MANUAL

PHILIPS

Cathode ray oscilloscope
GM 5605

66 402 58.2-10 1/864/01

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Important!

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

GENERAL PART

Introduction

The cathode ray oscilloscope GM 5605 has an extensive field of application and is particularly suitable for use in service workshops and for educational purposes. For X and Y deflection the apparatus contains d.c. amplifiers having the same properties (X-Y oscilloscope). The GM 5605 is, therefore, extremely suitable for displaying the relationship between two quantities, e.g. frequency and phase relationships. Moreover, voltages can be displayed as a function of time by means of the incorporated time-base generator.

Technical data **II**

Properties expressed in numerical values for which a tolerance has been stated are guaranteed at nominal mains voltages on the voltage adapter. Numerical values without tolerances indicate the properties of the average instrument and are only given for the information of the user.

Cathode-ray tube circuit

Tube	
a. type	DH7–78 flat screen (other screen types can be supplied)
b. effective screen area	6 × 5 cm (width × height)
c. total accelerating voltage	1750 V
Graticule	10 × 8 div. (1 div. = 5.5 mm)

Y amplifier

Type	d.c. amplifier
Deflection sensitivity	adjustable to 8 calibrated values: 0.01–0.03–0.1–0.3–1–3–10–30 V/div. Tolerance: ± 3 % Between the steps, the sensitivity can be continuously adjusted in a ratio of 1 : 3.5 (uncalibrated).
Frequency response	0–200 kc/s (— 3 dB). Via the capacitor input the bandwidth is: 5 c/s–200 kc/s.
Overshoot	1 % for pulses with a rise time of ⩾ 25 ns
Sweep expansion	3 × the useful screen height, i.e. 1.5 × upwards and downwards from the centre. At maximum expansion the peaks of the signal can be displayed undistorted by means of the vertical shift control.
Input	
a. input sockets	4-mm plug sockets
b. input resistance	500 kΩ
c. input capacitance	45 pF in position "0.01 V/div." of the attenuator switch 25 pF in the positions "0.03" and "0.1 V/div." 55 pF in the other positions.
d. maximum permissible input voltage at d.c. input	400 $V_{r.m.s.}$

e. Maximum permissible d.c. voltage at the a.c. input — 300 V
f. RC time of the capacitor input — 50 ms

X amplifier

Type — d.c. amplifier

Deflection sensitivity — adjustable to 7 calibrated values: 0.03–0.1–0.3–1–3–10–30 V/div.
Tolerance: ± 3%
Between the steps, the sensitivity can be continuously adjusted in a ratio of 1 : 3.5 (uncalibrated).

Response curve — 0–200 kc/s (— 3 dB). Via the capacitor input the bandwidth is: 5 c/s–200 kc/s.

Overshoot — 1 % for pulses with a rise time ⩾ 25 ns.

Sweep expansion — 3 × the useful screen width, i.e. 1.5 × to the left and to the right from the centre.
At maximum expansion the peaks of the signal can be displayed undistorted by means of the horizontal shift control.

Input
a. input sockets — 4-mm plug sockets
b. input resistance — 500 kΩ
c. input capacitance — 45 pF in position "0.03 V/div" of the attenuator switch
25 pF in the position "0.1 V/div."
55 pF in the other positions.
d. maximum permissible input voltage on d.c. input — 400 $V_{r.m.s.}$
e. Maximum permissible d.c. voltage on the a.c. input — 300 V
f. RC time of the capacitor input — 50 ms

Phase difference of the amplifiers

Phase difference — ⩽ 5° for frequencies of 0–200 kc/s, provided that the two continuous attenuator controls are adjusted to " ×1".

Time base generator

Sweep times — adjustable in 12 steps from 20 μs/div. to 100 ms/div. at a time base length of 10 divisions.

Mode of operation — triggered

Triggering	internal or external
a. required picture height for internal triggering	0.5 division for frequencies of 5 c/s–200 kc/s.
b. required voltage for external triggering	0.5 V_{p-p} for frequencies of 5 c/s–200 kc/s. The maximum voltage amounts to 10 V_{p-p} (in view of crosstalk).
c. input impedance of socket "EXT.TRIGG."	1 MΩ//20 pF

Supply

Mains voltage	voltage adapter for 110 – 125 – 145 – 200 – 220 and 245 V. The mains frequency may range from 40–100 c/s (mains frequencies < 50 c/s only at nominal mains voltage). Power consumption is 80 W.
Influence of mains-voltage variations of ± 10%	The Y and X deflection sensitivity changes inversely proportional to the mains voltage.

Mechanical data

Dimensions	height 25 cm width 16 cm depth 35 cm
Weight	10 kg

Accessories III

1 mains flex
1 manual
2 test cables

DIRECTIONS FOR USE AND APPLICATIONS

Installation

A. ADJUSTING TO THE LOCAL MAINS VOLTAGE

The apparatus can be adjusted to mains voltages of 110–125–145–200–220 and 245 V by means of a voltage adapter.
The adjusted value can be read through the round opening in the rear panel. The instrument is adjusted to another mains voltage as follows.

- Remove the cover plate at the rear (Fig. 1).
- Pull the adapter out a little, turn it until the correct voltage value is uppermost and then press the adapter back again.
- Refit the cover plate.

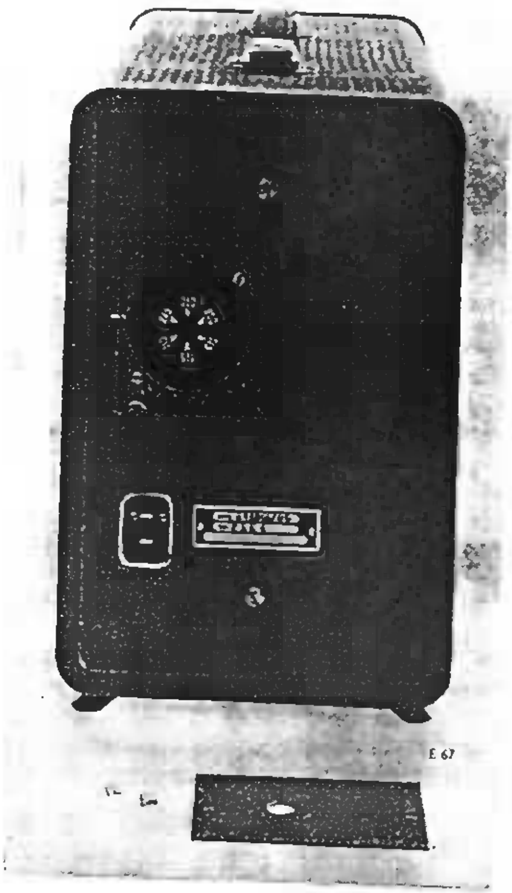

Fig. 1. Adjusting to the local mains voltage

B. EARTHING

Earth the instrument in accordance with the local safety regulations. This may be done

- via the mains flex, if the apparatus has a 3-core mains flex provided with a plug with rim-earthing contacts, or
- via one of the earthing sockets ("⏚") at the front of the apparatus.

Double earthing connections may cause hum and must be avoided.

C. CHECKING BEFORE SWITCHING ON

- Check the setting of the mains voltage adapter (see section A).
- Check whether the apparatus has been properly earthed (see section B).
- Set knob "INTENS." to position "0".
- Connect the apparatus to the mains via the mains flex.

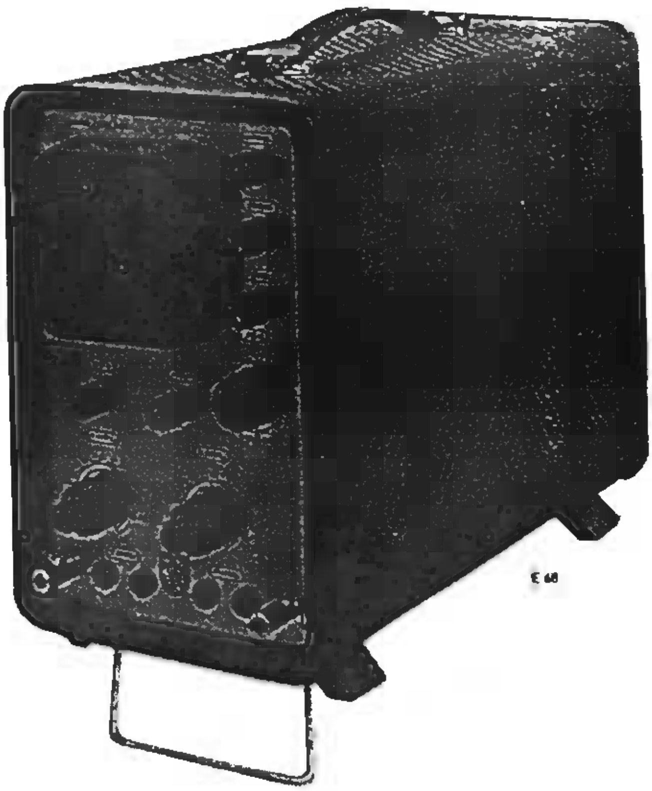

Fig. 2. If desired the apparatus can be tilted by means of the stand provided on the bottom

D. SWITCHING ON

Switch on the apparatus by setting knob "INTENS." from position "0" to approximately its central position.

A stationary picture of maximum brightness, left on the screen for too long a time may permanently damage the screen.

Operation II

A. PRELIMINARY SETTING

- Set all knobs to the positions indicated in Fig. 3.
- Adjust the time base line to the centre of the screen by means of the knobs "↓Y↑" and "←X→".
- Check whether the time base line appears horizontally on the screen. If necessary, reposition the picture tube in accordance with section VI.H.1.
- Adjust the definition and the brightness of the picture by means of the controls "FOCUS." and "INTENS.".

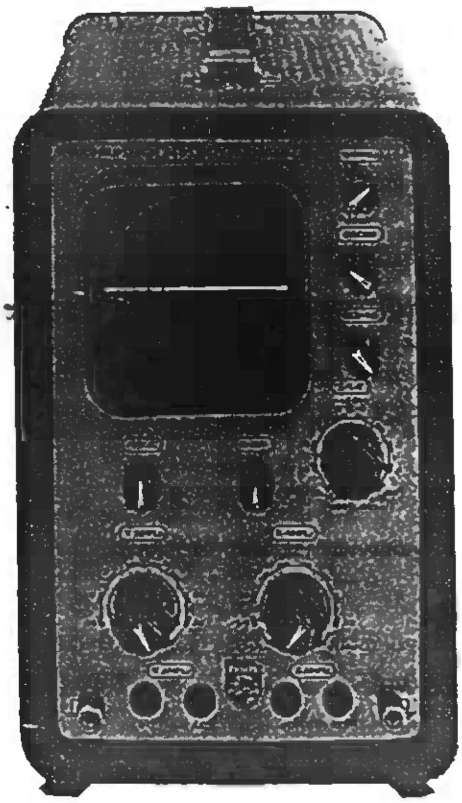

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Fig. 3. Preliminary setting

Notes

- If the time base line cannot be displayed by means of knobs "←X→" and "↑Y↓", potentiometer "DC-Balance" of the Y amplifier (accessible on the left-hand side of the apparatus) must be turned until the time base line appears. This potentiometer must be adjusted in such a way, that the picture does not shift if the continuous control "Y AMPL." is turned (see section V.F.1).
- If knob "X AMPL." is in position "0.3 V/div.", knob "DC-Balance" of the X amplifier (accessible on the right-hand side of the apparatus) must be adjusted in such a way, that the light spot on the screen no longer shifts if the continuous control is turned (see section V.G. 1).
  With cathode ray tubes, astigmatism may arise. Then the light spot on the screen is not round. This can be corrected by means of potentiometer "ASTIGM.", accessible on the left-hand side of the apparatus.

B. DISPLAYING WAVEFORMS

1. Time base internally triggered

- Adjust as described under "Preliminary setting" (page 14).
- Turn knob "STAB." anti-clockwise, until the time base line just disappears.
- Apply a voltage to the d.c. or a.c. input of the Y amplifier.
- Turn knob "STAB." until a stable picture is obtained.
- Place knobs "Y AMPL." and "/\/\" in the required position.

Note: If no triggering occurs at minimum setting (0.5 div.), potentiometer "LEVEL" (R513, in the right-hand side wall) must be adjusted according to section V.H.1.

2. Time base externally triggered

- Adjust as described under "Preliminary setting" (page 14).
- Turn knob "STAB." anti-clockwise until the time base line just disappears.
- Apply a voltage to the d.c. or a.c. input of the Y amplifier.
- Apply an external trigger voltage to socket "EXT.TRIGG." on the right-hand side of the apparatus (if the picture must be stationary, this voltage must be derived from the voltage from which the Y signal also originates).
- Place knobs "Y AMPL." and "/\/\" at the required position.

C. HOW TO USE THE X INPUT

If a voltage is applied to both amplifiers, these voltages can be compared with each other and their relationships can be made visible.
Some of these applications are also mentioned in chapter III.

- Connect the voltages to be compared to the input sockets "DC (AC) Y AMPL." and "DC (AC) X AMPL.".
- Place switches "Y AMPL." and "X AMPL." in the desired position.
- Set the continuous control "X AMPL" to position "×1".

The picture can now be brought on the screen by means of the shift controls "↓Y↑" and "←X→".
In order to obtain good stationary pictures, the voltages on the two amplifier inputs should be synchronous.

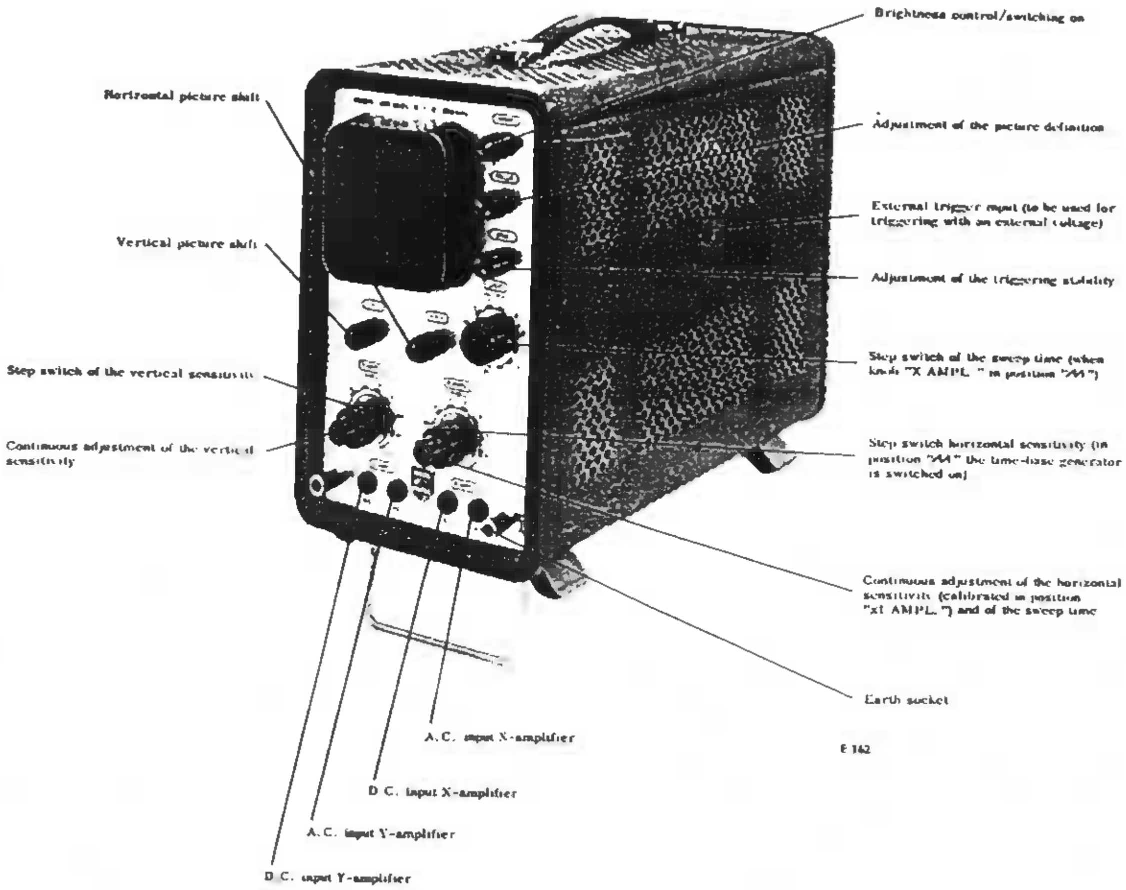


Fig. 4. Functions of the controls and sockets

Applications III

A. MEASURING THE AMPLITUDE

- Measure the distance between the peaks, e.g. 3 div. (see Fig. 5).
- Determine the position of knob "Y AMPL."
  (continuous attenuator in position "×1"), e.g. 10 V/div.

Now the amplitude amounts to 10 (attenuator position) ×3 (picture height) = 30 V.

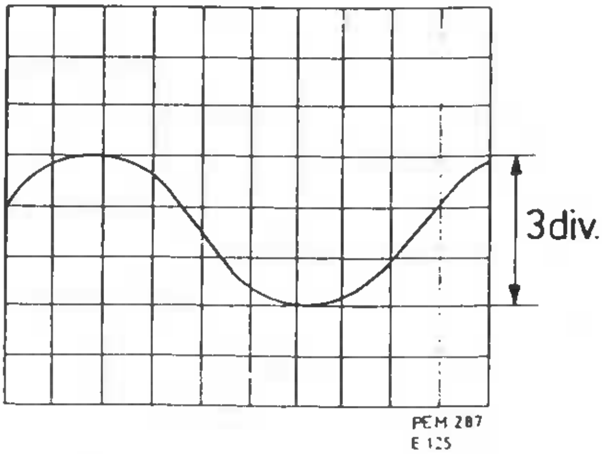


Fig. 5. Measuring the amplitude

B. USING THE X INPUT

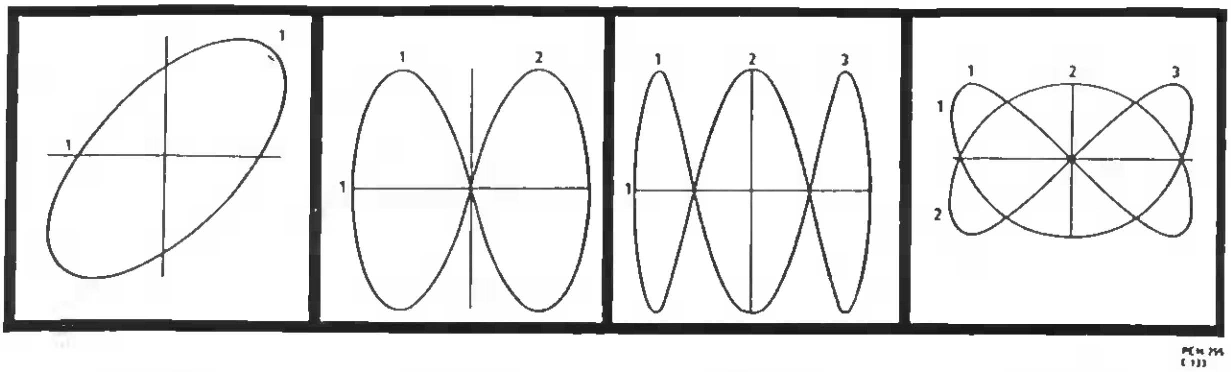
The following examples can be mentioned:
Frequency measurements
Phase measurements
Displaying characteristics
Etc.

