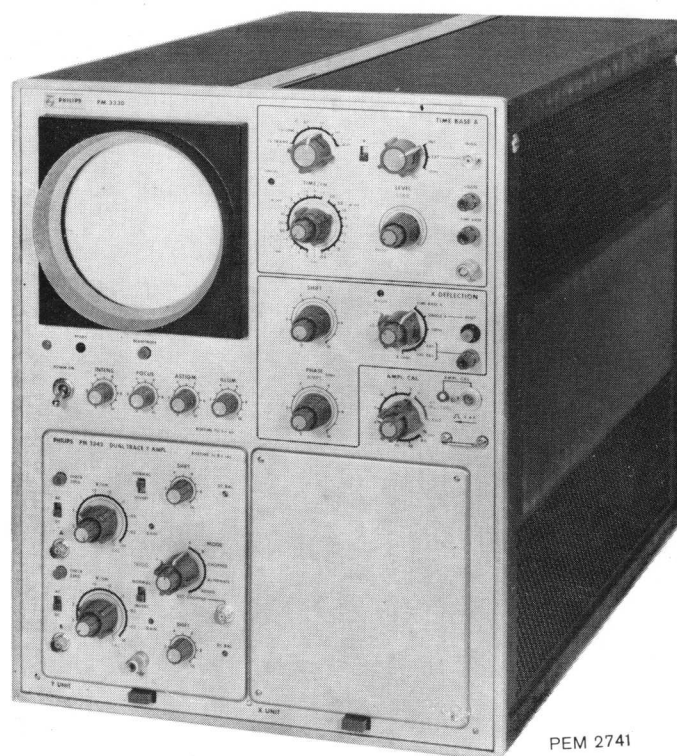


PHILIPS



PEM 2741

PM 3330 LABORATORY PLUG-IN OSCILLOSCOPE

9444 033 30031

9499 440 05511

1/270/2/03

IMPORTANT

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

Contents

GENERAL INFORMATION

I. Characteristics	7
II. Description of the block diagram	11

DIRECTIONS FOR USE

III. Installation	13
A. Air filter	13
B. Adjusting to the local mains voltage	13
C. Fuses	14
D. Earthing	15
E. Plug-in units	15
F. Switching on	16
IV. Controls and their functions	17
A. Cathode-ray tube circuit	17
B. Beam finder	18
C. Z-Modulation	18
D. Y-Deflection	18
E. X-Deflection	18
F. X-Shift	19
G. Time base A	19
H. Trigger unit	20
J. Calibration unit	22

SERVICE DATA

V. Explanation of the circuit diagram	23
A. Cathode-ray tube circuit	23
B. Power supply	23
C. Y-Amplifier	26
D. Calibration unit	28
E. X-Amplifier	29
F. Time-base generator A	32
G. Trigger unit A	42
H. Trigger amplifier	47
VI. Gaining access to the parts	48
A. Detaching the side panels	48
B. Removing the knobs	48
C. Removing the bezel	48
D. Detaching the rear panel	48

VII. Maintenance

A. Air filter	49
B. Segment switches	49
C. Fans	49
D. Cabinet plates	49

VIII. Checking and adjusting

A. Genral	50
B. Switching on	50
C. Low supply voltages	50
D. High voltage supply	51
E. Mains current	51
F. Cathode-ray tube circuit	51
G. DC Balance Y-amplifier	54
H. DC Balance X-amplifier	54
J. DC Balance trigger amplifier	54
K. Intensity modulation	54
L. Alternate	55
M. Y-Amplifier	55
N. Calibration voltage and current	56
O. X-Amplifier	57
P. Beamfinder	59
Q. Time base A and trigger unit	59

IX. Replacing parts

A. Fuses	63
B. Mains transformer	63
C. Fans	63
D. Power transistors on the rear panel	63
E. Cathode-ray tube	63
F. Text plate	63
G. Printed-wiring boards U11 and U12	63
H. HT unit	63
J. Valves and semi-conductors	63

X. Information for assistance in fault finding

A. Mains transformer voltages	64
B. Voltages and wave-forms in the apparatus	64
C. Remarks	64

XI. List of service parts

A. Mechanical parts	70
B. Electrical parts	71

List of figures

Fig.	Page	Fig.	Page
1	Schematic survey of the controls	10	37
2	Rear side of the apparatus	13	38
3	Fuses on X-plug-in compartment	14	39
4	a. Front-view with coded controls and lamps	15	40
	b. Rear-view with Z-modulation input terminals and switch	16	41
5	Controls of the CRT adjustments	17	42
6	Z-modulation busses	18	43
7	X-deflection selector	18	44
8	Gate and time-base output	19	44
9	X-deflection by mains frequency	19	44
10	X-deflection shift controls	19	45
11	Time-coefficient control	19	46
12	Magnifier of X-deflection	19	46
13	Calculation of time-coefficient	20	47
14	Stability-control	20	48
15	Trigger source selection	20	49
16	Trigger polarity selection	21	51
17	Trigger mode selection	21	55
18	Calibration unit	22	56
19	Grid-circuit of the CRT	23	57
20	Simplified diagram of overload protection	24	58
21	Power supply output characteristic	24	59
22	Power supply load characteristic	24	60
23	Inductance reducing the effect of deflection plate capacitance	26	61
24	Deflection-plate capacitances forming part of a lumped-line	26	62
25	Individual LC-section	26	63
26	Calibration unit circuit	28	64
27	Survey of functions of the horizontal amplifier circuit	29	65
28	Simplified diagram of the time-base amplifier	30	66
29	Magnifier circuit	31	67
30	Pre-amplifier circuit	31	68
31	Block-diagram of time-base A	32	69
32	Sweep-gating multivibrator	33	70
33	Gate output and unblanking circuit	34	71
34	Miller-circuit	35	72
35	Triggering of the Miller run-up circuit without Hold-off circuit	35	73
36	Effect of Hold-off circuit	36	36
			37
			38
			39
			40
			41
			42
			43
			44
			44
			44
			45
			46
			46
			47
			48
			49
			51
			52
			53
			53
			54
			54
			55
			55
			56
			57
			58
			58
			62
			64
			65
			66
			67
			68
			69
			79

Fig.		Page	Fig.		Page
74	Printed circuit board U6 (TV sync.)	80	85	Circuit diagram of the trigger amplifier and printed circuit board U21 (trigger amplifier)	91
75	Printed circuit board U7 (horizontal pre-amplifier)	81	86	Circuit diagram of the trigger unit	93
76	Printed circuit board U8 (rectifiers)	82	87	Circuit diagram of the time-base generator A	95
77	Printed circuit board U11 (power supply II)	83	88	Circuit diagram of the time-coefficient switch	95
78	Printed circuit board U12 (power supply I)	84	89	Circuit diagram of the pre-amplifier	96
79	Printed circuit board U14 (power amplifier)	85	90	Circuit diagram of the horizontal amplifier	97
80	Printed circuit board U16 (CRT circuit)	86	91	Circuit diagram of the power supply I	99
81	Printed circuit board U17 (power-supply resistors)	87	92	Circuit diagram of the power supply II	101
82	Printed circuit board U18 (power-supply resistors)	88	93	Circuit diagram of the high voltage unit	102
83	Circuit diagram of the vertical amplifier and printed circuit board U22 (delay line driver)	89	94	Circuit diagram of the calibration unit	103
84	Circuit diagram of the CRT circuit	90	95	Plug connections	104

GENERAL INFORMATION

INTRODUCTION

The PHILIPS PM 3330 is a cathode-ray oscilloscope with a wide range of applications.

This is obtained by providing the apparatus with plug-in units which cover various application facilities. The basic oscilloscope contains a vertical (Y) amplifier with a constant bandwidth and gain.

The total gain and bandwidth of the vertical (Y) channel are dependant on the type of plug-in units used.

The horizontal (X) channel contains a time-base generator and an amplifier.

Plug-in units for horizontal (X) deflection permit the connection of a second time-base generator (which also can be used as a delay unit for the time-base generator of the basic oscilloscope) or an amplifier unit with which the PM 3330 can function as an X-Y oscilloscope.

The cathode-ray tube gives a clearly defined display. An internal graticule guarantees parallax-free measurements.

Tolerance

Properties, expressed in numerical values with statement of tolerances are guaranteed by the factory. Numerical values without tolerances are intended for information purposes only and indicate the properties

of an average apparatus. The numerical values hold good for nominal mains voltages unless otherwise stated.

I. Characteristics

CATHODE-RAY CIRCUIT

Tube

a. type	D13-16GH/01, flat screen. Screen diameter 13 cm
b. phosphor	Medium short persistence, green (GH).
c. usable viewing area	6 cm vertical × 10 cm horizontal
d. accelerating potential	10000 V
e. graticule	internal, marked in 6 vertical and 10 horizontal 1-cm divisions with 2-millimeter markings on the center lines. Graticule illumination is continuously variable.
Unblanking	DC-coupled
Z-Modulation	external
a. voltage required	15 V _{p-p} for frequencies from 300 Hz
b. input impedance	25 kΩ//35 pF
c. input RC-time	0.5 ms

Y-DEFLECTION

Final amplifier

a. type	DC-amplifier
b. rise time	5 ns
c. bandwidth	0...70 MHz
d. delay	by means of an internal delay line. Effective delay ≥ 60 ns.
Plug-in unit	see the relevant manual.

X-DEFLECTION

Optional

- a. Time base A
- b. Single (time base A)
- c. 50 Hz (adjustable phase and amplitude)
- d. EXT. (1 : 1)
- e. EXT. (1 : 10)
- f. X-plug-in unit

TIME-BASE GENERATOR

- a. Time coefficient
adjustable to 23 calibrated values:
viz. 50, 100, 200, 500 etc. ns/cm up to 1 s/cm.
Tolerance: $\pm 3\%$
Continuous control between the steps is possible (non-calibrated).
- b. Magnification
1,2 and $5\times$.
Tolerance: $\pm 2\%$
- c. Operation
triggered,
free running,
single shot (not possible with automatic triggering).
- d. Triggering source
internal,
external,
internal by means of a voltage with /the mains frequency (adjustable phase).
Slope
+ or —
Operation
AUT.: 10 Hz...1 MHz ("LEVEL" and "STAB." switched off)
HF : RC-time 80 μ s. (up to 60 MHz with PM 3333)
LF : Bandpass 3 Hz-1 MHz. RC-time 56 ms resp. 160 ns
DC
TV LINE : "LEVEL" and "STAB." switched off.
TV FRAME : "LEVEL" and "STAB." switched off.
- e. Required trace height for internal triggering
See the manual of the relevant plug-in unit.
- f. Required voltage for external triggering
0.4 V_{p-p} up to 60 MHz; V_{p-p} up to 100 MHz. In the positions "TV FRAME" and "TV LINE" 1 V_{p-p} positive video.
1 V_{p-p} in the position "AUT." at 1 MHz.
- g. Input impedance
1 $M\Omega$ /30 pF for the positions "AUT.", "HF", and "DC".
- h. Trigger, level internal
adjustable over 6 cm trace-height
external
adjustable over 6 V_{p-p} .

X-INPUT

- a. amplifier
DC-amplifier
- b. input
asymm. – 4 mm socket
input impedance
1 $M\Omega$ /55 pF
- c. deflection coefficient
0.5 V/cm (EXT")
5 V/cm ("1 : 10 EXT")
- d. bandwidth
0...1 MHz
- e. deflection
10 cm
- Plug-in unit
See the manual of the relevant plug-in unit.

CALIBRATION UNIT

- a. Voltage square-wave voltage with frequency of 2 kHz, adjustable to 18 values, viz. 0.2, 0.4, 0.8, 2 etc. mV_{p-p} up to 80 V_{p-p} .
Tolerance: $\pm 1\%$
Source resistance in mV-range: 50 Ω
- b. Current square-wave current with frequency of 2 kHz, 4 mA_{p-p} . Tolerance: $\pm 1\%$
(At the same time a square wave voltage is present having an amplitude of .5 V_{p-p} and a rise time of 70 nanosec.)

Output voltages

- a. Gate voltage + 35 V_{p-p} starting at 0-level, synchronous with the time-base voltage.
- b. Sawtooth voltage + 90 V_{p-p} starting at 0-level
- c. Calibration voltage see calibration unit

Power supply

By means of a voltage adapter adjustable to mains voltages of 110 V – 125 V – 145 V – 200 V – 220 V and 245 V.
Mains frequency: 40 – 100 Hz. With mains frequencies ± 50 Hz, the mains voltage should not exceed the nominal value.

Power consumption

600 W at maximum (plug-in units included).

Mechanical details

Cast aluminium front and rear frame.
Two-piece cabinet (skin plate).

Dimensions weight

Height : 46 cm
Width : 34.5 cm
Depth : 68 cm (knobs and air filter included)
Weight : 42 kg

OPERATING CONDITIONS

Ambient temperature: 0...35° C.
At too high an internal temperature, the instrument is switched off by means of a thermal relay.

ACCESSORIES

- manual
- mains flex
- 4 air filters 4822 480 40012
- cable (BNC-4mm) 4822 320 10043
- adapter plug (BNC-4 mm) PM 9051
- Viewing hood PM 9371
- Dummy unit PM 3360.

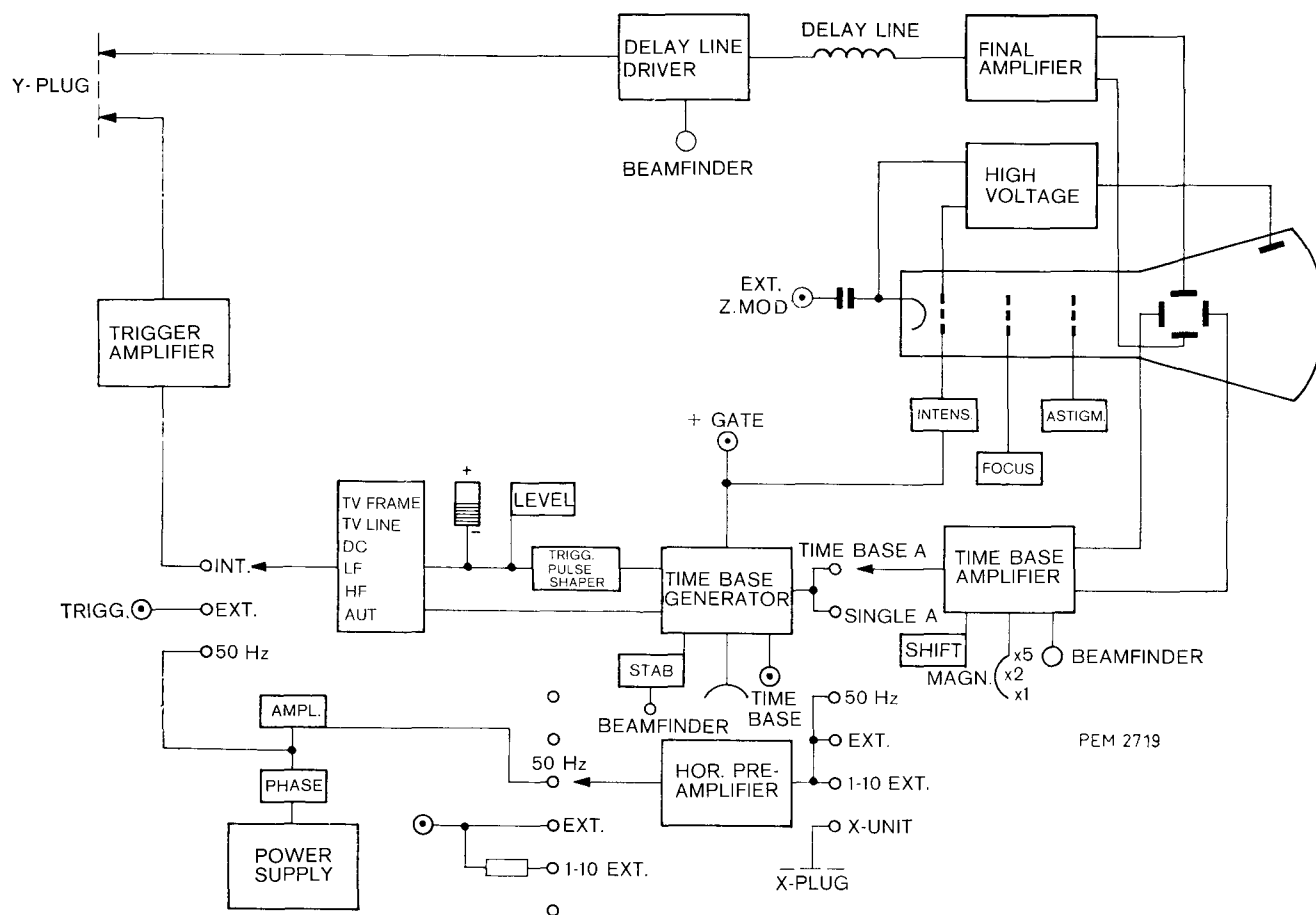


Fig. 1. Schematic survey of the controls

II. Description of the block diagram

Y-AMPLIFIER

The Y-amplifier is a symmetrical DC-amplifier, which consists of:

- a. a delay-line driver
- b. a delay line
- c. a final stage which supplies the deflection voltage for the cathode-ray tube.

The Y-deflection plates have been divided in four sections, included in a lumped line, which forms the anode impedance of the output valves.

TIME-BASE GENERATOR

The time-base generator is of the Miller-integrator type. Here the charging capacitors and resistors which are selected by means of the knob TIME/cm, have been included.

The STAB. control regulates whether or not the time-base generator operates.

X-AMPLIFIER

The X-amplifier consists of

- a) a pre-amplifier,
- b) a magnifier circuit and
- c) a time-base amplifier.

The pre-amplifier is a DC-amplifier, which is used for the amplification of an external signal or an internal voltage with the mains frequency.

The magnifier circuit contains the X-shift control and the magnification switch.

The time-base amplifier supplies a symmetrical voltage for the deflection plates of the cathode-ray tube.

TRIGGER AMPLIFIER

The trigger amplifier amplifies the trigger signal from the Y-plug-in unit.

TRIGGER UNIT

The trigger unit contains the trigger-pulse shaper which supplies the trigger pulse for the starting of the sawtooth generator.

The signal is taken from an internal or external source and, via selectable high-pass filters, it is fed to the trigger pulse shaper.

The polarity and the level of the trigger signal can be adjusted.

In the trigger unit also a synchronization separator for TV signals has been included, by which triggering on these signals is possible.

CATHODE-RAY TUBE

The controls "INTENS.", "FOCUS" and "ASTIGM." regulate the voltages on the several electrodes of the cathode-ray tube.

An HT unit supplies the positive post-accelerating voltage and the negative voltages for the cathode and the Wehnelt-cylinder.

The cathode of the cathode-ray tube is via a coupling capacitor accessible for external Z-modulation, on the rear of the instrument.

CALIBRATION UNIT

The calibration unit consists of an astable multivibrator the output of which is connected via a voltage divider with a socket on the front plate.

A selector enables selection of 18 different voltages and a calibrated current (together with a rapidly rising square wave voltage).

POWER SUPPLY

The mains voltage, via a transformer and rectifier circuit, is applied to a number of control circuits, which supply the stabilized voltages for the various circuits.

These supplies are electronically protected against overloading or short-circuiting.

BEAMFINDER

By depressing the beamfinder, the amplification of the X- and Y-final amplifiers is considerably reduced and the sawtooth generator obtains the free-running position.

DIRECTIONS FOR USE

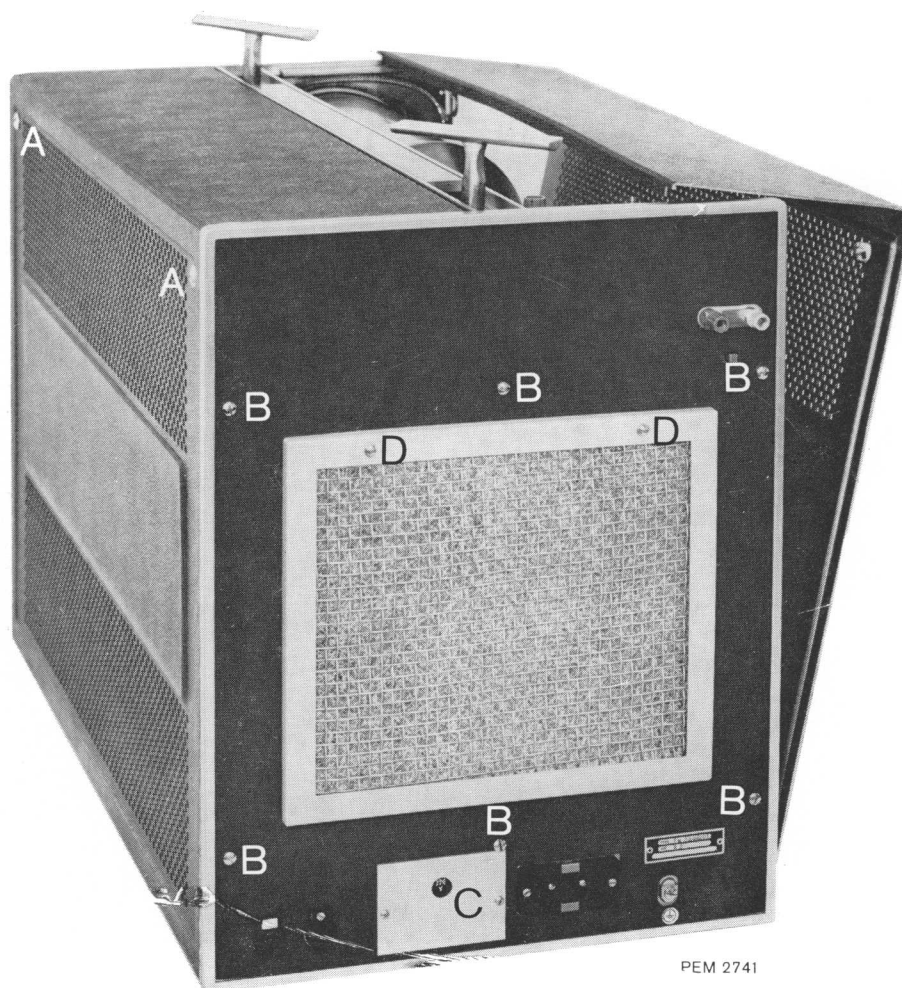
III. Installation

A. AIR FILTER

The instrument is cooled by means of two fans. The air is drawn in via an air filter at the rear. To assure free circulation of the air, the instrument must be placed so, that the air intake is not blocked; moreover it is recommended to clean the air filter at regular intervals (see chapter VII)

B. ADJUSTING TO THE LOCAL MAINS VOLTAGE

By means of a voltage adapter at the rear of the instrument, adjustment to one of the mains voltages 110 V, 125 V, 145 V, 220 V, 220 V and 245 V is possible. The voltage adjusted can be read through opening "C" in the cover plate. (see Fig. 2).



PEM 2741

Fig. 2. Rear side of the apparatus

C. FUSES

On the rear side of the instrument two 4-A fuses have been fitted. If the instrument is connected to a mains voltage of less than 200 V, the 8-A fuses included with

the oscilloscope should be mounted. These fuses can be found in the instrument on the screening partition over the X-plug-in compartment. (See Fig. 3).

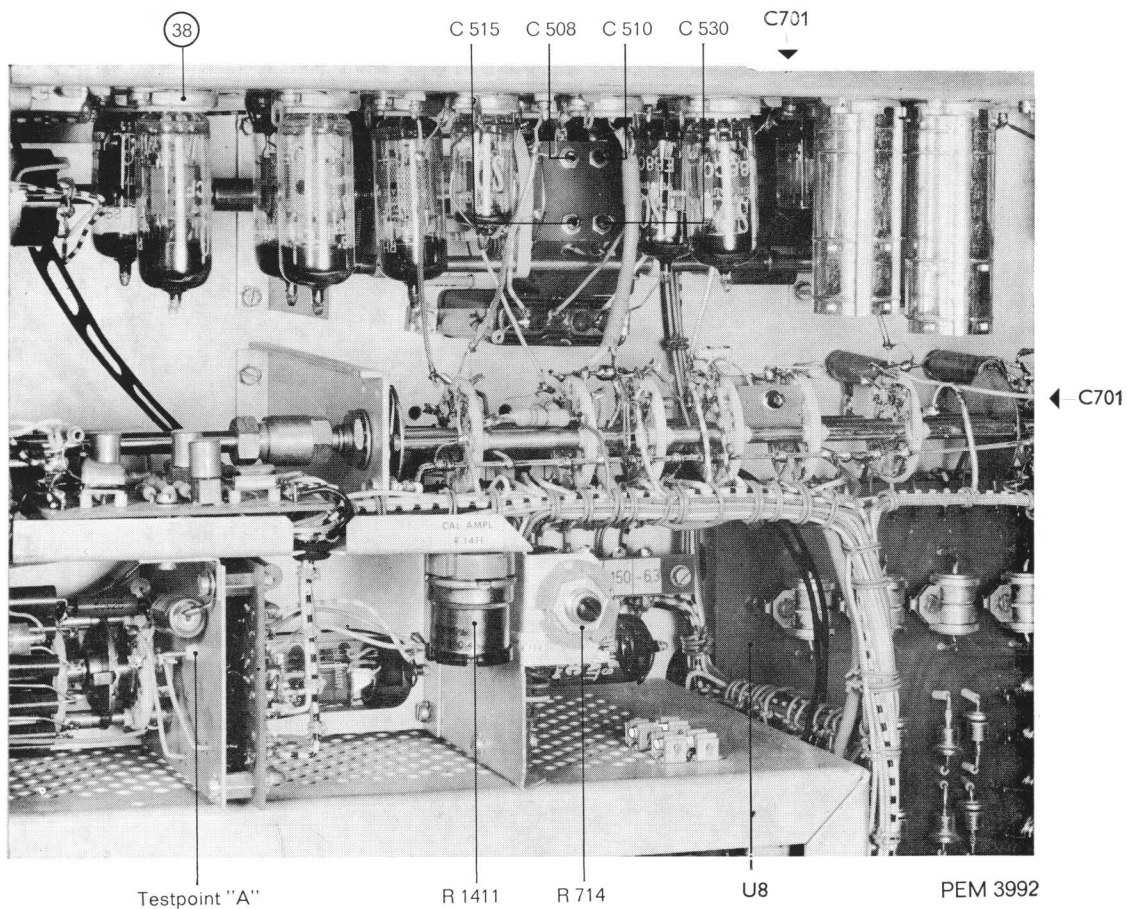


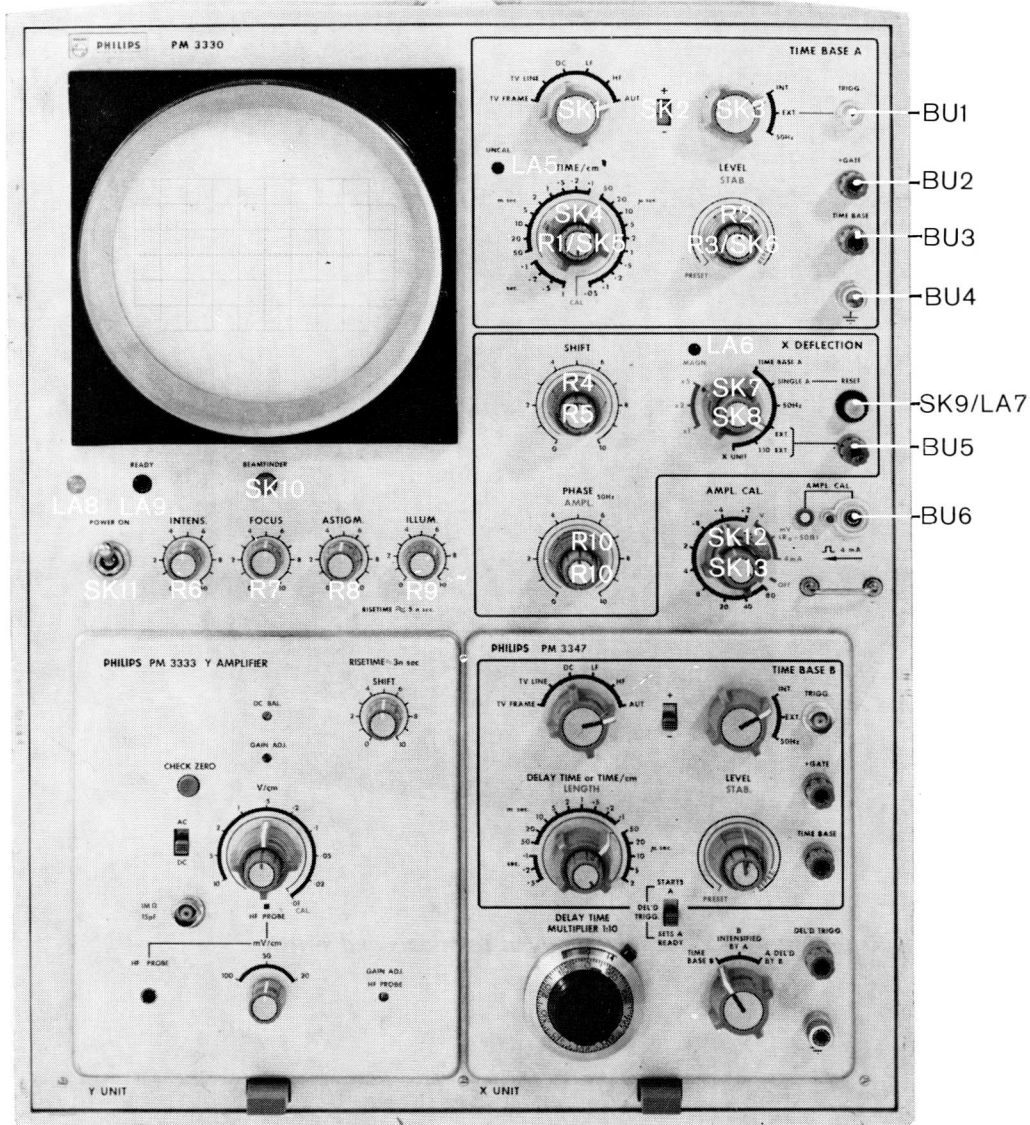
Fig. 3. Fuses on X-plug-in compartment

D. EARTHING

The instrument may be earthed via one of the terminals $\perp$ on the front or the rear side, or via the mains flex if this has a plug with rim-earthing contacts. Double earthing may cause hum and must be avoided.

E. PLUG-IN UNITS

The instrument only operates if a Y-unit has been inserted.



PEM 2741

Fig. 4a. Frontview with coded controls and lamps

F. SWITCHING-ON

The instrument is switched on by means of the "POWER ON" switch. The white pilot lamp will light up. The supply voltages are applied via a time-delay relay to allow a brief valve-warm-up period. If after approximately 30 seconds the "READY" lamp starts glowing, the instrument is ready for use. (Fig. 5)

If, when using the oscilloscope, the Y-plug-in unit is detached from the instrument, the relay releases ("READY" lamp extinguishes).

When a Y-plug-in unit is inserted again, a brief warming-up period follows, after which the "READY" lamp lights up. The instrument then is ready for use again.



Fig. 4b. Rear view with Z-modulation input terminals and switch

IV. Controls and their functions

A. CATHODE-RAY TUBE CIRCUIT

The brightness of the oscilloscope display is adjusted with the "INTENS." control.

