

# PHILIPS

## AC - millivoltmeter

# PM 2554

9447 025 541.1



## Instruction Manual

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#### NOTE:

The design of this instrument is subject to continuous development and improvement. Consequently, this instrument may incorporate minor changes in detail from the information contained in this manual.

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## 1. INTRODUCTION

## GENERAL

The Philips AC millivoltmeter PM 2554 is a sensitive and accurate measuring instrument suitable for floating measurements from 50  $\mu\text{V}$  up to 300 V in the frequency range from 2 Hz up to 12 MHz.

The instrument can be powered by mains.

By the very great bandwidth and sensitivity the instrument has a wide range of applications, e.g. measurements on LF and HF amplifiers, carrier-wave telephony, electro-acoustical as well as for measurements on transducers and measuring-transformers, etc.

The d.c. or a.c. output chosen by an internal jumper, makes it possible to employ the instrument as an a.c./d.c. converter or as an a.c. amplifier.

The instrument has a great indicating speed, a high temperature stability and is quickly ready for use.

The 12 measuring ranges of 1 mV up to 300 V f.s.d. overlap so that a high reading accuracy is obtained.

The moving-coil instrument is provided with a mirror scale with the ranges 0-30 and 0-100 as well as dB scale from  $-20\text{ dB} \dots + 2\text{ dB}$  (total span  $-80\text{ dB} \dots + 52\text{ dB}$ ).

By means of the measuring-probe PM 9336 the input impedance can be changed from  $1\text{ M}\Omega // 30\text{ pF}$  except capacity measuring cable (100 pF) into  $10\text{ M}\Omega // 11\text{ pF}$  to permit measurements on very high ohmic circuits.

## 2. TECHNICAL DATA

Properties expressed in numerical values with tolerances are guaranteed by the factory.

Numerical values without tolerances serve only for information and represent the properties of an average instrument.

## 2.1. Electrical

|                    |   |
|--------------------|---|
| Measuring range    | 50 $\mu\text{V}$ ...300 V divided into 12 ranges from 1 mV...300 V (f.s.d.)   |
| dB Measuring range | $-80\text{ dB} \dots + 52\text{ dB}$ (12 ranges)<br>0 dB = 1 mW into $600\ \Omega$ , 0.775 V  |
| Frequency range    | 2 Hz...12 MHz   |
| Input impedance    | direct $1\text{ M}\Omega // 33\text{ pF}$<br>with PM 9336: $10\text{ M}\Omega // 11\text{ pF}$  |
| Accuracy           | Frequency<br>10 Hz — 400 kHz $\pm 1\%$ of reading, $\pm 1\%$ f.s.d.<br>2 Hz — 10 Hz $\pm 3\%$ of reading, $\pm 1\%$ f.s.d.<br>400 kHz — 2 MHz $\pm 2\%$ of reading, $\pm 1\%$ f.s.d.<br>2 MHz — 6 MHz $\pm 2\%$ of reading, $\pm 3\%$ f.s.d.<br>6 MHz — 12 MHz $\pm 4\%$ of reading, $\pm 4\%$ f.s.d. |

*Note: By application of probe PM 9336 the accuracy will decrease 3% of reading.*

|  |   |
|--|---|
| Pre-deflection                                       | < 3 scale divisions (terminating resistance $\leq 500 \Omega$ )<br>Influence on accuracy: 10% pointer deflection $\leq 0.45\%$<br>30% pointer deflection $\leq 0.15\%$  |
| Temperature range                                    | 0...+ 45°C  |
| Temperature coefficient                              | $\leq 1^{\circ}/\infty/^{\circ}\text{C}$  |
| Effect of mains voltage variations                   | Additional error of $1^{\circ}/\infty$  |
| Rectifying circuit for the meter section             | Average value rectifier   |
| Meter scale  | Mirror scale with knife-edge pointer<br>Calibrated in rms values of sinusoidal input voltages<br>Linear division from 0...103 and 0...325<br>dB scale from -20 dB...+ 2 dB  |
| Overload protection                                  | In the ranges 1 mV to 300 mV:<br>300 V for frequencies between 2 Hz and 10 kHz<br>10 V for frequencies above 10 kHz<br>Other ranges:<br>300 V for frequencies between 2 Hz and 12 MHz   |
| Max. permissible voltage (all ranges)                | Between Hi and Lo 400 Vd.c.<br>Between Lo and housing 500 Vd.c. or 500 V <sub>pp</sub>  |
| Common mode rejection ratio (between Lo and housing) | In the 1 mV range:<br>Frequency<br>10 Hz ... 1 kHz > 140 dB<br>1 kHz... 10 kHz > 130 dB<br>10 kHz...100 kHz > 120 dB<br><br><i>Note: These values decrease with 10 dB/range in the higher ranges.</i>   |
| Impedance between Lo and housing                     | 1 G $\Omega$  |
| Output   | D.c. or a.c. output (chosen by internal jumper)   |
| D.C. output  | Output resistance 1 k $\Omega$<br>Output voltage 1 V short-circuit proof  |
| A.C. output  | Output impedance 600 $\Omega$ in serial with 47 $\mu\text{F}$<br>Output voltage 50 mV short-circuit proof   |
| Accuracy d.c. output                                 | Frequency<br>10 Hz - 400 kHz $\pm 1\%$ of reading, $\pm 1\%$ f.s.d.<br>2 Hz - 10 Hz $\pm 3\%$ of reading, $\pm 1\%$ f.s.d.<br>400 kHz - 2 MHz $\pm 2\%$ of reading, $\pm 1\%$ f.s.d.<br>2 MHz - 6 MHz $\pm 2\%$ of reading, $\pm 3\%$ f.s.d.<br>6 MHz - 12 MHz $\pm 4\%$ of reading, $\pm 4\%$ f.s.d. |
| Supply   | Mains voltage:<br>90 V...132 V or<br>180 V...265 V, 50/60 Hz.   |

Long-term stability                              At min. 90 operating days  $1^0/00$  of f.s.d. on the average.

## 2.2. Mechanical

|            |                 |        |
|------------|-----------------|--------|
| Dimensions | Height          | 145 mm |
|            | Width           | 236 mm |
|            | Depth           | 298 mm |
| Weight     | Approx. 3.5 kg. |        |

## 3. ACCESSORIES

### 3.1. Supplied as part of the equipment.

- Measuring cable for voltages above 3 mV and frequencies below 100 kHz
- Manual.

### 3.2. Optionally available.

- Measuring probe (10:1) PM 9336 (fig. 1 page 22)
- Measuring cable BNC—BNC PM 9074  
Length 1 m Impedance  $50 \Omega$
- Measuring cable BNC—BNC PM 9075  
Length 1 m Impedance  $75 \Omega$
- Measuring cable BNC—BNC PM 9076  
Length 1 m Impedance  $135 \Omega$

#### 4. PRINCIPLE OF OPERATION

Blockdiagram fig. 2 (page 22)

The test voltage connected to the "INPUT" socket is supplied to the input attenuator. This is a capacitively compensated and fully screened voltage divider with a proportion of 1:1 or 1000:1. The output of the attenuator is connected to the input of the impedance transformer consisting of a feedback two-stage amplifier.

The main attenuator following it is an ohmic voltage divider operating in steps of 10 dB and ensuring a constant and low impedance for the pre-amplifier

The latter consists of two amplifier stages with a high input impedance and a low output impedance.

The amplifier stage supplies the voltage for the a.c. output and the rectifier circuit, the rectifiers of which are included in the feedback network of an amplifier. The rectified current, which is proportional with the input voltage, flows through a test resistor.

The voltage drop across this resistor is measured differentially by means of a d.c. amplifier supplying the current for the test instrument. This amplifier also supplies the voltage for the d.c. output.

A reference voltage supplied by a calibrating-voltage generator.

With the aid of this voltage the unit can be calibrated in the 100 mV range. Furthermore this voltage renders it possible to adjust the attenuator probe; this should be done in the 10 mV range. The unit can be fed from the mains.

The equipment power supply voltage is stabilized to ensure that variations in mains supply voltage do not influence the display.

## 5. INSTALLATIONS

## DIRECTIONS FOR USE

Before any other connection is made, the protective earth terminal shall be connected to a protective conductor (see section: EARTHING).

### 5.1. Mains supply and fuse

Before inserting the mains plug into a mains socket, make sure that the instrument is set to local mains voltage. The instrument is wired for operation from a 180 V...265 V, 50/60 Hz mains voltage.

#### 5.1.1. Adapting of the mains voltage

Adaption of the instrument for other mains voltages is possible by altering the wiring of the mains transformer (see fig. 3 page 26)

To adapt the mains voltage proceed as follows:

- Remove the top cover by removing the two screws A (see fig. 5 page 26)
- Change the wiring of the transformer according to figure 3 page 26

The PM 2554 is suitable for mains voltages of 90 V...132 V and 180 V...265 V, 50/60 Hz.

### 5.2. Fuse

Make sure that only fuses with the required current rating and of the specified types are used. The use of repaired fuses and the short-circuiting of fuse holders is prohibited.

The rating of the mains fuse of the instrument should be: 50 mA d.a. for 180 V...265 V  
100 mA d.a. for 90 V...132 V

### 5.3. Earthing

The instrument should be connected to a protective earth in accordance with the local safety regulation. This can be effected via the 3-core mains lead. The mains plug should only be inserted in a socket outlet provided with a protective contact, the protective action of which is not cancelled by the use of an extension card or device without protective conductor.

### 5.4. Rackmounting

The PM 2554 can be mounted in a 19" rack by using a mounting-set as shown in fig. 22 page 27. This set is not delivered by Philips.



## 6. OPERATION

### 6.1. Mechanical zerosetting

- Place the meter in a horizontal position and check the zero-setting of the meter.
- If necessary correct the setting by means of plastic screw "A", fig. 4 (page 26)

### 6.2. Switching on

The instrument is ready for use after connection to the mains and earthing.

It is switched on by means of switch POWER ON (S 2).

A warming-up time of approximately 30 min. should be observed to obtain full accuracy.

### 6.3. Calibration

#### 6.3.1. Instrument

- Select measuring range 100 mV
- Put the signal lead (Hi) to the connector X4 at the rear
- Adjust the meter to 100 scale divisions with potentiometer "CAL" (R 80).

#### 6.3.2. Measuring probe PM 9336

- Before adjusting, the instrument should be calibrated as described above
- Select measuring range 10 mV
- Put the signal lead (Hi) to the connector X4 at the rear
- Adjust the probe by means of adjusting screw "A", fig. 1 (page 22).

### 6.4. Measuring

- Select the correct measuring range with range selector S 101
- Connect the test voltage to coaxial socket "INPUT" (X1) with the delivered measuring cable.

*Notes:*

- *By means of the 10:1 measuring probe PM 9336 the input impedance can be increased from  $1\text{ M}\Omega//30\text{ pF}$  (except capacity of the cable:  $100\text{ pF}$ ) to  $10\text{ M}\Omega//11\text{ pF}$ .  
This permits of carrying out measurements on very high-ohmic circuits.*
- *Do not use the delivered measuring cable for measuring voltages below 3 mV, and/or with a frequency above 100 kHz.*
- *In case of measurements of voltages in the lowest range, (1 mV) or with high frequencies (above 1 MHz) it may occur that h.f. interference signals respectively the standing wave ratio will influence the results.  
Therefore it is advised to shield the measurements circuit.*
- *For measurements at low frequencies, switch SLOW-FAST (S 102) should be set in position SLOW to obtain a proper reading.  
As a result the indicating speed of the meter will be reduced and the pointer deflection will become more stable.*

## 6.5. Output (X2 and X3)

The instrument is provided with a floating output.  
The Lo is directly connected to the shield of the "INPUT" connector X1.  
By means of an internal jumper or a d.c. output or an a.c. output is selected.  
(see fig. 16 page 42).

### 6.5.1. D.C. output

The output voltage is proportional to the input voltage and is 1 V at full scale deflection, irrespective of the selected measuring range.

The output resistance is approx.  $1\text{ k}\Omega$ .

### 6.5.2. A.C. output

The output voltage is proportional to the input voltage and is 50 mV at full scale deflection, irrespective of the selected measuring range.

The output impedance is approx.  $600\ \Omega$  in serial with  $47\ \mu\text{F}$ .

## 6.6. Errors due to distortion.

Although the meter indicates the mean value of the full-wave rectified voltage, the scale of the instrument is calibrated in rms values of sinewave voltages. As a result measuring errors will arise when measuring non-sinusoidal voltage.

The values of these depend on the coefficient of non-linear distortion.

