 1 MΩ, 5%; > 1 MΩ, 10%

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
— 0,5 W ≦ 5 MΩ, 1%; > 5 ≦ 10 MΩ, 2%; > 10 MΩ, 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 0,5 W ≦ 1,5MΩ, 5%; > 1,5MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 1 W ≦ 2,2 MΩ, 5%; > 2,2 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 2 W 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
— 0,4 – 1,8 W 0,5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
— 5,5 W ≦ 200 Ω, 10%; > 200 Ω, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
— 10 W 5%

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
— 500 V

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
— 700 V

Ceramic capacitor, "pin-up"
Keramikkondensator "Pin-up" (Perltyp)
Keramische kondensator "Pin-up" type
Condensateur céramique, type perle
Condensador cerámico, versión "colgable"
— 500 V

"Microplate" ceramic capacitor
Miniatur-Scheibenkondensator
"Microplate" keramische kondensator
Condensateur céramique "microplate"
Condensador cerámico "microplaca"
— 30 V

Mica capacitor
Glimmerkondensator
Micakondensator
Condensateur au mica
Condensador de mica
— 500 V

Polyester capacitor
Polyesterkondensator
Polyesterkondensator
Condensateur au polyester
Condensador polyester
— 400 V

Flat-foil polyester capacitor
Miniatur-Polyesterkondensator (flach)
Platte miniatuur polyesterkondensator
Condensateur au polyester, type plat
Condensador polyester, tipo de placas planas
— 250 V

Paper capacitor
Papierkondensator
Papierkondensator
Condensateur au papier
Condensador de papel
— 1000 V

Wire-wound trimmer
Drahttrimmer
Draadgewonden trimmer
Trimmer à fil
Trimmer bobinado

Tubular ceramic trimmer
Rohrtrimmer
Buisvormige keramische trimmer
Trimmer céramique tubulaire
Trimmer cerámico tubular

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.
Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.
Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.
Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.
Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

Resistors

No.	*Code number*	*Value*		*Tol.*	*Watt.*	*Description*
R1	4822 071 00849	47	Ω	10%	3	Potentiometer
R101	2 × 901/330K	661	kΩ	1%	0.25	Carbon (in series)
R103	901/510K + 901/3K	513	kΩ	1%	0.25	Carbon (in series)
R108	901/0-510K	0-500	kΩ	5%	0.25	Choice-resistor
R201	B8 305 17D/70K	70	kΩ	1%	0.1	Carbon
R202	901/30K + 901/39K	69	kΩ	1%	0.1	Carbon (in series)
R204	901/W1E	1	Ω	5%	0.4	Wire-wound
R205	901/10E + 901/13E	5.6	Ω	10%	0.25	Carbon (in parallel)
R225	901/2M2-6M8	2.2	MΩ-6.8 MΩ	5%	0.5	Choice-resistor
R301	901/30K + 901/2K7	32.7	kΩ	1%	0.25	Carbon (in series)
R302	901/10K + 901/100E	10.1	kΩ	1%	0.25	Carbon (in series)
R303	901/1K2 + 901/2K	3.17	kΩ	1%	0.25	Carbon (in series)
R305	901/300E + 901/16E	316	Ω	1%	0.25	Carbon (in series)
R401	B8 305 17D/450K + 901/13K	463	kΩ	1%	0.25	Carbon (in series)
R402	901/100K + 901/11K	111	kΩ	1%	0.25	Carbon (in series)
R501	901/W68E	68.4	Ω	1%	0.25	Carbon
R502	901/W18E + 901/W3E5	21.6	Ω	1%	0.4	Wire-wound (in series)
R503	901/W6E8	6.84	Ω	1%	0.4	Wire-wound
R504	901/W2E2	2.16	Ω	1%	0.4	Wire-wound
R505 R506 R507 R508 R509	4822 216 00508					Shunt
R510	B8 305 17D/70E + 901/20E	90	Ω	1%	0.25	Carbon (in series)
R511	B8 305 17D/700E + 901/200E	900	Ω	1%	0.25	Carbon (in series)
R512	901/10K + 901/100E	10.1	kΩ	1%	0.25	Carbon (in series)
R515	901/W10E	10	Ω	1%	0.4	Wire-wound
R516	901/W91E	91	Ω	1%	0.4	Wire-wound
R517	901/W10E	10	Ω	1%	0.4	Wire-wound
R518	901/W2E2	1.1	Ω	1%	0.4	Wire-wound (2 in parallel)

No.	Code number	Value		Tol.	Watt.	Description
R519	901/W910E	910	Ω	½%	0.4	Wire-wound
R520	4822 149 00356	200	Ω	10%	0.9	Potentiometer
R521	4822 149 00356	200	Ω	10%	0.9	Potentiometer
R601	4822 143 00608	684	kΩ	1%	0.25	Carbon
R602	B8 305 23D/900K	900	kΩ	1%	0.25	Carbon
R603	B8 305 23D/900K + 901/68K	968	kΩ	1%	0.25	Carbon (in series)
R604	B8 305 23D/980K + 901/10K	990	kΩ	1%	0.25	Carbon (in series)
R701	M7 632 58	9	MΩ	1%	0.25	Carbon