Frequency measurement by means of Lissajous figures

If a voltage of unknown frequency is applied to the Y amplifier, the light spot on the screen will describe a so-called Lissajous figure, under the influence of a voltage of known frequency applied to the X amplifier. Dependent on the frequency the image will show a certain number of peaks. The unknown frequency

$$f_x = \frac{\text{number of peaks at the top}}{\text{number of peaks at the side}} \times \text{known frequency.}$$

Some common Lissajous figures are shown in Fig. 6, in which 50 c/s is used as reference frequency.



50 c/s 100 c/s 150 c/s 75 c/s

Fig. 6. Examples of Lissajous figures

Phase measurements

Phase angles can be measured by means of a Lissajous figure (ellipse) The image must then lie symmetrically round the centre.

The following applies irrespective of the quadrant in which the phase angle is found: the sine of phase angle φ is determined by the ratio a/b (see Fig. 7).

In the figure, sine φ = 2 div./4 div. = 0.5. The phase angle φ is then 30°. If the top of the ellipse is at the right of the screen, the phase angle is in the first quadrant (30°) or in the fourth quadrant (360°–30° = 330°).

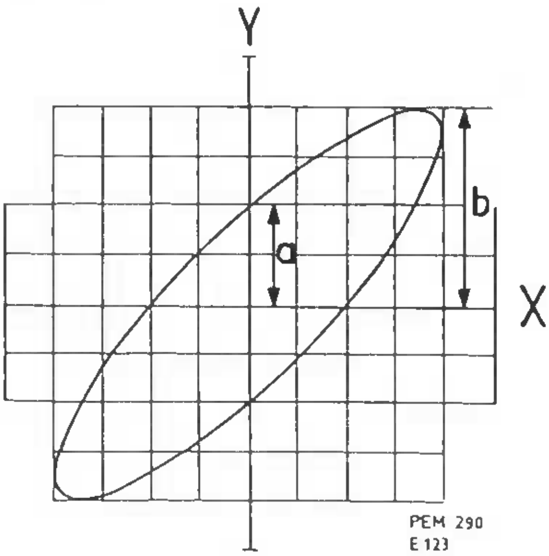


Fig. 7. Determining the phase angles sine $\varphi = a/b$

If the top is at the left of the screen, the angle is in the second quadrant (180°–30° = 150°) or in the third quadrant (180 + 30° = 210°). For determination of the quadrant proceed as follows:

- Include a circuit as shown in Fig. 8 into the lead to the X amplifier with closed switch.
- Open the switch and turn the potentiometer from minimum to maximum value. In doing so, the shape of the ellipse must clearly change.

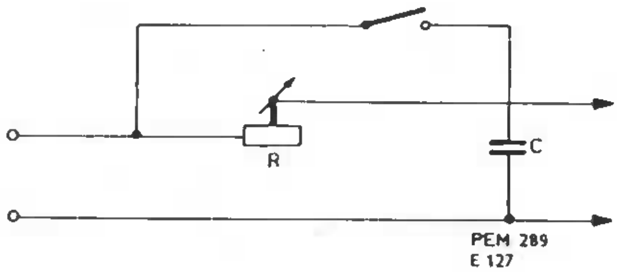


Fig. 8. Network for quadrant determination

Phase angle (thus also a) becomes	*Quadrant*	*Quadrant*
larger	2. (90°–180°)	1. (0°–90°)
smaller	3. (180°–270°)	4. (270°–360°)

If the picture appears as a straight diagonal on the screen, the phase angle is 0° (360°) or 180° (Fig. 9).

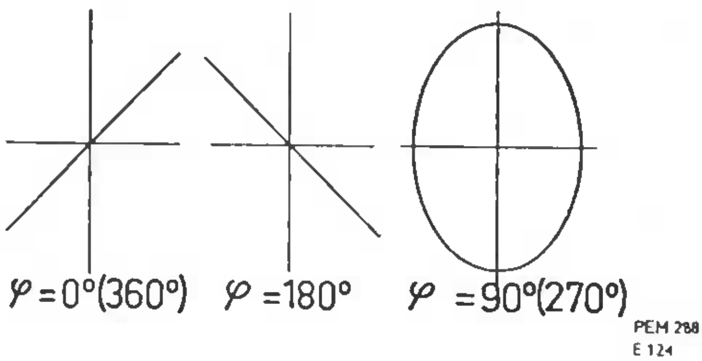


Fig. 9. Some particular phase angles

C. DISPLAYING A DIODE CHARACTERISTIC

In displaying a diode characteristic the current through the diode is plotted as a function of the voltage across the diode. For this, use can be made of the circuit shown in Fig. 10. Voltage source E supplies a low sinewave voltage. The resistance R must be small with respect to the expected internal resistance of the diode. The voltage across R, which is directly proportional to the anode current, is fed to the Y amplifier. The anode voltage is applied to the X amplifier. Now a curve is displayed which represents the relationship between anode current and anode voltage.

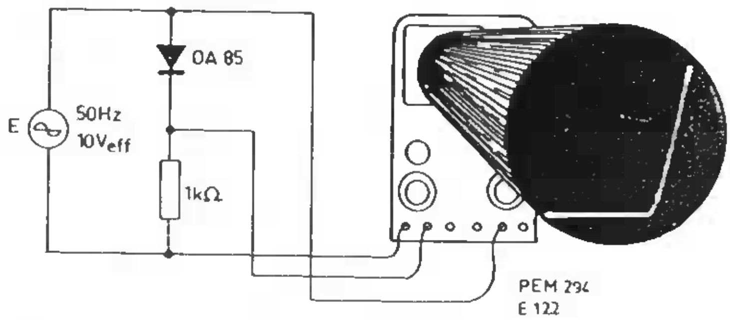


Fig. 10. Displaying the diode characteristic of the OA 85

D. DISPLAYING A HYSTERESIS LOOP

In displaying hysteresis loops of magnetic material, the magnetic induction B is plotted as a function of the field strength H. If the iron core of a coil contains no air gaps, the field strength is proportional to the current through the number of windings. The primary current is thus a measure of the field strength H. A resistor Rp is connected in series with the primary winding. The voltage across this resistor is applied to the X input (see Fig. 12).

The voltage across the secondary winding is Us = k.dB/dt.
Here k is a constant.
This voltage is integrated by an RC network (R>> 1/ωc). The voltage across the capacitor then becomes Uc = k.B/R.C. The induction B is thus proportional to the voltage across the capacitor. This voltage, which is low and must be adequately amplified, is fed to the Y amplifier.

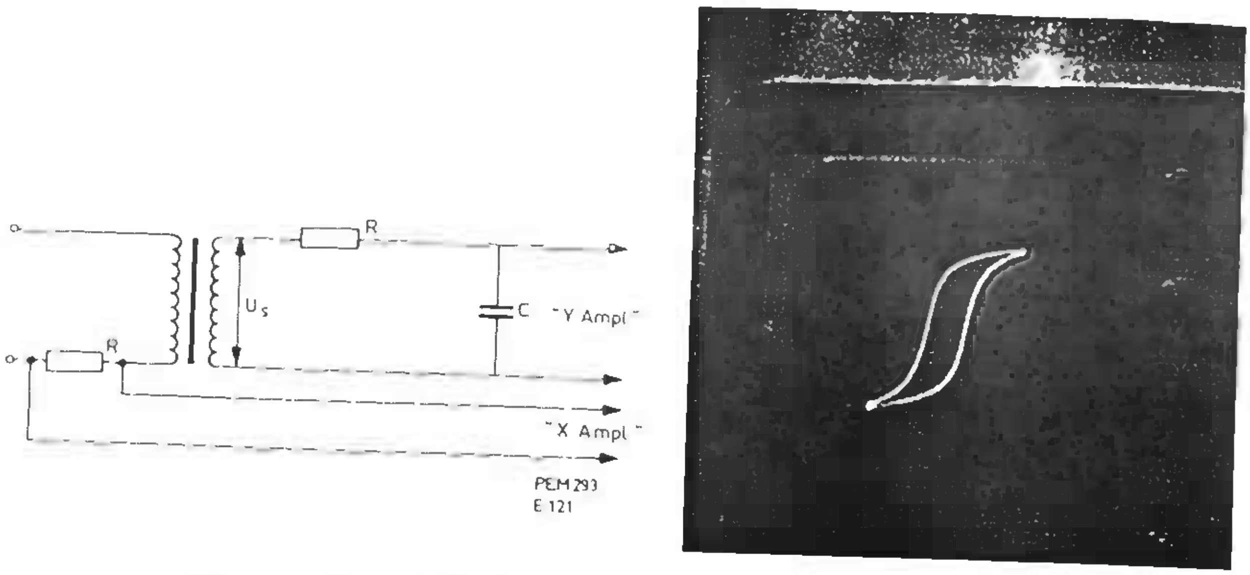


Fig. 11. Displaying a hysteresis loop

Note – It is possible that the trace is displayed as a mirror image with respect to the Y axis. The peak of the hysteresis loop is brought to the right of the screen by reversing the connections of one of the coil windings.

SERVICE DATA

Circuit diagram

I

A. Y AMPLIFIER (unit A, Fig. 29)

The amplifier for the Y deflection is a d.c. coupled push-pull amplifier. The voltage under test is connected to socket BU2 (DC) or to socket BU3 (AC) and subsequently applied to the output amplifier via an attenuator circuit and a phase inverter.

1. Attenuator circuit

An attenuator circuit, which is operated by means of SK3, is included in the input circuit of the Y amplifier.
In the positions "3 V/div." and "10 V/div." of SK3, the signal to be measured is attenuated by the voltage dividers R34-R26//R41 and R35-R27//R41
A step attenuator with high impedance (R36-R28 ... R32) is included in the other positions of SK3. The attenuator switch has eight calibrated positions. By means of the trimmers C27, C28 and C29 and the capacitors C30, C31, C32 and C33, the attenuators are adjusted in such a way that in all positions of SK3 the attenuation is frequency independent.

2. Phase inverter stage

Via the attenuator circuit the signal to be measured is applied to the phase inverter stage with the valves B1 and B2. This stage is driven on the control grid of valve B1. Valves B1 and B2 are coupled via the common cathode resistor R40. As the control grid of B2 is connected to earth via R42, this valve is driven by a voltage whose magnitude is equal to the signal to be measured, but opposed in phase to the latter. The voltage on the anodes of B1 and B2 are symmetrical with respect to the average d.c. voltage difference between these anodes.
The amplitude of the signal can be adjusted continuously by varying the value of the anode resistors R43 and R49 – and thus the amplification – by means of potentiometer R6.
Turning potentiometer R6 would also result in a variation of the average d.c. voltage on the input of the next amplifier stage (B1′–B2′), which would

give rise to a shift of the light spot on the screen. This is avoided by equalizing the values of the d.c. voltages on the anodes of B1′ and B2′ by means of potentiometer R57 (DC-Balance), so that no d.c. voltage arises across R6.

Resistor R37 in the control grid circuit of valve B1 serves to limit the grid current in the case of positive input signals. The adverse influence of this resistor on the square wave response is eliminated by parallel capacitor C34.

3. Output stage

Output amplifier B3–B3′ is preceded by the cathode followers B1′ and B2′, which are provided to reduce the influence of the high input capacitance of the output valves on the anode impedance of the valves B1 and B2. As a result the bandwidth of the amplifier is larger than if the valves B1 and B3 or B2 and B3′ were directly coupled to the preceding stage. The shift controls R4–R4′ are included in the control grid circuit of the cathode followers. By means of these potentiometers the d.c. voltage on the control grids of B1′ and B2′ can be varied. The variation on the grid of B1′ opposite to that on the grid of B2′. As a result the image will shift in the vertical direction across the screen. The shift voltage is applied to the control grids of B1′ and B2′ via the voltage dividers with high impedance R76–R64 and R72–R70 respectively. By means of these voltage dividers the anode potentials of valves B1 and B2 are made independent of the position of the shift controls (R4, R4′), so that the d.c. balance is maintained. Capacitors C36 and C37 prevent the voltage dividers from affecting the square wave response. By means of potentiometer R80 the feedback of both output valves is adjusted in such a way that the maximum Y sensitivity is 10 mV_{p-p}/div.

The symmetry of the signal in the output stage is increased due to the common cathode resistor. The anodes of B3 and B3′ are directly connected to the Y deflection plates. For driving the time base generator in the case of internal triggering use is made of that part of the anode voltage of B3, which is applied to the first valve (B501) of the trigger pulse shaper via switch SK5.

B. TRIGGER PULSE SHAPER (unit D, Fig. 31)

The trigger pulse shaper consists of an amplifier stage (B501) and a Schmitt trigger (B502–B502′).

The trigger signal, which may originate from the Y amplifier (R85) as well as from an external voltage source, is applied to the control grid of

valve B501 via C501. The anode of this amplifier valve is d.c. coupled to the input of the Schmitt trigger (B502–B502′). A Schmitt trigger is a multivibrator with two stable conditions, viz.
B502 conductive, B502′ cut off, and
B502 cut off, B502′ conductive.
The condition is changed by applying a positive pulse to the control grid of the non-conductive valve or a negative pulse to the grid of the conductive valve. By means of R513 the Schmitt trigger B502–B502′ is adjusted in such a way that in the waiting position (i.e. if no trigger voltage is applied) valve B502 is cut off and B502′ conductive. During the positive-going part of the cycle the amplified trigger signal applied to the control grid of B502 will drive the valve into conduction at a certain level (the upper threshold voltage). Due to the common cathode resistor and the d.c. coupling between the anode of valve B502 and the control grid of valve B502′ a cumulative switching phenomenon takes place, as a result of which valve B502′ is cut-off. This results in a positive voltage at the anode of B502′.
During the negative half of the cycle of the amplified trigger signal, valve B502 will be cut-off at a certain level (lower "threshold voltage"). Due to the repetitive switching action, valve B502′ becomes conductive, so that a negative voltage arises at the anode of this valve. In the case of a repetitive trigger signal it is necessary for the correct functioning of the trigger pulse shaper that both threshold voltages are exceeded. The trigger sensitivity of the trigger pulse shaper is thus determined by the difference in level between the two threshold voltages. This difference is adjusted by means of potentiometer R513, so that the position of this potentiometer is decisive for the trigger sensitivity.
The positive and negative voltage transients at the anode of valve B502′ are differentiated by capacitor C503 and resistor R521 into small positive and negative pulses, which are applied to the Schmitt trigger B503–B503′ in the time base generator.
The control range of R3 is adjusted by selection of resistor R522. The capacitors C502 and C517 in the anode leads of valves B502 and B501 respectively serve to improve the rise time of the pulse shaped voltages.

C. TIME BASE GENERATOR (unit D, Fig. 31)

1. Principle

The sawtooth voltage is obtained by means of a Schmitt trigger and a "bootstrap" integrator. The working of the Schmitt trigger is the same as that of the trigger described in chapter B "Trigger pulse shaper". By means of potentiometer R3 ("STAB.") the multivibrator is adjusted in such a way that it can operate both free running and triggered. R3, however, must be so adjusted that valve B503′ is cut-off and B503 conductive (in that case no time-base line is visible on the screen). In this condition, the control grid potential of B503 is equal to the cathode potential of this valve, because the control grid is connected to the positive supply voltage via R530–R531 and GR503. The working principle of the "bootstrap" integrator is shown in the figure below.

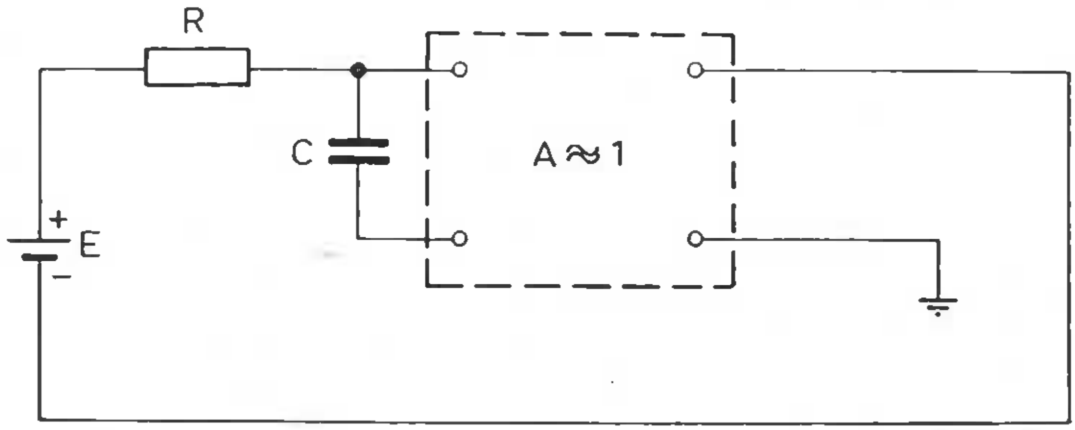


Fig. 12. Block diagram of the "bootstrap" integrator

This circuit ensures that the charging current of capacitor C remains constant, independent of the charge of capacitor C, so that the charge curve is of good linearity.
A voltage variation across capacitor C is applied to resistor R via an amplifier with an amplification factor $A \approx 1$ and battery E.
The voltage across resistor R – and thus the charging current through the capacitor – therefore remains constant, which results in a linear charge curve of the capacitor.