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

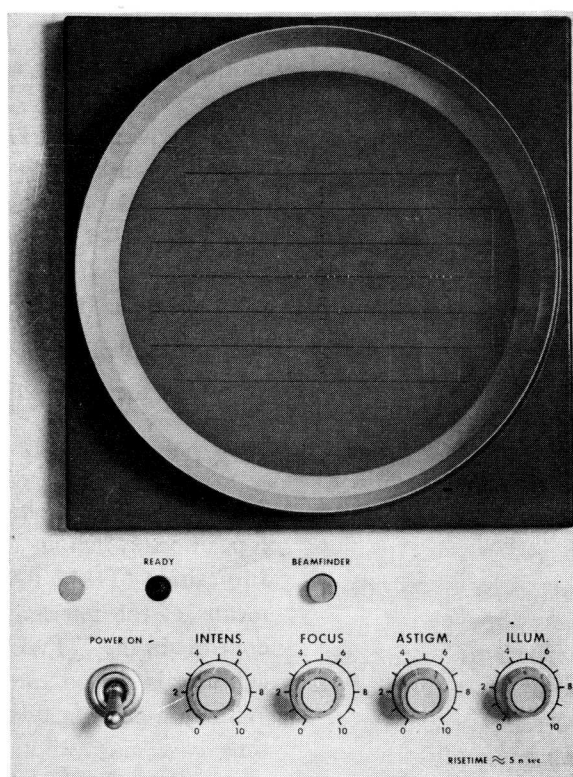
The "FOCUS" and "ASTIGM." controls adjust the fineness of the oscilloscope display.

Both controls influence each other.

The cathode-ray tube is provided with an internal graticule.

The graticule can be illuminated. The illumination can be controlled by knob "ILLUM".

The graticule illumination is particularly important for photography. For this, refer to the manual of the camera.



PEM 3993

Fig. 5. Controls of the CRT adjustments

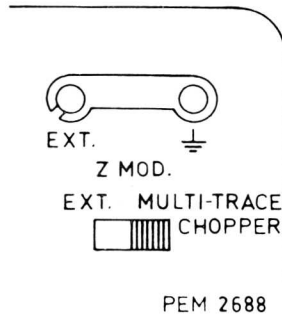


Fig. 6. Z-modulation terminals

B. BEAMFINDER

By depressing the button "BEAMFINDER", the display is considerably reduced. Owing to this, the electron beam will be visible on the screen in spite of the magnitude of the input signal or the position of the shift controls. During the depression of the "BEAMFINDER" button, the display can be centred by means of the shift controls.

C. Z-MODULATION

The intensity of the CRT display can be modulated by connecting an alternating voltage to the terminals "EXT." and " $\perp$ " on the rear of the apparatus.

For this purpose, the earthing bar should be disconnected and the switch should be set to position "EXT." The voltage is connected to the cathode of the CRT; an increasing voltage causes a decreasing intensity.

When a multi-trace plug-in unit is used, the switch should be set to position "MULTI-TRACE CHOPPER."

For this plug-in unit, see the manual concerned.

When terminal "EXT." is not used, the earthing bar should be connected to avoid interference voltages on the cathode of the CRT and the selector should be put to position "MULTITRACE CHOPPER".

D. Y-DEFLECTION

The controls for the Y-deflection are on the Y-plug-in units. For the explanation, refer to the relevant manual.

E. X-DEFLECTION

The X-deflection voltage is selected by means of the 6-position switch in the "X-DEFLECTION" frame. In position "TIME BASE A", deflection is effected by means of the internal time-base generator. With the controls in the "TIME BASE A" frame, the time-base generator is started and the time coefficient is adjusted. With non-periodical signals, a continuously working time base may produce a distorted display. In such cases, the deflection switch should be set to position "SINGLE A". The time-base generator is then blocked. This blocking situation can be discontinued by depressing the "RESET" button.

If the time base had been adjusted to the free-running position (with aid of the controls in the "TIME BASE A" frame) it will complete one cycle and will be blocked afterwards. A next sweep of the time-base generator can be effected by depressing the "RESET" button again. If the time-base has been adjusted to the trigger position, the lamp in the "RESET" button will light up after depressing the "RESET" knob. The time-base generator will then start on the next trigger pulse. When the time-base generator starts, the lamp extinguishes.

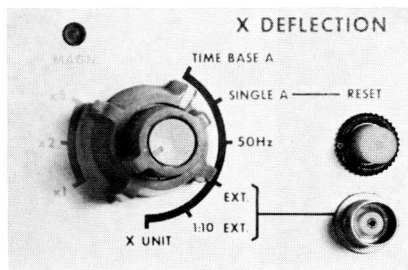


Fig. 7. X-deflection selector

After having completed one cycle, the time-base generator will be blocked again.

A new sweep can be effected by depressing the "RESET" button and by applying a new trigger pulse.

The time-base voltage and a synchronous gate voltage are available from sockets "TIME BASE" and " + GATE" with a low output resistance. (Fig. 8)

In the "50 Hz" position, deflection is effected by a sine-wave voltage with the mains frequency. This voltage can be varied in amplitude and phase by means of the double control knob "PHASE, AMPL. 50 Hz." (Fig.9)

In the "EXT." and "1 : 10 EXT." positions a voltage should be applied to the relevant terminals in order to deflect the trace in X-direction. The deflection coefficient is "0.5 V/cm" in the "EXT." position and "5 V/cm" in the "1 : 10 EXT." position.

In the "X-UNIT" position the deflection is effected by an X-plug-in unit (see for this unit the relevant manual).

F. X-SHIFT

The trace can be shifted in X-direction by means of the "SHIFT" controls. The smallest knob has a small control range and is intended for fine-adjusting the position of the display on the X-axis, particularly when the time-base is magnified. (Fig. 10)

G. TIME-BASE A

1. Adjusting the time coefficient

By means of the "TIME/cm" double knob, the various time coefficients of the sawtooth generator can be adjusted. With the continuous control in the fully clockwise position (marked "CAL") the time coefficients are calibrated. When rotating the continuous control, the "UNCAL" lamp indicates that the time-base generator is not calibrated any longer. (Fig. 11)

2. Magnification

The gain of the X-amplifier is controlled with the magnifier switch in the "X-DEFLECTION" frame. (Fig. 12) With this switch the time-base length can be magnified by a factor 2 or 5. In the position " $\times 2$ " and " $\times 5$ " the "MAGN." lamp glows.

The magnification only works for sawtooth voltages obtained from "TIME-BASE A" or "TIME-BASE B" (PM 3347).

The time coefficient of the whole system is obtained by dividing the time setting of the "TIME/cm" switch by the magnification factor. (Fig. 13)



Fig. 8. Gate and time-base output

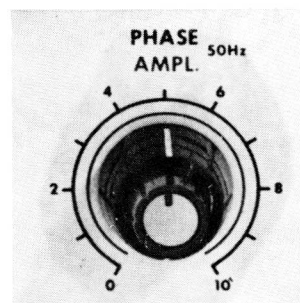


Fig. 9. X-deflection by mains frequency

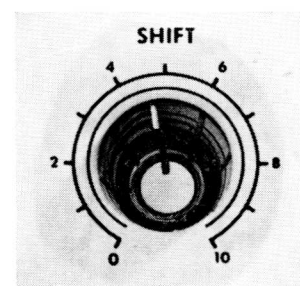


Fig. 10. X-deflection shift controls

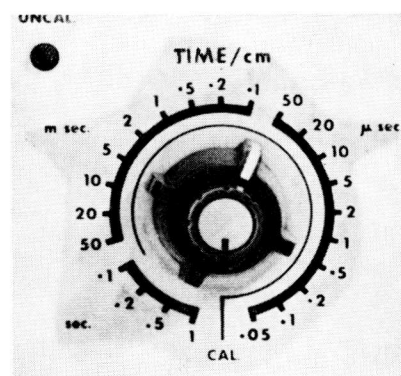


Fig. 11. Time-coefficient control

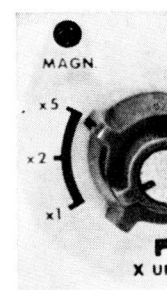


Fig. 12. Magnifier of X-deflection

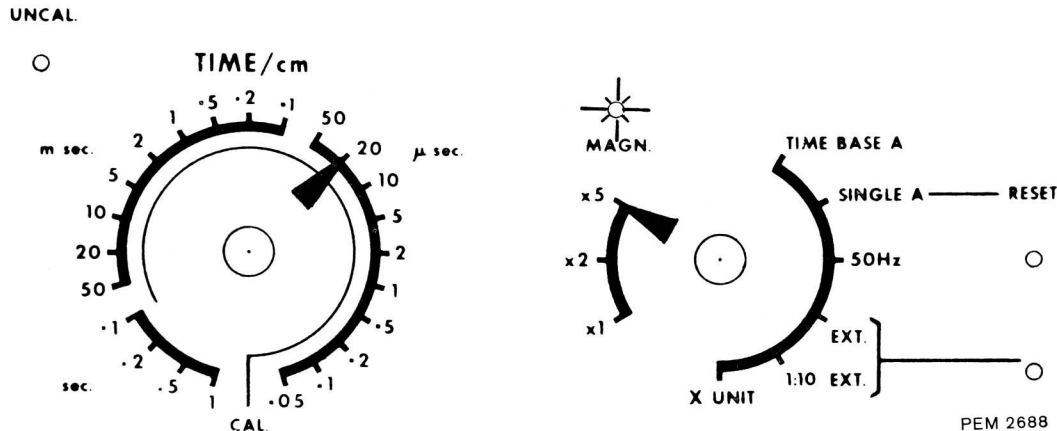


Fig. 13. Calculation of time-coefficient

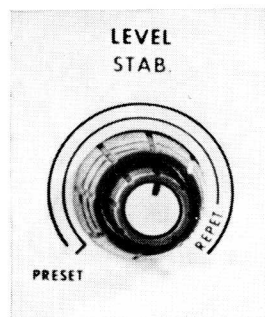


Fig. 14. Stability-control

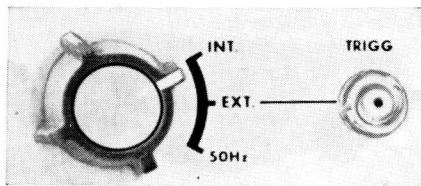


Fig. 15. Trigger source selection

Example

$$\text{time coefficient: } \frac{20 \mu\text{sec./cm}}{5} = 4 \mu\text{sec./cm.}$$

3. Stability

With a triggered time-base, it is sufficient in most cases to set the "STAB." control in the "PRESET" position (switch anti-clockwise). (Fig. 14)

If it is impossible to obtain a stable triggering in this way, the trigger position can be accurately adjusted by means of the "STAB." control.

To this end, remove the input signal of the Y-amplifier (with "EXT." triggering, remove the trigger signal). Turn the "STAB." control from the right-hand stop anti-clockwise until the display just disappears from the screen.

This is the most sensitive trigger position of the time-base generator.

With the "STAB." control turned to the right-hand stop ("REPET."), the time-base generator is free-running.

H. TRIGGER UNIT

1. Trigger source

The trigger pulse, required to start the time-base generator, is derived from a signal which is applied via the "INT.-EXT.-50 Hz" switch. (Fig. 15)

INT. The trigger signal is obtained from the Y-plug-in unit.

EXT. The trigger signal is derived from a voltage applied to the "TRIGG." terminal.

50 Hz The trigger signal is derived from an internal voltage with the mains frequency. The phase of this voltage can be varied with the "PHASE" control in the "X-DEFLECTION" frame. (Fig. 9)

2. Polarity and trigger level

The point in a period at which the time-base starts (and at which the signal becomes visible on the screen) is selected with the $\pm$ polarity switch and the "LEVEL" control. (Fig. 16)

When the polarity switch is in the "+" position, the sawtooth generator starts on the positive-going edge of the signal. With the "LEVEL" control the level on the positive-going edge can be adjusted.

When the polarity switch is in the "—" position, the starting can be adjusted to the negative-going edge by means of the "LEVEL" control.

3. Trigger mode

The coupling between the trigger-signal input and the trigger-pulse shaper is selected by means of the "TRIGGER MODE" switch. (Fig. 17)

AUT. The trigger unit is then AC-coupled.

The starting of the time-base is automatically controlled. When a trigger signal is present, the time-base is triggered.

When no signal is applied, the time-base generator is automatically adjusted to its free-running position, so that there is always a line visible on the screen.

In this position the "LEVEL" and "STAB". controls are inoperative.

The "AUT." position is suitable for normal use of the time-base only. For "SINGLE A" display one of the other positions of the mode switch could be used.

H.F. The AC-coupling is now so, that l.f. components, such as hum, do not influence the triggering.

L.F. In this position, triggering takes place for sine-wave signals from approx. 3 Hz up to approx. 1 MHz.

D.C. The trigger unit is DC-coupled

The time-base can then be triggered with a very slowly varying voltage.

TV LINE and TV FRAME

The "TV LINE" and "TV FRAME" positions are used for the triggering on TV signals.

In the first case the time-base is started by a pulse with the line frequency. In the "TV FRAME" position the time base is started with a pulse with the frame frequency.

With "INT. TRIGGERING" the polarity switch should be in the "+" position, when the amplifier is driven with a video signal with positive going sync. pulses and in the "—" position, when a video signal with negative-going sync. pulses is used.

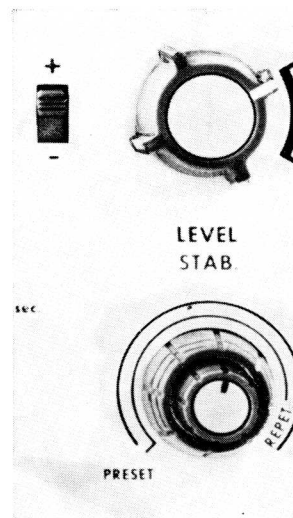


Fig. 16. Trigger polarity selection

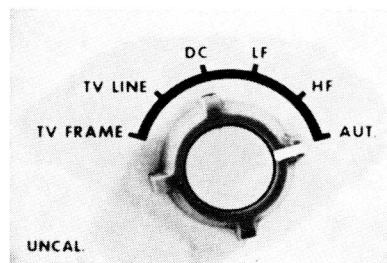


Fig. 17. Trigger mode selection

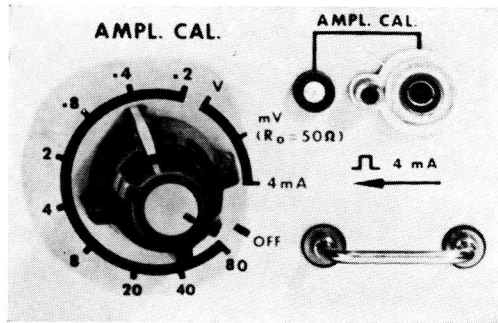


Fig. 18. Calibration unit

With "EXT. TRIGGERING" the trigger unit only works when a video signal with negative-going sync. pulses is applied to the socket "TRIGG." The polarity switch should be in the "—" position in this case. The knobs "LEVEL" and "STAB." are inoperative in both of the TV positions.

J. CALIBRATION UNIT

With switch "AMPL. CAL." a calibration voltage respectively calibration current can be selected. (Fig. 18) They are intended for checking and, if necessary, correcting the horizontal or vertical deflection system.

The voltage is taken off between the 4-mm socket or the measuring-probe contact, and the relevant earthing socket.

Especially with the small calibration voltages it is important to use this earthing socket.

The voltage values have been adapted to the deflection coefficients of the plug-in units, so that always a trace height of 4 cm can be obtained.

The current bracket can be used for checking a current measuring probe.

A rapidly rising square wave voltage is offered at the output terminal, simultaneously with the 4 mA calibration current, to enable adjusting the special HF. probe PM 9332.

SERVICE DATA

V. Explanation of the circuit diagram

A. CATHODE-RAY TUBE CIRCUIT (Fig. 84)

The CRT, which is provided with an internal graticule, has its cathode at a potential of 1440 Volts negative with respect to earth. The post-deflection accelerator is at a potential of 8600 Volts positive with respect to earth.

Potentiometer R6 "INTENSITY" controls the beam current, R7 "FOCUS" and R8 "ASTIGMATISM" focus the spot at the screen.

The following potentiometers are placed inside the apparatus: R318 to compensate for cushion and barrel distortions; R320 adjusts the potential of the internal electrical screen to be equal to the average value of the vertical plates. R314 centers the beam through the deflection plates to obtain an equal light distribution over the screen.

In order to let the horizontal deflection of the spot exactly coincide with the internal graticule, a magnetic field is generated by a coil which is mounted inside the mu-metal magnetic screen around the tube. The direction and intensity of this magnetic field can be adjusted by R319 – R321.

A pair of coils are fitted to the neck of the CRT, for adjusting the deflections due to the X- and Y-systems. Correct adjustment of toe currents through these coils by R327 and R328 will make the deflections exactly perpendicular and center the useful scan for uniform overlap of the graticule.

If it is desired to intensity-modulate the beam, the modulating signal can be connected to BU9, which is connected to the cathode via blocking capacitor C303 and switch SK14.

Normally BU9 is earthed to BU10 by a bus-bar to decouple the cathode (via C303).

Switch SK14 must be thrown when a multitrace plug-in unit is used, connecting the cathode to a single-transistor amplifier.

The latter receives blanking pulses from the unit which are generated during switching over when operating in the chopped mode.

Unblanking pulses generated by time-base A or time-base B during the sweep of the spot are DC-coupled to the grid of the CRT via a floating grid supply (Fig. 19) located at the HT supply. The positive terminal of this supply is directly coupled to the cathode-follower B502" of the time-base circuit. At fast sweep-rates it is difficult to push up this supply fast enough to unblank the CRT in the required time. Therefore an AC-path is provided via C301.

B. POWER SUPPLY

1. General

The power supplies up to 400 Volts are constructed with solid state elements; the high-tension supply (10 kV) is regulated by vacuum-tubes.

2. Mains transformer

The primary side of the mains transformer is provided with two 110 Volts windings, a 15 Volts winding and a 20 Volts winding, the latter two connected in series. In this way it is possible to adapt the transformer to one of the line-voltages 110 V – 125 V – 145 V – 200 V – 220 V – 245 V.

The motors of the two cooling-fans are permanently connected to the 110 Volts windings.

They are connected so that their stray magnetic fields counteract each other.

A thermal cut-out (RE1003) protects the apparatus from overheating. It switches off the mains supply at a temperature of approximately 60°C. The transformer is protected by 2 fuses (slow-blow); the mains is switched by a double pole switch (SK11).

Some of the windings delivering a filament supply are connected to a DC-supply, namely:

S15 to 12 V pos., S16 to 70 V neg., S17 to 70 V pos., S18 to 1440 V neg., S13 and S14 are earthed.

3. Solid state power supplies

a. Negative 150 Volts (Fig. 91)

The voltage delivered by winding S2 is rectified by a full-wave bridge-type rectifier consisting of 4 diodes BY127 (GR1021 ... GR1024) and smoothed by capacitor C1021 (200 µF). The series elements of the voltage regulator consist of four power transistors ASZ15 (TS1032 ... TS1035) which are connected in series.

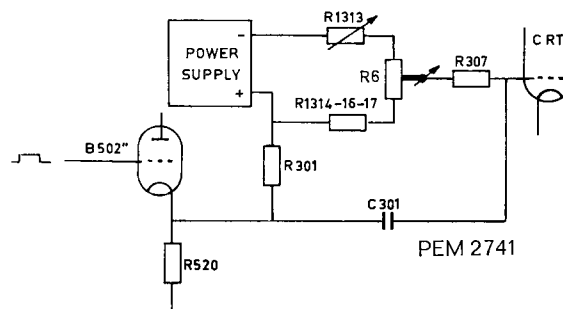


Fig. 19. Grid-circuit of the CRT

b. Positive 130 Volts

This supply is built like the negative 150 Volts supply. The very value of the output voltage is determined by the precision metal-film resistors R1071 – R1072 – R1076 – R1077. No adjustment is needed if the 150 Volts supply gives exactly its nominal voltage. A reference voltage derived from this supply is fed to the base of TS1031. The base of TS1030 receives the error signal and a signal which is proportional to the ripple over C1016. The amplitude of the latter signal can be adjusted to a minimum ripple at the output by changing the value of R1062.

Diode GR1031 is essential for the protection and re-setting of the power supply in case of a short circuit.

c. Positive 200 Volts

A tension of 200 Volts is obtained by connecting a 70 Volts supply on top of the 130 Volts supply, the operation being the/same as the latter one.

d. Positive 330 Volts

The supply of 330 Volts is obtained by adding 130 Volts to the 200 Volts supply.

e. Positive 400 Volts

The supply of 400 Volts is obtained by adding 70 Volts to the 330 Volts supply.

f. Positive 70-24-12-6.3 Volts.

Negative 70-24-12-6.3 Volts.

These tensions are supplied by separate power supplies except the 12 Volts positive and negative, which are derived from the 24 Volts supplies merely by using a resistor and a Zener diode for each.

The circuits including the overload protection are constructed according to the principles mentioned in the description of the negative 150 Volts supply and the positive 130 Volts supply.

g. Time delay

A time delay is built in to allow the filaments of the vacuum tubes to warm up before applying the voltages of the various power supplies.

It consists of the bi-metal relay RE1001 which closes a contact after about 30 seconds upon switching on. The contact energises relay RE1002 which keeps itself energised over a change-over contact and an interconnection to earth via two interconnected terminals at

the left-hand (Y) plug-in unit. When changing over, the contact of RE1002 breaks the energising circuit of RE1001.

Immediately upon switching on the mains, lamp LA8 "POWER ON" lights. When relay RE1002 is energised lamp LA9 "READY" lights.

The time delay also operates after changing the Y plug-in unit; removing the X plug-in unit has no influence.

h. High voltage power supply (see Fig. 93)

The high tension is obtained by transforming and rectifying the output voltage of a 40 kHz Hartley oscillator. The oscillator circuit contains windings S1 and S2 of transformer T1301 and the tube B1301.

At the secondary side, S3 delivers tension to the half-wave rectifier GR1302 which is followed by a smoothing filter consisting of C1307, resistor R1312 and capacitor C1308. A tension of 1760 Volts must be present over capacitor C1307. The positive side of this floating power-supply is connected to cathode-follower B502" /via R301, receiving the "unblanking" pulse of the time-base generator A. The negative side is connected via R1313 to R6 which is the intensity control of the cathode-ray tube.

It is possible to adjust the range of R6 by adjusting R1313. The other side of potentiometer R6 is connected via R1314, R1316 and R1317 to the positive side of the power-supply. S4 and S5 deliver a tension to the voltage tripler consisting of three 10 kV rectifiers GR1303 – 4 – 5 and capacitors C1309 – 11 – 12. It provides 8600 Volts positive for the post deflection accelerator anode. A half-wave rectifier GR1301 connected to S4 provides 1440 Volts negative for the cathode-supply of the cathode-ray tube. The – 1440 V supply is provided with a 2.2 M Ω bleeder, consisting of R1327 (1 M Ω) and R1328 (1.2 M Ω). Part of the – 1440 voltage, according to the setting of potentiometer R1326 ("HT ADJ."), is compared with the stabilised 150 Volts negative supply by the right-hand triode of B1302. If variations in load should tend to change the 1440 Volts negative tension, an error-signal will exist between the cathode and grid of this triode. This signal is amplified once more by the left-hand triode of B1302. The output of the latter triode varies the screen-grid voltage of the oscillator tube B1301, thereby controlling its output.

As the output of the floating supply and the 8600 Volts positive supply are proportional to the output of the oscillator these two supplies are indirectly stabilised.

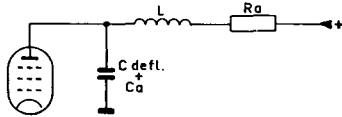


Fig. 23. Inductance reducing the effect of deflection-plate capacitance

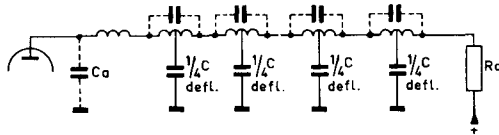
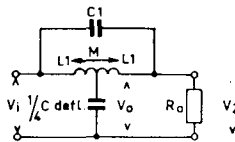


Fig. 24. Deflection-plate capacitances forming part of a lumped-line



$$\frac{|V_1|}{|V_2|} = 1 \quad \frac{V_0}{V_i} = \frac{1}{1 - \left(\frac{f}{f_c}\right)^2 + j\alpha \left(\frac{f}{f_c}\right)}$$

α = constant, depending on M
 f_c = cut-off frequency

Fig. 25. Individual LC-section

C. Y-AMPLIFIER (Fig. 83)

1. Coupling to the cathode-ray tube

If the deflection plates of the cathode-ray tube (CRT) were connected directly to the anodes of the output stage, the pass-band would be too low due to the capacitive load of the deflection plates. This is known from the equation for the cut-off frequency which is

$$f_{3dB} = \frac{1}{2\pi RC}$$

where C is the total effective capacitance between the anodes and earth, and R is the anode load (600 Ω). It has been common practice, to reduce the effect of the deflection plate capacitance by the addition of some inductance to the anode circuit (see Fig. 23). However in this instrument the idea has been taken a stage further by dividing the vertical deflection plates into 4 sections.

The four plates are then interconnected externally to form a lumped-constant line, which is terminated by a network of inductors and resistors providing a purely ohmic termination. Thus the input impedance is virtually resistive (Fig. 24). This system has the advantage over past practice, in that the pass-band of the individual LC sections (Fig. 25) is much higher when the C is $\frac{1}{4}$ of the total capacitance, as it is here, than if all the plate capacitance is present in one unit.

Coils L31 and L34 form the inductance of the lumped-line, which is terminated by the network between L32 to L35. The relevant inductors and resistors R75 have to be adjusted for optimum step-response. R99 must be adjusted so that the DC-potential of the vertical deflection plates is equal to the DC-potential of the horizontal deflection plates.

2. Output stage

The lumped-line is connected via L30 and L37 to the anodes of two tubes E55L (B5, B6) which form the push-pull output stage.

At the cathode side a frequency-dependent network R90-C55 reduces the negative feedback at high frequencies to compensate the losses at the anode-circuit and deflection system.

The quiescent plate-current of both output-tubes must be equal which can be achieved by adjusting R82. The gain of this stage can be adjusted by changing R89.

Because of the high capacitance (28 pF) between grid and cathode of the high slope output-tubes E55L, the driving voltage must be supplied by a low impedance source. This is done by a cross-coupled cathode-follower (B4', B4'') E188CC, which has the property

that the output impedance at the higher frequencies is about half the impedance of an ordinary cathode-follower.

3. Delay line

The cross-coupled cathode-followers receive their signals from a 150 nano-second delay line, which is incorporated to make it possible to display the part of the signal which triggered the time-base.

To avoid reflections, both ends of the delay line are terminated with a resistance of $270\ \Omega$, the characteristic impedance. The delay line is coupled to the grids of the cross-coupled cathode-follower via coils L27' and L27'' to provide an ohmic termination in conjunction with the input capacity of the cathode-follower. The output of the driver-stage is coupled to the input of the delay line via coils L26 and L28 for the same reason.

4. Driver stage

The driver stage of the delay line consists of two transistors TS28, TS29 operating as a push-pull amplifier.

At the emitter side a network is provided giving a frequency dependent negative feedback. It comprises the resistors R51, 52, 56, coil L38 and the capacitors C33, 34, 35, 36, and compensates also for the losses due to the skin-effect in the delay-line. When pushing button SK10, termed the "BEAMFINDER", the emitter-resistors are connected to earth via R64, thereby limiting the collector current in such a way that the spot cannot be deflected off the screen.

The driver-stage is fed by a hybrid 1 : 1 amplifier. With potentiometer R32 the amplification can be adjusted exactly to unity, potentiometer R39 adjusts the dc balance of the driver-stage. The diodes GR29 ... GR32 in the emitter circuit of TS26 – TS27 allow the amplifier to be overdriven.

D. CALIBRATION UNIT (Fig. 26 and Fig. 94)

The calibration unit generates a square wave signal with a repetition frequency of about 2000 c.p.s. and an accurately known amplitude. Its output is available at BU6 with an amplitude which is selectable in steps between 80 V and 200 micro-Volts.

An a-stable multivibrator formed by the triode and pentode parts of B1401 (E80CF) switches the voltage of the anode of the pentode between an adjustable positive tension of about 80 Volts and a negative tension of about 50 Volts with respect to earth.

When the pentode is conducting, cathode-follower B1402 (5718) is entirely cut off. The voltage of its cathode rests at earth potential.

When the pentode is cut off, the grid voltage of B1402 is determined by the setting of potentiometer R1411 which can be adjusted so that cathode is lifted to a potential of exactly 80 Volts.

The precision attenuator R1417 ... R1427 divides this tension into steps of 80–40–20–8–4–2–0.8–0.4–0.2 Volts.

If switch SK13 is in the position "V" the amplitude of the output signal is expressed in Volts, the actual value being selected by SK12 out of the above-mentioned range. If SK13 is in the position "mV", a 1 : 1000 attenuator converts the range to millivolts. In the "mV" position the output resistance is fixed at 50 Ω . If switch SK13 is put in the position "4 mA" a square-wave current with an accurately known value of 4 mA flows through a bracket on the front panel. At the same time a negative going square-wave voltage is available at BU6. This voltage has a rapid rise-time (70 nsec.) due to the switching action of transistor TS1401.

When the triode section of B1401 is cut off, transistor TS1401 is also cut off, so that the output is determined by the -6.3 V supply and voltage divider R1431 ... R1434. (-500 mV) When the triode is conductive, the transistor is bottomed so that the output voltage is at its minimum value. The switching speed is improved by the blocking action of diode GR1402.

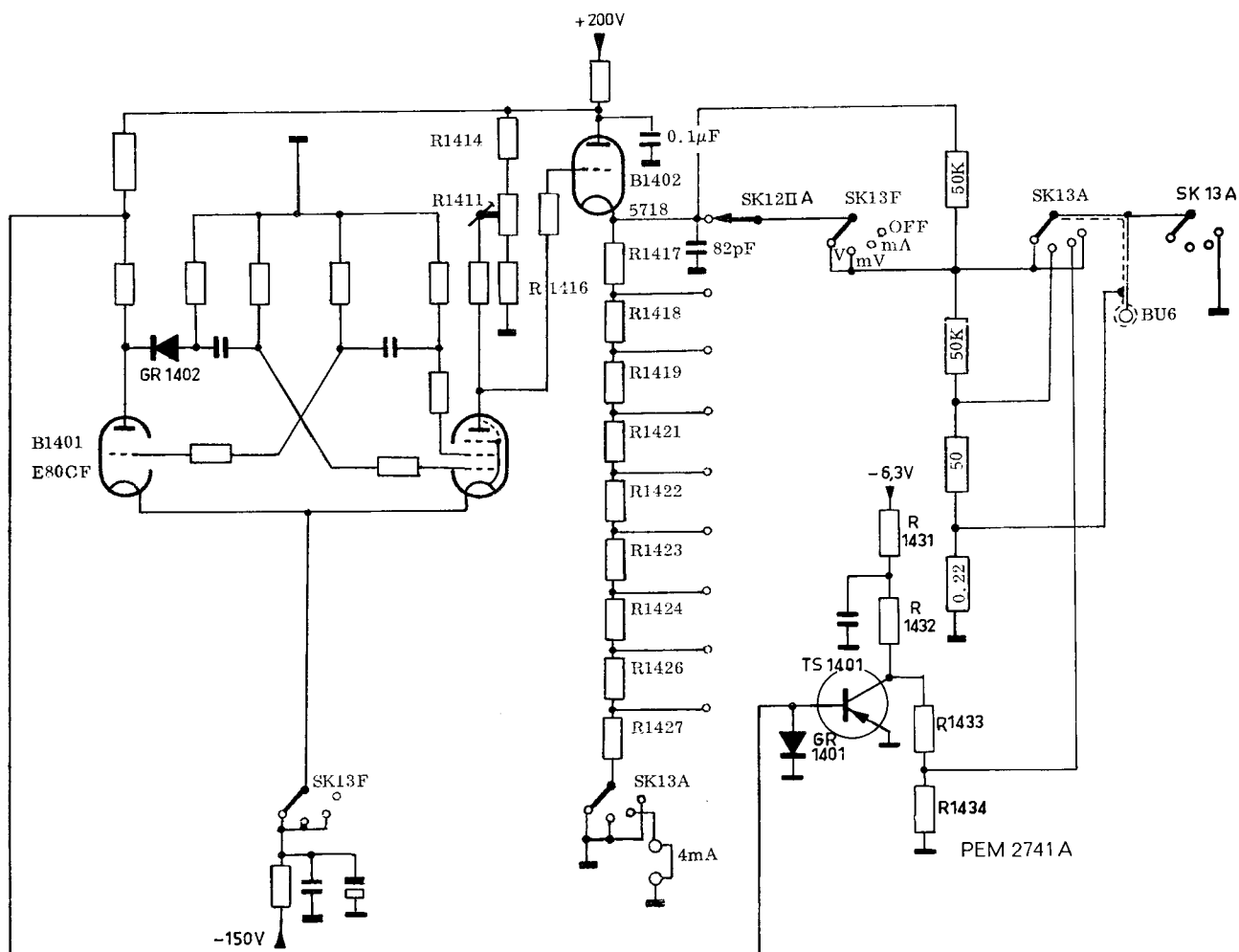


Fig. 26. Calibration unit circuit

E. X-AMPLIFIER

The horizontal amplifier can be divided roughly into a pre-amplifier, a magnifier circuit and a time-base amplifier.

