Technical data

III

Properties expressed in numerical values with tolerances stated are guaranteed by the manufacturer. Numerical values without tolerances represent the properties of an average instrument and merely serve as a guide.

Voltage measurements

Full measuring range	10 μV...1000 V (f.s.d.)
With probe GM 6071	10 V...30 kV (6 ranges)
Ranges "mV" "V"	0.01...1000 (10 μV... 1 V) f.s.d. 0.01...1000 (10 mV...1000 V) f.s.d. (11 range steps)
Input resistance mV V	≥ 8 MΩ 100 MΩ ± 4%
With measuring probe GM 6071	1000 MΩ ± 5%
Measuring accuracy	10 μV range ± 3% higher ranges ± 1.5%
Measuring accuracy with probe	± 6%

Current measurements

Full measuring range	10 pA...1 A (f.s.d.)
Ranges "nA" "μA" "mA"	0.01...1000 (10 pA...1 μA) f.s.d. 0.01...1000 (10 nA...1 mA) f.s.d. 0.01...1000 (10 μA...1 A) f.s.d. (11 range steps)
Max. voltage drop	≤ 50 mV, in 1A range max. 100 mV
Measuring accuracy	10 pA-range ± 3% higher ranges ± 1.5%

Resistance measurements

Reciprocal scale	Initial value : 5 End value : 50

Full measuring range	5 kΩ...500 GΩ f.s.d.
Ranges "kΩ"	5 kΩ...500 MΩ f.s.d. (1/10 of it 5 GΩ)
"MΩ"	5 MΩ...500 GΩ f.s.d. (1/10 of it 5 TΩ)
Measuring accuracy	± 3% of conductance $\left(\frac{1}{R}\right)$

General data

Preliminary deflection	In the most sensitive ranges up to 0.1 ≤ 5% of f.s.d.
Polarity indication	Distinct indication at 3% of f.s.d.
Calibration	With internal calibration voltage of 10 mV ± 0.2% (not suitable for external calibration purposes)
Hum filter	An AC voltage (r.m.s. value) with a frequency of ≤ 50 Hz and an amplitude of 66 dB higher than f.s.d. causes an additional error of < 2%. (76 dB at peak to peak value)
Recorder output	Output voltage at f.s.d. ± 5V $\left\{\begin{array}{l}+3\%\\-0\%\end{array}\right.$ Maximum load: 5 mA Dynamic internal resistance: ≤ 5 Ω Rise time: 0.8 sec. (in the most sensitive ranges 2 secs) Overshoot: < 5%
DC-AC convertor	photo-chopper
Temperature range	For values specified: 5°...45° C with additional error of 1%: −10°C...50°C **Exception:** In position "V" a temperature coefficient of: + 0.7%/10 °C above 25 °C — 0.7%/10 °C below 25 °C should be taken into account
Long-term stability	After 1 hour warming up: in position "mV": ±3μV (non cumulative). In position "V": ±3mV

Max. permissible voltage	"V-range": 1200 V d.c., 800 V a.c. mV ranges from 0.01...30 mV: 250 V d.c. or a.c. 100 mV...1000 mV: 400 V d.c. or c.a.
Mains supply	Inverted guard system
Power supply	115 V or 230 V ± 15% Mains frequency: 50 or 60 Hz
Power consumption	approx. 6 W
Mechanical data	According to modular system, 3 modules Dimensions: Height: 180 mm Width: 217 mm Depth: 255 mm Weight: 5.6 kg

Accessories

IV

Mains lead
Measuring lead
Manual

OPTIONALLY AVAILABLE

HT probe GM 6071

This probe is suitable for measuring direct voltages up to 30 kV.
Maximum measuring error 6% (in conjuction with PM 2436)
Input resistance: 1000 MΩ

UHF probe PM 9200

This is suitable for measuring alternating voltages from 3 mV – 16 V.

Frequency response:	100 kHz – 1 MHz	± 10%
	1 MHz – 300 MHz	± 5%
	300 MHz – 800 MHz	± 10%

At frequencies above 30 MHz these tolerances only apply if T-connector PM 9250 is employed.
Max. permissible direct voltage on the probe: 450 V

Input capacitance:	2 pF
Input impedance at	1 MHz: 110 kΩ
	10 MHz: 80 kΩ
	50 MHz: 25 kΩ

T-connector PM 9250

Impedance:	50 Ω
Frequency response:	0.1...1000 MHz
Standing wave ratio:	for frequencies up to 800 MHz: 1.1
	for frequencies from 800...1000 MHz: 1.2

Fig. 2. HT measuring probe GM 6071

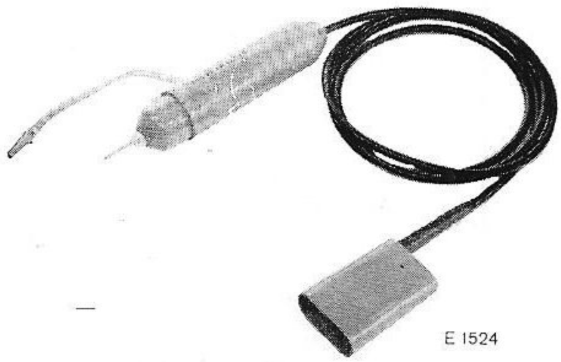


Fig. 3. UHF probe PM 9200

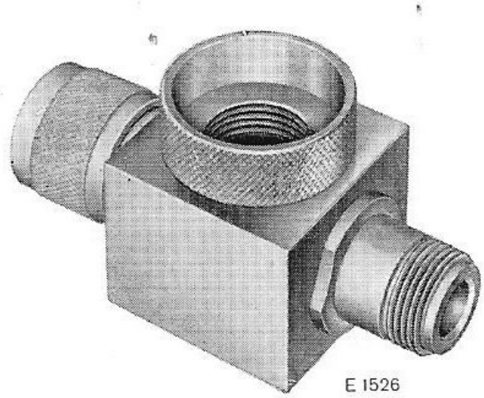


Fig. 4. UHF T-connector PM 9250

Operation

VI

1. Switching on

The PM 2436 has no mains switch, but only a switch "SECONDARY POWER ON" which is included in the secondary circuit. The instrument is switched on by means of this switch, after which the pilot lamp next to it will light up.

2. Calibration

The instrument can be calibrated by means of the internal calibration voltage cel.

- Place the instrument in a horizontal position and check the mechanical zero setting in the switched off condition.
  If the pointer is not at zero, readjustment is possible by means of the plastic screw below the meter.
- Switch on the instrument.
- Depress buttons "V/I" (SK3/IV) and "mV" (SK3/V).
- Set the range selector (SK4) to 0.01.
- Short-circuit sockets V "HI" and "LO" (BU4 and BU5).
- After a warming up time of approx. 5 minutes, set the pointer to zero by means of 0 control R1, by setting the pointer of the polarity indicator to mid-position (the exact mid-position corresponds to the position of the pointer when the instrument is switched off).
- Depress button "CAL" (SK3/VII).
- The pointer should now indicate exactly 100; in the case of deviations readjustment is possible by means of screwdriver control "CAL" (R2).

3. Measurements

Pre-selection of the desired mode is effected by depressing the relevant button, the ranges being divided by a factor 1000. The numbers on the range selector scale of SK4 correspond to the end-of-scale values of the pre-selected current, voltage or resistance ranges and at the same time form the multiplication factors for the range values selected by means of the buttons.

Example: Button "μA" depressed.

Range selector at position "10".
Indication: 60.
Result: μA. 10 = 10 μA (f.s.d.)
The indication 60 then corresponds to **6 μA**

or: Button "MΩ" depressed.
Range selector at position 5 K.
Indication: 10.
Result: MΩ . 5 K = 5 GΩ (f.s.d.)
The indication 10 then corresponds to **10 GΩ**.

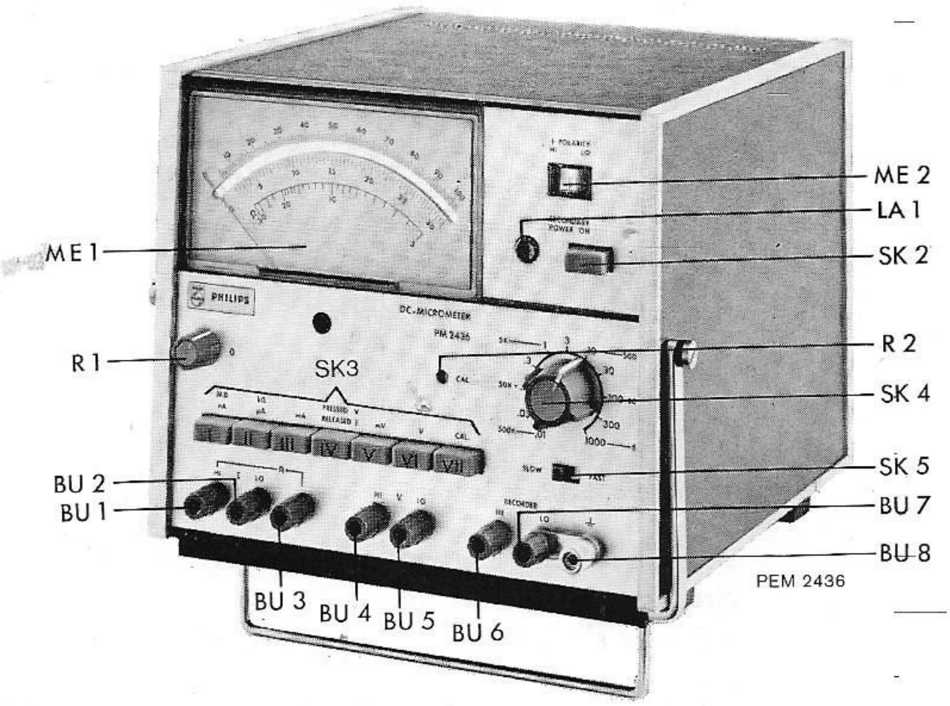


Fig. 6. Front view

A. DIRECT VOLTAGE

For direct voltage measurements buttons "V/I" (SK3/IV) and "mV" or "V" (SK3/V, or VI) should be depressed. The 11 measuring ranges of rotary switch SK4 cover the mV pre-selection range from 10 μV...1 V and the V pre-selection range from 10 mV...1000 V (full-scale deflection).

The measuring object should be connected to the sockets V "HI" and "LO" (BU4 and BU5). For sensitive measurements it should be observed that the potential which is closest to chassis potential is connected to socket "LO" (LOW). The hum filter exerts a damping of > 100 dB for 50 Hz alternating voltages. For other mains frequencies, e.g. 60 Hz, the filter should be modified according to the instructions given in chapter XI.10 "Checking and adjusting".

The polarity of the voltage measured is indicated by means of the polarity indicator, which indicates whether the plus-pole is connected to sockets HI or LO. As this indicator has a very high sensitivity, it is extremely suitable for zero adjustment of the instrument but also for null adjustments in compensation circuits and measuring bridges. The slightly instable zero indication in the most sensitive range is normal and is caused by amplifier noise.

In the case of measurements in the μV range special attention should be paid to the measuring set-up, in order to avoid external influences, which may cause considerable measuring errors. For this the following is recommended:

- Before each measurement, check the electrical zero setting, by short-circuiting the connection sockets at open measuring circuit and adjusting the pointer to minimum deflection by means of potentiometer R1.
- The connection leads should be kept as short as possible, or screened leads should be used.
- If required, screen the complete measuring set-up.
- Ensure that the insulation is correct.
- Make sure that the HIGH - LOW connection is correct.
- Connect the screenings to the housing or to LOW.
- Do not move or touch the measuring leads during the measurement (this will cause crackle or electrostatic charge displacements).
- Use switch "SLOW" when the indication is not stable.

H.T. measurement

For measuring direct voltages higher than 1000 V H.T. measuring probe GM 6071 should be employed. By means of this probe it is possible to measure voltages up to 30 kV. The probe should be connected to sockets V "HI" and "LO". For the further data reference is made to the specification of the measuring probe.

UHF voltage

By means of UHF probe PM 9200 it is possible to measure UHF voltages from 3 mV...16 V in a frequency range of 100 kHz...800 MHz. For measurements to co-axial leads T-connector PM 9250 can be employed (impedance 50 Ω).
The UHF probe may be connected to sockets V, "HI" and "LO". For further data concerning UHF probe PM 9200 and T connector PM 9250 reference is made to the relevant manuals.