2. Working

The circuit employed in the GM 5605 is shown in Fig. 13.
If no trigger signal is applied, the potential on the control grid of valve B501′ is determined by the cathode voltage of valve B503. The voltage across the time base capacitor (C505... C516) is then almost equal to this cathode voltage, which amounts to approximately 100 V.
As soon as a trigger voltage is applied, valve B503 is made non-conductive by the positive trigger pulses at the cathode of B503. Owing to the repetitive switching action, the condition of the multivibrator changes into B503′ conductive and B503 cut-off. Now the potential of the control grid of B501′ is undefinite, but in principle will tend to rise to the anode potential of valve B501′. However, the time base capacitor does not allow a sudden voltage rise, but will be charged in accordance with an e-power curve. Owing to the charging, the control grid potential of valve

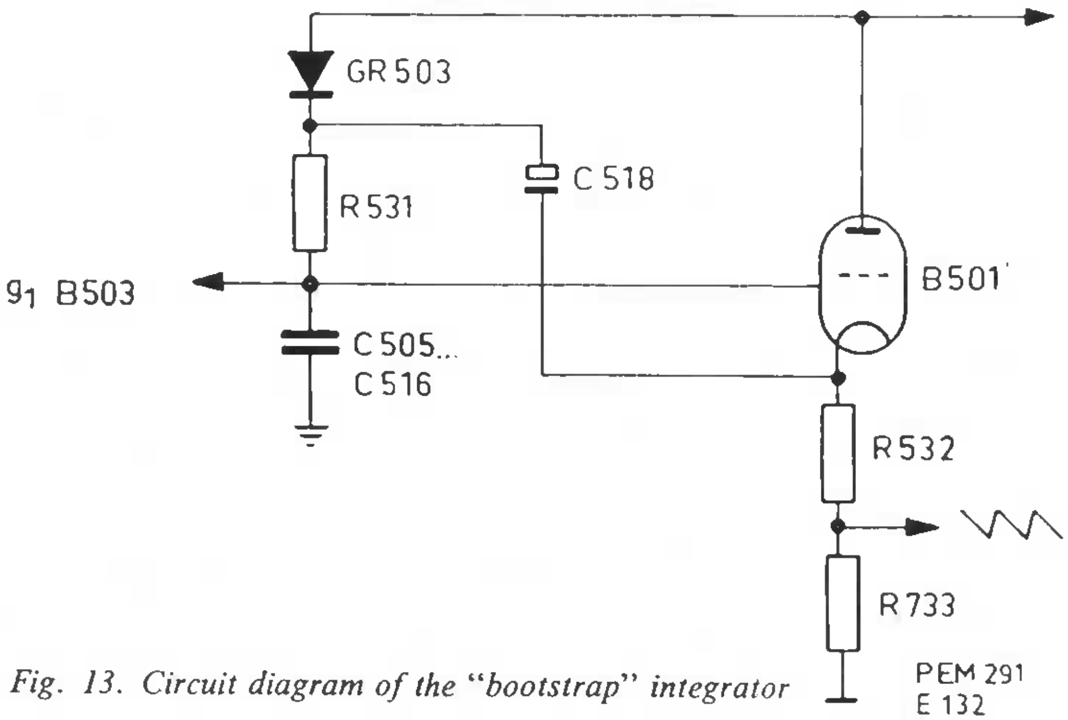


Fig. 13. Circuit diagram of the "bootstrap" integrator

B501′ will rise a little, as a result of which the cathode potential rises to the same extent. This voltage rise is applied to the cathode of diode GR503 via capacitor C518, so that the diode is cut-off. The voltage across resistor R531 + R533 thus remains constant.
If the voltage across the time base capacitor rises further, the process described will be continued. The time base capacitor is thus charged by

a constant current supplied by capacitor C518, as a result of which the voltage across this capacitor increases linearly (this is the forward sweep of the sawtooth voltage). As soon as the amplitude of the sawtooth voltage has reached a given value, valve B503 becomes conductive.
As a result the Schmitt trigger B503–B503′ switches over to the condition B503 conductive – B503′ cut-off. The voltage on the control grid of B503 then drops to the cathode voltage of valve B503. The resultant grid current of valve B503 causes the control grid voltage of valve B501′ to drop likewise. This voltage drop is applied to the cathode of diode GR503 via valve B501′ connected as a cathode follower and capacitor C518. This diode becomes again conductive and the potential of the junction R531–C518 is again determined exclusively by the potential of the anode of valve B501′. In this period the time base capacitor discharges across R530, across the diode formed by the control grid and the cathode of valve B503 and across resistor R521 until the voltage across the capacitor is equal to the cathode voltage of B503 (this is the flyback of the sawtooth voltage). At the end of the flyback C518 is charged again via diode GR503 and the low output impedance of cathode follower B501′. This condition, the waiting period, is maintained until multivibrator B503–B503′ is again changed over by a trigger pulse.

3. Linearity of the sawtooth voltage

The sawtooth voltage has a good linearity due to the good transmission of the cathode follower, the large capacitance of capacitor C518 and the use of diode GR503.

4. Sweep time

The slope of the sawtooth voltage – and thus the sweep time per division– depends upon both the value of the time base capacitor and the charging current. The sweep time can thus be varied by changing the value of the time base capacitor. The time base capacitors are selected with SK2, by means of which twelve sweep times can be adjusted. By means of R533 the charging current is adjusted in such a way that the sweep times per unit of length comply with the orientation values on the text plate to within 25%.

5. Sawtooth voltage

The sawtooth voltage is available across resistor R733 (Fig. 33). The amplitude of the voltage applied to the X amplifier is determined by the value of R733.

D. X AMPLIFIER (unit C, Fig. 33)

Except for the input circuit and the anode circuit of valve B703 the X amplifier is equal to the Y amplifier.

1. Input circuit

As desired, either an external voltage or the sawtooth voltage can be applied to the X amplifier. In the first position of SK4 the sawtooth voltage is taken from resistor R733 and applied to the input of the amplifier. An external deflection voltage can be applied directly (via socket BU4) or via an isolating capacitor (via socket BU5).
The position of the time base line on the screen is determined by the potential on the control grid of valve B702. This potential can be adjusted by means of potentiometer R746. In the other positions of SK4 the control grid is connected to earth via R746 and at the same time the screen grid voltages of the valves B501 and B503 are switched off. As a result the time base generator no longer starts, so that there is no risk of crosstalk in the X amplifier.
The attenuator circuit, which is operated with switch SK4, is built up in the same way as the circuit of the Y amplifier. The only difference is that the step attenuator has only four possibilities of attenuation, so that the deflection sensitivity of the X amplifier can be adjusted to seven values. By means of trimmers C727, C728 and C729 and capacitors C733, C730, C731 and C732 the attenuators are adjusted in such a way that in all positions of SK4 the attenuation is frequency independent.

2. Amplifier stages

The amplifier stages are practically identical to those of the Y amplifier. The difference is that the anode resistor of B703 is not divided into two halves, as the anode resistor of B3. The anode potentials of valves B701 and B702 are equalized by means of R757 (DC-Balance), so that the image does not shift in the horizontal direction if continuous attenuator R7 is turned. With the double potentiometer R5–R5′ the image can be shifted horizontally across the screen. By means of R780 the sensitivity of the amplifier is adjusted to 30 mV_{p-p}/div.
The anodes of the valves B703 and B703′ are directly coupled to the X deflection plates.

E. CATHODE RAY TUBE CIRCUIT (unit B, Fig. 35)

1. Intensity and brightness control

The brightness of the picture can be changed by varying the potential on the Wehnelt cyclinder by means of R1.
A pulse-shaped voltage, which is applied to the Wehnelt cylinder via capacitor C519, is taken from the anode of B503. This pulse-shaped voltage is high during the forward sweep of the sawtooth voltage and low during the flyback. As a result the electron beam is suppressed during the flyback of the sawtooth voltage, because the positive peak of the pulse-shaped voltage is retained by diode GR301 almost on the level adjusted with R1. Capacitor C301 serves to prevent crosstalk of the brightness pulse on the negative supply voltage and to smooth the ripple of the negative supply part.

2. Focusing and astigmatism

The line on the screen can be adjusted sharply by means of potentiometer R2. This potentiometer regulates the voltage on the focusing anode g3 of valve B301. Astigmatism of the electrostatic lens can be corrected by adjusting the voltage on the last acceleration anode (g4) to the correct value by means of potentiometer R305.

3. Barrel and pincushion distortion

This is due to faults (for instance fringe areas) in the electrostatic lens and can be corrected by adjusting the voltage at the beginning of the post-accelerating coil to a certain value by means of potentiometer R309.

F. SUPPLY PART (unit E, F, Fig. 38)

The supply part delivers voltages of +280 V, +160 V, −150 V and +1610 V.
The voltage of +280 V is electronically regulated and stabilised.

1. +280 V

The Graetz circuit GR 1001 . . . GR 1004 supplies a full-wave rectified voltage, which is applied to the control circuit.
This control circuit consists of a series regulator (B 1001), control valve (B1001′) and a stabiliser (B1002). The latter keeps the cathode of B1001′ at a constant potential of 85 V. A load variation or mains voltage variation in the +280-V supply circuit will result in a change of the +280-V

voltage. This voltage variation is passed to the control grid of valve B1001 via the voltage divider R1009//R1012–R1011. The voltage applied to the control grid is considerably amplified owing to the large anode resistor (R1005).

From the anode of valve B1001′ the amplified signal, which is opposed in phase to the original voltage variation, is applied to the control grid of series regulator B1001. As a result this valve, dependent upon a positive or negative voltage variation of the +280-V voltage, will carry less or more current, so that the original voltage variation is compensated for. The ripple voltage on the +280-V voltage is also fed back. The feedback factor for the ripple voltage is, however, much greater than that for the d.c. voltage, due to the use of capacitor C1003 in parallel with R1009.

The current which must be supplied by the +280-V supply part is larger than that supplied by the series regulator. Resistor R1003 is, therefore, connected in parallel with B1001.

Voltage divider R1003–R1004 is provided for hum compensation.

2. +160 V

This voltage is derived from the +280-V supply voltage by means of voltage divider R1019–R1020.

3. −150 V

This is the full-wave rectified and smoothed a.c. voltage supplied by winding S3 of the supply transformer.

The voltage of −150 V is among others applied to the Wehnelt cylinder of the cathode ray tube via R1.

The brightness of the picture can thus be adjusted by means of potentiometer R1.

4. +1610 V

The a.c. voltage taken from winding S7 of the supply transformer is halfwave rectified by means of valve B1003. The rectified voltage is applied to the post-acceleration anode of the cathode ray tube.

5. Heater voltage

The heater voltages for the various valves are derived from windings S4, S5, S6 and S8.

The windings S5 and S6 are brought at a d.c. voltage potential.

This prevents breakdown in case the maximum permissible voltage difference between heater and cathode is exceeded.

Gaining acces to the parts II

A. REMOVING THE CABINET PANELS

The cabinet consists of a number of separate panels, which may be removed individually.

Rear panel

This may be removed after the two screws "A" on the rear panel have been loosened a few turns (Fig. 14).

Top panel

After the rear panel has been detached, the top panel may be removed by loosening the two screws "B" a few turns (Fig. 14).

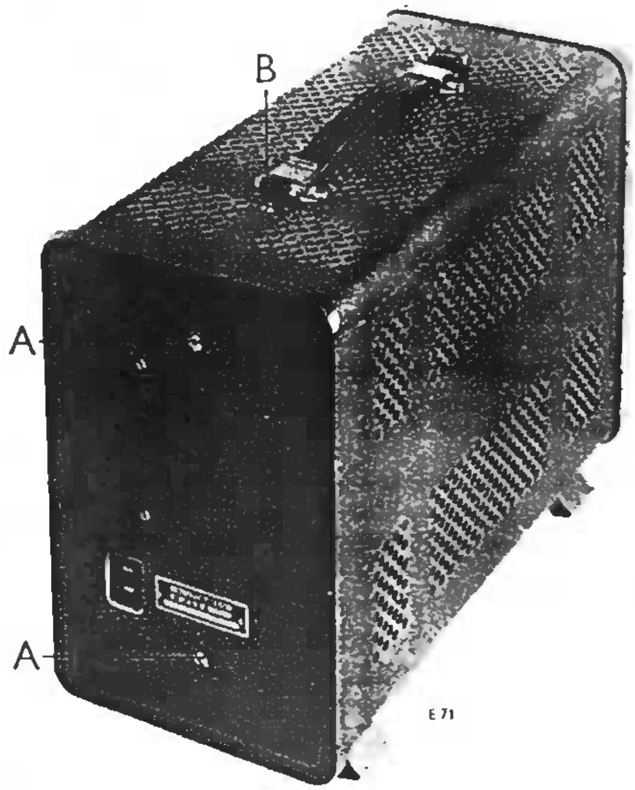


Fig. 14. Removing the cabinet panels

Side panels

After the rear panel has been detached, the side panels may be removed by sliding them slightly backwards and subsequently lifting them sideways out of the frame.

Bottom panel

After detaching the rear panel, the bottom panel may be removed by unscrewing the four screws "C" (Fig. 16).

B. REMOVING THE KNOBS (Fig. 15)

Single knobs

- Remove cap "A".
- Loosen nut "B". The knob may now be slid off the spindle.

Double knobs

- Remove cap "A".
- Loosen nut "B". Now the smallest knob can be slid off the spindle.
- Loosen nut "C". Now the large knob can be slid off the spindle.

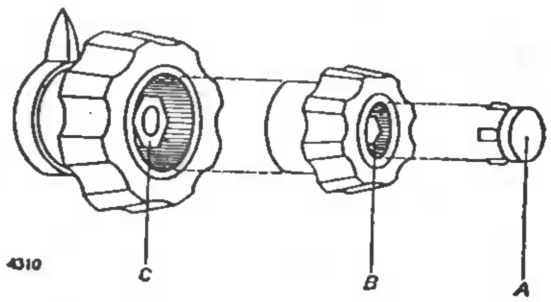


Fig. 15. Removing the knobs

C. REMOVING THE FRONT PANEL

- Remove the cabinet panels according to section II.A.
- Remove the knobs according to section II.B.
- Unsolder the connecting wires of sockets BU1 and BU6.
- Unscrew the rings of sockets BU2 . . . BU5.
- Remove the 10 screws "S" (Fig. 16).
- Remove the front panel (consisting of front frame and text plate).

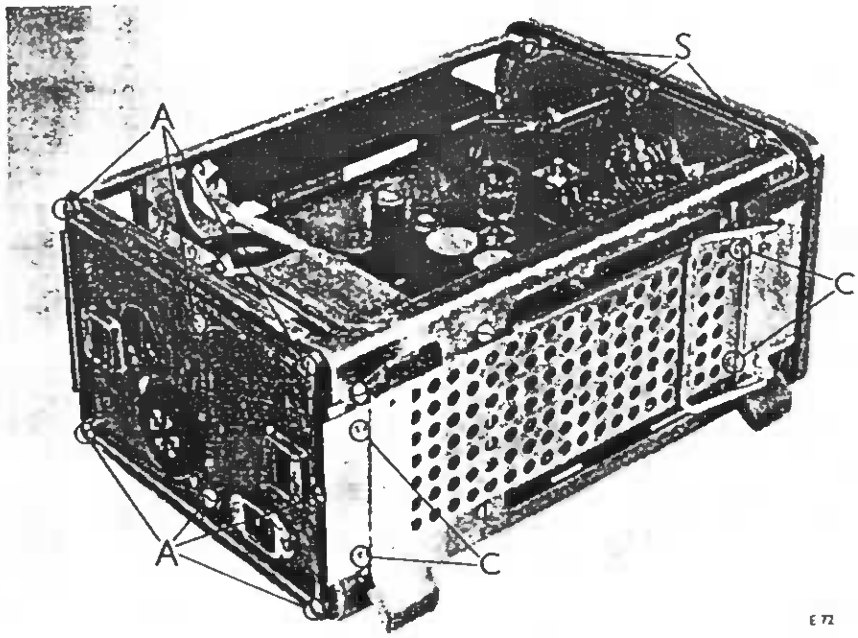


Fig. 16. Removing the bottom plate and front panel

D. REMOVING THE WINDOW AND THE GRATICULE

- Turn the window approximately 15° anticlockwise and remove it from the front panel (Fig. 17).
  Now the graticule can be pushed out of the window.
- The window can be adjusted horizontally by moving the stop bracket at the rear of the front panel. Before moving the bracket, first loosen the two fixing screws a little.

GM 5605 newalg

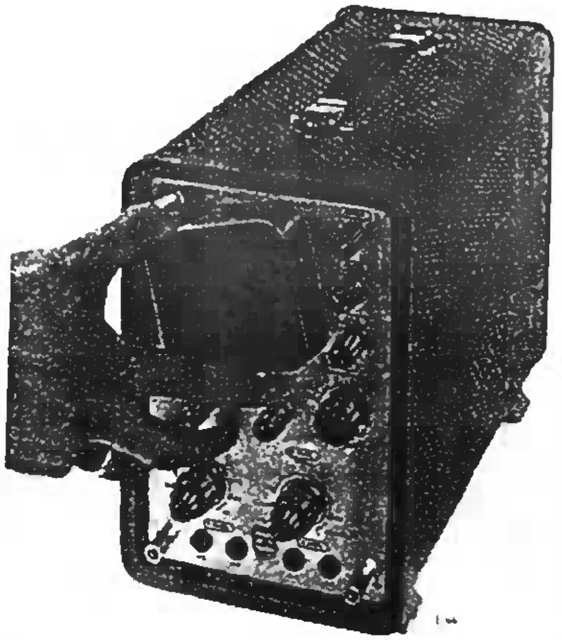


Fig. 17. Removing the graticule

Maintenance III

A. WAFER SWITCHES

If these switches no longer function properly due to soiling, they can be lubricated with switch oil (see "List of mechanical parts", page 56). This oil has both cleaning and lubricating properties. After lubrication, the switch must be rotated a few times through all positions.

B. CABINET PANELS

If the PVC-coated cabinet panels have become dirty they can, after removal, be washed with water and soap (Chapter II.A); if necessary, use some scouring powder.

Adjusting elements and their functions IV

The sequence below is arbitrary. For complete adjustment it is advisable to adhere to the sequence given in Chapter V.

Adjustment	*Adjusting element*	*Measuring instrument*	*Recommended PHILIPS apparatus*	*Chapt. V section*
Barrel or pincushion distortion	R309	L.F. generator	GM 2317	D
Astigmatism	R305	L.F. generator	GM 2317	E
Control range R2	R304	L.F. generator	GM 2317	E
Y amplifier				
– Zero setting	R57	None		F1
– Sensitivity	R80	L.F. generator	GM 2317	F2
– Square wave response SK3	C27, C28, C29	Square wave voltage generator	GM 2324	F4
X amplifier				
– Zero setting	R757	None		G1
– Sensitivity	R780	L.F. generator	GM 2317	G2
– Length of time base line	R733, R746	None		G3
– Square wave response SK4	C727, C728, C729	Square wave voltage generator	GM 2324	G5
– Phase characteristic	C39	L.F. generator	ZV 2312	G10
Time base generator				
– Internal triggering	R513	L.F. generator	ZV 2312	H1
– Stability	R522			G3
– Sweep times	R533			H4
Supply				
– Ripple voltage on +280 V	R1004	L.F. a.c. voltmeter	GM 6012	C
– +280-V voltage	R1011	d.c. voltmeter	GM 6058	B

Checking and adjusting

V

The tolerances given below are factory tolerances, which apply only if the apparatus is readjusted. They may deviate from the tolerances mentioned in the technical data (General part, chapter II).

A survey of the adjusting elements and their functions is given on page 37.

A. MAINS CURRENT

At 220 V, 50 c/s the current taken from the mains must not exceed 420 mA.

B. SUPPLY VOLTAGE +280 V

Check whether the supply voltage on the cathode of valve B1001 is between 278 V and 282 V.
If necessary, select another value for R1011.

C. RIPPLE ON THE SUPPLY VOLTAGE +280 V

Check whether the ripple voltage on the cathode of valve B1001 does not exceed 10 mV. If necessary, select another value for R1004.