Capacitors

No.	Code number	Value		Tol.	Voltage	Description
C103	C 005 AA/16E	16	pF			Trimmer
C106	C 005 AA/16E	16	pF			Trimmer
C107	4822 069 00682	0.47	μF	10%	250 V	
C108	C 004 FA/6E	6.4	pF			Trimmer
C109	C 005 CC/60E	60	pF			Trimmer
C110	909/C160	160	μF		4 V	Electrolytic
C111	4822 069 00669	320	μF		6.4 V	Electrolytic
C112	909/W10	10	μF		16 V	Electrolytic
C201	4822 069 00903	400	μF		16 V	Electrolytic
C202	909/X64	64	μF		16 V	Electrolytic
C203	4822 069 00903	400	μF		16 V	Electrolytic
C204	4822 069 00682	0.47	μF	10%	250 V	
C210	909/W20	20	μF		6.4 V	Electrolytic
C211	4822 069 00601	0.33	μF		250 V	
C309	905/D3K3 + 905/D620E	3920	pF	1%	500 V	Styroflex (2 in parallel)
C701	4822 069 01016	6	pF			Trimmer

Miscellaneous

T201	4822 216 00401	Transformer
L201	4822 128 00463	Choke 120 μH

Transistors and diodes

TS101	BC107	Silicon-planar transistor
TS102	4822 130 40177	Field effect transistor (2 N 4360)
TS103	AF126	Germanium transistor
TS104	ASY27	Germanium transistor
TS105	BC107	Silicon-planar transistor
TS106	ASY27	Germanium transistor
TS201	AD139	Germanium transistor
TS202	BCY34	Silicon transistor
TS203	ASY29	Germanium transistor
TS204	ASY27	Germanium transistor
TS205	BC107	Silicon-planar transistor
TS206	AF126	Germanium transistor
TS207	AF126	Germanium transistor
TS208	ASY27	Germanium transistor
TS209	ASY29	Germanium transistor
GR1	BZZ19	Zener diode
GR101	OA91	Germanium diode
GR102	BZY62	Zener diode
GR103	OA79	Germanium diode
GR104	OA79	Germanium diode
GR105	OA200	Silicon diode
GR201	AAZ12	Germanium diode
GR202	AAZ12	Germanium diode
GR203	BZY58	Zener diode
GR204	BZY59	Zener diode
GR205	OA91	Germanium diode
GR206	OA91	Germanium diode
GR207	OA91	Germanium diode
GR208	OA91	Germanium diode