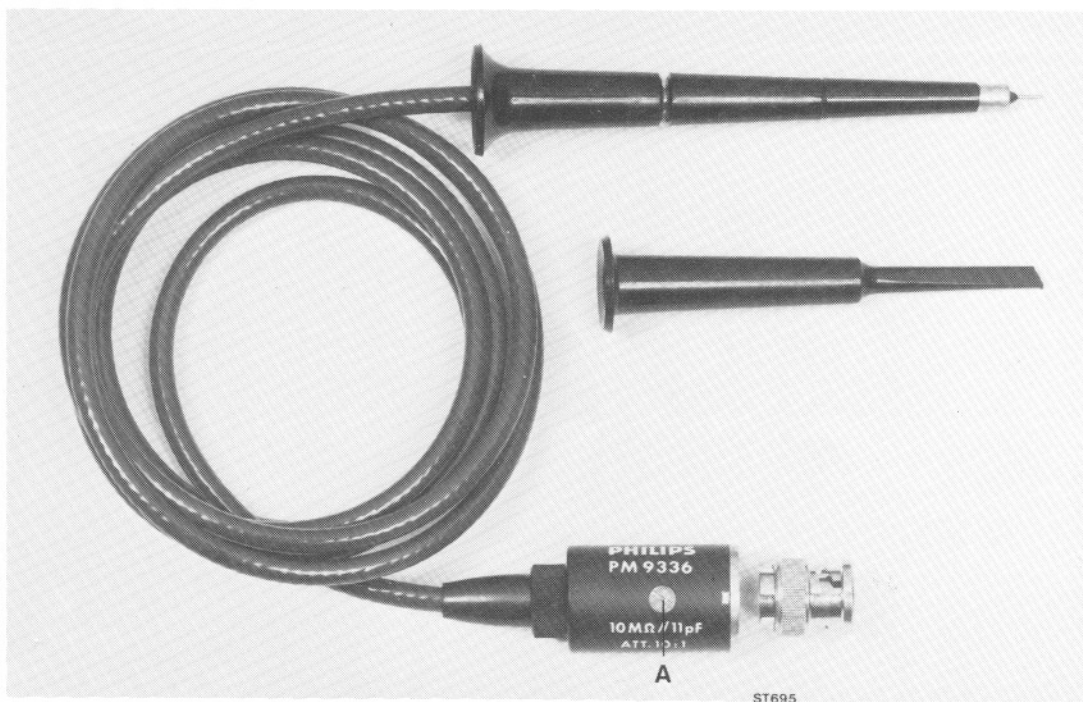


Fig. 1.

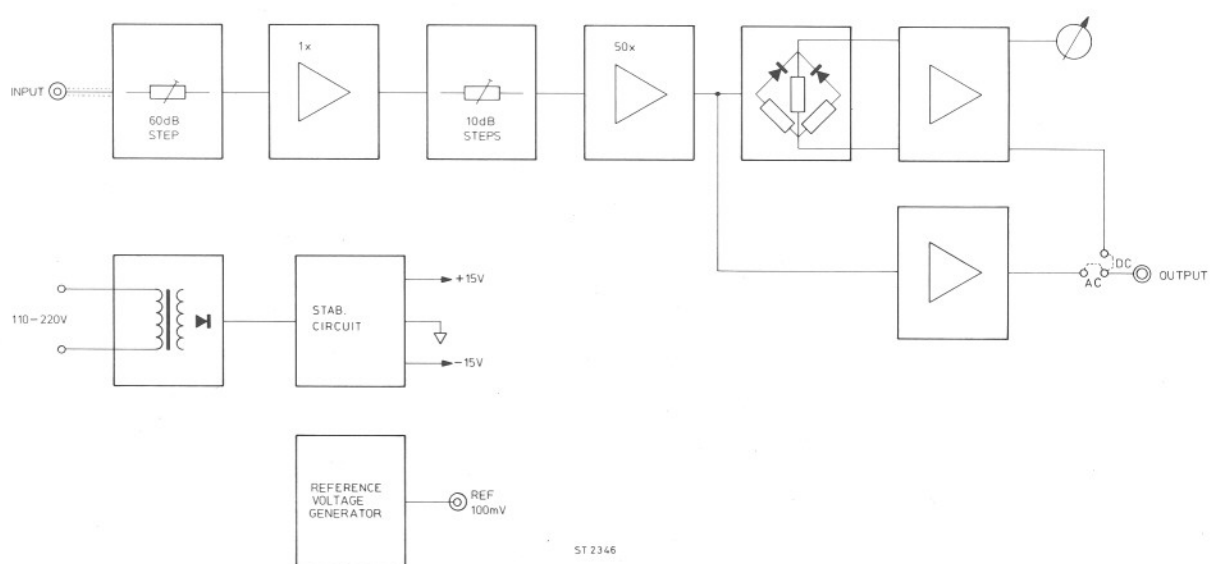


Fig. 2.

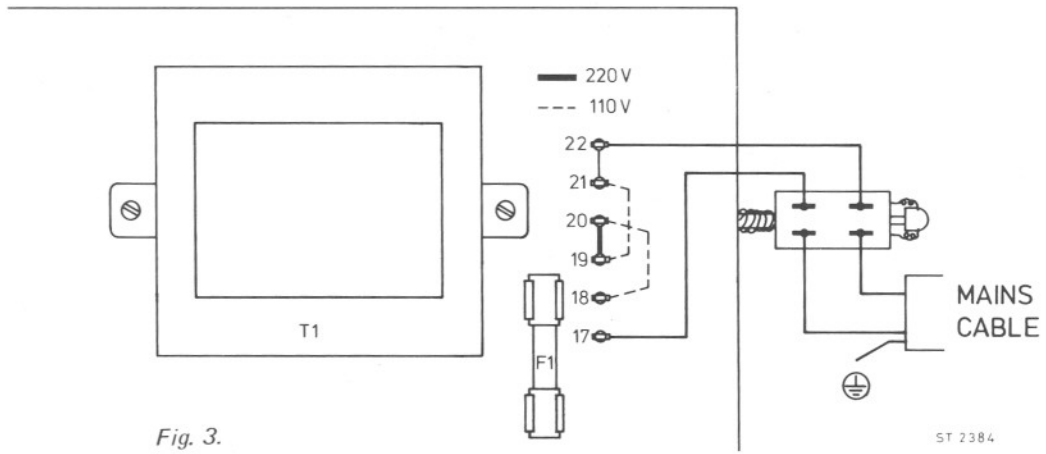


Fig. 3.

ST 2384

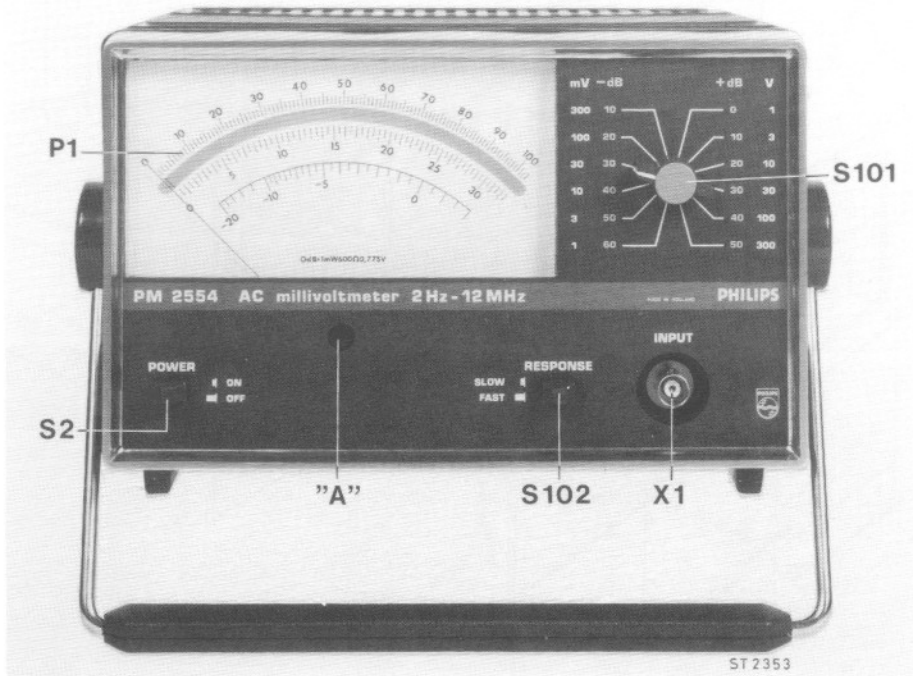


Fig. 4.

ST 2353

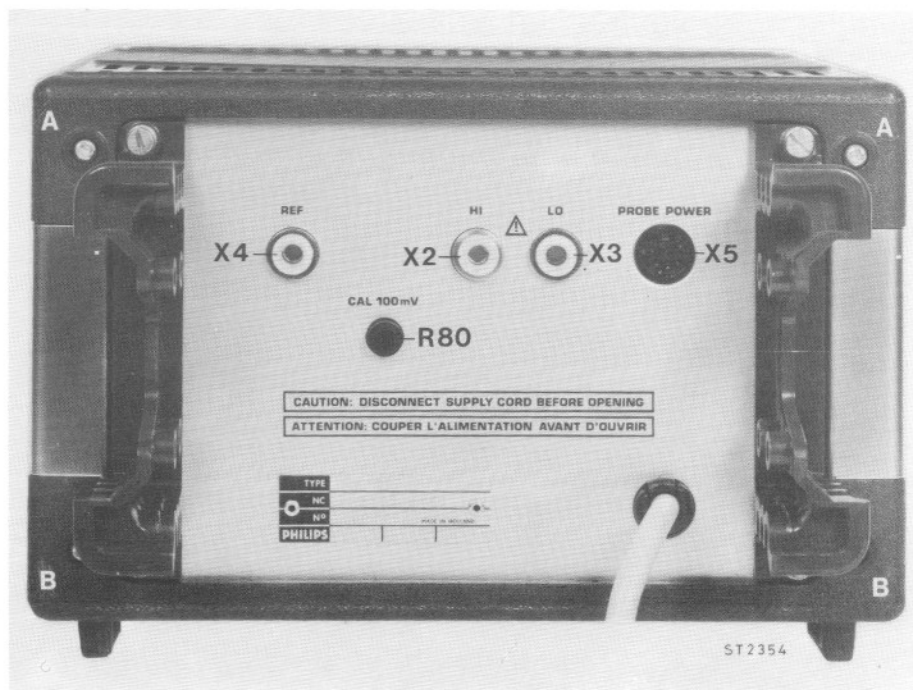
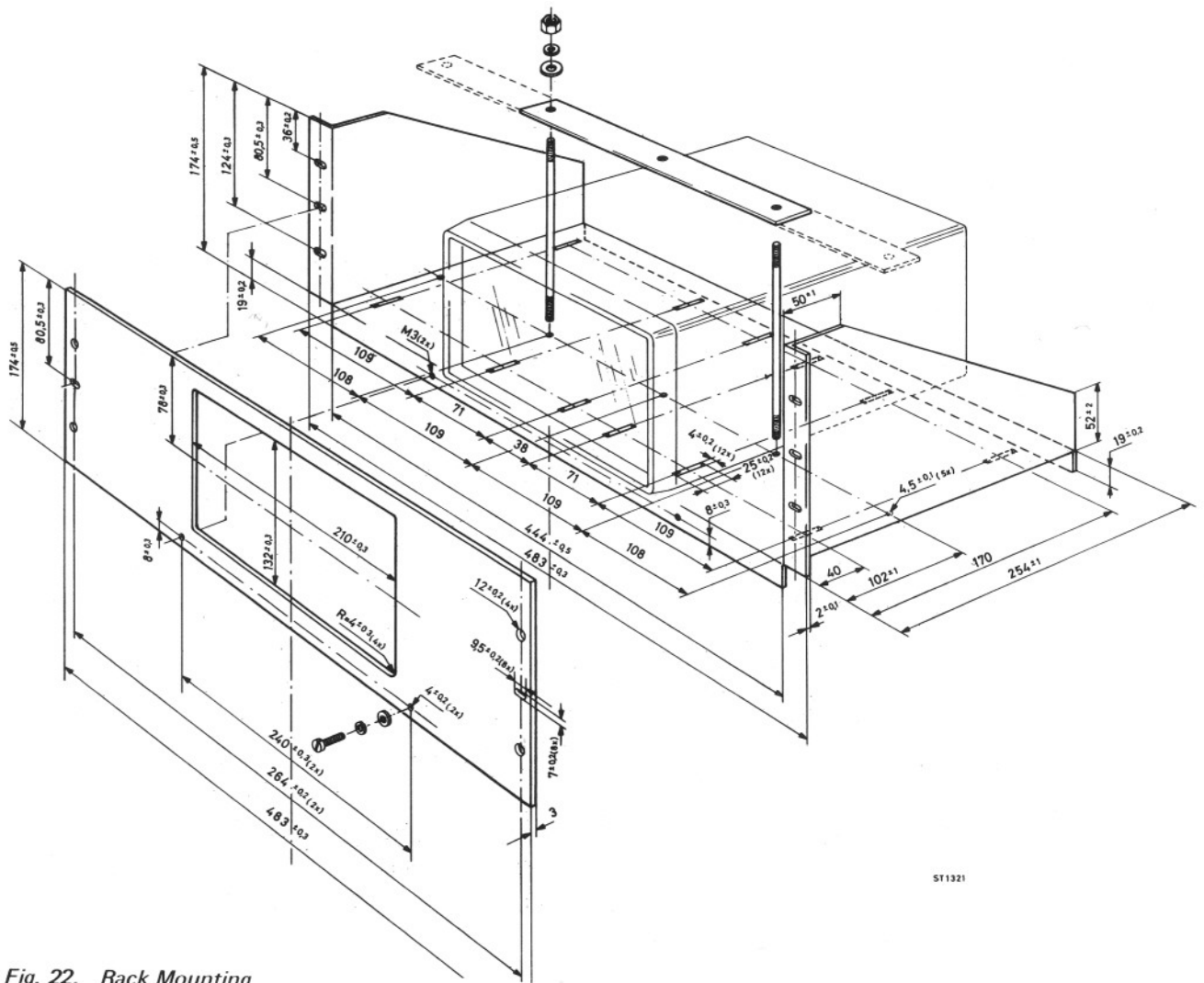


Fig. 5.

