PHILIPS

DIGITAL MULTIMETER

PM 2420

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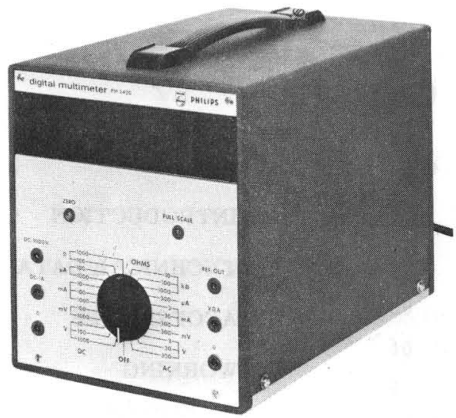


PEM 4707

PHILIPS

Manual

DIGITAL MULTIMETER

PM 2420

9448 024 20011

9499 480 00711 1/868/1/01

CS19576

Contents

Important

In correspondence regarding this instrument quote the complete type number and serial number, as stated on the type plate at the rear of the instrument.

List of figures

GENERAL

I. INTRODUCTION

Instrument PM 2420 is a compact multi-range DVM of the so-called RAMP type. Characteristic of the RAMP principle is the simplicity of operation, which makes this DVM ideally suitable for use as a general purpose instrument.
Operation is facilitated by the possibility of selecting all measuring ranges by means of a single knob. It is obvious that the combination of digital read-out system and monoknob range selection ensures fast and simple, yet accurate reading.

II. TECHNICAL DATA

Values with specified tolerances are guaranteed by the factory. Numerical values without tolerances represent the properties of an average instrument and serve only as a guide.

A. VOLTAGE MEASUREMENTS

1. Direct voltages

Measuring range	0.1 mV...1000 V
5 ranges	100 mV, 1000 mV, 10 V, 100 V, 1000 V (full scale)
Accuracy	Ranges 100 mV and 1 V: ± 0.5 % of full scale ± 1 digit Ranges 10 V, 100 V and 1000 V: ± 0.2 % of full scale ± 1 digit
Resolution	0.001 of full scale
Input resistance	1 MΩ: 100 mV, 1000 mV range 5 MΩ: 100 V range > 10 MΩ: 10 V range 10 MΩ: 1000 V
Measuring time	< 2 s.
Permissible overranging	5 % of full scale

2. Alternating voltages

Measuring range	1 mV_{rms}...300 V_{rms}
4 ranges	300 mV, 3 V, 30 V, 300 V (full scale)
Accuracy	± 1 % of full scale ± 1 digit
Frequency range	40 Hz...10 kHz
Resolution	1/3 x 0.01 of full scale
Input impedance	5 MΩ//100 pF: ranges 300 mV and 3 V 10 MΩ//50 pF: ranges 30 V and 300 V
Measuring time	< 3 s.
Permissible overranging	10 %...30 % of full scale, depending on the frequency applied (40 Hz...400 Hz = 30 %)

B. CURRENT MEASUREMENTS

1. Direct currents

Measuring range	0.1 μA...1 A
5 ranges	100 μA, 1000 μA, 10 mA, 100 mA, 1000 mA (full scale)
Accuracy	± 1 % of full scale ± 1 digit
Resolution	0.001 of full scale
Voltage drop	≤ 100 mV
Measuring time	< 2 s.
Permissible overranging	5 % of full scale

2. Alternating currents

Measuring range	1 μA_{rms}...300 mA_{rms}
4 ranges	300 μA, 3 mA, 30 mA, 300 mA (full scale)
Accuracy	± 1.5 % of full scale ± 1 digit
Frequency range	40 Hz...10 kHz
Resolution	1/3 x 0.01 of full scale
Voltage drop	≤ 300 mV
Measuring time	< 3 s.
Permissible overranging	10 %...30 % of full scale, depending on the frequency applied

C. RESISTANCE

Measuring range	0.1 Ω... 1 MΩ
5 ranges	100 Ω, 1000 Ω, 10 kΩ, 100 kΩ, 1000 kΩ (full scale)
Accuracy	± 0.5 % of full scale ± 1 digit
Resolution	0.001 of full scale
Measuring current	1 mA for 100 Ω, 1000 Ω, 10 kΩ ranges 100 μA for 100 kΩ range 10 μA for 1000 kΩ range
Measuring time	< 2 s.
Permissible overranging	< 5 % of full scale

D. GENERAL DATA

Display

	3 digital indicator tubes (character size 15 mm). Indicator provided for 10^3 full scale display, for the figure "1" only
Polarity indication	Automatic, with two pilot lamps
Decimal points	Automatically coupled to range selector

Input

Measuring input	floating
Maximum permissible voltages	

Value	Ranges
1000 V DC	≥ 10 V DC and ≥ 300 mV AC
150 V DC	< 10 V DC and Ω-ranges*)
330 V DC	≥ 300 mV AC

*) In these cases the overload indication lamp lights up, if the voltage exceeds 100 V DC.

Maximum permissible currents

Value	Range
20 mA AC/DC	100 μA DC and 300 μA AC
60 mA AC/DC	1000 μA DC and 3 mA AC
150 mA AC/DC	10 mA DC and 30 mA AC
1500 mA AC/DC	100 mA DC and 300 mA AC
5 A AC/DC	1000 mA DC

Maximum permissible voltage on "0" sockets — 500 V DC with respect to chassis.

Calibration — Internal calibration voltage is available on socket "REF OUT"

Voltage — 9.99 V

Accuracy — ± 0.1 %

Temperature coefficient — 0.01 %/°C

Common mode rejection — ≥ 120 dB

Series mode rejection — > 30 dB

Ambient temperature — +5 °C...+45 °C

Power supply

Mains voltage — 127 V or 220 V, ± 10 %

Frequency — 50...60 Hz

Consumption — 5 VA

E. MECHANICAL DATA

Dimensions	Height	170 mm
	Width	150 mm
	Depth	250 mm
Weight	3.4 kg	

III. ACCESSORIES, supplied with PM 2420

Set of measuring leads

Manual

IV. WORKING

A. PRINCIPLE

A simplified block diagram of a DVM based on the ramp principle is shown in Fig. 1.

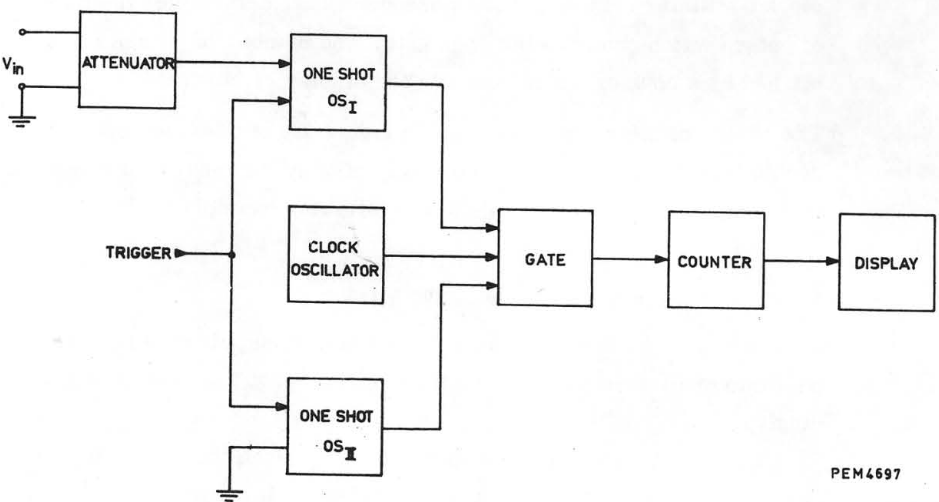


Fig. 1. Simplified block diagram

If the measurement is started two multivibrators of the one-shot type, OS_I and OS_{II}, are triggered.
From that moment on the capacitor included in each multivibrator is charged linearly from a certain positive voltage level to a negative level.
This waveform, the voltage level of which varies linearly with time, is called a ramp voltage.
The ramp voltage of OS_I is compared with the voltage to be measured, while the ramp voltage of OS_{II} is compared with earth. Both multivibrators are reset as soon as the slope of the ramp voltage has reached the level of the input voltage and earth respectively. Consequently each multivibrator produces a signal with a pulse width, which is proportional to the time of scanning.

If the voltage to be measured is called e_x and earth e_o the pulse width of OS_I may be written as $t_1 = c.(e_x - V)$ and the pulse width of OS_{II} as $t_2 = c.(e_o - V)$.
The difference between both pulse widths is then determined by $t_3 = t_1 - t_2 = c.(e_x - e_o)$, which is proportional to the input voltage level. This pulse is used to control the gate through which pulses of an internal clock oscillator have to pass. Consequently, t_3 determines the number of pulses which can pass the open gate. The number of pulses is established by a counter which controls the display circuit.

The choice of the ramp slope and the frequency of the clock oscillator enables the read-out circuit to directly display the measured value. In this respect reference is made to the following example.

Ramp slope	: 1 V/ms
Frequency of clock oscillator	: 390 kHz

If the counter is allowed to count for 10 ms, 1000 pulses of the clock oscillator will pass the gate and the number "1000" is displayed accordingly.
This figure will actually correspond to 10 V, since the ramp slope chosen is 1 V/ms. Consequently, 500 pulses will correspond to 5 V and one pulse to 10 mV.

Fig. 2 shows a pulse diagram of the voltage-to-time conversion in a ramp type DVM.

B. DESCRIPTION OF THE BLOCK DIAGRAM (Fig. 3)

Input circuit

Dependent on the selected DC voltage range, the direct voltage will be:

A. Attenuated, if the 1000 V and 100 V ranges have been selected (DC attenuator)
B. Amplified, if the 1000 mV and 100 mV ranges have been selected
C. Applied direct to the ADC in the 10 V range.

Consequently, the direct voltage will always reach the ADC at a level of 10 V full scale.

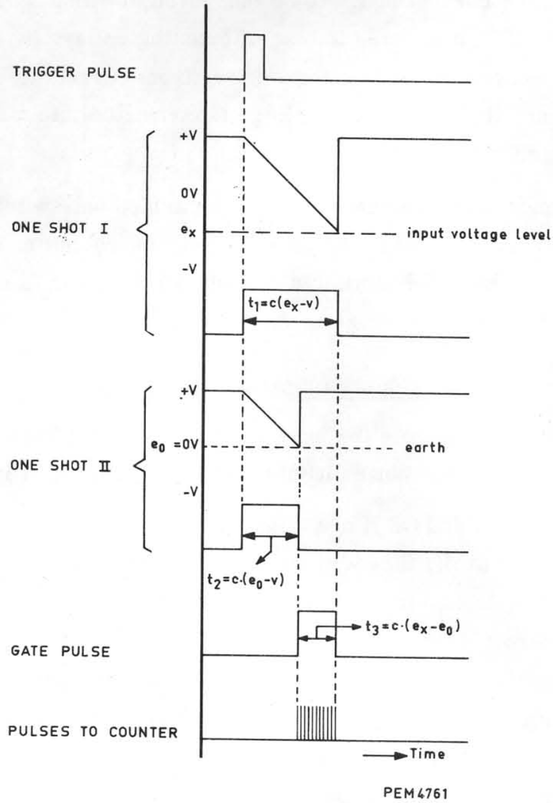


Fig. 2. Voltage-to-time conversion

If direct currents have to be measured, switch I_{dc} is closed and the current is converted into a direct voltage by shunting the input (R_S). This direct voltage is amplified as a DC signal in the 100 mV range.

If alternating voltage have to be measured, the signal has to be converted into a direct voltage.
After passing the AC attenuator and the impedance transformer, the signal is applied to the operational amplifier which also functions as a rectifier. The direct voltage obtained, will be proportional to the r.m.s. value of the alternating voltage originally applied to the instrument (for pure sinewave signals).

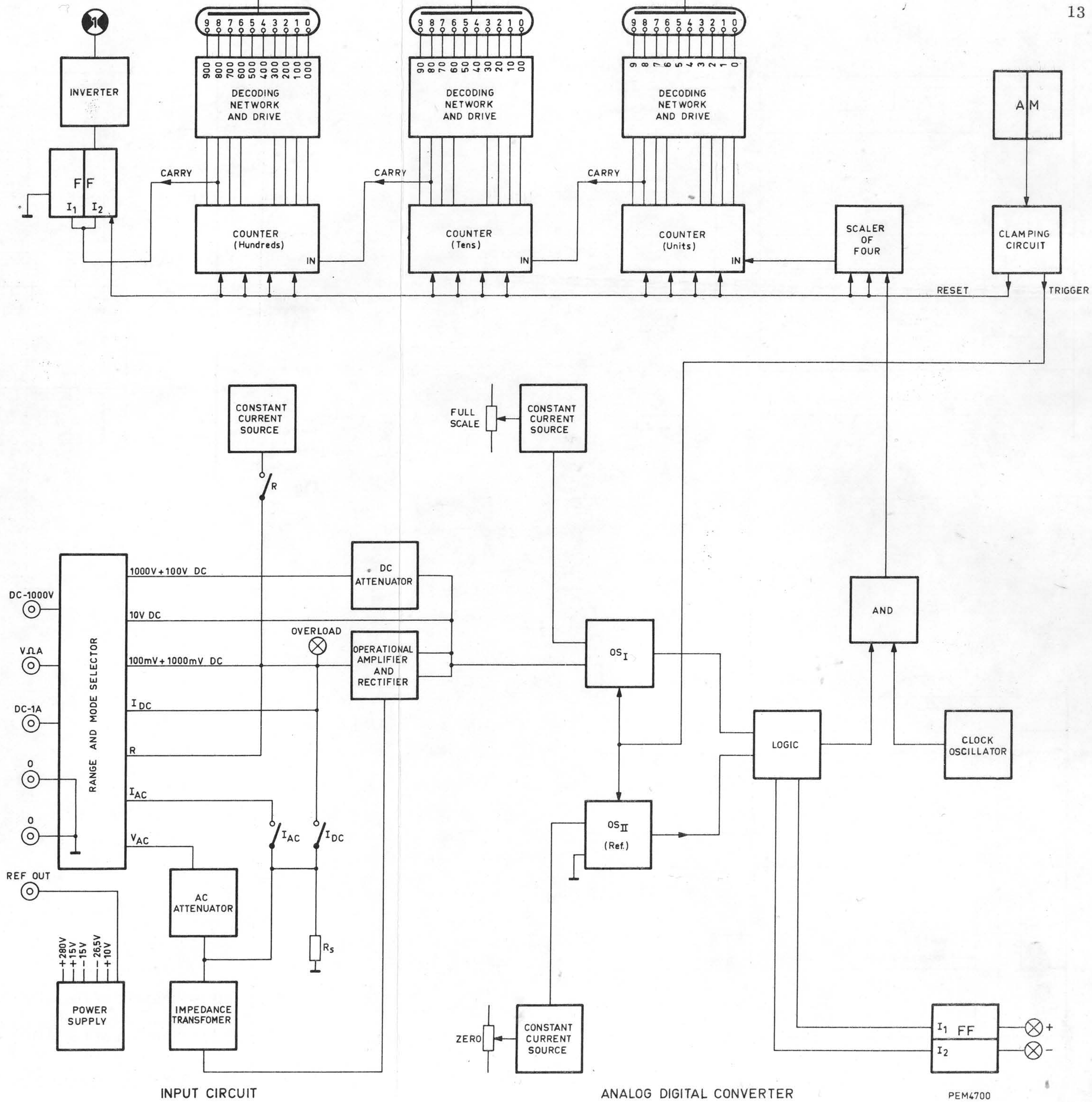


Fig. 3. Block diagram

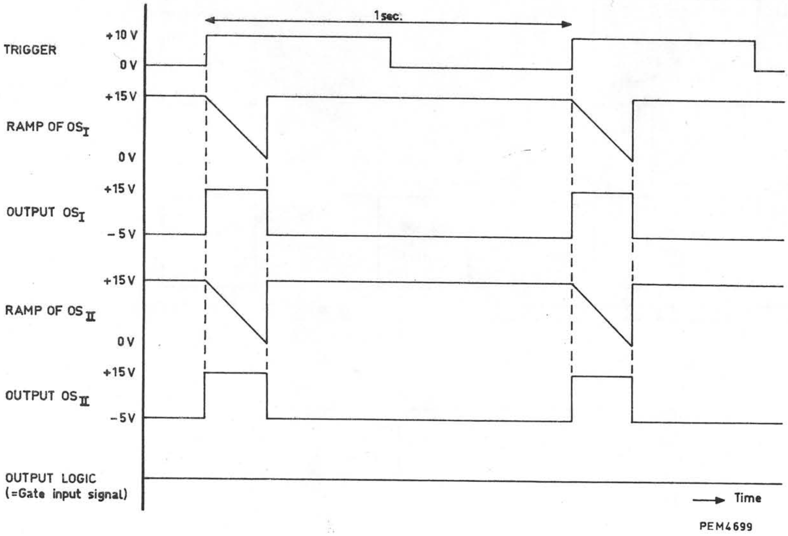

1sec.
TRIGGER
+10 V
0 V
+15 V
RAMP OF OS I
0 V
+15 V
OUTPUT OS I
- 5 V
+15 V
RAMP OF OS II
0 V
+15 V
OUTPUT OS II
-5 V
OUTPUT LOGIC
(=Gate input signal)
Time
PEM4699

Fig. 4a

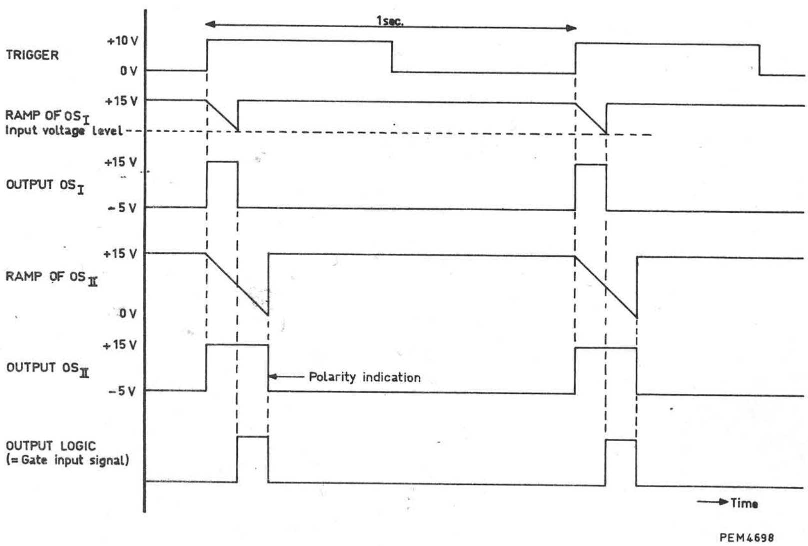

1sec.
TRIGGER
+10 V
0 V
+15 V
RAMP OF OS I
Input voltage level
+15 V
OUTPUT OS I
- 5 V
+15 V
RAMP OF OS II
0 V
+15 V
OUTPUT OS II
-5 V
Polarity indication
OUTPUT LOGIC
(= Gate input signal)
Time
PEM4698

Fig. 4b

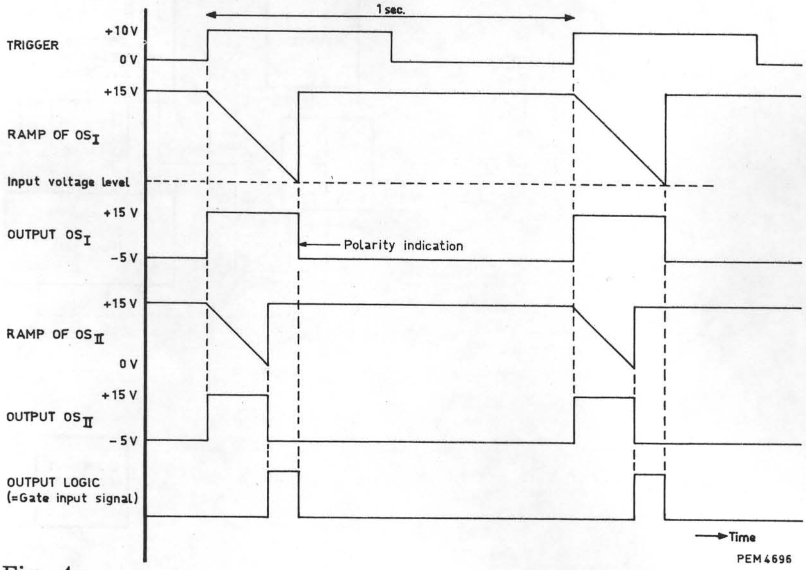
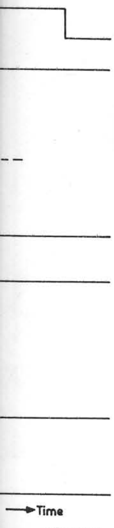


Fig. 4c

Fig. 4a. Pulse diagram of the ADC, with the input socket connected to "O"

b. Pulse diagram of the ADC, with the input voltage positive with respect to "O"

c. Pulse diagram of the ADC, with the input voltage negative with respect to "O"



onnected to "O"

ositive with respect to "O"

egative with respect to "O"

If alternating currents have to be measured, switch I_{ac} is closed a current is first converted into an alternating voltage by shunting th with the same resistors (R_s) used for direct currents.
Afterwards, this alternating voltage is converted into a direct volt as indicated in the previous paragraph.