These circuits are interconnected by MODE switch SK7, having the positions: "TIME-BASE A", "SINGLE A", "50 Hz", "EXT.", "1 : 10 EXT.", "X UNIT". A survey is given at Fig. 27.

Switch SK8 is coaxial to this switch. It switches the magnifier circuit in the positions: " $\times 1$ ", " $\times 2$ ", " $\times 5$ ".

1. Time-base amplifier

The whole circuit (Fig. 28) is a para-phase amplifier, which is driven at one grid whilst the other grid is earthed, so that a symmetrical output waveform is produced from a non-symmetrical input. The time-base generator output is applied to the grid of cathode follower B705 (left-hand triode).

The high stability of the amplifier is obtained by using shunt feedback at the two pentodes B703 and B704, as well as series feedback at the right-hand triode of B705 and the left-hand triode of B702. In this way the gain of the amplifier is nearly independent of valve characteristics. The overall gain is adjusted at R738 "X-GAIN ADJ." DC-balance of the complete amplifier and the CRT is adjusted at R731 "X DC-BAL."

A contact of SK10 "BEAMFINDER" normally shorts R735. If push-button SK10 is operated, this resistor limits the current through the time-base amplifier in such a way, that the electron beam cannot be deflected off the screen.

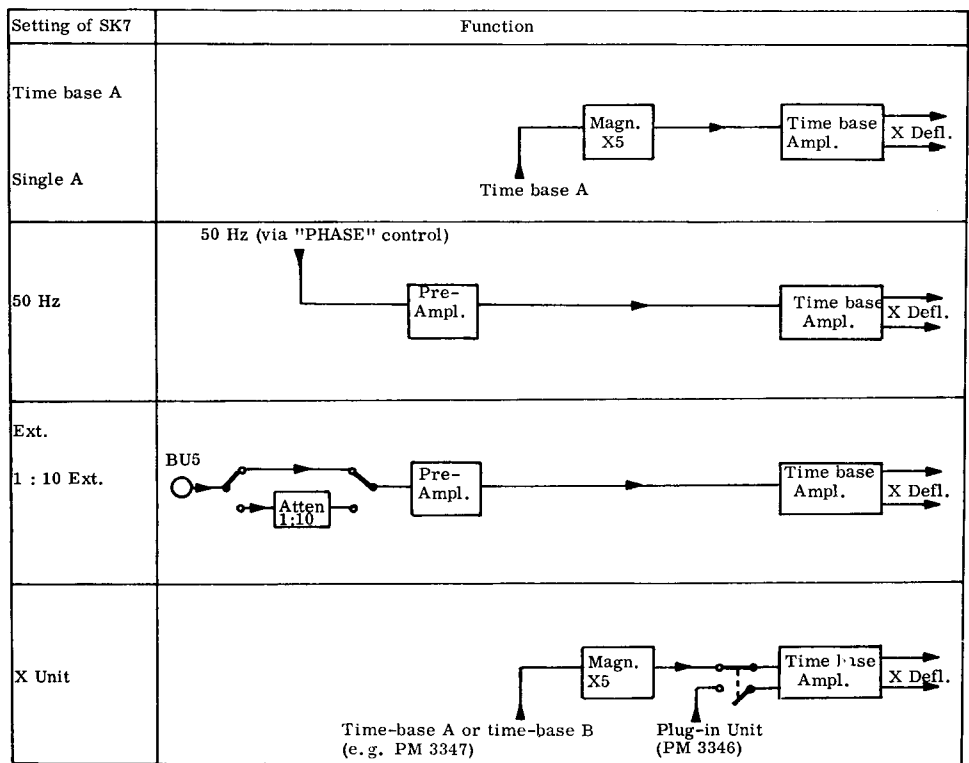
2. Magnifier circuit

The circuit (Fig. 29) consists of a cathode-follower B701' with a fixed attenuator with 3 positions: " $\times 1$ ", " $\times 2$ ", " $\times 5$ " in its cathode-circuit. The attenuation is maximal at the " $\times 1$ " position of SK8 and zero at the " $\times 5$ " position.

When SK8 is at the positions " $\times 2$ " and " $\times 5$ " the lamp "MAGN." glows. In position " $\times 5$ " sweep linearity is adjusted at C709 (located at the time-base amplifier), in position " $\times 2$ " at C711 and in position " $\times 1$ " at C710.

Horizontal positioning of the trace is effected by front panel controls R4 and R5 "SHIFT" which vary the DC-level at B701" grid. Resistor R717 isolates the grid circuit from the preceeding stages; frequency compensation is carried out by C707.

In positions "50 Hz", "EXT." and "1 : 10 EXT." of SK7 the range of the controls is made five times smaller by switching-in resistor R721. At the same time magnifier-switch SK8 is made inoperative.



PEM 2741

Fig. 27. Survey of functions of the horizontal amplifier circuit

3. Pre-amplifier

If it is desired to use an externally generated waveform for horizontal deflection this voltage may be connected to the horizontal input terminal BU5. When SK7 is at "EXT." this signal is amplified at B706 (Fig. 30) and used to drive the time-base amplifier.

"LEVEL ADJ." R714 ensures that, without an input signal, the DC-level at the anode of B706 is such that the spot is in the middle of the screen. For large input

signals at BU5, switch SK7 is set at "1 : 10 EXT." so that a 1 : 10 attenuator (compensated by C701) is interposed between the signal and the pre-amplifier B706.

Horizontal deflection with an externally generated waveform can also be carried out by using X-amplifier unit PM 3346. The signal is then injected at the grid of B702 right-hand tube (Fig. 28) whilst the grid of B705 left-hand tube is earthed, via SK7, at the PM 3346 unit so that the shift controls R4 and R5 are inoperative.

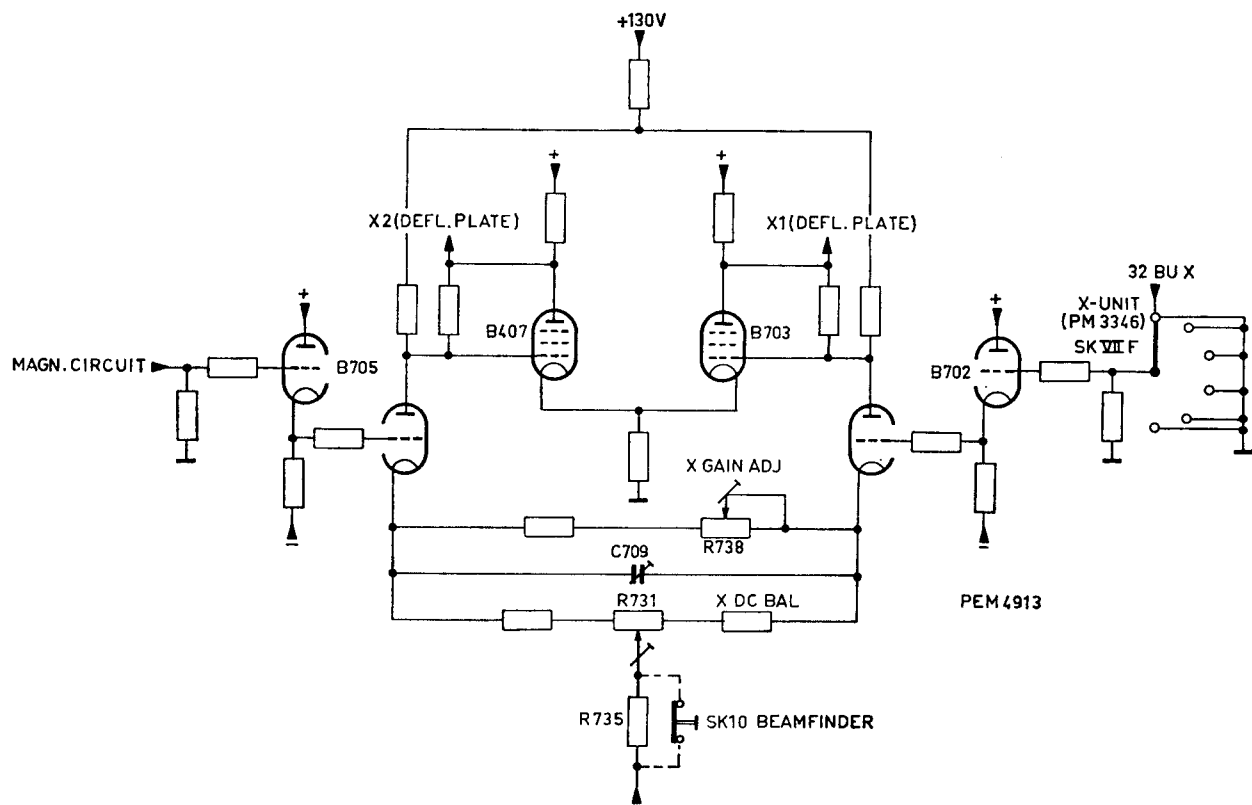


Fig. 28. Simplified diagram of the time-base amplifier

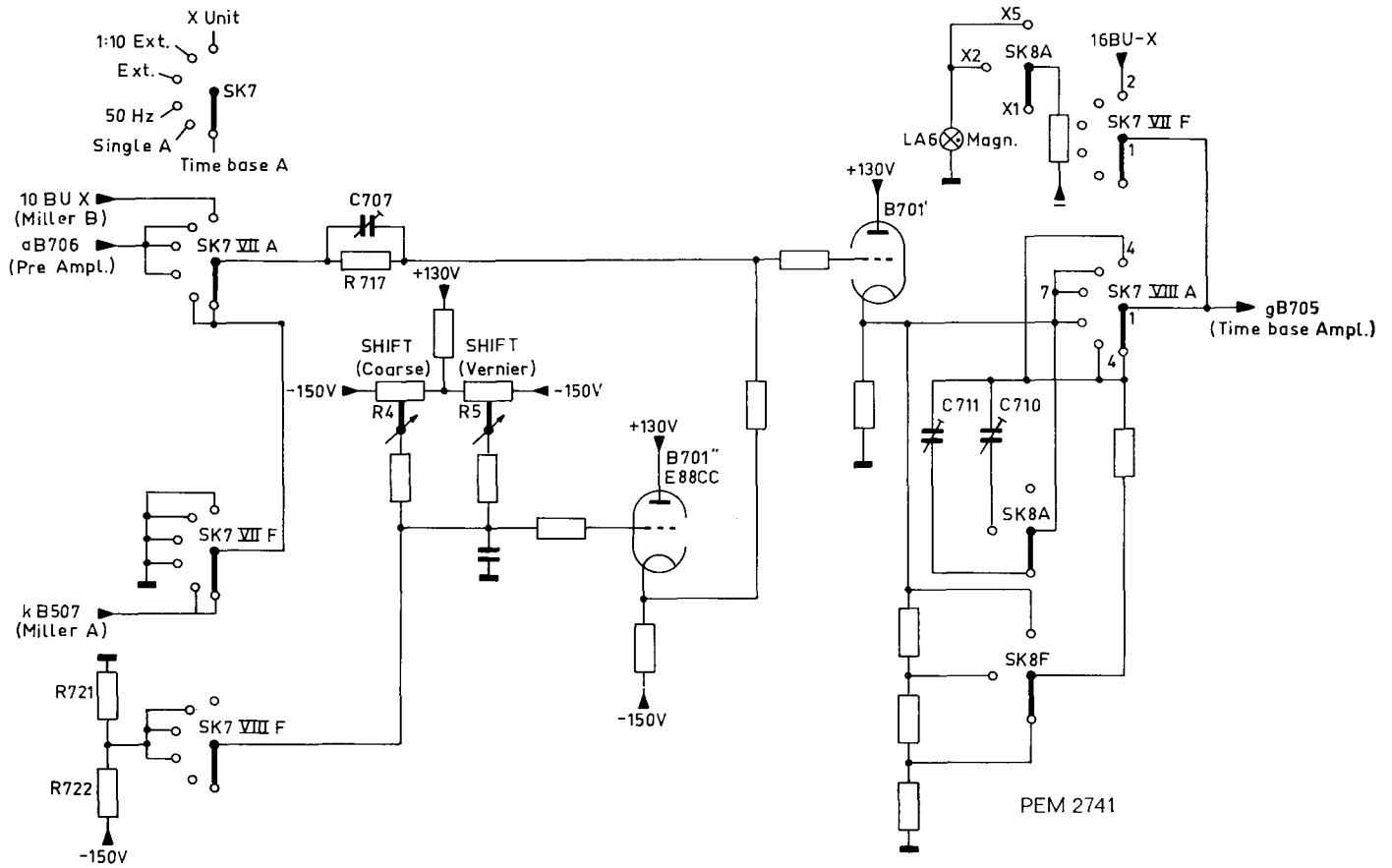


Fig. 29. Magnifier circuit

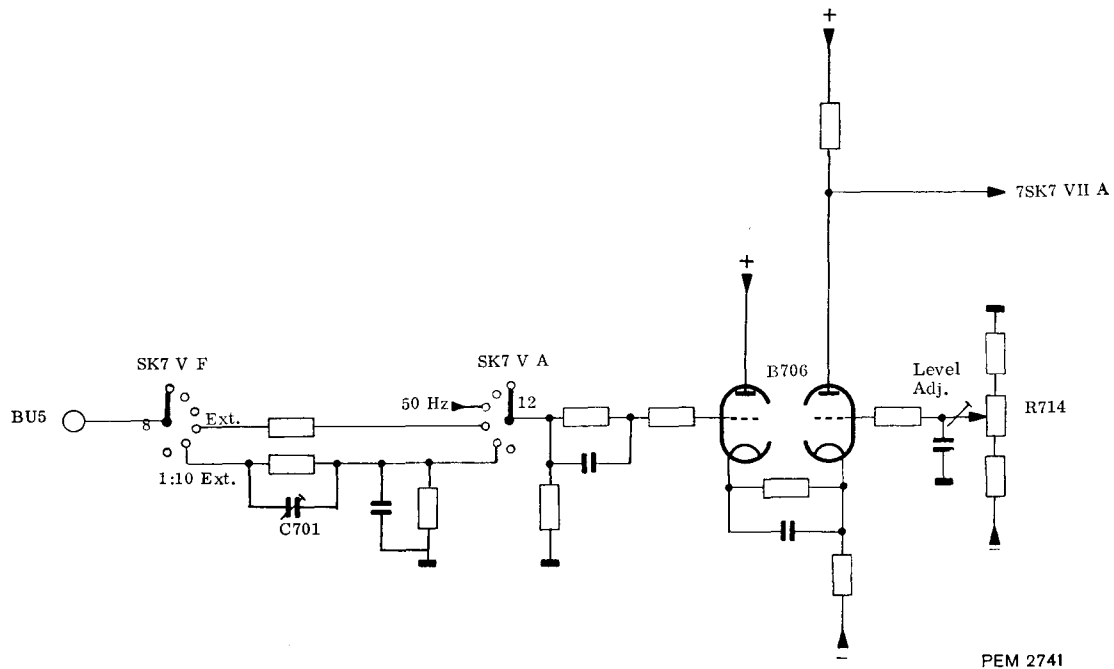


Fig. 30. Pre-amplifier circuit

The lock-out multivibrator provides the stability circuit with single sweep facilities:

- in the "free running" mode; after a sweep of the time-base, the "RESET" button must be depressed in order to initiate the next sweep.
- in the "triggered" mode, the "RESET" button must be depressed and then the sweep occurs upon the arrival of a trigger pulse at the S.G.M.V.

3. Sweep-gating multivibrator (Fig. 32)

The circuit consists of a bi-stable multivibrator B501 – B503 (Schmitt-trigger) with a cathode-follower B502' interposed between these two valves.

The quiescent condition (valve B501 conducting and B503 cut-off) is known as the first stable state.

When a negative trigger pulse arrives at the grid of B501 from trigger unit A (via pulse-transformer T401) the Schmitt-trigger circuit is driven in its second stable state: B501 is cut-off, B503 is conducting.

The voltage rise at the anode of B501 is "speeded-up" by the shunt-peaking circuit L501 – R503, which results in some overshoot.

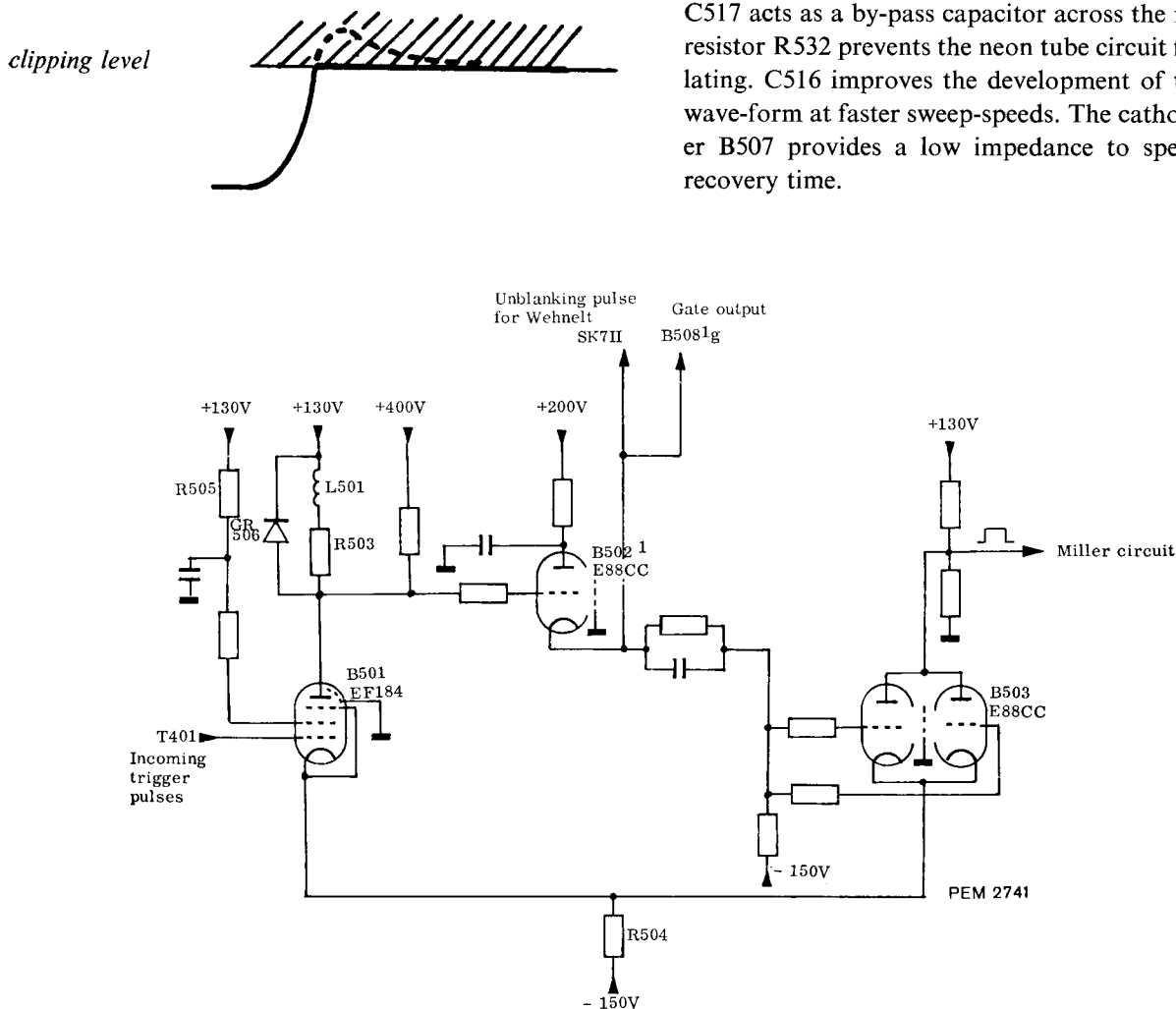


Fig. 32. Sweep-gating multivibrator

The overshoot is "clipped" by diode GR506 so that a clean fast-rising pulse appears at the anode of B501. Cathode-follower B502' is interposed to improve the switching-time.

The positive-going pulse is fed from the cathode of cathode-follower B502' via switch SK7 and cathode-follower B502" to the Wehnelt-cylinder for the unblanking pulse (Fig. 33) and to the "GATE" output socket via cathode follower B508'. The "GATE" and the unblanking pulse last as long as a time-base sweep.

4. Miller run-up circuit (Fig. 34)

In the quiescent condition both diodes B504 are conducting. The current flowing from the 150 Volts negative supply through R_L and the upper diode is low and this diode clamps the grid of B506 at about -2 Volts with respect to earth. More current flows through the lower diode so that the cathode of B507 is at about -10 Volts with respect to earth. Thus the voltage across the timing capacitor C_L is only about 8 Volt.

The neon tube B514 provides a DC-coupling between the Miller-anode B506 and cathode-follower B507. C517 acts as a by-pass capacitor across the neon tube; resistor R532 prevents the neon tube circuit from oscillating. C516 improves the development of the run-up wave-form at faster sweep-speeds. The cathode-follower B507 provides a low impedance to speed up the recovery time.

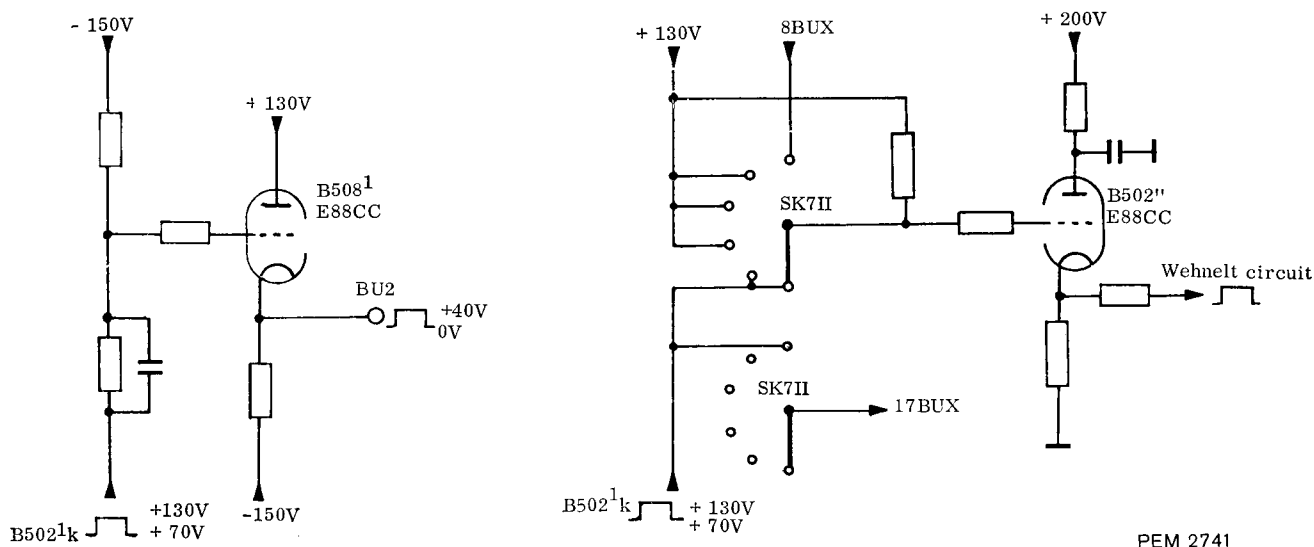


Fig. 33. Gate output and unblanking circuit

When the sweep-gating multivibrator is switched to its second stable state the incoming negative step cuts off both diodes. Consequently the grid of B506 tries to go negative but is prevented from doing so by the negative feedback.

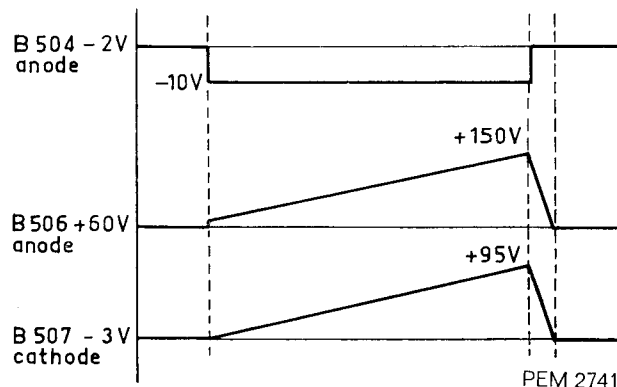
The gain of B506 is about 100 so that any feed-back variation through the timing capacitor keeps the grid-voltage virtually constant. Thus the current through R_L is constant and C_L is charged linearly. Therefore the voltage at B507 cathode rises linearly. The anode of B506 starts at +60 Volts and runs to +150 Volts, whilst the cathode of B507 starts at -3 Volts and runs to +95 Volts. To stop the run-up, the gating waveform is made positive, thus the upper diode conducts and

clamps the grid of the Miller tube to the output of the S.G.M.V.

The anode voltage therefore decreases and the grid and cathode of the cathode-follower B507 becomes less positive.

The cathode voltage of the cathode-follower (which is the output of the time-base generator) falls to a fixed level and is then "clamped" to that level as the lower diode begins to conduct at -3 Volts. This voltage is established by voltage divider R523 - R524 and it is fed to the diodes via diode GR501.

The speed at which the positive-going ramp voltage rises is determined by the values of C_L and R_L , which are selected by switch SK4 (not shown in the circuit) and the aiming voltage.



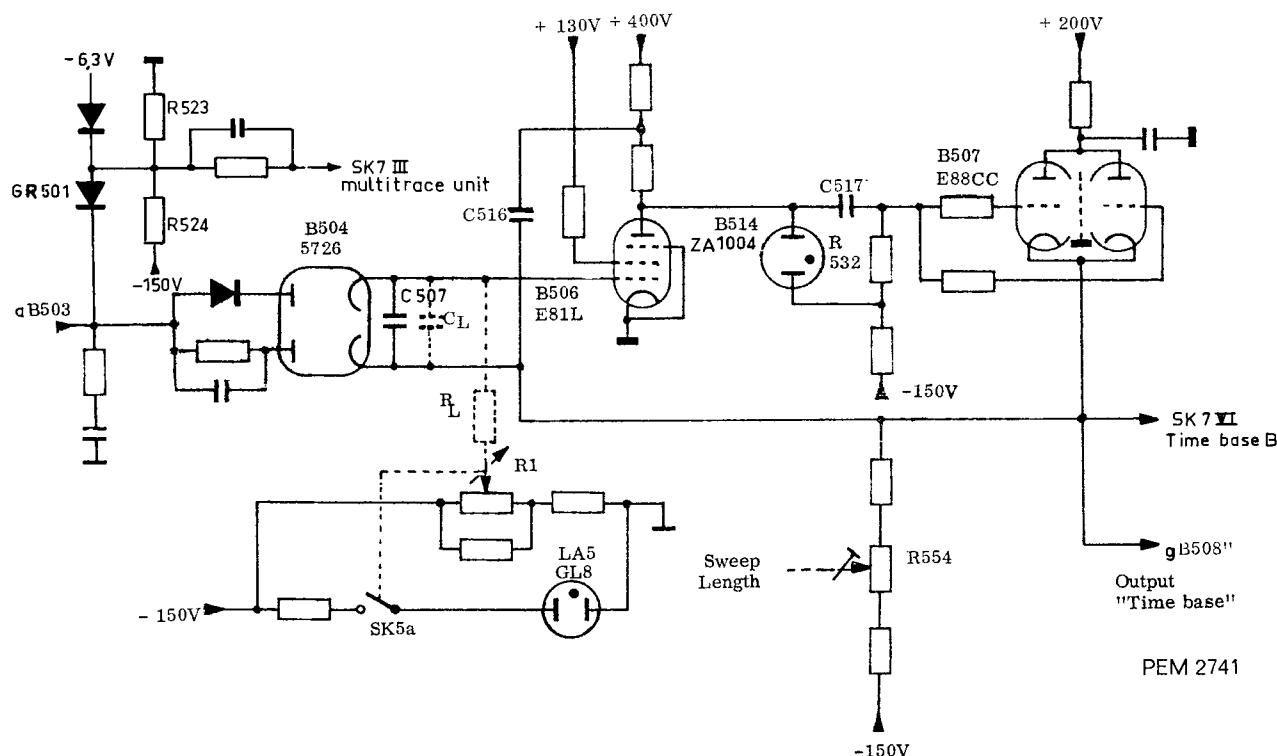


Fig. 34. Miller-circuit

Intermediate (uncalibrated) sweep speeds, slower than the calibrated ones, can be selected by control R1. This is done by connecting the timing resistor to other voltages than -150 Volts so that the charging current in the capacitor can be continuously varied. Immediately R1 is rotated anti-clockwise, SK5a closes and the lamp "UNCAL" lights. An external sawtooth output voltage is available at socket BU3 "TIME-BASE" via cathode-follower B508". To control a multi-trace plug-in unit when operated in the "alternate" mode a part of the S.G.M.V. output is routed to this unit via SK7.

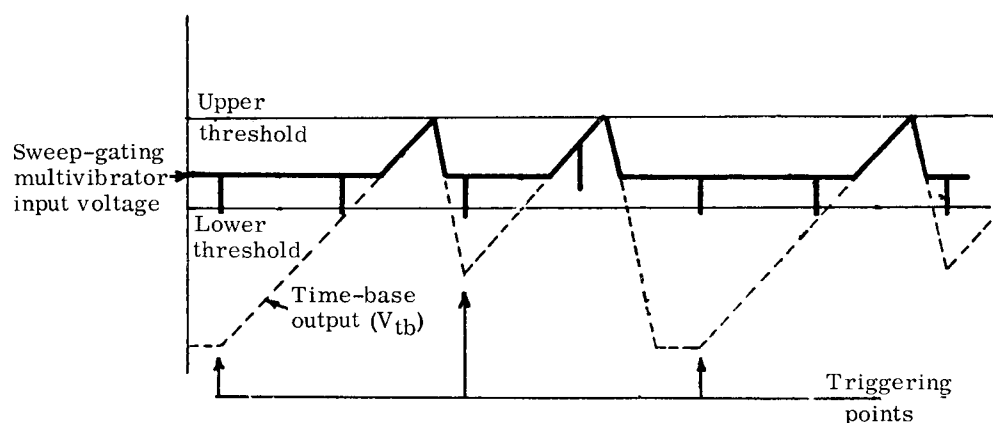
5. Hold-off circuit

Potentiometer R554 "SWEEP LENGTH" (preset

adjustment) provides an adjustable portion of the time-base generator output to the hold-off circuit.

This tension is ultimately fed back to the sweep-gating multivibrator grid so that when the sample amplitude exceeds the upper hysteresis of the sweep-gating multivibrator the latter returns to its first stable state. It will be seen (Fig. 35) that the portion of the time-base generator output voltage (V_{tb}), which is fed to the S.G.M.V., is clipped so that only the most positive part is used.

Thus it is possible for the input voltage of the S.G.M.V. to cross the lower threshold value before V_{tb} has reached its quiescent level. When this occurs the fly-back will not be complete for all successive sweeps and it will be impossible to obtain the desired static display.