ST 2354



ST 1321

Fig. 22. Rack Mounting

## 7.1. Measuring section

**Input circuit, fig. 6**

The test voltage connected to X1 is supplied to the impedance transformer stage via C1 and S 101/1f and S 101/2r (direct input) or via S 101/1f; R1...R4; C4...C6; C50...C56 and S 101/2r (via high ohmic, frequency-independent 1000:1 attenuator).

In both cases the input capacitance is equalised by means of C3, so that a possible probe (PM 9336) can be used in every test area.

**Impedance transformation circuit, fig. 7**

This circuit consists of a two-stage amplifier V5 and V6, the output signal of which is fully fed back. Thus a stable single amplifier with a low output impedance is obtained.

For the protection of the field effect transistor V5 two protective diodes V2 and V4 are provided which in the reverse direction are connected between the input and V1 and V3 respectively.

If the input voltage exceeds the zener voltage of V1, or V2 or V4 will become conductive, as a result of which the voltage on the gate of V5 is limited.

The current through the diodes is limited by the impedance of the input circuit R 106—R 7 and C8. In the voltage divider that follows now and that consists of S 101/3r, R 119...R 126 and R 128...R 132 the test voltage is attenuated in steps of 10 dB. C 118 and C 119 prevent the frequency-response curve from rising.

**Amplifier, fig. 8**

This consists of two feedback circuits, viz. V7 with V8 and V9 with V10.

A d.c. feedback from nodal point R40 and R41 via R31 to the base of V7 is wired across the whole assembly. The amplification of the first circuit is determined by R34 and R35 and that of the second circuit by R38 and R37.

The RC network R33 and C22 blocks oscillations from the first circuit.

**AC—DC converter, fig. 9, 10**

This converter contains the amplifier stages V12 and V15 with V16 coupled by the emitter-follower V14 and the current source V18.

Test resistor R65 is included in the feedback network together with the rectifier circuit.

V15 and V16 together constitute an amplifier stage in cascode arrangement. Thus feedback from the output signal to the input of this amplifier stage is avoided.

By means of a differential amplifier A2 the operating point of V16 compared with the voltage obtained from voltage divider R58 — R59. A possible deviating voltage is amplified and fed back to the base of V12 so that the voltage is corrected. The voltage on the collector of V16 has been chosen so that it is equal to the emitter voltage plus half the knee voltage of V19 and V20; consequently the latter diodes can never become conductive on account of a voltage difference between the collector of V16 and the emitter of V12.

To prevent the a.c. signal from the collector of V16 from being fed back to the base of V12 via the differential amplifier, C33 has been applied across this amplifier. As a result of this the variable-gain amplifier behaves as an integrator with a time constant governed by C33 and R56. The property of this integrator is that it passes on signal with frequencies below  $f = \frac{1}{2\pi \cdot RC}$  after amplification, but attenuates signals strongly if their frequency is higher.

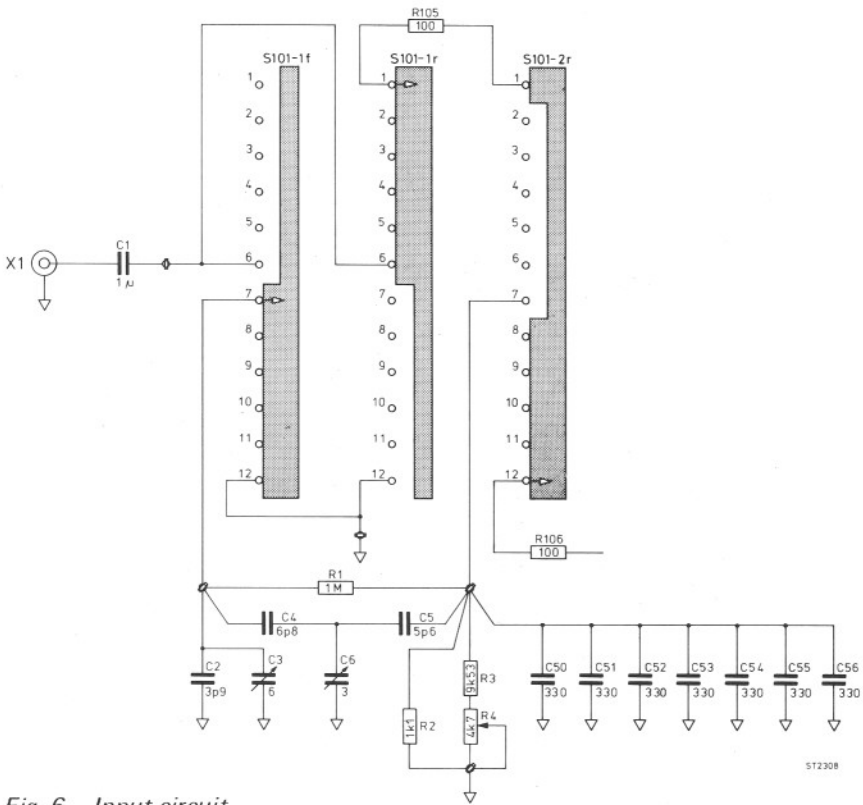


Fig. 6. Input circuit.

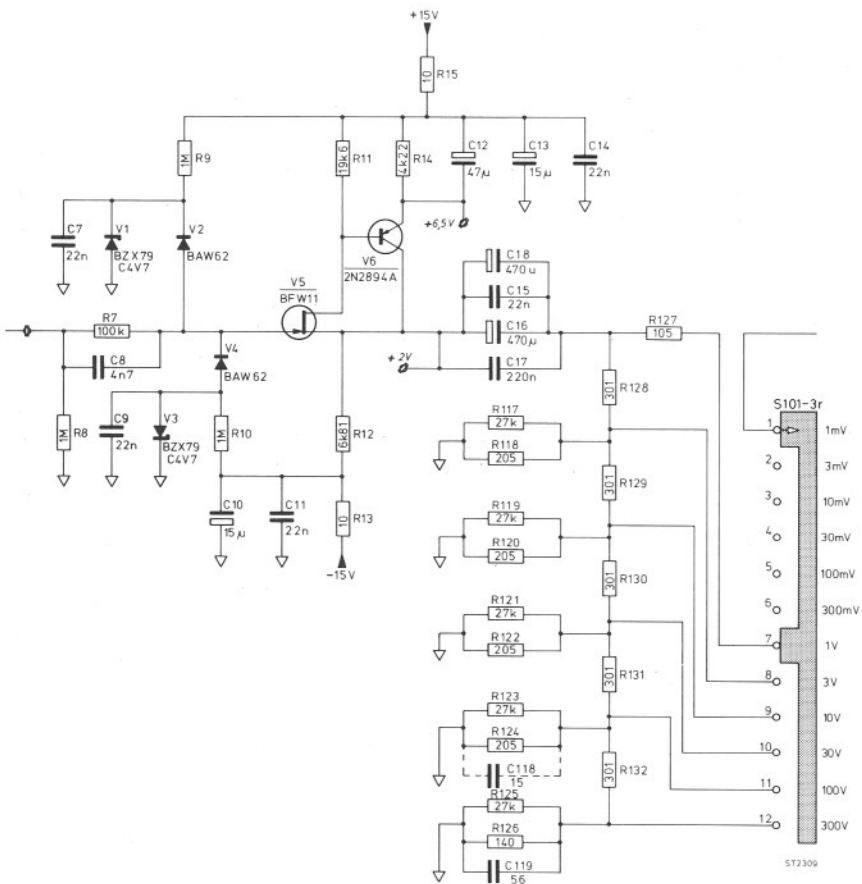


Fig. 7. Impedance transformation circuit

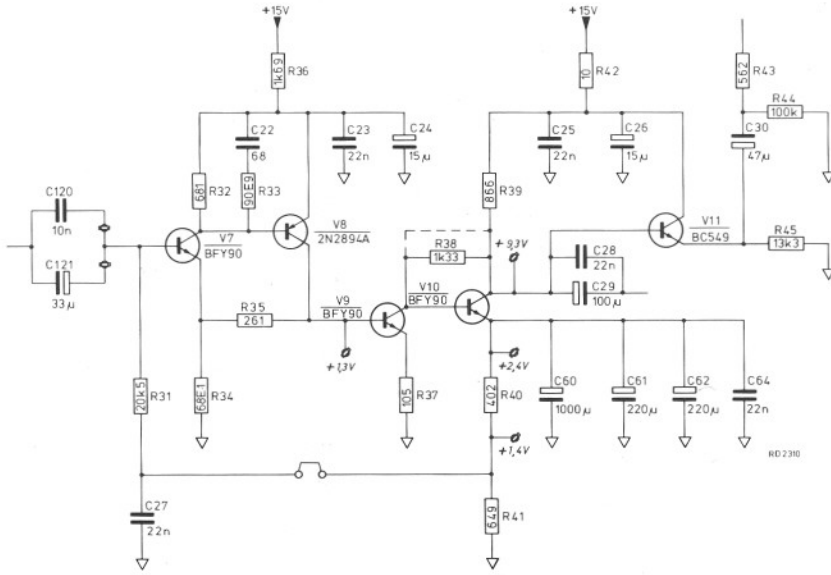


Fig. 8. AC Amplifier



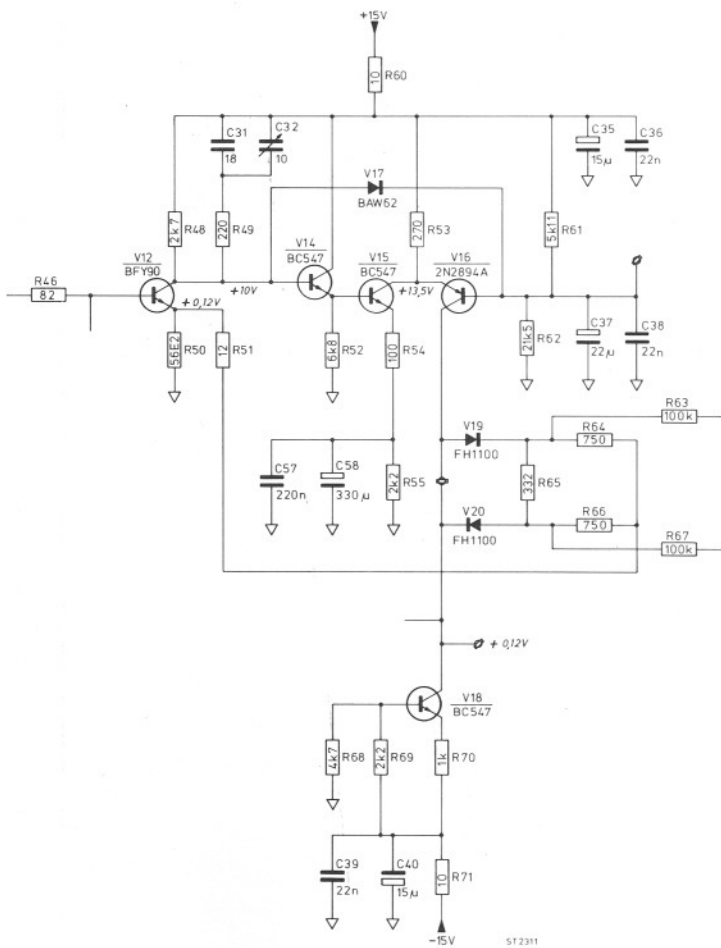


Fig. 9. AC - DC Converter

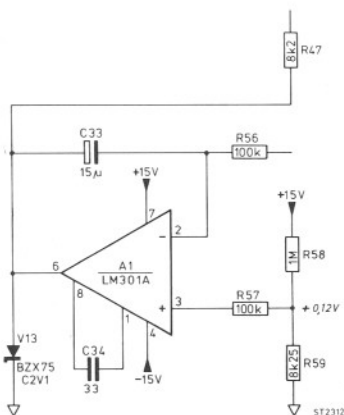


Fig. 10. Feedback circuit

### **DC amplifier, fig. 11**

The dc voltage which appears over the measuring resistor R65 is fed via resistors R63 and R67 which, together with the resistors R27 and R73 determine the amplification factor (X1) for dc signals. The ripple voltage at the output of the amplifier A2 is suppressed by the capacitors C45 and C42 and the resistor R73.

Owing to the circuit arrangement by which capacitors C45 and 42 can be switched using S 102 the ripple suppression is also effective at very low frequencies. At the same time the meter response is damped so that unwanted vibration of the meter needle is reduced. The offset voltage for A2 is determined by resistor R91.

### **7.2. Supply section, fig. 12**

The two primary windings S1 and S2 of transformer T1 can be connected in series or in parallel by connecting together the appropriate soldering pins.

For mains voltages between 180 and 265 volts the windings must be connected in series and for voltages between 90 and 132 volts in parallel.

The output of T1 is rectified by V21 and smoothed by C46.