D. BARREL AND PINCUSHION DISTORTION

- Apply a sinusoidal voltage of 50 c/s to BU3.
- Also apply a sinusoidal voltage to BU5, however, of a frequency of 10 kc/s.
- Adjust the amplitudes of both voltages in such a way that a uniformly lit square of 7.5 × 7.5 divisions is obtained.
- Reduce a possible barrel or pincushion distortion to minimum by means of R309. When adjusted correctly, no point of the sides of the square must fall within a concentric square of 7 × 7 divisions.
- Display a line on the screen which makes an angle of 30° with the Y axis. (Two voltages of equal phase, frequency 1 kc/s, on BU3 and BU5).
- Check that this line is straight.

If necessary, adjust R309 in such a way that both requirements are met as far as possible.

E. FOCUSING AND ASTIGMATISM

- Display a circle of a diameter of 4 cm on the screen (apply two sinusoidal voltages with a phase difference of 90° to the X and Y input).
- Set R305 in such a way that the picture can be adjusted sharply by means of R2, both at high and low brightness.
- If necessary, select another value for R304.

F. Y AMPLIFIER

1. Zero setting

- Set SK3 to position "30 V/div.".
- Set SK4 to position "/\/\".
- Turn R3 clockwise.
- Adjust the time base line to the centre of the screen by means of R4.
- Adjust R57 in such a way that the line does not move, if R6 is turned (with shorted input).

2. Sensitivity

- Set SK3 to position ".01 V/div.".
- Turn R6 clockwise, R7 anti-clockwise and R513 clockwise.
- Set SK*8* to position "/\/\'..
- Adjust R3 in such a way that the time base generator just cuts out.
- Apply to BU2, a voltage of 80 mV_{p-p}, frequency 2 kc/s.
- Adjust R513 in such a way that a triggered image appears.
- Adjust R80 in such a way that the picture height is 8 divisions.

3. Y shift

- Apply a sinusoidal voltage (frequency 2 kc/s) to BU2 of such a value that the picture height is 3 divisions (the voltage must be symmetrical with respect to earth).
- Increase the input voltage by a factor 8.
- Both with R4 fully anti-clockwise and fully clockwise it must be possible to display the peaks of the sinewaves undistorted within the graticule. If necessary, replace valves B1 and B2 and repeat the adjustment from item F1 onwards.

4. Step attenuator

Check the attenuation with SK3 in the following positions (R6 fully clockwise):

Position SK3	*Voltage on BU2*	*Picture height*
.01 V_{p-p}/div.	28.25 $mV_{r.m.s.}$	7.8 div.-8.2 div.
.03 V_{p-p}/div.	84.75 $mV_{r.m.s.}$	
.1 V_{p-p}/div.	0.2825 $V_{r.m.s.}$	
.3 V_{p-p}/div.	0.8475 $V_{r.m.s.}$	
1 V_{p-p}/div.	2.825 $V_{r.m.s.}$	
3 V_{p-p}/div.	8.475 $V_{r.m.s.}$	
10 V_{p-p}/div.	28.25 $V_{r.m.s.}$	
30 V_{p-p}/div.	84.75 $V_{r.m.s.}$	

5. Continuous attenuator

- Turn R6 fully clockwise.
- Apply a sinusoidal voltage to BU2 of a frequency of 2 kc/s and an amplitude such that the picture height amounts to 3.5 divisions.
- Turn R6 fully anti-clockwise.
  The picture height must now lie between 0.7 and 1 division.

6. Square wave response

- Turn R6 clockwise.
- Set SK3 to position ".01 V/div."
- Apply a square wave voltage of a frequency of 2 kc/s to BU2.
  The picture height must amount to approximately 8 divisions.
- Compare the square wave response with Fig. 18.

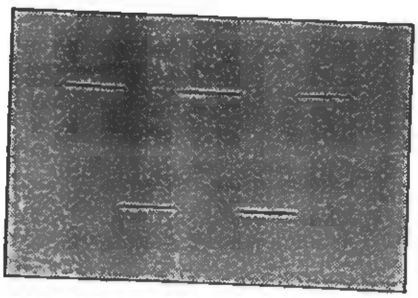


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Fig. 18. Square wave response of the Y amplifier

7. Square wave response of step attenuator

- Turn R6 fully clockwise.
- Connect a square wave voltage of a frequency of 2 kc/s to BU2.
- Adjust the square wave response according to the table below:

Position SK3	*Adjust with*
.03 V/div	C27 (see Fig. 18)
.1 V/div	C28 (see Fig. 18)
.3 V/div	C29 (see Fig. 18)

Check the other positions.

8. Amplitude/frequency characteristic

- Turn R6 fully clockwise.
- Set SK3 to position ".01 V/div".
- To BU2 apply a sinewave voltage of a frequency of 2 kc/s and an amplitude such that the picture height is 8 divisions. If the sensitivity is adjusted correctly (see item 2), the voltage on BU2 must amount to approximately 28.3 $mV_{r.m.s.}$
- Increase the frequency of the voltage on BU2 to 200 kc/s, but keep the amplitude constant. Now the picture height must be at least 6 divisions.
- Check whether a d.c. voltage connected to BU3 is blocked by the built-in isolating capacitor C26.

9. Hum in the Y amplifier

The hum in the Y amplifier must not exceed 0.2 divisions with SK3 in position ".01 V/div.".

G. X AMPLIFIER

1. Zero setting

- Set SK4 to position "30 V/div.".
- Adjust the spot to the centre of the screen by means of R5.
- Adjust R757 in such a way that the spot does not move if R7 is turned (with shorted input).

2. Sensitivity

- Set SK4 to position ".03 V/div.".
- Turn R7 clockwise.
- To BU5 apply a signal of 300 mV_{p-p} of a frequency of 1 kc/s.
- Adjust R780 in such a way that the horizontal deflection covers 10 divisions.

3. Length of the time base line

- Set SK4 to position "⩘".
  No input voltage on the input sockets.
- Turn R7 fully anti-clockwise.
- By means of R5 adjust the spot to the centre of the screen.
- Set SK2 to position "2 msec/div".
- With R3 set at 45° from the left-hand stop, adjust the time base generator to free-run by means of R522 (in doing so, the apparatus must be at operating temperature).
- Adjust R746 in such a way that the time base line is symmetrical with respect to the centre of the screen.
- Select such a value for R733 that the length of the time base line lies between 11 and 13 divisions in all positions of SK2.
- If necessary, readjust R746.

4. X shift

- Apply a sawtooth voltage to BU3.
- To BU5 apply a sinusoidal voltage of a frequency of 2 kc/s and an amplitude such that the picture height is 3 divisions (the voltage must be symmetrical with respect to earth).
- Increase the amplitude of the input signal by a factor 10.
- Both with R5 fully anti-clockwise and fully clockwise it must be possible to display the peaks of the sinewaves undistorted within the graticule.

If necessary, valves B701 and B702 may be replaced and the adjustment repeated from item E1 onwards.

5. Step attenuator

Check the attenuation with SK4 in the following positions (R7 fully clockwise):

Position SK4	*Voltage on BU4*	*Picture width*
.03 V_{p-p}/div.	84.75 $mV_{r.m.s.}$	
.1 V_{p-p}/div.	0.2825 $V_{r.m.s.}$	
.3 V_{p-p}/div.	0.8475 $V_{r.m.s.}$	
1 V_{p-p}/div.	2.825 $V_{r.m.s.}$	7.8–8.2 divisions
3 V_{p-p}/div.	8.475 $V_{r.m.s.}$	
10 V_{p-p}/div.	28.26 $V_{r.m.s.}$	
30 V_{p-p}/div.	84.75 $V_{r.m.s.}$	

6. Continuous attenuator

- Turn R7 fully clockwise.
- To BU4 apply a sinewave voltage of a frequency of 2 kc/s and an amplitude such that the picture height is 3.5 divisions.
- Turn R7 fully anti-clockwise.
- Now the picture width must be between 0.7 and 1 division.

7. Square wave response

- Turn SK4 and R7 fully clockwise.
- Apply a square wave voltage to BU4 of a frequency of 2 kc/s. The picture width must be approximately 8 divisions.
- The square wave response must at least be in accordance with Fig. 19.

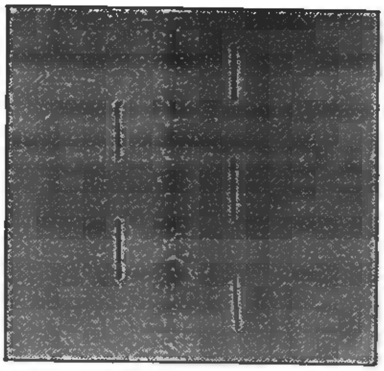

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Fig. 19. Square wave response of the X amplifier

8. Square wave response of step attenuator

- Turn R7 fully clockwise.
- To BU4 connect a square wave voltage of a frequency of 2 kc/s.
- Adjust the square wave response according to the table below.

Position SK4	*Adjust with*
0.1 V/div.	C727 (Fig. 19)
0.3 V/div.	C728 (Fig. 19)
1 V/div.	C729 (Fig. 19)

Check the other positions.

9. Frequency response curve

- Turn SK4 and R7 fully clockwise.
- Set SK3 to position "30 mV/div.".
- To BU4 connect a sinewave of a frequency of 2 kc/s and an amplitude such that the picture width is exactly 8 divisions. If the X sensitivity (see point E.2) is correctly adjusted, the voltage on BU4 must amount to about 85 mV.
- Increase the frequency of the voltage on BU4 to 200 kc/s, but keep the amplitude constant. Now the picture width must be at least 6 divisions.

10. Phase characteristic

- Set SK3 and SK4 to position ".03 V/div.".
- Turn R6 and R7 clockwise.
- Apply a sinusoidal voltage to BU2 and BU4 of a frequency of 5 c/s. Both voltages must have the same phase and the same amplitude. Both voltages must have the same phase and the same amplitude. Now an ellipse arises on the screen. In the way described in Chapter "Phase measurements", determine the angle φ which the ellipse makes with the X axis. The deviation from 35° must not exceed 5°.
- Repeat this measurement at frequencies of 100 kc/s and 200 kc/s. Tolerance 5°.

11. Hum in the X amplifier

With SK4 in position ".03V/div" the hum in the X amplifier must not exceed 0.1 division.

12. Crosstalk

- Set SK3 to position "0.1 V/div".
- Turn R6 and R7 clockwise.
- Set SK4 to position ".03 V/div".
- Short-circuit BU4 with respect to earth.
- Apply a pulse-shaped voltage of 100 mV_{p-p} to BU2, with a repetition frequency of 200 kc/s. The X deflection must not exceed 0.2 division.

H. TIME BASE GENERATOR

1. Internal triggering

- Turn R513 clockwise and R7 anti-clockwise.
- Set SK4 to position "N\".
- Adjust R3 so that the time base generator has just cut out.
- Apply to BU2 a sinusoidal voltage of a frequency of 1 kc/s and an amplitude such that the picture height is 0.5 division.
- Adjust R513 in such a way that a triggered picture appears on the screen.
- Change the frequency of the input voltage successively from 5 c/s to 200 kc/s. With a correct adjustment of R3, the picture must be stationary at these frequencies, even if R7 is turned clockwise.

2. External triggering

- To BU7 apply a voltage of 0.5 V_{p-p} which derived from the same voltage source as the voltage applied to BU2.
- With a correct adjustment of R3, the time base generator must start smoothly and the picture must be stationary at frequencies of 5 c/s and 200 kc/s.

3. Linearity of the time base

- Set SK2 to position ".02 ms/div.".
- Apply a sinusoidal voltage to BU2, with a frequency of 50 kc/s and with such an amplitude that the picture height amounts to 8 divisions.
- Display a number of periods on the screen and by means of R7 adjust the second period from the left to a width of 2 divisions. The second period from the right may be max. 0.5 divisions wider or narrower than 2 divisions.

4. Time base sweep times

- Set SK2 to position ".02 ms/div.".
- Apply a square wave voltage to BU2, with a frequency such that a complete period is traced on each division of the graticule. The picture height must be 8 divisions.
- Now the value of the frequency of the square wave voltage must lie between 37.5 and 62.5 kc/s. If required, correct the sweep time by selecting another value for R533.
- Check all positions of SK2 (see table below).

Position SK2	*Frequency square wave voltage*
.05 ms/div.	15,000-25,000 c/s
.1 ms/div.	7,500-12,500 c/s
.2 ms/div.	3,750- 6,250 c/s
.5 ms/div.	1,500- 2,500 c/s
1 ms/div.	750- 1,250 c/s
2 ms/div.	375- 625 c/s
5 ms/div.	150- 250 c/s
10 ms/div.	75- 125 c/s
20 ms/div.	37.5- 62.5 c/s
50 ms/div.	15- 25 c/s

Replacing parts

VI

A. THERMAL FUSE

The supply transformer is protected by a thermal fuse which blows if the temperature of the supply transformer exceeds 125°. Before replacing the blown fuse, the cause must be traced first. The new fuse must be fixed to the spring "S" and then be pulled onto the hook "H" (see Fig. 20; to this end remove the rear panel and the left-hand side panel in accordance with the instructions given in section II.A).

B. SUPPLY TRANSFORMER

- Remove the cabinet panels in accordance with the instructions given in section II.A.
- Remove the seven screws "A" (see Fig. 16). Now the rear mounting plate can be pulled a little from the frame.
- Unsolder all connections of the transformer.
- Remove the four bolts and nuts"B" (Fig. 21).
- Now the transformer can be removed from the apparatus at the left-hand side.

C. SWITCHES SK2, SK3, AND SK4

- Remove the front panel according to section II.C.
- Loosen the two screws by means of which the switch is fitted to the foremost mounting plate.

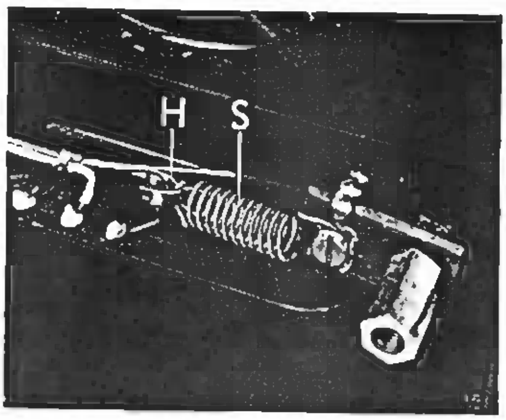

Fig. 20. Replacing the thermal fuse

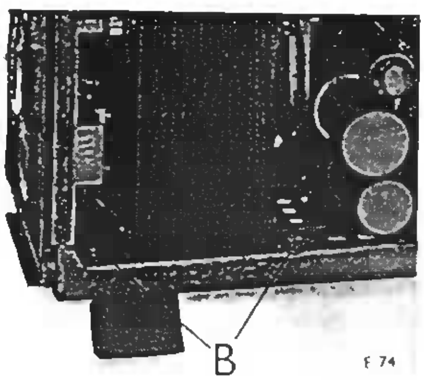

Fig. 21. Replacing the supply transformer

- Unsolder the connecting wires of the switch.
- Remove the switch from the foremost mounting plate.

D. SWITCH WAFERS SK2

- Remove the cabinet panels according to section II.A.
- Remove the four fixing screws from the two metal mounting strips.
- Unsolder the connections of the wafer to be replaced and slide it from the switch.

E. SWITCH WAFERS SK3

- Remove switch SK3 according to section VI.C.
- Remove the six fixing screws from the two metal mounting strips.
- Remove the mounting strips and the trimmer holder.

Now the switch wafers can be easily removed.

F. SWITCH WAFERS SK4

- Remove switch SK4 according to section VI.C.
- Remove the six fixing screws from the two metal mounting strips.
- Remove the mounting strips and the trimmer holder.
- Remove potentiometer R7 together with its fixing bracket.

Now the switch wafers can be easily removed.

G. POTENTIOMETERS ON THE FRONT PANEL

- Remove the front panel according to section II.C.
- Unsolder the connections from the appropriate potentiometer.
- Remove the fixing nut from the potentiometer.
- Remove the potentiometer from the foremost mounting plate.

H. CRT AND VALVES

1. Cathode ray tube

- Remove the cabinet panels according to section II.A.
- Remove the window together with the graticule according to section II.D.
- Remove anode connection "A" (Fig. 22) at the top of the cathode ray tube.

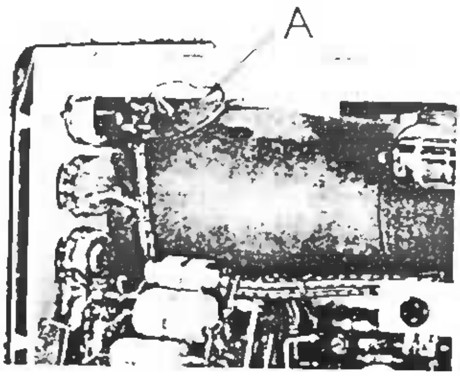

Fig. 22. Anode connection

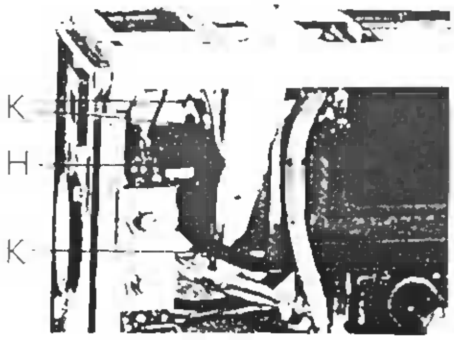

Fig. 23. Positioning the c.r.t.

- Remove the tube holder (for connection see page 87).
- Hold the tube at the front and then pull it from the protective housing and rubber cap. When the tube is inserted it is recommended to sprinkle a little talcum powder over the lower part of the tube, so that it slides more easily into the rubber cap. See to it that the protective casing is not damaged (dents etc.).

After the new cathode ray tube has been inserted make sure that the time base line runs exactly horizontally. If this is not the case, the tube can be correctly positioned by means of lever "H" (Fig. 23; if necessary, first loosen the screws "K" a little).
Subsequently the quality of the picture, the deflection sensitivity and the sweep times of the time base must be checked and readjusted, if necessary (sections V.B, V.C, V.D.2, V.E.2 and V.F.4).

2. Valves, diodes and other components

All component parts have been taken from normal production stock. After replacement of valves or other component parts it may be necessary to readjust the appropriate part of the circuit. (See chapter V, "Checking and adjusting").
New valves can be aged by allowing the apparatus to be switched on for 100 hours. Aging can also take place outside the apparatus. The valves are then connected as diodes (in the case of pentodes connect the grids and in the case of triodes the grid to the anode). The anode voltage is so chosen that the quiescent current at normal heater voltage is 1/6th of the maximum permissible cathode current.