PEM 2741

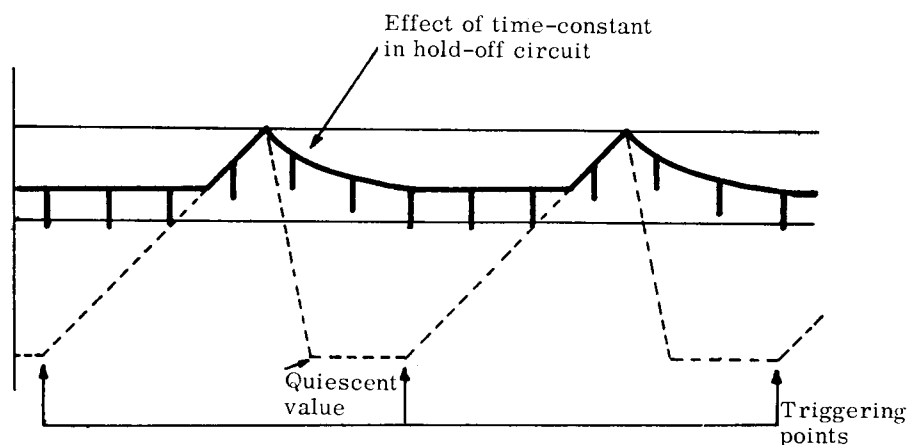
Fig. 35. Triggering of the Miller run-up circuit without Hold-off circuit

To avoid this trouble the hold off circuit is incorporated to stretch that portion of the time-base fly-back signal which is fed to the S.G.M.V. (Fig. 36). Thus the S.G.M.V. is prevented from switching until V_{tb} has had time to reach its quiescent level. The stretching is provided by the action of $C536 + C_{ho}$ and $R607 + R_{ho}$ (Fig. 37). When the portion of the ramp from the "SWEEP-LENGTH" control increases in amplitude, the voltage at the cathode of B509' rises and capacitor $C536 + C_{ho}$ is rapidly charged up.

When the time-base generator output falls to its quiescent value, cathode-follower B509' is cut off due to its

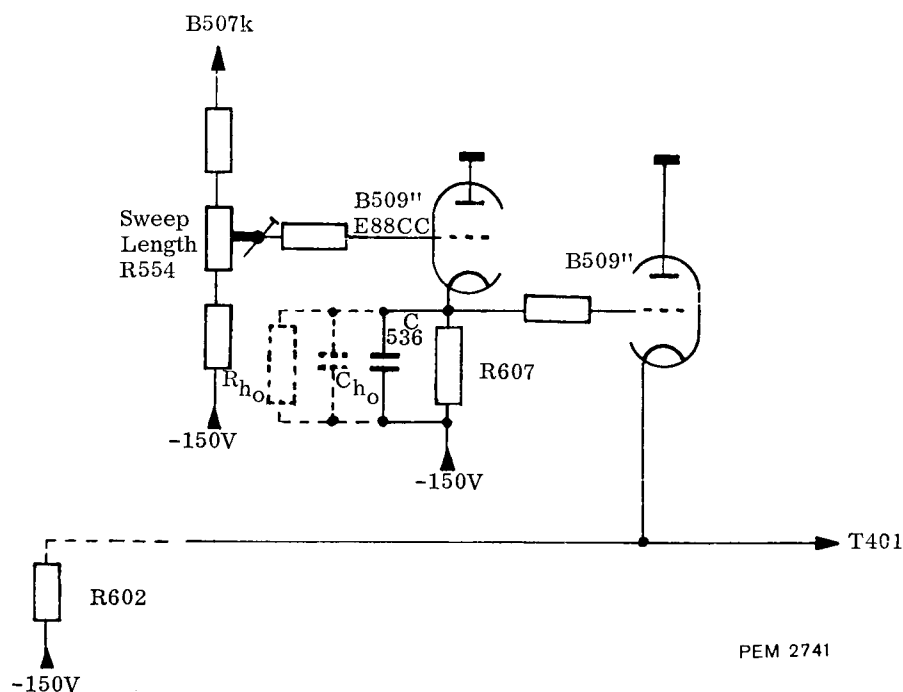
capacitive loading and the charge on the capacitors leaks away through $R607 + R_{ho}$ with the result that the hold-off circuit output waveform falls according to the RC-discharge relationship. Thus the input grid voltage of the sweep-gating multivibrator drops slowly, so that a further trigger pulse cannot start a new sweep by driving the sweep-gating multivibrator past its lower hysteresis limit, until the time-base voltage reaches its quiescent value.

If the "TIME/cm" switch is set for a slow sweep rate a larger RC combination is selected for the hold-off



PEM 2741

Fig. 36. Effect of Hold-off circuit



PEM 2741

Fig. 37. Hold-off circuit

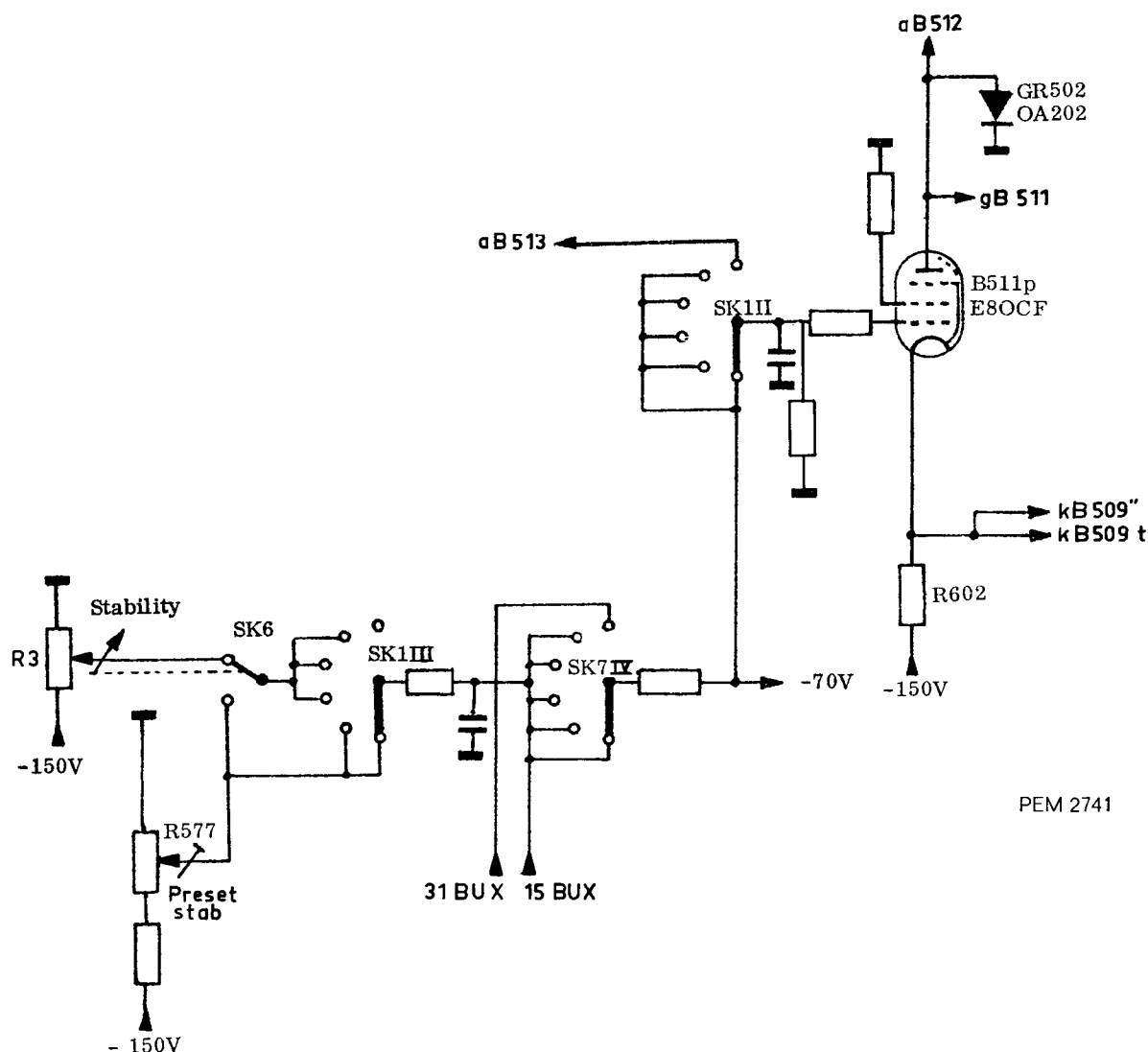
circuit in order to increase the hold-off intervals which must overlap the fly-back intervals.

Coupling of the hold-off circuit to the sweep-gating multivibrator is effected via cathode-follower B509" and the secondary winding of T401 directly to B501 control grid.

6. Stability circuit

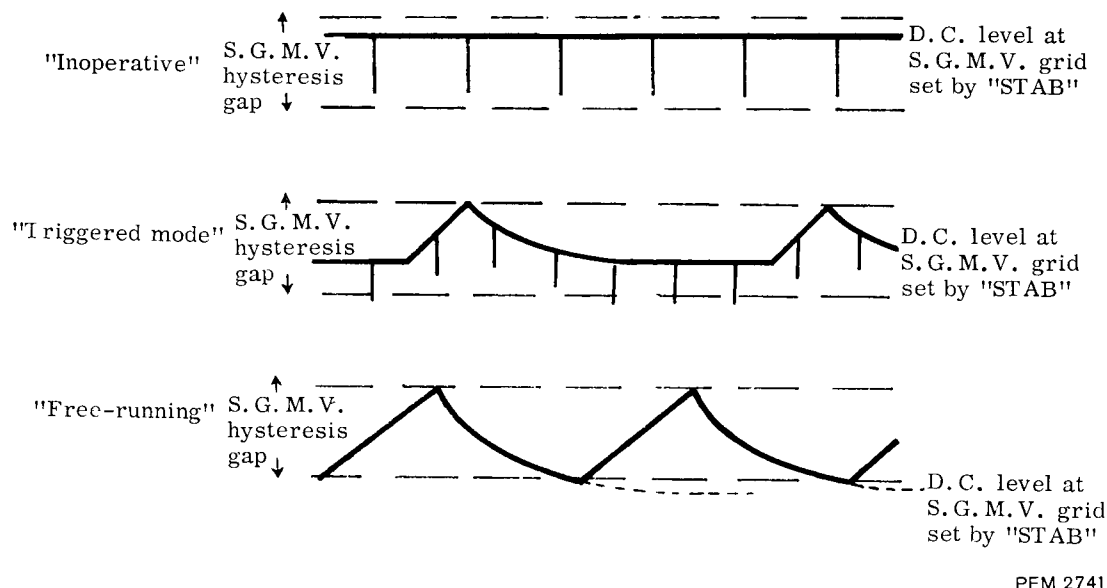
The stability control circuit (Fig. 38) comprising cathode-follower B511 p and associated switches, permits the

setting of the DC-level at the sweep-gating multivibrator (S.G.M.V.) input grid so that incoming negative trigger pulses can drive the S.G.M.V. into its second stable state thus starting the sweep (triggered mode). A "PRESET" position for the triggered mode is also provided (fully anti-clockwise setting of R3 "STAB." operates switch SK6). The "PRESET" potentiometer (R577) is preadjusted for stable triggering.



PEM 2741

Fig. 38. Stability control circuit



When the stability ("STAB.") control is set clockwise ("REPET") the input DC-level at the S.G.M.V. grid is below the lower hysteresis limit, the S.G.M.V. is actuated and the sweep begins. The resulting ramp sample from the "SWEEP-LENGTH" control reaches the upper hysteresis limit of the S.G.M.V. and the circuit returns to its first stable state. The sweep stops and consequently the output voltage of the "hold-off" circuit drops to its quiescent voltage.

When the "hold-off" voltage falls below the lower hysteresis limit of the S.G.M.V. the circuit returns to the second stable state and a new sweep begins. In this way the "REPET" setting of the control "STAB." permits the circuit to "free-run" so that a trace is shown without incoming signal. The oscilloscope delivers a sawtooth waveform (at BU3) and a gating waveform

(at BU2) which can be used for driving external circuits.

In positions "TV FRAME" and "TV LINE" of SK1, the "STAB." control is inoperative, whilst in the position "AUT." of SK1 stability control is taken over by the auto-stability circuit.

7. Auto-stability circuit

When switch SK1 is at "AUT." the stability and preset stability controls are not effective, but the D.C. level at the S.G.M.V. input grid is automatically set to make the time base "free-run". This is effected by the auto-stability circuit (Fig. 39).

The input to this circuit is taken from the anode of B402 in trigger unit A. When no trigger input signal is present the anode voltage at B513p is below the lower

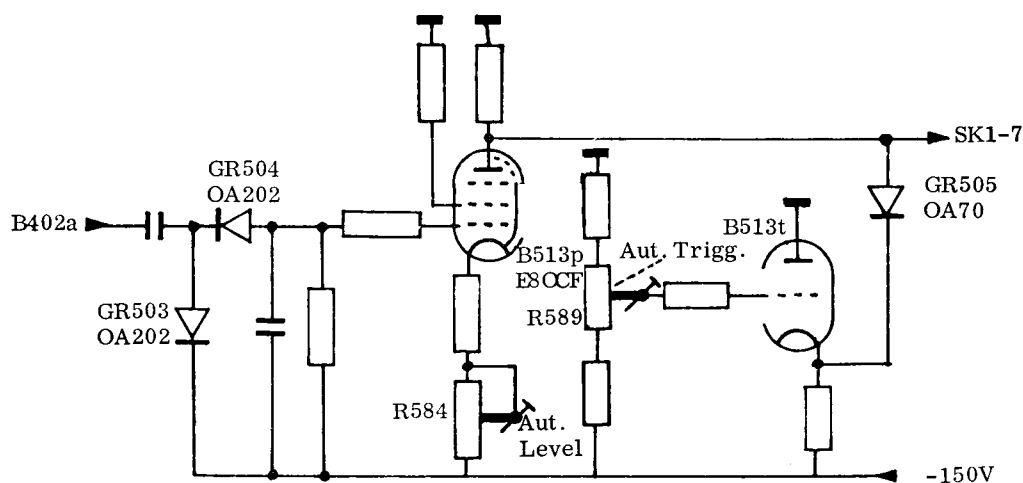


Fig. 39. Auto-stability-circuit

hysteresis level of the S.G.M.V. (thus the time-base free-runs).

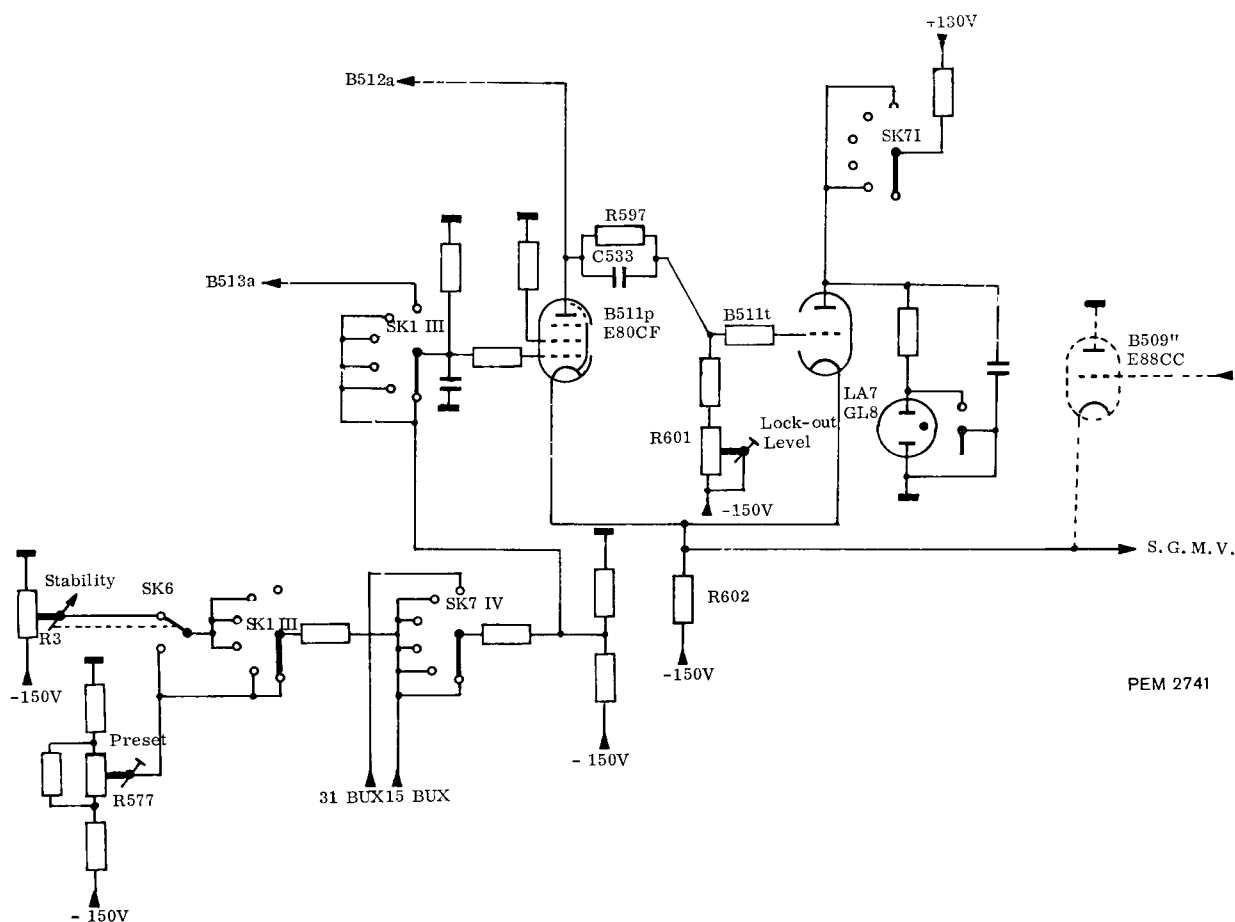
This voltage level is set by means of preset potentiometer R584 "AUT. LEVEL".

Incoming trigger signals are rectified by GR503 and GR504, smoothed and applied to the grid of B513p, thus causing the anode voltage to rise. The S.G.M.V. input (coupled to B513p in the auto-stability position) will also rise so that the time-base will no longer free-run but will respond to trigger pulses. However, as the trigger signal can vary over a wide range of amplitude while the trigger pulses to the S.G.M.V. are of fixed amplitude, GR505 is used as a catch diode to prevent the anode of B513p going so positive that the time-base can no longer trigger. The bias-voltage for GR505 is adjusted by R589 "AUT. TRIGG".

8. Lock-out multivibrator circuit

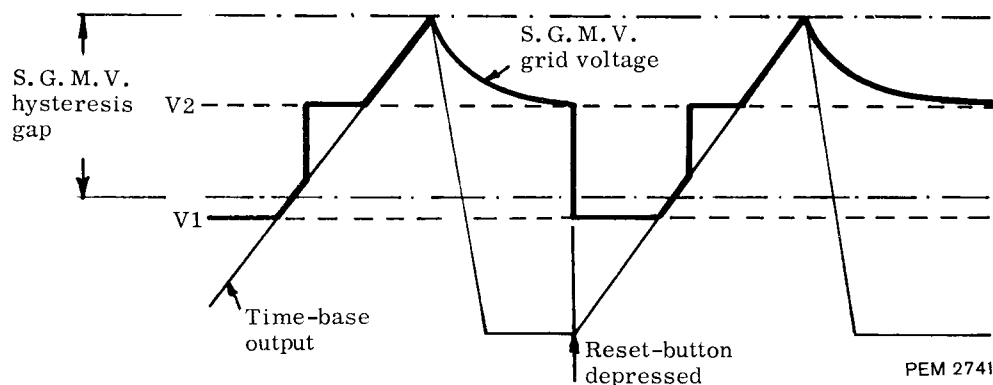
Normally, valve B511t is inoperative and cathode-follower B511p functions as a part of the stability control circuit (Fig. 38). However, when switch SK7 is set to "SINGLE A" or "X-UNIT", tube B511t receives an anode-supply and thus the circuit is modified so that B511p and B511t together form a bi-stable circuit known as the lock-out multivibrator (Fig. 40).

On pressing the reset-button, or when a pulse from the X-unit arrives, B511t is cut off whilst B511p functions as a simple cathode-follower; lamp LA7 glows (not applicable when the position "X-UNIT" is used). This we will call stable state A of the lock-out multivibrator. When the "STAB" control is set to "REPET." the input grid voltage of the S.G.M.V. is set below its lower hysteresis limit and a sweep commences.



PEM 2741

Fig. 40. Lock-out multivibrator



When the ramp-voltage at the hold-off cathode-follower grid (B509") rises above V_1 the cathodes of B509" and B511t also rise and tube B511p is cut off. The lock-out multivibrator switches into its second stable state, state B (V_2) i.e. B511t conducts and B511p is cut off (lamp LA7 is extinguished).

The ramp voltage continues to rise and when the output voltage of the hold-off circuit rises to the S.G.M.V. upper hysteresis limit, the latter reverts to its first stable state.

Consequently the time-base generator waveform return to the quiescent level.

The current flowing through B511t causes a voltage-drop across R602 that keeps the cathode of B509" at V_2 . Thus B509" cuts off so that the current flowing through R602 is that which is flowing through B511t. Thus the voltage at the S.G.M.V. input grid remains at V_2 which is so high that, even if trigger pulses were present, the sweep could not occur.

This situation can be maintained indefinitely until cancelled by operation of the "RESET" button in the reset circuit.

9. Reset circuit (Fig. 41)

When the push-button "RESET" is depressed or a pulse arrives from a plug-in unit e.g. PM 3347, capacitor C527 couples the resulting positive voltage step to the grid of tube B512.

The resulting negative voltage step at the anode of B512 is coupled to the lock-out multivibrator, thus driving it back into its stable state A. The S.G.M.V. input voltage is restored to V_1 and a new sweep begins.

10. Triggered mode of the single sweep

If it is desired to trigger the single sweep, the "STAB." control must first be set as for triggered operation of the time-base generator. The "RESET" button is then

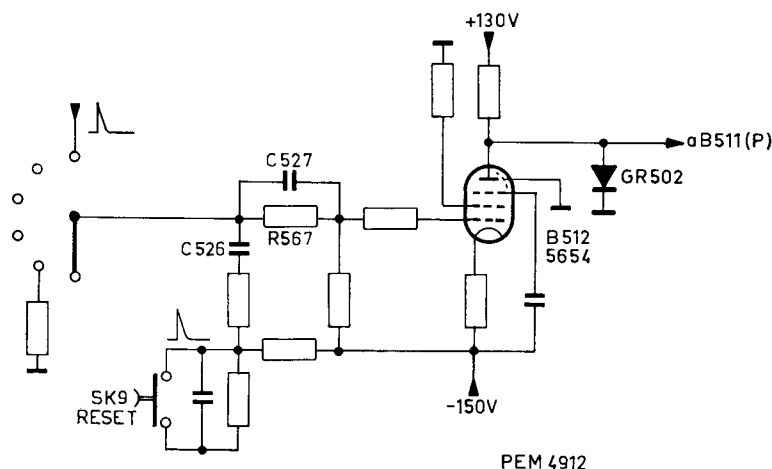


Fig. 41. Reset circuit

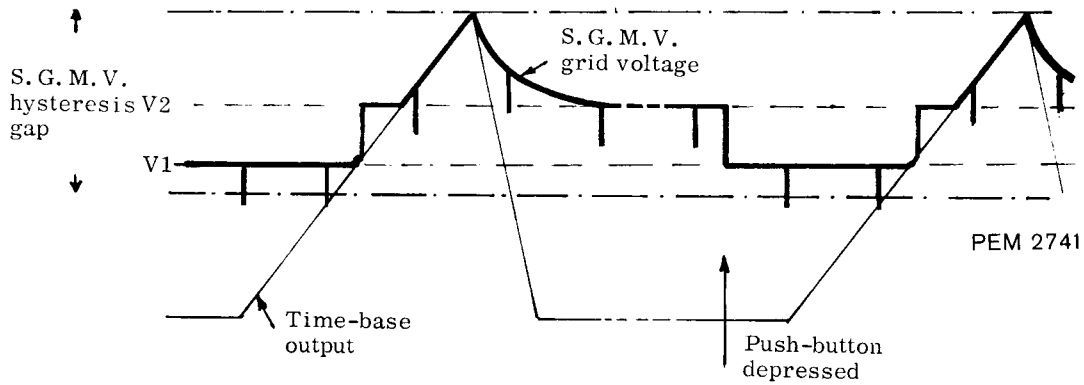


Fig. 42. Reset circuit operating in a "triggered" mode

operated and the next trigger pulse starts the sweep. The operation of the circuit is virtually the same as for that described above, with the exception that, after the depression of the "RESET" button, the S.G.M.V. input falls to the DC-level selected for triggered opera-

tion (Fig. 42). When the trigger pulse appears the sweep commences and the lamp is extinguished after the lock-out multivibrator has gained stable state B. The level of V2 can be adjusted with potentiometer R601 "LOCK-OUT LEVEL".

G. TRIGGER UNIT A

1. Introduction

The circuit provides fast-rise pulses for the triggering of the time-base generator sweep-gating multivibrator. These pulses can be derived from either internal or external sources.

2. Source selection

The trigger signal source is selected by switch SK3, Fig. 43. In the position "INT." two similar, but anti-phase, signals are "picked-off" from the trigger amplifier.

In the position "EXT." the trigger signal is derived from a signal connected to socket BU1 "TRIGG." and in position "50 Hz" from a mains frequency signal derived from a winding of the mains transformer.

3. Slope selection

With the aid of SK2, Fig. 43, triggering can be effected on the positive or negative slope of the displayed signal.

This is achieved by routing the trigger signal to either B400 or B400', Fig. 49 (note: when SK3 is at "INT." anti-phase signals appear simultaneously at the grids of B400 and B400'. In the other positions of SK3 one input is always kept at earth potential.)

4. Mode selection

Mode selection is effected by switch SK1, Fig. 43.

This permits the time-base to trigger on the frame or line pulses of a television video signal, on low or high frequency signals; while in the position "AUT" the time-base will "ree-run" in the absence of a signal (horizontal line on the CRT) and triggers as soon as there is a signal.

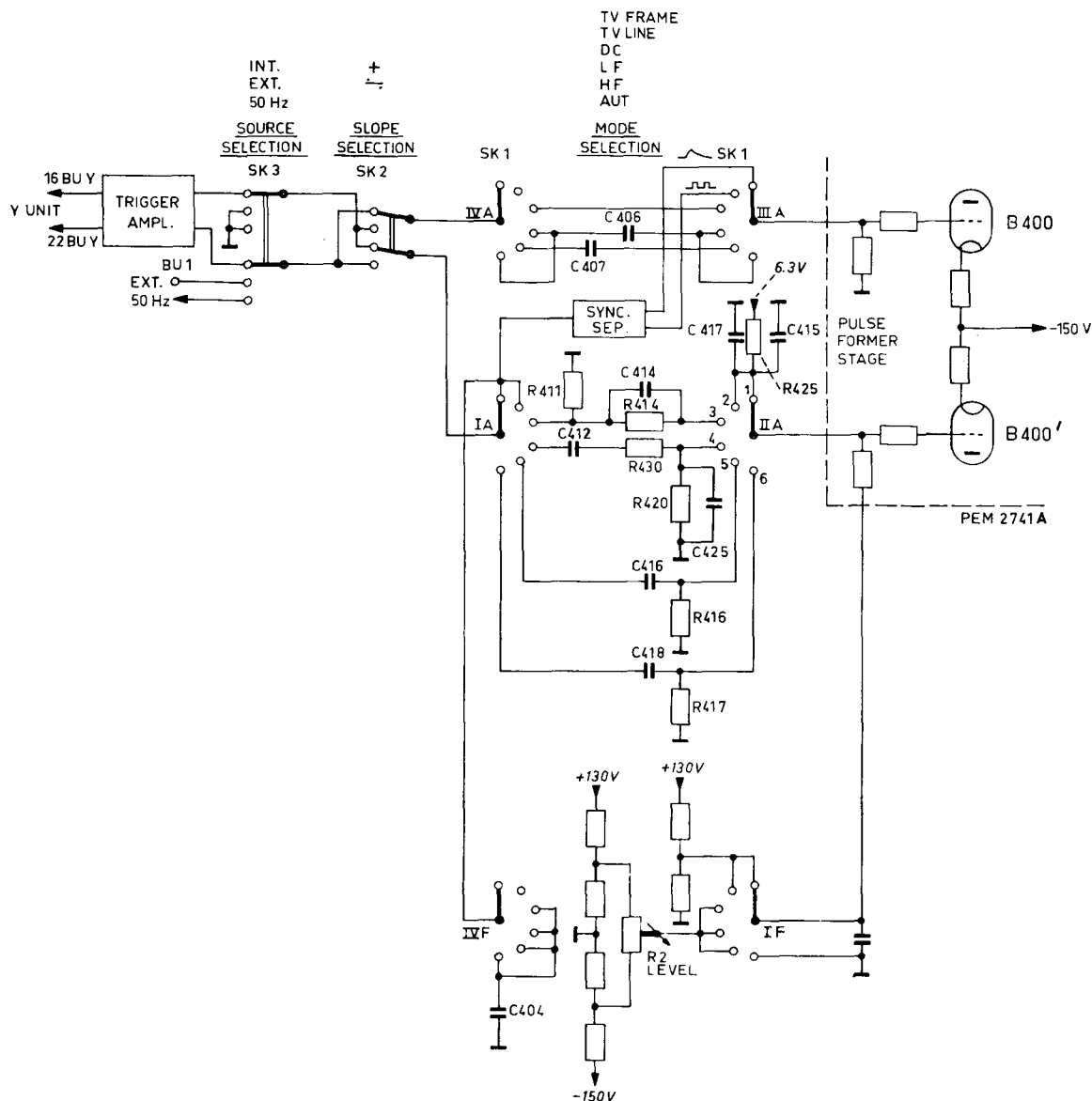


Fig. 43. Trigger unit A

a. TV Line and TV Frame

When a TV video signal is fed to the input terminal of the Y-amplifier, two anti-phase signals are "picked-off" via switch SK3 (at position "INT.") and depending on the position of SK2 ($\pm$) one of them is fed to the Synchronisation Separator see Fig. 44. The latter works only for negative synchronisation pulses (positive video signal) and the connections are so arranged that if a positive video signal is present at the Y-amplifier input, then SK2 must be set to "—" in order to select the appropriate signal.

The Synchronisation separator also works for an external signal (i.e. SK3 at "EXT.") provided that it is a positive video signal.

Diode GR401 fixes the base of the synchronisation pulse at earth potential.

The signal passes to the emitter-follower stage (TS401) and then to the clipping stage TS402. The output

voltage of TS402 is fed to emitter-follower TS403, which provides a low impedance output to the following stage.

The resulting positive-going line pulse is fed via C413 to the trigger circuit when SK1 is at "TV-LINE".

In the position "TV-FRAME" of SK1 the synchronisation pulses are integrated and clipped. This removes the line-pulses leaving the frame-pulses which are fed to the trigger circuit (see Fig. 44).

When the TV positions are not selected the input of the synchronisation separator is earthed to prevent cross-talk.

When SK1 is at the TV positions the "LEVEL" control is inoperative and the level is determined by a voltage divider at the grid of B400', in order to obtain stable triggering under these conditions.

The stability control in the time-base A circuit is at the "PRESET" position (the continuous control is not effective).