If resistance measurements have to be carried out switch R is c and a constant current is fed into the relevant resistor. It is obvio that the direct voltage available across this resistor is measured a described for direct voltage measurements.

Analogue-to-Digital Converter (ADC)

The direct voltage from the input circuit is applied to the ADC, wh consists of two one-shot multivibrators, OS I and OS II in Fig. 3.

As soon as OS I and OS II are triggered by pulses from an internal multivibrator (AM), they will switch over to another position. Mul brator OS II, locked to zero, will again switch over if the slope ha reached zero.
Consequently, OS II supplies a squarewave pulse with a constant pu width. Multivibrator OS I, locked to the direct voltage level from t input circuit, will again switch over, if the slope has reached the direct voltage level of the input. Consequently, OS I supplies a squ wave pulse with a pulse width varying according to the level of the input voltage.

The squarewave pulses of both multivibrators are fed into a logic circuit, which detects the difference in pulse width of the two signa Consequently, the squarewave pulse leaving the logic circuit will b proportional to the value of the voltage, current or resistance, app to the input of the instrument, see Figs. 4a, b and c.

The capacitors of both multivibrators are linearly charged by gene which supply a constant current. These generators can be adjusted means of potentiometers "ZERO" and "FULL SCALE".
When short-circuiting the input, the ramp of both multivibrators w have the same slope (adjustable with "ZERO"), and there will be n difference in pulse width (see Fig. 4a).

When calibrating (with "FULL SCALE") the difference of the pulse-widths will be such that the signal from the logic circuit corresponds to full-scale display (see Fig. 4c). The required voltage (-9.99 V) is available on socket "REF. OUT".

The logic circuit has two functions:

1. To open or to close the oscillator gate, dependent on the presence of a logic output signal.

2. To determine the polarity

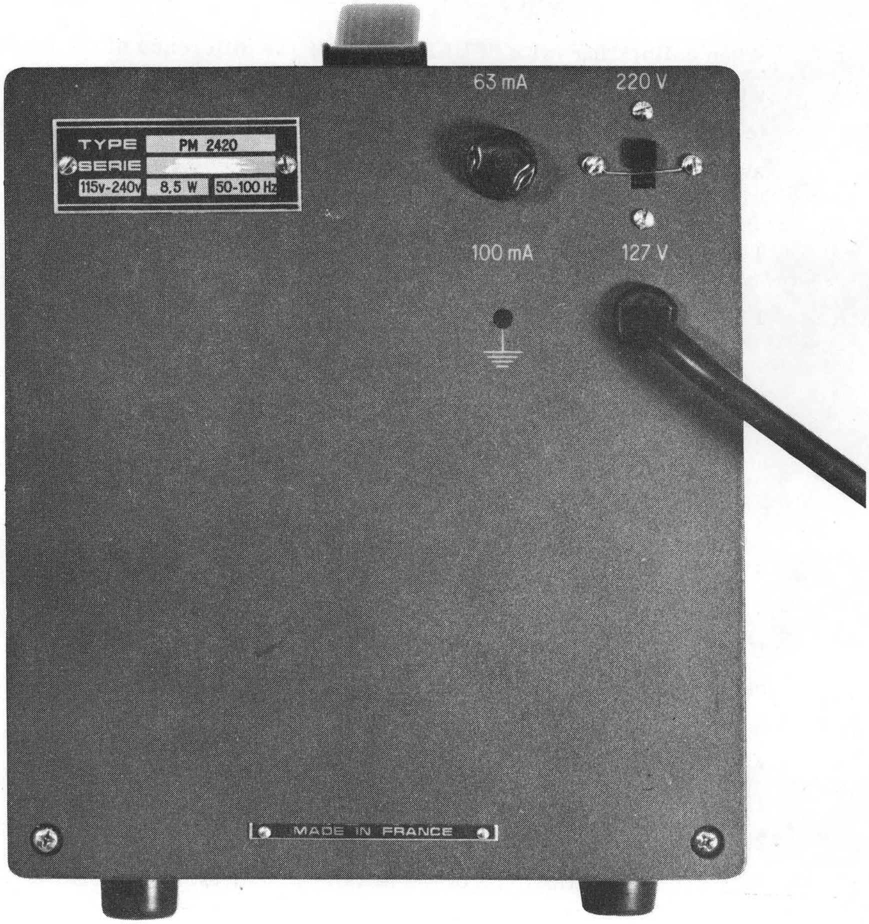
   The output signals of OS I and OS II are inverted by the logic circuit. The last trailing edge of one of the inverted signals determines the polarity. Should the OS II signal be last, the polarity will be positive. It will be negative, if the OS I signal is last (see Figs. 4b and c).

If the oscillator gate is open, the clock pulses originating from the clock oscillator, will be passed on to a four-scaler. The pulses from this network are applied to the counter.
Astable multivibrator AM has three functions:

1. To trigger OS I and OS II, to ensure synchronous operation.
2. To reset all flip-flops of the counter to position zero.
3. To reset the flip-flops of the scaler-of-four to position zero.

Counter

The counter consists of a three-decade counting unit, based on the 1 - 2 - 4 - 8 code.
The digits of each decade are determined by the position of the flip-flops. Decoding is effected by ten NAND gates for each decade. After 999 pulses the hundreds decade supplies a carry-pulse to the flip-flop controlling the one thousand indicator.
See the information on over-ranging, maximum permissible voltages etc., in the TECHNICAL DATA.



PEM 4702

Fig. 5. Rear view

When calibrating (with "FULL SCALE") the difference of the pulse-widths will be such that the signal from the logic circuit corresponds to full-scale display (see Fig. 4c). The required voltage (-9.99 V) is available on socket "REF. OUT".

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1. To open or to close the oscillator gate, dependent on the presence of a logic output signal.

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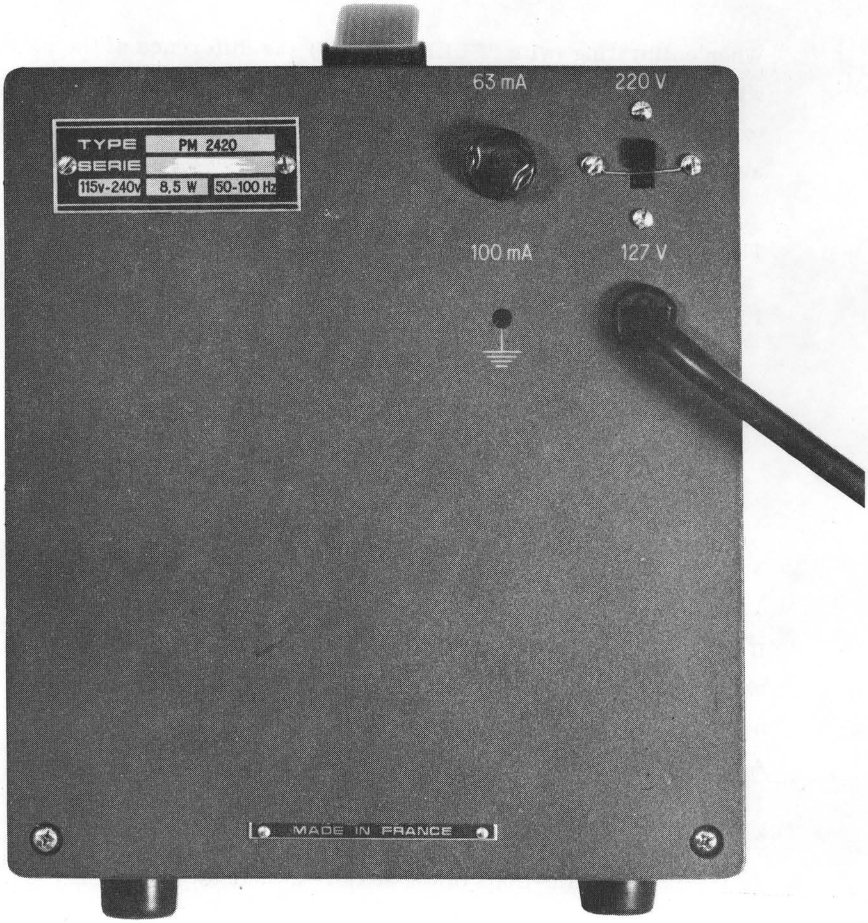
See the information on over-ranging, maximum permissible voltages etc., in the TECHNICAL DATA.



PEM 4702

Fig. 5. Rear view

DIRECTIONS FOR USE

V. INSTALLATION

A. ADJUSTMENT TO THE MAINS VOLTAGE

Check that the voltage adapter on the rear panel has been set to the local mains voltage.
The instrument is suitable for use at a mains voltage
of 127 V AC (115...140 V AC)
or 220 V AC (200...240 V AC).

B. FUSE

The rating of the fuse at the rear should be 100 mA, delayed action, for the voltage range 115 V...140 V and 63 mA, delayed action, for mains voltages from 200 V...240 V.

C. EARTHING

The instrument should be earthed in accordance with local safety regulations. This instrument offers the following possibilities:

a. Earthing via the 3-core mains cable, which should be connected to a wall socket with rim-earthing contacts.
b. Earthing via the earthing socket marked " ⏚ ", on the rear.

Avoid double earthing, which may cause hum.

VI. OPERATION

A. SWITCHING ON

The instrument is switched on with the monoknob. The digital indicator tubes should light up.

B. CALIBRATION

Note: By allowing the instrument to warm up for a few minutes the necessity of recalibration after a short period is avoided.

- Set the monoknob to position "10 V DC".
- Short-circuit sockets "VΩA" and "0".
- Adjust the digital display to "000" with potentiometer "ZERO" (screwdriver adjustment on the front, see Fig. 6). If the pilot lamps "+"/"-" light up alternately, this is an indication that the zero setting has been effected most accurately.
- Connect socket "VΩA" to socket "REF OUT".
- Adjust the digital display to "999" with potentiometer "FULL SCALE" (screwdriver adjustment on the front, see Fig. 6).

C. MEASURING

- Calibrate the instrument (see VI. B).
- The following measurements can be carried out, if the measuring leads are connected to sockets "VΩA" and "0", and the appropriate ranges have been selected with the monoknob:
  direct voltages up to 100 V
  alternating voltages up to 300 V
  direct currents up to 100 mA
  alternating currents up to 300 mA and
  resistance up to 1 MΩ.

Notes

- Direct voltages exceeding 100 V, with a maximum of 1000 V, can be measured via a separate socket "DC-1000 V", if the monoknob has been set to position "1000 V DC".

- Direct currents exceeding 100 mA, with a maximum of 1 A, can be measured via a separate socket "DC-1 A" if the monoknob has been set to position "1000 mA DC".
- For DC measurements the polarity of the voltage on socket "VΩA" with respect to socket "0", is indicated by two pilot lamps, displaying "+" or "-".
- If floating measurements are carried out, the voltage between sockets "0" and earth (= chassis) should not exceed 500 V DC.
- Theoretically, a maximum indication of "1500" is possible. However, the slope linearity decreases so that the indicated value is no longer reliable. The accuracy is not affected by over-ranging to:
  5 % of full scale for DC measurements (no overloading allowed in 1000 V range)
  10 %...30 % of full scale for AC measurements (dependent on the frequency applied)
  5 % of full scale for resistance measurements.
- In ranges $\leq$ 10 V DC and $\leq$ 1000 Ω the "OVERLOAD" pilot lamp will light up, if the applied voltage exceeds 100 V DC.
- In ranges "1000 mV" and "100 mV" an incorrect indication may occur as a result of the offset current (about 100 nA) of the operational amplifier. This offset current passes the output impedance of the circuit under test and causes a voltage: $I_{offset} \times R$ across this circuit. If possible, choose the output impedance of the circuit under test as low as possible (< 1 kΩ).

SERVICE DATA

VII. CIRCUIT DESCRIPTION

A. GENERAL

This chapter describes the function of a certain circuit during the measuring process. At the end of this manual illustrations are given of the corresponding printed wiring boards and the circuit diagram (Fig. 43). If any switches are involved, these items are drawn in the "OFF" position. Reference to a certain contact of a switch is made as follows: switch/wafer, front (f) or rear (a) /contact; e.g. SK1/IIa/12 means: switch 1 (= monoknob), wafer 2 rear side, contact 12.

B. POWER SUPPLY (Fig. 35)

1. Transformer

Primary

Windings S1 + S2 can be connected for 220 V mains voltages and winding S2 for 115 V mains with slide switch SK2. Permissible voltage deviation is ± 10 %.

Secondary

The secondary windings S3, S4 + S5, S6 and S7 supply the AC voltages to the 4 separate rectifying circuits.
These circuits deliver a non-stabilized voltage of +280 V and 4 stabilized voltages of +15 V, -15 V, -26.5 V and +10 V, with respect to the common zero of the circuitry ($\perp$).

2. Voltage source +280 V

The +280-V-voltage is used for the digital indicator tubes, the polarity neon lamps, the decimal-point neon lamp, the "1000" indicator tube. This voltage is obtained from a half-wave voltage doubler consisting of C13, GR1, GR2 and C14.

3. Voltage sources +15 V and -15 V

The secondary voltage of windings S4 and S5 is approx. 25 V_{rms}, which is rectified with bridge-rectifier GR8 and smoothed by capacitors C1 and C4. After the rectifier the circuit is divided into a positive and a negative circuit with common zero. Since the stabilisation circuits for positive and negative voltages are symmetrical with respect to common zero, only the positive circuit will be described in detail. The parts stated between brackets refer to the negative stabilisation circuit.
The voltage across R6 and P1 (R12 and P2) is compared with the reference voltage across Zener-diode GR2 (GR4). Transistors TS2 (TS4) operates as a difference-amplifier and controls series regulator TS1 (TS3). The output voltage is adjusted by potentiometer P1 (P2). Fast output voltage variations are applied to the base of TS2 (TS4) via C2 (C5).

4. Voltage source -26.5 V

This control circuit is, in principle, similar to the circuitry of the +15 V or -15 V source. The reference voltage is derived from Zener diode GR4 (-15 V source). The series regulator consists of TS5 and TS6 in a Darlington circuit. The output voltage is adjusted by potentiometer P3.

5. Voltage source +10 V

This source is only stabilised as regards mains voltage variations by Zener-diodes GR8, GR9 and transistor TS8. Output voltage variations are compensated for to some extent by a large capacitor, C12.

C. INPUT CIRCUIT

The input circuit brings the input signal at a DC voltage level of 10 V f.s.d. for DC measurements and resistance measurements, and at a level of 3 V f.s.d. for AC measurements.

1. DC voltage circuits (Fig. 7)

Dependent on the position of the range selector the input voltage on socket "VΩA" will be:

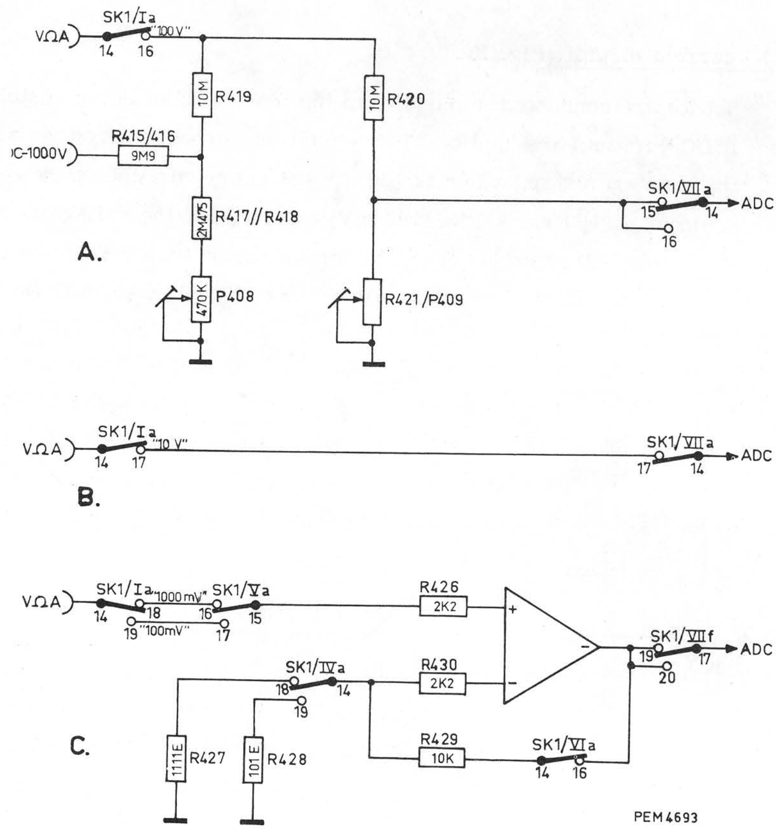


Fig. 7. DC voltage circuits

A. attenuated in the range "100 V". The attenuation factor is adjusted to 10 by potentiometer P409.

B. applied direct to the ADC (range "10 V")

C. amplified in the ranges 1 V (amplification factor 10) and 100 mV (amplification factor 100).

Voltages exceeding 100 V should be connected to socket "DC-1000 V". They are applied to the ADC via an attenuator, having an attenuation factor of 100. The attenuation factor can be adjusted by potentiometer P408.

2. DC current circuit (Fig. 8)

Shunts are connected in parallel to the input with selector switch SK1/Ia if DC currents are applied. These currents produce a voltage across the shunt-resistor, which is 100 mV for every current range at full scale (e.g. 100 mA x 1 Ω = 100 mV). After this, the voltage is applied to the amplifier via SK1/Va. The amplification factor amounts to 100. The output voltage (100 x 100 mV = 10 V) is applied to the ADC via SK1/VIIf.