5r Replacing parts

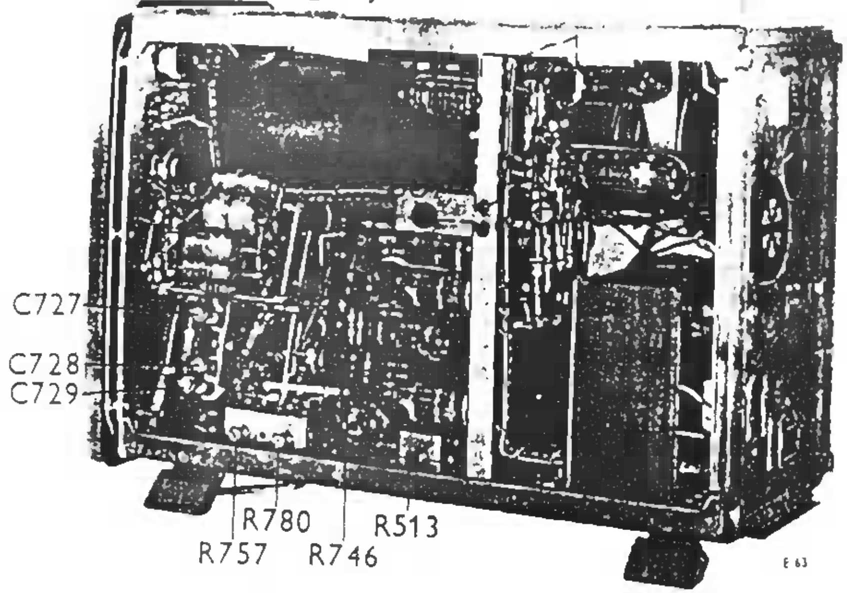

Fig. 24. Right-hand side view adjusting elements and units

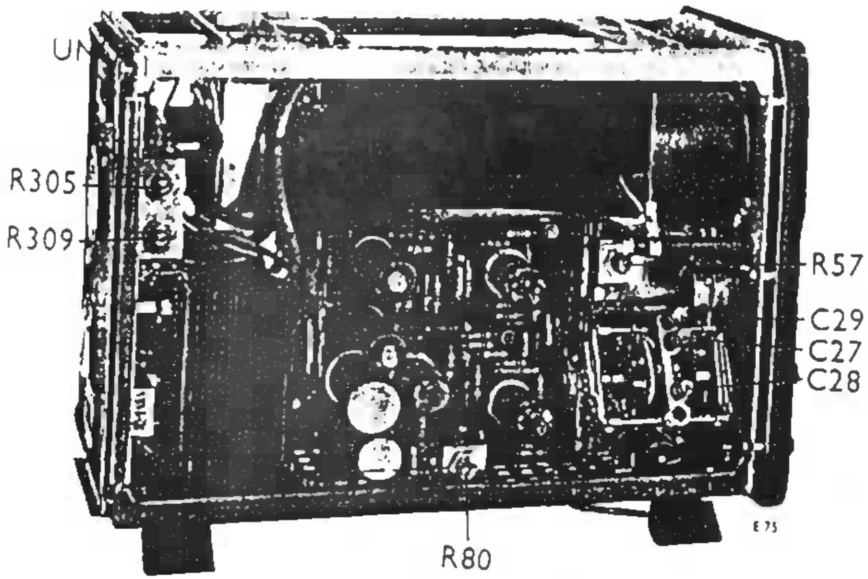

Fig. 25. Left-hand side view with adjusting elements and units

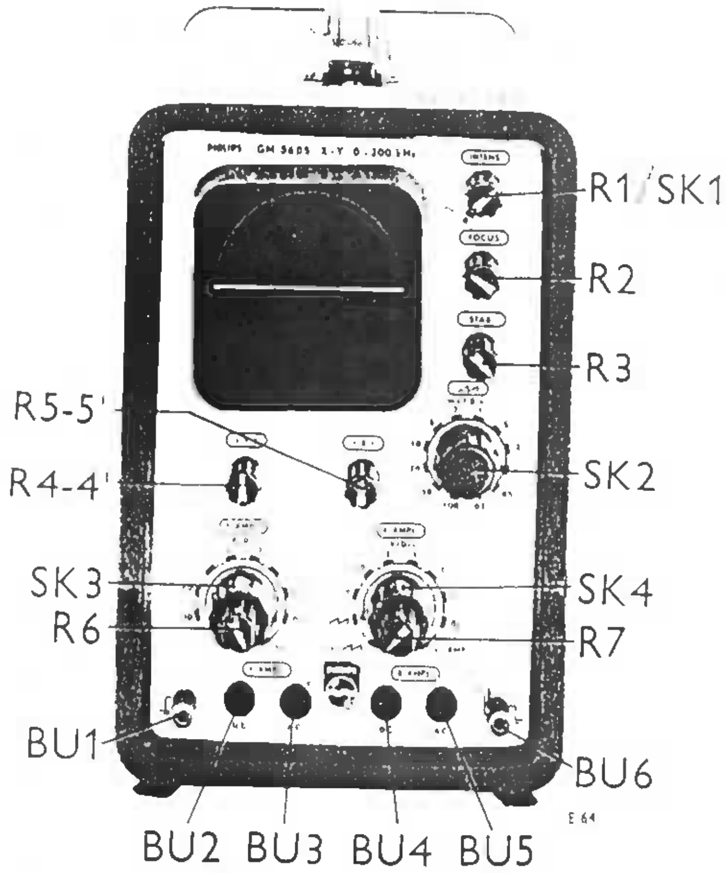

Fig. 26. Front view with adjusting elements

The quiescent current for the various valves is as follows:

B1, B2, B501, B502, B503, B701, B702:	ECF 80 4 mA (triode and pentode in parallel)
B3, B703	ECC 85 3 mA (both triodes in parallel)
B1003	5642 0.5 mA
B1001	ECL 82 7 mA (triode and pentode in parallel)

Fault finding

VII

The arrangement of the component parts is shown in Figs. 28 ... 38. To enable faults to be traced quickly, the principal voltages and waveforms are shown in the drawings of the printed wiring boards and in the circuit diagrams. To enable faults to be remedied quickly, one should be familiar with the working of the apparatus and the instructions relating to its adjustment (chapters I and V). If necessary, you can always apply to the PHILIPS Service Organisation.

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List of parts VIII

A. LIST OF MECHANICAL PARTS

Item	*Number*	*Code number*	*Description*	*Minimum stock*				
				Number of apparatus				
				S	*1*	*3*	*5*	*10*
1	1	M7 076 17	Handle	**	–	–	–	1
2	2	E2 742 67	Bracket	**	–	–	–	2
3	1	M7 193 01	Text plate	**	–	–	–	1
4	7	M7 773 53	Knob 14 mm ø for spindle 6 mm ø	*	–	1	2	3
5	5	B1 891 49	Knob with arrow for spindle 14 mm ø	**	–	1	2	3
6	3	973/52	Knob 22 mm ø	*	–	–	1	2
7	1	973/D51	Cap for knob 22 mm ø	**	–	–	–	1
8	3	973/P55	Arrow for knob 22 mm ø	**	–	–	1	2
9	1	M7 350 27	Window	*	–	–	–	1
10	1	M7 749 07	Graticule	*	–	–	–	1
11	1	M7 134 86	Contrast-enhancing plate	**	–	–	–	1
12	4	P7 655 14	Foot	**	–	–	2	4
13	2	973/58	Knob 14 mm ø for spindle 4 mm ø	*	–	–	1	2
14	4	979/11	Socket	*	–	1	1	1
15	4	M7 080 86	Nut	**	–	–	1	2
16	1	M7 737 11	Mains voltage adapter	*	–	–	–	1
17	1	08 290 50	Mains connection	*	–	–	–	1
18	2	M7 603 89	Earth terminal	*	1	1	3	5
19	1	M7 751 78	Switch socket	*	2	1	2	3
20	1	P4 655 88	Box	**	–	–	2	4
21	1	M7 289 49	Anode contact cap	*	–	–	1	2
22	1	404 67	Valve holder (B 301)	*	–	–	–	2
23	8	976/PW 9 × 12	Valve holder noval	*	1	3	5	8
24	1	976/PW 7 × 12	Valve holder min.	*	–	–	1	2
25	4	910/18 × 110	Strip 110 mm	**	–	–	–	2

Number	*Code number*	*Description*	*Minimum stock*				
			Number of apparatus				
			S	*1*	*3*	*5*	*10*
100	A3 320 36	Soldering eyelet	**	10	10	15	25
2	978/4 × 65	Coaxial plug	*	1	1	2	2
2	M7 340 18	Plug pin	*	–	1	1	2
2	978/1 × 4AP	Plug	*	1	2	2	3
1 m	R 209 KA/11BBO	H.F. cable		2	2	3	4
2	P5 657 09/159 AA	Trimmer holder	*	–	–	1	2
10 cc	971/71	Switch oil	*	–	–	–	10cc
1	08 290 49	Female plug	*	–	–	1	3

Purpose of the column S

Components not marked

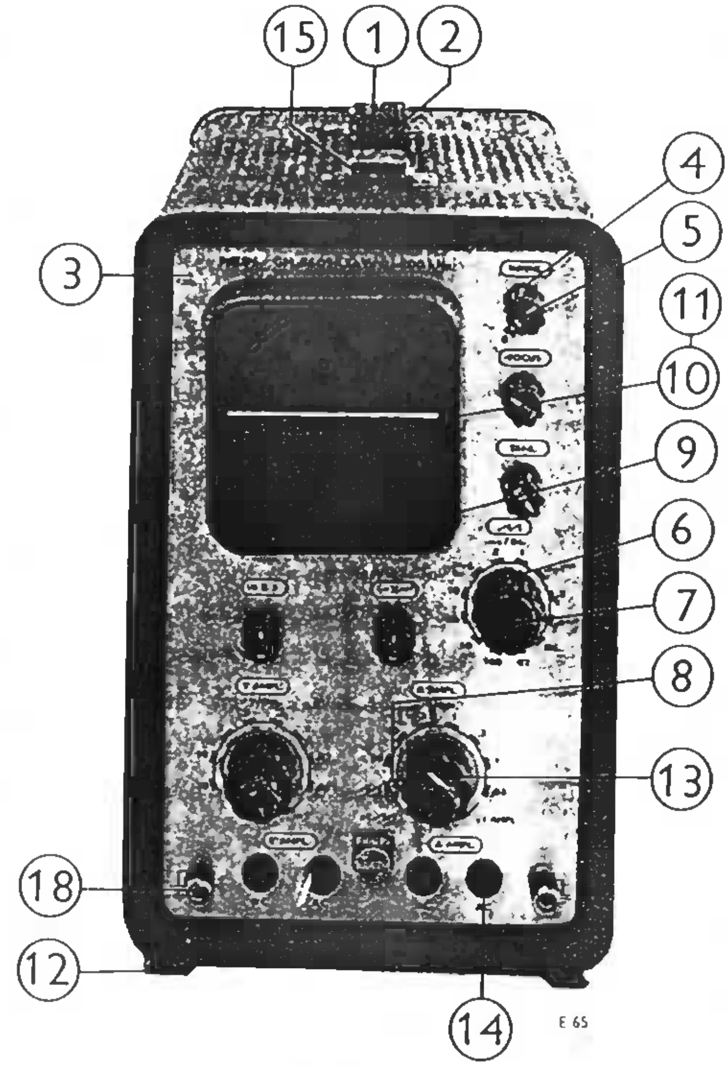
These should be present at the Service Department in the country concerned or at the customer's who is using the apparatus.
They include:
a. nearly all electrical components;
b. mechanical parts which are vulnerable, or which are subject to wear.

Components marked with one star

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

Components marked with two stars

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



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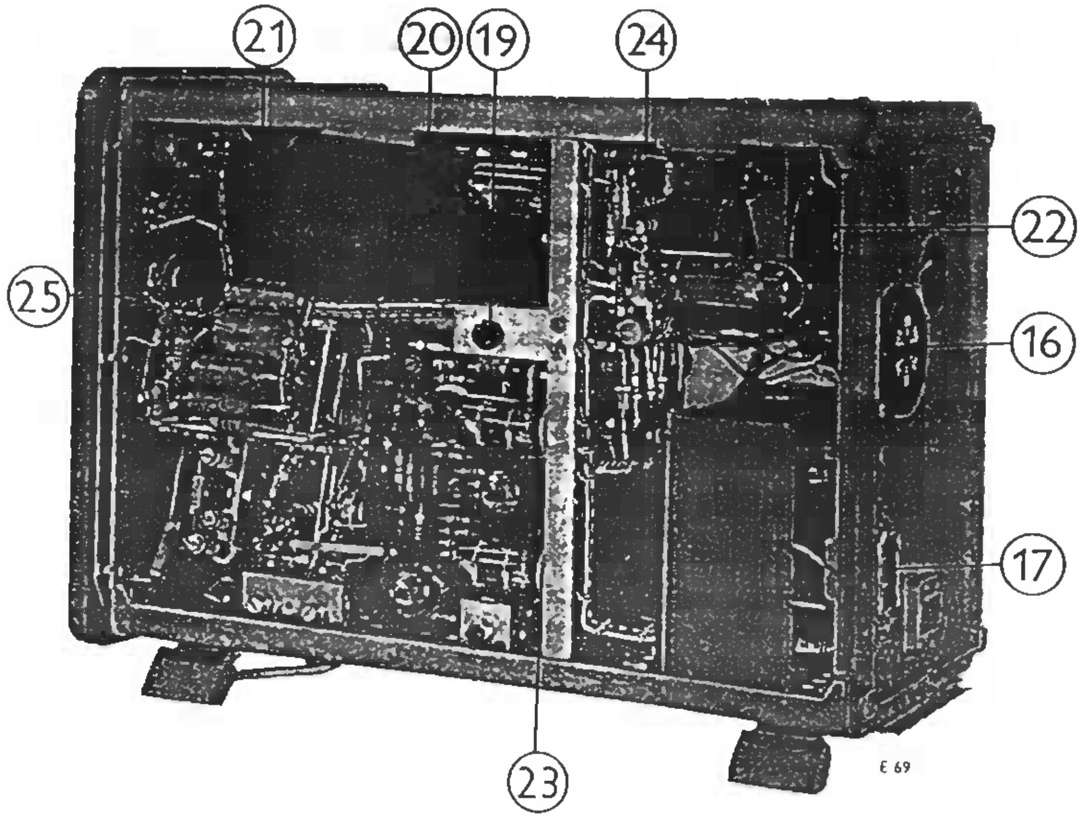

E 69

B. LIST OF ELECTRICAL PARTS ELEKTRISCHE EINZELTEILE ELEKTRISCHE ONDERDELEN NOMENCLATURE ÉLECTRIQUE

- The indication "PW" means, that the component concerned is a of type for mounting on a printed-wiring plate.
- Die Angabe „PW" bedeutet, dass der diesbezügliche Teil speziell für Montage auf Leiterplatten bestimmt ist.
- De aanduiding „PW" betekent, dat het desbetreffende onderdeel speciaal voor montage op gedrukte bedradingsplaten is bestemd.
- L'indication "PW" indique, que cette pièce est du type pour montage sur une plaque de câblage imprimé.
- The correct values of selected resistors and capacitors have been fixed when adjusting the instrument in the factory.
- Die richtigen Werte der Abgleichwiderständen und -Kapazitäten sind bei der Einstellung in der Fabrik festgelegt.
- De juiste waarden van de keuzeweerstanden en -condensatoren zijn bij het afregelen in de fabriek bepaald.
- Les valeurs exactes des résistances et des capacités d'ajustage sont choisies lors de la fabrication de l'appareil.
- All resistors are vaporized carbon resistors, unless otherwise stated.
- Sofern nicht anders angegeben, handelt es sich hierbei um Kohlewiderstände.
- Alle weerstanden zijn opgedampte koolweerstanden, tenzij anders aangegeven.
- Toutes les résistances sont du type au carbone vaporisé, sauf indication différente.

Für die englische Wörter lese man in deutsch, holländisch oder französisch:
Voor de Engelse tekst kan men in het Duits, Nederlands of Frans lezen:
Pour le texte anglais on lit en allemand, hollandais ou en français:

Service part	Bestellnummer	Bestelnummer	Numéro de code
Value	Wert	Waarde	Valeur
Tolerance	Fehlergrenzen	Tolerantie	Tolérance
Power	Leistung	Vermogen	Wattage
Voltage	Spannung	Spanning	Tension
Description	Beschreibung	Omschrijving	Désignation
Potentiometer (potm) linear	Pot. linear	Lineaire koolpot.	Potentiomètre au carbon linéair
Wire-wound	Drahtwiderstand	Draadgewonden	Bobineé
2 in parallel	2 parallel	2 parallel	2 en parallèle
Choice resistor	Abgleichwiderstand	Keuzeweerstand	Résistance d'ajustage

Capacitors–Kondensatoren–Condensatoren–Condensateurs

No.	*Service part*	*Value*	*Voltage V*	*Tolerance %*	*Description*
C26	906/V100K	0.1 μF	700	10	Paper
C27	C 004 FA/20E	20 pF			Trimmer
C28	908/P10E	10 pF			Trimmer
C29	C 004 FA/20E	20 pF			Trimmer
C30	904/22E	22 pF	500	10	Ceramic
C31	904/1K	1000 pF	500	—20/+50	Ceramic
C32	904/10E	10 pF	500	±3 pF	Ceramic
C33	904/56E	56 pF	500	10	Ceramic
C34	906/22K	22000 pF	400	10	Polyester
C35	904/2K2	2200 pF	500	—20/+50	Ceramic
C36	904/270E	270 pF	500	10	Ceramic
C37	904/270E	270 pF	500	10	Ceramic
C38	904/680E	680 pF	500	—20/+50	Ceramic
C39	904/8E2	8.2 pF	500	$\pm\frac{1}{2}$ pF	Ceramic

Resistors–Widerstände–Weerstanden–Résistances

No.	*Service part*	*Value*	*Power W*	*Tolerance %*	*Description*
R4	E 091 CG/00B12	500 kΩ			Potm. tandem lin.
R6	916/GL 200K	200 kΩ			Potm. log.
R25	901/1M	1 MΩ	0.25	1	1
R26	901/200K	0.2 MΩ	0.25	1	
R27	B8 305 23D/52K6	52600 Ω	0.25	1	
R28	901/12K	12 kΩ	0.1	1	
R29	B8 305 25D/3K33	3330 Ω	1	1	
R30	B8 305 25D/1K16	1160 Ω	0.1	1	
R31	B8 305 25D/333E	333 Ω	0.1	1	
R32	B8 305 25D/167E	167 Ω	0.1	1	
R34	B8 305 26D/333K	333 kΩ	0.25	1	
R35	B8 305 17D/450K	450 kΩ	0.25	1	
R36	B8 305 26D/483K	483 kΩ	0.25	1	