B. DIRECT CURRENT

For this measuring mode, sockets I "HI" and "LO" (BU1 and BU2) can be used. Similar to voltage measurements, the pole closest to earthing potential should be connected to socket "LO" (LOW) in the case of direct current measurements to sensitive circuits.
The polarity indicator indicates whether the positive pole is connected to HI or LO.
The nA, μA or mA ranges can be pre-selected by means of push-buttons. The three ranges can then be further selected by means of range selector SK4:

nA: 10 pA...1 μA
μA: 10 nA...1 mA
mA: 10 μA...1 A
(full scale deflection)

As regards the measuring set-up for small currents, the same precautions apply as for voltage measurements (see under A).

C. RESISTANCE MEASUREMENT

Resistance values are basically determined in the same way as currents. An internal –5 V voltage source is connected in series with the unknown resistance Rx. By means of the internal source, resistances (Rx) from 5 kΩ to 5 TΩ (Tera Ohm) can be measured. When using a higher, external voltage it is possible to accurately measure higher resistances. For resistance measurements the test object should be connected to the sockets "Ω" (BU1 and BU3) which are marked with an interconnection line.

Pre-selection of the ohm ranges is effected by means of 2 push-buttons MΩ and kΩ, which at the same time represent the multiplication factor for the range steps selected with the rotary switch. The outer numbers (blue) on the range selector scale correspond to the digit 5 on the instrument scale. The following measuring ranges are then obtained for the pre-selected ranges MΩ and kΩ:

Button	*Switch position SK4 (example)*	*Measuring range at instrument*
kΩ	5	5 kΩ . . .50 kΩ
kΩ	500	500 kΩ . . . 5 MΩ
kΩ	500 K	500 MΩ . . . 5 GΩ
MΩ	5	5 MΩ . . .50 MΩ
MΩ	500	500 MΩ . . . 5 GΩ
MΩ	500 K	500 GΩ . . . 5 TΩ

Resistance values lower than 5 kΩ can be measured by means of an external series resistor R_v, connected according to Fig. 7.

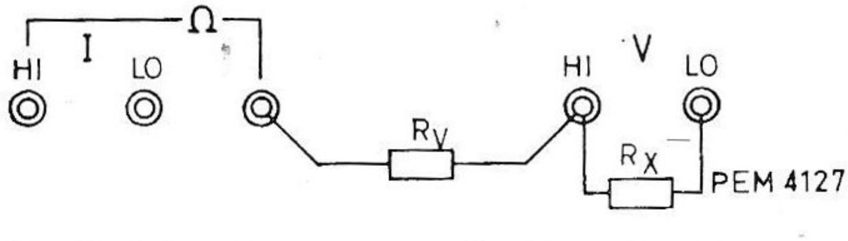


Fig. 7. Measuring resistance values lower than 5 kΩ

For this measurement the measuring value should not be read from the ohm scale but from scale 0...30 or 0...100, while buttons "V/I" and "mV" should be depressed.

Measuring range (f.s.d.)	*Switch positions SK4*	*Series resistor Rv*
1 kΩ ... 30 kΩ	1 ... 30	5 MΩ
10 Ω ... 300 Ω	1 ... 30	50 kΩ
1 Ω ... 30 Ω	1 ... 30	5 kΩ

The measuring accuracy when using external series resistors is the same as for voltage measurements with an additional error dependent on the tolerance of the series resistor used.

D. LEAKAGE CURRENT MEASUREMENTS OF SEMI-CONDUCTORS

The internal –5 V voltage permits of measuring the leakage current I_0 of semi-conductors ($I \leq 1$ mA; I max. approx 2 mA).

Connection (Fig. 8):

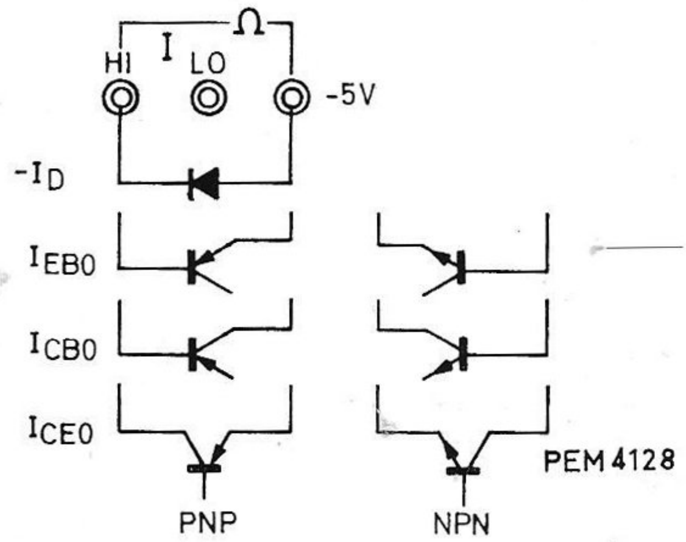


Fig. 8. Measuring the leakage current of semi-conductors

Measurement:

- Depress button nA, μA or mA and select the appropriate measuring range by means of switch SK4. Direct reading of the leakage current I_0 is possible.
- At very small leakage currents short or screened connection leads should be employed. Static charges will give rise to measuring errors; do not touch the measuring set-up!

– With open measuring circuit check the electrical zero setting and readjust it, if required (adjust the pointer of the polarity indicator to mid-position).

E. MEASURING THE THRESHOLD VOLTAGE OR BREAKDOWN VOLTAGE OF SEMI-CONDUCTORS

The internal –5 V voltage source is also suitable for measuring the threshold voltage V_D of diodes and transistors, up to a maximum value of 5 V.

Before connecting the semi-conductor under test, a protection resistor R_v should be connected for current limitation, according to Fig. 9.

Resistance value of R_v, e.g. for	1 mA	=	5 kΩ
	100 μA	=	50 kΩ
	1 μA	=	5 MΩ

Connection:

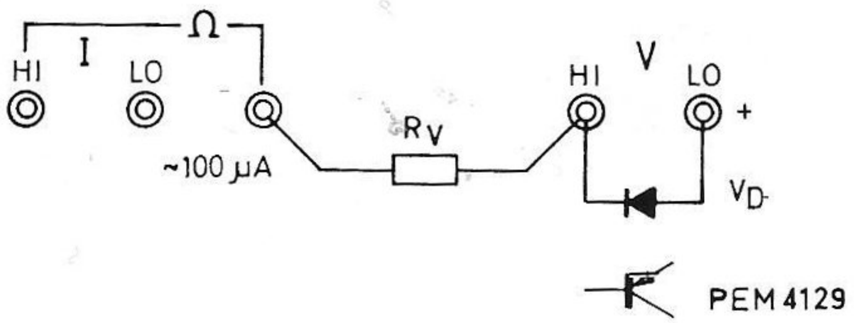


Fig. 9. Measuring the threshold voltage or breakdown voltage of semi-conductors

Measurement:

– Depress buttons "I/V" and "V" and select the appropriate measuring range, e.g. 1, by means of the range selector.

– The instrument gives a direct reading of the threshold voltage or breakdown voltage V_D.