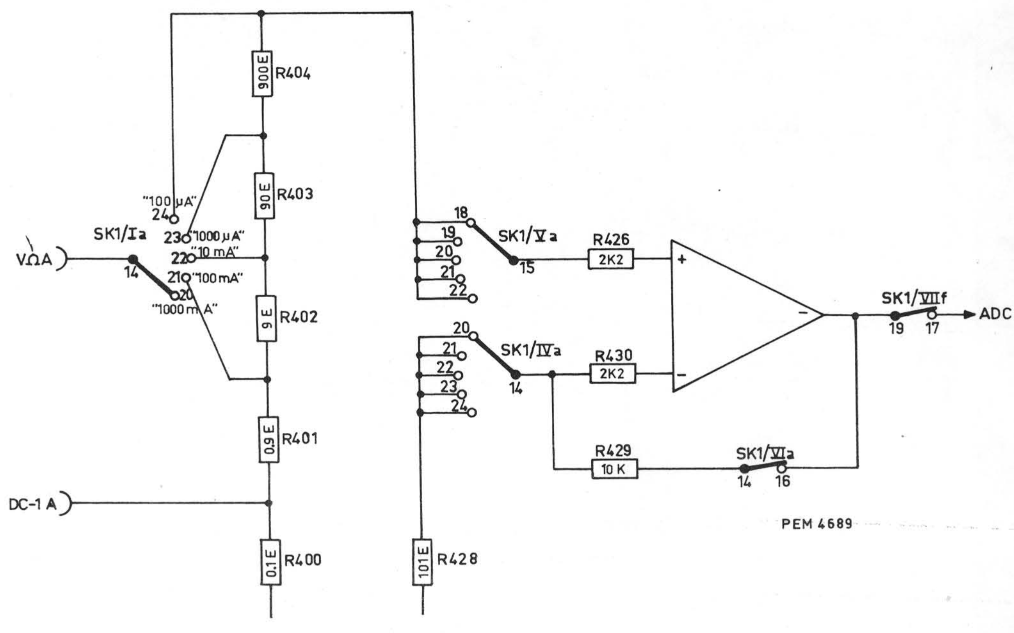


Fig. 8. DC current circuit

3. Circuit for resistance measurements (Fig. 9)

Resistance measurements are, in fact, translated into DC voltage measurements. A DC current of 1 mA is applied to the unknown resistor Rx if the range selector has been set to position 100 Ω, 1000 Ω or 10 kΩ. A voltage of 0.1 V, 1 V and 10 V respectively will occur across Rx at a maximum. This voltage is fed into the ADC as already described for

DC voltage measurements under points C1, B and C. If position "100 kΩ" is selected the direct current is 0.1 mA and in position "1000 kΩ" it is 10 μA, which corresponds to 10 V full scale. This DC voltage is applied direct to the ADC.

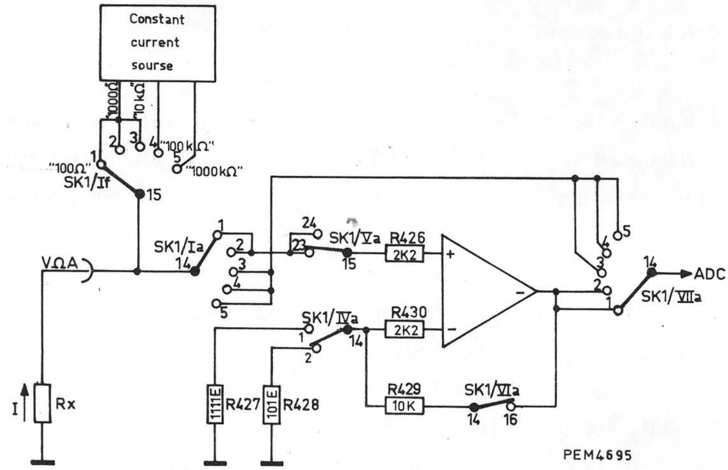


Fig. 9. Circuit for resistance measurements

4. <u>AC voltage circuit</u> (Fig. 10)

AC voltages are translated into DC voltages of 3 V fsd. The ranges "300 mV" and "3 V" are connected direct to the impedance transformer, while the ranges "30 V" and "300 V" are connected to a frequency-independent attenuator, which causes an attenuation of 100 : 1. Afterwards, the signal is also applied to the impedance transformer.
The output voltage of the impedance transformer is applied to the operational amplifier via P406 + R432//R439 + C410 for the 300 mV and 30 V AC voltage ranges and all AC current ranges. If the 3 V and 300 V voltage positions have been chosen the output signal will leave the transformer via P405 + R431//C409. After this both signals are amplified and rectified by the operational amplifier in question. The full-wave rectified signal is applied to a filter via SK1/VIa/14 and SK1/VIf/15, where the signal is smoothed. The output DC voltage, which is propor-

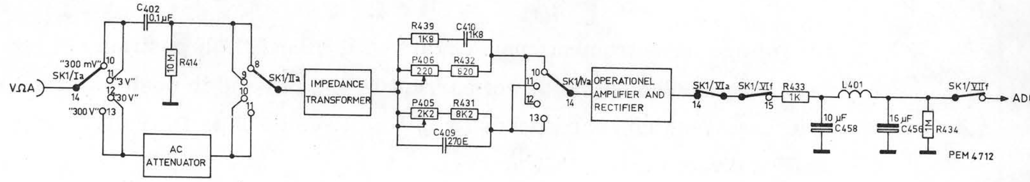


Fig. 10. AC voltage circuit

tional to the r.m.s. value of the applied signal (for pure sinewaves), is connected to the ADC via SK1/VIIIf/6 and -/7. More details regarding the operational amplifier and rectifier circuit are given in point 9.

5. AC current circuit (Fig. 11)

AC currents are converted into AC voltage signals by means of shunts, which is in accordance with the description given for DC currents. The AC voltage signal of 0.3 V f.s.d. across the shunt selected, is subsequently applied to the impedance transformer which is also used for AC voltage measurements (see point 4, AC voltage circuit).

6. Constant current source (for resistance measurements)

In the case of resistance measurements a constant current is applied to the unknown resistor. This current has been derived from a constant current source, consisting of transistors TS400 and TS401. Since the base

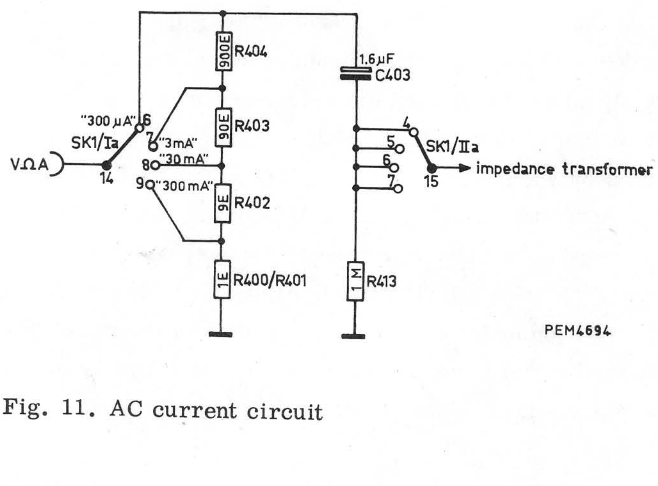


Fig. 11. AC current circuit

voltage of TS401 is kept at a constant level by means of emitter-follower TS400, the base current of TS401 will also be kept at a constant value. The total collector current is determined by the collector resistor. In position "1000 kΩ" the emitter current is 10 μA and can be adjusted by potentiometer P402 of the collector circuit.

In position "100 kΩ" the collector resistance consists of P402 + R412//P401 + R411 + R410. In that case the emitter current is 0.1 mA and can be adjusted by P401. In any other range the emitter current is 1 mA and is adjustable by potentiometer P400 of the collector circuit consisting of P402 + R412//P400 + R409.
The current source is protected against overloads by fuse VL402.

7. Impedance transformer

In order to prevent the attenuator and the circuit to be tested from being loaded due to the relatively low input impedance of the operational rectifier, this section is preceded by an impedance transformer, which consists of FET TS403 and emitter-follower TS402.

8. Operational amplifier (Fig. 12)

The amplifier is a multipurpose functional NEXUS block, type SQ-10a. With a perfect amplifier (very high input impedance, very high gain and very low output impedance) the amplification factor will be:

$\frac{R429 + R427}{R427}$ = 10 x (for the ranges "1 V DC" and "1000 Ω") and

$\frac{R429 + R428}{R428}$ = 100 x (for the "100 mV DC" range, all DC current ranges and the 100 Ω range).

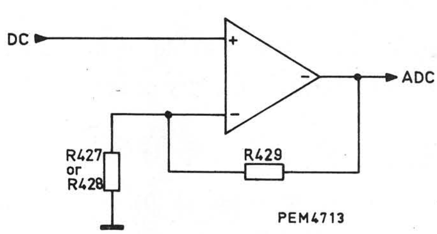


Fig. 12. Operational amplifier circuit

9. Operational amplifier and rectifier circuit (Fig. 13)

For AC measurements diode GR409 is circuited in parallel with the operational amplifier via SK1/IVf/3, the interconnected rotor contacts and SK1/IVa/14. The positive input is connected to common zero via SK1/Vf/12 and 13. The positive part of a sinewave signal at the output is short-circuited via GR409. However, the negative part causes a voltage drop across R429 via GR408, which is applied to the filter. The amplification factor is determined by the ratio of R429 and P406 + R432//R439 + C410 or the ratio of R429 and P405 + R431//C409. This factor will be 10 or 1 and can be adjusted with potentiometers P406 and P405 respectively. For data and connections of the operational amplifier refer to chapter XV, dealing with "Functional Blocks".

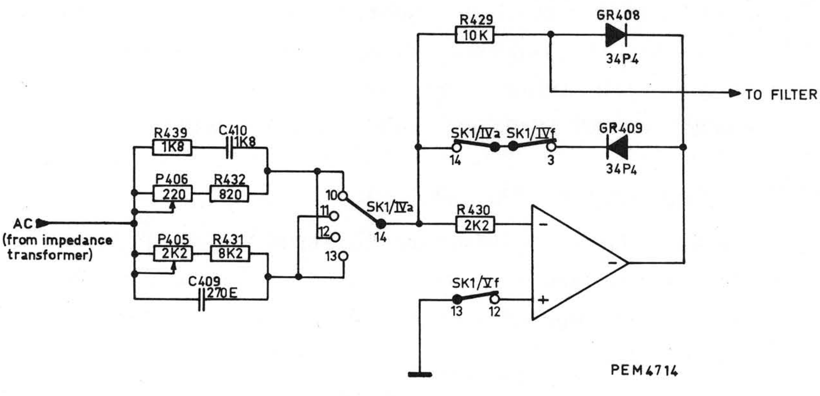


Fig. 13. Operational amplifier and rectifier circuit

D. ANALOGUE-TO-DIGITAL CONVERTER

The ADC consists of two monostable multivibrators and two constant current sources to ensure linearity of the ramp slopes.

1. Monostable multivibrator I (OS_I) Fig. 14

In the stable position transistor TS307 is cut off, and its collector has a voltage level of -5 V. TS303 is conductive and its collector has a level of +15 V, which means that TS302 is cut off. Capacitor C302 is not charged, since both sides have a +15 V voltage level.

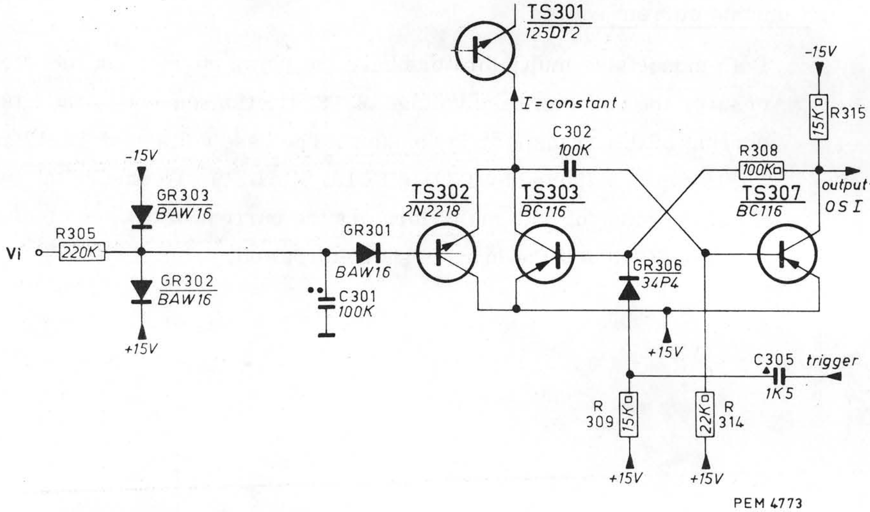


Fig. 14. Monostable multivibrator

If the leading edge of the trigger pulse passes GR306, it will cut off TS303 and TS307 will become conductive. The collector voltage of TS307 will increase to +15 V.

Subsequently the constant current source discharges capacitor C302 linearly and as soon as the emitter voltage of TS302 has become equal to the base voltage of TS302 (= input voltage Vi), TS302 will become conductive. TS307 is cut off and its collector potential will be -5 V, so that TS303 will become conductive again. The next change-over will take place as soon as the next leading edge of the trigger pulses is applied.

Consequently, the pulse-width on the collector of TS307 completely depends on the input voltage level: the smaller the input voltage, the longer the slope of the ramp and thus the larger the pulse width will be.

2. Monostable multivibrator II (OS_{II})

This multivibrator consists of transistors TS305, TS306, and TS308, and capacitor C312. It operates in the same way as the one described before, however, the input of OS_{II} is referred to zero. The output pulse with a constant pulse width, is taken from the collector of TS308.

3. Constant current source

Both monostable multivibrators have their own current source. TS317 ensures the constant base voltage of TS301. Consequently, the base current of this transistor is constant. The base voltage of TS317 and TS318 can be adjusted by P301 ("FULL SCALE"). To ensure the symmetry of the slope of both multivibrators the current of OS_{II} can be adjusted by P304 (ZERO) if the input is short-circuited.

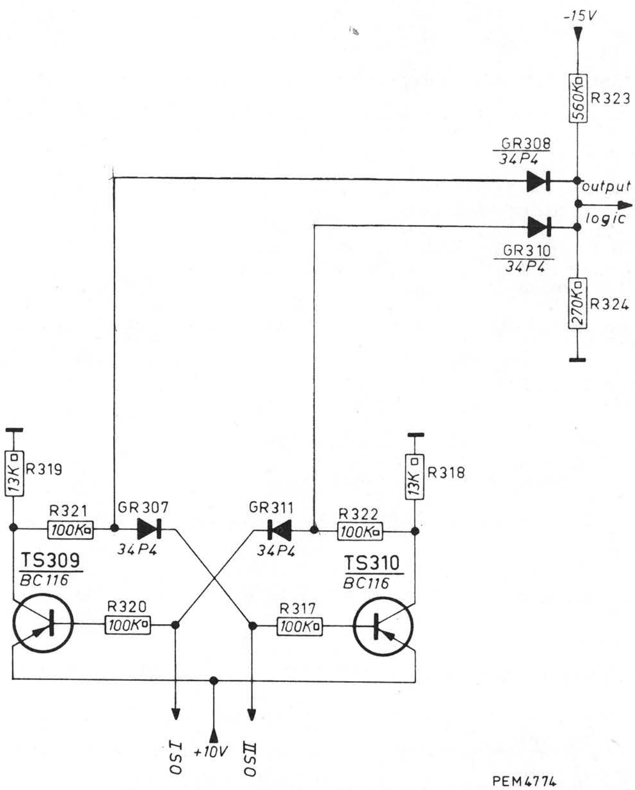


Fig. 15. Logic circuit

E. LOGIC CIRCUIT (Fig. 15)

The logic circuit, consisting of difference amplifier TS309 and TS310 with OR gate, compares the output pulses of the two monostable multivibrators. The resultant signal is a pulse, with a width, which is proportional to the difference between both original pulse widths. This output signal controls a gate.

There are 4 possibilities, viz.:

1. Output level of both multivibrators (OS_I and OS_{II}) is -5 V (TS307 and TS308 are cut off).
   TS309 and TS310 are conductive. The collector voltages in question are at a +10 V level. GR307 and GR311 are then conductive. The relevant anodes are kept at about -5 V, so that diodes GR308 and GR310 are cut off. The output level will then be approx. -5 V.
2. Output level of both multivibrators is +15 V (TS307 and TS308 are conductive).
   TS309 and TS310 are cut off. The collector voltages are at zero level. GR307 and GR311 are cut off, but GR308 and GR310 are conductive. Consequently, the output level is approx. 0 V.
3. Output level of multivibrator OS_I is -5 V and the level of OS_{II} is +15 V. TS309 is conductive and TS310 is cut off. The collector voltage of TS309 is +10 V, while TS310 is at 0 V level. Under these conditions GR308 will be conductive and the output level will be +10 V.
4. Output level of multivibrator OS_{II} is -5 V and the level of OS_I is +15 V, which means that GR310 is conductive and the output level will be +10 V.

F. GATE

The gate circuit consists of transistors TS312 and TS313 in series. The gate is open if the base of TS312 is positive (+10 V, see E.3 + E.4). If the gate is open, pulses of the clock oscillator (see below) are allowed to pass the gate to the four-scaler.

G. CLOCK OSCILLATOR

The clock signal is produced by an LC-oscillator, consisting of TS314, T301 and C306. The oscillating frequency is 390 kHz ± 1 % and can be adjusted by T301. Via R326 the signal is applied to the gate.

H. POLARITY INDICATION (Fig. 16)

If a positive voltage is applied, OS_I will give a pulse with a smaller pulse-width than OS_{II}. The output signals of the logic circuit have reversed polarity. As soon as a positive edge is applied to flip-flop FF1 via input I1, it will change over to remain in that position till the next

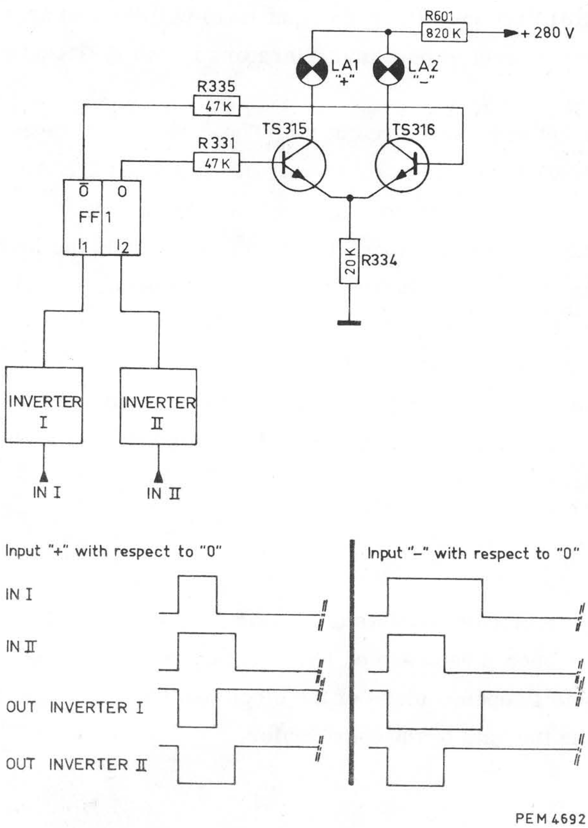


Fig. 16. Polarity indication circuit

positive edge is applied. Output "$\overline{0}$" will be +10 V and output 0 approx. 0 V. TS316 is conductive and TS315 will be cut off so that indicator LA2 lights up. After max. 10 ms. later a positive pulse will be applied via input I2. FF1 changes over and output "$\overline{0}$" will have become approx. 0 V and the "0" output +10 V, so that TS315 and TS316 will be conductive and blocked respectively and LA1 lights up. FF1 will remain in this position until the next positive pulse arrives via I1. This signal is applied approx. 1 sec. later but immediately after this a positive pulse is applied via I2, so that + indicator LA1 remains on. If a negative voltage is applied, OS_I will give a pulse with a larger pulse-width than OS_{II}. As a result the first positive pulse will light the + indicator LA1 for a moment, however, the second positive pulse will light LA2, the negative indicator.

J. FOUR-SCALER

If the gate is open (see F), the clock oscillator pulses are fed to the four-scaler, consisting of flip-flops FF2 and FF3. The output pulses of this scaler are applied to the units decade of the counter.

K. COUNTER

The counter has three decades, viz. one for the units, tens and hundreds. Each decade unit has 4 flip-flops. These 4 flip-flops have a counting capacity of 16 digits in total, 10 of which are used to control the decimal display.
The measurement is started, as soon as the astable multivibrator (see chapter L) initiates a negative pulse. At the same moment a reset pulse is applied to the flip-flops of the decades via a clamping circuit. These flip-flops are reset to zero, so that all $\overline{0}$ outputs are +10 V and all 0 outputs are 0 V. The output pulses originating from the four-scaler are supplied to FF4 and any negative pulse will change the flip-flop position. Flip-flop FF5 changes over, if FF4 supplies a negative pulse via GR33. This negative pulse will not influence the position of FF7, because the negative pulse will keep the transistor cut off. After 9 pulses the decade will be in position 1 - 0 - 0 - 1 (see table). Since output $\overline{0}$ of flip-flop FF7 is connected to the input of FF5 via GR34, this FF5 input

is blocked. The subsequent negative pulse from FF4 will have no influence on FF5 so that the signal is applied to FF7 via input I1, which cuts off the transistor so that the flip-flop changes over again. The switch positions of the flip-flops are given in the table below.