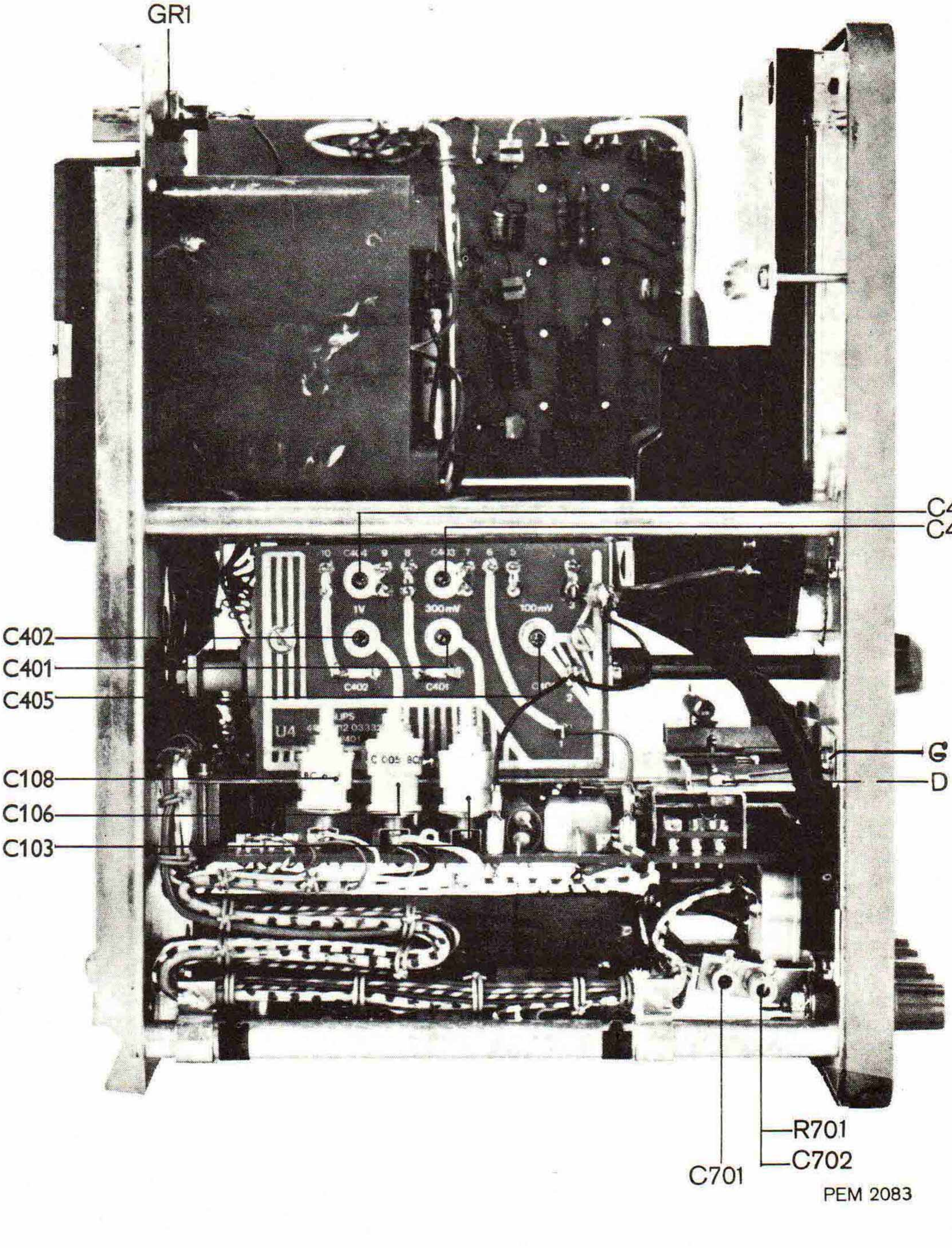
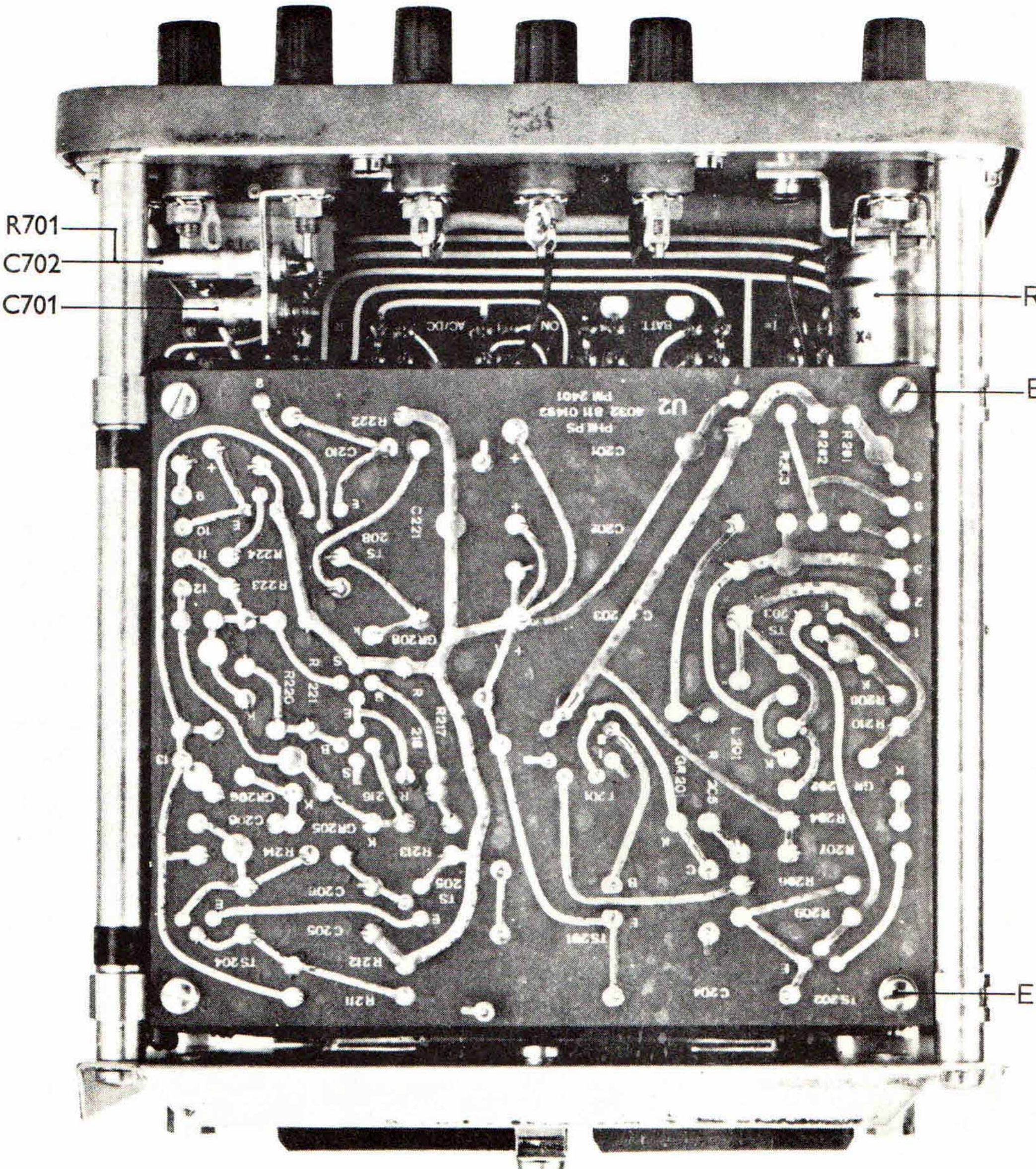