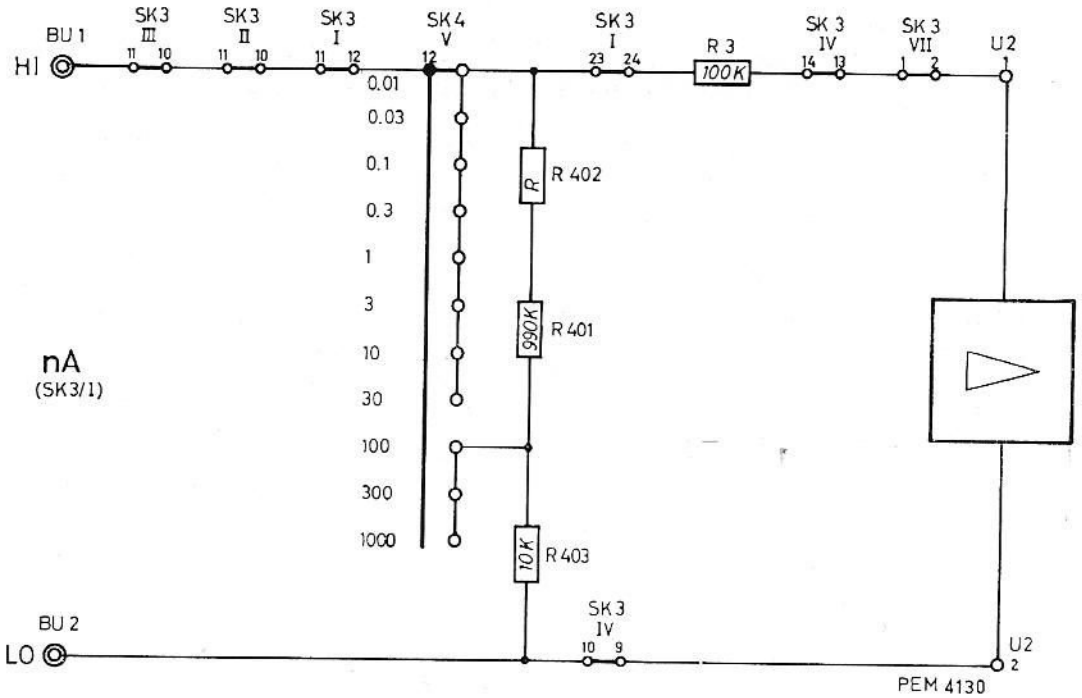


Fig. 10. Input circuit for nA, μ A and mA ranges

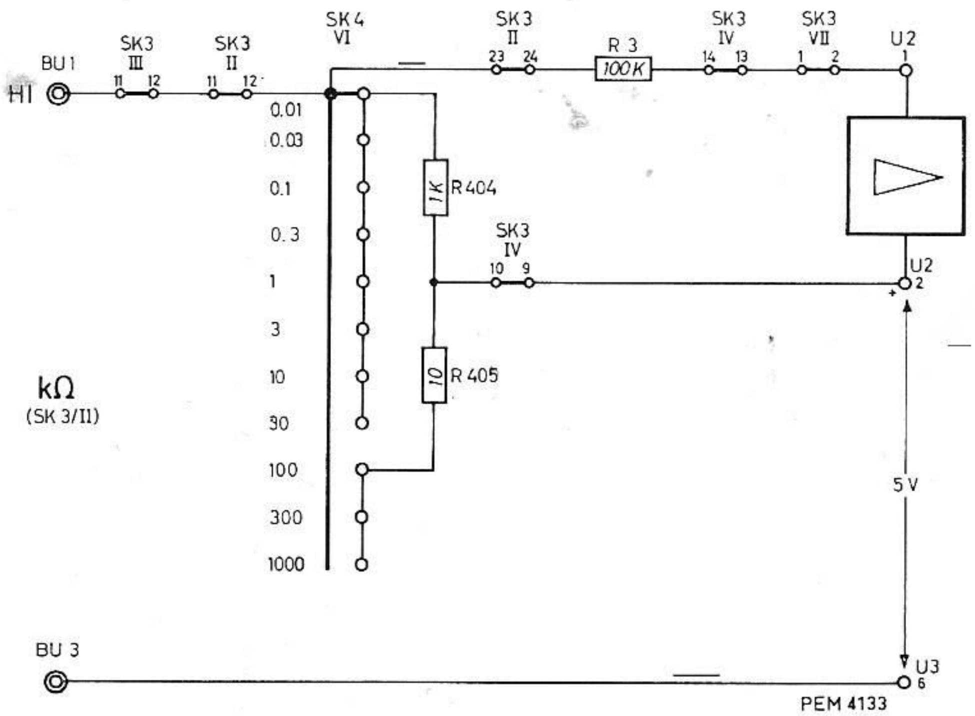
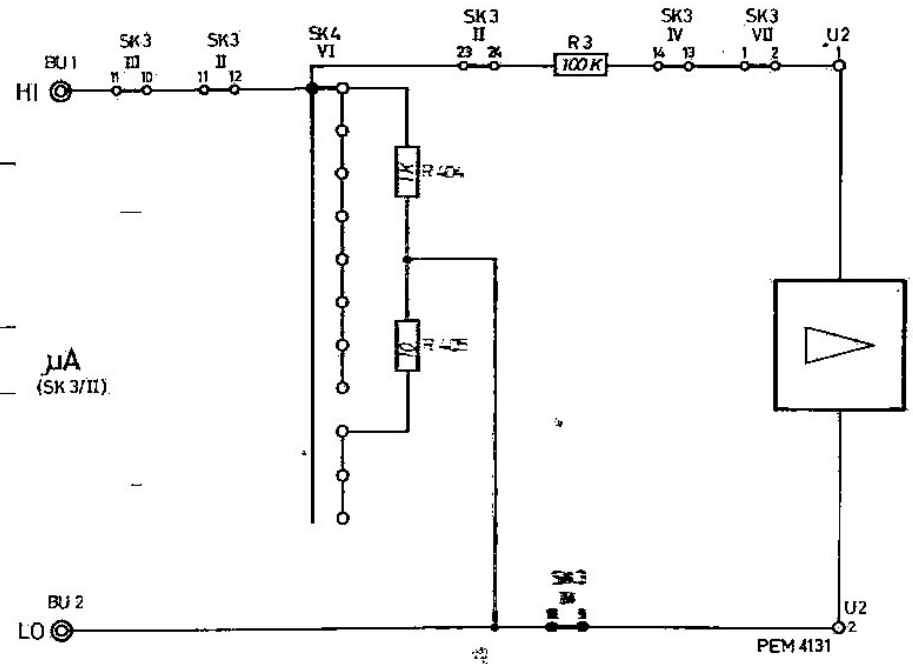
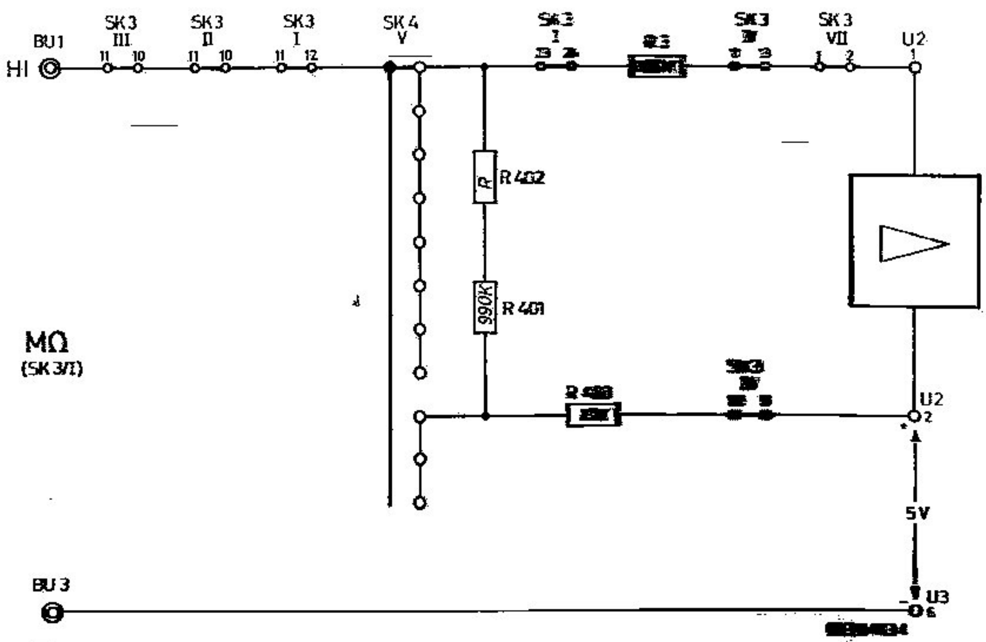
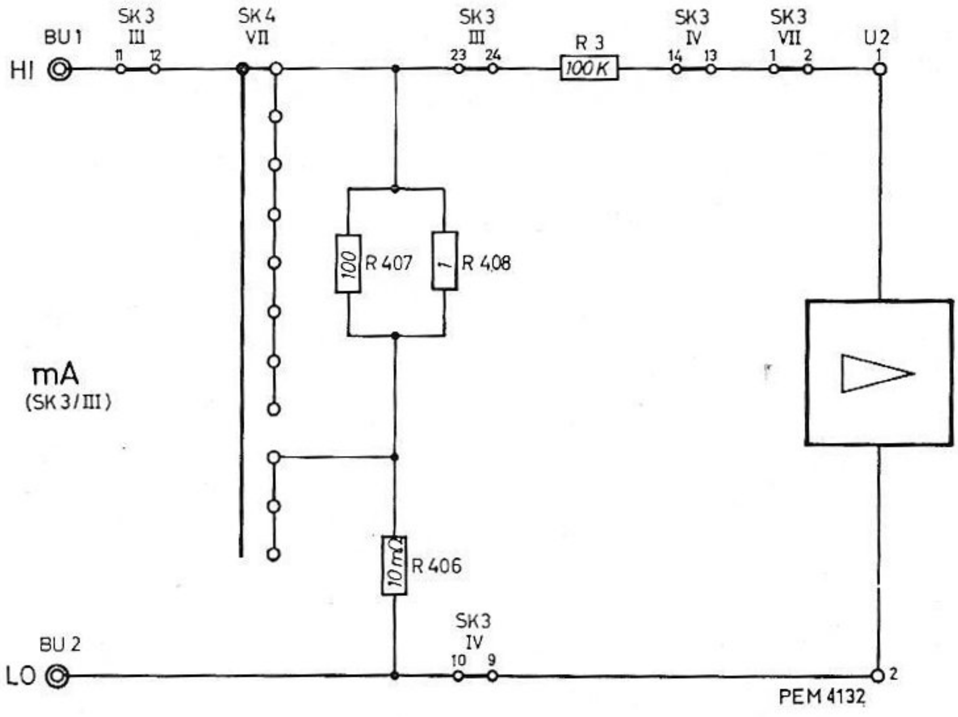


Fig. 12. Input circuit for kΩ and MΩ ranges


BU 1
HI
SK3 III 11 10
SK3 II 11 12
SK4 VI
SK3 II 23 24
R 3
100 K
SK3 IV 14 13
SK3 VII 1 2
U2 1
1K
R 404
10
R 405
µA
(SK 3/II)
BU 2
LO
SK3
U2 2
PEM 4131


BU1
HI
SK3 III 11 10
SK3 II 11 10
SK3 I 11 12
SK 4 V
SK3 I
SK3 VII 1 2
U2 1
R
R 402
990K
R 401
MΩ
(SK 3/I)
R 400
U2 2
5V
BU 3
U3 6


BU 1
HI
SK 3
III
11 12
SK 4
VII
SK 3
III
23 24
R 3
100 K
SK 3
IV
14 13
SK 3
VII
1 2
U 2
1
100
R 407
1
R 408
mA
(SK 3/III)
10 mΩ
R 406
SK 3
IV
10 9
BU 2
LO
2
PEM 4132

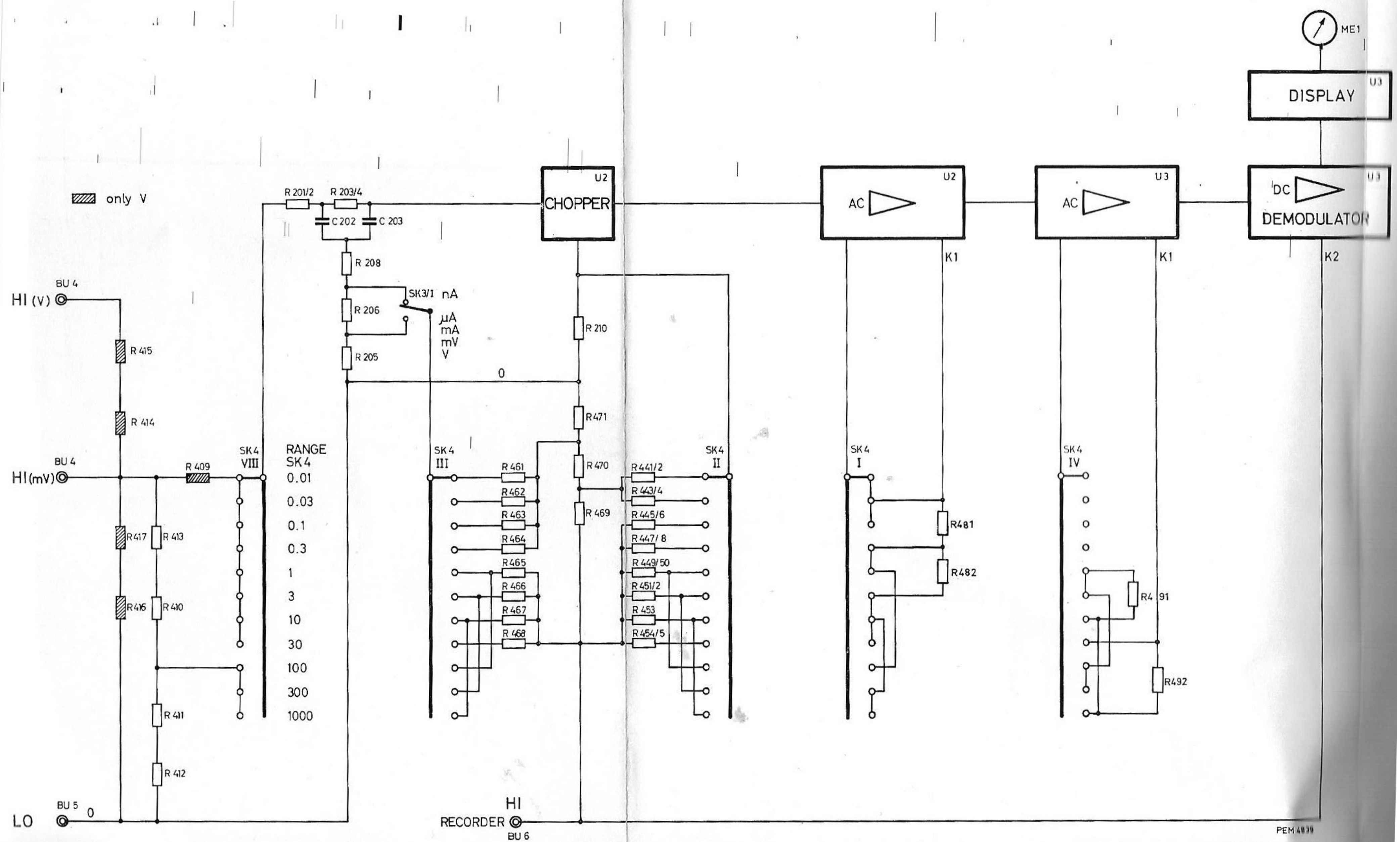


Fig. 11. Input circuit for mV and V ranges

For the mV ranges the input circuit is connected direct, this applies to all ranges from 0.01...30; this is followed by a division in the ratio $\frac{1}{100}$ for the range steps 100, 300, and 1000.

The following table gives the gain factors of the a.c. amplifiers together with the measuring ranges.

Range	*AC I*	*AC II*	
0.01	660	550	± 10%
0.03	660	500	± 10%
0.1	660	500	± 10%
0.3	200	500	± 10%
1	200	166	± 10%
3	66	166	± 10%
10	66	50	± 10%
30	66	16.6	± 10%
100	200	166	± 10%
300	66	166	± 10%
1000	66	50	

From the d.c. amplifier a negative d.c. feedback voltage is applied to the chopper, which varies in accordance with the range. The feedback circuit is determined by switch wafer SK4/II.

B. INPUT FILTER

Between the input attenuator and the amplifier input a hum filter is included, which consists of RC element R201/C202 and the shunted T-filter R202/C203, R205...R208, R203, R204/C204. The damping exerted by the input filter is ≥ 100 dB (at 50 Hz or 60 Hz).

The damping at 50 Hz is adjusted by means of R204. Resistor R208 is proportioned so that the damping is adapted to 60 Hz when this resistor is shorted out.

To reduce the rise time of the filter the d.c. output voltage of the filter is fed back to R206. As a result a voltage is obtained at C203 and C204, which has the same polarity as the input voltage. The voltage difference will consequently become smaller so that the rise time is reduced. The feedback voltage is reduced by resistance divider R461...R468 and R206 (nA/μA, mA, mV, V) in accordance with the measuring range selected (see Fig. 12).

Neon lamp B201 as well as diodes GR201/GR202 serve for protection against excess voltages at the input.

C. AC AMPLIFIERS AND DEMODULATOR

First AC amplifier (U2)

The test signal from the range selector is fed to the filter, and from the filter to the chopper. The latter converts the d.c. signal into an alternating voltage which is applied to the input stage of the amplifier via C205 and R228.

The first of the three amplifier stages TS201...TS203 consists of a transistor having a high gain factor (BC109 C), followed by two other amplifier stages. TS204 is circuited as an emitterfollower and functions as impedance matching. The degree of negative feedback of the a.c. amplifier is determined by the resistance ratio of R218/R217 and R215, R481 and R482. C208 serves for separating the d.c. potential or for decoupling the a.c. feedback voltage.