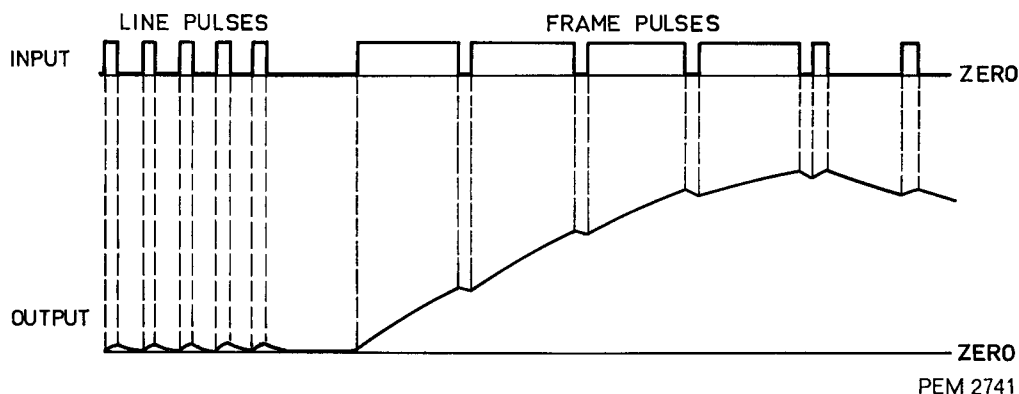
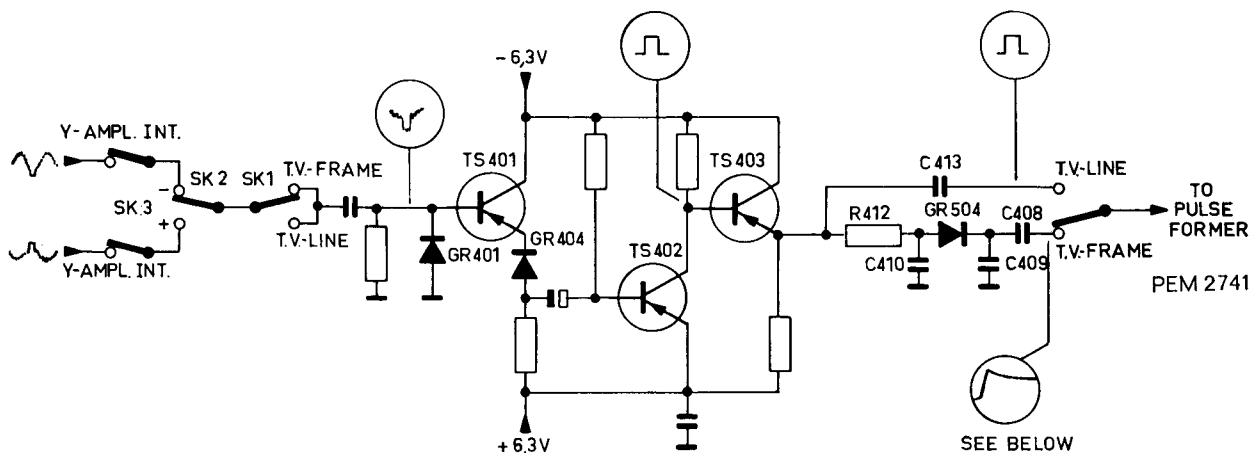


Fig. 44. Synchronisation separator

b. DC

In position "DC" of SK1 the signal "picked-off from the Y amplifier or external trigger signal is DC-coupled through the unit to the pulse former-stage.

When SK3 is at "INT" the two outputs from the Y-plug-in unit are fed to the balanced trigger-amplifier keeping hum and drift to a minimum.

In this mode the control "LEVEL" is effective in changing the DC-level at B204 grid and hence the anode level at B491.

Resistors R414 – R417 – R416 ensure that the impedance, against which the level control voltage has to work, is the same for both AC and DC-coupling of the trigger. Thus the level range in these positions of SK1 will remain the same.

c. LF

Coupling from the trigger source is via C412 and C406, with a time constant of 56 milli-seconds, restricting the bandwidth at the lower side to approx. 3 Hz. R420//C425 (160 ns) restrict the bandwidth at the high side to approx 1 MHz.

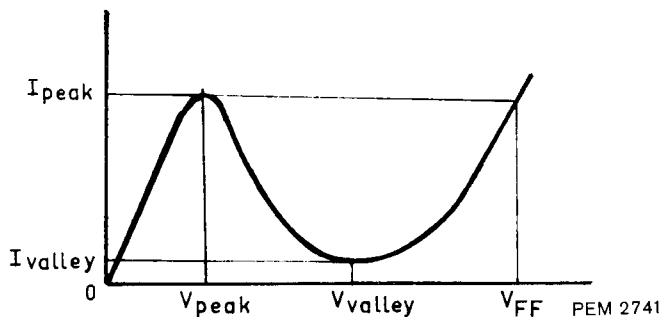


Fig. 45. Tunnel-diode characteristic

d. HF

As for low frequencies but with coupling via C416 and C407. The time constant is 80 micro-seconds and therefore rejects the lower frequencies.

e. AUT

In this position of SK1 both valve grids of B400 are at earth potential. The auto-stability detector in the time-base A circuit is coupled-in/by SK1 to ensure that the time-base free-runs when no input is present at the trigger unit thus giving rise to a line on the CRT.

With an input to the trigger unit (resulting in a trigger signal) the auto-stability circuit responds to the signal at the anode of B402 and sets the S.G.M.V. for triggered operation.

Controls "STAB" and "LEVEL" are not effective.

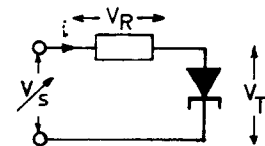


Fig. 46. Tunnel-diode circuit

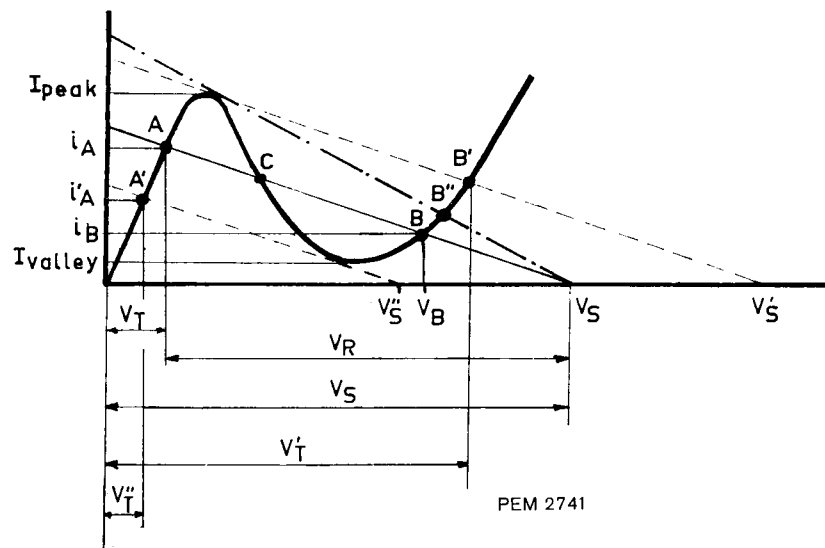


Fig. 47. Load-lines

5. Pulse former circuit and tunnel diode

The anode circuit of B401 comprises a tunnel diode to deliver fast-switching pulses for the triggering of the time-base generator. The characteristic of the tunnel diode is shown at Fig. 45. Typical values for V_{peak} and V_{valley} resp. are 60 mV and 350 mV at $I_{\text{peak}} = 10 \text{ mA}$ and $I_{\text{valley}} = 1,3 \text{ mA}$. Another important point is V_{ff} (500 mV), at which the current is again I_{peak} . Consider a voltage-source V_s connected to the tunnel diode via resistor R , Fig. 46. V_s and R can be selected so that the load-line crosses the characteristic at 3 point. viz. A, B, C, Fig. 47. A and B are stable points of adjustment, C is not stable. If the voltage increases to V_s' , the load-line will shift parallel to itself until it cuts the characteristic only at one point, B'. A decrease of V_s gives V_s'' and A'. A single point of intersection can also be obtained by decreasing R , so that B'' is gained. Suppose the voltage-source and series-resistor to be adjusted so that point A of the load-line ABC is obtained. The current "i" through the circuit equi equals " i_A ",

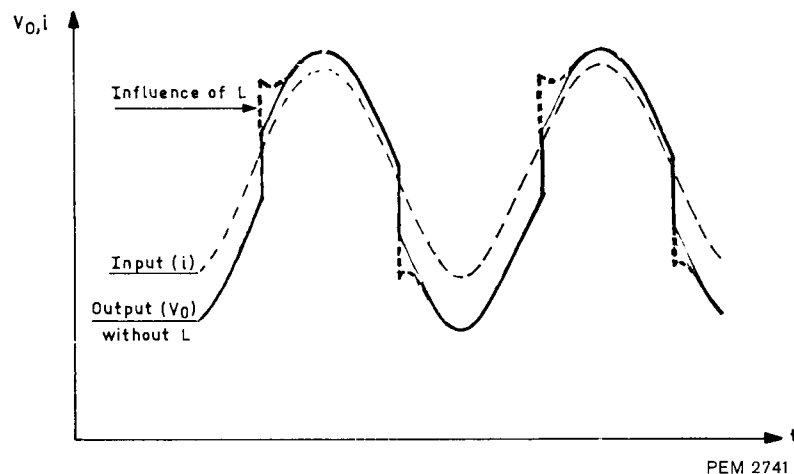
the voltage-drop over the tunnel diode amounts to V_T and the voltage-drop over the resistor to V_R .

If V_s increases to V_s' point A will follow the diode characteristic until "i" just surpasses I_{peak} . Then the voltage-drop over the tunnel diode will suddenly increase from V_{peak} to $V_{T'}$ due to the characteristics of the diode.

The transistion from V_T to $V_{T'}$ happens vary fast, about 1 nano-second, and is a property of the tunnel-diode itself.

If V_s decreases again, point B' will follow the diode characteristic until "i" equals I_{valley} . Then the diode switches from V_{valley} to V_T .

When an alternating voltage is superimposed on the DC-bias V_s , the voltage over the tunnel-diode will be an alternating voltage with very steep sides. This effect can be extended by providing an AC-impedance formed by an inductance (see Fig. 48). The L/R time-constant must be high compared with the speed of transition but low compared with the applied AC. Then the diode switches from V_{peak} to V_{ff} .



PEM 2741

Fig. 48. Transient peaking

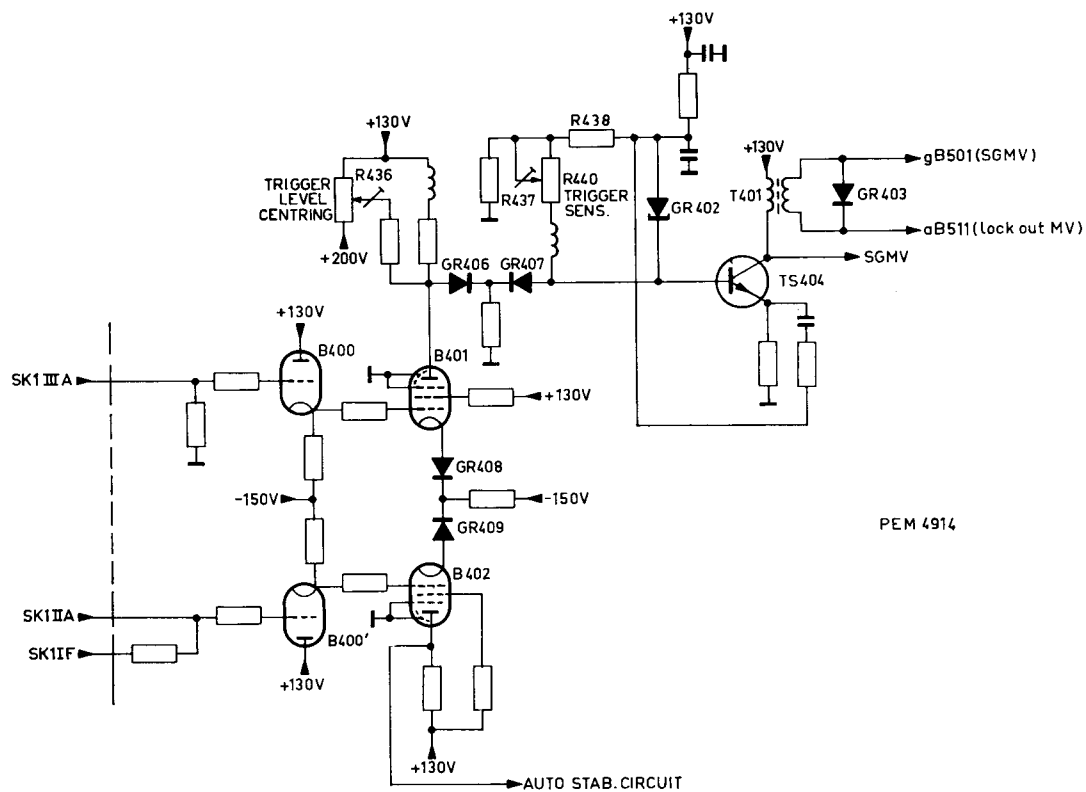


Fig. 49. Pulse former stage

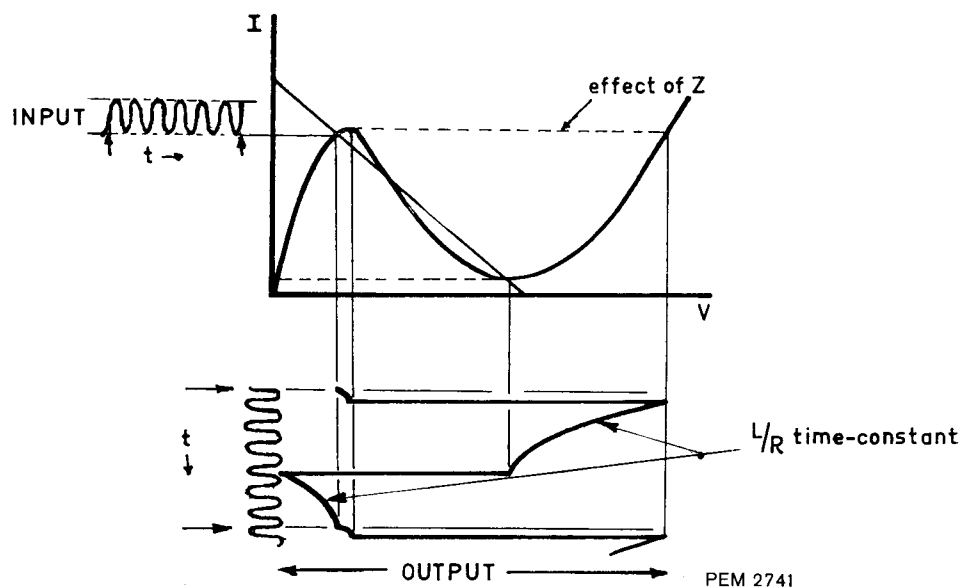


Fig. 50. Frequency dividing

In the actual circuit, Fig. 49, V_s is formed by the voltage drop across R438, the load resistance R is represented by R440 "TRIGG. SENS". The tunnel diode circuit is coupled to the anode of B401 via diode switch GR406-GR407. In quiescent condition both diodes are turned on, thus connecting the tunnel diode direct to the anode.

When polarity switch SK2 ($\pm$) is in position "+" and a positive-going signal arrives at the control-grid of B401, the anode voltage will decrease and GR406 is cut-off. As a result the current through the tunnel diode increases and, assuming that the tunnel diode was in stable state "A" (Fig. 47), it will switch over, via V_{FF} , to stable state "B". Thus a positive-going voltage-step is offered to transistor TS404. When the input signal goes negative, the anode voltage will increase until the diode switch is again in equilibrium. Next, diode GR406 will be conductive, but GR407 is cut-off when the input signal is still going further negative. Meanwhile, the tunnel diode switches over from stable state "B", via V_{valley} , to stable state "A".

On the whole it may be stated that the voltage-swing of V_s is limited by the action of the diode switch. The equilibrium of the diode switch in quiescent condition can be adjusted by R436 "TRIGG. LEVEL CENTRING".

The tunnel diode circuit also functions as a frequency divider for trigger inputs with very high repetition rates because the diode has a maximum switching rate due to its L/R time constant. See also Fig. 50.

Transistor TS404 amplifies the small voltage drop across the tunnel diode to about 2 V, necessary to drive the SGMV. Pulse transformer T401 reverses and differentiates the signal, after which the positive-going pulses are short-circuited by diode GR403. The remaining negative-going spikes (Fig. 51) are used to trigger the SGMV.

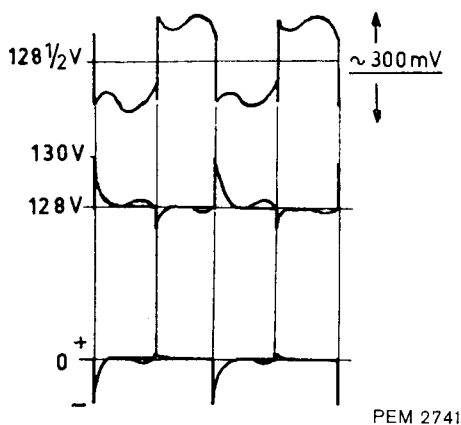


Fig. 51. Output of pulse former stage

6. Trigger level selection

After a preliminary adjustment of R436 "TRIGG. LEVEL CENTRING", the point of equilibrium of diode switch GR406-GR407 will be influenced by the average anode current of B401. When SK1 "TRIGGER MODE" is in position "DC", "LF" or "HF" the anode current can be varied via B402 and B400' by means of "LEVEL" potentiometer R2. It is thus possible to start the sweep at any desired level on the displayed waveform.

By operating switch SK2 ($\pm$) the signals which arrive at the control grids of B400 and B400' are interchanged. As the signals are in phase-opposition, the starting point of the sweep is shifted 180° .

H. TRIGGER AMPLIFIER (Fig. 85)

The trigger amplifier is fitted to provide the trigger unit A with control signals having an adequate amplitude. The amplifier is a push-pull type, delivering two signals which are in phase-opposition.

The first stage consists of a hybrid circuit viz. cathode-follower B451 and emitter-followers TS451, 452, thus having an output impedance low enough to drive the amplifier stage.

The latter is constructed as a series- and shunt-feedback amplifier containing transistors TS453, TS454, TS456, TS457. To balance the output voltage, extra current is fed into the shunt-feedback stage from potentiometer R485. The d.c. level of the output voltage is adjustable by means of potentiometer R484.

The amplifier drives the output stage, which is provided with two complementary emitter-followers (TS458, TS459 or TS461, TS462) to obtain a push-pull output capable to charge and discharge rapidly the input capacitance of the subsequent circuits.

Diodes GR451...GR454 also determine the d.c. setting of the output emitter followers.

With trimmer C450 the input capacitance of the trigger amplifier can be adjusted. To achieve good triggering in the AC positions of the trigger mode switch, when the entire trace is shifted, DC feedback has been applied. The DC feedback is obtained by 2 electrolytic capacitors in the emitter circuit of TS453-TS454. These capacitors are short-circuited when either SK1 "TRIGG. MODE" is in position "DC" or SK7 "X-DEFL." is in position "X-UNIT".

VI. Gaining access to the parts

A. DETACHING THE SIDE PANELS

Caution!

Very high voltages are generated in this instrument, so that, when effecting repairs to the inside of the instrument, great care should be taken.

The instrument has one plate on each side, each fixed with two fasteners A Fig. 2.

Loosen the fasteners and pull the panels away from the frame.

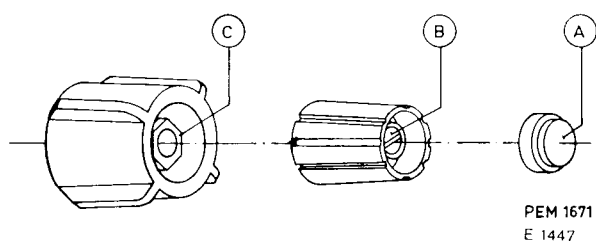


Fig. 52. Remove the knobs

B. REMOVING THE KNOBS (See Fig. 52)

1. Single knobs

- Remove cap A
- Loosen screw B
- Pull the knob off the spindle

2. Double knobs

- Remove cap A
- Remove screw B
- Remove the inner knob
- Loosen nut C
- Pull the outer knob off the spindle

C. REMOVING THE BEZEL

- Grip the bezel and pull back the lower part
- Remove the bezel

D. DETACHING THE REAR PANEL (See Fig. 2)

- Remove the six fixing screws B
- Pull the panel away from the frame

VII. Maintenance

A. AIR FILTER (see Fig. 53)

In particular when the instrument is used in a dusty environment the filtermats should be replaced or cleaned at regular intervals. Cleaning is done in the easiest way with the aid of a vacuum cleaner. The filter holder can be bent downwards after removing the two fixing screws D. (see Fig. 2)

The filtermat can then be easily replaced.

B. SEGMENT SWITCHES

If, due to soiling, these switches should not function properly any longer, lubrication should never take place with switch-oil; only some acid-free vaseline may be applied.

After lubricating, the switch should be set to all positions a few times.

C. CABINET PLATES

If the plastic-covered cabinet plates are dirty, they can be washed with water and soap; if necessary with some abrasive powder.

D. PREVENTIVE INSPECTION

Due to the complicated character of the instrument, it is advised to check its operation at regular intervals e.g. every 500 working hours.

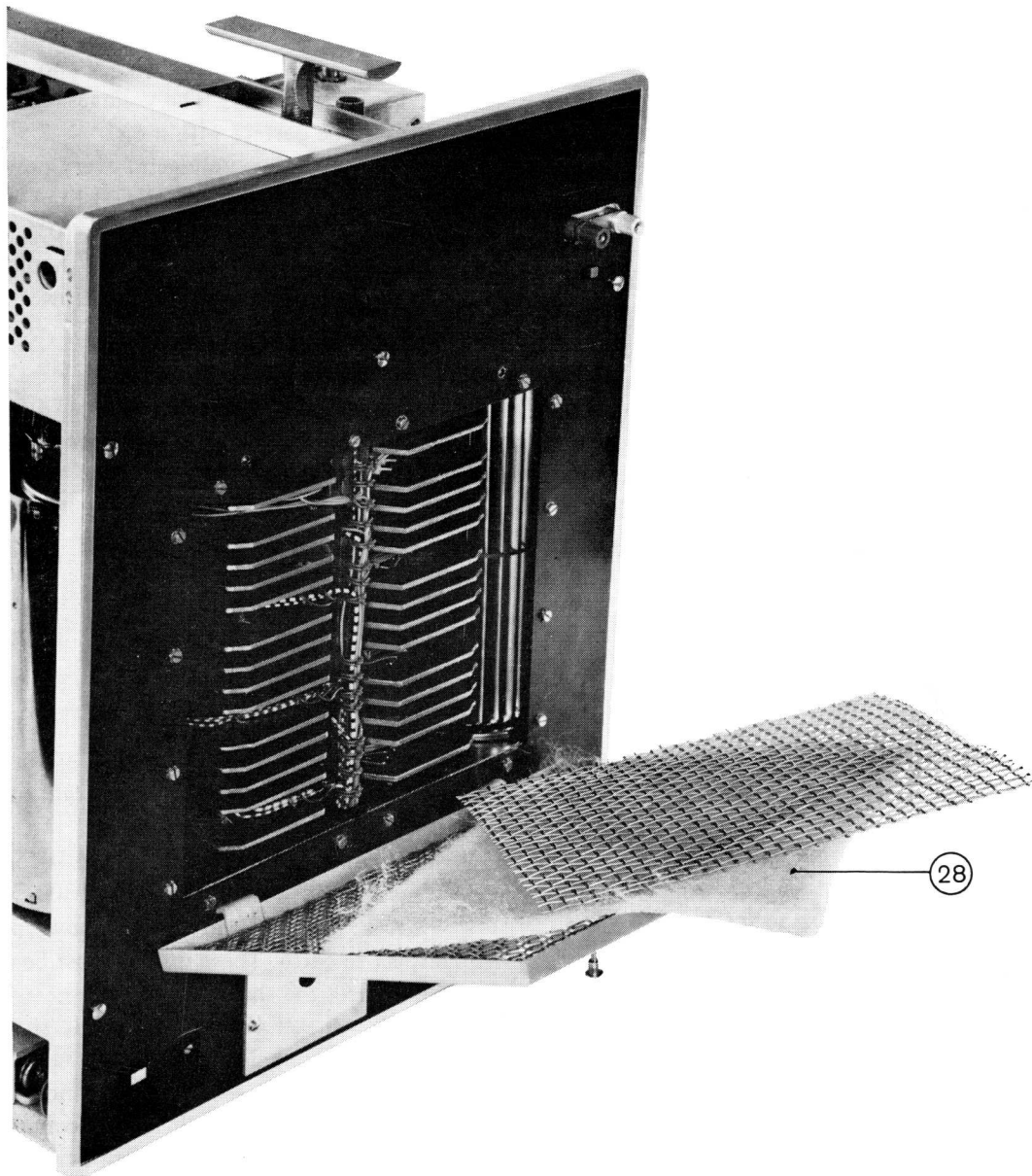


Fig. 53. Filter-mat

VIII. Checking and adjusting

The tolerances mentioned are factory tolerances; they apply when the apparatus is readjusted completely. They may differ from the data given in chapter I.

A. GENERAL INFORMATION

With the aid of these data, it is possible to carry out all the adjustments of the basic oscilloscope and to check the proper operation of the instrument. For checking and adjusting, a test-unit (PM 3361) is available. In this chapter is described how it should be used.

Various adjustments are interconnected. If such an adjustment is described prior to this, an indication will be given as to which previous adjustment is dependent on that adjustment. It is then necessary to check that previous adjustment.

For a complete adjustment of the instrument the sequence as described in this chapter is to be preferred.

Note: In cases where Y-plug-in unit PM 3333 is mentioned a Y-plug-in unit PM 3332 will do equally well.

B. SWITCHING-ON

With the mains voltage adapter the instrument should be adjusted to the local voltage.

- Plug test unit PM 3361 into the Y-plug-in compartment.
- Switch on the instrument with the switch "POWER ON".

The white pilot lamp LA8 should light up and both fans should rotate.

- Check that after 25...35 seconds, the supply voltages are switched on by relay RE1002. The "READY" lamp should light up.

C. LOW SUPPLY VOLTAGES

If it is necessary to readjust the supply voltages, then the adjustments of the time-coefficients, the calibration voltage and the high supply voltage should be checked again.

The low supply voltages may be checked with test-unit PM 3361; the latter should be plugged into the Y-plug-in compartment. By this, the power supplies can be nominally loaded.

- Set switch "X-DEFLECTION" (SK7) to "SINGLE" and "AMPL. CAL" (SK13) to "OFF".
- Set the test-selector of the test-unit to "POWER SUPPLY" and adjust the measuring range to "—150".

R 1098 (Fig. 71)

- By means of the adjusting potentiometer "—150 V" (R1098) precisely adjust the voltage to the correct value. At the meter of the test-unit this is indicated by the figure 0.
- Check the ripple voltage on the —150 V voltage with an oscilloscope, connected to the terminals "RIPPLE" and " $\frac{1}{\infty}$ " of the test-unit.
At full load of the power supply (test-selector on the test-unit set to "HIGH LOAD") and at mains voltage fluctuations of + and —10%, the ripple voltage may not exceed 5 mV_{p-p}.
- Furthermore, check all the other supply voltages up to the +400 V voltage.
After correct adjustment of the —150 V voltage, the voltages +130 V, +200 V, +330 V and +400 V should be correct within a tolerance of 4%. The voltages +70 V, +6.3 V, —6.3 V and —70 V should be correct within 2%. The voltages +12 V and —12 V should be correct within 6%.
- Measure the ripple voltage of every power supply at full-load (test-selector to "HIGH LOAD"). At mains voltage fluctuations of + and —10%, the peak-to-peak value of the ripple voltage should not exceed the value indicated in the table below.

Power supply	Ripple voltage	If necessary, adjust with
+130 V	20 V _{p-p}	R1062
+200 V	40 mV _{p-p}	R1059
+330 V	75 mV _{p-p}	R1045
+400 V	80 mV _{p-p}	R1025
—70, —6.3, +6.3, +70 V	10 mV _{p-p}	—

If necessary, the short-circuit protection can be checked as follows.

- Short-circuit the +400 V to the —150 V voltage.
- Measure the voltage of the +400 V, +330 V, +200 V, +130 V and —150 V power supplies with respect to earth. These must almost be equal to 0 V.
- Disconnect the short-circuit
- Measure the +400 V voltage. It should have its normal value again.

The + and —70 V, + and —24 V and + and —6.3 V voltages should also regain their normal values after having been short-circuited to earth.

D. HIGH VOLTAGE SUPPLY

This voltage determines the deflection sensitivity of the CRT

If the high voltage is readjusted, it is necessary to check the horizontal and vertical sensitivity of the basic oscilloscope.

R 1326 (Fig. 54)

- Turn "INTENS" (R6) fully anti-clockwise.
- Measure the -1440 V voltage with respect to earth on winding S18 of the mains transformer (red wire). If necessary, adjust this voltage with potentiometer "HT ADJ." (R1326). The maximum hum must be less than $1.5 V_{p-p}$.
- The voltage on junction R1318-C1313 in the HT-unit should have a value between $+8300$ and $+8900$ V with respect to earth, after adjustment of the -1440 V voltage.

E. MAINS CURRENT

At a mains voltage of 200 V, 220 V or 245 V, the current consumption of the basic oscilloscope with Y-plug-in unit should not exceed 3.0 A, and at a mains voltage of 110 V, 125 V or 145 V it should not exceed 5.5 A.

F. CATHODE-RAY TUBE CIRCUIT

1. Level X-Y-plates

- Interconnect the X-deflection plates and the Y-deflection plates.

R 99 (Fig. 55)

- Measure the voltage difference between both pairs of plates. The voltage difference, which is adjustable with variable resistor R99, should not exceed 2 V.

R 320 (Fig. 54)

- The voltage difference between the interconnected Y-deflection plates and point g7 of the CRT (connection point 7 of the tube holder) should be adjusted to 0 V with potentiometer "SHIELD" (320)
- Remove the interconnections.

2. Beam centring R314 (Fig. 54)

- Set "X-DEFLECTION" (SK7) to "50 Hz".
- Adjust R6 "INTENS" to maximum brightness and R10 "AMPL. 50 Hz" to maximum deflection.
- Adjust R314 "BEAM CENTRING" so that the screen shows no bright blurs (due to electron scattering by the X-plates), when the line is shifted to the extreme left and right sides by "SHIFT" potentiometer R4.

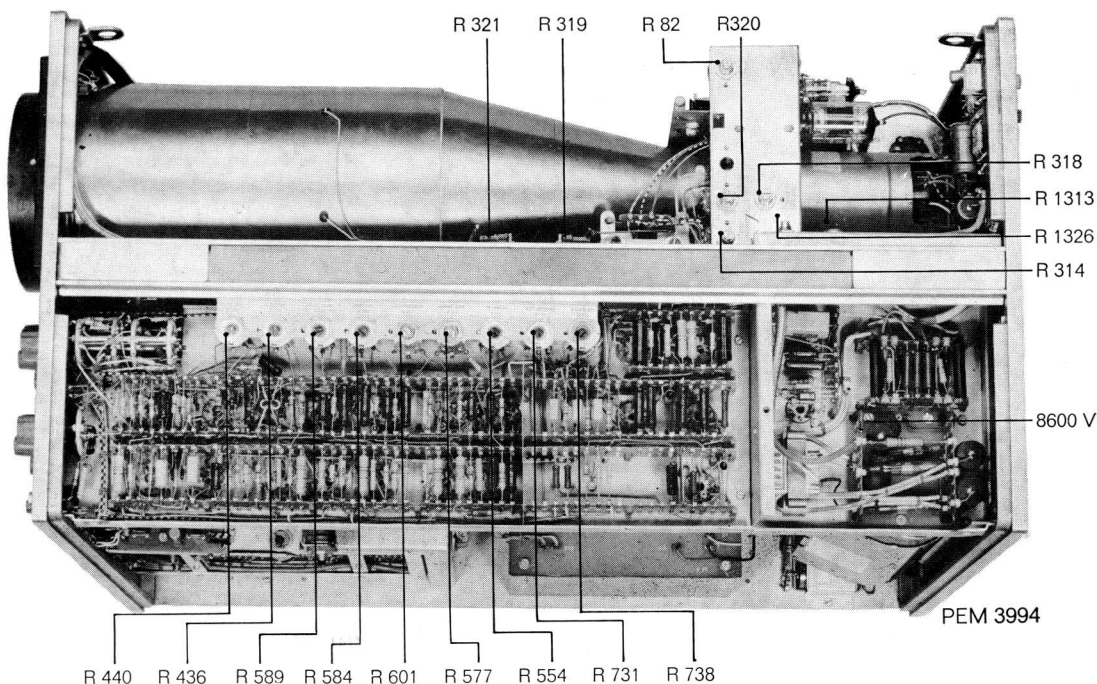


Fig. 54. Top-view of the interior

3. Intensity

R1313 (Fig. 54) R302 (Fig. 56) R306 (Fig. 69)

- "X-DEFLECTION" (SK7) to "50 Hz".
- "INTENS" (R6) to point 3 of the scale.
- Adjust potentiometer "INTENS" (1313) so that the time-base line is just not visible.
- Turn "INTENS" (R6) fully clockwise.
- Select such a value for resistor R302 that the voltage over R308 (Fig. 80) is 6,8 Volts (cathode current is 250 μ A)
- After selecting the correct value for R302, check the adjustment of R1313; if necessary readjust this potentiometer.
- Set SK7 to "TIME BASE A" "Time/cm" (SK4) to "10 msec/cm", "TRIGG. MODE" (SK1) to "AUT." SK3 to "50 Hz".
- Adjust R6 to low intensity.
- Adjust R306 to minimum beam-modulation.