The current source consisting of V23–26 and R84 delivers the current for the equipment and at the same time provides a stabilized supply voltage via zener diodes V24 and V25.

The adjusting current for V23 is delivered by the current source consisting of V22–25 and R83.

R82 is the starting resistor for both current sources.

### **7.3. Reference voltage generator, fig. 13**

The generator consists of a CMOS circuit with a time constant determined by R85 and C47. The supply voltage for this circuit is further stabilized by means of zener diode V27, resulting in the square wave at the output (pin 10) being extremely stable.

This voltage is applied to a potential divider consisting of resistors R86 to 89 and a proportion of it is applied to reference output X4.

Applying this voltage to the 100 mV range enables the instrument to be calibrated.

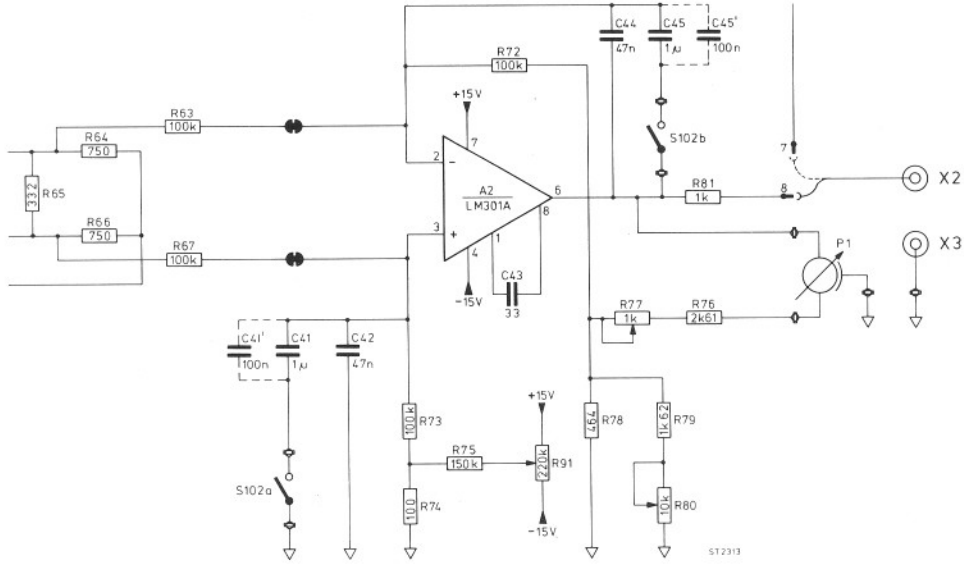


Fig. 11. DC Amplifier

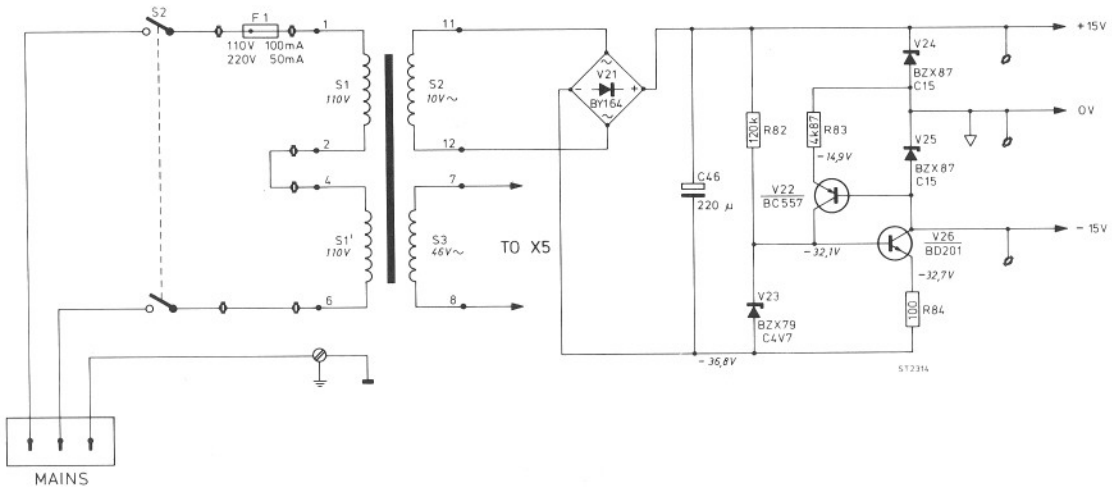


Fig. 12. Mains section

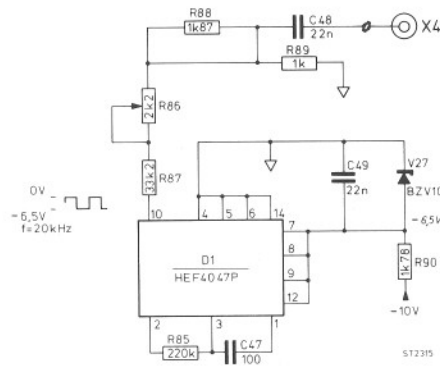


Fig. 13. Reference voltage generator

## 8. ACCESS

The opening of parts, or removal of covers, is likely to expose live conductors. The instrument should therefore be disconnected from all voltage sources before any opening of parts or removal of covers is started.

During and after dismantling, bear in mind that capacitors in the instrument may still be charged even if it has been separated from all voltage sources.

USE A WELL-FITTING CROSSHEAD SCREW-DRIVER TO DISMANTLE THE INSTRUMENT TO PREVENT THE CORSS-SLOTTED SCREWS FOR DAMAGE.

### 8.1. Dismantling

#### 1. Top cover

- Remove both screws "A" (fig. 5)
- Lift the cover at the rear and slide it backwards from the unit.

#### 2. Bottom cover

- Remove both screws "B" (fig. 5)
- Lift the cover at the rear and slide it backwards from the unit.

## 9. MAINTENANCE AND SERVICING

AC millivoltmeter PM 2554 requires no maintenance because the instrument contains no components which are subject to wear.

However, to ensure reliable and faultless operation, the instrument should not be exposed to moisture, heat, corrosive vapours and excessive dust.

### 9.1. Service hints

If service work must be performed, the following points should be taken into account to avoid damage of the instrument.

- In case of measurements on a switched-on instrument proceed carefully to avoid short-circuits by means of measuring clips or measuring hooks.
- For soldering use absolutely acid-free soldering tin.
- For all soldering work on the printed circuit boards, use a miniature soldering iron (35 W max.) with a thin-cleaner or a vacuum soldering iron.
- On the printed wiring boards jumpers are introduced at the conductor side; they can be used to interrupt circuits in order to test the functioning of the corresponding circuit.
- The dc settings of the instrument given on the circuit diagram are measured with the input short circuited. These values represent an average instrument.

## 10. CHECKING AND ADJUSTING

### 10.1. General

The tolerances stated in this chapter correspond to the factory data; they apply when the instrument is readjusted completely. Such data may differ from these given in chapter 2. Technical Data.

To calibrate this instrument, only reference voltages and measuring equipment with the required accuracy should be applied.

Before calibration, a warming-up time of approximately 30 minutes should be taken into account.

### 10.2. Survey of adjusting elements

The next table gives a survey of the adjustments and checking procedure.

For a complete adjustment adhere to the sequence of point 3 of this chapter.

| Adjusting unit | Fig. | Adjustment or final adjustment        | Required measuring or auxiliary instrument  | Adjust according to chapter 10 sub-point |
|----------------|------|---------------------------------------|---|--|
| R80            | 18   | Calibrating the instrument            |   | 3.4                                      |
| R4             | 19   | Frequency-independent voltage divider | LF generator precision<br>LF millivoltmeter   | 3.5                                      |
| R91            | 18   | Zero point DC amplifier               | Voltmeter, for instance<br>PM 2403  | 3.3                                      |
| R77            | 18   | DC output                             | LF generator, precision<br>LF millivoltmeter.<br>Voltmeter, for instance<br>PM 2421 | 3.4                                      |
| R86            | 18   | Reference voltage                     | LF generator, precision<br>LF millivoltmeter  | 3.6                                      |
| C3/C6          | 18   | Frequency-independent voltage divider | LF generator, precision<br>LF millivoltmeter.<br>Probe PM 9336                      | 3.5                                      |

### 10.3 Adjusting procedure

#### 10.3.1. Mechanical zero-setting

- Check with the unit switched off whether the mechanical zero adjustment of the pointer is correct. Deviations can be corrected by means of the correction screw. The unit should be placed horizontal in this case.

### 10.3.2. Supply voltages

- The value adjusted by means of the wiring of T1 (see fig. 3) must correspond with the local mains voltage
  - The mains fuse must have a current value of 50 mA d.a. (90 V...132 V) or 100 mA d.a. (180 V...265 V)
  - The supply voltages are + 15 V and – 15 V with respect to 0
- |             |                     |
|-------------|---------------------|
| Test points | + 15 V: cathode V24 |
|             | 0 V: cathode V25    |
|             | – 15 V: anode V25   |

### 10.3.3. Zero-setting d.c. amplifier

- Set S 101 to position 300 mV
- Measure the voltage on the d.c. output
- Adjust this voltage to 0 V by means of potentiometer R91
- Set S 101 to position 1 mV
- The pre-deflection must be less than 3 scale deviations (sd.)

### 10.3.4. Adjusting the d.c. output

- Set S 101 to position 30 mV
- Connect a voltage of  $31.6 \text{ mV} \pm 0.2\%$ ; 1 kHz to X1
- Adjust the test system to 100 sd by means of R80
- Measure the voltage on the d.c. output X2 and X3
- Adjust the voltage to  $1 \text{ V} \pm 0.2\%$  by means of R77

### 10.3.5. Adjusting the frequency-independent voltage divider

- Set S 101 to position 10 V
- Connect a voltage of  $10 \text{ V} \pm 0.2\%$  400 Hz to X1
- Adjust the test system to 100 sd by means of R4
- Increase the frequency to 50 kHz
- Adjust the test system to 100 sd by means of C6
- Set S 101 to position 100 mV
- Connect a voltage of  $1 \text{ V} \pm 0.2\%$  to X1 via a PM 9336 probe
- Note down the deflection of the test system.
- Increase the frequency to 50 kHz
- Adjust the system to the value noted by means of the trimming potentiometer in the probe
- Set S 101 to position 1 V
- Connect a voltage of  $10 \text{ V} \pm 0.2\%$ , 200 Hz to X1 via the probe now adjusted
- Noted down the deflection of the test system
- Increase the frequency to 50 kHz
- Adjust the system to the latter value by means of C3.

### 10.3.6. Adjusting the reference generator

- Set S 101 in position 100 mV
- Apply a voltage of  $100 \text{ mV} \pm 0.2\%$  1 kHz to X1
- Adjust the test system to 100 sd by means of R80
- Interconnect X1 and X4
- Adjust the test system to 100 sd by means of R86

**10.3.7. Ripple suppression**

(Only necessary if C41 or C45 has to be replaced)

- Set S 101 in position 1 V
- Set S 102 in position slow
- Connect a voltage of 0.9 V 2 Hz to X1
- The total swing of the needle should be smaller than 0.5 sd
- If necessary add a capacitor of 0.1  $\mu$ F in parallel with R41 or R45

**10.3.8. Final check**

After the above adjustments, the instrument must comply with the specifications given in the table below.

| Position S 101 | Supply  |         |  | Indication in sd test system | D.C. Output    |
|----------------|---------|---------|--|------------------------------|----------------|
| 10 mV          | 10 mV   | 10 kHz  |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |
| 30 mV          | 31.6 mV | 10 kHz  |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |
| 100 mV         | 100 mV  | 10 kHz  |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |
| 100 mV         | 100 mV  | 400 kHz |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |
| 100 mV         | 100 mV  | 10 Hz   |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |
| 100 mV         | 100 mV  | 2 Hz    |  | 100 $\pm$ 3.5%               | 1 V $\pm$ 3.5% |
| 100 mV         | 100 mV  | 2 MHz   |  | 100 $\pm$ 2 %                | 1 V $\pm$ 2.5% |
| 100 mV         | 100 mV  | 6 MHz   |  | 100 $\pm$ 4 %                | 1 V $\pm$ 4 %  |
| 100 mV         | 100 mV  | 12 MHz  |  | 100 $\pm$ 7 %                | 1 V $\pm$ 7 %  |
| 1 V            | 1 V     | 10 kHz  |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |
| 1 V            | 1 V     | 12 MHz  |  | 100 $\pm$ 7 %                | 1 V $\pm$ 7 %  |
| 3 V            | 3.16 V  | 10 kHz  |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |
| 10 V           | 10 V    | 10 kHz  |  | 100 $\pm$ 1.5%               | 1 V $\pm$ 1.5% |

*Note:— Accuracy of the voltage supplied: + 0.5%**— In case of a to high indication at 2 Hz C60 should be increased or C16 should be decreased.*

**10.3.7. Ripple suppression**

(Only necessary if C41 or C45 has to be replaced)

- Set S 101 in position 1 V
- Set S 102 in position slow
- Connect a voltage of 0.9 V 2 Hz to X1
- The total swing of the needle should be smaller than 0.5 sd
- If necessary add a capacitor of 0.1  $\mu$ F in parallel with R41 or R45