Depending on the measuring range, R481 and R482 in the feedback circuit are switched-in giving three different gain factors (see table for the gain factors together with the measuring ranges).

R219 and C210 forms a filter for the suppression of hum voltages.

Second AC amplifier (U3)

The output signal from the first a.c. amplifier on U2 is capacitively coupled to difference amplifier TS301/TS302 via C211. This difference amplifier, in conjunction with TS303 and TS304, has the same function as that in the first a.c. amplifier. In the ranges 0.01, 0.03, 0.1 and 0.3 the amplification factor is 500. Resistors R309 and R311 determine the basic degree of feedback and at higher measuring ranges the feedback is varied by means of R491 and R492 via connection points U3/12 and U3/14.

RC element R344/C301 forms a negative feedback branch for TS303 to prevent parasitic oscillations.

Demodulator (Fig. 13)

The demodulator converts the a.c. signal into a d.c. voltage. Chopper and demodulator drive is effected synchronously from T101 by a 120 V, 50 Hz signal. This results in phase-selective rectification. The zener diodes serve for keeping the base currents for switching transistors TS305 and TS306 constant.

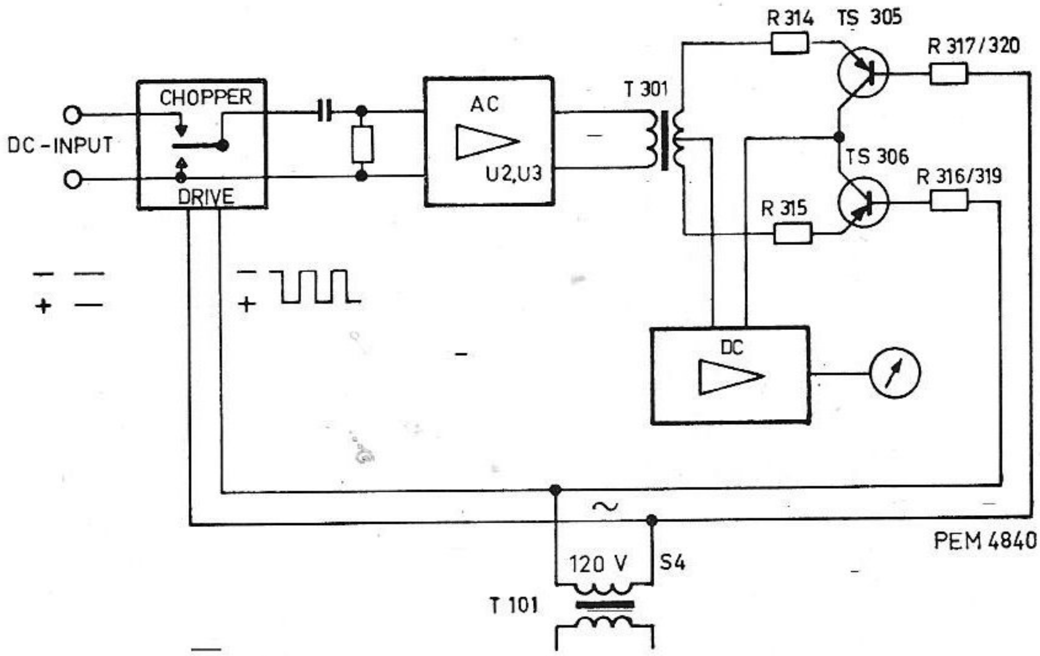


Fig. 13. Demodulator

The alternating voltage on T301 is alternately rectified and blocked by TS305 and TS306.

This results in a direct voltage at the output with the same polarity as the input voltage.

D. DC AMPLIFIER

The demodulated direct voltage is first applied to the difference amplifier consisting of TS309 and TS310. Via R342 and R343 part of this voltage is applied to the base of TS309 for biasing this transistor. The second d.c. amplifier stage is formed by another difference amplifier (TS311/TS312). TS313 amplifies the d.c. signal in the third stage. Negative feedback across the complete d.c. amplifier circuit is effected via R356/C311...C313.

The recorder output potential across U3/4-5 and 0 serves as negative feedback voltage for the complete amplifier circuit.

E. INDICATING CIRCUIT

To obtain polarity independent pointer deflection, transistors TS314 and TS315 are arranged so, that the pointer always deflects to the right (Fig. 14).

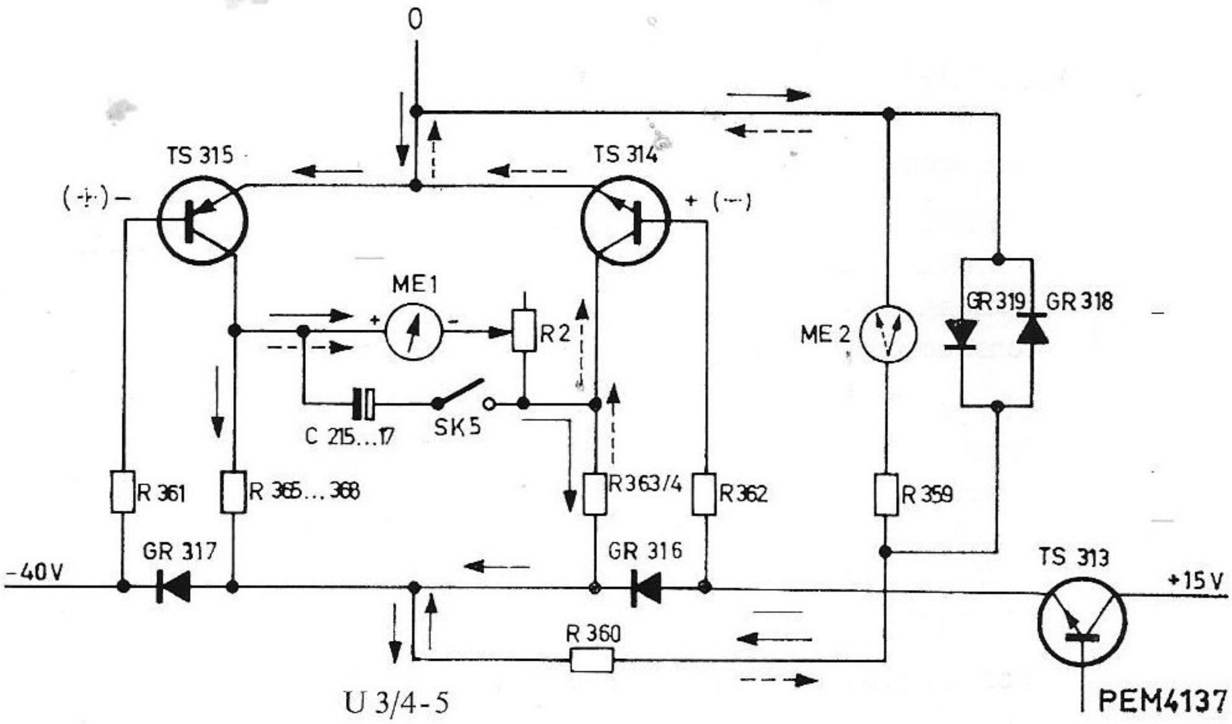


Fig. 14. Indicating circuit

Diodes GR316 and GR317 provide a biasing voltage for the base emitter junctions of the two transistors.
When, for instance, point U3/4-5 is positive with respect to 0 (Fig. 14), TS314 is on and TS315 is cut off; as a result there will be a current to "0" via R365-368, + ME1, — ME1, R2, TS314 and also via R363, R364 and TS314. If point U 3/4-5 is negative, TS314 will be off and TS315 is conductive; the current will then flow from "0" to "—" via TS315, + ME1, — ME1, R2, R363, R364 and via TS315, R365-368 to "—".

Resistors R367/R368 serve for balancing the meter current. By means of potentiometer R2 the instrument can be adjusted to nominal value of the calibration voltage.

Capacitors C315...C317 exert a damping on the meter, and can be switched on by means of SK5 in the case of a strongly fluctuating measuring voltage.

The output voltage on point U3/4-5 also serves for controlling polarity indicator ME2. This indicator is connected to this voltage via series resistors R359/R360 (overload protection by GR318, GR319).

F. POWER SUPPLY

1. Mains transformer

The mains transformer has been designed according to the "INVERTED GUARD" system. This system has the same advantages as the GUARD versions. The "INVERTED GUARD" system, however, has several constructional advantages.

The primary winding is electrically and mechanically isolated from the secondary side. By separately screening the primary winding, earthing currents in the primary section, which is connected to mains earth, can flow off. The capacitance between the primary and secondary windings is very low due to this construction, so that the measuring earth (instrument housing) is not affected by the mains circuit.

For the proper working of the instrument, however, it is important that all screenings are correctly connected. Therefore, special attention should be paid to the correct connection of various points in the case of disassembly.

Important:
The safety earth of the mains is connected to the primary housing, but **not** to the instrument housing.

In order to permit connection to 110-145 V and 200-245 V mains, the mains transformer has been provided with two primary windings S1 + S2, which can be connected in series or in parallel by means of switch SK1. The two secondary windings S3 and S4 can be disconnected by means of switch SK2.

2. Voltage stabilising

Mains transformer T101 supplies an alternating voltage of approx. 41 V to Grätz rectifier GR310. C307 serves for smoothing the direct voltage. The control circuit with TS307 stabilises the output current as follows (Fig. 15):
The base-emitter voltage of TS307 is determined by voltage divider R323, GR309 and R326, the reference voltage being supplied by zener diode GR309 (V_2). The constant current flows via the collector-emitter junction of TS307 and via R322. If the voltage on C307 increases, this rise is followed by control voltage V_{BE}, and the current remains constant.

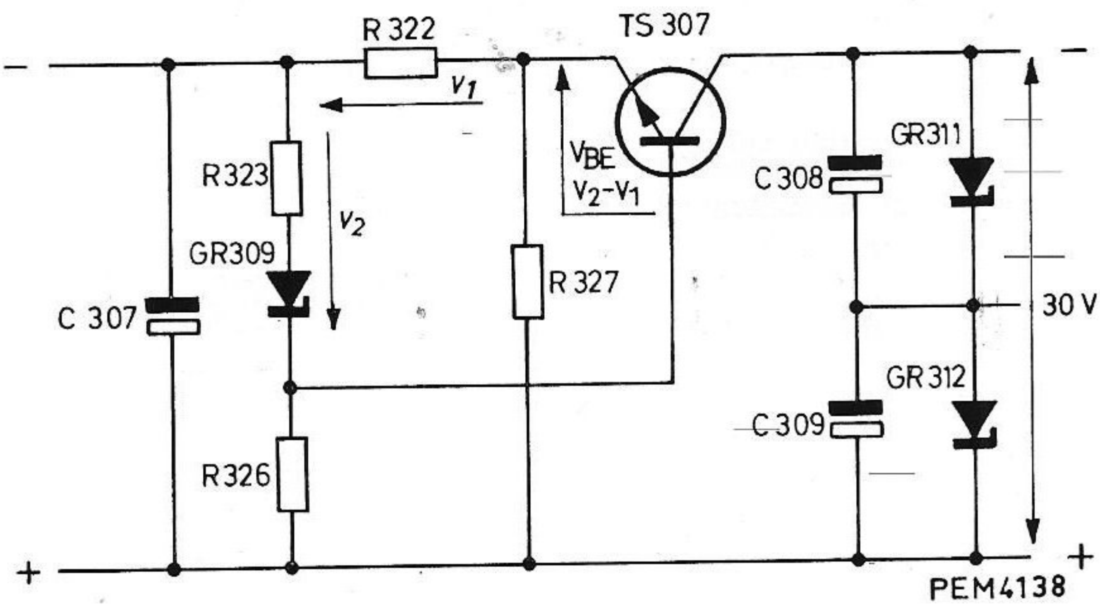


Fig. 15. Control circuit

R322 and R327 have been proportioned so that max. hum suppression is obtained.

The 30-V output voltage is divided into two voltages of 15 V by zener diodes GR311 and GR312, and smoothed by C308 and C309. Further stabilisation is effected by means of resistors R324/R325 and zener diodes GR313/GR314. This voltage serves for obtaining the reference voltage for difference amplifier TS309/TS310 and is determined by voltage divider R345...R348 and R342/R343.
Voltage divider R332...R335 supplies a voltage for zero adjustment, which can be carried out by means of dual potentiometer R1.
The —15 V and + 15 V voltages (with respect to 0) serve for supplying the amplifier circuits.

3. —5 V voltage

This voltage is derived from the 24 V supply voltage (9 V + 15 V). TS308 serves as series regulator in the voltage divider and stabilises the voltage at 5 V. Voltage divider R338...341 supplies the reference voltage for TS308.