4. Trace rotation

R319-R321 (Fig. 54)

- Check that the mechanical alignment of the measuring graticule is correct. If necessary the CRT can be rotated until the graticule is in the correct position. (Loosen screws A, fig. 69)
- Display a time-base line and adjust the potentiometers

"TRACE ROTATION" (R319 – 321) so, that the time-base line is written parallel to the horizontal lines of the graticule. (See also point F8)

5. Focus and astigmatism

R324 (Fig. 56)

- Insert a Y-plug-in unit into the Y-plug-in compartment. (Any unit except the test-unit will do).
- Apply a sine-wave voltage to the Y-unit.
- Adjust time-base A for a triggered display and adjust the trace height to 6 cm.
- It should be possible to adjust for a clearly defined trace with potentiometers "FOCUS" (R7) and "ASTIGMATISM" (R8).

The potentiometer "FOCUS" should be approximately in its centre position. If necessary, select a different value for R324.

6. CRT Geometry (Fig. 58)

R318 (Fig. 54)

This adjustment slightly influences the deflection sensitivity of the CRT.

If the geometry is readjusted, it is necessary to check the horizontal and vertical deflection sensitivity of the basic oscilloscope.

Apply a square-wave voltage (e.g. the calibration voltage) to the Y-plug-in unit and adjust the peak-to-

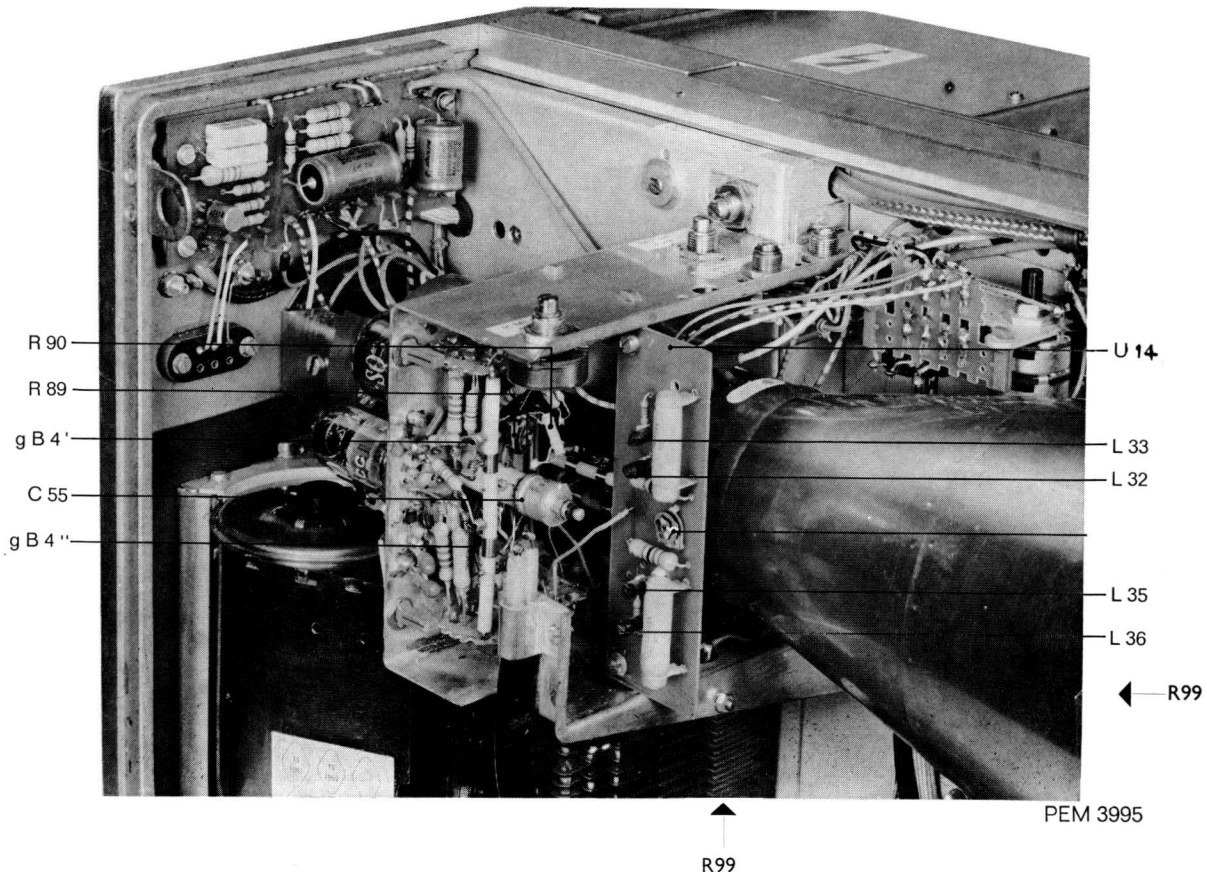


Fig. 55. Close-up of the final stage of the Y-amplifier (U14)

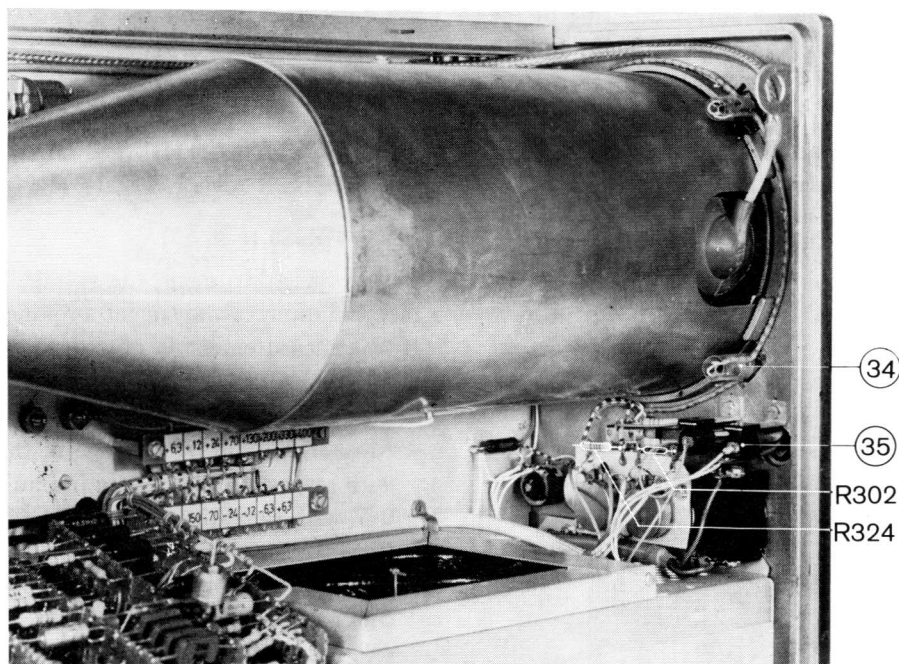


Fig. 56. Close-up of the rear of the CRT controls

peak value of this voltage so that a vertical deflection of ≥ 18 cm is obtained.

Potentiometer "PATT. DIST." (R318) should then be adjusted for minimum curvature of the vertical lines. See also Fig. 58.

7. Symmetrical deflection

R328 (Fig. 57)

- Set "X-DEFLECTION" (SK7) to "50 Hz" and turn "AMPL." (R10) fully clockwise.
- Apply a sine-wave voltage with a frequency of 100 kHz and a peak-to-peak value for 20 cm deflection to the Y-plug-in unit.
- Adjust "SYMMETR." (R328) so, that in vertical direction the display is symmetrical with respect to the measuring graticule.

8. Orthogonality

R327 (Fig. 57)

Before this adjustment is carried out, it is necessary that the geometry has been well-adjusted (see point F6). Set switch "X-DEFLECTION" (SK7) to "50 Hz" and adjust the horizontal deflection to 6 cm with "AMPL." (R10).

Apply a sine-wave voltage with a frequency of 100 kHz the Y-plug-in unit and also adjust the deflection to 6 cm.

Adjust potentiometer "PERPENDICULARITY" (R327) so, that the sides of the display are perpendicular to each other. Check this with the aid of the measuring graticule on the CRT.

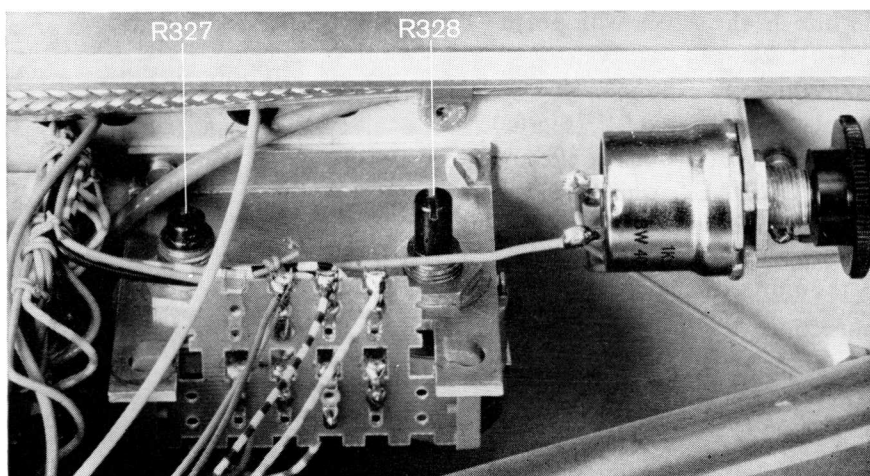


Fig. 57. Close-up of the "Perpendicular" and "Symmetry" control

During the adjustment, always adjust one side of the display parallel to the horizontal graticule lines with "TRACE ROTATION" (R319–R321) and adjust the deviation of the other side of the display to minimum with R327. After correct adjustment of R327, all sides of the display should be parallel to the graticule lines

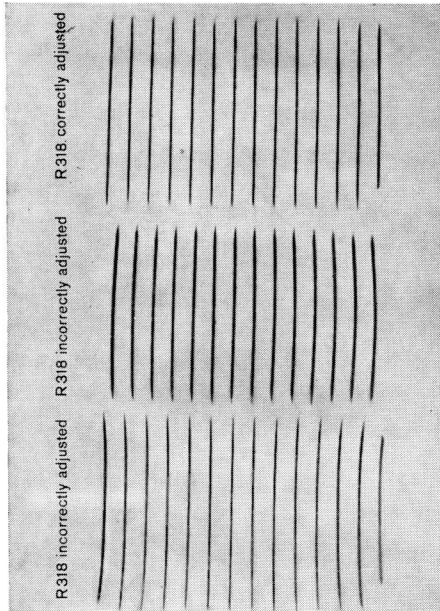


Fig. 58. Adjustment of "Pattern distortion" control

G. ADJUSTING THE DC BALANCE OF THE Y-AMPLIFIER

R82 (Fig. 54) R39 (Fig. 62)

Before carrying out this adjustment, first make sure that the "TRACE ROTATION" (point F4) and the Symmetrical deflection (point F7) adjustments are correctly adjusted.

- Set the knobs mentioned below to the following positions: "X-DEFLECTION" (SK7) to "50 Hz" "50 Hz AMPL." (R10) "CLOCKWISE"
- Interconnect the control grids of B4' and B4" (Fig. 5)
- Adjust "INTENS." (R6) for normal intensity.
- Centre the time-base line on the screen with potentiometer "DC-BAL.II" (R82).
- Remove the interconnection
- Interconnect the control grids of B1 and B1'. (Fig. 62) When using the test-unit PM 3361 this can be effected by depressing button "DC-BAL." while the test selector is in position "POWER SUPPLY".
- Centre the time-base line on the screen with potentiometer "DC-BAL. I" (R39).
- Remove the interconnection.

H. ADJUSTING THE DC BALANCE OF THE X-AMPLIFIER

R731 (Fig. 54)

- Short-circuit the control grid of B705 (point 7 of the valve support) to earth.

- Centre the spot on the screen with potentiometer "X.DC-BAL." (R731).
- Remove the interconnection.

J. ADJUSTING THE DC BALANCE OF THE TRIGGER AMPLIFIER

R484-R485 (Fig. 53)

Before this adjustment, the voltage levels on the symmetrical input of the trigger amplifier should be equal. If this measurement is not carried out with test-unit PM3361 in the basic oscilloscope, it necessary to interconnect the control grids of B451" and B451'.

- Measure the output voltage of the trigger amplifier with respect to each other and adjust this voltage to 0 V with potentiometer "TRIGG. DC. LEVEL II" (R485).
- Measure the voltage level of the amplifier with respect to earth and adjust with the aid of potentiometer "TRIGG. DC. LEVEL I" (R484) to 0 V.

K. INTENSITY MODULATION

1. External

- Remove the earthing strip between the terminals "EXT." (BU9) and "⊥" (BU10) on the rear of the instrument.
- Set switch "Z.MOD." (SK14) to position "EXT.".
- Apply a sine-wave voltage of 15 V_{p-p}, frequency 10 kHz, to terminal "EXT.".
- Apply the same voltage to the input of the Y-plug-in unit.
- Adjust "TIME-BASE A" for a triggered display. With correct adjustment of potentiometer "INTENS" (R6) an intensity-modulated trace should be visible.
- Remove the applied voltage from BU9 and the Y-input and connect the earthing strip again.

2. Multi-trace chopper

This check can be carried with the aid of test-unit

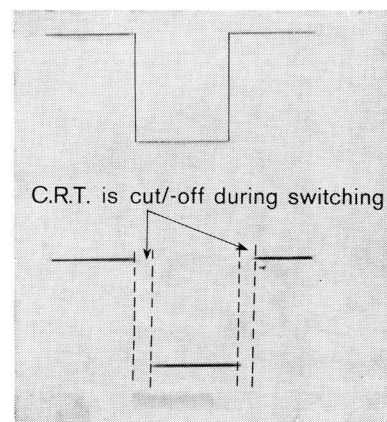


Fig. 59. Z-modulation when operating in the "chopped" mode

PM3361, the test-selector of which should be in position "BLANKING" (CHOPPED).

- Adjust "TIME-BASE A" so that it triggers on the chopper frequency.
- Set "Z.MOD." (SK14) to position "MULTI-TRACE CHOPPER". The edges of the switching pulses should not be visible.

If this measurement is carried out with a multi-trace plug-in unit (e.g. PM 3342), it is not possible to trigger on the chopper frequency internally. In this case the blanking can be checked by making sure that the haze between both time-base lines disappears in position "MULTI-TRACE CHOPPER" of SK14. (Fig. 2).

- Set switch "Z.MOD." to position "EXT." again.

L. ALTERNATE

This check can be carried out with test-unit PM 3361 the test-selector of which should be in position "ALTERNATE". If a multi-trace plug-in unit is used this should also be set position "ALTERNATE."

- Set "TIME-BASE A" to free-running with a time-coefficient of 1 $\mu\text{sec./cm}$.
- Check that the chopper is controlled by a pulse from "TIME-BASE A". In this case two complete time-base lines should be displayed.

M. Y-AMPLIFIER

For adjusting the deflection coefficient and H.F. square wave response of the Y-amplifier, two square-wave voltages in anti-phase having a value of 600 mV_{p-p} on an 18 V d.c. level and a rise-time of 2.5 nsec. are required. These voltages are supplied by test-unit PM 3361. Switch SK5 of the test-unit signal should be adjusted to 20 kHz.

1. LF squarewave response

R32 (Fig. 53)

- Insert a Y-plug in unit and apply a square wave voltage having a frequency of 20 kHz.
- Adjust "TIME-BASE A" to obtain a triggered display. Time coefficient: 10 $\mu\text{sec./cm}$.
- Adjust potentiometer R32 "SQUAREWAVE ADJ." so that no tilt is visible.

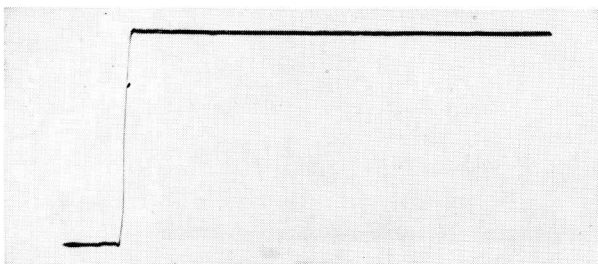


Fig. 60. Vertical amplifier correctly adjusted

2. Deflection coefficient

R89 (Fig. 55)

- Insert test-unit PM 3361.
- Set the test-selector to position "CAL./4 cm".
- Adjust "TIME BASE A" to its free-running position; time coefficient .2 $\mu\text{sec./cm}$.
- The sensitivity should be so that a vertical deflection of 4 cm is obtained; tolerance 2.5%. This can be adjusted with potentiometer R89.

3. HF square-wave response

- Set the test-selector to position "RISE TIME".
- Adjust "TIME-BASE A" for a triggered display; time coefficient .05 $\mu\text{sec./cm}$.
- The reproduced square-wave voltage should have a flat top. The overshoot should not exceed 1% and the rise time should be minimum.

If the amplifier does not meet the above requirements, it can be readjusted as follows.

- Set the frequency of the test-unit signal to 500 kc/s.

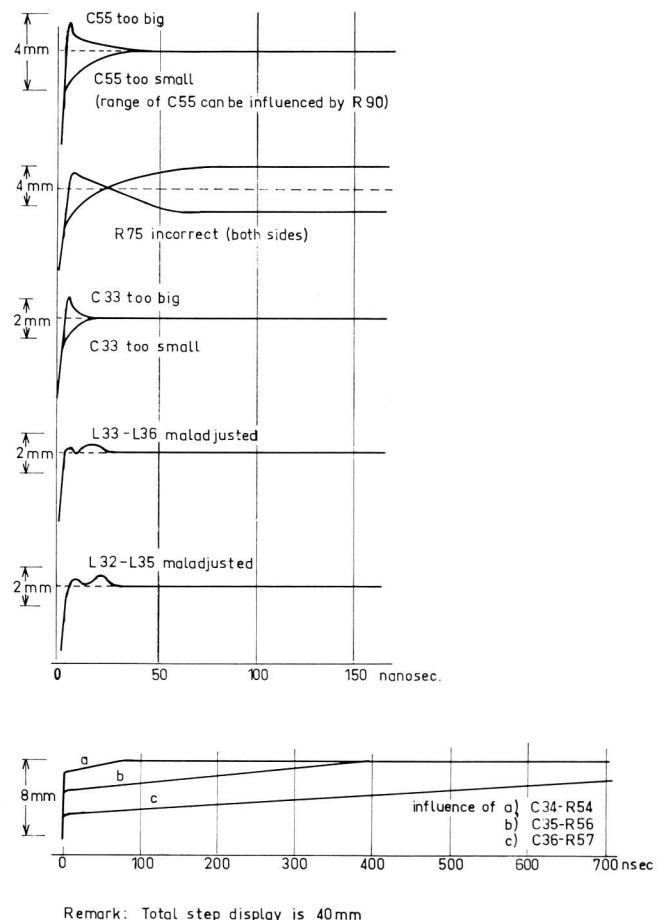


Fig. 61. Y-amplifier adjustment

C33-C34-C35-C36-R51-R53-R54-R56 (Fig. 62)

C55-L32-L33-L35-L36-R75-R90 (Fig. 55)

- Adjust "TIME-BASE A" to obtain a triggered display. Time-coefficient: $0.05 \mu\text{sec/cm}$.
- Simultaneously adjust C55 and R75 (Fig. 55) to a minimum rise-time ($\geq 6 \text{ nsec.}$) and a flat top of the squarewave. The influence of C55 can be restricted or increased by changing the value of R90 (Fig. 55). The transition between the leading edge and the flat top of the display can be squared and flattened out by C33 and R53.
- If necessary, adjust L32-L35 and/or L33-L36 to minimum distortion, due to reflections. (First 20 ns)
- If any tubes or transistors have been replaced it is possible that the H.F. components should be boosted. This can be done by varying the time constant of C36-R51 for the first 1500 ns, C35-R56 for the first 400 ns., C34-R54 for the first 75 ns. This necessitates a complete check of the H.F. squarewave response.
- Replace the test unit by a Y plug-in unit.
- Apply square wave voltage with frequencies of 10 kHz and 10 Hz to the Y-amplifier.
- At these frequencies check the squarewave response; the top should be flat.

4. Frequency-response curve

After the Y-amplifier has been adjusted for correct square-wave response (see M3) the frequency response curve of the basic amplifier together with Y-plug-in unit PM 3333 should be so that the -3dB point lies at a frequency which exceeds 60 MHz.

The frequency response curve can be measured with,

for instance, the PHILIPS AM-FM generator GM2621 and the PHILIPS HF millivoltmeter GM 6025.

The voltage with the reference frequency and the 60 MHz frequency, which are applied to the Y-plug-in unit to check the -3dB point, should be exactly equal. During this measurement the measuring pin of the probe should be connected to the centre contact of the "AC-DC" switch in the plug-in unit; the housing of the probe should directly be earthed, so without the use of an earthing cable (see Fig. 63).

- Set the deflection coefficient of the plug-in unit to 10 mV/cm .
- Connect output socket "HF II" of the auxiliary generator via a terminated $50\text{-}\Omega$ cable to the input of the Y-plug-in unit.
- Adjust the frequency to 4.5 MHz.
- Adjust the generator voltage for a 6 cm deflection.
- Increase the frequency to 60 MHz; with the same value of the input voltage, the vertical deflection should exceed 4.2 cm.

5. Deflection and shift

- Insert the Y-plug-in unit PM 3333 into the plug-in compartment of the basic oscilloscope and adjust its "GAIN ADJ." and "DC-BAL."
- Adjust the deflection coefficient to " 10 mV/cm ".
- Apply a triangular or sine-wave voltage with a value of $180 \text{ mV}_{\text{p-p}}$ and a frequency of approximately 2 kHz to the input.
- With the vertical SHIFT control it must be possible to display the upper and lower peaks of the signal within the measuring graticule.
- With this triple over-driving no distortion of the trace should occur.

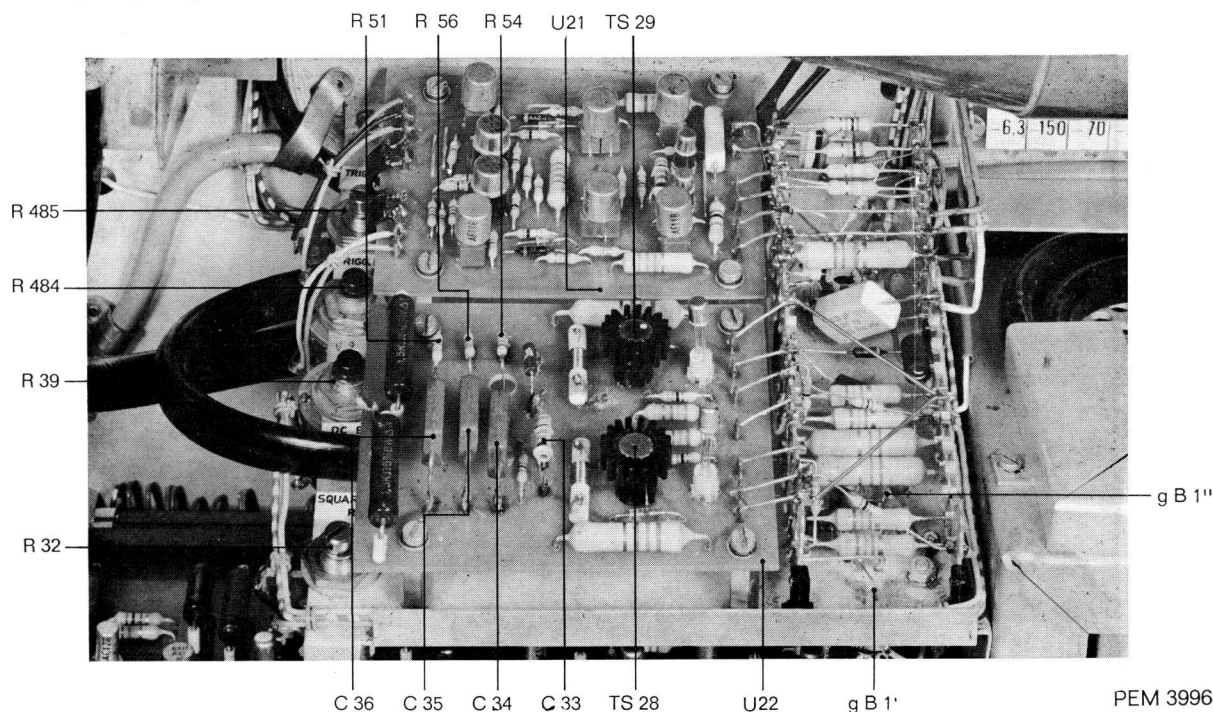


Fig. 62. Close-up of the delay line driver and the trigger amplifier

PEM 3996

N. CALIBRATION VOLTAGE AND CURRENT

R1411 (Fig. 3)

- Set "AMPL. CAL." (SK12) to position "80" and SK13 to position "OFF".
- Measure the DC-voltage at the testpoint "Cal testpoint +80 V" (Fig. 3) with respect to earth and with "CAL. AMPL." (R1411) adjust this voltage to 80 V; tolerance $< 0.5\%$.

The accuracy of the calibration voltages and of the calibration current are, after adjusting the 80 V, determined by the precision resistors of the attenuator.

- In all position of SK12, check that on socket "AMPL. CAL." (BU6) a square-wave voltage is available with a frequency of 2 kHz.

In one of the positions of SK12, also check the 1 : 1000 attenuation of the calibration voltage on BU6 with SK13 in position "mV".

- Measure the symmetry of the square-wave voltage

by connecting a DC-voltmeter to BU6 and measuring the average value.

This should be equal to half the peak-to-peak value (within 10%) of the calibration voltage which is indicated on the text plate.

- Set SK13 to position "4 mA".

A square wave current should flow through the current bracket with the same frequency and pulse shape as the calibration voltage.

- Check that a square wave voltage approx. $0.5 V_{p-p}$, rise time ± 70 nsec. (to be used for the adjustment of HF probe PM 9332 A/10) is present.
- Set SK13 to position "OFF".

There should be no voltage on output socket BU6.

O. X-AMPLIFIER

The sensitivity of the time-base amplifier is so adjusted, that, when driving this amplifier with the time-base generator, the correct time coefficient is obtained.

To measure the time coefficient, a number of voltages with accurately known frequencies are required.

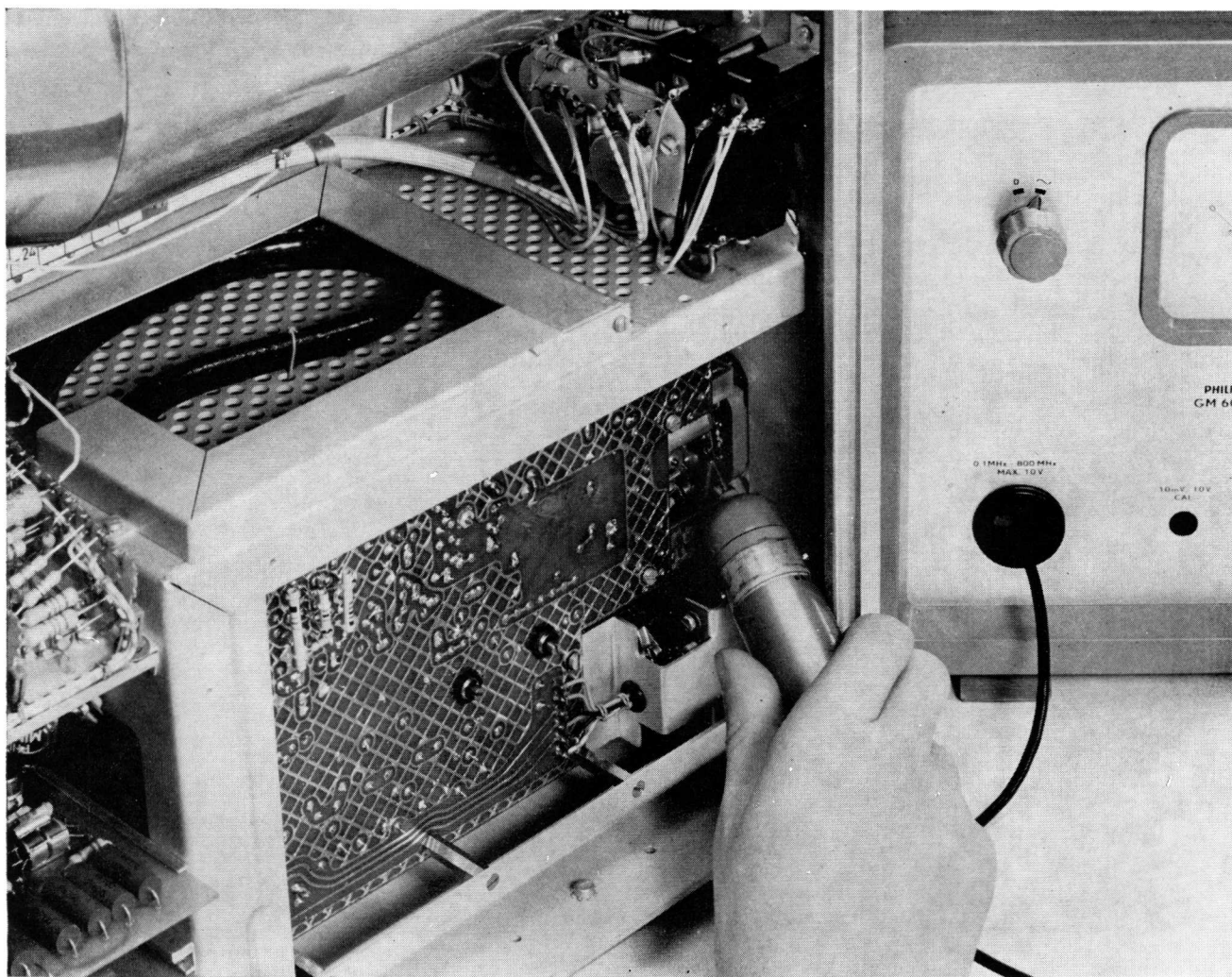


Fig. 63. Measuring the frequency characteristic

1. Deflection coefficient

R738-R554 (Fig. 54)

- Insert unit PM 3333 into the Y-plug-in compartment; apply time markers at intervals of precisely 1 msec. to the input of the Y-unit.
- Set the following knobs to the indicated positions:
 "TIME/cm" (SK4) to "1 msec/cm".
 "MAGNIFIER" (SK8) to " $\times 1$ ".
 "TIME/cm" (R1) to "CAL."
- Adjust "LEVEL" (R2) for a stationary display.
- Adjust the sensitivity with potentiometer "X-GAIN ADJ." (R738) so, that 8 pulses have a width of exactly 8 cm (symmetric with respect to the centre of the screen).