**10.3.8. Final check**

After the above adjustments, the instrument must comply with the specifications given in the table below.

| Position S 101 | Supply |    | Indication in sd test system |     | D.C. Output    |
|----------------|--------|----|------------------------------|-----|----------------|
| 10 mV          | 10     | mV | 10                           | kHz | 1 V $\pm$ 1.5% |
| 30 mV          | 31.6   | mV | 10                           | kHz | 1 V $\pm$ 1.5% |
| 100 mV         | 100    | mV | 10                           | kHz | 1 V $\pm$ 1.5% |
| 100 mV         | 100    | mV | 400                          | kHz | 1 V $\pm$ 1.5% |
| 100 mV         | 100    | mV | 10                           | Hz  | 1 V $\pm$ 1.5% |
| 100 mV         | 100    | mV | 2                            | Hz  | 1 V $\pm$ 3.5% |
| 100 mV         | 100    | mV | 2                            | MHz | 1 V $\pm$ 2.5% |
| 100 mV         | 100    | mV | 6                            | MHz | 1 V $\pm$ 4 %  |
| 100 mV         | 100    | mV | 12                           | MHz | 1 V $\pm$ 7 %  |
| 1 V            | 1      | V  | 10                           | kHz | 1 V $\pm$ 1.5% |
| 1 V            | 1      | V  | 12                           | MHz | 1 V $\pm$ 7 %  |
| 3 V            | 3.16   | V  | 10                           | kHz | 1 V $\pm$ 1.5% |
| 10 V           | 10     | V  | 10                           | kHz | 1 V $\pm$ 1.5% |

*Note:— Accuracy of the voltage supplied: + 0.5%**— In case of a too high indication at 2 Hz C60 should be increased or C16 should be decreased.*



## 11. LIST OF PARTS

## 11.1 Mechanical

| Item | Fig. | Qty. | Ordering number | Description          |
|------|------|------|-----------------|----------------------|
| 1    | 14   | 1    | 5322 447 94068  | Top and bottom cover |
| 2    | 14   | 2    | 5322 460 64003  | Ornamental strip     |
| 3    | 14   | 2    | 5322 535 74367  | Spindle for handle   |
| 4    | 14   | 1    | 5322 520 34138  | Bearing bush, left   |
| 5    | 17   | 1    | 5322 520 34139  | Bearing bush, right  |
| 6    | 14   | 1    | 5322 498 74003  | Cab for handle       |
| 7    | 14   | 1    | 5322 498 54032  | Handle assey         |
| 8    | 14   | 1    | 5322 460 64002  | Ornamental frame     |
| 9    | 16   | 1    | 5322 414 64039  | Knob for S 101       |
| 10   | 14   | 1    | 5322 414 74019  | Cab for knob         |
| 11   | 14   | 1    | 5322 526 44136  | Insulating bush      |
| 12   | 17   | 1    | 5322 405 94159  | Clip                 |
| 13   | 16   | 1    | 5322 532 54209  | Coppling piece       |
| 14   | 14   | 1    | 5322 535 74394  | Spindle              |
| 15   | 17   | 1    | 5322 535 94637  | Extension spindle    |
| 16   | 16   | 1    | 5322 532 64119  | Bush                 |
| 17   | 16   | 2    | 5322 462 44175  | Foot                 |
| 18   | 17   | 1    | 5322 492 64337  | Retaining spring     |
| 19   | 15   | 4    | 5322 462 44121  | Foot                 |

## 11.2 Miscellaneous

| Item | Fig. | Qty. | Ordering number | Description           |
|------|------|------|-----------------|-----------------------|
| 20   | 16   | 1    | 4822 253 30003  | Fuse 50 mA da 5 x 20  |
| 21   | 14   | 1    | 5322 344 64055  | Measuring system      |
| 22   | 17   | 1    | 5322 276 14085  | Fast-Slow switch      |
| 23   | 17   | 1    | 4822 276 10554  | Mains switch          |
| 24   | 16   | 1    | 5322 273 64036  | Range switch          |
| 25   | 16   | 1    | 5322 146 24186  | Mains transformer     |
| 26   | 14   | 1    | 5322 267 14022  | HF-Con BNC            |
| 27   | 15   | 1    | 5322 267 30231  | Connector Hi          |
| 28   | 15   | 1    | 5322 267 30231  | Connector Lo          |
| 29   | 15   | 1    | 5322 267 30231  | Connector REF         |
| 30   | 15   | 1    | 5322 267 54072  | Connector 8-P         |
| 31   | —    | 1    | 5322 320 14093  | Measuring cable       |
| 32   | 16   | 2    | 4822 253 30006  | Fuse 100 mA da 5 x 20 |
| 33   | 14   | 2    | 5322 414 14011  | Push botton knob      |
| 34   | 15   | 1    | 5322 321 14001  | Mains cable           |
| 35   | 15   | 1    | 5322 325 50101  | Cable grommet         |
| 36   | 16   | 1    | 5322 462 44362  | Protective cover      |