Stabilisation

At zero load the emitter current of TS308 will not exceed approx. 3 mA. The output voltage of —5 V remains practically constant for currents < 3 mA. At higher loads the base emitter voltage decreases and cuts off the transistor. On account of this the circuit is short-circuit proof.

4. Calibration voltage (U2)

For the calibration of the amplifier an accurate calibration voltage is necessary. This voltage is supplied by a mercury cell BA1. Resistors R223...R227 form a voltage divider. For adjustment to exact 10 mV resistors R225 and R226 are used.

Gaining access to the parts

1. Removing the cabinet

Top cover

Turn the bayonet screws at the rear of the instrument a quarter turn and slide off the cover in backward direction.

Side panels

Remove the two screws of the carrying handle, remove the bracket. The plates which are fitted in the chassis at the rear, should be lifted out slightly at the front and can then be pulled out.

Bottom plate

Remove the two screws at the rear of the instrument and slide the plate backwards.
Before this the tilting bracket should be removed. This can be done by compressing it slightly and taking it out of the holder.

2. Printed circuit boards U2 and U3

U2

- Remove the bottom and side plates.
- Remove the two screws "A" (Fig. 16) and take out the lower screening plate. The wiring side of the printed circuit board is now accessible.

For the component side:

- Pull out the chopper, after releasing the clamping bracket.
- Remove the 4 screws "B" (Fig. 16).
- The printed circuit board can now be hinged out (remove the other screening half).

U3

- Remove the top plate.
- Remove the 4 fixing screws of the printed circuit board.
- The printed circuit board can now be hinged out.

3. Mains transformer U1

- Remove the side plates and the top plate.
- Remove mains fuse VL1.
- Remove the 4 screws "C" (Fig. 5).
- The complete unit can now be taken out of the instrument at the left.
- The covers can be lifted off by means of a screwdriver. Before unsoldering the connection wires, they should be marked.

Caution! The screenings should never be interchanged.

4. Moving-coil instrument ME1

- Remove all cabinet plates.
- Remove the two ornamental frames (loosen the screws in the rearmost feet).
- Remove the 4 fixing screws of printed circuit board U3.
- Remove the reinforcement piece by loosening the 2 screws "D" (Figs. 17 and 18).
- Remove the 4 screws "E" (Figs. 17, 18).
- The upper front section with meter ME1, SK1, LA1, and ME2 can now be slightly lifted up and tilted forward (if necessary, remove the Philips emblem or press the text plate forward).
- Unsolder the connection wires at the meter.
  Caution! The meter housing is sensitive to heat!
- Remove the 3 fixing screws by means of which the meter is secured to the chassis plate.

5. Attenuator unit U4

- Remove the side plates and the top plate.
- Remove screws "F" (Fig. 18).
- Remove the switch knob, by first removing the knob cap and loosening the nut of the clamping cone.
- Loosen the central fixing nut of the switch.
- The complete attenuator unit can now be pulled backwards and taken out sideways.

6. Push-button switch SK2

- Remove the side plates and the top plate.
- Remove printed circuit board U3.
- Unsolder the connection wires at SK2 (note the wire colours)
- Loosen the fixing screws and take out the switch.

7. Push-button switch SK3

- Remove the side plates and the top plate.
- Note the wire colours of the connection wires (e.g. on Fig. 28).
- Unsolder the wires.
- Remove the two fixing screws at the side and remove the push-button assembly.

8. Pilot lamp LA1

- Remove the top plate.
- Slide the plastic holder **forward**, e.g., with the aid of a screwdriver.
- The lamp now protrudes from the instrument and can be easily replaced.
- Push back the lamp together with the holder as far as the stop.

9. Lower text plate

- Remove all the cabinet plates.
- Unsolder all the connection wires at the sockets and remove the sockets.
- Remove the two knobs (remove the caps and loosen the nuts of the clamping cones).
- Loosen the fixing screws D, E, G and H at the sides. (Figs. 17 and 18)
- Remove 2 screws at one side of printed circuit boards U2 and U3.
- The two side frames can now be slightly pressed apart, so that the text plate can be removed. The plate is cemented onto the chassis plate (by means of Sprey cement no. 77 of 3M).

10. Upper text plate

- Remove all the cabinet plates.
- Remove the right-hand ornamental frame.
- The upper text plate should now be carefully detached with the aid of a knife as it is cemented onto the chassis (by means of Sprey cement no. 77 of 3M).

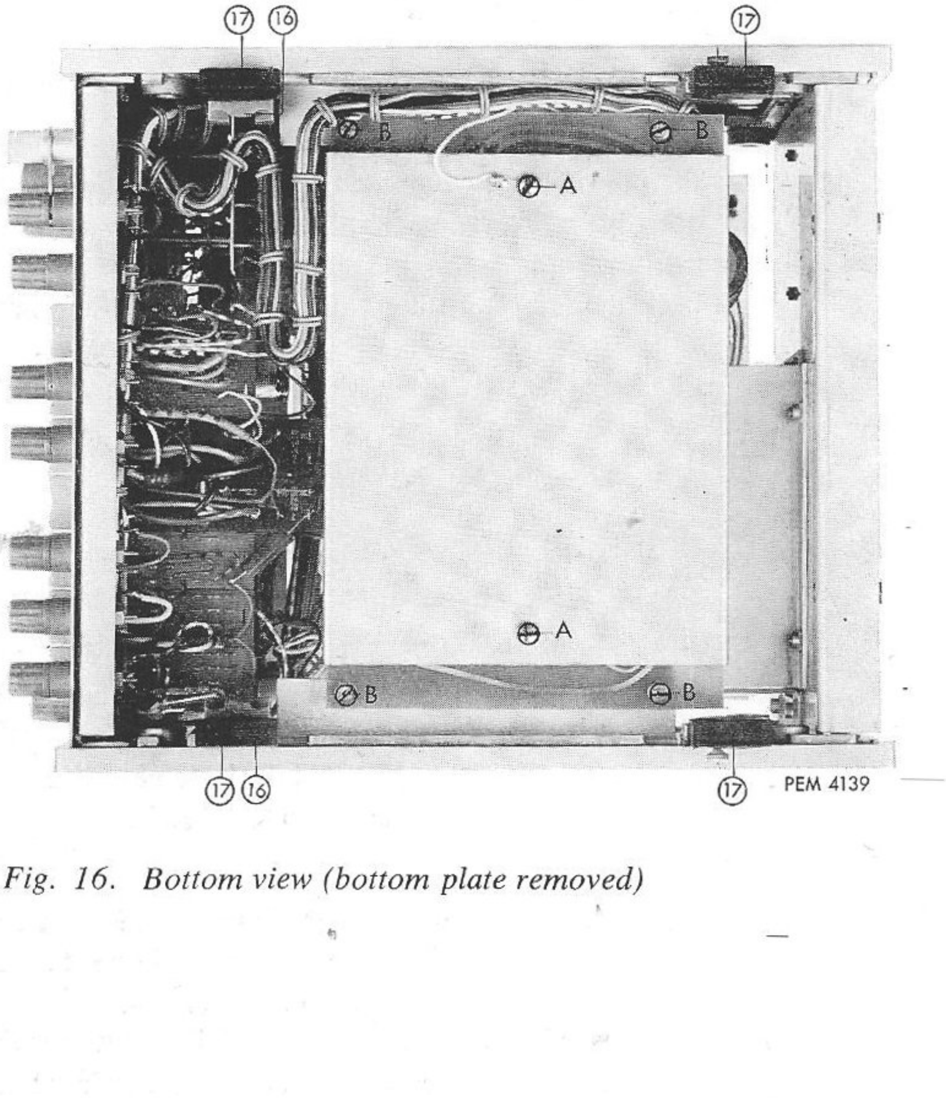


Fig. 16. Bottom view (bottom plate removed)

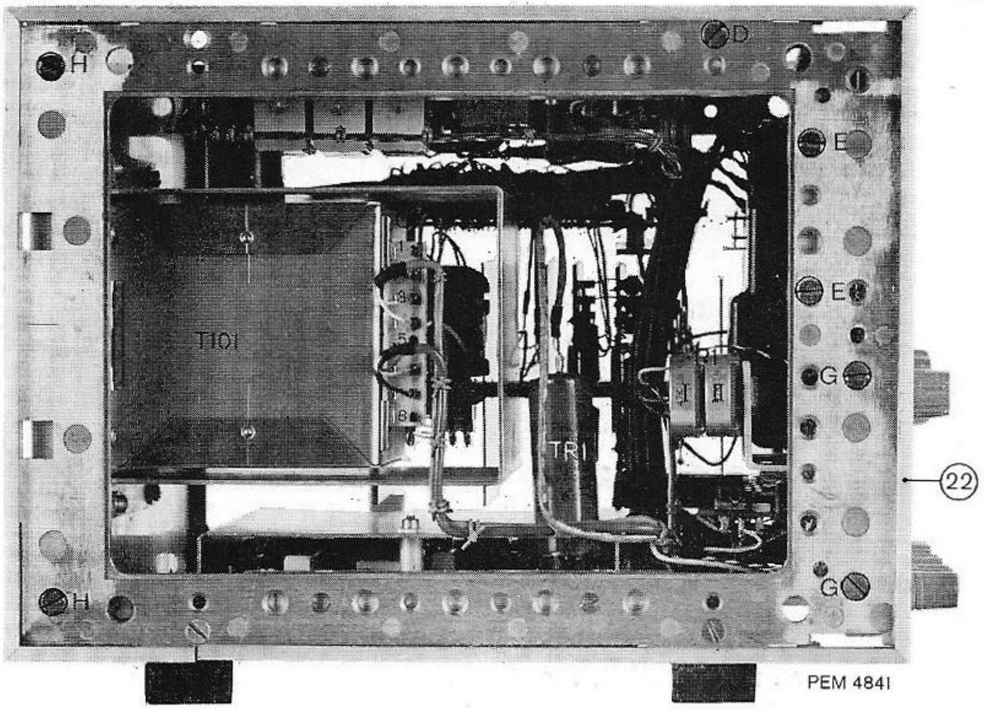


Fig. 17. Left-hand side

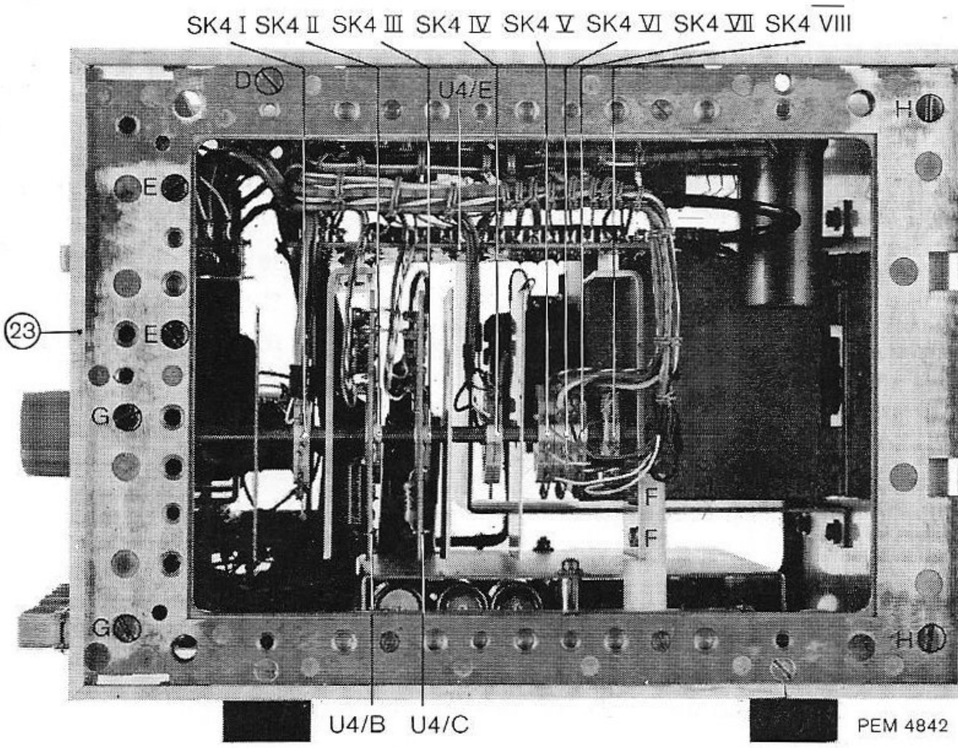


Fig. 18. Right-hand side

Maintenance

IX

The maintenance of this fully transistorised instrument is restricted to the stators of the rotary switch and the push-button mechanism.