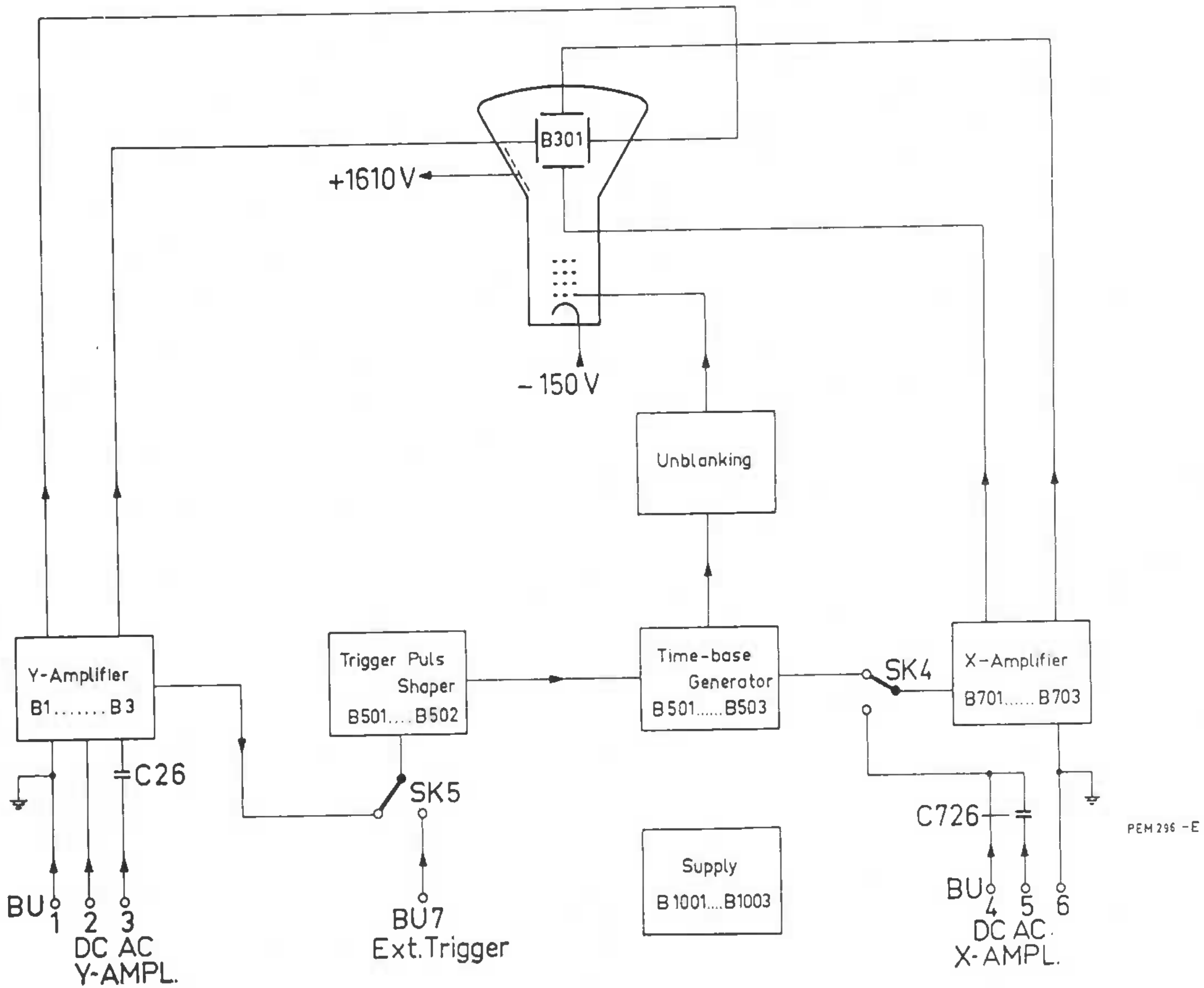

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Fig. 27. Block diagram

No.	*Service part*	*Value*	*Power W*	*Tolerance %*	*Description*
R37	901/100K	0.1 kΩ	0.25	5	
R38	901/100E	100 Ω	0.25	5	
R40	48 766 05/22K	22 kΩ	8	5	Wire-wound
R41	901/1M	1 MΩ	0.25	5	
R42	901/100E	100 Ω	0.25	5	
R43	901/4K7	4700 Ω	0.25	5	
R44	901/100E	100 Ω	0.25	5	
R45	938/B20K	20 kΩ	8	5	Wire-wound
R47	901/100E	100 Ω	0.25	5	
R48	901/12K	12 kΩ	0.25	5	
R49	901/4K7	4800 Ω	0.25	5	
R55	901/3K3	3300 Ω	0.25	5	
R56	901/12K	12 kΩ	0.25	1	
R57	916/GE 500K	500 kΩ			Potm. lin.
R58	901/100E	100 Ω	0.25	5	
R59	901/1K5	1500 Ω	0.25	5	
R62	901/1K5	1500 Ω	0.25	5	
R63	901/100E	100 Ω	0.25	5	
R64	901/100K	0.1 MΩ	0.25	5	
R67	901/82K	82 kΩ	0.25	5	
R68	901/82K	82 kΩ	0.25	5	
R70	901/100K	0.1 MΩ	0.25	5	
R71	901/100E	100 Ω	0.25	5	
R72	901/6M8	6.8 MΩ	0.25	10	
R73	901/27K	27 kΩ	0.25	5	
R76	901/6M8	6.8 MΩ	0.25	10	
R77	901/100E	100 Ω	0.25	5	
R79	901/27K	27 kΩ	0.5	5	
R70	E 098 CG/00A01	1 kΩ			Potm. lin.
R81	901/8K2	8200 Ω	0.5	5	
R82	901/15K	15 kΩ	0.5	5	
R85	901/6K8	6800 Ω	0.5	5	

Valves–Röhren–Buizen–Tubes

B1	ECF 80
B2	ECF 80
B3	ECC 85

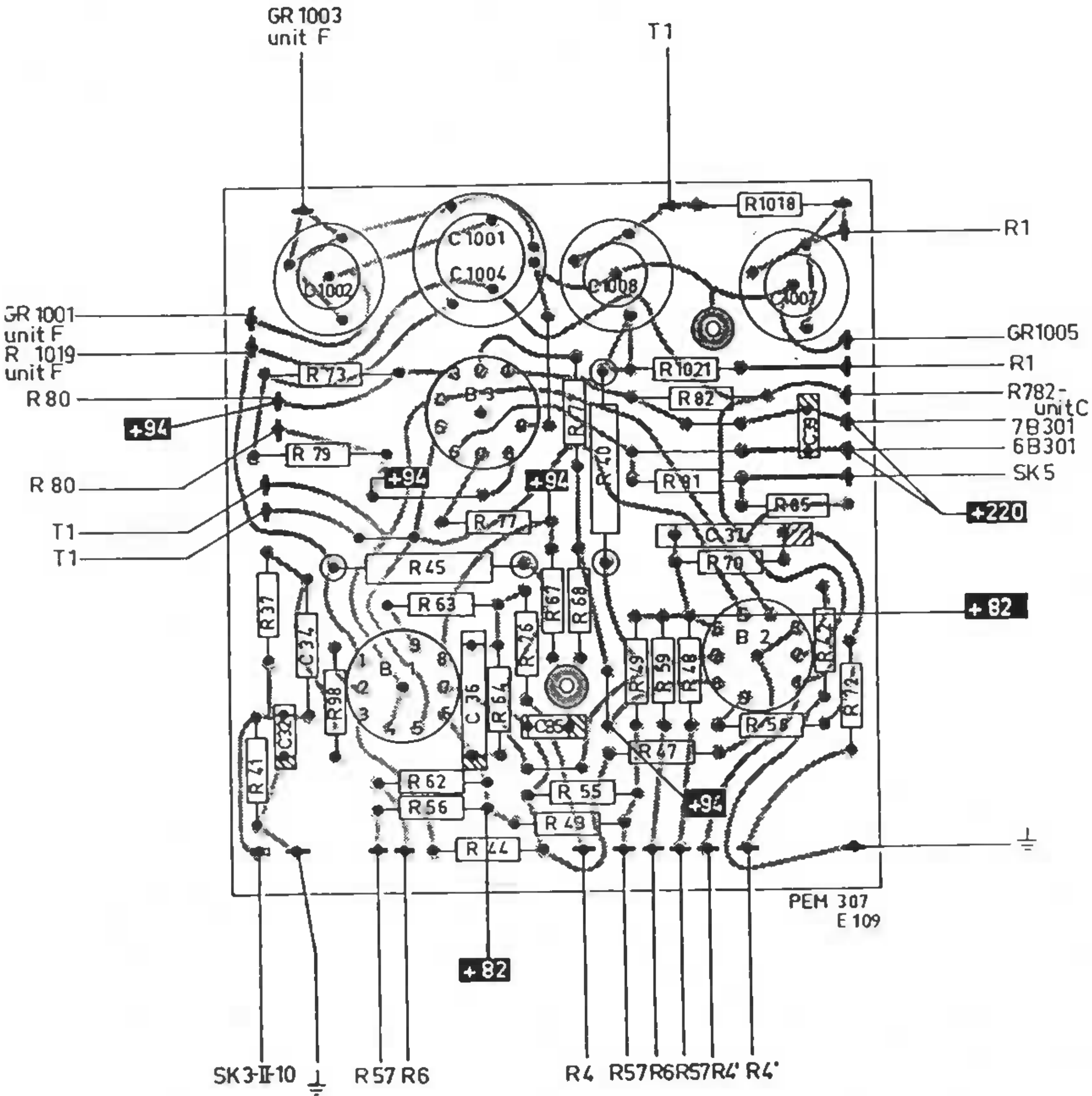
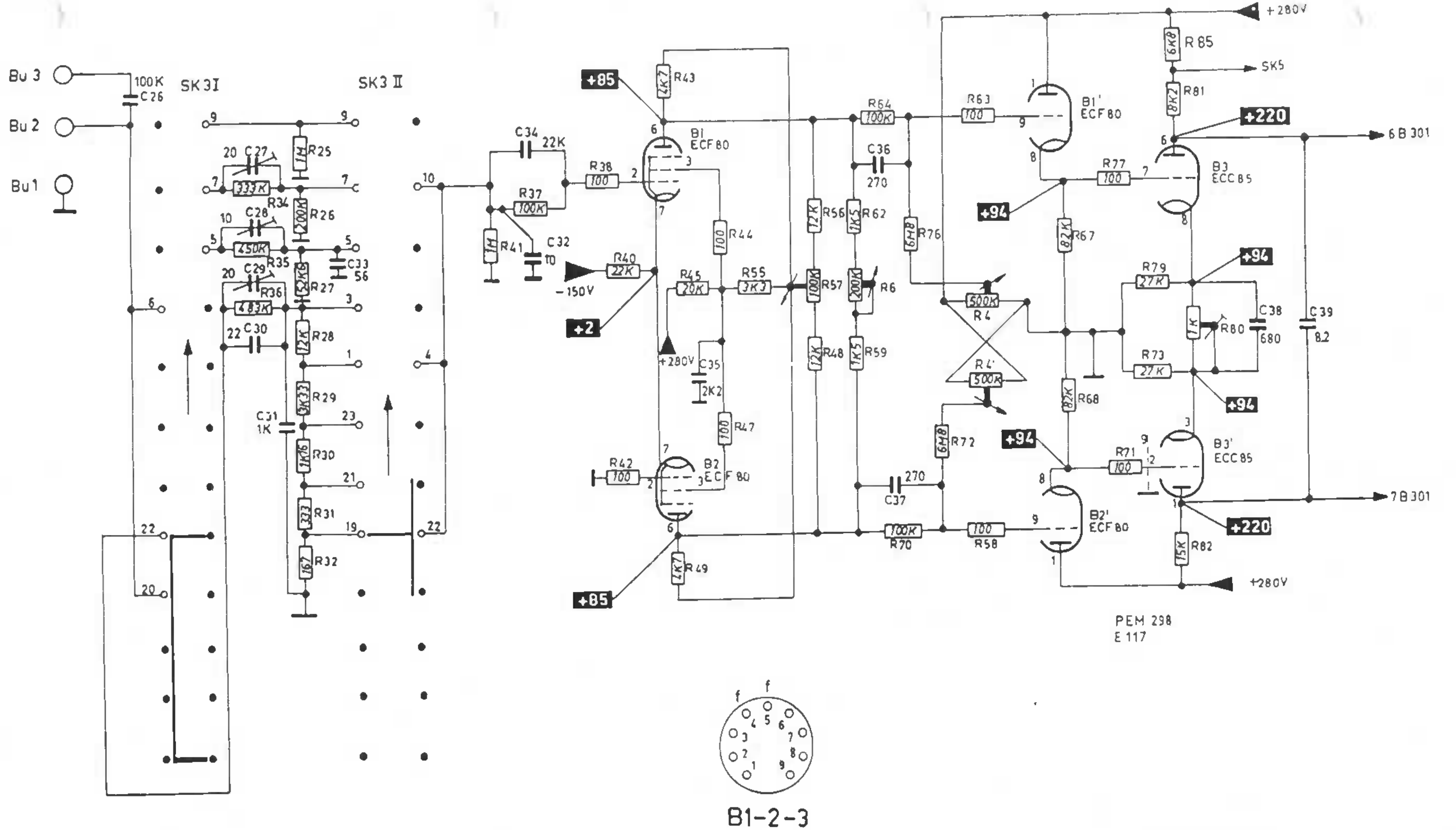


Fig. 28. Unit A; Y-amplifier



R57 = 500 kΩ

Fig. 29. Diagram of the Y-amplifier

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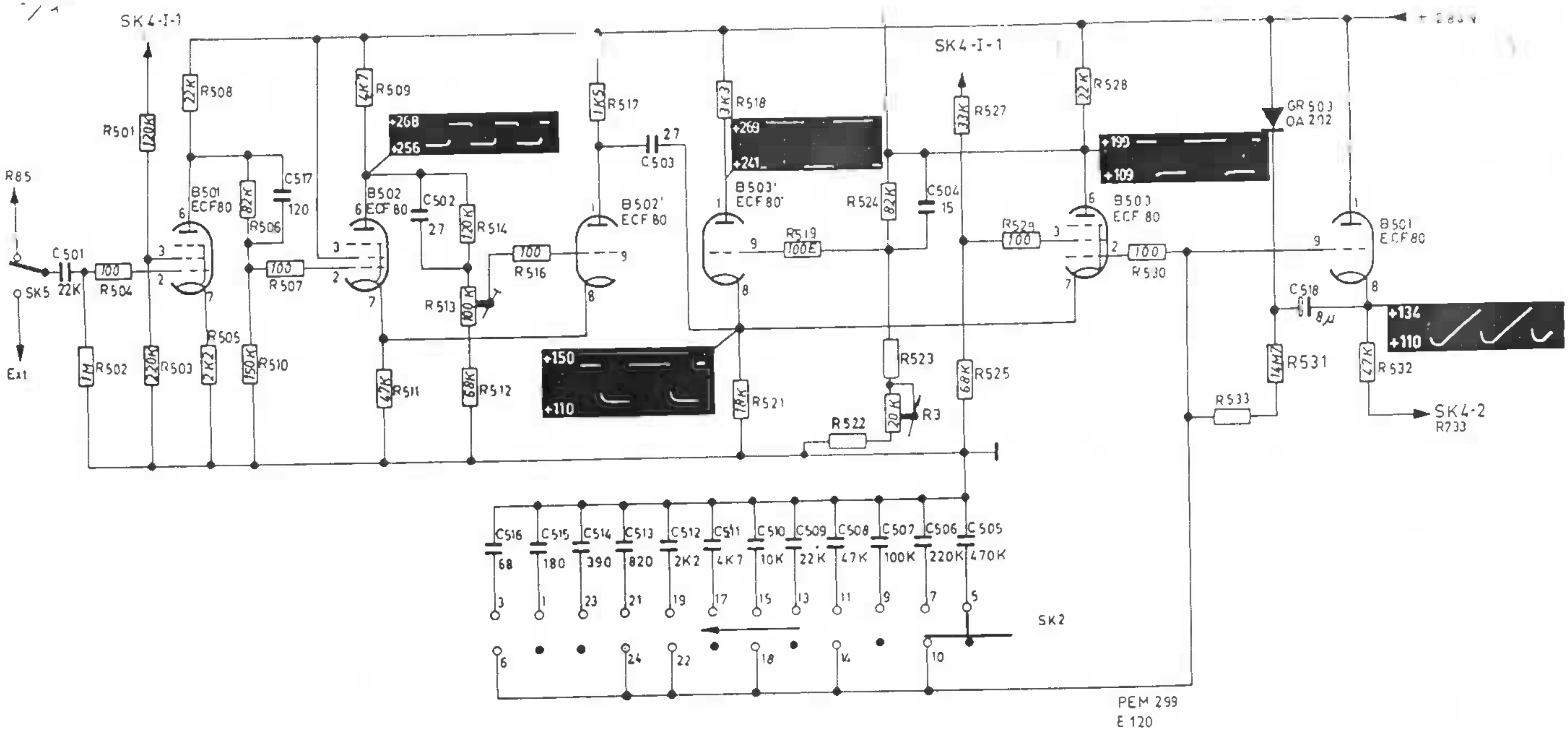

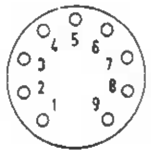

B501 - 502 - 503

R522 = 47 kΩ
R520 is connected in parallel with R522

Fig. 31. Diagram of the trigger-pulse shaper and of the time-base generator

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Capacitors–Kondensatoren–Condensatoren–Condensateurs

No.	*Service part*	*Value*	*Voltage V*	*Tolerance %*	*Description*
C501	904/22K	22000 pF	500	—20/+50	Ceramic
C502	904/27E	27 pF	500	10	Ceramic
C503	904/27E	27 pF	500	10	Ceramic
C504	904/15E	15 pF	500	10	Ceramic
C505	906/470K	0.47 μF	400	10	Polyester
C506	906/220K	0.22 μF	400	10	Polyester
C507	906/100K	0.1 μF	400	10	Polyester
C508	906/47K	47000 pF	400	10	Polyester
C509	906/22K	22000 pF	400	10	Polyester
C510	906/10K	10000 pF	400	10	Polyester
C511	906/4K7	7400 pF	400	10	Polyester
C512	906/2K2	2200 pF	400	10	Polyester
C513	904/820E	820 pF	500	—20/+50	Ceramic
C514	904/390E	390 pF	500	10	Ceramic
C515	904/180E	180 pF	500	10	Ceramic
C516	904/68E	68 pF	500	10	Ceramic
C517	904/120E	120 pF	500	10	Ceramic
C518	AC 8128/8	8 μF	350		Electrolytic (PW)
C519	906/V82K	82000 pF	700	10	Paper

Resistors–Widerstände–Weerstanden–Résistances

No.	*Service part*	*Value*	*Power W*	*Tolerance %*	*Description*
R3	916/GE 20K	20 kΩ			Potm. lin.
R501	901/120K	120 kΩ	0.25	5	
R502	901/1M	1 MΩ	0.25	5	
R503	901/220K	220 kΩ	0.25	5	
R504	901/100E	100 Ω	0.25	5	
R505	901/1K	1 kΩ	0.25	5	
R506	901/82K	82 kΩ	0.25	5	
R507	901/100E	100 Ω	0.25	5	
R508	901/22K	22 kΩ	0.25	5	