For the following points 2 and 3 it is necessary that the potentiometer "TB LENGTH" (R554) has been properly adjusted (see point Q7).

2. Output preamplifier

R714 (Fig. 3)

- Set time-base A to its free-running position and adjust the time-base line symmetrically with respect to the centre of the screen with "SHIFT" (R4-R5)

- Set "X-DEFLECTION" (SK7) to position "EXT." and connect socket "EXT." (BU5) to earth.
- With "X-PREAMPL. LEVEL" (R714) adjust the output level of the preamplifier so, that the spot is in the centre of the screen.
- Remove the earthing connection from BU5.

3. Horizontal shift

- Set time-base A to its free-running position and adjust "MAGNIFIER" (SK8) to position " $\times 1$ ".
- With "SHIFT" (R4-R5) it should be possible to place the beginning and the end of the time-base line over the centre of the screen.
- With "VERNIER" (R5) it should be possible to shift the trace approximately 2.5 cm.

4. Square-wave response

C707 (Fig. 64) C701 (Fig. 3)

- Set the time-coefficient of time-base A to ".2 msec/cm".
- Apply the sawtooth voltage from time-base A (BU3) to the Y-plug-in unit, the deflection coefficient of which has been adjusted to "20 V/cm".

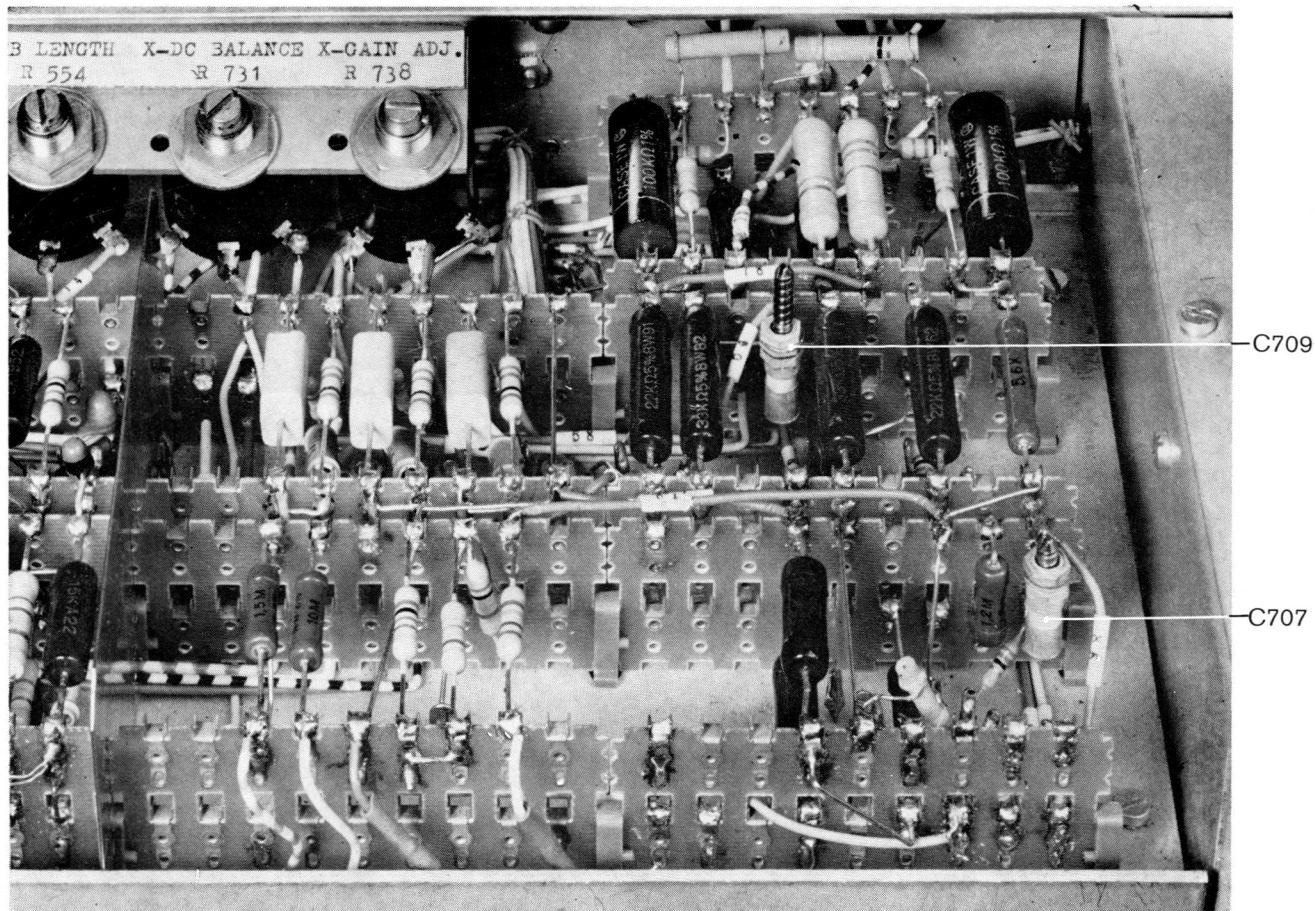
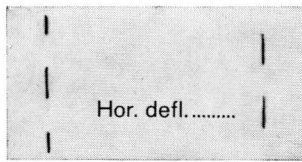


Fig. 64. Close-up of the X-amplifier

- Apply a square-wave voltage of 4 V_{p-p} to the X-amplifier by connecting calibration voltage socket BU6 terminal "EXT." (BU5).
- Apply this voltage also to terminal "TRIGG." (BU1) to trigger time-base A externally.
- Set "X-DEFLECTION" (SK7) to position "EXT."
- After having adjusted for a stationary display, trimmer C707 should be adjusted for optimum reproduction of the square-wave.
- The deflection coefficient on socket "EXT." (BU5) should amount to .5 V/cm; tolerance 10%.
So the length of the time-base line amounts to 7.2...8.8 cm.

Fig. 65. X-amplifier step-response



Horizontal deflection with voltage of 4 V and 40 resp. applied to "EXT." (BU5); SK7 in positions "EXT." and "1 : 10 EXT." respectively.

- Set "X-DEFLECTION" (SK7) to position "1 : 10 EXT."
- Increase the input voltage to 40 V_{p-p} and adjust trimmer C701 for optimum reproduction of the square-wave voltage.
- In position "1 : 10 EXT." the deflection coefficient on terminal "EXT." (BU5) should amount to 5 V/cm tolerance 10% (the length of the time-base line should amount to 7.2...8.8 cm). "MAGNIFIER" (SK8) should have no influence on the display in both positions of SK7.

5. Frequency-response curve of the preamplifier.

- Set "X-DEFLECTION" (SK7) to position "EXT."
- Apply a sine-wave voltage with a frequency f kHz to terminal "EXT." (BU5) with such an amplitude that a horizontal deflection of 8 cm is obtained.
- Increase the frequency of the input voltage to 1 MHz (keep the amplitude constant); the horizontal deflection should then exceed 5.6 cm.

6. 50 Hz X-deflection

- Set "X-DEFLECTION" (SK7) to position "50 Hz"
- It should be possible to adjust for a horizontal deflection from $0 \geq 8$ cm with potentiometer R10. In this position of SK7, "MAGNIFIER" (SK8) should have no influence on the display.

P. BEAMFINDER

Before carrying out this check, it is necessary that the sensitivity of the X- and Y-amplifier has been correctly adjusted (see points L1 and N1).

Y-direction

- Turn the "SHIFT" control of the Y-plug-in unit fully clockwise and fully anti-clockwise, resp.
- Without an input signal, check that by depressing "BEAMFINDER" (SK10), the sensitivity of the Y-amplifier is decreased so, that in both extreme positions of the "SHIFT" control the time-base line is displayed within the measuring graticule.

X-direction

- Set "X-DEFLECTION" (SK7) to "TIMEBASE A".
- Set "STABILITY" (R3) to "PRESET" and "TRIGGER MODE" (SK1) to "HF".
Without an input signal on the Y-plug-in unit, no trace may be visible.
- Check that by depressing "BEAMFINDER" (SK10) the time-base generator is set to its free-running position and that the time-base line is displayed on the screen.
At the same time, horizontal sensitivity should be so reduced that the deflection does not exceed 5 cm.

Q. TIME-BASE A AND TRIGGER UNIT

For the next checking and adjusting points, the below-mentioned switches should be set to the following positions.

- "TRIGGER MODE" (SK1) to "LF"
- "TRIGGER SOURCE" (SK3) to "INT."
- "X-DEFLECTION" (SK7) to "TIME-BASE A"
- "MAGNIFIER" (SK8) to " $\times 1$ "
- "STABILITY" (R3) to "PRESET"

If a different position is required, this is indicated in the description of the regarding check-up or adjustment.

1. Stability

R577 (Fig. 54)

- Set "LEVEL" (R2) to the centre position.
- Apply a sine-wave voltage with a frequency of 10 Hz to Y-plug-in unit PM 3333 and adjust the trace-height to 3 cm.
- Set "TIME/cm" (SK4) to position "1 msec/cm".
- Turn potentiometer "PRESET STAB." (R577) fully clockwise. From this position, turn anti-clockwise till a well-triggered display is obtained.
- Check the triggering with different time coefficients: no dual traces should occur. If necessary R577 should be slightly readjusted.

- Plug the DELAY TIME BASE unit PM 3347 into the X-compartment and set SK6 to "SETS A READY", SK7 to "A DEL'D BY B."
- Set "X-DEFLECTION" (SK7) on the basic oscilloscope to "X-UNIT", R3 to "PRESET" and SK1 to "LF".
- Check that a properly triggered display is obtained at various settings of "TIME/cm" (SK4); if necessary readjust R577.

2. Trigger sensitivity

R440-R436 (Fig. 54)

- Set "STABILITY" (R3) to "PRESET".
- Set SK4 to .1 msec/cm.
- Switch "LEVEL" off by short-circuiting the cursor of R2 to earth.
- Apply such a voltage to Y-plug-in unit PM 3333 that the trace-height amounts to 2 mm. This can be easily done by applying the .2 calibration voltage to the input of the amplifier, the deflection coefficient of which should be adjusted to "1 V/cm".
- Turn "LEVEL SENS" R436 to mid-position and adjust "TRIGG. SENS" R440 to obtain a stationary display with correct trigger polarity.
- With R436 adjust for a running display again and turn R440 clockwise till a stationary trace is obtained
- Repeat the adjustments of R436 and R440 till it is no longer possible to adjust for a running or dual trace with R436.
- Next set R436 to the centre of the control range where triggering occurs.
- Remove the earthing connection.

3. Trigger slope and level

- Apply a sine-wave voltage of 10 kHz to the Y-plug-in unit and adjust for a trace-height of 6 cm.
- Set the trigger slope switch (SK2) to position "+". The time-base should start on the positive-going edge of the sine-wave. With SK2 in position "–", starting should occur on the negative-going edge.
- It must be possible to shift the starting point continuously across the entire trace-height of 6 cm with potentiometer "LEVEL" (R2).
- With "LEVEL" (R2) fully clockwise as well as anti-clockwise, the time-base generator should not operate.

4. Internal triggering

TV FRAME

- Set "TRIGGER MODE" (SK1) to "TV FRAME".
- Apply a positive video signal to the Y-plug-in unit PM 3333.
- Set "TRIGGER SLOPE" (SK2) to "–".
- Check that, with a trace-height of 2 cm minimum, a trace is displayed, which is triggered on the frame synchronization pulses.

In this case the trace will start with a frame synchronization pulse.

In the position "TV FRAME", "LEVEL" and "STAB." should have no influence.

TV LINE

- Set "TRIGGER MODE" (SK1) to "TV LINE".
 - Apply a positive video signal to the Y plug-in unit PM 3333.
 - Set "TRIGGER SLOPE" (SK2) to "–".
 - Check that, with a trace height of 2 cm minimum, a trace is displayed, which is triggered on the line synchronization pulses.
- In this case the trace will start with a line-synchronization pulse.

In the position "TV LINE", "LEVEL" and "STAB." should have no influence.

DC

R485 (Fig. 62)

Before this measurement is carried out, it is necessary that the balance of the Y-amplifier, and the trigger amplifier has been correctly adjusted (see points G and I).

- Set "TRIGGER MODE" (SK1) to "LF"
- Apply a sine wave voltage with a frequency of 10 kHz to Y-plug-in unit PM 3333 and adjust for a trace height of 3 mm.
- Adjust "LEVEL" (R2) so, that when switching "TRIGGER SLOPE" (SK2) from + to –, the time-base generator keeps operating, without requiring readjustment of "LEVEL" (R2).
- With "Y-SHIFT" adjust the trace symmetrically around the centre of the screen.
- Set "TRIGGER MODE" (SK1) to "D.C." and leave "LEVEL" and "SHIFT" in the above-mentioned positions.
- If necessary adjust potentiometer "TRIGG. D.C. LEVEL II" (R485) so that in both positions of the "TRIGGER SLOPE" (SK2) a triggered display is obtained.
- When shifting the trace vertically, the starting point of the time-base line should shift smoothly over the edge of the sine wave, but should remain at the same place on the screen.

LF

- Set "TRIGGER MODE" (SK1) to "LF".
- Apply a sine-wave voltage with a frequency of 3 Hz to the Y-plug-in unit PM 3333 and adjust for a trace height of 3 mm.
- It must be possible to trigger the time-base generator with this input voltage by means of "LEVEL" (R2).

Note: It is easier to preset "LEVEL" (R2) with a higher frequency of the input voltage.

- "Y-SHIFT" of the Y-plug-in unit may have no influence on the trigger level which has been adjusted with "LEVEL" (R2).

HF

- Set "TRIGGER MODE" (SK1) to "HF".
- Apply a sine-wave voltage with a frequency of 3 Hz to the Y-plug-in unit PM 3333 and adjust for a trace height of 6 cm.
With this l.f. voltage no triggered display should be obtained.
- Increase the frequency of the input voltage to 2 kHz and 10 MHz respectively and adjust for a trace height of 3 mm.
It must be possible to trigger the time-base generator with the input voltage by means of "LEVEL" (R2).
- With an input voltage having a frequency of 30 MHz it must be possible to trigger the time-base generator at a trace height of 8 mm.
- At an input voltage of 60 MHz it must be possible to trigger at a trace height of 20 mm.

AUT.

R584-R589 (Fig. 54)

- Set "TRIGGER MODE" (SK1) to "AUT."
- Turn potentiometers "AUT. TRIGG. LEVEL" (R589) and "AUT. FREE-RUN" (R584) fully anti-clockwise.
- Without input voltage on the Y-plug-in unit, potentiometer "AUT. FREE-RUN." (R584) should be turned so far clockwise, that a time-base line just appears; then turn R584 15° further clockwise.
- Apply a voltage with a frequency of 10 Hz to Y-plug-in unit PM 3333 and adjust for a trace height of 3 cm.
- Turn potentiometer "AUT. TRIGG. LEVEL" (R589) fully clockwise; next anti-clockwise until the time-base generator triggers. Check this on all positions of "TIME cm" (SK4).
- Vary the trace-height from 0 to 6 cm.
From maximum 5 mm up to 6 cm trace-height the time-base generator should be triggered with the input voltage.
With a trace-height lower than the trigger limit the time-base generator should remain free-running. Without input voltage the time-base line should remain visible.
- Check that the time-base generator is triggered at a trace height of 8 mm at maximum with frequencies of 10 Hz and 1 MHz.
In position "AUT.", "LEVEL" and "STAB." should have no influence.

5. External triggering

- Set "TRIGGERING SOURCE" (SK3) to "EXT."
- Apply to "EXT." (BU1) a sine-wave voltage of 0.3 V_{p-p} from the same source as the voltage which has been connected to the Y-plug-in unit.
- Adjust the frequency of the input voltage to 10 kHz and set "TRIGGER MODE" SK1 to "HF".
- After correct adjustment of "LEVEL" (R2) the time-base generator should be triggered by the external voltage on terminal "EXT." (BU1).
- Now remove the voltage from "EXT." (BU1). The time-base generator should not be triggered any longer and consequently the time-base line should not be visible.

6. 50 Hz Triggering

- Set "TRIGGER SOURCE" (SK3) to "50 Hz".
- Apply a sine-wave voltage with the mains frequency to the Y-plug-in unit.
- Set "TRIGGER MODE" (SK1) (SK1) to "LF".
- With "LEVEL" (R2) the time-base generator should be triggered on the internal voltage with the mains frequency.
- It should be possible to shift the starting point of the time-base generator over the edge of the sine-wave for more than 120° with potentiometer "50 Hz PHASE" (R10).

7. Time-base amplitude

R554 (Fig. 54)

- Plug unit PM 3333 into the Y-plug-in compartment and apply time markers at intervals of precisely "2 msec." to the Y-nit.
- Set "TIME/cm" (SK4) to "2 msec./cm" and adjust for a triggered display.
- Adjust potentiometer "TB LENGTH" (R554) for a length of the time-base line to 10 cm.
- In all positions of SK4 the length of the time-base line should exceed 9.5 cm.

8. Time-coefficient and linearity.

C510, 508, 515, 530 (Fig. 3), C709 (Fig. 64), C710, C711, (Fig. 69) R555

Before this check and adjustment is carried out, it is necessary that the sensitivity of the time-base amplifier has been correctly adjusted (see point O1).

- Apply a sine wave voltage of precisely 10 MHz to the Y-unit and set the control knobs to the following positions:
"TIME/cm" (SK4) to ".05 $\mu\text{sec/cm}$ "
"MAGNIFIER" (SK8) to " $\times 1$ "
"TIME/cm" (R1) to "CAL."
- Adjust "LEVEL" (R2) for a triggered display.

- With trimmer C510 adjust the time coefficient so, that the last three periods together have a width of 6 cm.
 - Apply a sine-wave voltage of precisely 50 MHz to the Y-unit and set "MAGN." (SK8) to " $\times 5$ ".
 - With C709, optimally adjust the linearity.
 - Set "MAGN." (SK8) to " $\times 1$ " and apply a sine wave voltage of precisely 10 MHz.
 - With C710 optimally adjust the linearity and then check the time-coefficient.
 - Adjust C510 so that 4 periods have a width of 8 cm; tolerance 1%.
 - Measure the time-coefficient and the linearity over 8 cm (symmetrically around the centre of the screen).
 - Apply a sine-wave voltage of precisely 50 MHz to the Y-unit and set "MAGN." (SK8) to " $\times 5$ ". 4 periods should have a width of 8 cm, tolerance 4%.
 - Set "MAGN." (SK8) to position " $\times 2$ ".
 - With C711 optimally adjust the linearity and then check the time coefficient: 10 periods should have a width of 8 cm; tolerance 4%.
 - Set "MAGN." (SK8) to position " $\times 1$ ".
 - Apply a sine-wave voltage of precisely 10 MHz to the Y-unit.
 - Set "TIME/cm" (SK4) to ".1 $\mu\text{sec./cm}$ ".
 - With C508 adjust the time-coefficient so, that 8 periods have a width of 8 cm; tolerance 1%.
 - Apply time markers at intervals of precisely 5 $\mu\text{sec.}$ to the Y-unit and set "TIME/cm" (SK4) to "5 $\mu\text{sec./cm}$ ".
 - With C530, adjust the time-coefficients so, that 8 periods have a width of 8 cm, tolerance 1%.
 - Apply time markers at intervals of precisely 100 $\mu\text{sec.}$ to the Y-unit and set "TIME/cm" (SK4) to ".1 msec./cm".
 - With C515, adjust the time-coefficients so, that 8 periods have a width of 8 cm; tolerance 1%.
 - Set "Time/cm" (SK4) to position "1 sec/cm" and apply an input signal of 1 Hz. Adjust R555 so that 8 periods have a width of 8 cm.
 - Check the time-coefficients in all remaining positions of "TIME/cm" (SK4), with "MAGN." (SK8) in position " $\times 1$ ".
- Always select the time intervals so that they correspond to the time, selected by "TIME/cm" (SK4). In each position 8 periods should have a width of 8 cm; tolerance 2.5%.
- Set "TIME/cm" (SK4) to position "1 msec./cm" and check the time coefficient with "MAGN." (SK8) to positions " $\times 2$ " and " $\times 5$ ".
- For position " $\times 2$ " of "MAGN." (SK8) time markers at intervals of precisely 500 $\mu\text{sec.}$ should be applied to the Y-unit.
- Check the time coefficients as follows:
- 8 periods should have a width of 8 cm; tolerance 4%.

For position " $\times 5$ " of "MAGN." (SK8) time markers at intervals of precisely 100 $\mu\text{sec.}$ should be applied to the Y-unit.

Check the time-coefficients as follows: 16 periods should have a width of 8 cm; tolerance 4%.

In the positions " $\times 2$ " and " $\times 5$ ", the lamp "MAGN." (LA6) should be aglow.

9. Continuous control of the time-coefficients

When "TIME/cm" (R) is turned fully anti-clockwise from its "CAL" position, the time-coefficient should continuously be increased up to ≥ 2.5 times the value in position "CAL". Check the correct operation of lamp "UNCAL" (LA5).

10. Single time-base

R601 (Fig. 54)

- Set the knobs to the following positions:
"X-DEFLECTION" (SK7) to "TIME-BASE A"
"MAGN." (SK8) to " $\times 1$ "
"STAB." (R3) to "PRESET"
"TRIGG. SOURCE" (SK3) to "INT."
- "LOCK OUT LEVEL" (R601) anti-clockwise
- Apply a sine-wave voltage with a frequency of 1 kHz to the Y-plug-in unit.
- Adjust "LEVEL" (R2) for a triggered display.
- Then set "X-DEFLECTION" (SK7) to "SINGLE A"
- Adjust "LOCK OUT LEVEL" (R601) so, that when depressing "RESET" (SK9) repeatedly, the trace is always written just once across the entire time-base length; then turn R601 about 15° further clockwise.
- Set "TRIGGER SOURCE" (SK3) to "EXT." and depress "RESET" (SK9). Lamp LA7 in the push-button should light up.
- When SK3 is reset to position "INT.", the trace should be written once and LA7 should extinguish.

11. Output terminals "+GATE" (BU2) and "TIME-BASE A" (BU3)

- Set time-base A to its free-running position, with a time-coefficient of ".1 msec./cm".
- The synchronous voltages of Fig. 66 should be available on output terminals BU2 and BU3.

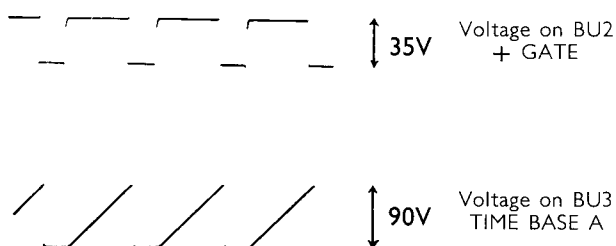


Fig. 66. Output wave-form of "+Gate" and "Timebase" busses

IX. Replacing parts

A. FUSES

The instrument is protected by two fuses.

When one or both fuses have blown, first locate the cause.

Note:

If the instrument is used for mains voltages of 110, 125 or 145 V, fuses of 8 A should be fitted.

B. MAINS TRANSFORMER

- Remove the cabinet plates
- Unsolder the transformer connections
- Remove both screws at the rear side.
- Remove the four fixing screws at the bottom of the instrument.

The transformer is then free and can be taken from the instrument.

C. FANS

- Detach the rear panel
- Remove the three fixing screws of the retaining ring at the upper side of the fan
- Unsolder the motor connections

The fan can then be taken from the frame by tilting it outwards.

Caution:

When remounting the fan, care should be taken that the connection wires to the motor are soldered to their original tags. Interchanging the wires causes magnetic hum.

D. POWER TRANSISTORS ON THE REAR PANEL

- Remove the rear panel
- Remove the unit with the power supply resistors
- As the connections of the power transistors are made by means of contract springs, it is possible to remove the transistors after unscrewing the fixing screws.

When remounting the transistors, ensure that the two insulation plates are fitted underneath.

The screws should be tightened with a torque of 8 kgcm.

E. CATHODE-RAY TUBE

- Remove the protective cap
- Remove the 4 light-guides
- Remove the anode cap.
- Loosen bolt "A" (Fig. 71) a couple of turns
- Remove screw "B" (Fig. 71) entirely
- Remove the tube holder of the CRT.

- Unsolder the 4 grey wires from the Y deflection coils
- Unplug the grey and yellow (marked) wires
- Unplug the white-grey wire.
- Unsolder the 4 wires of the quadrupole coil (L302–L303) from print unit U20 (Fig. 71)
- Remove the CRT by pushing it forward out of the screening pipe

F. TEXT PLATE

- Remove the knobs
- Remove the terminals and the sockets
- Remove the current bracket
- Remove the central fixing nuts of the "POWER ON" and the "RESET" switches
- Remove the central fixing nut of the switch "AMPL. CAL."
- Remove the bezel
- Unscrew the four fixing screws of the mounting plate of the bezel
- Remove the plastic sleeves from the fittings of the graticule illumination lamps
- Pull the mounting plate of the bezel slightly from the instrument and unsolder the connection wires of the fittings of the lamps
- Remove the mounting plate
- Remove the three screws/at the bottom of the text plate
- Remove the text plate from the frame

G. PRINTED-WIRING BOARDS U11 AND U12 Fig. 71

- Remove the fixing strip FS
- Pull the printed wiring boards from the instrument (plug-in connection)

H. HT UNIT

After removing the two fixing screws, the screening plate can be removed. The components of the HT unit can then be easily replaced.

J. VALVES AND SEMI-CONDUCTORS

All valves and semi-conductors are normal production types.

After replacement of valves and semi-conductors it may be necessary to readjust the relevant circuits.

For this see chapter VIII "Checking and adjusting". New valves can be aged by switching on the instrument for 100 hours.

Aging can also be carried out separately from the instrument by connecting the valves as a diode.

(In case of a pentode connect the grids and in case of a triode connect the grid to the anode.)

The anode voltage must be so selected that at a normal filament voltage the quiescent current through the valve is 1/6 of the maximum permissible cathode current.

X. Information for assistance in fault finding

A. MAINS TRANSFORMER VOLTAGES

The available unloaded voltage tapings are listed in Fig. 67 in the form of a table.

The loaded transformer voltages are indicated in the circuit diagram.

They are measured across the windings with a voltmeter GM 6012.

B. VOLTAGES AND WAVEFORMS IN THE APPARATUS

The D.C. voltage levels in the power supplies are measured under the following conditions:

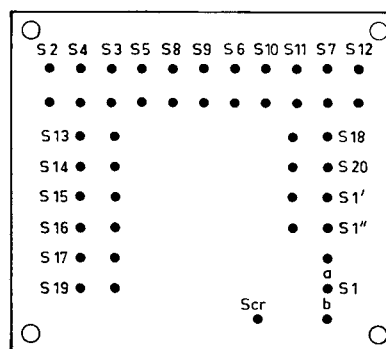
- Switch "X-DEFLECTION" to "SINGLE A"
- Switch "AMPL. CAL" to "OFF."
- Plug test unit PM 3361 into the Y-compartment

The ripple voltages are measured with an oscilloscope (PM 3230). The D.C. voltages in the entire instrument are measured with the PHILIPS voltmeter PM 2430. The waveforms at the Y-amplifier are measured with another oscilloscope PM 3330 and plug-in unit PM 3332. The signal is delivered by test unit PM 3361, with its test selector set to "RISE TIME MAIN AMPLIFIER".

C. REMARKS

Whenever it is desired to send the instrument to a PHILIPS workshop, the following points should be observed:

- carefully pack the apparatus in the original packing, or, if not available, in a wooden crate.
- indicate as completely as possible the symptoms of the faults,
- tie on a label bearing name and address of sender,
- send the instrument to the appropriate PHILIPS address provided by the local organisation.