If required, the switch spindle bearings and the movable mechanical parts of the push-button switches may be lubricated lightly with thin oil (sewing machine oil). For the stators it is advisable to use Molycote grease.
In the case of poor contact, the switch contacts should only be treated with the special switch oil (ordering number, see list of mechanical parts).

To ensure reliable and proper working, the instrument should be protected against dust, moisture and heat.

Service hints

Due to the very high degree of feedback in the complete amplifier circuit the effective input voltage at the amplifier will be only 0.5% of the voltage before the chopper. Therefore it is practically impossible to display the signal of a closed amplifier circuit with the aid of an oscilloscope.

Only in the 30 mV range (in that case the signal voltage is approx. 150 μV at 30 mV input voltage) or if the polarity of the voltage to be measured is reversed, the signal can be displayed weakly, e.g. on point 9 or 11 of U3.

When the gain factor of the individual stages has to be checked or if other checks have to be made, it is recommended to remove the chopper and to apply a signal ($\leq$ 1 mV) of approx. 60 Hz to the socket of TR1, point 7. This signal can then be followed properly through the individual amplifier stages.

The connections of the chopper drive should not be interchanged; otherwise this will cause full-scale deflection at the meter (recorder output approx. 10 V).

Survey of adjusting elements

X

Checking and adjusting should be effected in accordance with the instructions of chapter XI "Checking and adjusting".

Adjusting element	*Fig.*	*Adjustment*	*Required auxiliary equipment*	*Chapter XI, point . . .*
		Mains supply	Variable transformer for 230 V. Multimeter P 817 00 or PM 2411	2
R338, R339	26	–5 V-voltage	resistor 5 kΩ ± 1%	3
R345, R346	26	Zero setting d.c. amplifier	DC voltmeter PM 2430	4
R367, R368	26	Symmetry adjustment	Direct voltage source 100 mV	5
R225, R227	28	Reference voltage "CAL"	Reference voltage 10 mV ± 0.1%	6
R412	26	"mV" voltage ranges	Reference voltage 100 mV ± 0.1%	7a
R417	26	"V" voltage ranges	Reference voltage 10 V ± 0.1%	7b
R402	26	"nA" current ranges	Direct voltage source 1.01 V ± 0.1% Direct voltage source 110 mV ±0.1% Digital voltmeter PM 2433 Metal film resistor 100 MΩ ± 0.1% Metal film resistor 10 MΩ ± 0.1%	8
R204	29	Hum filter	Variable isolating transformer Resistor: 4K2 Capacitors: 150 K – 2 × 270K LF voltmeter PM 2452	9

Checking and adjusting

The tolerances in the following description only apply to a completely readjusted instrument and may therefore deviate from the values specified in chapter III.
The following adjustments may only be effected if auxiliary equipment with the required specification is available.

1. Mechanical zero setting

With the instrument switchend off, check whether the mechanical zero setting of the pointer is correct. Deviations can be adjusted by means of the correction screw. For this adjustment the instrument should be placed in a horizontal position.

2. Connection of the measuring instrument

For the following checks the measuring instrument should be supplied by the nominal mains voltage ± 5%, preferably via a variable transformer. The mains voltage should be checked by means of a voltmeter.

Current consumption	*Instrument switched on*	*No-load*
at 110 V	58 mA	12 mA
at 230 V	30 mA	6 mA

3. —5 V voltage

Measuring circuit: Fig. 19.

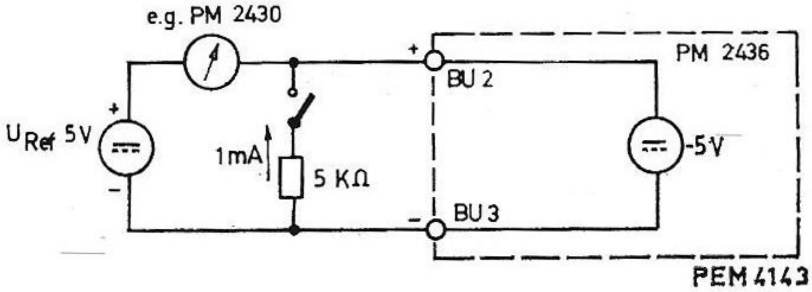


Fig. 19. Adjusting the –5 V voltage

Adjustment:

Adjustment of the –5 V voltage is effected by means of resistors R333 and R339.
Tolerance –5 V: ± 5 mV
This voltage and its tolerance should also be maintained at a 1 mA load. For this purpose a 5 kΩ resistor (± 1%) should be connected to BU2 and BU3.

4. Adjustment of the DC amplifier

- Short-circuit the demodulator input, by interconnecting points U3/9 and U3/10 (remove jumper U3/9-U3/11).
- Connect a mV meter, e.g. PM 2430, to sockets BU6 and BU7.
- Adjust the voltage to ≤ 300 mV with R345 and R346.
- Remove jumper U3/9-U3/10 and interconnect U3/9 and U3/11.

5. Symmetry adjustment

For this adjustment the pointer deflection should be adjusted to exactly the same value at different polarity of the input signal.

Adjustment:

- Effect zero setting with the aid of R1.
- Depress buttons "I/V" and "mV" (SK3/IV and V).
- Set range selector SK4 to 10.
- Apply a 10 mV voltage to BU4 and BU5, + pole to HI.
- Set the pointer exactly to 100 with the aid of potentiometer "CAL" (R2).
- Reverse the polarity of the input voltage.
- Adjust the pointer to exactly 100 with the aid of R367 and R368.
- Check that the pointer deflection is exactly the same at different polarity of the input voltage.
- Calibrate the instrument ("CAL").

6. Reference voltage "CAL"

Required reference voltage: 10 mV ± 0.1%.
- Effect zero setting with the aid of R1.
- Apply a reference voltage of 10 mV ± 0.1% to BU4 and BU5.
- Depress buttons "V/I" and "mV" (SK3/IV and SK3/V).
- Set range selector SK4 to 10.

- Adjust the pointer exactly to 100 with the aid of potentiometer "CAL" (R2).
- Depress button "CAL" (SK3/VII).
- Adjust the pointer exactly to 100 with the aid of R225 and R226.
- Repeat this check by comparing the internal reference voltage with the external reference voltage.

7. Adjustment of the voltage ranges

a. mV range

- Effect zero adjustment (R1).
- Effect "CAL" adjustment (R2) with the aid of a screwdriver.
- Depress buttons "V/I" (SK3/IV) and "mV" (SK3/V).
- Set range selector SK4 at 1000.
- Apply a voltage of 1 V ± 0.1% to BU4 and BU5.
- Adjust the pointer exactly to 100 with the aid of R412.
- Check the polarity by reversing the polarity of the input voltage.

b. V range

- Effect zero adjustment (R1).
- Effect "CAL" adjustment (R2) with the aid of a screwdriver.
- Depress buttons "V/I" (SK3/IV) and "V" (SK3/VI).
- Set range selector SK4 to 10.
- Apply a voltage of 10 V ± 0.1% to BU4 and BU5.
- Adjust the pointer exactly to 100 with the aid of R417.
- Check the polarity by reversing the polarity of the input voltage.

8. Adjustment of the nA current ranges

Measuring circuit: Fig. 20.

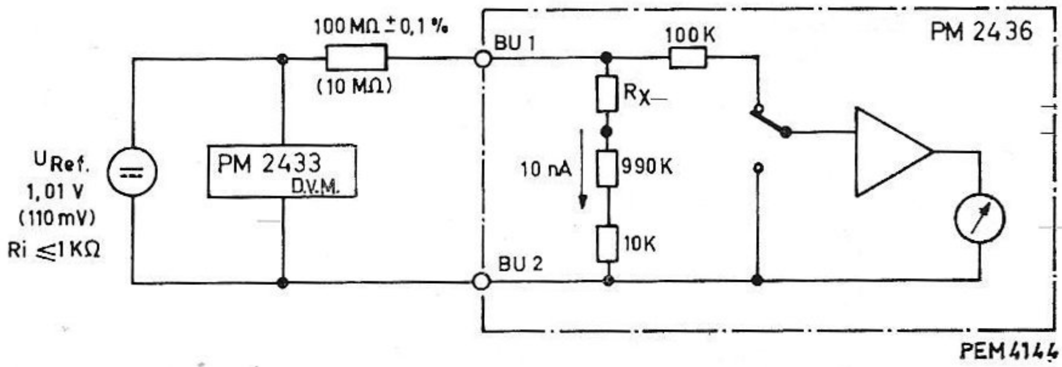


Fig. 20. Measuring circuit for adjusting the nA current ranges

- Adjust the zero setting.
- Effect "CAL" adjustment.
- Depress button "nA".
- Set range selector SK4 to 10.
- Apply a reference voltage of 1.01 V ± 1%.
- This adjustment can also be effected with the aid of a 10 MΩ resistor. The reference voltage should then be 110 mV (check with the aid of digital voltmeter).
- Adjust the pointer exactly to 100 with R402.

9. Adjusting the hum filter

Adjustment is effected with the aid of R204 at a frequency of 50 Hz. Damping ≥ 100 dB.
When the measuring instrument operates at 60 Hz, resistor R208 should be shunted. The damping of ≥ 100 dB will then shift towards 60 Hz.

Measuring circuit: Fig. 21.

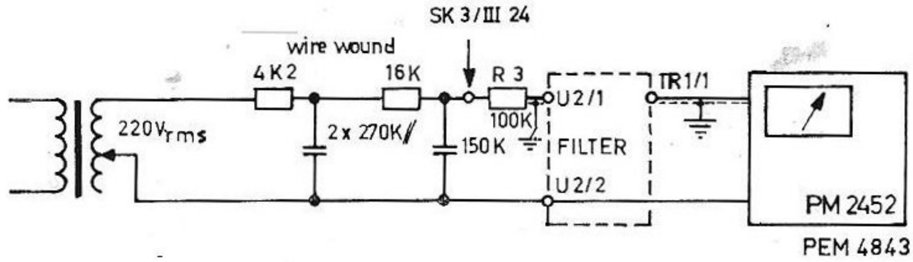


Fig. 21. Measuring circuit for adjusting the hum filter

For supplying the filter a filtered 50 Hz voltage of 100 Vr.m.s. is required. This voltage is obtained with the aid of a variable isolating transformer. The two filters should be connected according to connection diagram, Fig. 21.

Adjustment:

- The supply voltage should be applied to point 24 of SK3/III (resistor R3) and point 2 of U2.
- None of the buttons should be depressed.
- Remove chopper TR1.
- Connect an a.c. millivoltmeter (e.g. PM 2452 or PM 2451) to connection point 1 of chopper TR1 and point 2 of U2.

– Replace R204 by a resistance decade (earth the housing of the decade!) and determine the value at which the millivoltmeter indicates minimum voltage (voltage approx. 0.4 mV).
– Fit a resistor of this value for R204.

10. Checking the current ranges

a. mA and μA ranges:

Measuring circuit Fig. 22.

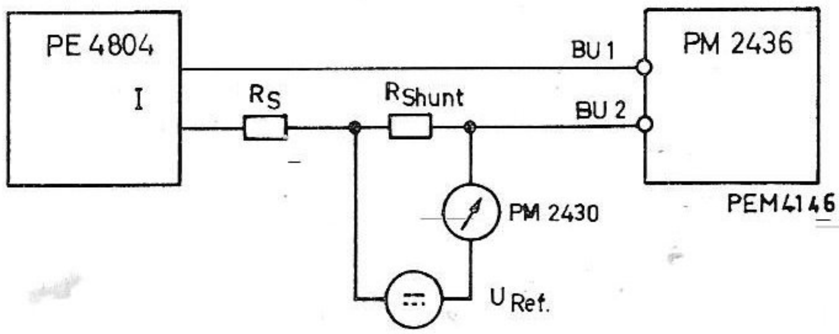


Fig. 22. Measuring circuit for checking the mA and μA current ranges

Current source I = 1A, e.g. PE 4804 with series resistor R_s
Reference voltage: 1 V ± 0.1%.
R shunt: Resistance decade ± 0.1%.
Null indicator: e.g. PM 2430.
Deflection of the meter: 100 ± 1 scale division.