Digit	FF7 (2^3)	FF6 (2^2)	FF5 (2^1)	FF4 (2^0)
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

The digits 0 up to 9 are determined by the switching positions of the flip-flops.

The tens and hundreds decade units operate in the same way and they are controlled by the carry-pulse made by the preceding decade unit. The last pulse of a sequence of 1000 will set the flip-flops to zero (indication 000) and the carry-pulse of the hundreds decade will control the 1000 indication (see point M).
Decoding is effected with NAND gates.

NAND gate (Fig. 17)

A NAND gate consists of an AND gate and an inverter. The output signal of an AND gate is "1" (= +10 V) if all inputs (P, Q, R, S) are "1". In any other situation the output signal is "0" (0 V). If the base of the inverter transistor is "1", this transistor will be conductive. Consequently the digit in series with the collector of that transistor, will light up. Diodes GR31 and GR32 ensure that the transistors of the inverter are cut off if the base receives a "0" signal from the gate.

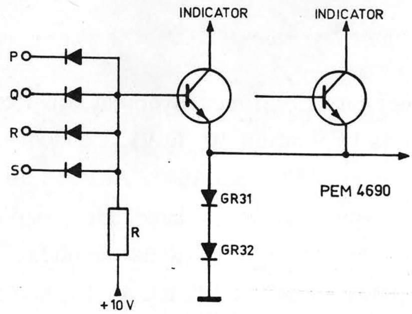


Fig. 17. Nand gate

L. ASTABLE MULTIVIBRATOR

The astable multivibrator supplies a squarewave pulse with a frequency of about 1 Hz, which is determined by R3, C501 and R7, C502. This pulse is subsequently applied to a clamping circuit for adapting it to the level used in the other circuits (+10 V and 0 V).

As soon as the multivibrator initiates a negative pulse the following situation arises:

a. the monostable multivibrators (OS_I and OS_{II}) of the ADC are triggered
b. the flip-flops of the counter are reset to zero
c. the flip-flops of the four-scaler are reset to zero
d. the flip-flop of the 1000 indication is reset to zero

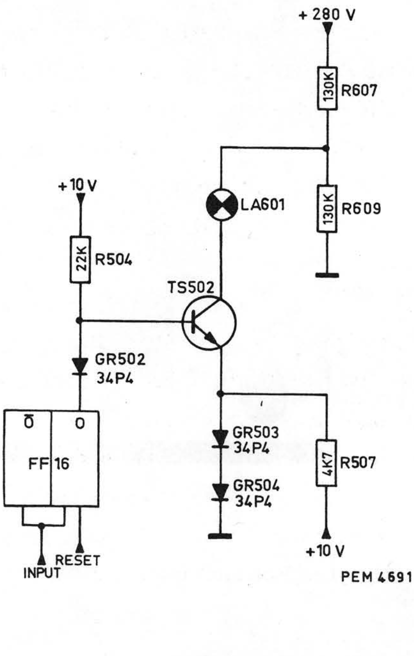


Fig. 18.
"1000" indication circuit

M. "1000" INDICATION

At the beginning of a measurement flip-flop FF16 is reset to "0" so that output 0 is in position "0" (0 V). Consequently TS502 is cut off and no current can pass lamp LA601. As soon as FF16 has changed over due to a carry-pulse from the hundreds decade unit, output 0 of FF16 will become "1" (+10 V), and TS502 is conductive, which means that lamp LA601 lights up and the digit 1 is displayed.

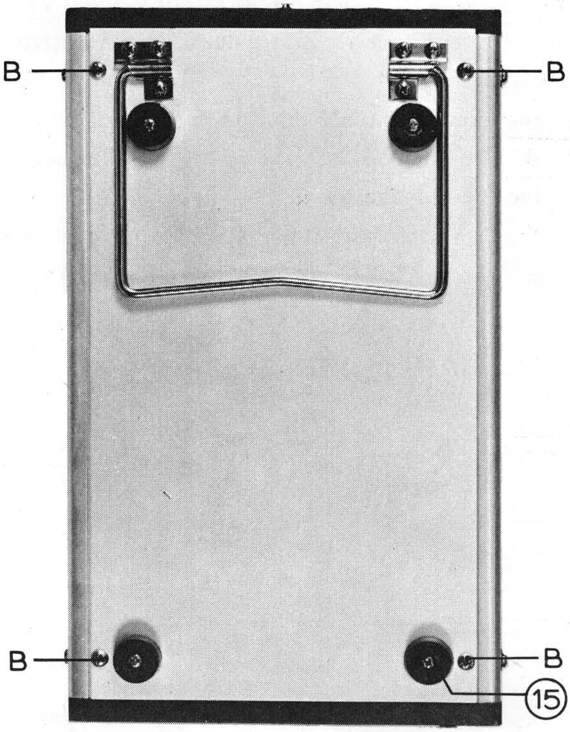


Fig. 19. Bottom view

VIII. DISASSEMBLING

A. HOUSING

- Remove two screws "A" (Fig. 24) at the right-hand side and two screws at the left-hand side.
- Lift the housing at the rear side and remove it.

Note: The housing is provided with a cam fitting in the front frame.

B. BOTTOM PANEL

- Remove four screws "B" (Fig. 19).
- Remove the bottom panel.

C. TEXT PLATE

- Remove four screws "C" (Fig. 24).
- Remove the text plate.

IX. REPLACING PARTS

A. FRONT FRAME

- Remove the housing, bottom panel and text plate (see VIII. A, B and C).
- Unsolder or disconnect the connections of all sockets mounted on the front frame.
- Remove the monoknob (see IX. C).
- Loosen the central fixing nut of the selector switch by means of a 12 mm box spanner.
- Remove the 8 screws at the front of the frame.
- Remove the frame.

B. REAR FRAME

- Remove the fuse holder.
- Remove the two screws of the voltage selector switch (220 V/127 V) and the locking spring.
- Remove the type plate (two screws).
- Remove the two screws "D" (Figs. 20 and 21) and "E" (Fig. 25).
- Unsolder the mains cable.
- Remove the two screws with which the mains transformer is fitted in the rear frame.
- Remove the rear frame.

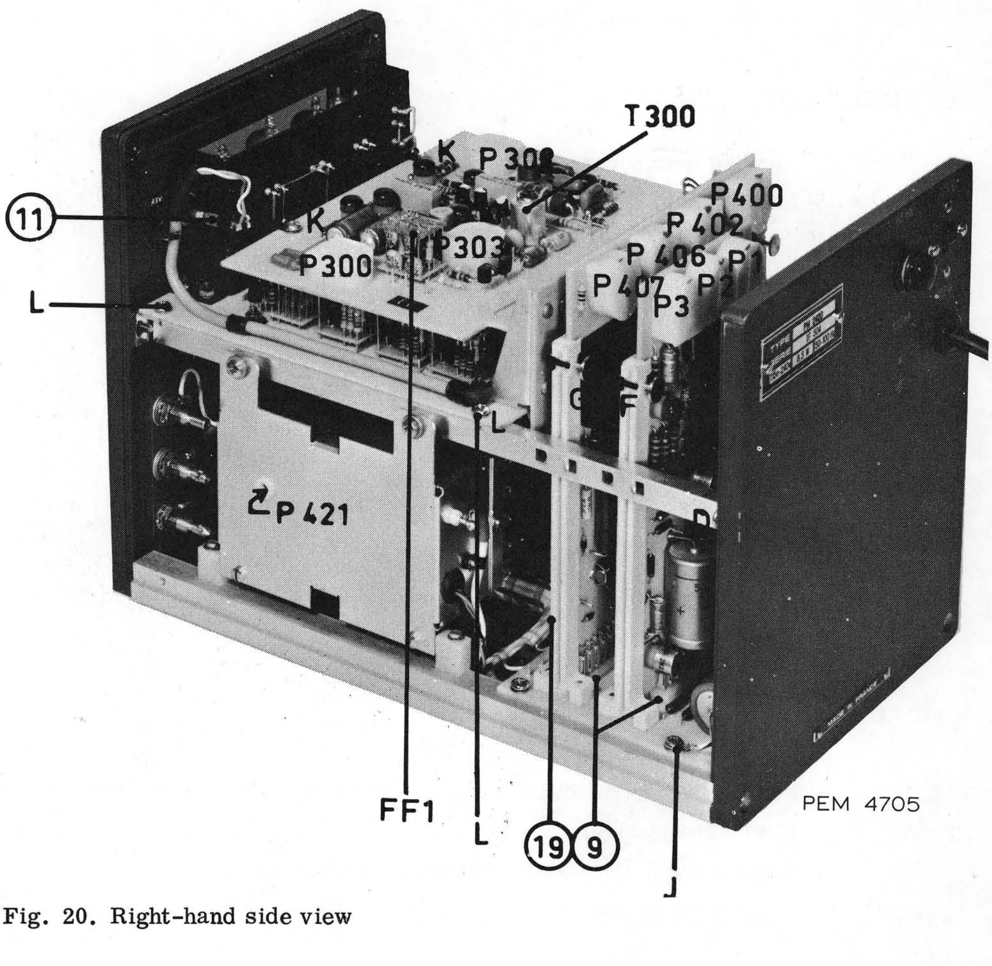


Fig. 20. Right-hand side view

C. MONOKNOB

- Remove the bottom panel and the text plate (VIII. B+C).
- Set the monoknob to position "3 V AC".
- Loosen the allen screw some turns.
  This screw is accessible from the bottom with a 2 mm allen key.
- Remove the monoknob.

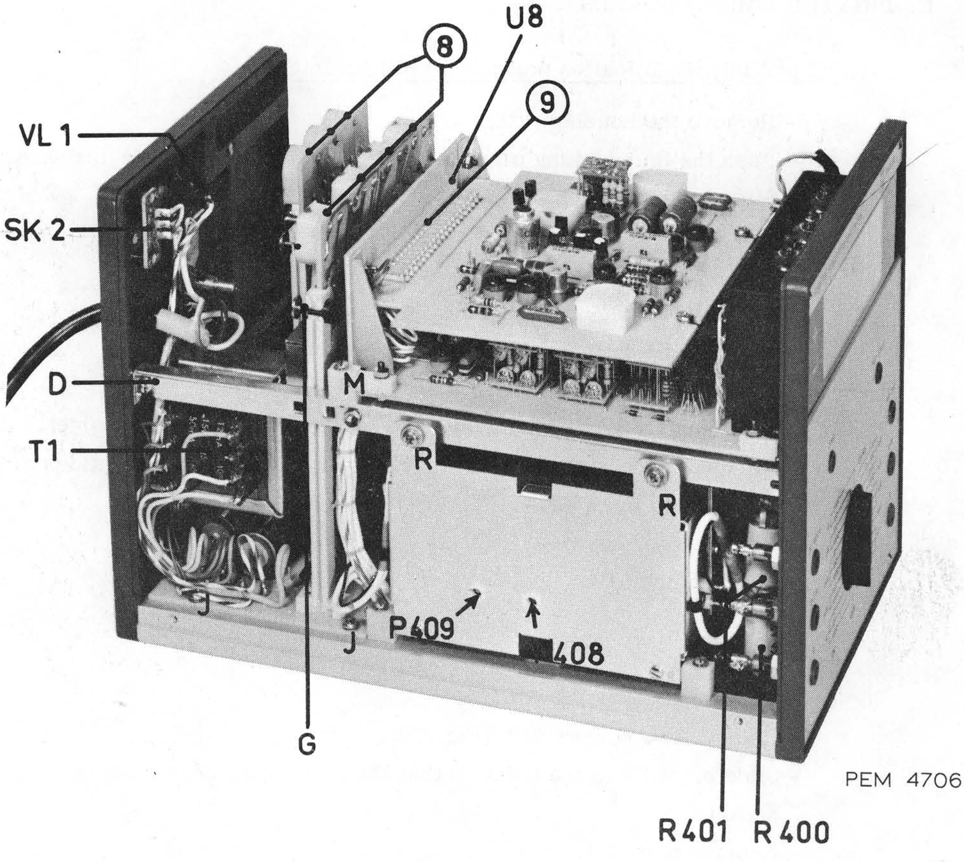


Fig. 21. Left-hand side view

D. SELECTOR SWITCH

- Remove the housing (see VIII. A).
- Remove the monoknob (see C).
- Unsolder the wires (mark them, if necessary!).
- Loosen the central fixing nut of the switch by means of a 12 mm box spanner.
- Remove the print plate at the back of the switch (two screws).
- Remove the switch.

Note: The switch is provided with a cam at the front for correct mounting.

E. PRINTED WIRING BOARDS

1. U2 and U4, stabilisation unit and amplifier unit

- Remove the housing (VIII. A).
- Push the four locking pins "F" and "G" (Figs. 20 and 21) forward.
- Slide the prints upwards.

2. U1, Supply unit

- Remove the housing (VIII. A).
- Remove the bottom panel (VIII. B).
- Remove U2 and U4 (E. 1).
- Unsolder all connection wires (component side and wiring side).
- Remove eight screws "H" (Fig. 31) with which the print-guides are mounted on print U1.
- Remove four screws "J" (Figs. 20 and 21).
- Remove print U1.

3. U3, ADC unit

- Remove the housing (VIII. A).
- Remove two screws "K" (Fig. 20).
- Slide print U3 to the front so that the print plate comes out of its socket.
- Remove print U3.

4. U5, Counter unit

- Remove the housing (VIII. A).
- Remove print U3 (E.3).
- Remove two screws "L" (Fig. 20).
- Remove screw "M" (Fig. 21).
- Remove two screws "N" (Fig. 32).
- Slide the print backwards, so that it comes clear of the pivot at the front.
- Lift the print up at the front and slide it out of the socket.

Note: U3 and U5 can be hinged out together (see Fig. 32) after loosening the screws "L" (Fig. 20).

5. U6, DC attenuator unit

- Remove the housing.
- Remove two screws "R" (Fig. 21).
- Hinge out the box.
- Remove two screws "S" (Fig. 32) and open the box.
- Unsolder the wires.
- Remove the four screws in the corners and remove the print.

6. U7, AC attenuator unit

- Remove the housing (VIII. A).
- Remove the screws "O" (Fig. 20).
- Hinge out the box.
- Remove two screws "P" (Fig. 32) and open the box.
- Remove four screws "Q" (Fig. 32).
- Unsolder the wires.
- Remove the mounting plate and print plate U7.

7. U8, Connection print

- Remove the housing.
- Remove print U3 (E.3).
- Remove print U5 (E.4).
- Unsolder all connection wires and remove the print.

F. ELECTRICAL COMPONENTS

1. Resistors

The instrument does not contain any selected resistors. However, the tolerances stated in the list of electrical parts, should be taken into consideration.

2. Capacitors

Capacitors C302 and C312 in the ADC (unit U3) are polycarbonate capacitors the temperature coefficient difference $\left(\frac{\Delta C302}{\Delta T^o} - \frac{\Delta C312}{\Delta T^o}\right)$ of which is lower than 20 ppm in the temperature range 0 ^oC - 50 ^oC.

If one of these capacitors turns out to be defective both capacitors should be replaced (for ordering number see list of electrical parts).

All other capacitors can be simply replaced,provided that capacitors of the correct tolerances are chosen.

3. Transistors

a. TS302 and TS305

Transistors TS302 and TS305 in the ADC (unit U3) are silicon transistors and are selected as regards amplification factor (α_{FE}). This factor should be: $20 < \alpha_{FE} < 40$ at $I_C = 100\ \mu A$ and $V_{CE} = 10$ V. Moreover:

$$0.9 < \frac{\alpha_{FE}\ TS302}{\alpha_{FE}\ TS305} < 1.1$$

If one of the transistors turns out to be defective both transistors should be replaced (for ordering number reference is made to the list of electrical parts).

b. TS400

Transistor TS400 is a PNP silicon transistor selected for an amplification factor between 30 and 60 at $I_C = 100\ \mu A$ and $V_{CE} = 10$ V. In case of replacement use the transistor stated in the list of electrical parts.

c. TS401

Transistor TS401 is a NPN silicon transistor selected for an amplification factor between 30 and 60 at $I_C = 100\ \mu A$ and $V_{CE} = 10\ V$.
In case of a replacement use the transistor stated in the list of electrical parts.

4. Diodes GR2 and GR4 on unit U2

Zener diode GR4 (type 1N753A or 1N754A) should be selected as regards zener voltage, which should lie between 6.2 V and 6.7 V at a zener current of 10 mA. Zener diodes, which do not comply with this requirements can be used for the replacement of GR2.

X. MAINTENANCE

The PM 2420 does not comprise any components which are subject to wear. Consequently, the instrument requires hardly any maintenance. Attention should be paid, however, to environmental conditions such as humidity, temperature and dust.
Under extreme conditions the accurate working of the instruments can not be guaranteed.
If necessary, the spindle of the range selector switch may be lightly oiled at the bearing points with thin lubricating oil (e.g. sewing machine oil). The stop should be greased with MOLYCOTE grease.
Should the contacts give rise to difficulties which may be solved by lubricating, only use the special switch oil, which can be ordered under the code-number stated in the list of mechanical parts.

XI. SURVEY OF ADJUSTMENTS

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

Adjusting element	Fig.	Adjustment or check	Required auxiliarly equipment	Adjust according to chapter XII point
--	--	Current consumption	Ammeter (e.g. Philips PM 2411)	A.1
--	--	+280 V source	DC voltmeter 1V-300V class 0.5	A.2.a
P1	20+34	+15 V source	DC voltmeter 1V-300V class 0.5	A.2.b.
P2	20+34	-15 V source	DC voltmeter 1V-300V class 0.5	A.2.c
P3	20+34	-26.5 V source	DC voltmeter 1V-300V class 0.5	A.2.d
--	--	+10 V source	DC voltmeter 1V-300V class 0.5	A.2.e
P300	20+36	Calibration voltage	Digital voltmeter (e.g. Philips PM 2433)	A.2.f
T300	20+36	Clock oscillator frequency	Electronic counter (e.g. Philips PM 6630)	B
P303 "ZERO"(P304)	20+36	Zero adjustment	--	C
P302 "FULL SCALE"(P301)	20+36	Full scale adjustment	--	D
P407, R427	20+38	100 mV DC range	DC voltage source, 100 mV - 100 V (e.g. GM 4561); Digital voltmeter (e.g. Philips PM 2433)	E.1
R426	38	1000 mV DC range	DC voltage source, 100 mV - 100 V (e.g. GM 4561); Digital voltmeter (e.g. Philips PM 2433)	E.2
--	--	10 V range	DC voltage source, 100 mV - 100 V (e.g. GM 4561); Digital voltmeter (e.g. Philips PM 2433)	E.3
P409	21+40	100 V range	DC voltage source, 100 mV - 100 V (e.g. GM 4561); Digital voltmeter (e.g. Philips PM 2433)	E.4
P408	21+40	1000 V range	DC voltage source (e.g. PE 4839/00)	E.5
P402	20+38	1 MΩ range	Resistor 1 MΩ ± 0.1 % (4822 116 50282)	F
P401	38	100 kΩ range	Resistor 100 kΩ ± 0.1 % (4822 116 50244)	F
P400	20+38	10 kΩ range	Resistor 10 kΩ ± 0.1 % (4822 116 50276)	F
--	--	1 kΩ range	Resistor 1 kΩ ± 0.1 % (4822 116 50274)	F
--	--	100 Ω range	Resistor 100 Ω ± 0.1 % (4822 116 50286)	F

Adjusting element	Fig.	Adjustment or check	Required auxiliarly equipment	Adjust according to chapter XII point
P406	20+38	0.3 V AC range	LF Generator 0.3 V - 30 V (e.g. Philips PM 5140)	G
P405	38	3 V AC range		
P421 }	20	30 V AC range	Accurate AC milli-voltmeter (e.g. PM 2433 + PM 2562)	
C452 }	31			
		DC current ranges	Current source (e.g. PE 4804 + series resistor) Digital voltmeter (e.g. PM 2433) Resistance decade, accuracy ± 0.1 %	H

XII. CHECKING AND ADJUSTING

The tolerances mentioned in this chapter only apply to a completely readjusted instrument and may therefore deviate from the data given in chapter II.