No.	*Service part*	*Value*	*Power W*	*Tolerance %*	*Description*
R509	901/4K7	4700 Ω	0.5	5	
R510	901/150K	150 kΩ	0.25	5	
R511	E 003 AG/D47K	47 kΩ	1	1	
R512	901/68K	68 kΩ	0.25	5	
R513	E098 CG/00A08	100 kΩ			Potm. lin.
R514	901/120K	120 kΩ	0.5	5	
R516	901/100E	100 Ω	0.25	5	
R517	901/1K5	1500 Ω	0.25	5	
R518	901/3K3	3300 Ω	0.5	5	
R519	901/100E	100 Ω	0.25	5	
R520	901/100K-4M7	0.1–4.7 MΩ			par. with R522
R521	48 766 05/18K	18 kΩ	8	5	Wire-wound
R522	902/K47K	47 kΩ	0.25	5	
R523	901/82K	82 kΩ	0.25	5	
R524	901/82K	82 kΩ	0.25	5	
R525	E 003 AG/D68K	68 kΩ	1	5	
R527	E 003 AG/D33K	33 kΩ	1	5	
R528	48 766 05/22K	22 kΩ	8	5	Wire-wound
R529	901/100E	100 Ω	0.25	5	
R530	901/100E	100 Ω	0.25	5	
R531	901/10M	10 MΩ	0.5	10	
R532	E003 AG/D47K	47 kΩ	1	1	
R533	901/		0.25	5	Choice resistor

Valves–Röhren–Buizen–Tubes–Diodes

B501	ECF 80
B502	ECF 80
B503	ECF 80
GR503	0A202

Capacitors–Kondensatoren–Condensatoren–Condensateurs

No.	*Servicepart*	*Value*	*Voltage V*	*Tolerance %*	*Description*
C726	906/V100K	0.1 μF	700	10	Paper
C727	C 004 FA/20E	20 pF			Trimmer
C728	908/P10E	10 pF			Trimmer
C729	C 004 FA/20E	20 pF			Trimmer
C730	904/22E	22 pF	500	10	Ceramic
C731	904/1K	1000 pF	500	—20/+50	Ceramic
C732	904/10E	10 pF	500	± 0.5 pF	Ceramic
C733	904/56E	56 pF	500	10	Ceramic
C734	906/22K	22000 pF	400	10	Polyester
C735	904/2K2	2200 pF	500	—20/+50	Ceramic
C736	904/150E	150 pF	500	10	Ceramic
C737	904/150E	150 pF	500	10	Ceramic
C738	904/560E	560 pF	500	10	Ceramic
C739	906/L100K	0.1 μF	125	10	Polyester

Resistors–Widerstände–Weerstanden–Résistances

No.	*Servicepart*	*Value*	*Power W*	*Tolerance %*	*Description*
R5	E 091 CG/00B12	500 kΩ			Potm. tandem lin.
R7	916/GL 200K	200 kΩ			Potm. log.
R725	901/1M	1 MΩ	0.25	1	
R726	B8 305 26D/176K	176 kΩ	0.25	1	
R727	B8 305 23D/52K6	52600 Ω	0.25	1	
R728	B8 305 23D/20K4	10200 Ω	0.1	1	(2 in par.)
R729	B8 305 25D/3K53	3530 Ω	0.1	1	
R730	901/1K	1 kΩ	0.1	1	
R731	B8 305 23D/500E	500 Ω	0.1	1	
R732	901/27K-150K	27–150 kΩ			par. with R733
R733	902/K2K7	2.7 kΩ	0.25	5	Choice resistor
R734	B8 305 26D/350K	350 kΩ	0.25	1	
R735	B8 305 17D/450K	450 kΩ	0.25	1	
R736	B8 305 26D/485K	485 kΩ	0.25	1	

No.	*Service part*	*Value*	*Power W*	*Tolerance %*	*Description*
R737	901/100K	100 kΩ	0.25	5	
R738	901/100E	100 Ω	0.25	5	
R739	901/270K	270 kΩ	0.25	5	
R740	48 766 05/22K	22 kΩ	8	5	Wire-wound
R741	901/1M	1 MΩ	0.25	5	
R742	901/100E	100 Ω	0.25	5	
R743	901/4K7	4.7 kΩ	0.25	5	
R744	901/100E	100 Ω	0.25	5	
R745	938/B20K	20 kΩ	8	5	Wire-wound
R746	E 097 AD/10K	10 kΩ			Potm. (PW)
R747	901/100E	100 Ω	0.25	5	
R748	901/12K	12 kΩ	0.25	5	
R749	901/4K7	4.7 kΩ	0.25	5	
R755	901/3K3	3.3 kΩ	0.25	5	
R756	901/12K	12 kΩ	0.25	5	
R757	916/GE 500K	500 kΩ			Potm. lin.
R758	901/100E	100 Ω	0.25	5	
R759	901/1K5	1.5 kΩ	0.25	5	
R762	901/1K5	1.5 kΩ	0.25	5	
R763	901/100E	100 Ω	0.25	5	
R764	901/100K	100 kΩ	0.25	5	
R767	901/82K	82 kΩ	0.25	5	
R768	901/82K	82 kΩ	0.25	5	
R770	901/100K	100 kΩ	0.25	5	
R771	901/100E	100 Ω	0.25	5	
R772	901/2M2	2.2 MΩ	0.25	10	
R773	901/27K	27 kΩ	0.5	5	
R776	901/2M2	2.2 MΩ	0.25	10	
R777	901/100E	100 Ω	0.25	5	
R779	901/27K	27 kΩ	0.4	5	
R780	E 098 CG/00A01	1 kΩ			Potm. lin.
R781	E 003 AG/D15K	15 kΩ	1	5	
R782	E 003 AG/D15K	15 kΩ	1	5	

Valves–Röhren–Buizen–Tubes

B701	ECF 80
B702	ECF 80
B703	ECC 85

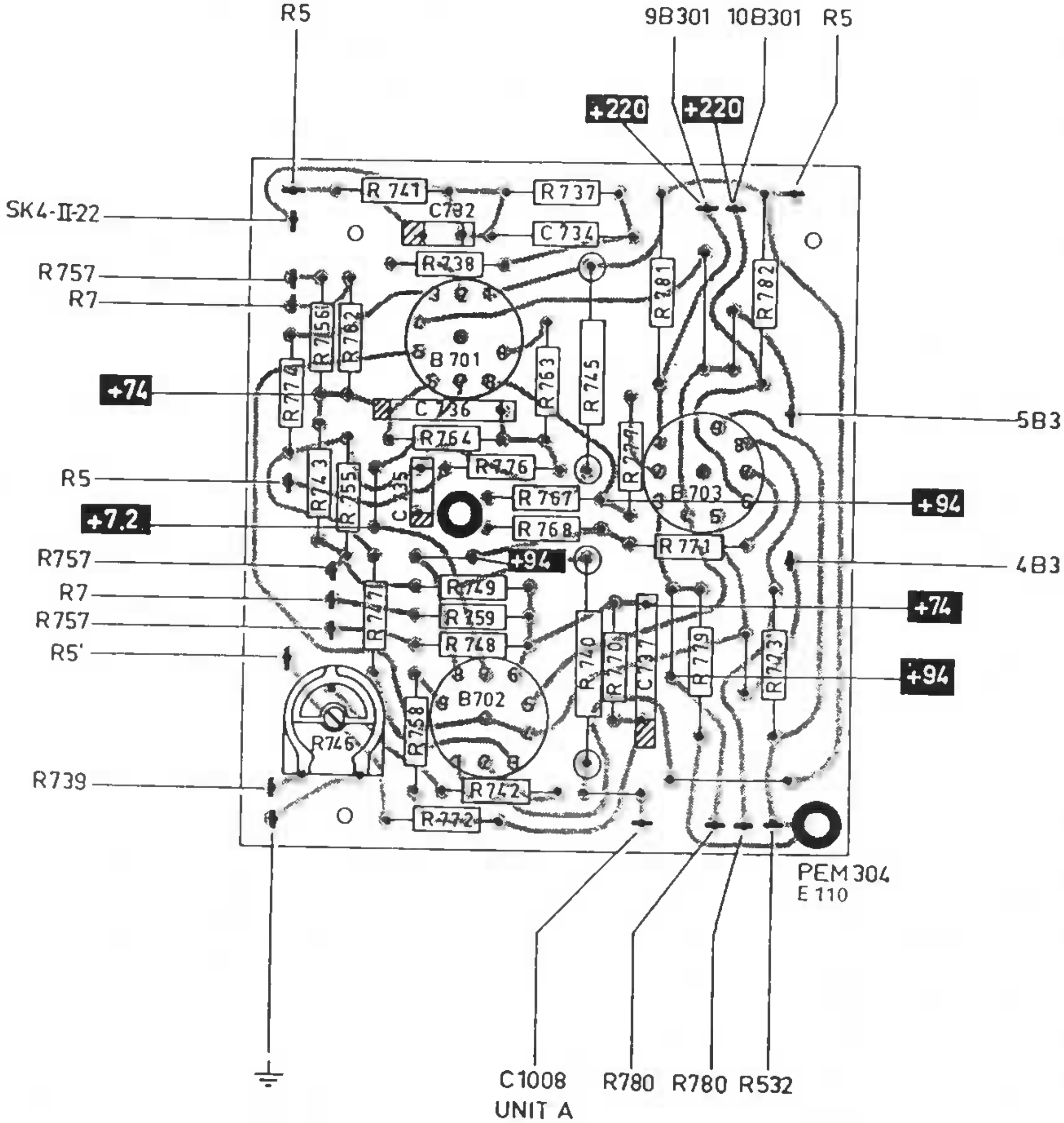
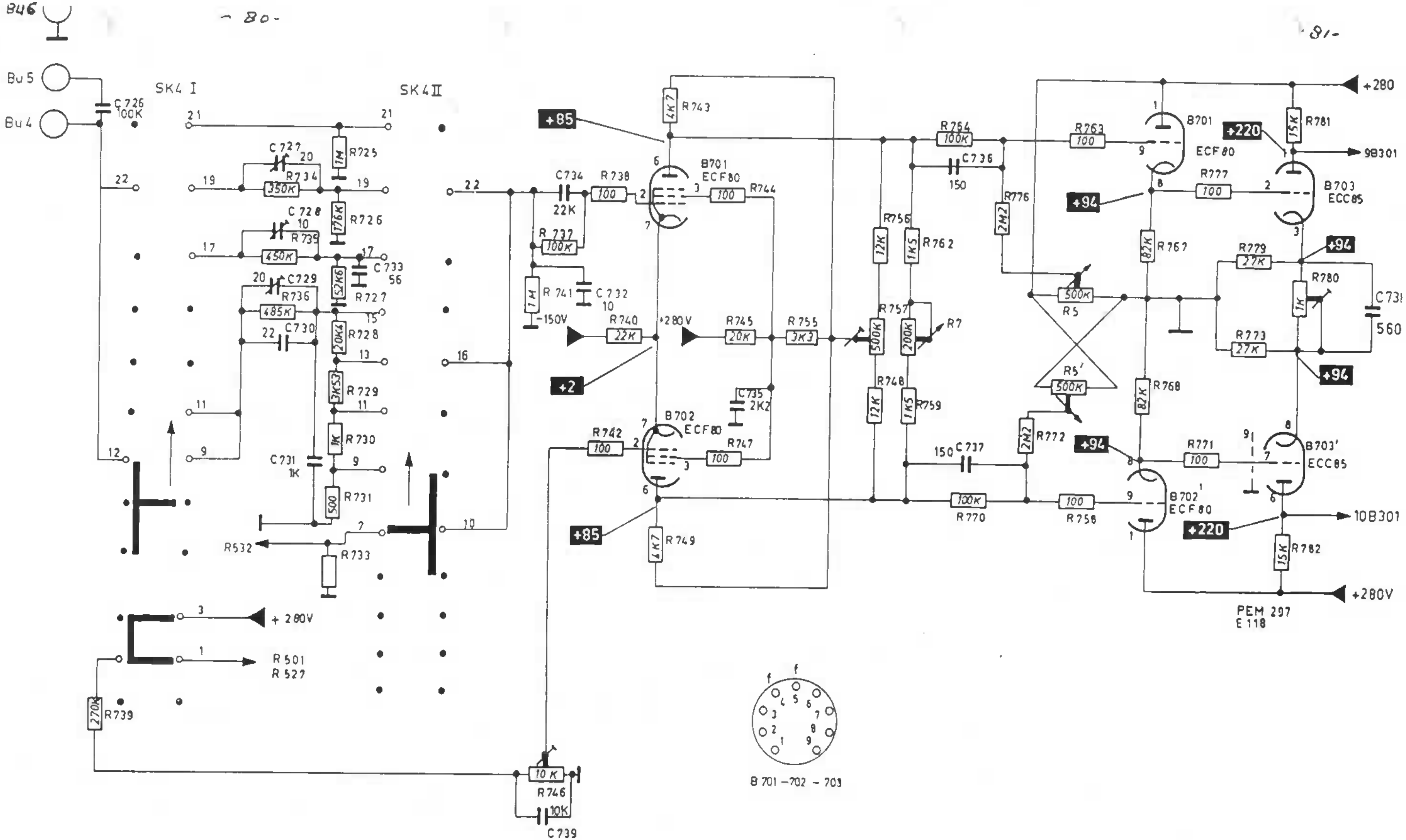


Fig. 32. Unit C; X-amplifier



R733 = 2.7 kΩ

R732 is connected in parallel with R733

Fig. 33. Diagram of the X-amplifier

Capacitor–Kondensator–Condensator–Condensateur

No.	*Service part*	*Value*	*Voltage V*	*Tolerance %*	*Description*
C301	906/10K	10000 pF	400	10	Polyester

Resistors–Widerstände–Weerstanden–Résistances

No.	*Service part*	*Value*	*Power W*	*Tolerance %*	*Description*
R2	916/GE 500K	500 kΩ			Potm. lin.
R301	901/10M	10 MΩ	0.25	10	
R302	901/470K	470 kΩ	0.25	5	
R303	901/56K	56 kΩ	0.25	5	
R304	901/				Choice resistor
R305	E 098 CG/00A15	1 MΩ	0.25	5	Potm. lin.
R307	901/220K	220 kΩ	0.25	5	
R308	901/470K	470 kΩ	0.25	5	
R309	916/GE 500K	500 kΩ			Potm. lin.

Valve–Röhre–Buis–Tube–Diode

B301	DH7-78	Cathode ray tube
GR301	0A 202	

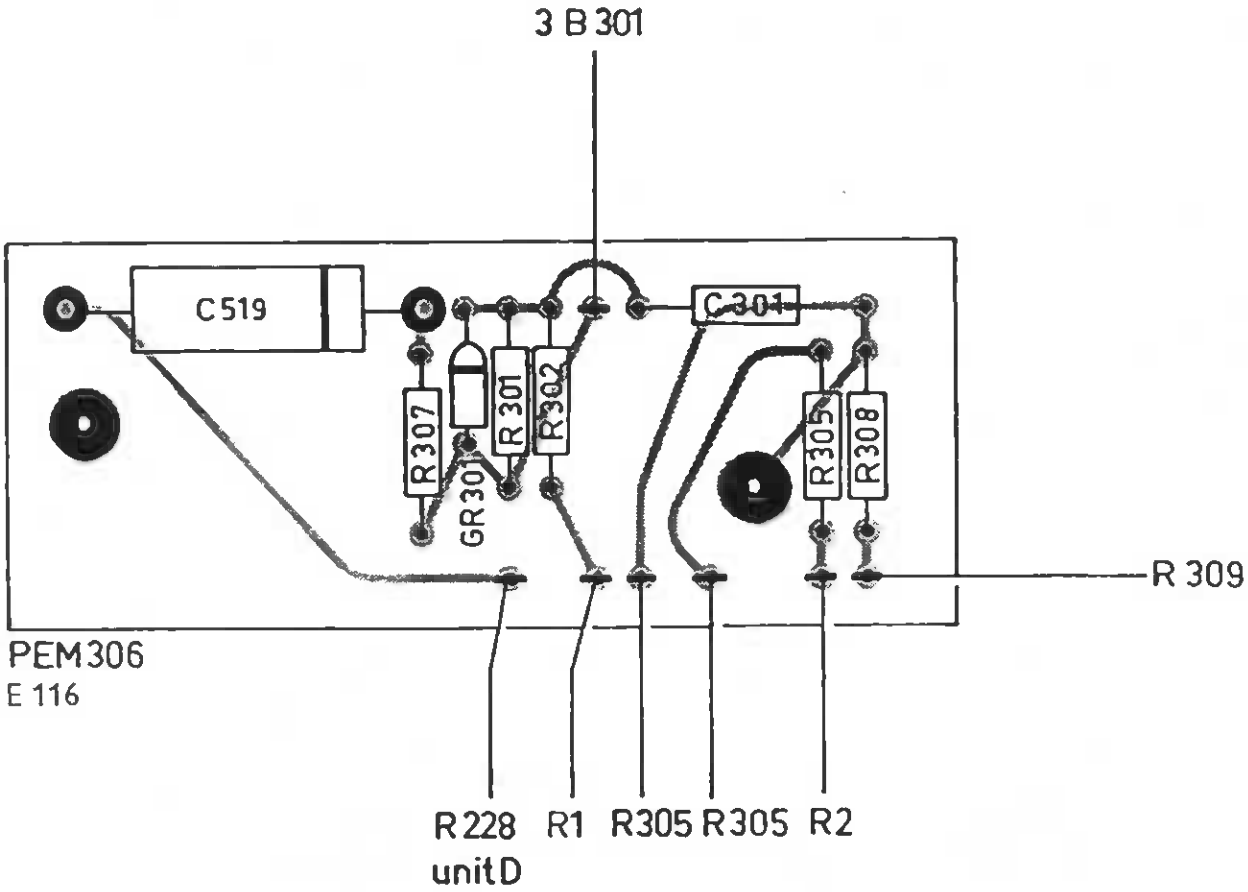


Fig. 34. Unit B; beam control

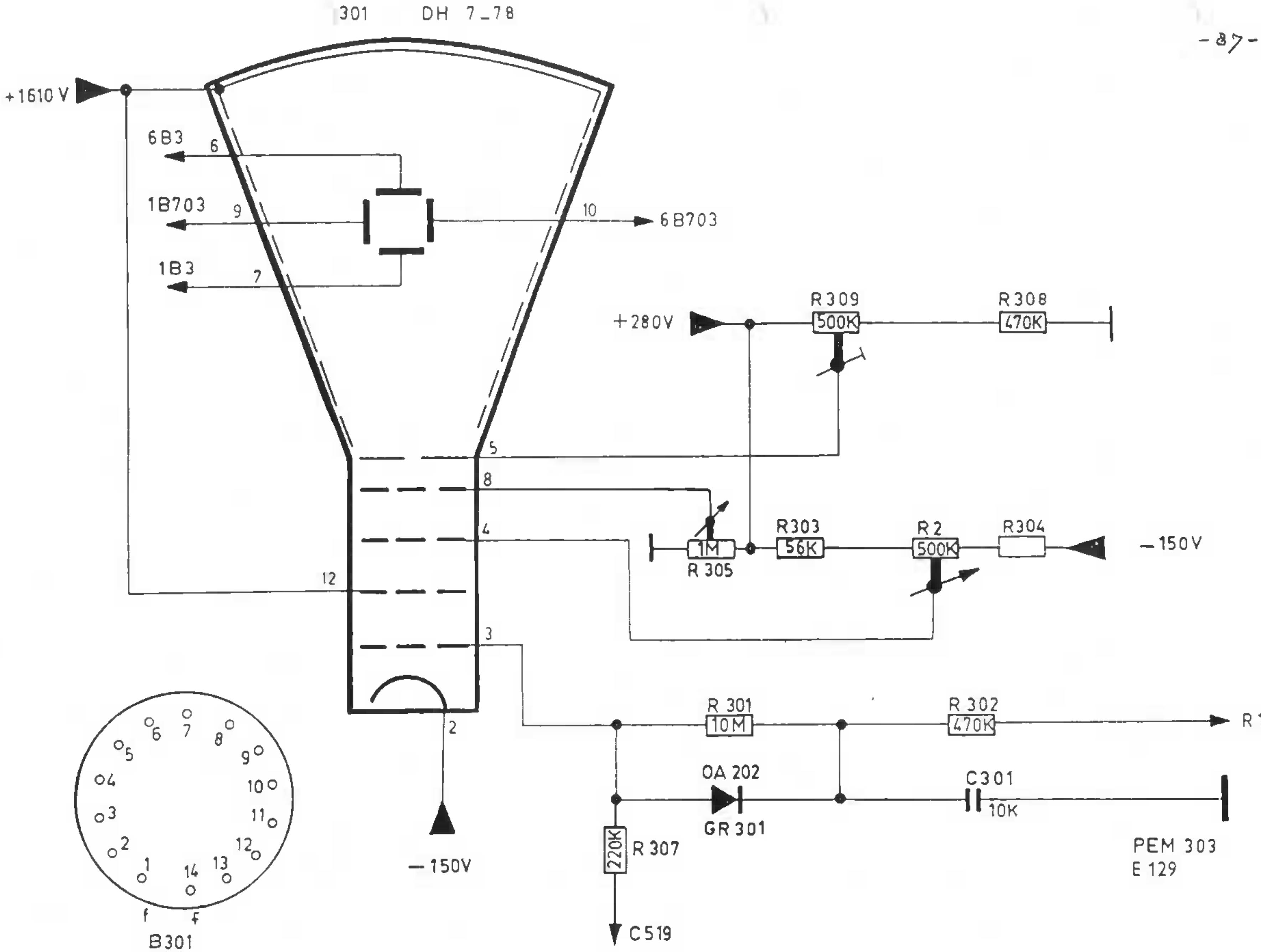


Fig. 35. Diagram of the cathode-ray tube circuit

88+89 blank.