Check the following ranges:

Button SK3	*Range SK4*	*R Shunt (Resistance decade)*	$U_{Ref.}$
mA	1000	1 Ω ± 0.1% Manganin wire	1 V ± 0.1%
mA	10	100 Ω ± 0.1%	1 V ± 0.1%
μA	1000	1 kΩ ± 0.1%	1 V ± 0.1%
μA	10	100 kΩ ± 0.1%	1 V ± 0.1%

b. nA Ranges

Measuring circuit: Fig. 23.

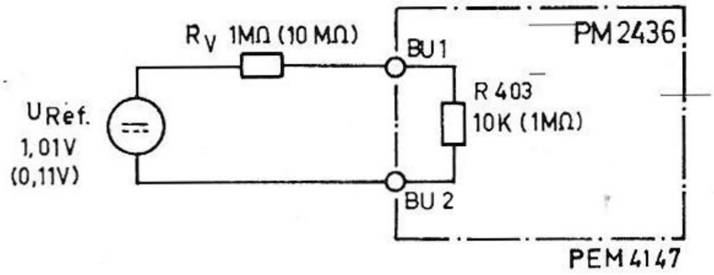


Fig. 23. Measuring circuit for checking the nA current ranges

1000 nA Range:

- Reference voltage source: 1.01 V ± 0.1%.
- Series resistor R_v: 1 MΩ ± 0.1%.
- Carry out zero adjustment and CAL adjustment.
- Connection: to BU1 and BU2.
- Depress button "nA".
- Set the range selector to 1000 (Ri = 10 kΩ).
- The instrument should give a deflection of 100 ± 1 scale division (1000 nA).
- Revers the polarity and check the indication.

10 nA Range:

- Reference voltage source: 0.11 V ± 0.1%.
- Series resistor R_v: 10 MΩ ± 0.1%.
- Carry out zero adjustment and CAL adjustment.
- Connection: to BU1 and BU2.
- Button "nA" depressed.
- Set the range selector to 10 (Ri = 1 MΩ).
- The meter should indicate 100 ± 1 scale division (10 nA).
- Reverse the polarity and check the indication.

11. Checking the voltage ranges

a. mV ranges

Measuring circuit: Fig. 24.

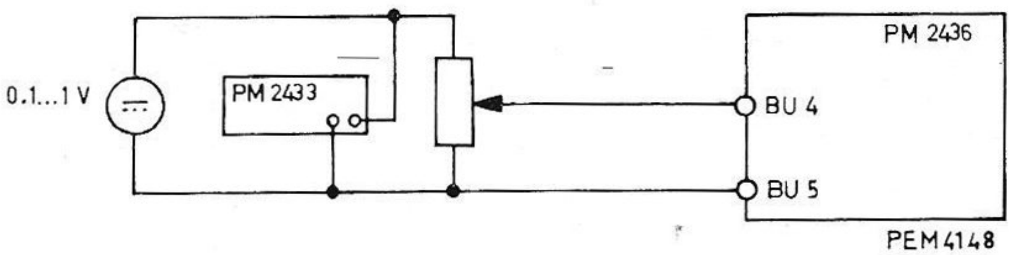


Fig. 24. Measuring circuit for checking the mV voltage ranges

Direct voltage source 0.1 V...1 V.
Digital voltmeter, e.g. PM 2433.
Precision voltage divider 1000 : 1 (± 0.1%).

- Make the measuring arrangement of Fig. 25.
- Set the direct voltage source to exactly 1000 mV.
- Check this with the digital voltmeter.
- Carry out zero adjustment and CAL adjustment.
- Apply the input voltage to BU4 and BU5.
- Depress buttons "V/I" (SK3/IV) and "mV" (SK3/V).
- Reverse the polarity.
- Check the following ranges of SK4:
  1000, 300, 100, 30, 10, 3 1.
- Carry out zero adjustment and CAL adjustment.
- Adjust the direct voltage source to exactly 100 mV.
- Check the following ranges of SK4:
  1; 0.3; 0.1; 0.03; 0.01.
  In the lowest range the indication is no longer stable due to amplifier noise, if required, change over to "SLOW".
- Reverse the polarity.

b. V-Ranges

After all the ranges have been checked in position mV (SK3/V). checking only one range is sufficient (e.g. 10 V range).

- Set the voltage source to 10 V ± 0.1% and check with the aid of the digital voltmeter.
- Depress buttons "V/I" (SK3/IV) and "V" (SK3/VI).
- Apply the voltage to BU4 and BU5.
- Set the range selector to 10.
- The meter should indicate 100 ± 1 scale division.

12. Checking the ohm ranges

For checking the ohm ranges only one measurement is necessary, as all the other ranges have been checked when checking the nA and μA current ranges. This check should be effected at the 5 kΩ range because in this case the current is largest (1 mA).

- Depress button kΩ (SK3/II).
- Set the range selector to 5.
- Connect a resistor of 5 kΩ ± 0.1% to BU1 and BU3.
- The meter should indicate 5 (ohm scale) or 100 ± 1 scale division.

13. Checking the recorder output

- Apply a voltage of e.g. 1 V to BU4 and BU5 (+ to BU4).
- Connect a digital voltmeter to BU6 and BU7.
- Connect a load resistor of 1 kΩ ± 5% in parallel with these sockets.
- When the meter indicates 100 the output voltage on BU6 should be +5 V ± 2%.
- Reverse the polarity of the input voltage.
  The output voltage on BU6 should now be –5 V ± 2%.

RESISTORS

No.	*Ordering number*	*Value*		*%*	*W*	*Description*
R1	4822 102 10032	2×47	kΩ			Dual potentiometer
R2	4822 103 20098	1.5	kΩ		3	Wire-wound potentiometer
R3	4822 116 50067	100	kΩ	1	0.25	Metal film
R201	4822 116 50067	100	kΩ	1	1	Metal film
R202	4822 116 50067	100	kΩ	1	0.25	Metal film
R203	4822 116 50275	130	kΩ	1	0.25	Metal film
R205	4822 116 50492	46.4	Ω	1	0.125	Metal film
R206	4822 116 50491	22.6	Ω	1	0.125	Metal film
R208	4822 116 50493	27.4	Ω	1	0.125	Metal film
R209	4822 116 50473	19.6	Ω	1	0.125	Metal film
R223	4822 116 50067	100	kΩ	1	0.125	Metal film
R224	4822 116 50226	787	Ω	1	0.125	Metal film
R228	4822 116 50463	10	kΩ	1	0.125	Metal film
R363	4822 116 50361	17.8	kΩ	1	0.125	Metal film
R365	4822 116 50361	17.8	kΩ	1	0.125	Metal film
R401	4822 116 50046	990	kΩ	0.5	0.25	Metal film
R403	4822 116 50276	10	kΩ	0.5	0.25	Metal film
R406	4822 115 80088	10	mΩ	0.1		Complete shunt
R409	4822 116 50067	100	kΩ	1	1	Metal film
R414	4822 111 40172	97	MΩ	2	1	Carbon
R442	4822 116 50022	1	MΩ	0.25	0.25	Metal film
R444	4822 116 50215	330	kΩ	0.25	0.25	Metal film
R446	4822 116 50022	1	MΩ	0.25	0.25	Metal film
R448	4822 116 50215	380	kΩ	0.25	0.25	Metal film
R450	4822 116 50067	100	kΩ	0.25	0.25	Metal film
R452	4822 116 50066	33	kΩ	0.25	0.25	Metal film
R453	4822 116 50276	10	kΩ	0.1	0.25	Metal film
R455	4822 116 50277	3.3	kΩ	0.25	0.25	Metal film
R469	4822 116 50495	2.2	kΩ	0.25	0.25	Metal film
R470	4822 116 50377	220	Ω	1	0.25	Metal film

CAPACITORS

No.	*Ordering number*	*Value*		*%*	*V*	*Description*
C201	4822 121 40061	0.22	μF	10	250	Polyester
C202	4822 121 40096	0.18	μF	10	100	Polyester
C203	4822 121 40217	0.82	μF	10	100	Polyester
C204	4822 121 40217	0.82	μF	10	100	Polyester
C205	4822 121 40171	0.022	μF	10	250	Polyester

No.	Ordering number			%	V	Description
C207	4822 121 40088	0.01	μF	10	250	Polyester
C208	4822 124 20402	320	μF		4	Electrolytic
C209	4822 124 20388	125	μF		16	Electrolytic
C210	4822 124 20388	125	μF		16	Electrolytic
C211	4822 121 40218	0.47	μF	10	100	Pdlyester
C212	4822 124 20417	1000	μF		4	Electrolytic
C213	4822 124 20417	1000	μF		4	Electrolytic
C214	4822 124 20417	1000	μF		4	Electrolytic
C303	4822 124 20413	640	μF		25	Electrolytic
C304	4822 124 20407	320	μF		4	Electrolytic
C307	4822 124 40055	250	μF		100	Electrolytic
C308	4822 124 20406	400	μF		16	Electrolytic
C309	4822 124 20406	400	μF		16	Electrolytic
C311	4822 121 40157	5.6	μF		100	Polyester
C312	4822 121 40157	5.6	μF		100	Polyester
C313	4822 121 40157	5.6	μF		100	Polyester
C314	4822 121 40089	0.015	μF	10	250	Polyester

MISCELLANEOUS

No.	Ordering number	Description
LA1	4822 134 20038	Neon lamp 100 V
B201	4822 134 20016	Neon lamp
VL1	4822 253 30006	Fuse 100 mA (delayed action) for 115 V
	4822 253 30003	Fuse 50 mA (delayed action) for 220 V
VL2	4822 252 20001	Thermal fuse
T1	4822 146 20331	Mains transformer
T301	4822 148 80012	LF transformer
U2	4822 216 70122	Printed circuit board, complete
U3	4822 216 70125	Printed circuit board, complete
U4/B	4822 216 70123	Switch wafer
U4/C	4822 216 70124	Switch wafer
U4/E	4822 216 70088	Printed circuit board
BA1		Mercury cell; Mallory, Type RM-625R

TRANSISTORS

No.	Ordering number	Type	
TS201	4822 130 40144	BC109 C	
TS202	4822 130 40239	BC109	
TS203	4822 130 40239	BC109	
TS204	4822 130 40184	BC107	
TS301	4822 130 40184	BC107	
TS302	4822 130 40184	BC107	
TS303	4822 130 40354	BC177	
TS304	4822 130 40184	BC107	
TS305	4822 130 40289	BCY32	
TS306	4822 130 40289	BCY32	
TS307	4822 130 40127	2N1613	
TS308	4822 130 40184	BC107	
TS309 / TS310	4822 130 40134	BCY55	Two silicon transistors in alumin[illegible] block
TS311	4822 130 40354	BC177	
TS312	4822 130 40354	BC177	
TS313	4822 130 40127	2N1613	
TS314	4822 130 40184	BC107	
TS315	4822 130 40354	BC177	

DIODES

No.	Ordering number	Type	
GR201	4822 130 30303	BAY32	
GR202	4822 130 30303	BAY32	
GR303	4822 130 30325	BZY94/C27	Zener
GR304	4822 130 30325	BZY94/C27	Zener
GR305	4822 130 30325	BZY94/C27	Zener
GR306	4822 130 30325	BZY94/C27	Zener
GR309	4822 130 30196	BZY60	Zener
GR310	4822 130 30279	BY123	Bridge rectifier
GR311	4822 130 30293	BZY88/C15	Zener
GR312	4822 130 30293	BZY88/C15	Zener
GR313	4822 130 30345	BZY63	Zener
GR314	4822 130 30345	BZY63	Zener
GR316	4822 130 30084	AAZ18	
GR317	4822 130 30084	AAZ18	
GR318	4822 130 30191	OA91	
GR319	4822 130 30191	OA91	