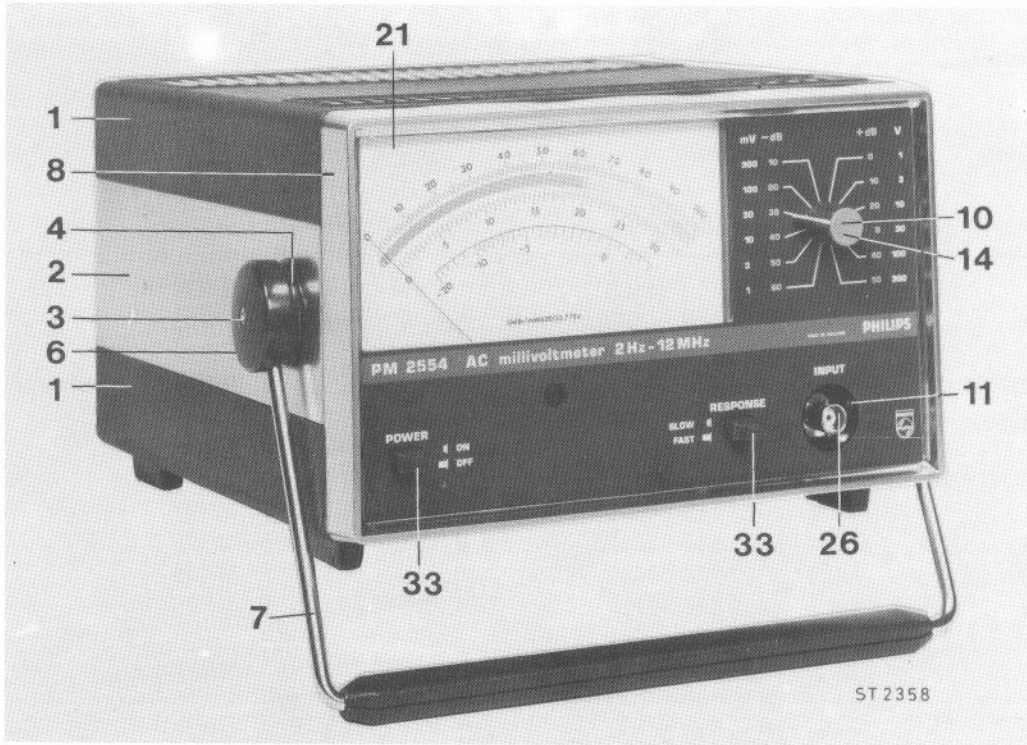


Fig. 14. Front view with item numbers

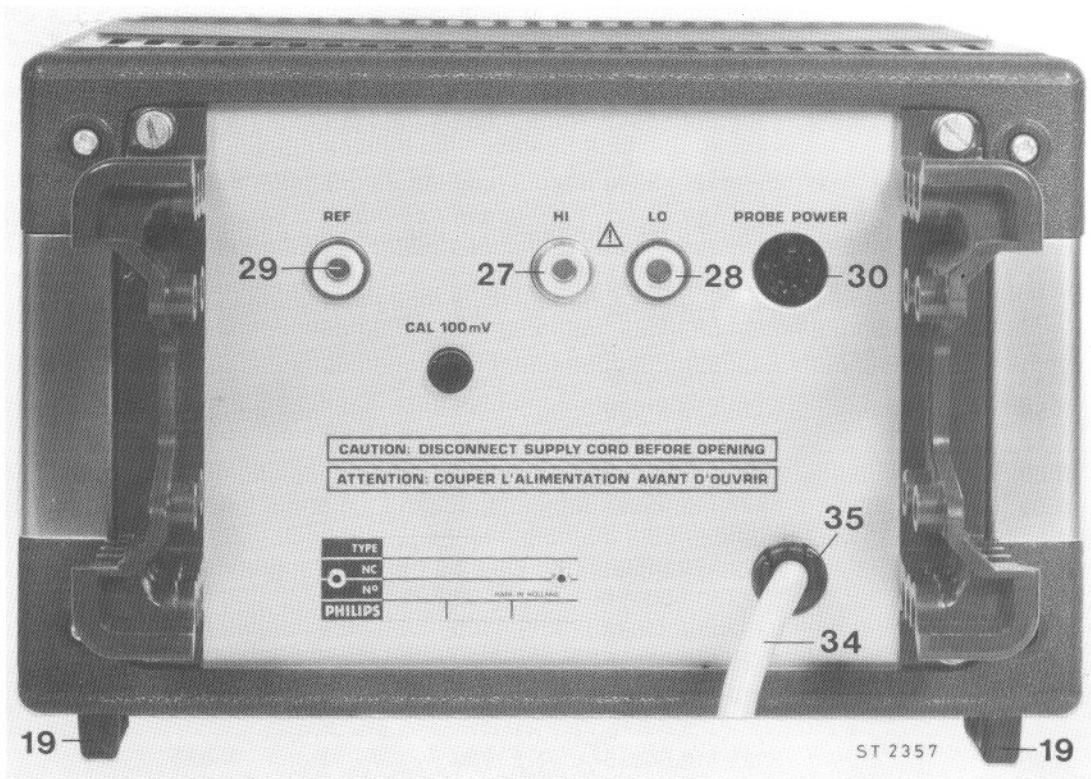


Fig. 15. Rear view with item numbers

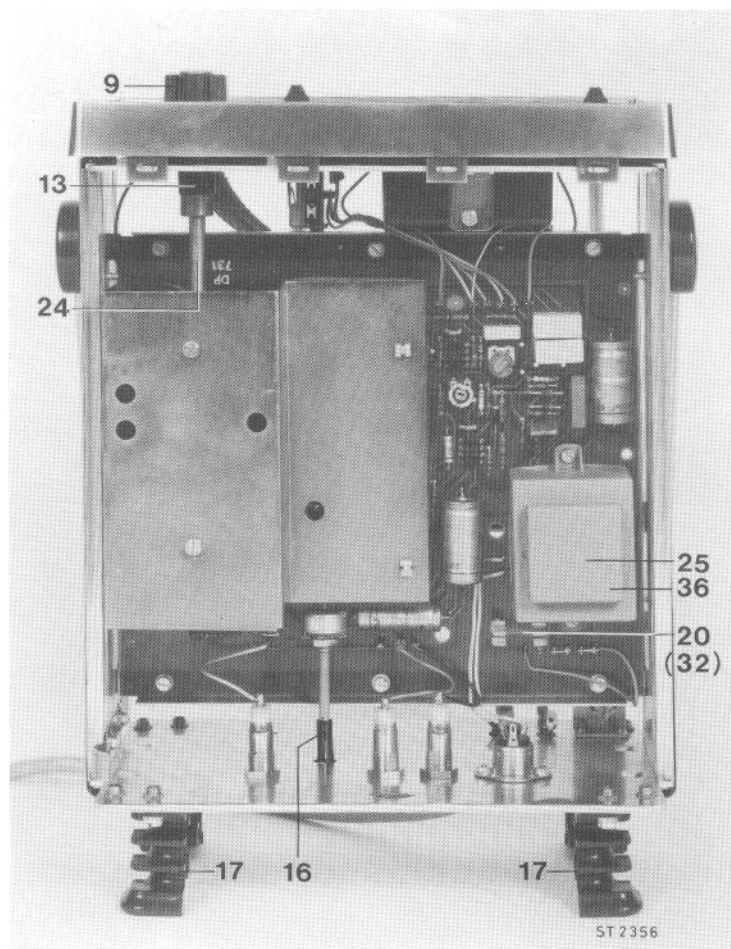


Fig. 16. Top view

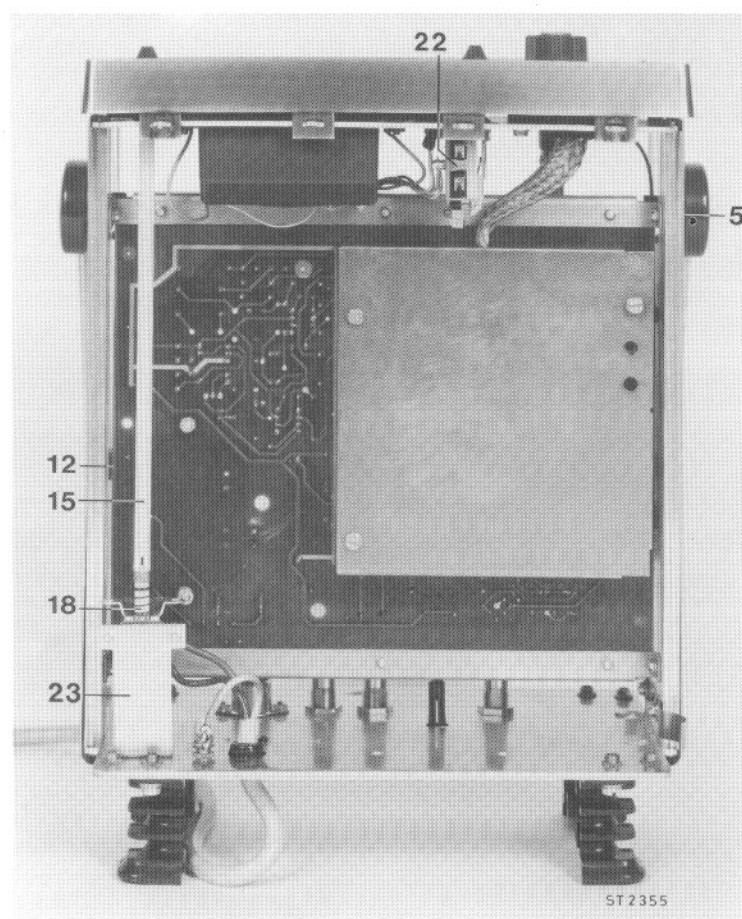


Fig. 17. Bottom view

## 11.3. Electrical

11.3.1. Resistors \*

| No.  | Ordering number | Value ( $\Omega$ ) | %  | Series             |
|------|-----------------|--------------------|----|--------------------|
| R 1  | 5322 116 54188  | 1 M                | 1  | MR30               |
| R 2  | 5322 116 54554  | 1,1 k              | 1  | MR25               |
| R 3  | 5322 116 54617  | 9,53 k             | 1  | MR25               |
| R 4  | 4822 101 20416  | 4,7 k              | 20 | 0.1W Potentiometer |
| R 7  | 4822 116 51123  | 100 k              | 1  | MR30               |
| R 8  | 5322 116 54188  | 1 M                | 1  | MR30               |
| R 11 | 5322 116 54641  | 19,6 k             | 1  | MR25               |
| R 12 | 5322 116 54012  | 6,81 k             | 1  | MR25               |
| R 13 | 5322 116 50452  | 10                 | 1  | MR25               |
| R 14 | 5322 116 50729  | 4,22 k             | 1  | MR25               |
| R 15 | 5322 116 50452  | 10                 | 1  | MR25               |
| R 31 | 5322 116 54643  | 20,5 k             | 1  | MR25               |
| R 32 | 5322 116 54534  | 681                | 1  | MR25               |
| R 33 | 5322 116 54466  | 90,9               | 1  | MR25               |
| R 34 | 5322 116 54455  | 68,1               | 1  | MR25               |
| R 35 | 5322 116 54502  | 261                | 1  | MR25               |
| R 36 | 5322 116 54567  | 1,69 k             | 1  | MR25               |
| R 37 | 5322 116 54472  | 105                | 1  | MR25               |
| R 38 | 5322 116 54561  | 1,33 k             | 1  | MR25               |
| R 39 | 5322 116 54543  | 866                | 1  | MR25               |
| R 40 | 5322 116 54519  | 402                | 1  | MR25               |
| R 41 | 5322 116 54532  | 649                | 1  | MR25               |
| R 42 | 5322 116 50452  | 10                 | 1  | MR25               |
| R 43 | 5322 116 54009  | 562                | 1  | MR25               |
| R 44 | 5322 116 54696  | 100 k              | 1  | MR25               |
| R 45 | 5322 116 54627  | 13,3 k             | 1  | MR25               |
| R 50 | 5322 116 54446  | 56,2               | 1  | MR25               |
| R 57 | 5322 116 54696  | 100 k              | 1  | MR25               |
| R 58 | 5322 116 54188  | 1 M                | 1  | MR30               |
| R 59 | 5322 116 54558  | 8,25 k             | 1  | MR25               |
| R 61 | 5322 116 54595  | 5,11 k             | 1  | MR25               |
| R 62 | 5322 116 50451  | 21,5 k             | 1  | MR25               |
| R 63 | 5322 116 54696  | 100 k              | 1  | MR25               |
| R 64 | 5322 116 54536  | 750                | 1  | MR25               |
| R 65 | 5322 116 54513  | 332                | 1  | MR25               |
| R 66 | 5322 116 54536  | 750                | 1  | MR25               |
| R 67 | 5322 116 54696  | 100 k              | 1  | MR25               |
| R 72 | 5322 116 54696  | 100 k              | 1  | MR25               |
| R 73 | 5322 116 54696  | 100 k              | 1  | MR25               |
| R 74 | 5322 116 54469  | 100                | 1  | MR25               |

\* Carbon resistors CR25 5% -0,125 W are not mentioned in this list

| No.   | Ordering number | Value ( $\Omega$ ) | %    | Series |               |
|-------|-----------------|--------------------|------|--------|---------------|
| R 76  | 5322 116 50671  | 2,61 k             | 1    | MR25   |               |
| R 77  | 4822 100 10037  | 1 k                | 20   | 0,05W  | Potentiometer |
| R 78  | 5322 116 50536  | 464                | 1    | MR25   |               |
| R 79  | 5322 116 54565  | 1,62 k             | 1    | MR25   |               |
| R 80  | 5322 101 24138  | 10 k               | 20   | MR25   |               |
| R 81  | 5322 116 54549  | 1 k                | 1    | MR25   |               |
| R 83  | 5322 116 50509  | 4,87 k             | 1    | MR25   |               |
| R 84  | 5322 116 54469  | 100                | 1    | MR25   |               |
| R 86  | 4822 100 10029  | 2,2 k              | 20   | 0,05W  | Potentiometer |
| R 87  | 5322 116 50482  | 33,2 k             | 1    | MR25   |               |
| R 88  | 5322 116 50728  | 1,87 k             | 1    | MR25   |               |
| R 89  | 5322 116 54549  | 1 k                | 1    | MR25   |               |
| R 90  | 5322 116 50729  | 4,22 k             | 1    | MR25   |               |
| R 91  | 4822 100 10088  | 220 k              | 20   | 0,05W  | Potentiometer |
| R 105 | 5322 116 54852  | 100                | 1    | MR30   |               |
| R 106 | 5322 116 54852  | 100                | 1    | MR30   |               |
| R 118 | 5322 116 54767  | 205                | 0,25 | MR24C  |               |
| R 120 | 5322 116 54767  | 205                | 0,25 | MR24C  |               |
| R 122 | 5322 116 54767  | 205                | 0,25 | MR24C  |               |
| R 123 | 4822 110 63145  | 27 k               | 5    | CR25   |               |
| R 124 | 5322 116 54767  | 205                | 0,25 | MR24C  |               |
| R 126 | 5322 116 50865  | 140                | 0,25 | MR24C  |               |
| R 127 | 5322 116 54472  | 105                | 1    | MR25   |               |
| R 128 | 5322 116 55038  | 301                | 0,25 | MR24C  |               |
| R 129 | 5322 116 55038  | 301                | 0,25 | MR24C  |               |
| R 130 | 5322 116 55038  | 301                | 0,25 | MR24C  |               |
| R 313 | 5322 116 55038  | 301                | 0,25 | MR24C  |               |
| R 132 | 5322 116 55038  | 301                | 0,25 | MR24C  |               |

11.3.2. Capacitors

| No.  | Ordering number | Value (F) | %      | V   | Description  |
|------|-----------------|-----------|--------|-----|--------------|
| C 1  | 4822 121 40117  | 1 $\mu$   | 10     | 400 | Polyester    |
| C 2  | 4822 122 31217  | 3,9 p     | 0,25pF |     | Ceramic      |
| C 3  | 4822 125 60037  | 6         |        | 500 | Trimmer      |
| C 4  | 4822 122 31192  | 6,8 p     | 0,25pF | 500 | Ceramic      |
| C 5  | 4822 122 31191  | 5,6 p     | 0,25pF | 500 | Ceramic      |
| C 6  | 5322 125 64011  | 3 p       |        | 500 | Trimmer      |
| C 7  | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 8  | 5322 121 44225  | 4,7 n     | 10     | 630 | Polyester    |
| C 9  | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 10 | 4822 124 20467  | 15 $\mu$  | -10+50 | 16  | Electrolytic |
| C 11 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 12 | 4822 124 20461  | 47 $\mu$  | -10+50 | 10  | Electrolytic |
| C 13 | 4822 124 20467  | 15 $\mu$  | -10+50 | 16  | Electrolytic |
| C 14 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 15 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 16 | 4822 124 20457  | 470 $\mu$ | -10+50 | 6,3 | Electrolytic |
| C 17 | 4822 121 40232  | 220 n     | 10     | 100 | Polyester    |
| C 18 | 4822 124 20457  | 470 $\mu$ | -10+50 | 6,3 | Electrolytic |
| C 22 | 4822 122 31076  | 68 p      | 2      | 100 | Ceramic      |
| C 23 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 24 | 4822 124 20467  | 15 $\mu$  | -10+50 | 16  | Electrolytic |
| C 25 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 26 | 4822 124 20467  | 15 $\mu$  | -10+50 | 16  | Electrolytic |
| C 27 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 28 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 29 | 4822 124 20462  | 100 $\mu$ | -10+50 | 10  | Electrolytic |
| C 30 | 4822 124 20461  | 47 $\mu$  | -10+50 | 10  | Electrolytic |
| C 31 | 4822 122 31061  | 18 p      | 2      | 100 | Ceramic      |
| C 32 | 4822 125 50062  | 10 p      |        | 250 | Trimmer      |
| C 33 | 4822 124 20467  | 15 $\mu$  | -10+50 | 16  | Electrolytic |
| C 34 | 4822 122 31067  | 33 p      | 2      | 100 | Ceramic      |
| C 35 | 4822 124 20467  | 15 $\mu$  | -10+50 | 16  | Electrolytic |
| C 36 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 37 | 4822 124 20459  | 22 $\mu$  | -10+50 | 10  | Electrolytic |
| C 38 | 5322 121 40308  |           |        |     | Polyester    |
| C 39 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |
| C 40 | 4822 124 20467  | 15 $\mu$  | -10+50 | 16  | Electrolytic |
| C 41 | 5322 121 40197  | 1 $\mu$   | 10     | 100 | Polyester    |
| C 42 | 5322 121 44138  | 47 n      | 10     | 100 | Polyester    |
| C 43 | 4822 122 31067  | 33 p      | 2      | 100 | Ceramic      |
| C 44 | 5322 121 44138  | 47 n      | 10     | 100 | Polyester    |
| C 45 | 5322 121 40197  | 1 $\mu$   | 10     | 100 | Polyester    |
| C 46 | 4822 124 20537  | 220 $\mu$ | -10+50 | 63  | Electrolytic |
| C 47 | 4822 122 31081  | 100 p     | 2      | 100 | Ceramic      |
| C 48 | 4822 122 30103  | 22 n      | -20+80 | 40  | Ceramic      |

| No.   | Ordering number | Value (F)  | %      | V   | Description  |
|-------|-----------------|------------|--------|-----|--------------|
| C 49  | 4822 122 30103  | 22 n       | -20+80 | 40  | Ceramic      |
| C 50  | 4822 122 30055  | 330 p      | -20+80 | 100 | Ceramic      |
| C 51  | 4822 122 30055  | 330 p      | 2      | 100 | Ceramic      |
| C 52  | 4822 122 30055  | 330 p      | 2      | 100 | Ceramic      |
| C 53  | 4822 122 30055  | 330 p      | 2      | 100 | Ceramic      |
| C 54  | 4822 122 30055  | 330 p      | 2      | 100 | Ceramic      |
| C 55  | 4822 122 30055  | 330 p      | 2      | 100 | Ceramic      |
| C 56  | 4822 122 30055  | 330 p      | 2      | 100 | Ceramic      |
| C 57  | 4822 121 40232  | 220 n      | 10     | 100 | Polyester    |
| C 58  | 4822 124 20465  | 330 $\mu$  | -10+50 | 10  | Electrolytic |
| C 60  | 4822 124 20508  | 1000 $\mu$ | -10+50 | 4   | Electrolytic |
| C 61  | 4822 124 20581  | 220 $\mu$  | -10+50 | 4   | Electrolytic |
| C 62  | 4822 124 20515  | 2200 $\mu$ | -10+50 | 6,3 | Electrolytic |
| C 64  | 4822 122 30103  | 22 n       | -20+80 | 40  | Ceramic      |
| C 70  | 4822 122 31058  | 15 p       | 2      | 700 | Ceramic      |
| C 118 | 4822 122 31058  | 15 p       | 2      | 100 | Ceramic      |
| C 119 | 4822 122 31074  | 56 p       | 2      | 100 | Ceramic      |
| C 121 | 4822 124 20468  | 33 $\mu$   | -10+50 | 16  | Electrolytic |