Fig. 10. Left-side view



PEM 2084

Fig. 11. Bottom view

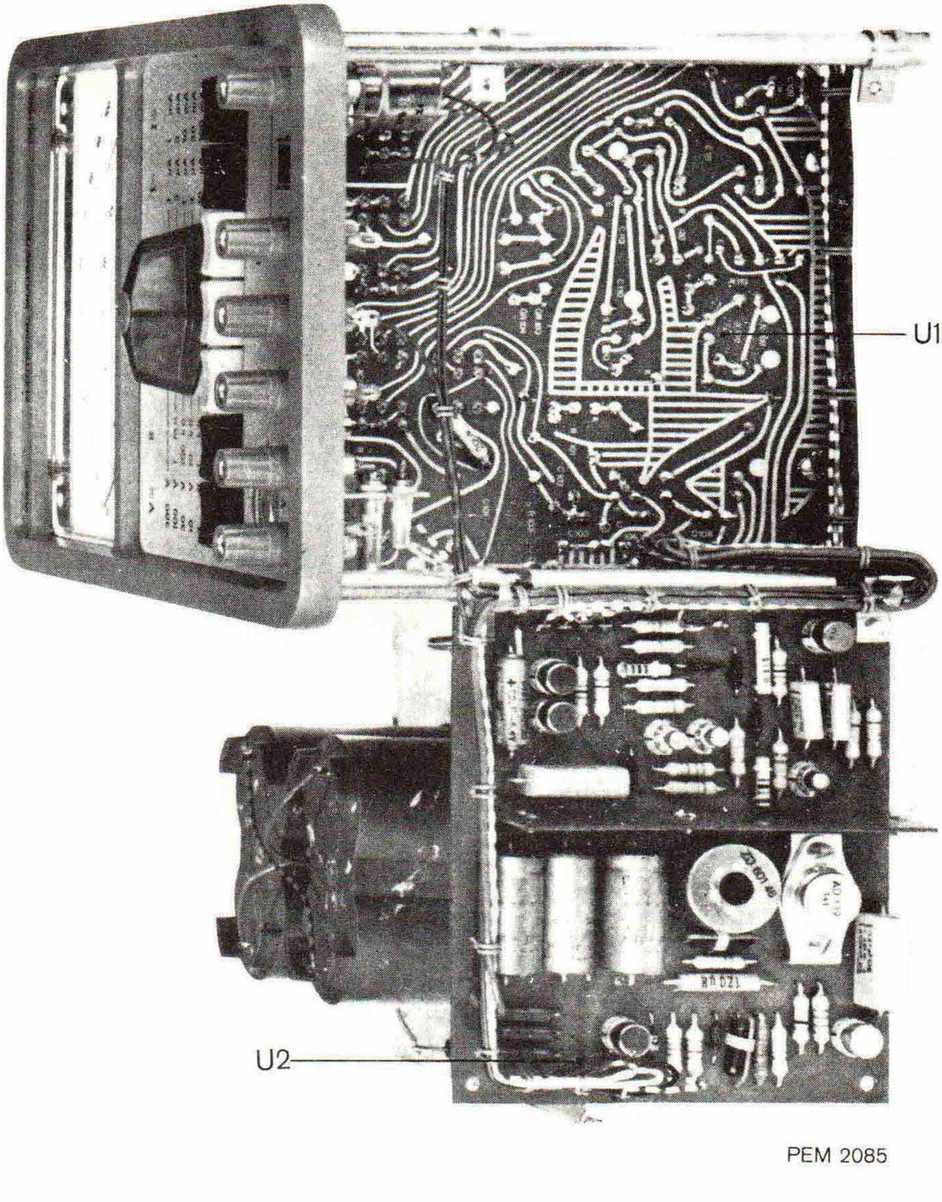