In chapter XI a survey is given of the adjustments, adjusting elements and the required equipment.

Recalibration may only be carried out if measuring instruments and voltage sources are available that comply with the requirements made.

A. POWER SUPPLY

1. Current consumption

- Connect the instrument to the nominal mains voltage via a variable transformer and an ammeter (e.g. multimeter PM 2411).
- Current consumption at 110 V : approx. 50 mA
  at 220 V : approx. 36 mA.

2. DC output voltages

Voltage source	Measuring point	Value	Adjusting element
a. +280 V	test point 19 (Fig. 33) and socket "0"	+280 V ± 14 V	none
b. +15 V	test point 16 (Fig. 34) and socket "0"	+15 V ± 750 mV	P1
c. -15 V	test point 18 (Fig. 34) and socket "0"	-15 V ± 750 mV	P2
d. -26.5 V	test point 20 (Fig. 34) and socket "0"	-26.5 V ± 130 mV	P3
e. +10 V	test point 21 (Fig. 34) and socket "0"	+10 V ± 1 V	none
f. -9.995 V	sockets "REF. OUT" and "0"	-9.995 V ± 10 mV	P300

B. CLOCK OSCILLATOR FREQUENCY

- Check the clock oscillator frequency. For this purpose connect an electronic counter between the emitter of TS314 and ⊥
- Adjust the counter to 1 second.
- The frequency should be 390 kHz $\pm$ 1 %
- If necessary, adjust T300.

C. ZERO ADJUSTMENT

- Set monoknob to position "10 V DC".
- Connect socket "VΩA" to "0"
- Set potentiometer "ZERO" (front) to the mid position
- Adjust potentiometer P303 to 0.00 indication (polarity indication lamps light up alternately).

D. FULL SCALE ADJUSTMENT

- Set monoknob to position "10 V DC"
- Interconnect sockets "VΩA" and "REF. OUT"
- Set potentiometer "FULL SCALE" (front) to the mid position
- Adjust potentiometer P302 to 9.99 indication

E. ADJUSTING THE DC VOLTAGE RANGES

1. <u>100 mV range</u>

- Set the monoknob to position "10 V DC"
- Interconnect sockets "VΩA" and "0"
- Adjust the indication to 0.00 with "ZERO"
- Set the monoknob to position "100 mV DC"
- Adjust potentiometer P407 to obtain 00.0 indication
- Apply 100 mV $\pm$ 0.1 % to the instrument. Check this voltage with a digital voltmeter.
- The indication should be: 99.6 ... 100.4. If not, the value of R427 should be changed
- Check the linearity by applying successively 0.1 mV; 0.2 mV; 0.4 mV; 0.8 mV; 1.6 mV; 3.2 mV; 6.4 mV; 11.1 mV; 22.2 mV; 33.3 mV; 44.4 mV; 55.5 mV; 66.6 mV; 77.7 mV; 88.8 mV and 99.9 mV.

2. <u>1000 mV range</u>

- Set monoknob to position "1000 mV DC"
- Apply 1 V $\pm$ 5.10^{-4} %. Check with a digital voltmeter.
- The indication should be: 996...1004. If not, the value of R426 should be changed.

3. <u>10 V range</u>

- Set monoknob to position "10 V DC"
- Apply 10 V $\pm$ 5.10^{-4} %. Check with a digital voltmeter
- Check the indication: 9.99 ... 10.01.
- Check the linearity by applying successively 0.01 V; 0.02 V; 0.08 V; 0.16 V; 0.32 V; 0.64 V; 1.11 V; 2.22 V; 3.33 V; 4.44 V; 5.55 V; 6.66 V; 7.77 V; 8.88 V and 9.99 V.

4. <u>100 V range</u>

- Set monoknob to position "100 V DC".
- Apply 100 V $\pm$ 5.10^{-4} %. Check with accurate digital voltmeter.
- Adjust the indication to 99.9 ...100.1 with potentiometer P409.

5. <u>1000 V range</u>

- Set the monoknob to position "1000 V DC"
- Apply 1000 V $\pm$ 5.10^{-4} % to sockets "1000 V DC" and "0". Check with an accurate DC Voltmeter
- Adjust the indication to 999...1001 with potentiometer P408.

F. ADJUSTING THE Ω-RANGES

Monoknob in position	Resistor to be connected to sockets "VΩA" and "0"	Indication	Adjust with
1000 kΩ	1 MΩ $\pm$ 0.1 %	997 ... 1003	P402
100 kΩ	100 kΩ $\pm$ 0.1 %	997 ... 1003	P401
10 kΩ	10 kΩ $\pm$ 0.1 %	997 ... 1003	P400
1 kΩ	1 kΩ $\pm$ 0.1 %	997 ... 1003	---
100 Ω	100 Ω $\pm$ 0.1 %	997 ... 1003	---

G. ADJUSTING THE AC VOLTAGE RANGES

Monoknob in position	Apply to sockets "VΩA" and "0"	Indication	Adjusting element
0.3 V	0.3 V, 1 kHz	298 ...302	P406
3 V	3 V, 1 kHz	2.98 ... 3.02	P405
30 V	30 V, 50 kHz	29.8 ... 30.2	P421
30 V	30 V, 10 kHz	29.8 ... 30.2	C452

Note: Check the applied voltage with an accurate AC millivoltmeter, class 0.2 (e.g. Philips AC to DC Converter PM 2562 + Digital voltmeter PM 2433).

Checking the 300 V AC range

- Set monoknob to position "30 V AC"
- Apply 3 V, 10 kHz, to sockets "VΩA" and "0"
- Indication 030 ± 1 %
- Apply 300 V, 50 or 60 Hz, to sockets "VΩA" and "0"
- Indication 300 ± 1 %.

H. CHECKING THE CURRENT RANGES

1. DC

Measuring set-up:

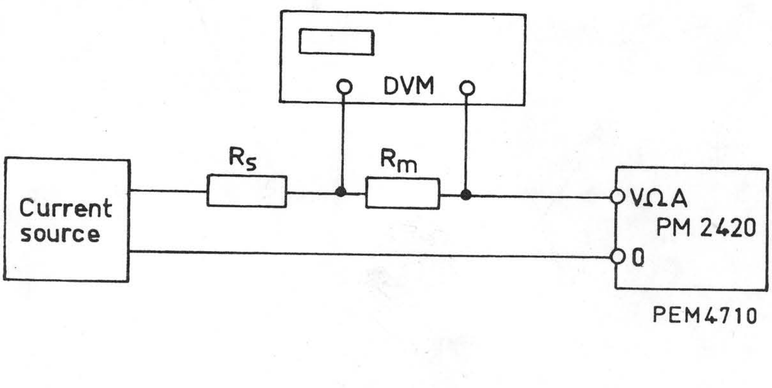


Fig. 22. Measuring set-up for checking the DC current ranges

Current source (e.g. PE 4804 + series resistor R_s) 100 μA - 1A
R_m = resistance decade box, accuracy 0.1 %.
Digital voltmeter e.g. PM 2433

Measuring procedure:

Measuring range	Value of R_s	Value of R_m	Adjust indication on PM 2433 to	Indication on PM 2420
100 μA	15 kΩ	1 kΩ	.1000 (range .3999)	99.0...101.0
1000 μA	15 kΩ	1 kΩ	1.000 (range 3.999)	99.0...101.0
10 mA	1 kΩ	100 Ω	1.000	99.0...101.0
100 mA	1 kΩ	10 Ω	1.000	99.0...101.0
1 A (via socket "1 A DC")		1 Ω	1.000	99.0...101.0

<u>AC</u>

A check of the AC current ranges is not necessary when the DC current ranges have been checked. The shunts used in the AC current section are the same as those used in the DC section.

XIII. TROUBLE SHOOTING

If the instrument appears to be out of order, it is advisable to check it systematically. The following instructions may greatly facilitate the fault finding. Data without tolerances represent the properties of an average instrument and may serve as a guide only.

1. The voltages mentioned in table 1 of Fig. 35 are the r.m.s. values of the voltages of the transformer at no-load. The values stated at the windings in the diagram represent the values valid under normal conditions.
   (Measurement carried out with AC millivoltmeter GM 6012).

2. In the circuit diagram of Fig. 43 DC voltages have been indicated at some points. These voltages have been measured with DC μV meter PM 2440 under the following conditions:
   - nominal mains voltage (220 V, 50 Hz)
   - calibrated
   - monoknob in position "10 V DC"
   - socket "VΩA" connected to socket "REF. OUT"

3. In table 1 and Fig. 23 below, the most important voltages and waveforms are given. Conditions:
   - nominal mains voltage (220 V, 50 Hz)
   - calibrated
   - voltages and waveforms with respect to circuit zero (socket "0")
   - monoknob in position "10 V DC" (unless otherwise stated)
   - socket "VΩA" connected to socket "REF. OUT" (unless otherwise stated)

   It is advised to follow the procedure given hereafter.

Table 1

To be measured	Measuring point	Fig.	DC level	Remark	AC waveform
Supply voltages	16	34	+ 14 V		
	17	34	0 V		
	18	34	- 14 V		
	20	34	- 26.5 V		
	21	34	+ 10.8 V		See Fig. 23 (I) } ripple
	19	33	+ 270 V		See Fig. 23 (II) } ripple
Reference voltage	socket "REF. OUT"		- 9.99 V ± 0.1 %		
Current source setting	1	36	- 13.5 V		
Trigger	CS4/19+20				See Fig. 23 (III)
Output OS_I	2	36			See Fig. 23 (IV)
Output OS_{II}	3	36			See Fig. 23 (V)
Logic input II	4	36			See Fig. 23 (VI)
Logic input I	5	36			See Fig. 23 (VII)
Logic output (gate input I)	6	36			See Fig. 23 (VIII)
Supply voltage +10V on ADC	7	36	+ 10.8 V		
Oscillator	9	36			See Fig. 23 (IX)
Oscillator out	10	36			See Fig. 23 (X)
Gate input II	8	36			See Fig. 23 (XI)

To be measured	Measuring point	Fig.	DC level	Remark	AC waveform
Gate out	CS4/9+10				See Fig. 23 (XII)
Output four-scaler	14	39			See Fig. 23 (XIII)
Carry to tens	13	39			See Fig. 23 (XIV)
Carry to hundreds	12	39			See Fig. 23 (XV)
Carry to thousands	11	39			See Fig. 23 (XVI)
Constant current source for resistance measurements	22	38	- 12.6 V	In position "10 V DC" of the monoknob and in the Ω-ranges, if a resistor is connected to the input	
AC current converted into an AC voltage	23	38			0.85 V_{p-p} at all AC current ranges, if an AC current of full scale value is applied to sockets "VΩA" and "0". Waveform depending on applied signal. See Fig. 23 (XVII)
Input impedance transformer	24	38	0 V		Amplitude a is: -0.85 V_{p-p} at ranges 300 mV and 30 V AC -8.5 V_{p-p} at ranges 3 V and 300 V AC if an A.C. voltage of full scale value is applied.

To be measured	Measuring point	Fig.	DC level	Remark	AC waveform
					Amplitude a is: 0.85 V_{p-p} at all AC current ranges if an AC current of full scale value is applied.
Output impedance trans-former	25	38	0 V		As indicated under "input impedance transformer".
(+) Input amplifier	26	38	- 1 V	At ranges 1000 V, 100 V and 10 V DC	
			100 mV	At range 100 mV DC	
			1 V	At range 1000 mV	
			100 mV	At all DC current ranges if a current of full-scale value is applied	
			- 100 mV	At the 100 Ω range if a resistor of full-scale value is applied.	
			- 1 V	At the 1000 Ω range if a resistor of full-scale value is applied.	
			0 V	At all other ranges	
Output amplifier	27	38	- 1.46 V	At 1000 V, 100V and 10 V DC ranges.	

To be measured	Measuring point	Fig.	DC level	Remark	AC waveform
			+ or - 10 V	At 1000 mV, 100 mV and DC current ranges, if full-scale values are applied. Polarity same as input polarity	
			- 10 V	At the 100 Ω and 1000 Ω range, if full-scale values are connected.	
			0 V	At the Ω-ranges, except 100 Ω and 1000 Ω-ranges.	
			- 0.76 V	At all AC positions, if full scale values are applied	See oscillogramme Fig. 23 (XVIII)
Input AC filter	28	38	- 3 V	At all AC ranges, if full scale values are applied to the input	See Fig. 23 (XIX)
Output AC filter	29	38	- 3 V	In all AC ranges, if full scale values are applied to the input.	See Fig. 23 (XX)

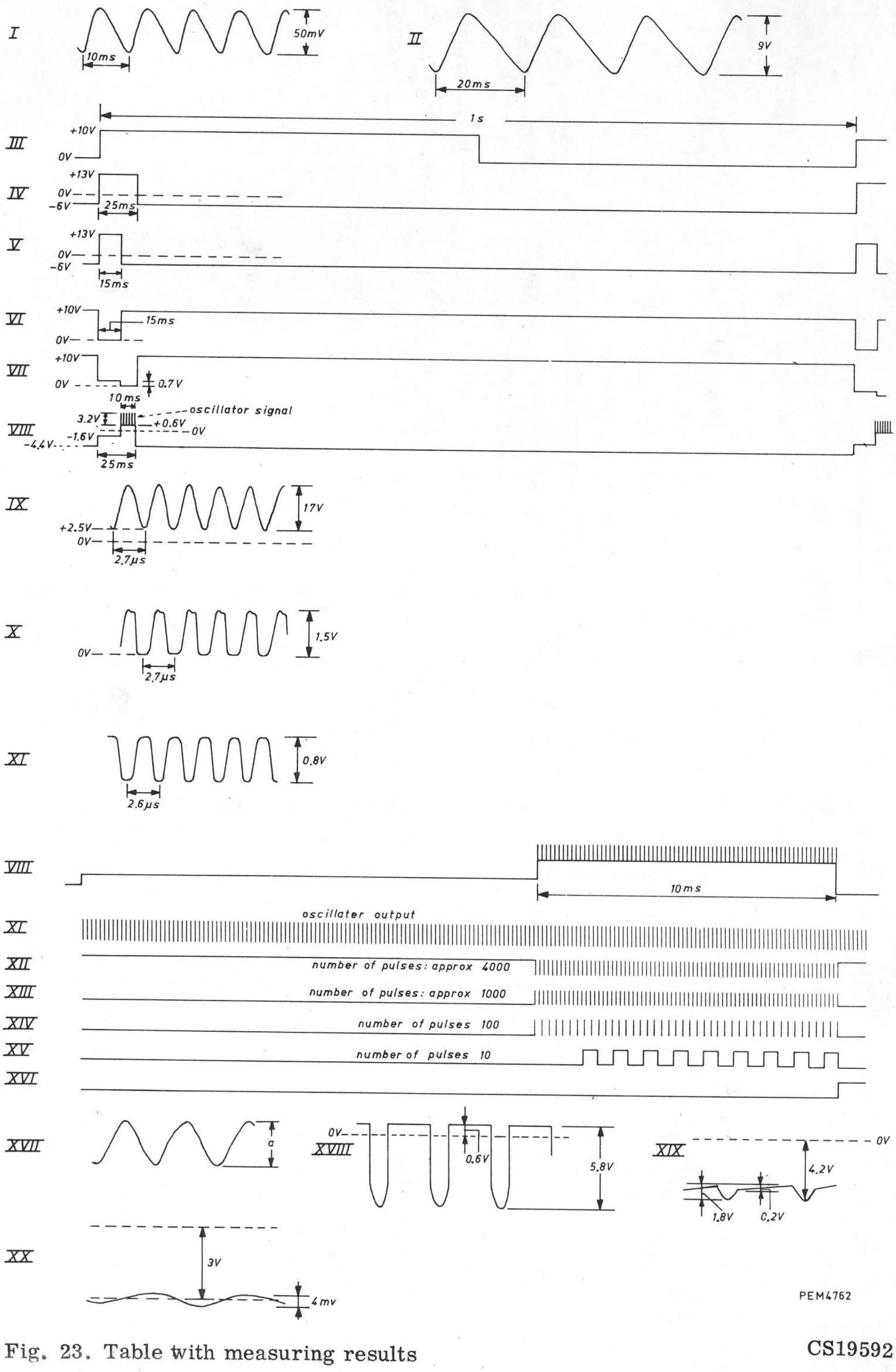


Fig. 23. Table with measuring results

CS19592

4. In a short time a large number of clock pulses is applied to the four-scaler. Moreover, the counter is reset every second. Therefore it is difficult to display the signals at the measuring points CS4/9+10, 14, 13, 12, 11 (see table 1) on an oscilloscope. Should the counter be out of order (unit U5) we may advise to remove the converter unit U3 (see IX.E3). Apply a square wave signal to point CS4/9 or 10. Unsolder also R502 and C503 on unit U5.
5. In position "10 V DC" the input is connected direct to the ADC. Therefore, it is suggested to start any repair check in this position, since under these circumstances the influence of the attenuators, amplifier, and rectifier will be negligible.
6. If the instrument does not function in the ranges 100 mV, 1000 mV, all DC current ranges and the resistance ranges "100 Ω" and "1000 Ω", this may be caused by fuse VL401 being defective.
7. Should all resistance ranges be out of order, this may be caused by VL402 being blown. In that case no current can pass through the resistor to be measured and, consequently, there is no voltage across the unknown resistance.

Remark

Should the instrument appear to be out of order, please apply for advise to the world-wide PHILIPS Service Organisation. If the repair work is to be effected at a Philips Service Centre please follow the procedure below:
- Attach a label to the instrument with full name and address of the sender
- Indicate as complete as possible the symptom(s) of the fault(s).
- Carefully pack the instrument in the original packing, or, if this is no longer available, in an other suitable packing.
- Send the instrument to the address mentioned by your local Philips representative.