### 11.3.3. Semiconductors

| No.  | Ordering number | Type          |
|------|-----------------|---------------|
| V 1  | 5322 130 34174  | BZX79-C4V7    |
| V 2  | 4822 130 30613  | BAW62         |
| V 3  | 5322 130 34174  | BZX79-C4V7    |
| V 4  | 4822 130 30613  | BAW62         |
| V 5  | 5322 130 40408  | BFW11         |
| V 6  | 5322 130 44127  | 2N2894A       |
| V 7  | 5322 130 40493  | BFY90         |
| V 8  | 5322 130 44127  | 2N2894A       |
| V 9  | 5322 130 40493  | BFY90         |
| V 10 | 5322 130 40493  | BFY90         |
| V 11 | 4822 130 40964  | BC549         |
| V 12 | 5322 130 40493  | BFY90         |
| V 13 | 5322 130 34049  | BZX75-C2V1    |
| V 14 | 4822 130 44257  | BC547         |
| V 15 | 4822 130 44257  | BC547         |
| V 16 | 5322 130 44127  | 2N2894A       |
| V 17 | 4822 130 30613  | BAW62         |
| V 18 | 4822 130 44257  | BC547         |
| V 19 | 5322 130 34062  | FH1100        |
| V 20 | 5322 130 34062  | FH1100        |
| V 21 | 4822 130 30414  | BY164         |
| V 22 | 4822 130 44256  | BC557         |
| V 23 | 5322 130 34174  | BZX79-C4V7    |
| V 24 | 5322 130 34156  | BZX87-C15     |
| V 25 | 5322 130 34156  | BZX87-C15     |
| V 26 | 5322 130 44325  | BD201 (TO220) |
| V 27 | 5322 130 34439  | BZV10         |

**11.3.4. Integrated circuits**

| No. | Ordering number | Type       |
|-----|-----------------|------------|
| D 1 | 5322 209 14125  | HEF 4047BP |
| A 1 | 5322 209 84679  | LM301AN    |
| A 2 | 5322 209 84679  | LM301AN    |



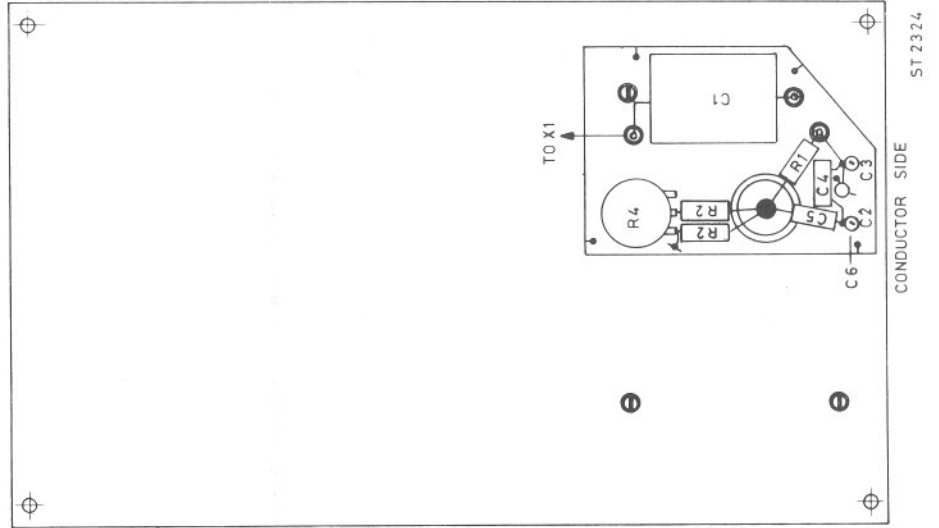
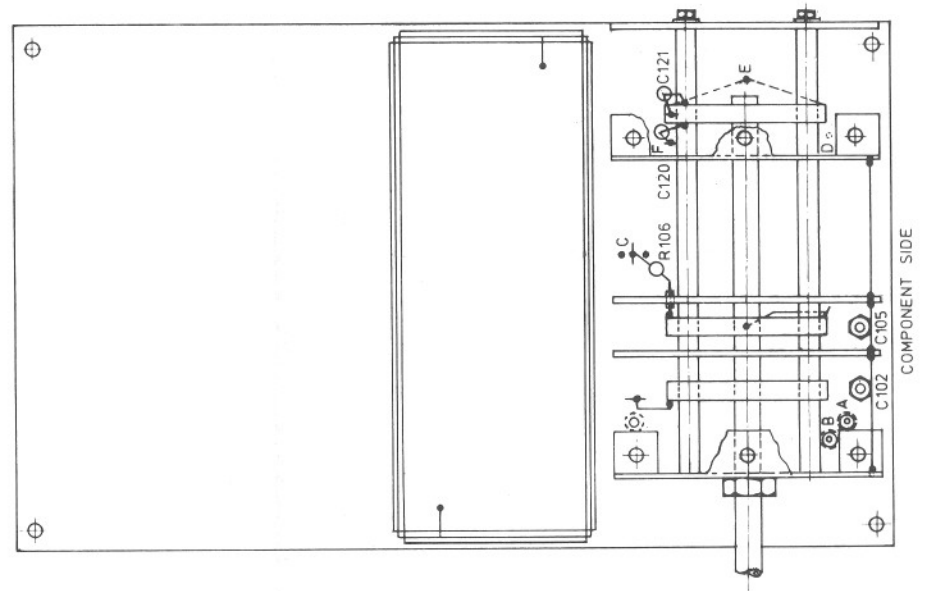
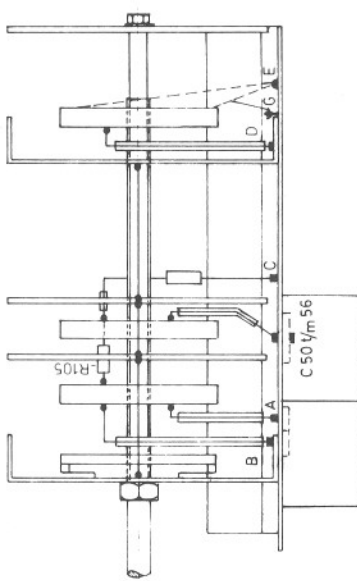