Fig. 12. Bottom view with folded-out printed wiring board U2

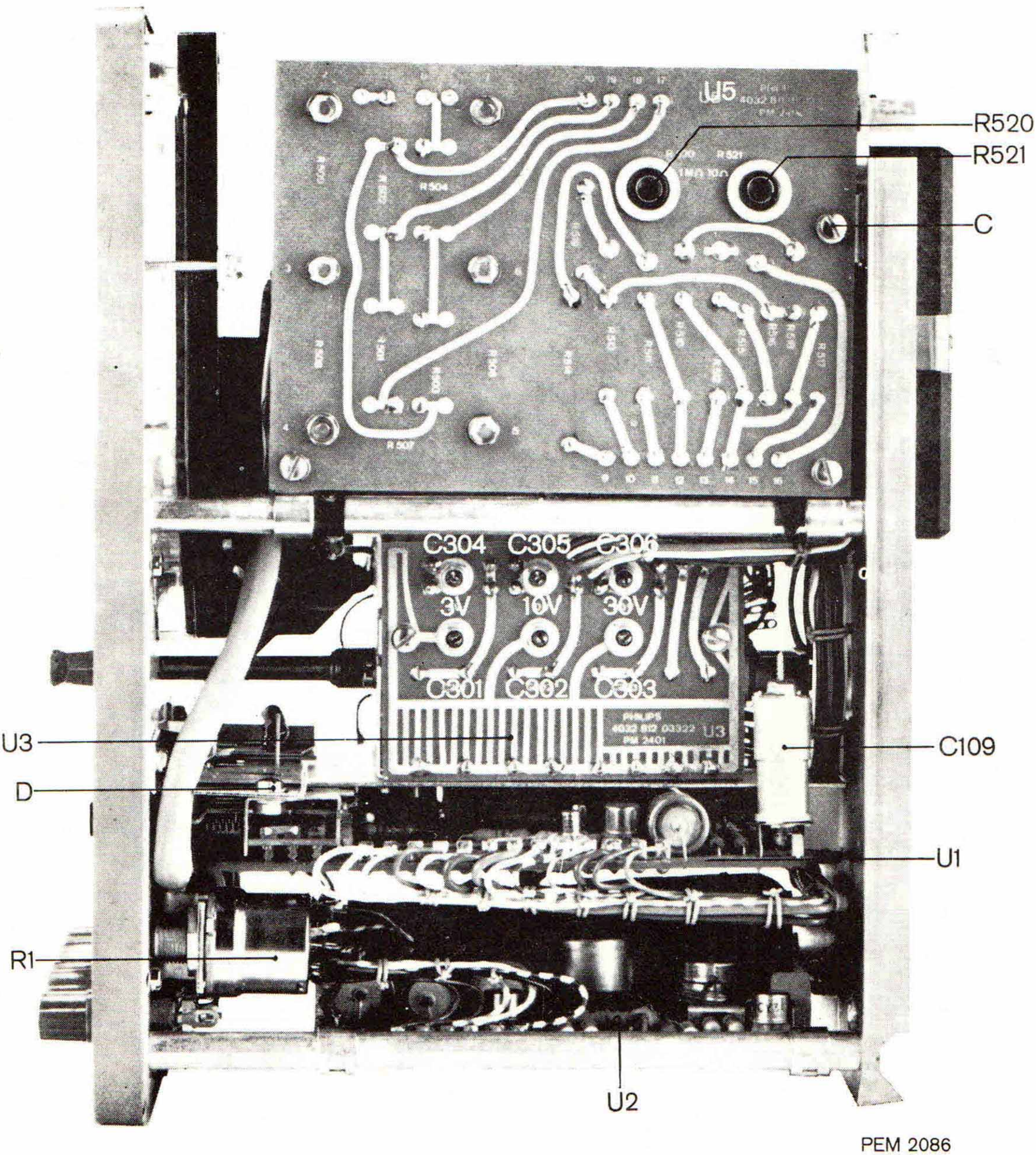


Fig. 13. Right-side view