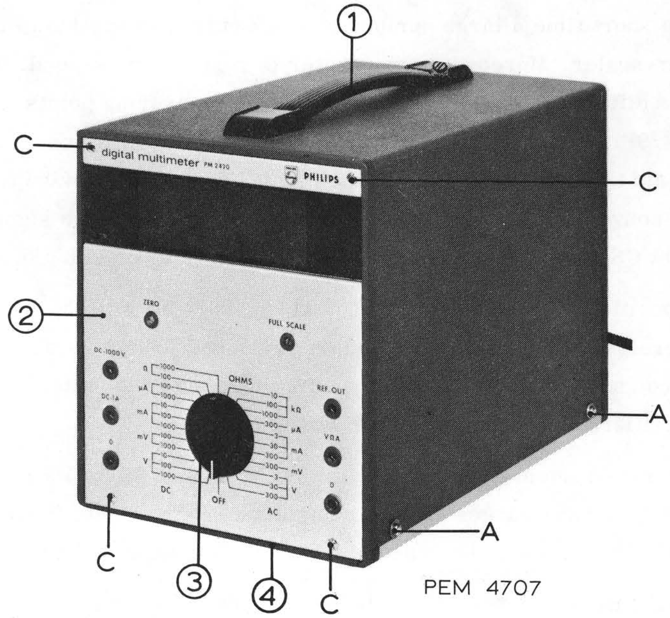


Fig. 24. Front view with item numbers

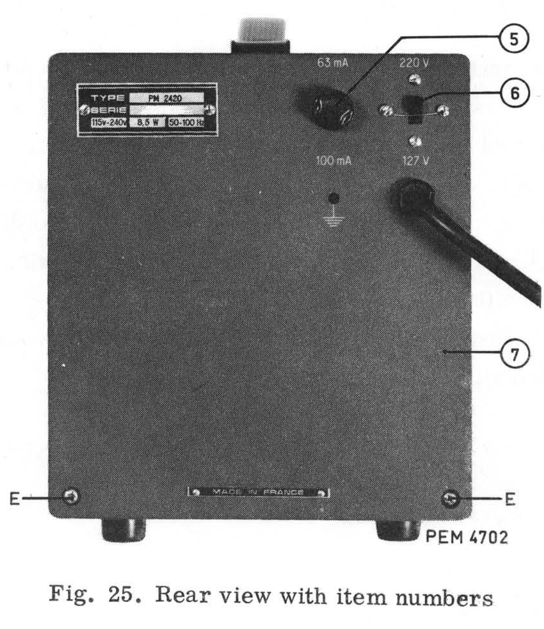


Fig. 25. Rear view with item numbers

XIV. LIST OF PARTS

A. MECHANICAL

Item	Fig.	Qty.	Ordering number	Description	Remark
1	24	1	4822 498 40263	Handle	Complete with two caps
2	24	1	4822 455 90338	Textplate	Complete with plastic window
3	24	1	4822 411 20135	Knob	For range selector
4	24	1	4822 693 90231	Front frame	With 6 sockets
5	25	1	4822 256 40017	Fuse holder	VL1
6	25	1	4822 277 20019	Slide switch	SK3
7	25	1	4822 693 90232	Rear frame	
8	20+21	5	4822 265 50024	Printconnector	
9	32	5	4822 255 30016	Lamp holder	For polarity lamps and decimal points
10	32	1	4822 255 30015	Lamp holder	For "1000" indicator
11	20	1	4822 255 30017	Lamp holder	For OVERLOAD lamp
12	32	3	4822 255 70145	Valve holder	For indicator tubes
13	20	4	4822 462 30114	Print guide	For units U2 and U4
14	31	1	4822 273 80128	Switch	SK1
15	19	4	4822 462 40207	Rubber studs	
16	--	30 cc	4822 390 10007	Switch lubricating	

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.

Component	Specification
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 ≦ 1,5 MΩ, 5% > 1,5 MΩ, 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.

Potentiometers

Nr.	On unit	Ordering number	Value		W	%	Description
P1	U2	4822 100 10014	2.5	kΩ			Carbon
P2	U2	4822 100 10014	2.5	kΩ			Carbon
P3	U2	4822 100 10014	2.5	kΩ			Carbon
P300	U3	4822 101 10062	5	kΩ			Carbon
P301	--	4822 103 20033	1	kΩ	1	20	Wire-wound
P302	U3	4822 100 10016	22	kΩ			Carbon
P303	U3	4822 100 10016	22	kΩ			Carbon
P304	--	4822 103 20163	5	kΩ	1	20	Wire-wound
P400	U4	4822 100 10014	2.5	kΩ			Carbon
P401	U4	4822 100 10016	25	kΩ			Carbon
P402	U4	4822 101 10056	250	kΩ			Carbon
P405	U4	4822 100 10014	2.5	kΩ			Carbon
P406	U4	4822 100 10011	220	kΩ			Carbon
P407	U4	4822 101 10053	50	kΩ			Carbon
P408	U6	4822 100 10082	470	kΩ			Carbon
P409	U6	4822 101 10057	100	kΩ			Carbon
P421	U7	4822 101 20281	5	kΩ			Carbon

Resistors

Nr.	On unit	Ordering number	Value		W	%	Description
R305	U3	4822 111 70107	220	kΩ	2	10	Carbon
R307	U3	4822 116 50198	110	kΩ		1	Metal film
R310	U3	4822 116 50198	110	kΩ		1	Metal film
R342	U3	4822 116 50198	68	kΩ		1	Metal film
R343	U3	4822 116 50111	39	kΩ		1	Metal film
R400	U4	4822 113 50073	0.1	Ω	1	1	Wire-wound
R401	U4	4822 113 50074	0.9	Ω	1	1	Wire-wound
R402	U4	4822 110 30061	9	Ω	$\frac{1}{2}$	1	Carbon (2x18 Ω in par.)
R403	U4	4822 110 30087	90	Ω	$\frac{1}{2}$	1	Carbon (2x180 Ω in par.)
R404	U4	4822 110 30114	900	Ω	$\frac{1}{2}$	1	Carbon (2x1K8 in par.)

Nr.	On unit	Ordering number	Value		W	%	Description
R408	U4	4822 113 80111	2.2	kΩ	7	5	Wire-wound
R409	U4	4822 116 50119	12	kΩ	$\frac{1}{4}$	5	Metal film
R410	U4	4822 116 50049	20	kΩ	$\frac{1}{4}$	5	Metal film
R411	U4	4822 116 50136	120	kΩ	$\frac{1}{4}$	5	Metal film
R412	U4	4822 110 30189	1.2	MΩ	$\frac{1}{4}$	5	Carbon
R415	U6	4822 116 50488	4.95	MΩ	1	2	Metal film
R416	U6	4822 116 50488	4.95	MΩ	1	2	Metal film
R417	U6	4822 116 50488	4.95	MΩ	1	2	Metal film
R418	U6	4822 116 50488	4.95	MΩ	1	2	Metal film
R419	U6	4822 116 50487	10	MΩ	2	2	Metal film
R420	U6	4822 116 50487	10	MΩ	2	2	Metal film
R421	U6	4822 116 50489	1.06	MΩ	2	2	Metal film
R426	U4	4822 113 80111	2.2	kΩ	7	5	Wire-wound
R427	U4	4822 116 50486	1111	Ω		$\frac{1}{4}$	Metal film
R428	U4	4822 116 50485	101	Ω		$\frac{1}{4}$	Metal film
R429	U4	4822 116 50463	10	kΩ		$\frac{1}{4}$	Metal film
R431	U4	4822 116 50102	8.2	kΩ	$\frac{1}{4}$	5	Metal film
R432	U4	4822 116 50098	820	Ω	$\frac{1}{4}$	5	Metal film
R451	U7	4822 116 50487	10	MΩ	2	2	Metal film
R452	U7	4822 116 50462	98.5	kΩ		1	Metal film

Capacitors

Nr.	On unit	Ordering number	Value		V	%	Description
C1	U2	4822 124 20374	64	μF	40		Electrolytic
C2	U2	4822 124 10004	10	μF	16		Electrolytic
C4	U2	4822 124 20374	64	μF	40		Electrolytic
C5	U2	4822 124 10004	10	μF	16		Electrolytic
C7	U2	4822 124 20355	10	μF	25		Electrolytic
C8	U2	4822 124 20381	64	μF	64		Electrolytic
C10	U2	4822 124 20411	500	μF	25		Electrolytic
C11	U2	4822 124 10004	10	μF	16		Electrolytic
C12	U2	4822 124 20411	500	μF	25		Electrolytic
C13	U1	4822 124 20434	16	μF	400		Electrolytic

Nr.	On unit	Ordering number	Value		V	%	Description
C14	U1	4822 124 20434	16	μF	400		Electrolytic
C302*	U3	4822 121 50408	0.1	μF	160	5	Polycarbonate
C306	U3	4822 121 50372	2200	pF	63	5	Styroflex
C307	U3	4822 124 20384	100	μF	16		Electrolytic
C308	U3	4822 121 40168	4.7	nF	250		Polyester
C309	U3	4822 124 10004	10	μF	16		Electrolytic
C310	U3	4822 124 20384	100	μF	16		Electrolytic
C311	U3	4822 121 40055	47000	pF			Polyester
C312*	U3	4822 121 50408	0.1	μF	160	5	Polycarbonate
C402	--	4822 121 40214	0.1	μF	1000		Paper
C403	U4	4822 124 20342	1.6	μF	64		Electrolytic
C408	U4	4822 124 20388	160	μF	16		Electrolytic
C409	U4	4822 121 50038	270	pF	160		Styroflex
C450	--	4822 120 60081	100	pF		5	Mica
C451	--	4822 120 60058	15	pF		5	Mica
C452	--	4822 125 60033	12	pF			Trimmer
C453	U7	4822 120 60107	2000	pF		5	Mica (2x1K in par.)
C454	U7	4822 124 20342	1.6	μF	64		Electrolytic
C455	U7	4822 120 50143	22000	pF	1000		Paper
C456	U4	4822 124 20357	16	μF	16		Electrolytic
C457	U4	4822 120 60107	1000	pF		5	Mica
C458	U4	4822 124 10004	10	μF	16		Electrolytic
C501	U5	4822 124 20346	4	μF	64		Electrolytic
C502	U5	4822 124 20346	4	μF	64		Electrolytic
C503	U5	4822 122 30092	180	pF	10		Ceramic

* See IX. F. 2

Miscellaneous

Nr.	Fig.	Ordering number	Description	Remark
U1	25	4822 216 70118	Printed wiring board	
U2	26	4822 216 70114	Printed wiring board	With components
U3	26	4822 216 70121	Printed wiring board	With components
U4	26	4822 216 70115	Printed wiring board	With components
U5	26	4822 466 10151	Printed wiring board	Without components
U6	26	4822 216 70117	Printed wiring board	With components
U7	26	4822 216 70116	Printed wiring board	With components
U8	22	4822 216 70119	Printed wiring board	
VL1	--	4822 253 30006	Fuse 100 mA (delayed action)	For mains voltages of 127 V
		4822 253 30004	Fuse 63 mA (delayed action)	For mains voltages of 220 V
T1	22	4822 146 40166	Mains-transformer	
T300	21	4822 158 30134	Oscillator coil	On unit U3
FF1	21	4822 209 80031	Module	Complete bistable multivibrator on U3
AM1	--	4822 209 80025	Module	Complete astable multivibrator on U5
FF2-FF16	--	4822 209 80026	Module	Complete bistable multivibrator on U5
D1-D3	--	4822 209 80027	Module	Complete decoder on U5
LA401	--	4822 134 40181	Pilot lamp 6 V, 50 mA	Overload indicator
L401	--	4822 158 20249	Choke	
--	--	4822 209 80028	Operationel amplifier	Nexus SQ-10A
VL401	--	4822 253 20002	Fuse 31 mA (quick)	On unit U4
VL402	--	4822 253 20002	Fuse 31 mA (quick)	On unit U4
B601	--	ZM1000	Indicator tube	
B602	--	ZM1000	Indicator tube	
B603	--	ZM1000	Indicator tube	
LA601	--	4822 134 20057	One thousand indicator	
LA602-LA605		4822 134 20058	Pilot lamp	Decimal points and polarity indicators

Transistors

Nr.	Ordering number	Type	Manufacturer
TS1	4822 130 40393	2N2195A	Sesco
TS2	4822 130 40394	2N2926	Sesco
TS3	4822 130 40395	BC139	Fairchild
TS4	4822 130 40396	BC116	Fairchild
TS5	4822 130 40396	BC116	Fairchild
TS6	4822 130 40396	BC116	Fairchild
TS7	4822 130 40396	BC116	Fairchild
TS8	4822 130 40393	2N2195A	Sesco
TS301	4822 130 40397	125DT2	Sesco
TS302 x	4822 130 40401	2N2218	Texas Instruments
TS303	4822 130 40396	BC116	Fairchild
TS304	4822 130 40397	125DT2	Sesco
TS305 x	4822 130 40401	2N2218	Texas Instruments
TS306	4822 130 40396	BC116	Fairchild
TS307	4822 130 40396	BC116	Fairchild
TS308	4822 130 40396	BC116	Fairchild
TS309	4822 130 40396	BC116	Fairchild
TS310	4822 130 40396	BC116	Fairchild
TS312	4822 130 40399	2N3605	Sesco
TS313	4822 130 40399	2N3605	Sesco
TS314	4822 130 40399	2N3605	Sesco
TS315	4822 130 40398	BSX21A	RTC
TS316	4822 130 40398	BSX21A	RTC
TS317	4822 130 40396	BC116	Fairchild
TS318	4822 130 40396	BC116	Fairchild
TS400 xx	4822 130 40402	BC116	Fairchild
TS401 xxx	4822 130 40403	125DT2	Sesco
TS402	4822 130 40394	2N2926	Sesco
TS403	4822 130 40404	2N3819	Texas Instruments
TS405	4822 130 40394	2N2926	Sesco

x Selected pair, see IX. F. 3a

xx Selected (red point), see IX. F. 3b

xxx Selected (orange point), see IX. F. 3c

Nr.	Ordering number	Type	Manufacturer
TS406	4822 130	2N4303	Sesco
TS501	4822 130 40396	BC116	Fairchild
TS502	4822 130 40398	BSX21A	RTC
TS1-10	4822 130 40398	BSX21A	RTC (10 pieces on U5)
TS101-110	4822 130 40398	BSX21A	RTC (10 pieces on U5)
TS1001-1010	4822 130 40398	BSX21A	RTC (10 pieces on U5)

Dioden

Nr.	Ordering number	Type	Manufacturer	
GR1	4822 130 30316	TV4F	Siemens	
GR2	4822 130 30316	TV4F	Siemens	
GR3	4822 130 30316	TV4F	Siemens	
GR4	4822 130 30316	TV4F	Siemens	
GR5	4822 130 30316	TV4F	Siemens	
GR6	4822 130 30316	TV4F	Siemens	
GR7 } GR8 }	4822 209 80029	TV4F	Siemens (module)	
GR1	4822 130 30315	1N752A	Inter Rectifier	on unit U2
GR2[x]	4822 130 30163	1N753A	Siemens	on unit U2
GR3	4822 130 30315	1N752A	Inter Rectifier	on unit U2
GR4[x]	4822 130 30163	1N753A	Siemens	on unit U2
GR5	4822 130 30315	1N752A	Inter Rectifier	on unit U2
GR6	4822 130 30314	DZ15A	Silec	on unit U2
GR7	4822 130 30314	DZ15A	Silec	on unit U2
GR8	4822 130 30315	1N752A	Inter Rectifier	on unit U2

[x] See IX.F.4

Nr.	Ordering number	Type	Manufacturer
GR9	4822 130 30315	1N752A	Inter Rectifier
GR301	4822 130 30317	BAW16	Texas Instruments
GR302	4822 130 30317	BAW16	Texas Instruments
GR303	4822 130 30317	BAW16	Texas Instruments
GR304	4822 130 30317	BAW16	Texas Instruments
GR306	4822 130 30318	34P4	Sesco
GR307	4822 130 30318	34P4	Sesco
GR308	4822 130 30318	34P4	Sesco
GR309	4822 130 30318	34P4	Sesco
GR310	4822 130 30318	34P4	Sesco
GR311	4822 130 30318	34P4	Sesco
GR400	4822 130 30317	BAW16	Texas Instruments
GR401	4822 130 30317	BAW16	Texas Instruments
GR402	4822 130 30317	BAW16	Texas Instruments
GR403	4822 130 30317	BAW16	Texas Instruments
GR404	4822 130 30319	40Z4	Sesco
GR405	4822 130 30319	40Z4	Sesco
GR406	4822 130 30317	BAW16	Texas Instruments
GR407	4822 130 30317	BAW16	Texas Instruments
GR408	4822 130 30318	34P4	Sesco
GR409	4822 130 30318	34P4	Sesco
GR502	4822 130 30318	34P4	Sesco
GR31	4822 130 30318	34P4	Sesco
GR32	4822 130 30318	34P4	Sesco
GR131	4822 130 30318	34P4	Sesco
GR132	4822 130 30318	34P4	Sesco
GR1031	4822 130 30318	34P4	Sesco
GR1032	4822 130 30318	34P4	Sesco

XV. FUNCTIONAL BLOCKS

1. General-purpose operational amplifier SQ-10a (Nexus)

These amplifiers have been designed for use in most analogue and digital circuits and systems. All units provide high gain, excellent stability and extremely low offset voltages and currents. Silicon semiconductors are used exclusively in all models.

Technical data

The specified data are subject to frequent change, because of continuing product improvement.

Output range	: min. $\pm 10\ V_{pp}$ min. ± 5 mA
DC open loop gain	: min. 60,000 typical 100,000
Gain test load	: 10 kΩ
Input bias current	: typical $\pm$ 30 nA, max. $\pm$ 100 nA } at 25 C temperature coefficient: typical 1.5 nA/^{o}C max. 2 nA/^{o}C
Offset voltage temperature coefficient	: typical $\pm$ 5 μV/^{o}C max. $\pm$ 20 μV/^{o}C
Offset/supply voltage stability coefficient	: typical 200 μV/V
Maximum frequency for full output	: typical 25 kHz
Small signal unity-gain cross-over frequency	: typical 2 MHz
Common mode input voltage	: max. $\pm$ 10 V
Typical DC input impedance	: differencial 0.3 MΩ common mode 30 MΩ
Power	: nominal $\pm$ 15 V max. $\pm$ 15 mA
External voltage offset trim potentiometer	: 50 kΩ

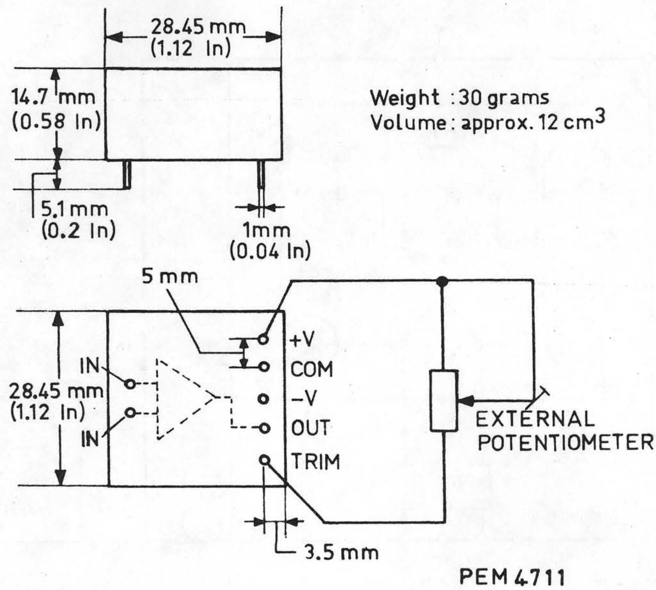


Fig. 26. Operational amplifier block

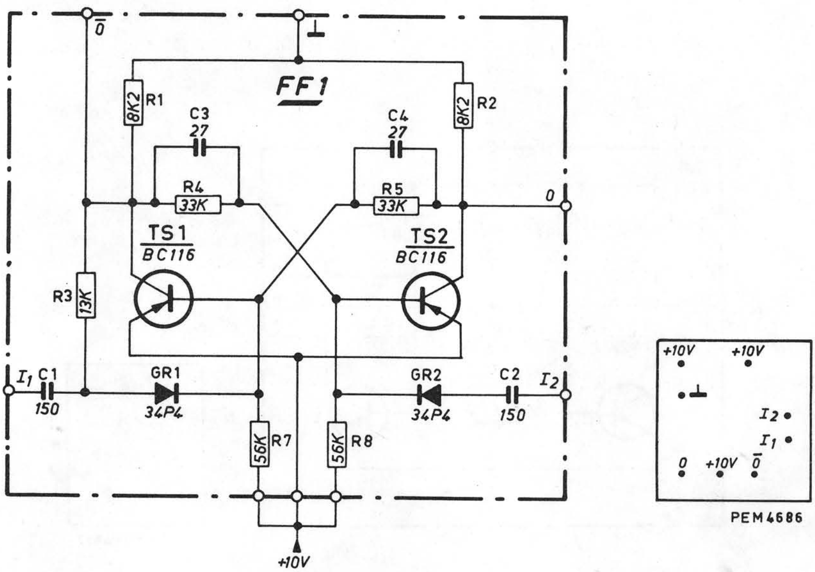


Fig. 27. Polarity indication flip-flop (FF1)

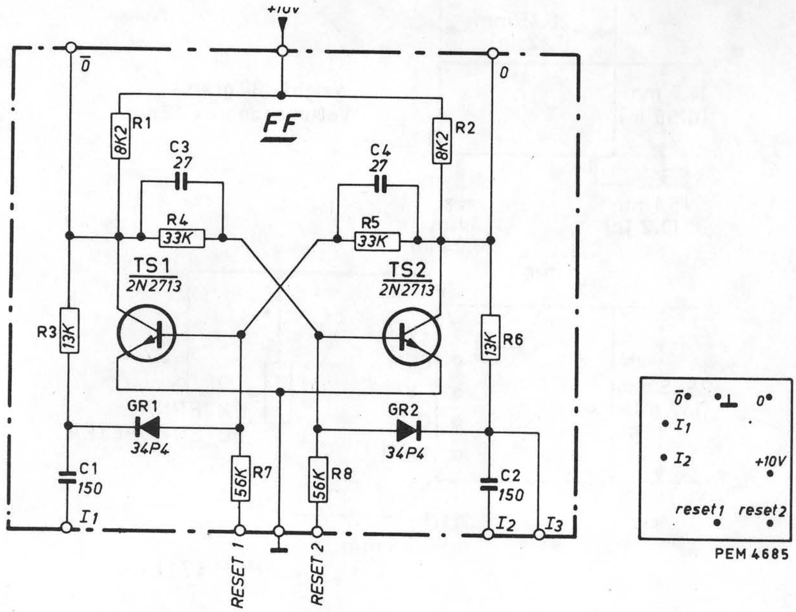


Fig. 28. Decade flip-flop (FF2...FF16)

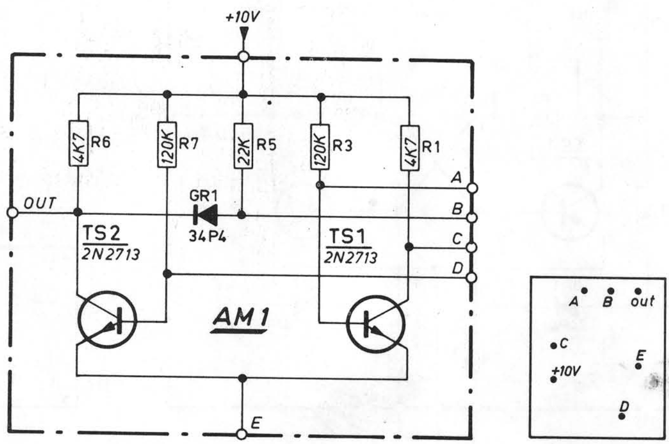


Fig. 29. Astable multivibrator AM1.