Capacitors–Kondensatoren–Condensatoren–Condensateurs

No.	*Service part*	*Value*	*Voltage V*	*Tolerance %*	*Description*
C1001	AC 8311/12,5 + 12,5	12.5 μF	500		Electrolytic (PW)
C1002	AC 8211/16	16 μF	500		Electrolytic
C1003	906/47K	47000 pF	400	10	Polyester
C1004	AC 8311/12,5 + 12,5	12,5 μF	500	.	See C1001
C1005	906/47K	47000 pF	400	10	Polyester
C1006	903/N200K	0.2 μF	2000		Box capacitor
C1007	AC 8210/16	16 μF	450		Electrolytic (PW)
C1008	AC 8210/16	16 μF	450		

Resistors–Widerstände–Weerstanden–Résistances

No.	*Service part*	*Value*	*Power W*	*Tolerance %*	*Description*
R1	916/DE 1M	1 MΩ			Potm. lin. with switch
R1003	931/A4K7	4.7 kΩ	16	10	Wire-wound
R1004	902/K27E	27 Ω	0.25	5	
R1005	901/1M	1 MΩ	0.25	5	
R1006	901/100E	100 Ω	0.25	5	
R1007	901/100E	100 Ω	0.25	5	
R1008	901/120K	120 kΩ	0.5	5	
R1009	901/1M2	1.2 MΩ	0.25	10	
R1010	901/4M7	4.7 MΩ	0.25	10	
R1011	901/6K8-15K	6.8 kΩ-15kΩ	0.25	5	Choice resistor
R1012	901/390K	390 kΩ	0.25	5	
R1013	901/22K	22 kΩ	0.25	5	
R1018	938/A6K8	6.8 kΩ	5.5	5	Wire-wound
R1019	901/560K	560 kΩ	0.25	5	
R1020	901/680K	680 kΩ	0.25	5	
R1021	901/680K	680 kΩ	0.25	5	

Other components – Übrige Teile – Overige onderdelen – D'autres pieces

B1001	ECL 82	
B1002	85 A2	
B1003	5642	
GR1001	OA 214	
GR1002	OA 214	
GR1003	OA 214	
GR1004	OA 214	
GR1005	B 250 C75	
VL1	974/T125	Thermal fuse 125°C
T1001	M7 615 28	Mains transformer

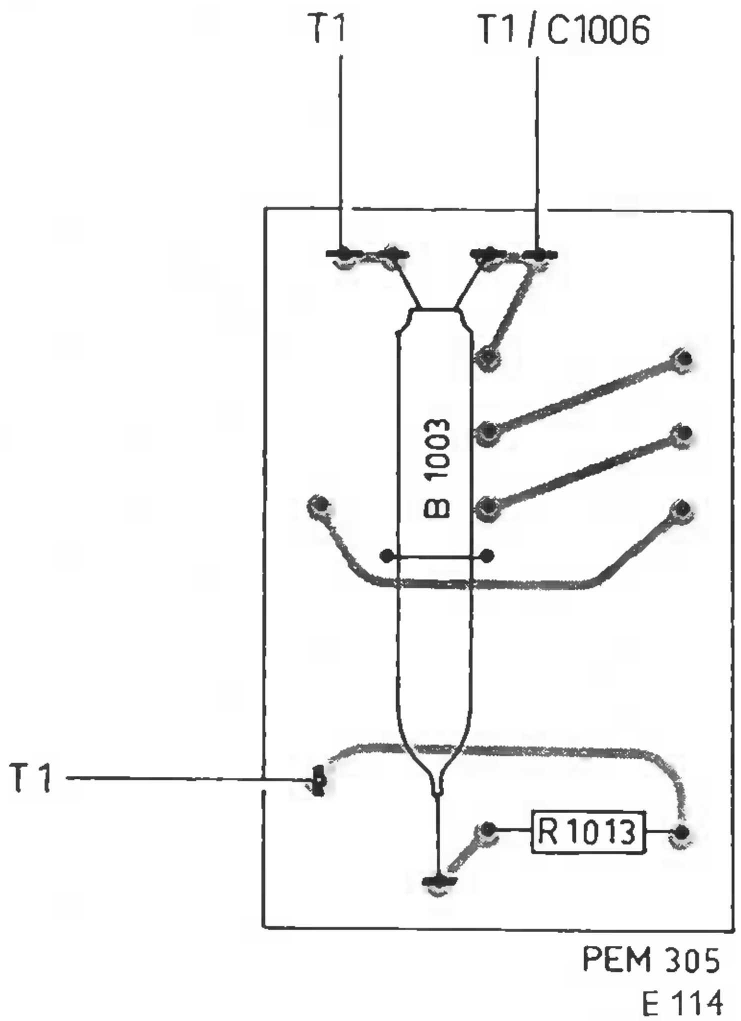


Fig. 36. Unit E; high tension unit

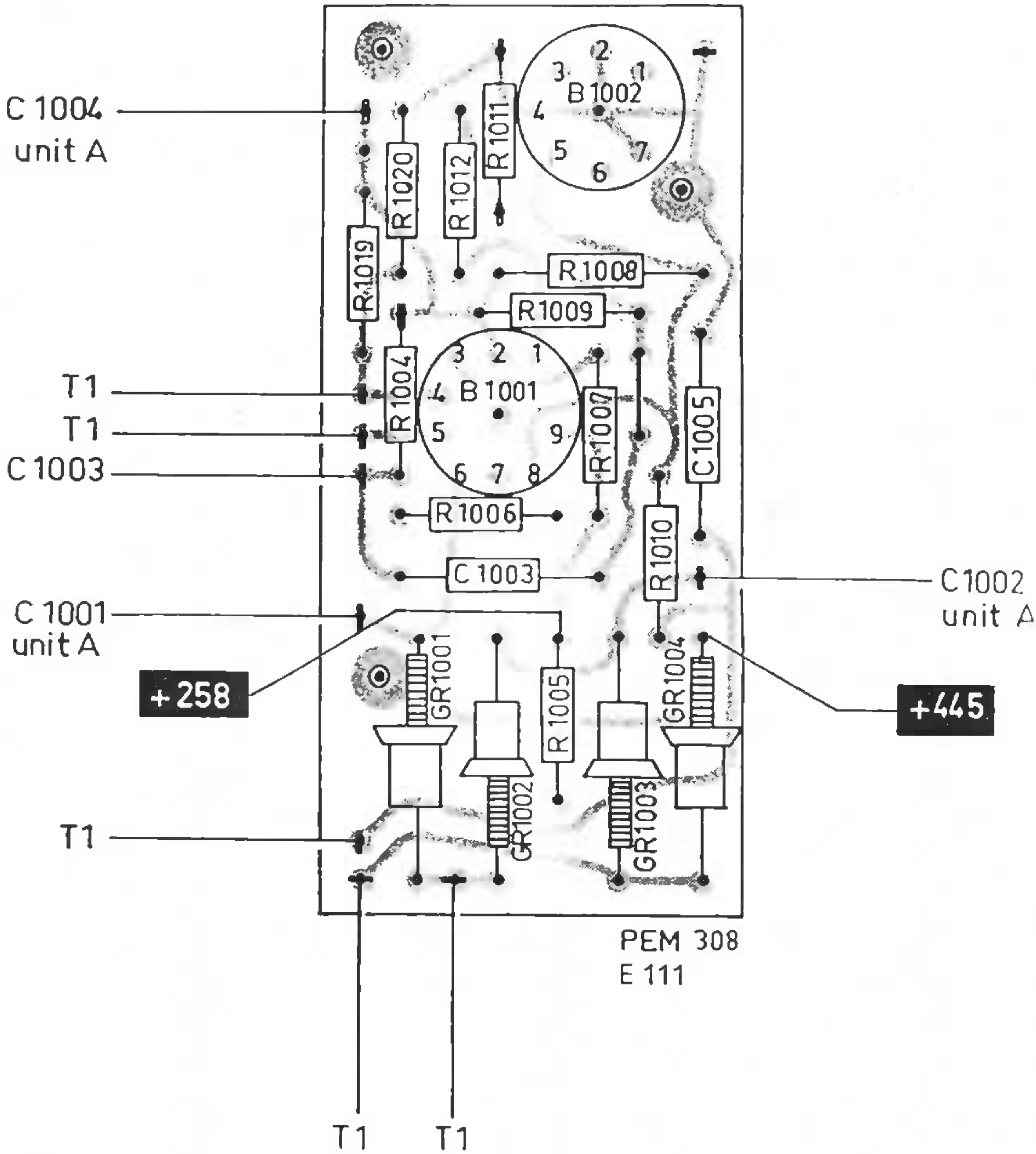
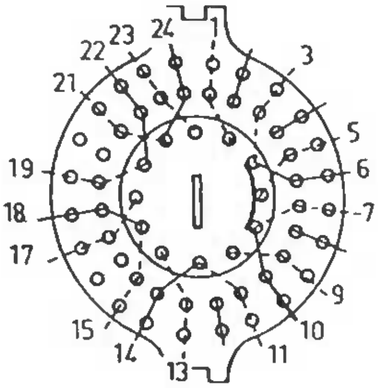
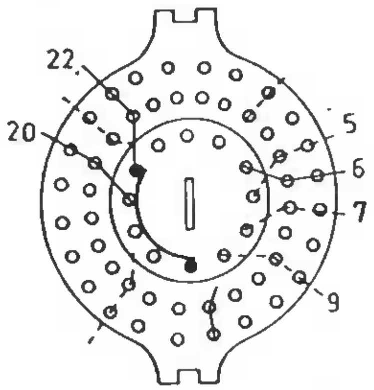


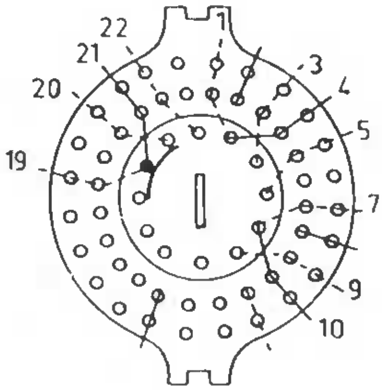
Fig. 37. Unit F; supply



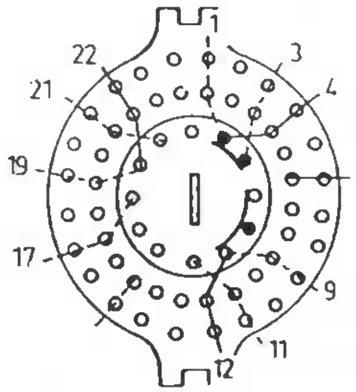
SK2 I



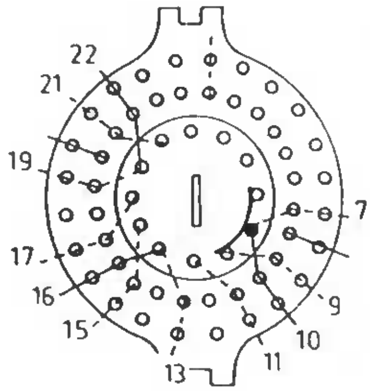
SK3 I



SK3 II

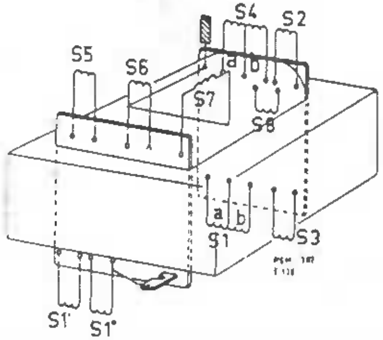


SK4 I

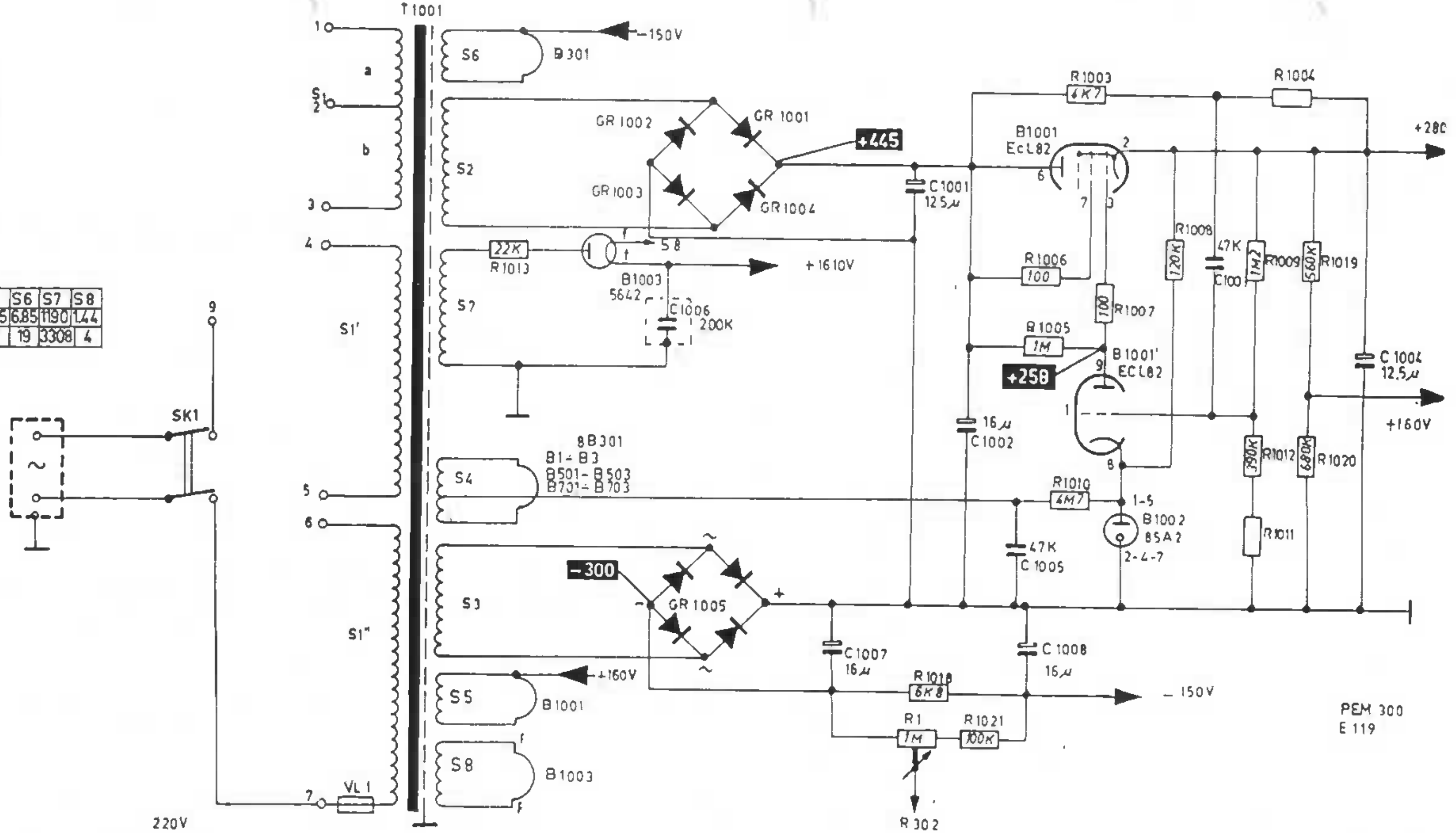


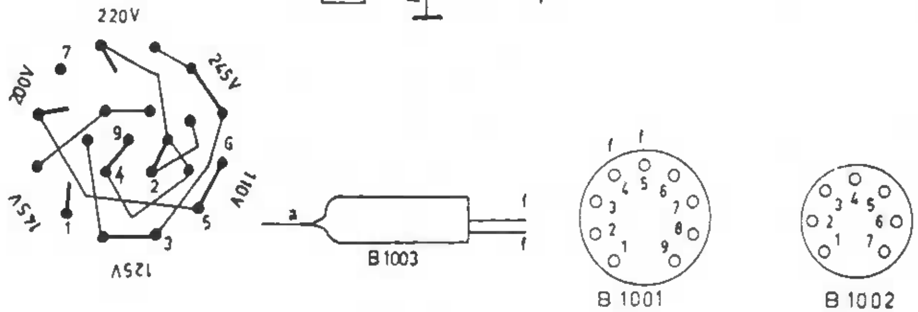
SK4 II

PEM 301
E 130



Code	S1a	S1b	S1'	S1"	S2	S3	S4a	S4b	S5	S6	S7	S8
Volts	15	20	110	110	354	238	3.6	3.26	6.85	6.85	1190	1.44
Turns	42	55	306	306	982	661	10	9	19	19	3308	4





R1021 = 680 kΩ VL1 is situated on the other side of point

Fig. 38. Diagram of the supply pa