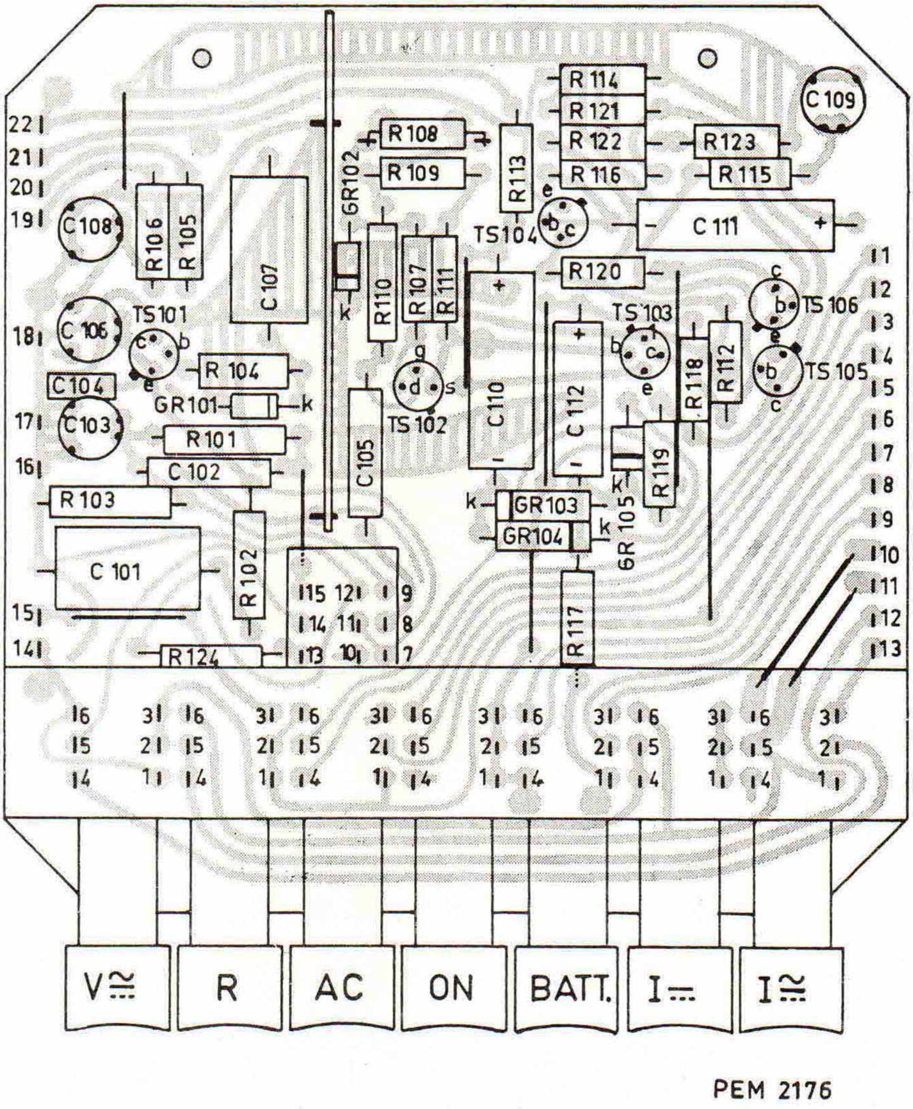
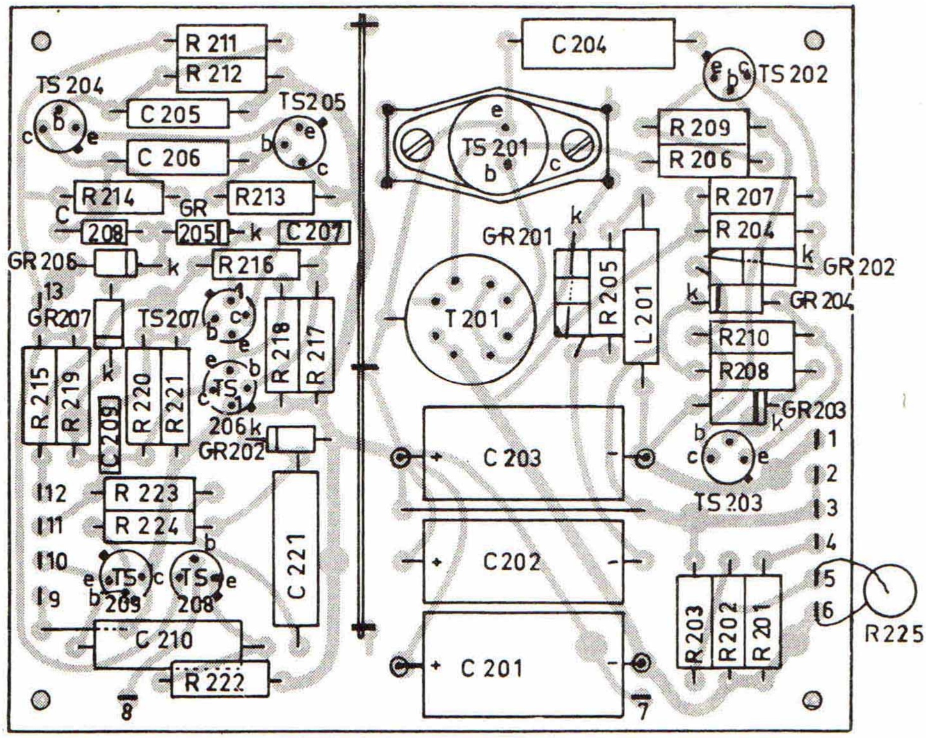
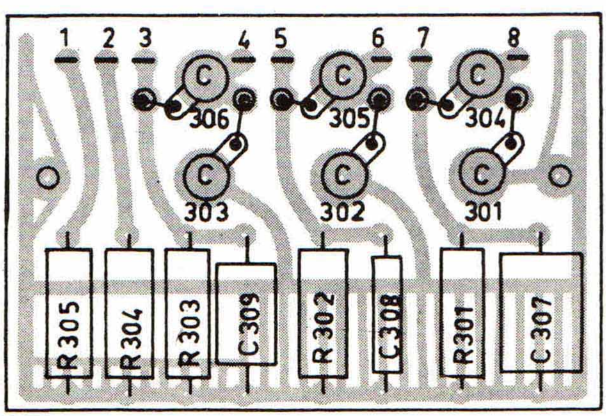