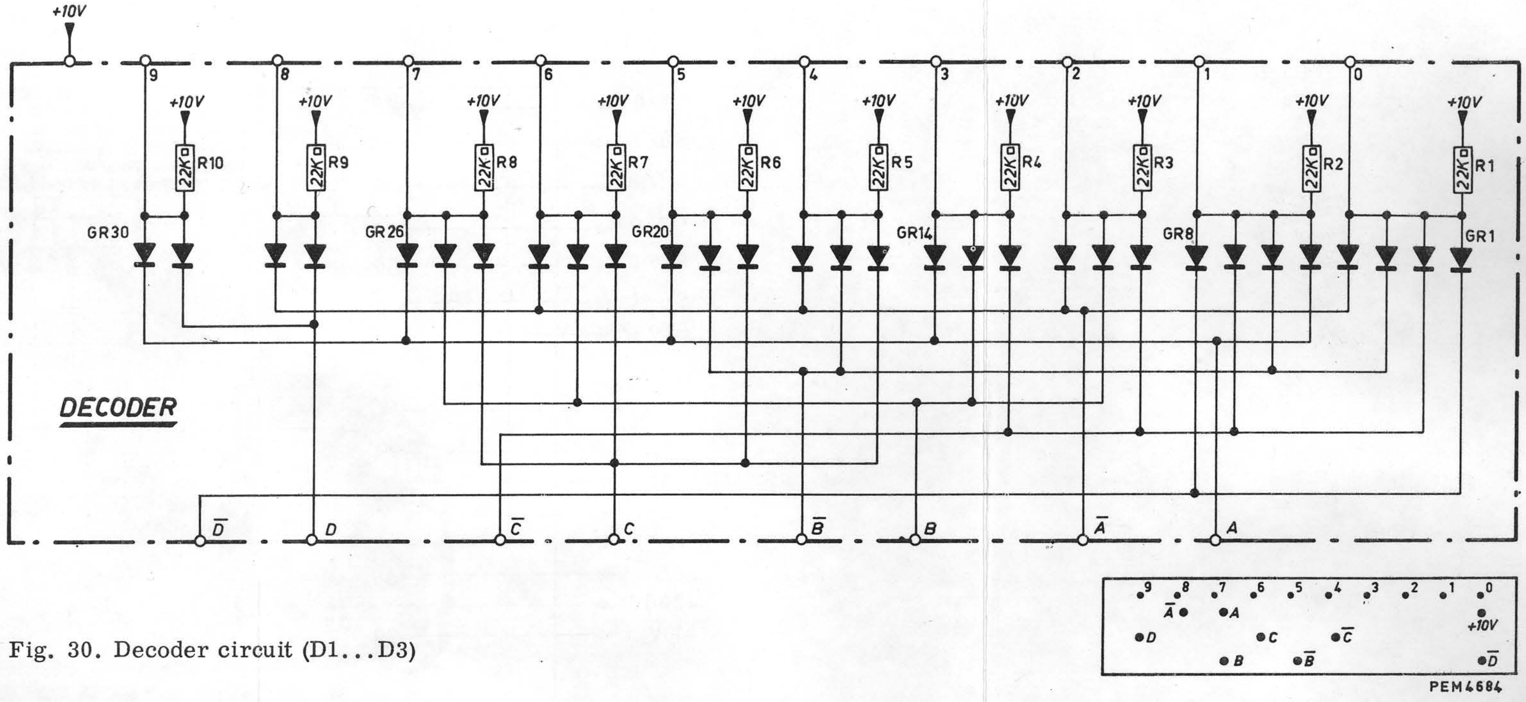


Fig. 30. Decoder circuit (D1...D3)

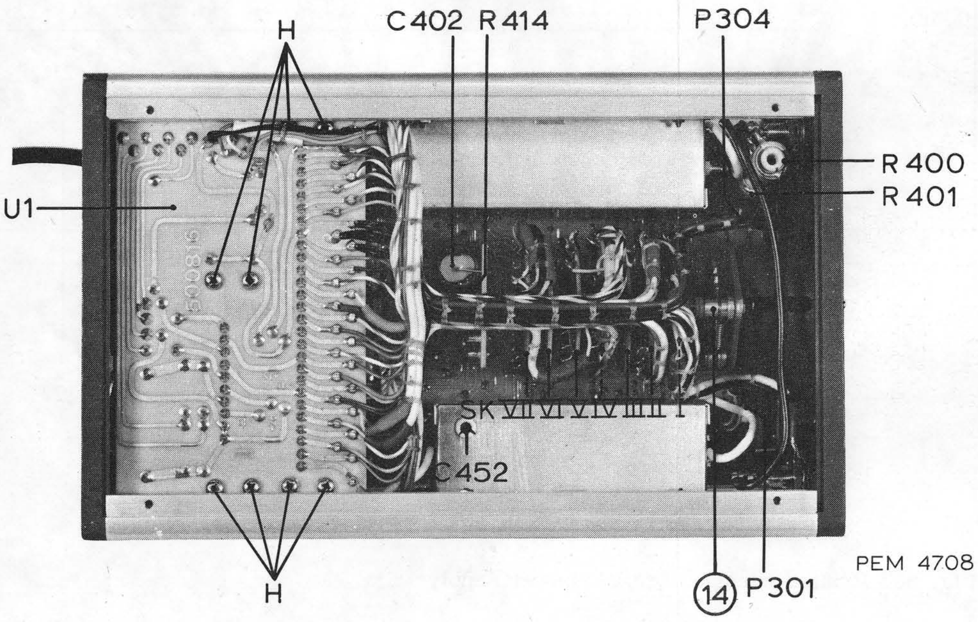


Fig. 31. Bottom view (bottom panel removed)

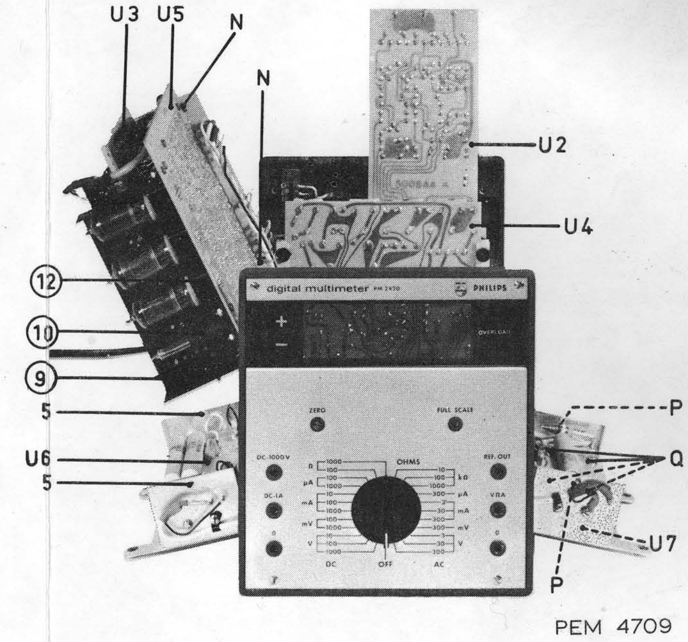


Fig. 32. Instrument opened for servicing purposes

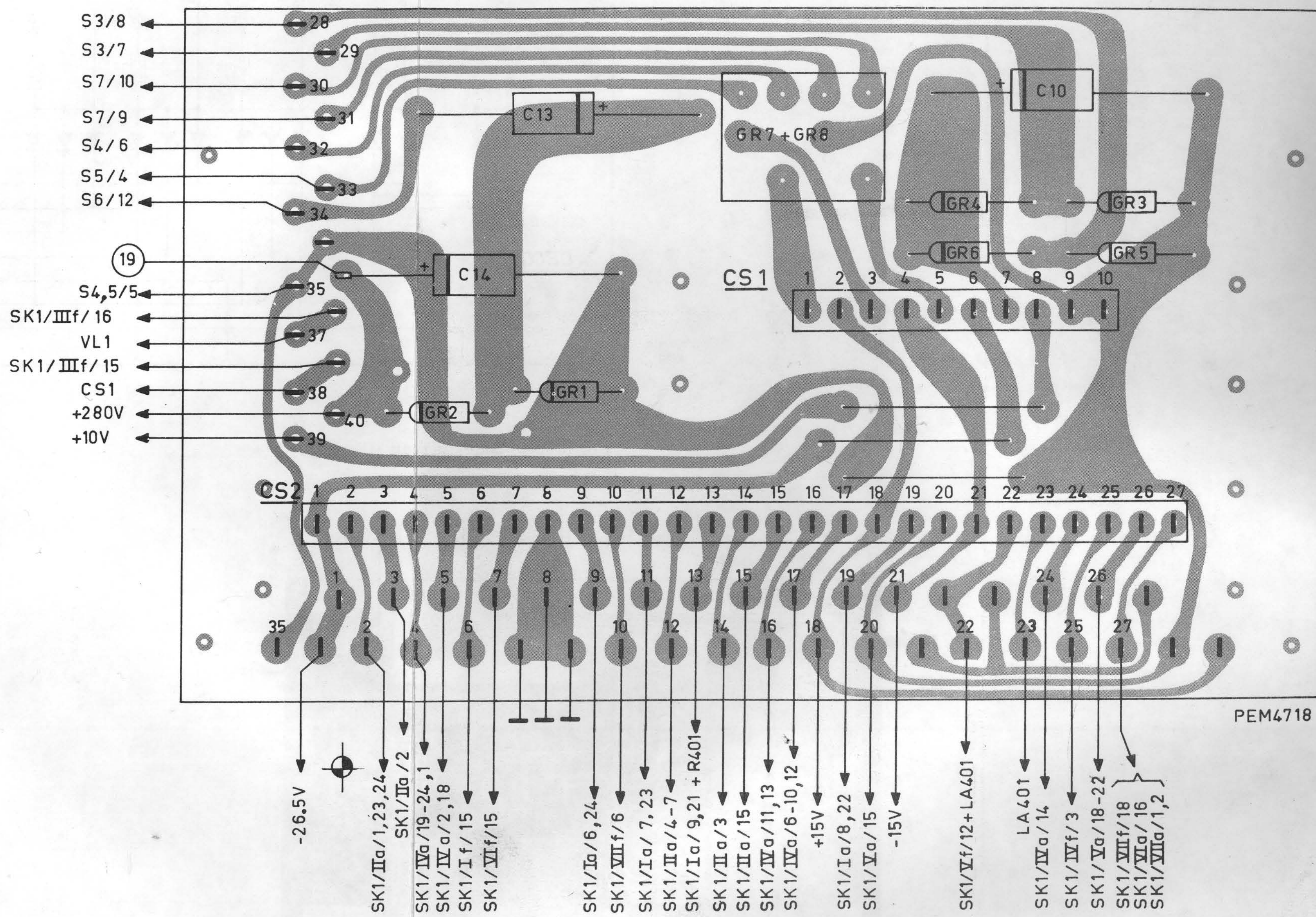


Fig. 33. Printed wiring board U1; power supply

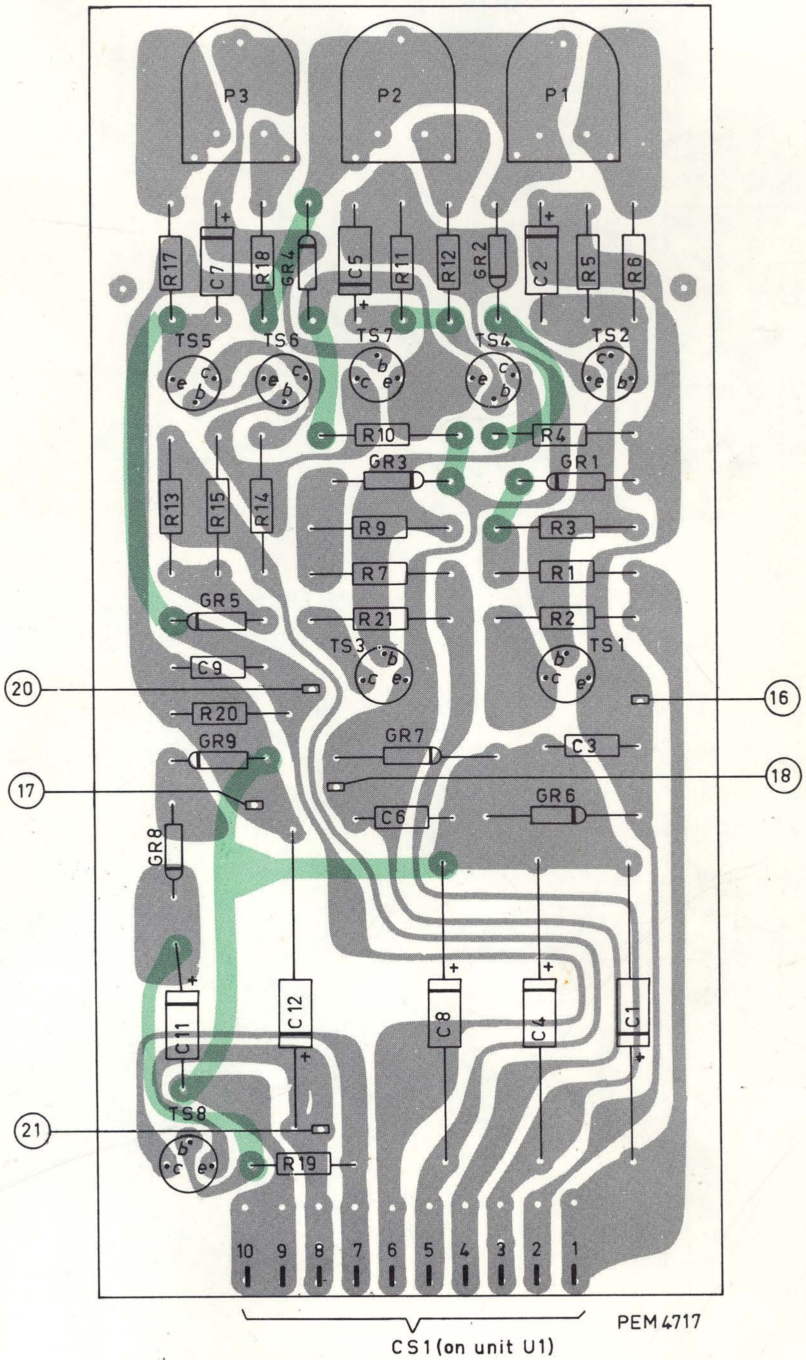
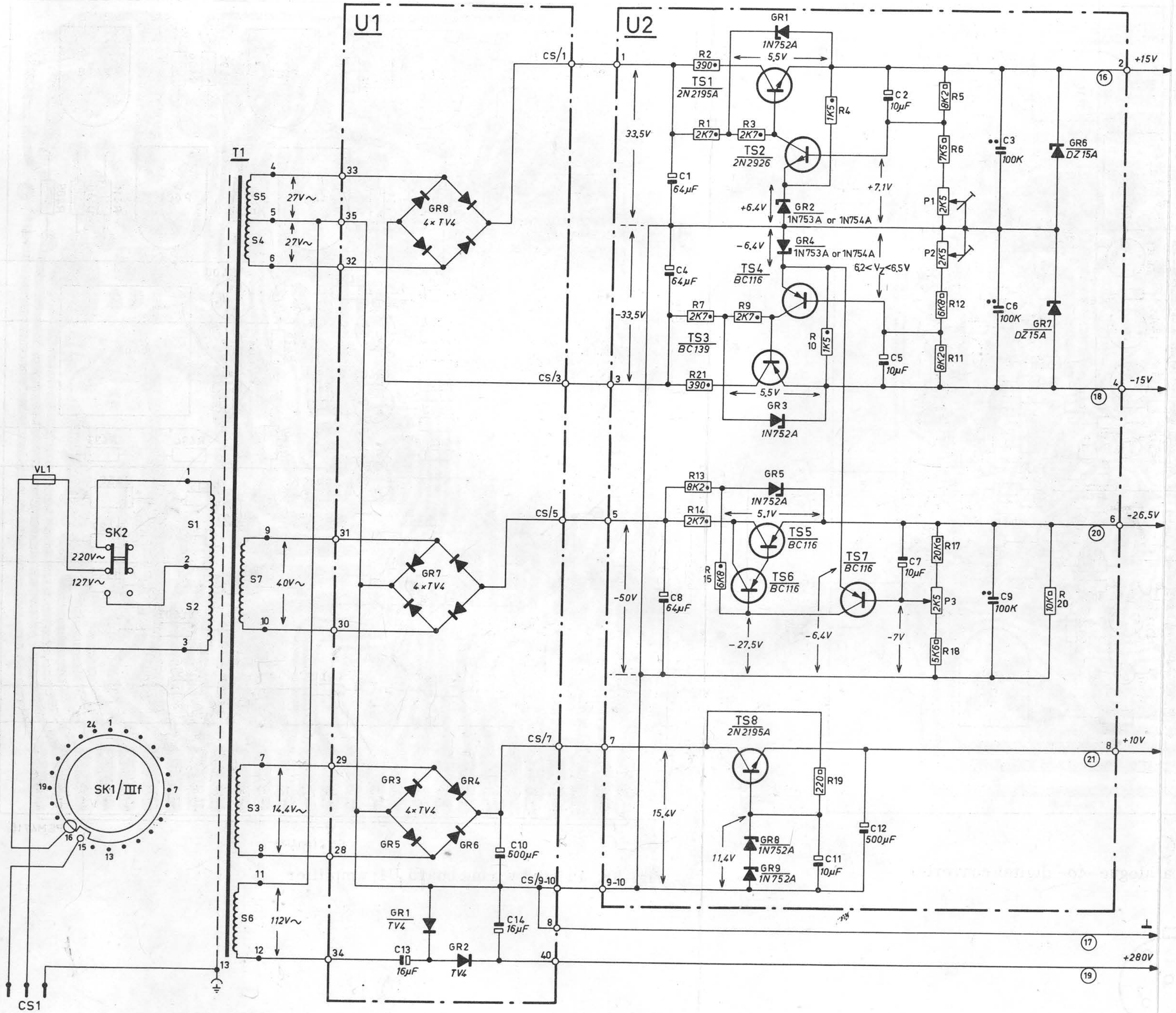
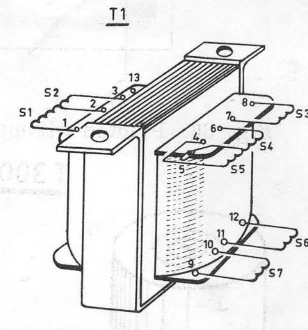