Fig. 20. Printed circuit board U1 with S 101

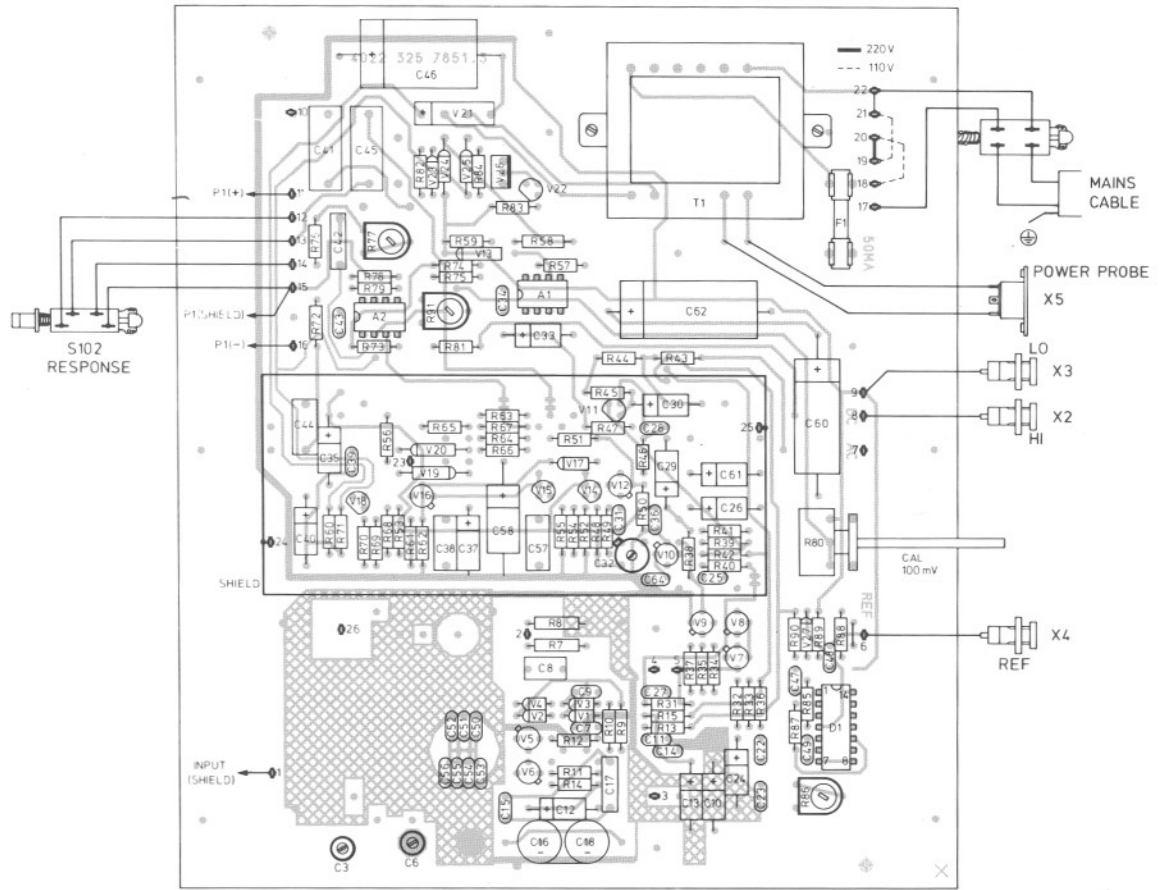


Fig. 18. Printed circuit board U1 Component side

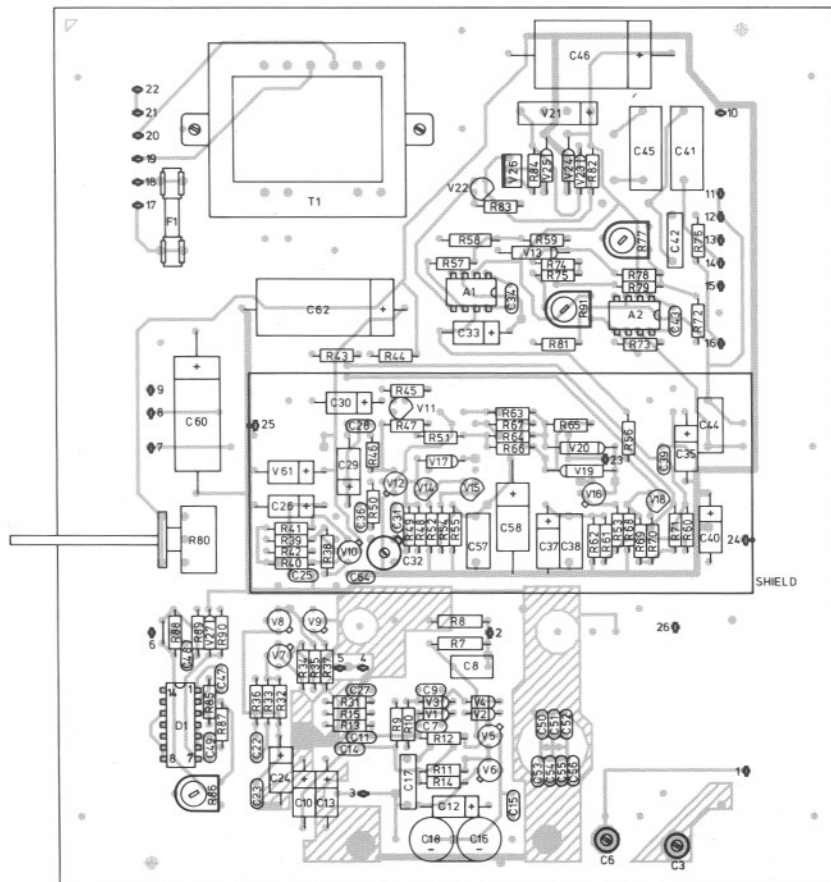
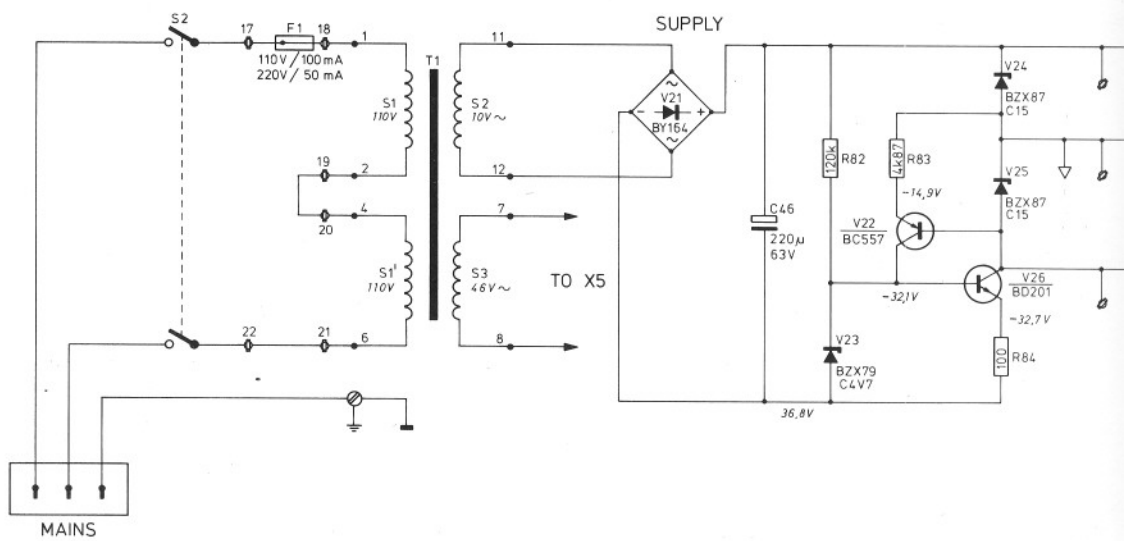
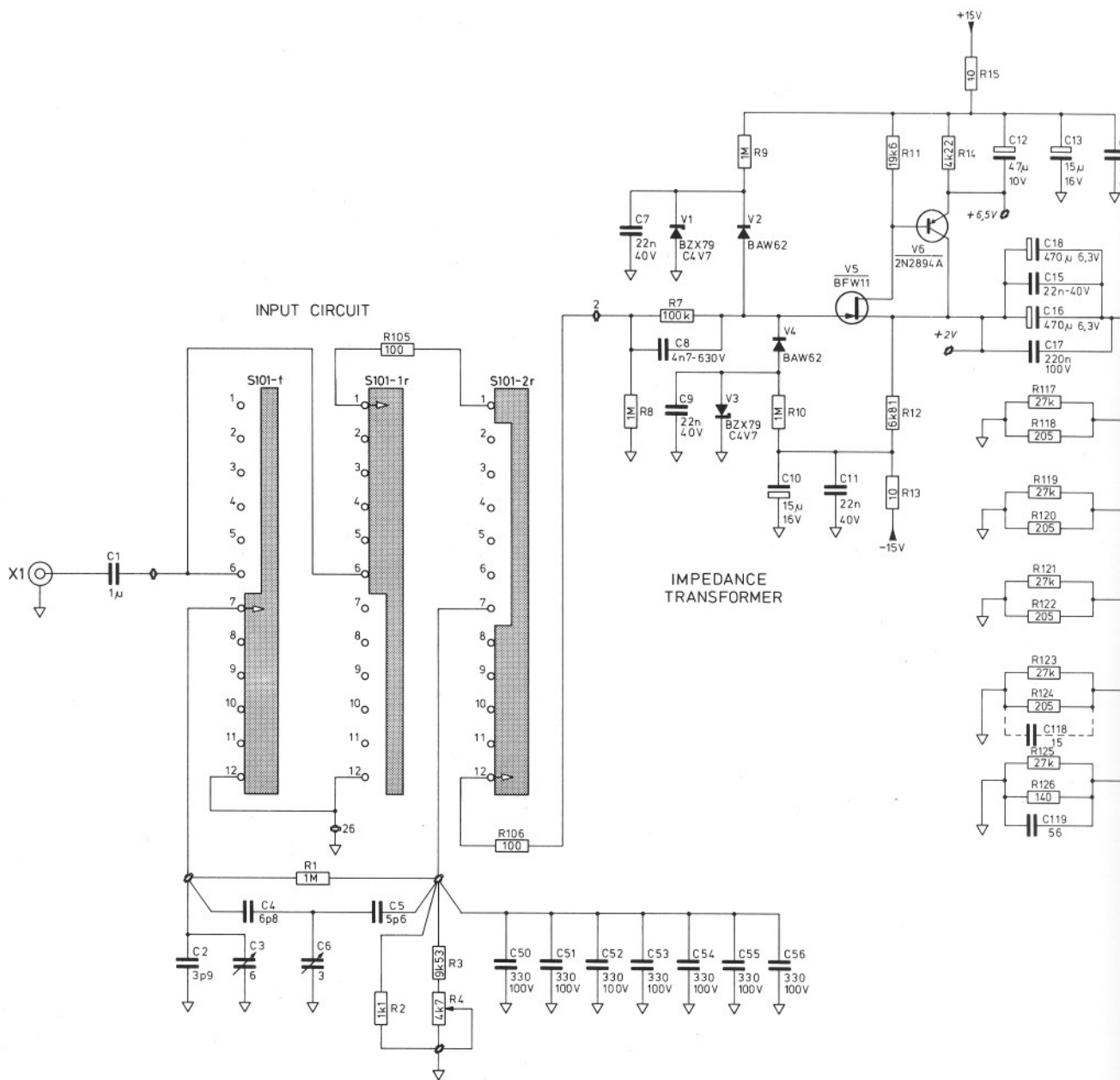
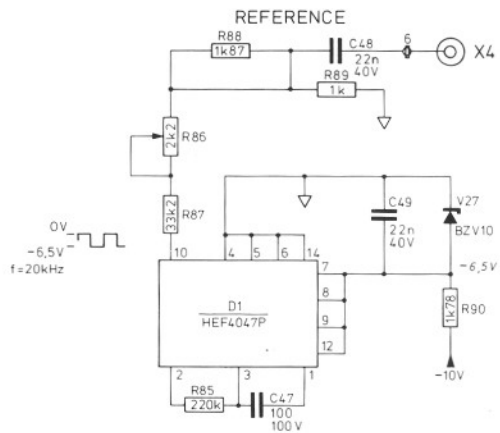
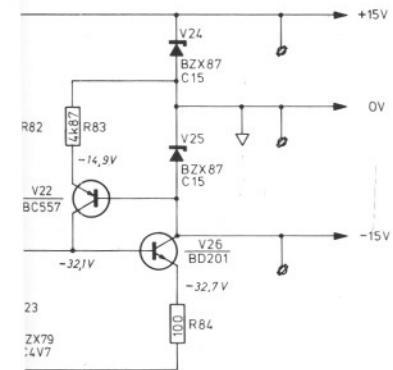
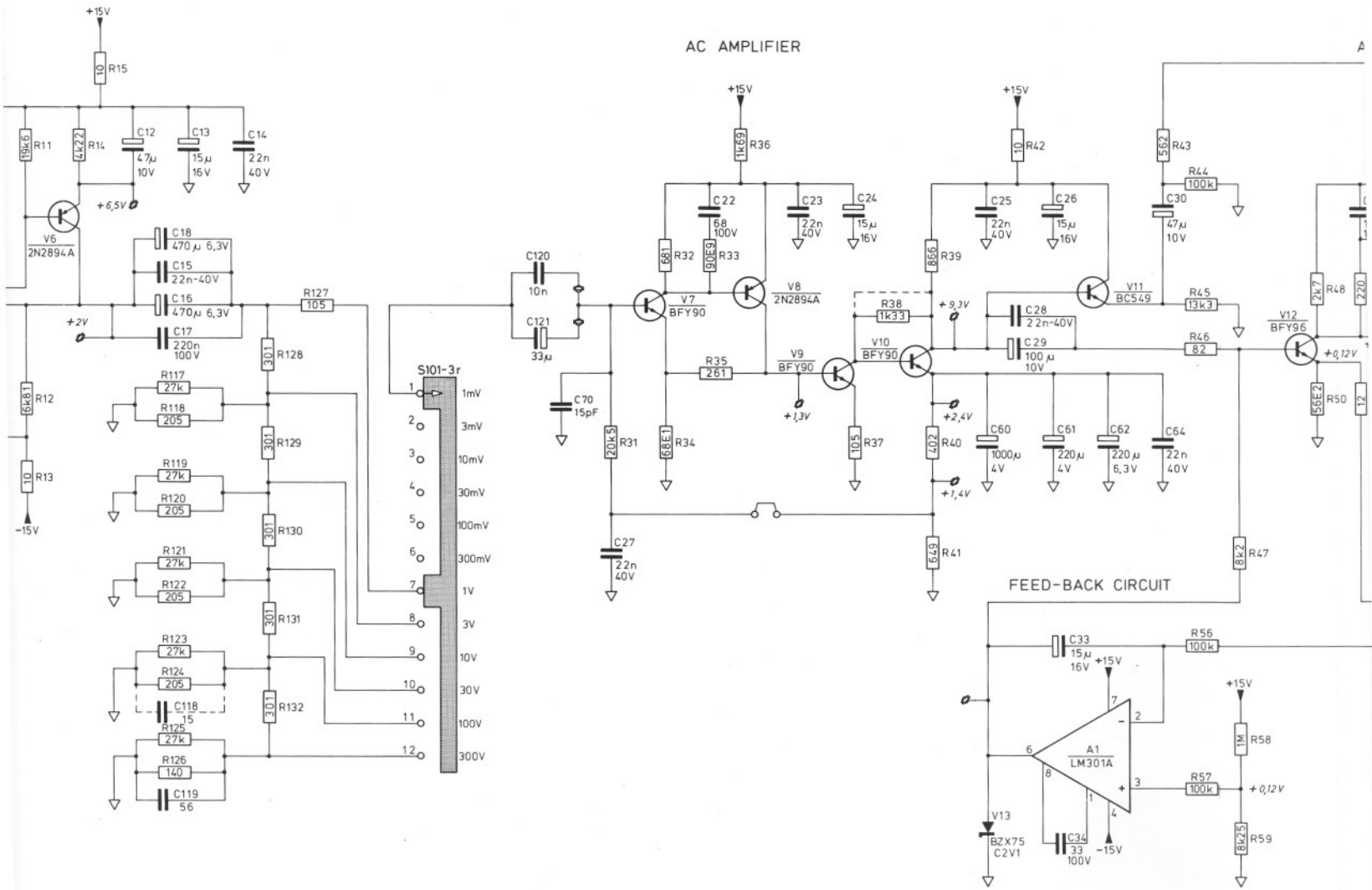


Fig. 19. Printed circuit board U1 Conductor side





AC-DC CONVERTER

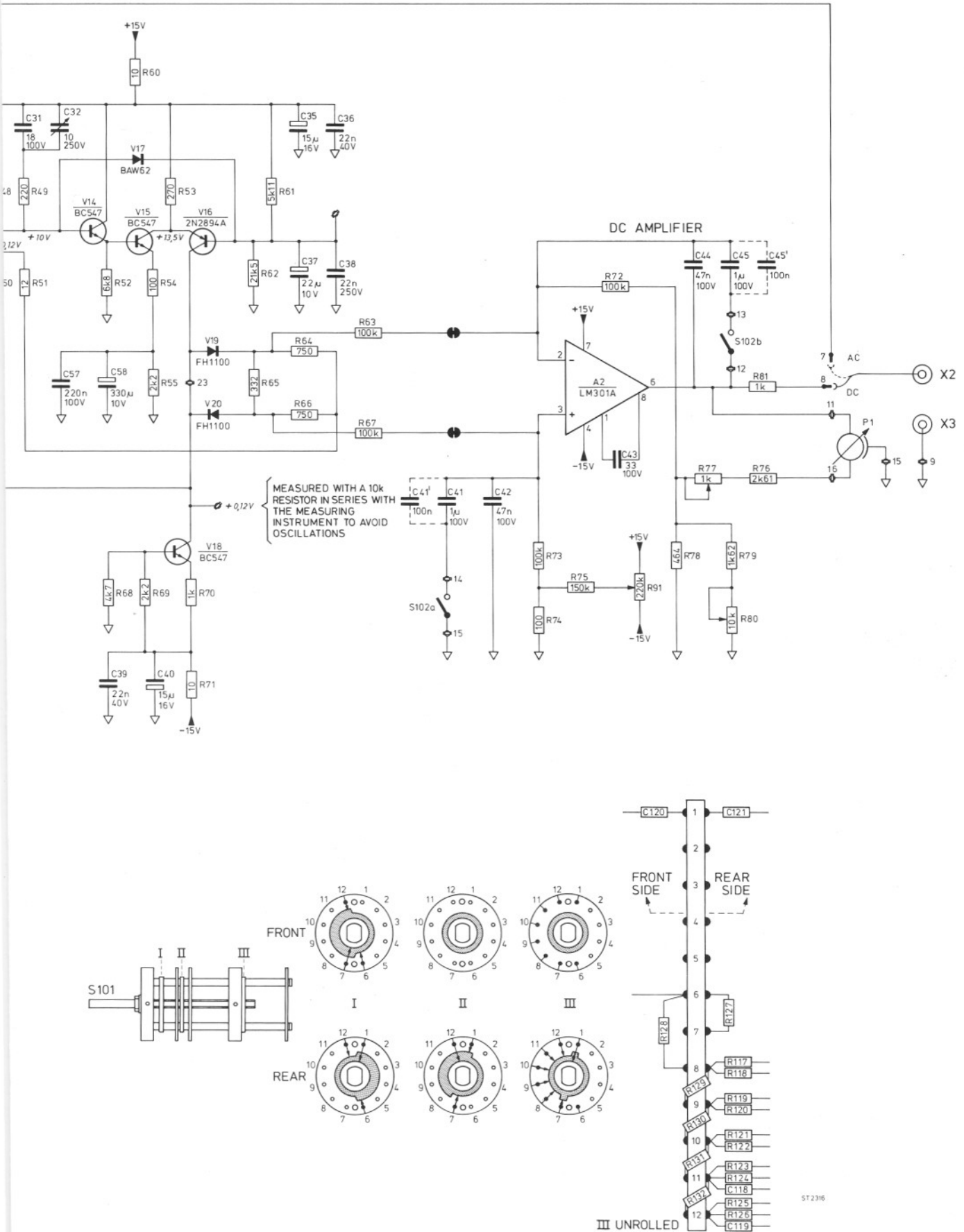


Fig. 21. Circuit diagram.