Fig. 14. Printed wiring board U1 with push-button switch



PEM 2177

Fig. 15. Printed wiring board U2



PEM 2178

Fig. 16. Printed wiring board U3

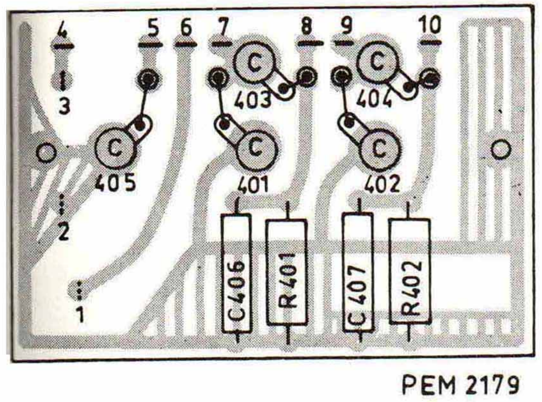


Fig. 17. Printed wiring board U4

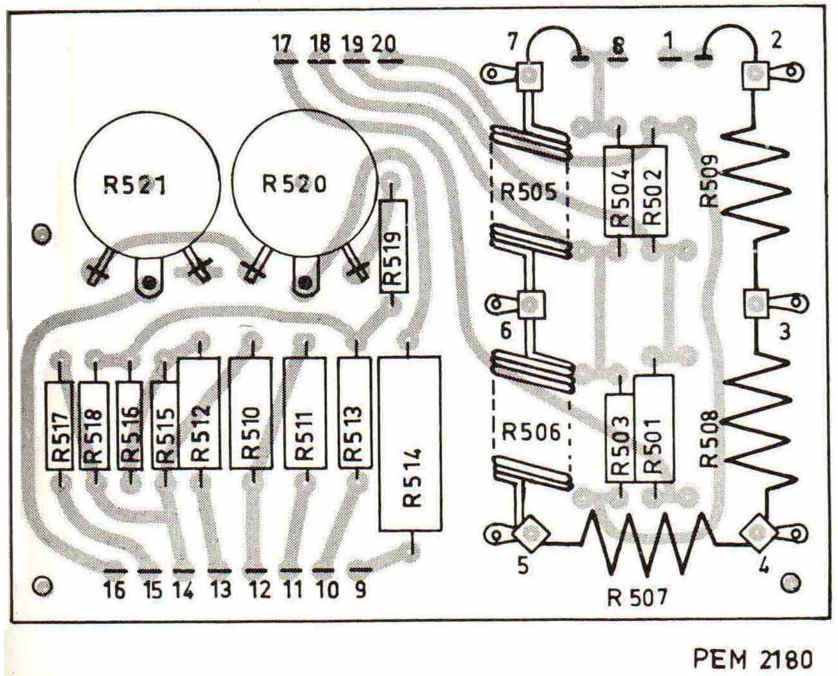


Fig. 18. Printed wiring board U5

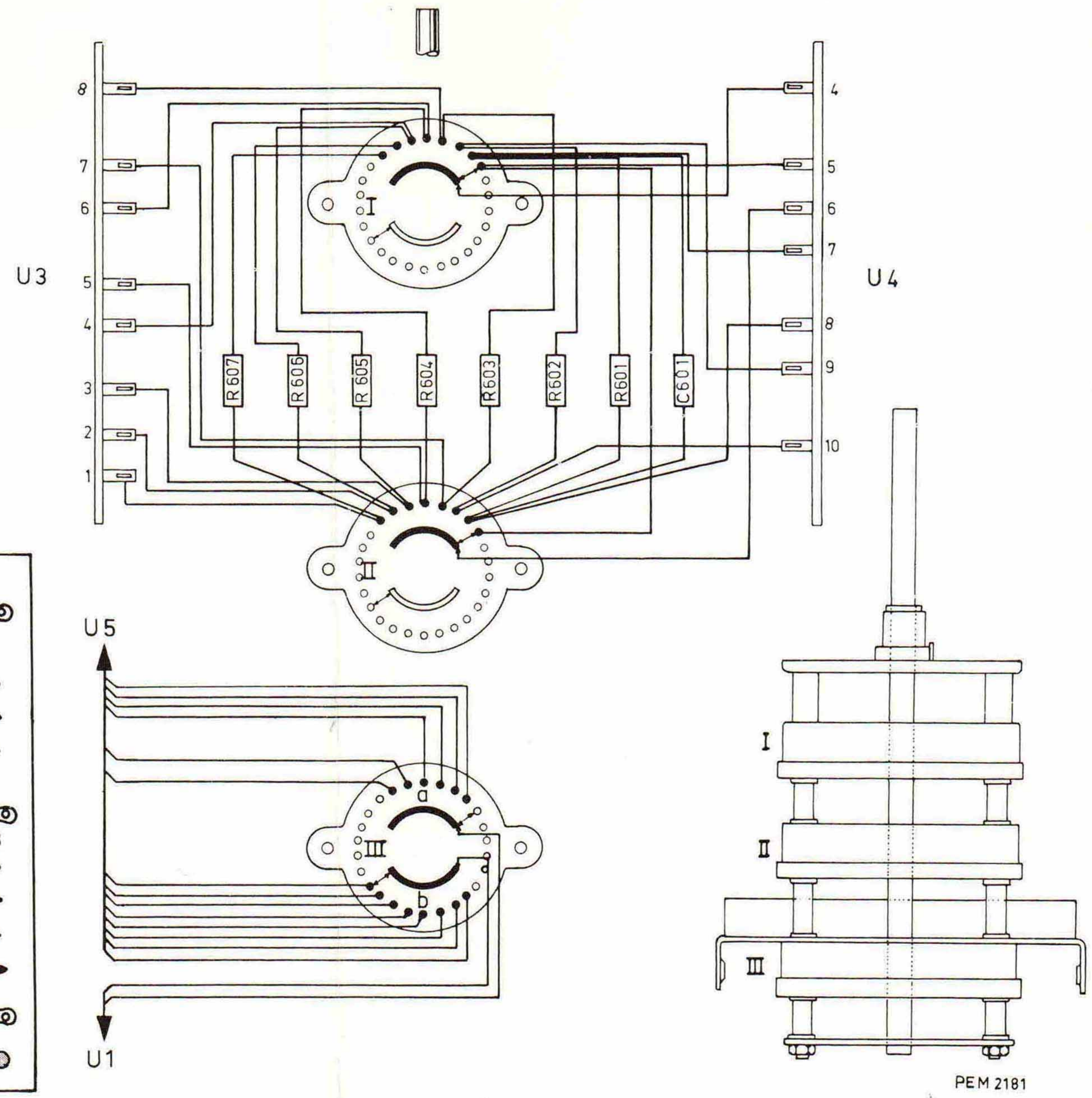
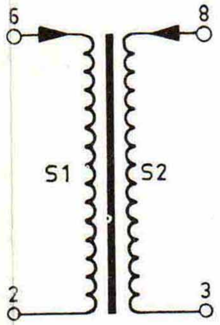