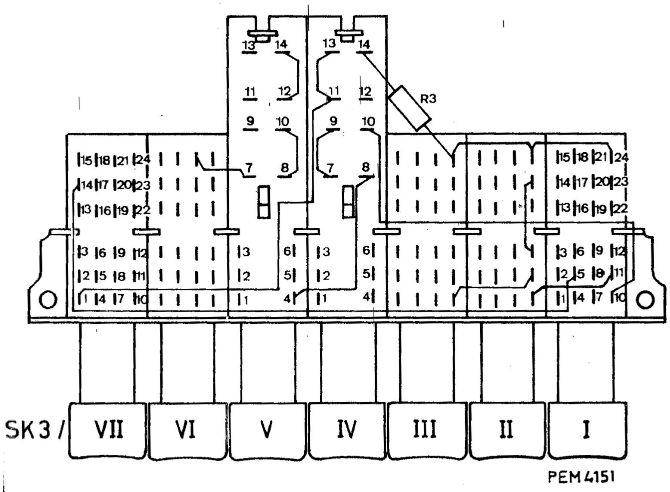


Fig. 28. Push-button switch SK3

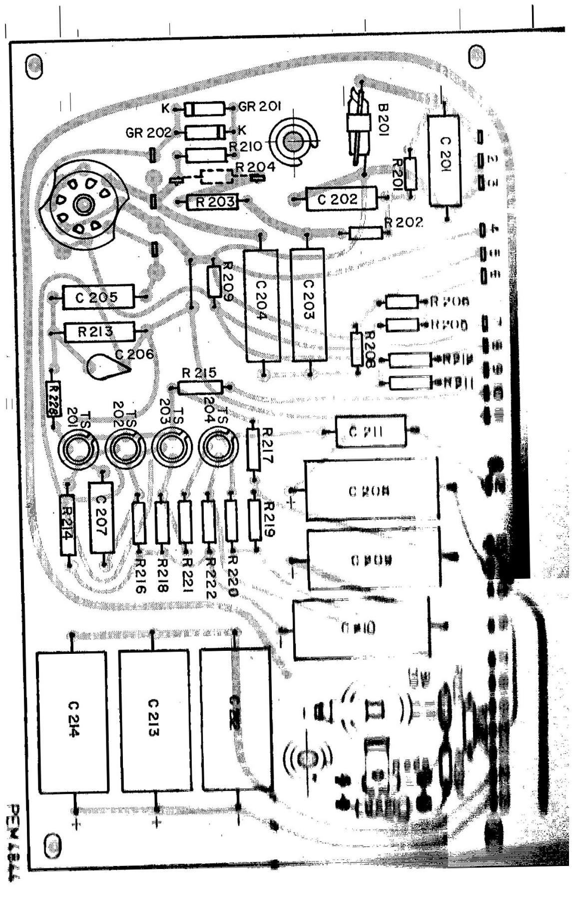


Fig. 29. Printed wiring board [illegible]

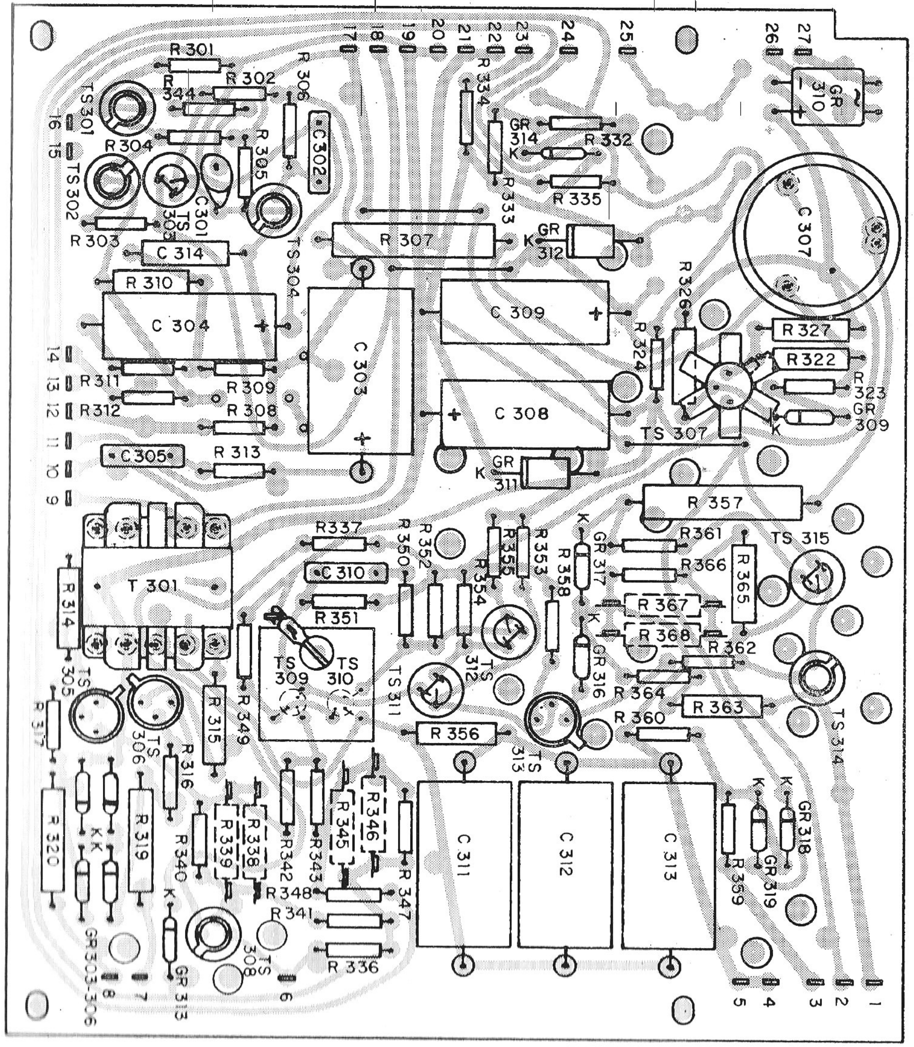
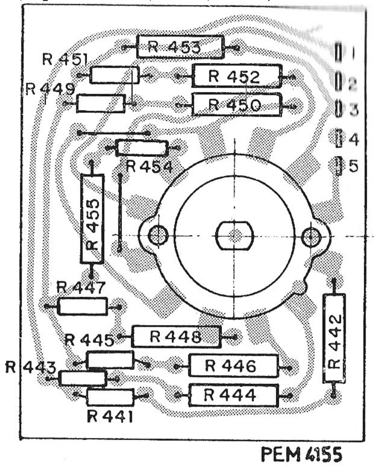


Fig. 30. Printed wiring board U3



U4/B

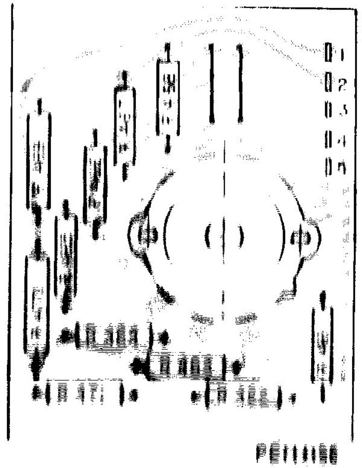


Fig. 31. Switch wafers U4/B

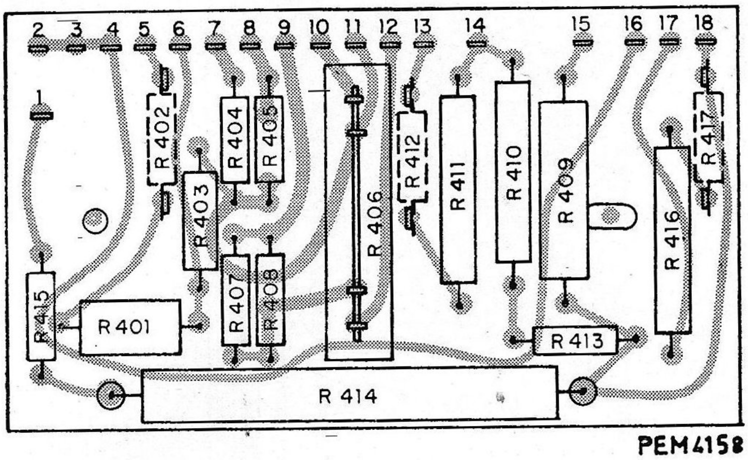


Fig. 32. Printed wiring board U4/E

Adjusting resistors

R204	10 kΩ ... 100 kΩ
R225	
R226	
R338	10 kΩ ... 100 kΩ
R339	100 kΩ ... ∞
R345	100 kΩ ... 470 kΩ
R346	470 kΩ ... ∞
R367	1 kΩ ... 10 kΩ
R368	10 kΩ ... ∞
R402	560 Ω ... 10 kΩ
R412	1 kΩ ... 10 kΩ
R417	560 Ω ... 10 kΩ

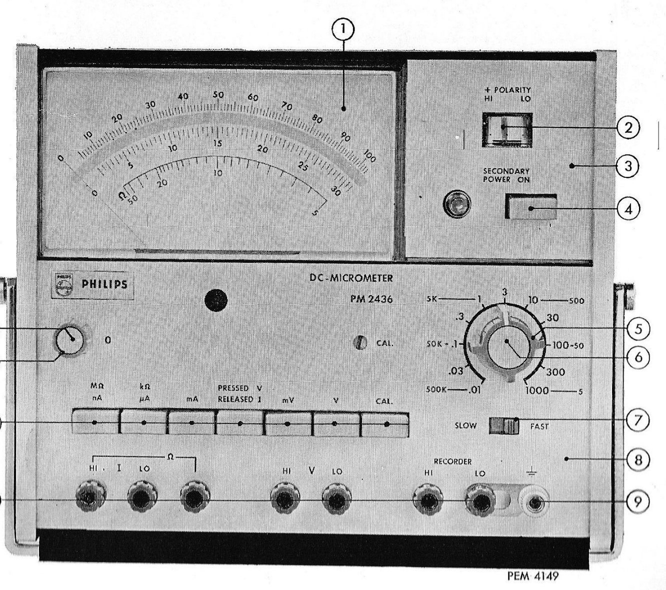


Fig. 25. Front view with indication of item numbers

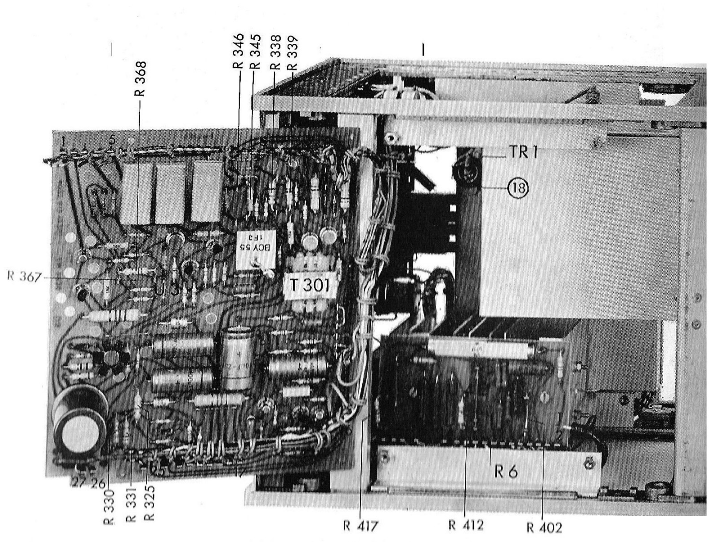


Fig. 26. Top view (U3 hinged out)

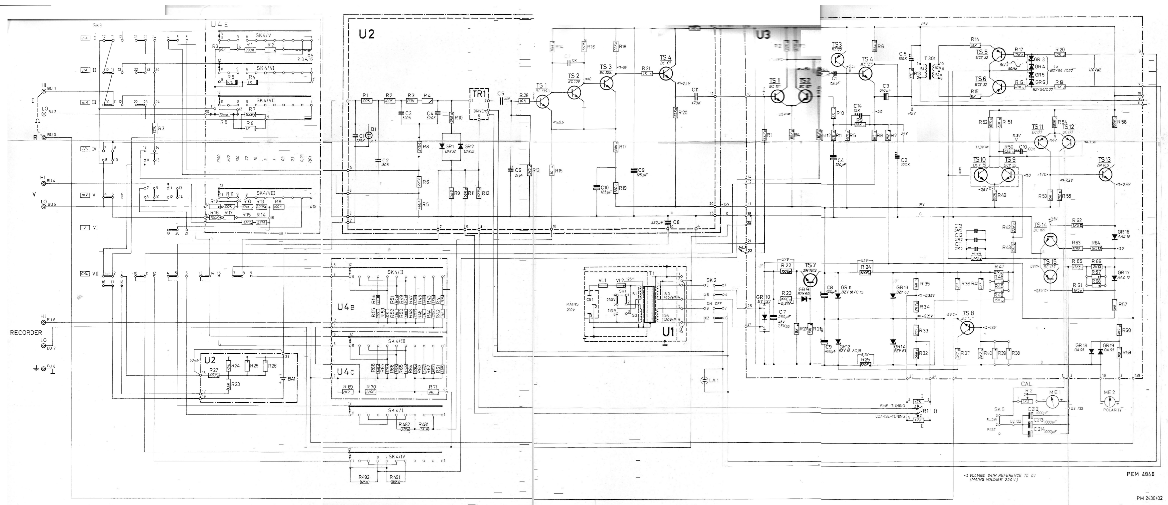


Fig. 33. Circuit diagram