Fig. 34. Printed wiring board U2; stabilizing circuit





	S1	S2	S3	S4	S5	S6	S7
VOLTAGE	94V	126V	17V	29,4V	29,4V	136V	44,5V

PEM4701

Fig. 35. Circuit diagram power supply and stabilizing circuit

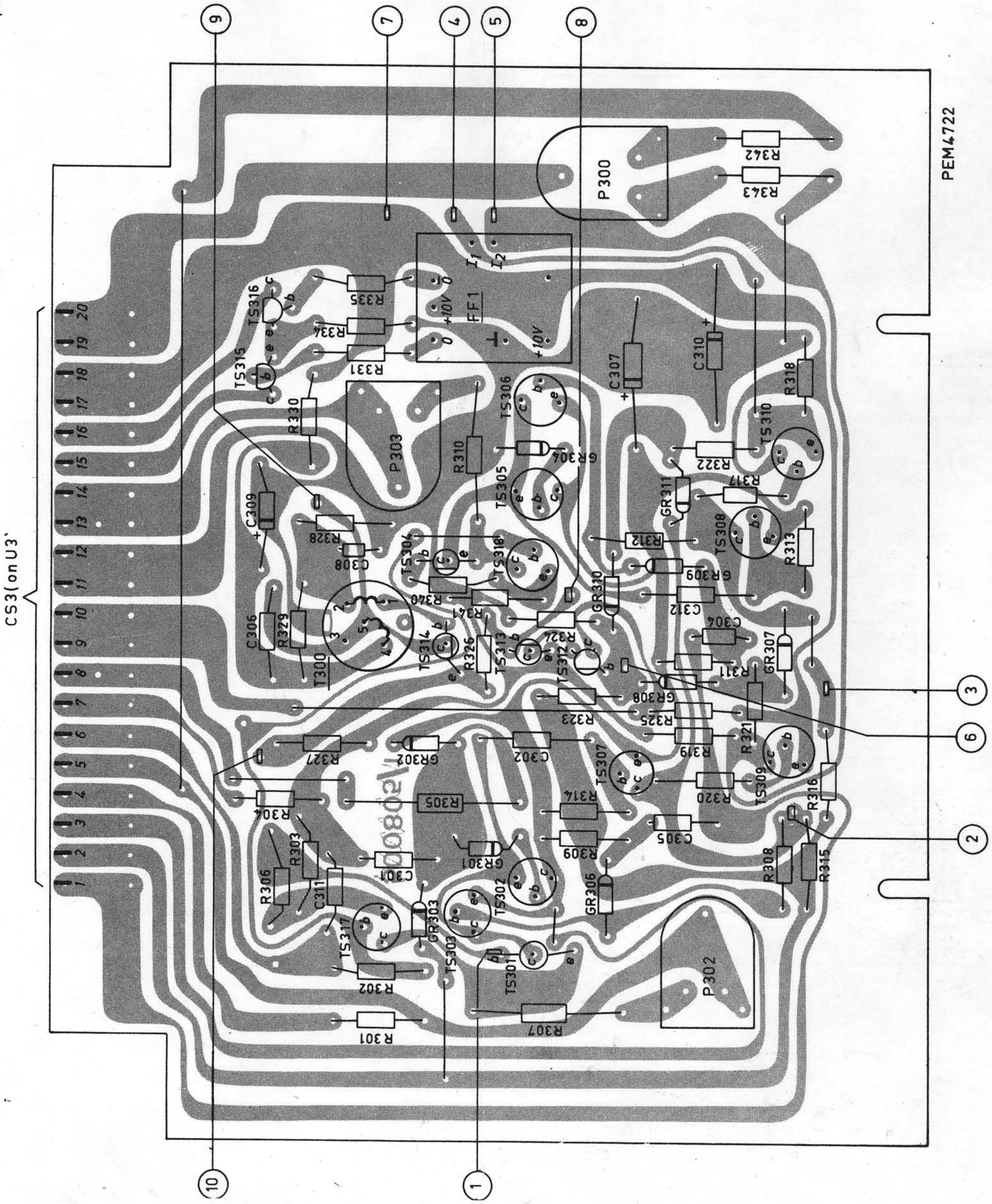


Fig. 36. Printed wiring board U3; analogue -to- digital converter

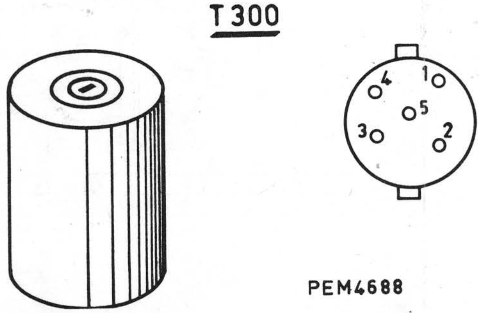


Fig. 37. Oscillator coil

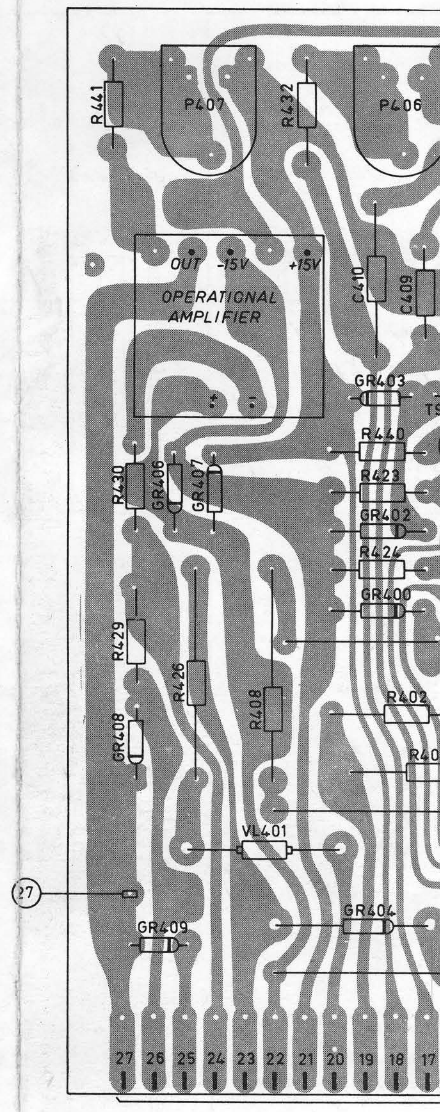


Fig. 38. Printed wiring board U

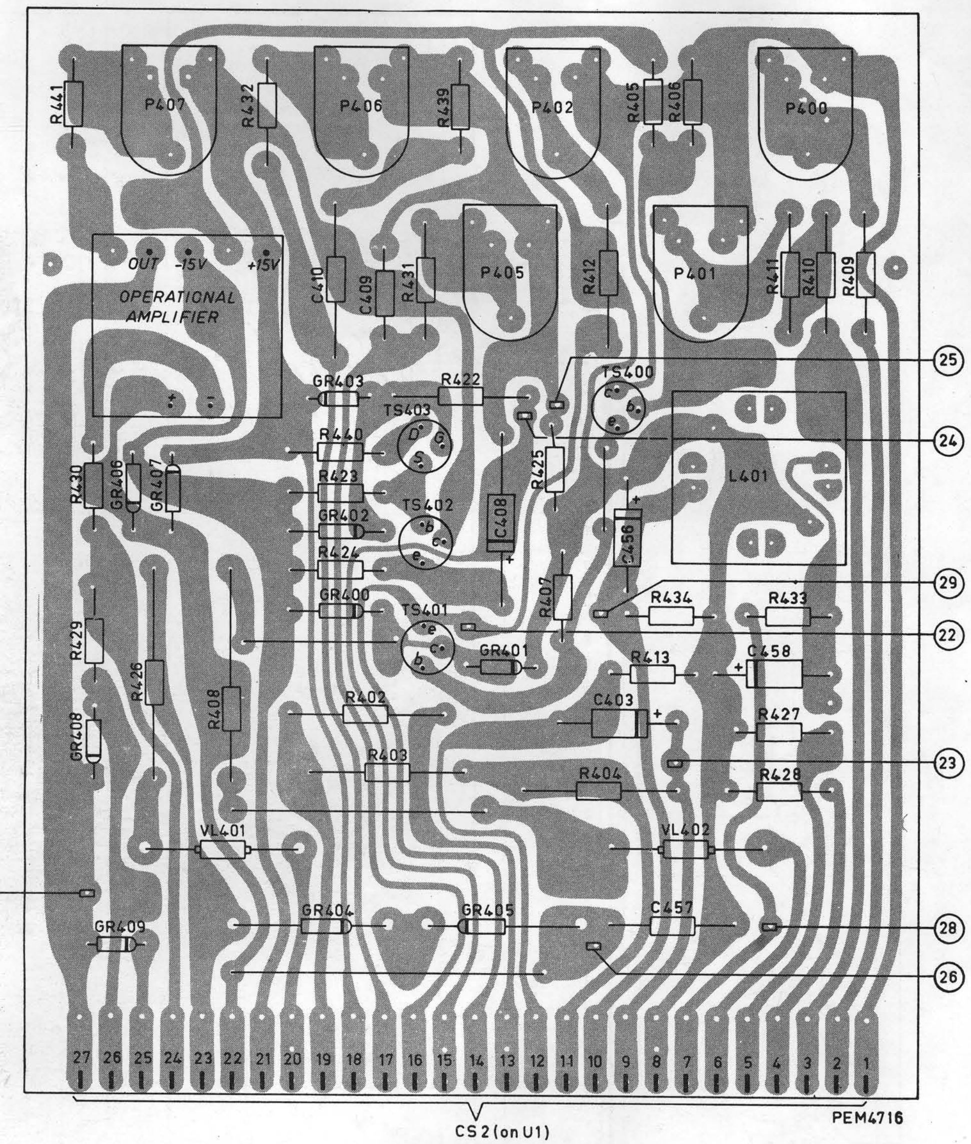


Fig. 38. Printed wiring board U4; amplifier

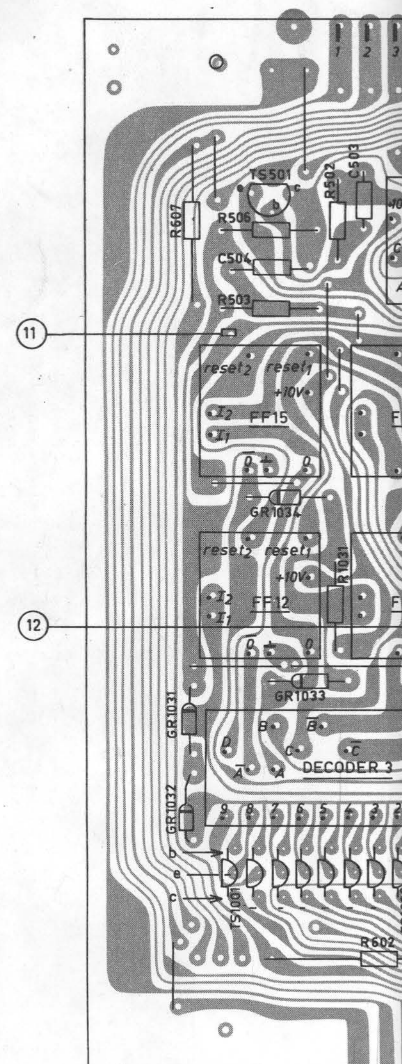


Fig. 39. Printed wiring boa

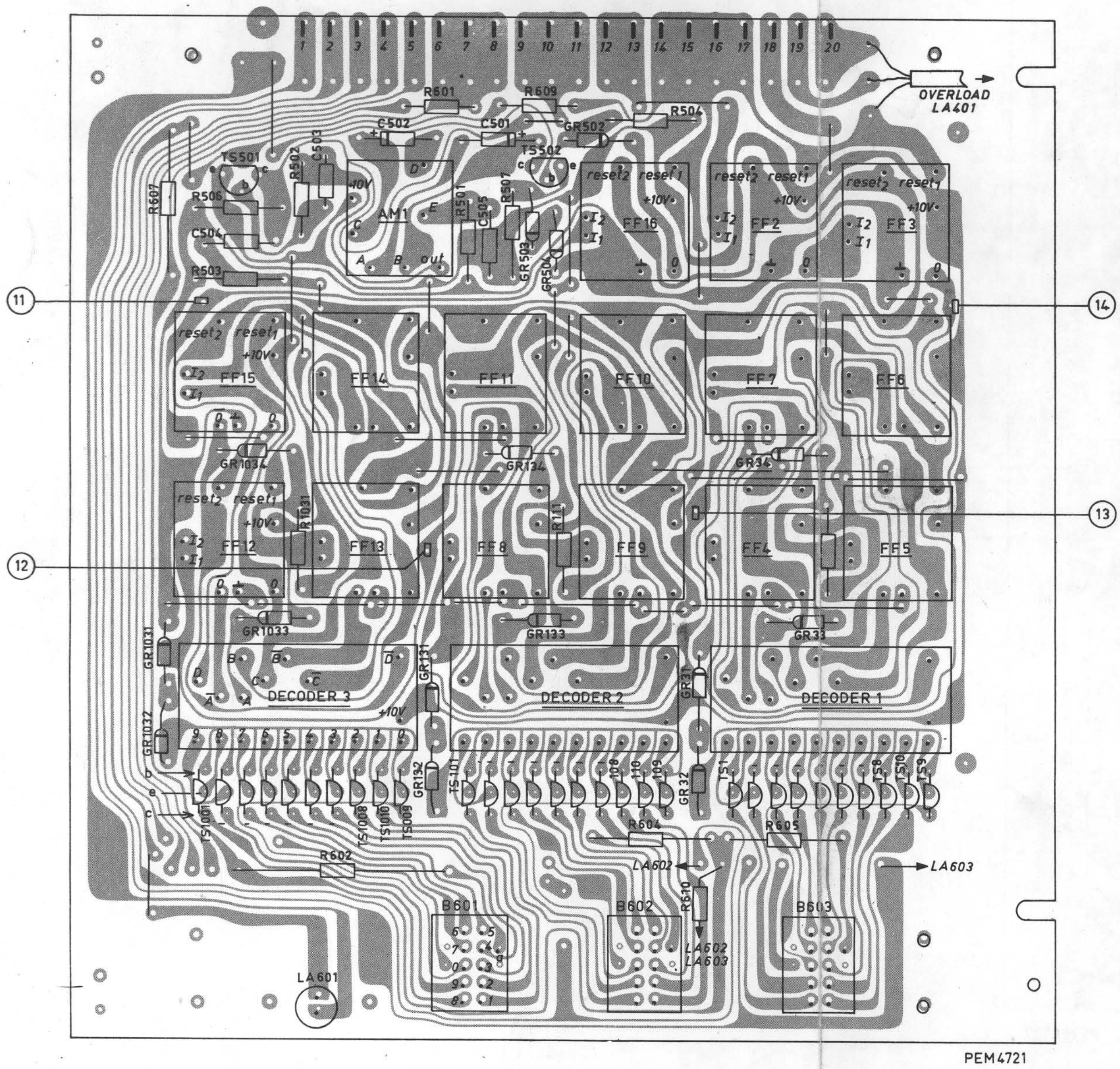


Fig. 39. Printed wiring board U5; counter

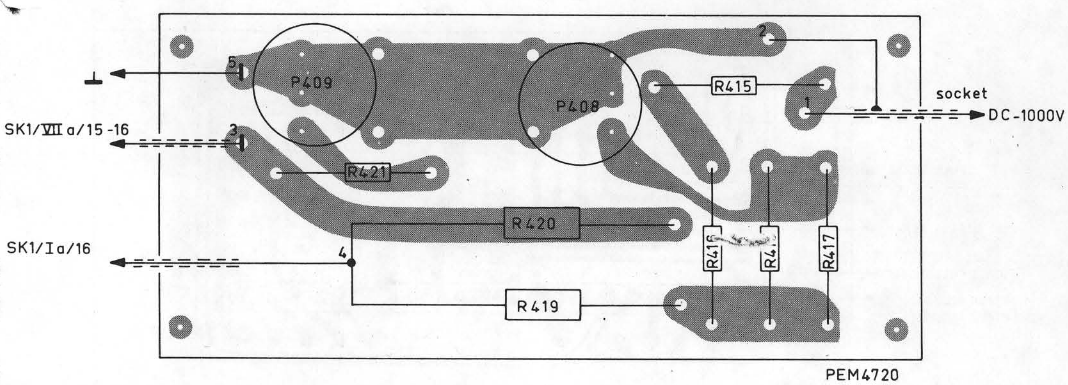


Fig. 40. Printed wiring board U6; DC attenuator

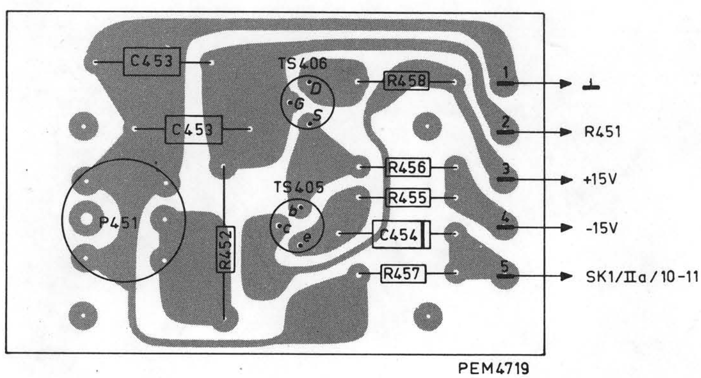


Fig. 41. Printed wiring board U7; AC attenuator

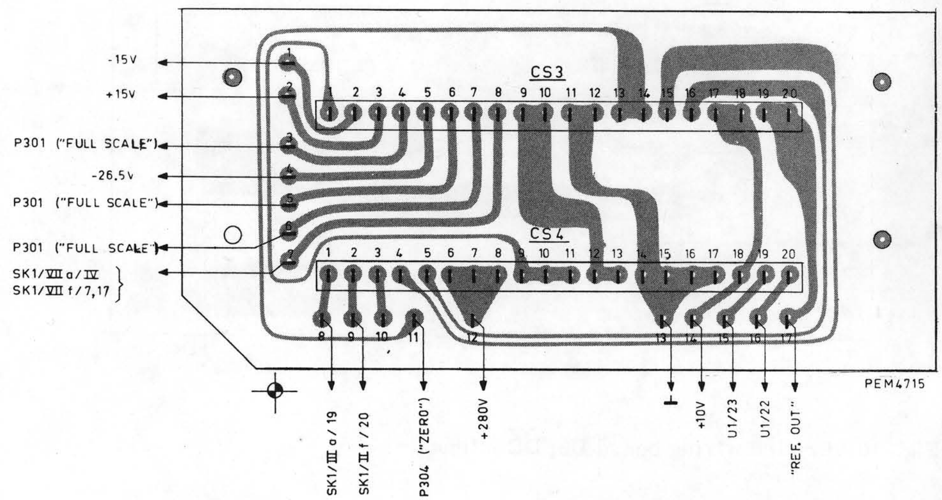


Fig. 42. Printed wiring board U8; interconnection board