Fig. 19. Switch SK1



Code	S1	S2
Turns	73.5	9.5

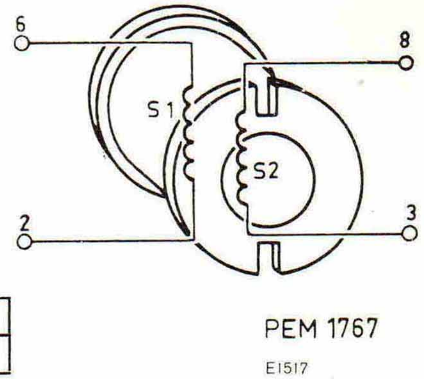


Fig. 20. Transformer T201

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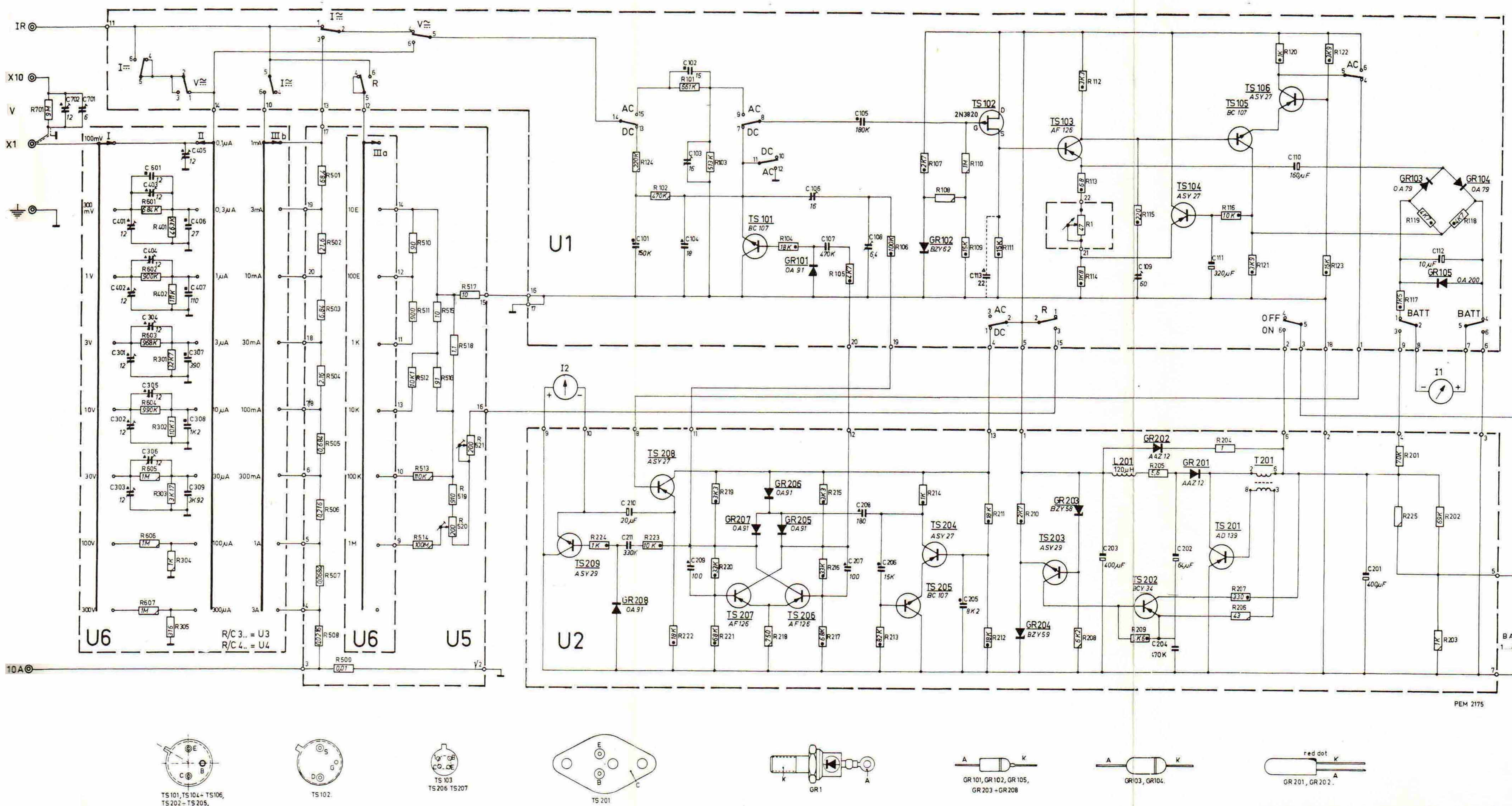

For 2 N 3820 (TS102) read 2 N 4360

Fig. 21. Circuit diagram

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