CODE	S1a	S1b	S1'	S2	S3	S4	S5	S6	S7	S8	S1''	
URNS	34	45	246	374	161	65	34	34	65	161	246	
VOLTS	15	20	110	167	72	29	15,2	15,2	29	72	110	
CODE	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
URNS	337	178	310	161	15	15	15	15	15	15	59	59
VOLTS	150,5	79,5	130,4	72	6,7	6,7	6,7	6,7	6,7	6,7	26,5	26,5

PEM 2731

Fig. 67. Mains-transformer data

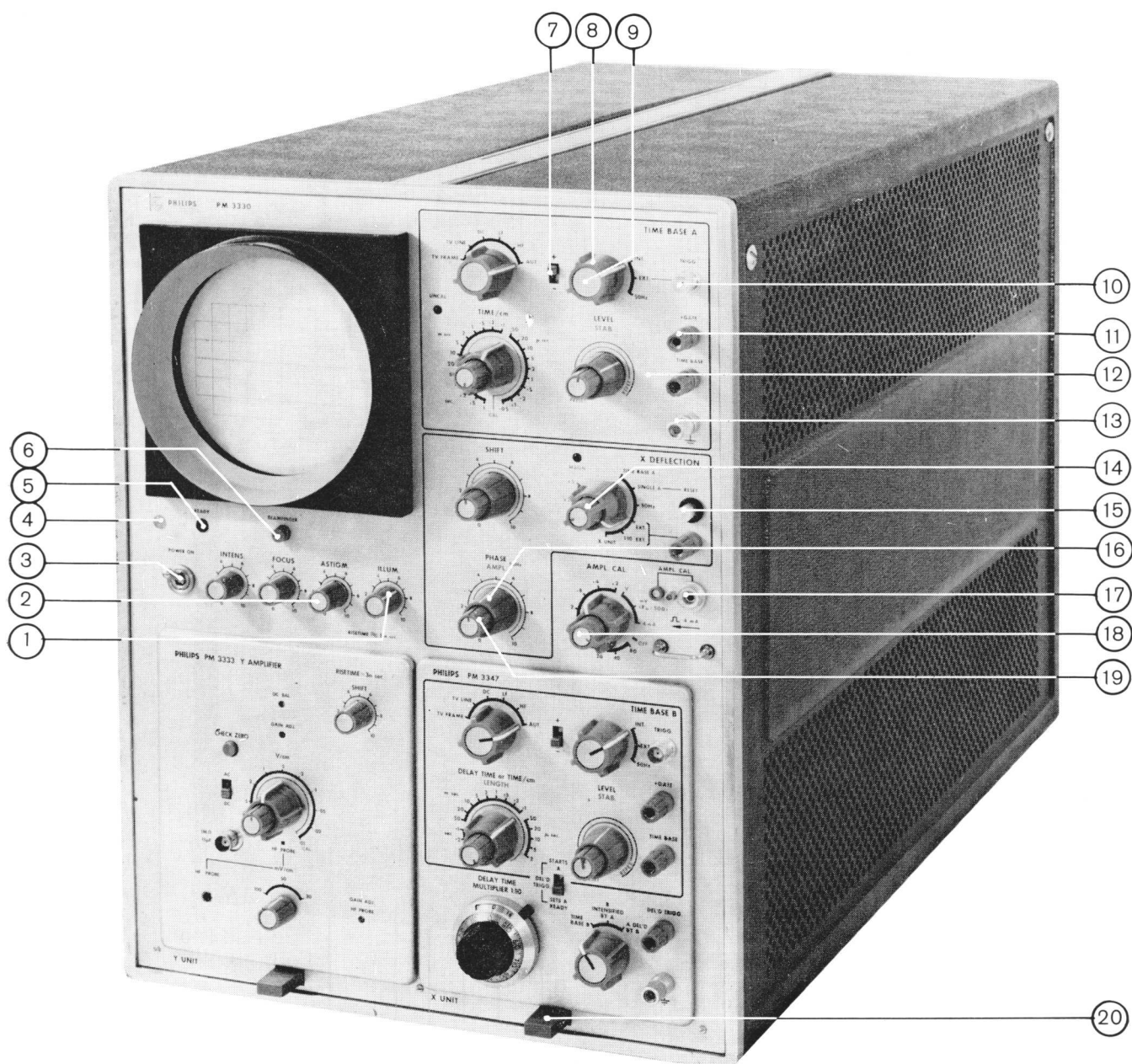


Fig. 68. Components at the front

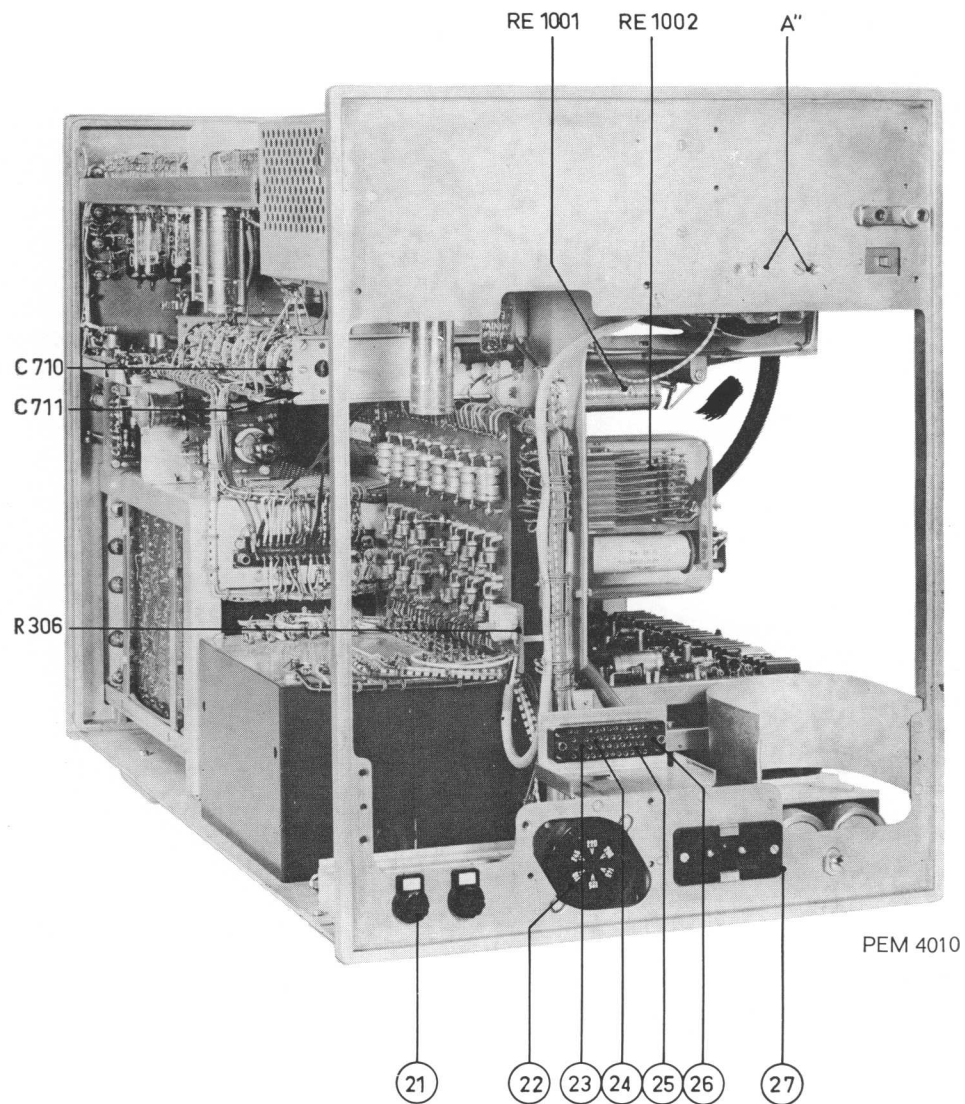


Fig. 69. Components at the rear

B O	F O	R O	V O	Z O	d O	j O	p O	u O	y O	CC O	
D O		N O	T O	X O	b O	f O	m O	s O	w O	AA O	EE O
E O		P O	U O	Y O	c O	h O	n O	t O	x O	BB O	
C O		M O	S O	W O	a O	e O	k O	r O	v O	z O	DD O

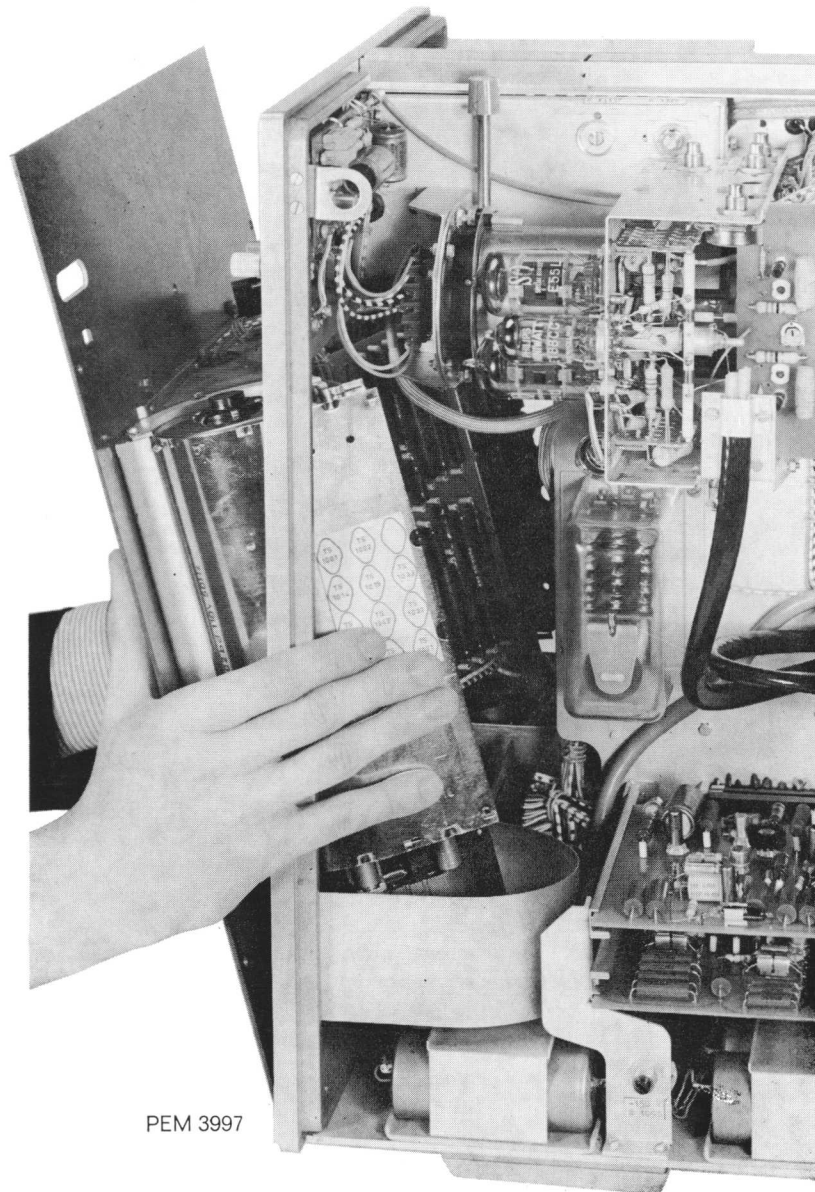


Fig. 70. Inserting the rear panel

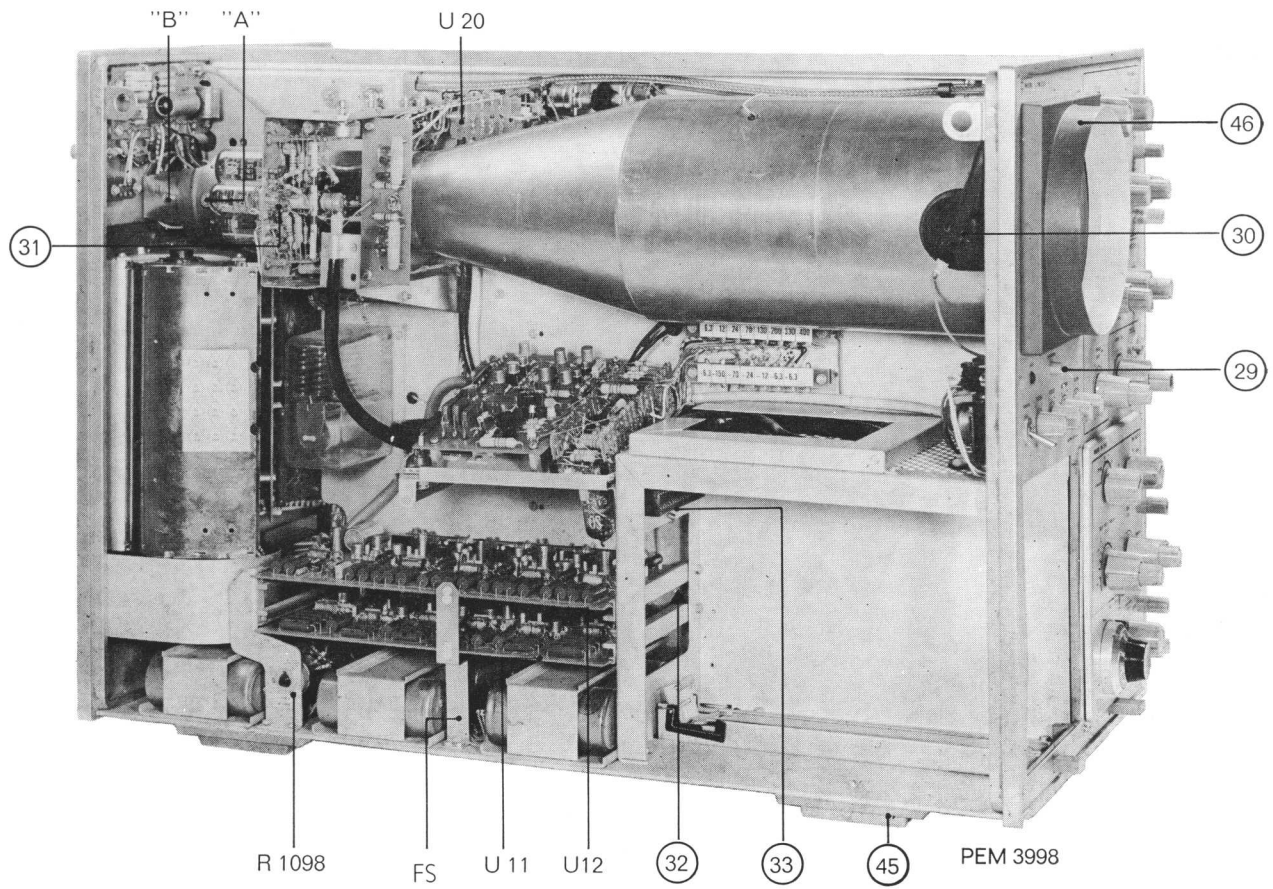


Fig. 71. Components at the interior (left side)

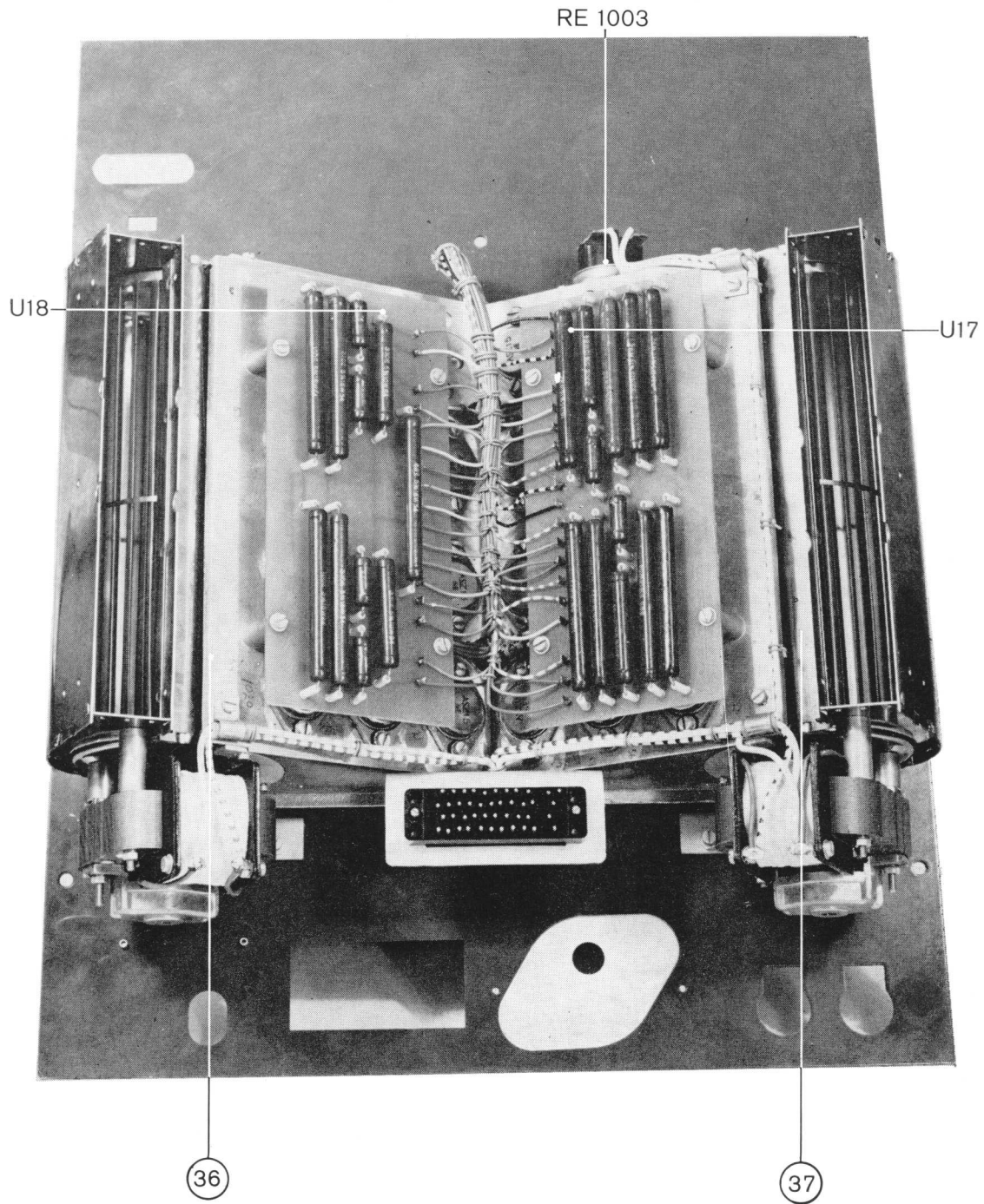


Fig. 72. Components at the interior (rear panel)

XI. List of service parts

A. MECHANICAL PARTS

<i>Item</i>	<i>Fig.</i>	<i>Ordering Code</i>	<i>Description</i>	<i>Qty.</i>
1	68	4822 413 30082	Knob 14 Ø, shaft 6 Ø	4
2	68	4822 413 70038	Cover, white	4
3	68	4822 277 10028	Mains switch	1
4	68	4822 381 10166	Lens, white	1
5	68	4822 381 10052	Lens, green	1
6	68	4822 276 10095	Push button switch	1
7	68	4822 277 20014	Sliding switch, 2 pos.	2
8	68	4822 413 40112	Knob 23 Ø, shaft 6 Ø	5
9	68	4822 413 70037	Cover, white	2
10	68	4822 265 10004	BNC-Connector	1
11	68	4822 290 40011	Terminal	4
12	68	4822 455 80003	Text plate	1
13	68	4822 290 40012	Terminal	2
14	68	4822 413 30084	Knob 14 Ø, shaft 4 Ø	2
15	68	4822 276 10125	Push button switch (SK9)	1
16	68	4822 413 40211	Knob 23 Ø, shaft 6 Ø	3
17	68	4822 267 30045	Socket (BU6)	1
18	68	4822 413 70039	Cover, red	6
19	68	4822 413 30085	Knob 14 Ø, shaft 4 Ø	4
20	68	4822 410 20253	Push button	2
21	69	4822 256 40012	Fuse holder	2
22	69	4822 272 10003	Voltage adapter	1
23	69	4822 268 20022	Centre bush	2
24	69	4822 321 20074	Contact socket (AMP)	5
25	69	4822 268 30018	Contact block (AMP)	1
26	69	4822 321 20074	Contact socket (AMP/	38
27	69	4822 265 20017	Mains connector	1
28	53	4822 480 40012	Filtermat	1
29	71	4822 413 30164	Knob (SK 10)	1
30	71	4822 290 30044	Anode-cap	1
31	71	4822 255 70019	Valve holder Noval	18
32	71	4822 267 70043	Contact block	2
33	71	4822 276 70005	Contact block	2
34	56	4822 255 20022	Lamp holder	4
35	56	4822 255 10007	Lamp holder	2
36	72	4822 361 10053	Ventilator, left	1
37	72	4822 361 10052	Ventilator, right	1
38		4822 255 70014	Valve holder Min.	2
39				
40		4822 255 70109	Valve holder for CRT	1
41		4822 273 70003	Calibration switch	1
42		4822 273 80038	Trigger switch	1
43		4822 273 70004	Sweep time switch	1
44		4822 273 80039	Deflection switch	1
45	71	4822 462 40168	Foot	4
46	71	4822 450 70014	Bezel	1
47		4822 480 30074	Grey lightfilter	1
48		4822 255 40054	Radiator	1

B. ELECTRICAL — ELEKTRISCH — ELEKTRISCH — ELECTRIQUE — ELECTRICOS

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

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

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

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

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

	Carbon resistor E24 series Kohleschichtwiderstand, Reihe E24 Koolweerstand E24 reeks Résistance au carbone, série E24 Resistencia de carbón, serie E24	0,125 W	5%		Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	1	$W \leq 2,2 \text{ M}\Omega, 5\%$ $> 2,2 \text{ M}\Omega, 10\%$
	Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	$0,25 \text{ W} \leq 1 \text{ M}\Omega, 5\%$ $> 1 \text{ M}\Omega, 10\%$			Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	2	W 5%
	Carbon resistor E24 series Kohleschichtwiderstand, Reihe E24 Koolweerstand E24 reeks Résistance au carbone, série E24 Resistencia de carbón, serie E24	$0,5 \text{ W} \leq 5 \text{ M}\Omega, 1\%$ $> 5 \leq 10 \text{ M}\Omega, 2\%$ $> 10 \text{ M}\Omega, 5\%$			Wire-wound resistor Drahtwiderstand Draadgewonden weerstand Résistance bobinée Resistencia bobinada		0,4 – 1,8 W 0,5%
	Carbon resistor E12 series Kohleschichtwiderstand, Reihe E12 Koolweerstand E12 reeks Résistance au carbone, série E12 Resistencia de carbón, serie E12	$0,5 \text{ W} \leq 1,5 \text{ M}\Omega, 5\%$ $> 1,5 \text{ M}\Omega, 10\%$			Wire-wound resistor Drahtwiderstand Draadgewonden weerstand Résistance bobinée Resistencia bobinada		$5,5 \text{ W} \leq 200 \Omega, 10\%$ $> 200 \Omega, 5\%$
					Wire-wound resistor Drahtwiderstand Draadgewonden weerstand Résistance bobinée Resistencia bobinada		10 W 5%
	Tubular ceramic capacitor Rohrkondensator Keramische kondensator, buistype Condensateur céramique tubulaire Condensador cerámico tubular		500 V		Polyester capacitor Polyesterkondensator Polyesterkondensator Condensateur au polyester Condensador polyester		400 V
	Tubular ceramic capacitor Rohrkondensator Keramische kondensator, buistype Condensateur céramique tubulaire Condensador cerámico tubular		700 V		Flat-foil polyester capacitor Miniatur-Polyesterkondensator (flach) Platte miniatuur polyesterkondensator Condensateur au polyester, type plat Condensador polyester, tipo de placas planas		250 V
	Ceramic capacitor, "pin-up" Keramikkondensator "Pin-up" (Perltyp) Keramische kondensator "Pin-up" type Condensateur céramique, type perle Condensador cerámico, versión "colgable"		500 V		Paper capacitor Papierkondensator Papierkondensator Condensateur au papier Condensador de papel		1000 V
	"Microplate" ceramic capacitor Miniatur-Scheibenkondensator "Microplate" keramische kondensator Condensateur céramique "microplate" Condensador cerámico "microplaca"		30 V		Wire-wound trimmer Drahttrimmer Draadgewonden trimmer Trimmer à fil Trimmer bobinado		
	Mica capacitor Glimmerkondensator Micakondensator Condensateur au mica Condensador de mica		500 V		Tubular ceramic trimmer Rohrtrimmer Buisvormige keramische trimmer Trimmer céramique tubulaire Trimmer cerámico tubular		



For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.

Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.

Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.

Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.

Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

RESISTORS

<i>No.</i>	<i>Ordering code</i>	<i>Value</i>	<i>Watts</i>	<i>%</i>	<i>Description</i>
R1	4822 101 40013	100 kΩ			Potentiometer lin
R2	4822 101 20147	100 kΩ			Dual potentiometer lin
R3		100 kΩ			Dual potentiometer lin
R4		200 kΩ			Dual potentiometer lin
R5	4822 102 10062	200 kΩ			Dual potentiometer lin
R6	4822 101 20117	1 MΩ			Potentiometer lin
R7	4822 101 20118	2.2 MΩ			Potentiometer lin
R8	4822 101 20115	470 kΩ			Potentiometer lin
R9	4822 103 30002	30 Ω			Potentiometer
R10	4822 102 10063	1 MΩ			Dual potentiometer
		lin			
		log			
		20 kΩ			
R32	4822 103 20092	2.2 kΩ	3		Wire wound potentiometer
R39	4822 103 20084	1 kΩ	3		Potentiometer lin
R53	4822 100 10057	100 Ω	0.5		Potentiometer lin
R75	4822 100 10019	250 Ω			Wire wound potentiometer lin
R76	4822 111 70063	3300 Ω	4		Carbon
R79	4822 111 70064	1200 Ω	4		Carbon
R81	4822 116 50374	390 kΩ	0.25		Metalfilm
R82	4822 101 20252	10 kΩ			Potentiometer lin
R87	4822 111 70062	1 kΩ	4		Carbon
R89	4822 10037	1 kΩ			Potentiometer lin
R91	4822 111 70062	1 kΩ	4		Carbon
R92	4822 116 50374	390 kΩ	0.25		Metalfilm
R98	4822 111 70105	560 Ω	6		Carbon
R99	4822 115 40087	820 Ω	16		Wire wound
R100	4822 111 70105	560 Ω	6		Carbon
R302	4822 110 40196...214	2.2...10 MΩ	0.5	10	Carbon choice
R306	4822 100 10038	500 Ω			Potentiometer lin
R314	4822 101 20113	100 kΩ			Potentiometer lin
R318	4822 101 20115	470 kΩ			Potentiometer lin
R319	4822 103 20084	1 kΩ	3		Wire wound potentiometer
R320	4822 101 20113	100 kΩ			Potentiometer lin
R321	4822 103 20084	1 kΩ	3		Wire wound potentiometer
R324	4822 110 40187...207	1...5.6 MΩ	0.5	10	Carbon choice
R327	4822 103 20092	2.2 kΩ	3		Wire wound potentiometer
R328	4822 102 30112	2 × 1 kΩ			Tamdenjpotentiometer
R436	4822 103 20175	22 kΩ	3		Wire wound potentiometer
R440	4822 102 20101	22 Ω	3		Wire wound potentiometer
R484	4822 103 20089	470 Ω			Potentiometer lin
R485	4822 103 20092	2.2 kΩ			Potentiometer lin
R535	4822 116 50071	750 kΩ	0.5	1	Metal film
R540	4822 116 50069	300 kΩ	0.5	1	Metal film
R541	4822 116 50116	150 kΩ	0.5	1	Metal film
R542	4822 116 50022	500 kΩ	0.5	1	Metal film (2 in par.)
R543	4822 116 50068	200 kΩ	0.5	1	Metal film
R544	4822 116 50067	100 kΩ	0.5	1	Metal film
R545	4822 111 40188	14.8 MΩ	0.5	0.7	Carbon
R546	4822 111 40188	7.5 MΩ	0.5	0.7	Carbon (2 in par.)
R547	4822 111 40139	3 MΩ	0.5	0.7	Carbon
R548	4822 111 40138	1.5 MΩ	0.5	0.7	Carbon
R553	4822 103 20089	470 MΩ	1		Wire wound potentiometer
R555	4822 110 50107...174	0-330 kΩ	0.25	5	Carbon choice
R577	4822 101 20113	100 kΩ	1		Potentiometer lin
R584	4822 103 20091	4.7 kΩ	1		Wire wound potentiometer

<i>No.</i>	<i>Ordering code</i>	<i>Value</i>	<i>Watts</i>	<i>%</i>	<i>Description</i>
R589	4822 103 20094	10 kΩ	3		Wire wound potentiometer
R601	4822 101 20113	100 kΩ			Potentiometer lin
R702	4822 116 50197	900 kΩ	0.25	1	Carbon
R703	4822 116 50017	111 kΩ	0.25	1	Carbon
R714	4822 103 20094	10 kΩ	3		Wire wound potentiometer
R717	4822 110 30189	1.2 MΩ	0.5	1	Carbon
R724	4822 110 30192	1.5 MΩ	0.5	1	Carbon
R727	4822 110 30136 (2 in parallel)	6 kΩ	0.5	1	Carbon
R728	4822 110 30115	2 kΩ	0.5	1	Carbon
R729	4822 110 30115	2 kΩ	0.5	1	Carbon
R731	4822 103 20099	3.3 kΩ	3		Wire wound potentiometer
R738	4822 103 20091	5 kΩ	3		Wire wound potentiometer
R42	4822 116 50068	100 kΩ	1	1	Metal film (2 in par.)
R753	4822 116 50068	100 kΩ	1	1	Metal film (2 in par.)
R1006	4822 113 80042	4.7 Ω	2		Wire wound resistor
R1008	4822 116 50066	33 kΩ	0.5	1	Metal film
R1009	4822 116 50033	5.6 kΩ	0.5	1	Metal film
R1014	4822 116 50066	33 kΩ	0.5	1	Metal film
R1016	4822 116 50065	76.7 kΩ	0.5	1	Metal film
R1017	4822 113 80088	330 Ω	16	5	Wire wound
R1018	4822 113 80088	330 Ω	16	5	Wire wound
R1019	4822 113 80088	330 Ω	16	5	Wire wound
R1024	4822 113 80041	2.7 Ω	2		Wire wound
R1025	902/K...		0.25	5	Choice resistor
R1027	4822 116 50064	68 kΩ	0.5	1	Metal film
R1028	4822 116 50033	5.6 kΩ	0.5	1	Wire wound
R1033	4822 116 50064	68 kΩ	0.5	1	Metal film
R1034	4822 116 50063	44.7 kΩ	0.5	1	Metal film
R1036	4822 113 80089	220 Ω	16	5	Wire wound
R1037	4822 113 80089	220 Ω	16	5	Wire wound
R1042	4822 113 80041	2.7 Ω	2		Wire wound
R1044	4822 116 50066	33 kΩ	0.5	1	Metal film
R1045	902/K...		0.25	5	Choice resistor
R1046	4822 116 50033	5.6 kΩ	0.5	1	Wire wound
R1051	4822 116 50066	33 kΩ	0.5	1	Metal film
R1052	4822 116 50065	76.5 kΩ	0.5	1	Metal film
R1053	4822 113 80091	180 Ω	16	5	Wire wound
R1054	4822 113 80091	180 Ω	16	5	Wire wound
R1056	4822 113 80091	180 Ω	16	5	Wire wound
R1057	4822 113 80091	180 Ω	16	5	Wire wound
R1059	902/K...		0.25	5	Choice resistor
R1062	902/K...		0.25	5	Choice resistor
R1068	4822 113 80041	2.7 kΩ	2		Wire wound
R1071	4822 116 50064	68 kΩ	0.5	1	Metal film
R1072	4822 116 50033	5.6 kΩ	0.5	1	Wire wound
R1076	4822 116 50064	68 kΩ	0.5	1	Metal film
R1077	4822 116 50062	89.6 kΩ	0.5	1	Metal film
R1084	4822 113 80041	2.7 Ω	2		Wire wound
R1087	4822 116 50165	20 kΩ	0.5	1	Metal film
R1096	4822 116 50056	33 kΩ	0.5	1	Metal film
R1097	4822 116 50165	20 kΩ	0.5	1	Metal film
R1098	4822 103 20091	4.7 kΩ	3		Wire wound potentiometer

<i>No.</i>	<i>Code number</i>	<i>Value</i>	<i>Watts</i>	<i>%</i>	<i>Description</i>
R1113	4822 113 80042	4.7 Ω	2		Wire wound
R1117	4822 116 50066	33 k Ω	0.5	1	Metal film
R1118	4822 116 50033	5.6 k Ω	0.5	1	Wire wound
R1122	4822 116 50066	33 k Ω	0.5	1	Metal film
R1123	4822 116 50061	87.6 k Ω	0.5	1	Metal film
R1127	4822 113 80092	68 Ω	16	5	Wire wound
R1136	4822 113 80039	1.1 Ω	2		Wire wound
R1139	4822 116 50134	10 k Ω	0.25	1	Metal film
R1141	4822 116 50008	2.2 k Ω	0.25	1	Metal film
R1144	4822 116 50134	10 k Ω	0.25	1	Metal film
R1146	4822 116 50059	77.7 k Ω	0.5	1	Metal film
R1152	4822 113 80003	18 Ω	16	5	Wire wound
R1154	4822 113 80038	0.27 Ω	2		Wire wound
R1159	4822 116 50008	2.2 k Ω	0.25	2	Metal film
R1161	4822 116 50375	820 Ω	0.25	1	Wire wound
R1164	4822 116 50008	2.2 k Ω	0.25	2	Metal film
R1166	4822 116 50058	72.1 k Ω	0.5	1	Metal film
R1172	4822 113 80003	18 Ω	16	4	Wire wound
R1174	4822 113 80038	0.27 Ω	2		Wire wound
R1179	4822 116 50008	2.2 k Ω	0.25	2	Metal film
R1181	4822 116 50375	820 Ω	0.25	1	Wire wound
R1184	4822 116 50008	2.2 k Ω	0.25	2	Metal film
R1186	4822 116 50057	69.1 k Ω	0.5	1	Metal film
R1188	4822 113 80092	68 Ω	16	5	Wire wound
R1197	4822 113 80039	1.1 Ω	2		Wire wound
R1201	4822 116 50134	10 k Ω	0.25	1	Metal film
R1202	4822 116 50008	2.2 k Ω	0.25	2	Metal film
R1206	4822 116 50134	10 k Ω	0.25	1	Metal film
R1207	4822 116 50033	5.6 k Ω	0.5	1	Wire wound
R1216	4822 113 80042	4.7 Ω	2		Wire wound
R1217	4822 116 50066	33 k Ω	0.5	1	Metal film
R1218	4822 116 50033	5.6 k Ω	0.5	1	Wire wound
R1223	4822 116 50066	33 k Ω	0.5	1	Metal film
R1224	4822 116 50056	49.3 k Ω	0.5	1	Metal film
R1313	4822 101 20116	1 M Ω			Potentiometer lin
R1326	4822 101 20114	200 k Ω			Potentiometer lin
R1410	4822 116 50144	50 k Ω	0.25	0.7	Metal film
R1411	4822 103 20094	10 k Ω	3		Wire wound potentiometer
R1412	4822 116 50144	50 k Ω	0.25	0.7	Metal film
R1415	4822 116 50268	50 Ω	0.25	1	Metal film
R1417	4822 116 50134	10 k Ω	0.5	1	Metal film
R1418	4822 116 50055	5680 Ω	0.25	1	Metal film
R1419	4822 116 50054	2780 Ω	0.25	1	Metal film
R1421	4822 116 50376	801 Ω	0.25	1	Wire wound
R1422	4822 116 50053	378 Ω	0.25	1	Metal film
R1423	4822 116 50377	220 Ω	0.25	1	Metal film
R1424	4822 116 50052	72.3 Ω	0.25	1	Metal film
R1426	4822 116 50051	35.9 Ω	0.25	1	Metal film
R1427	4822 116 50051	35.9 Ω	0.25	1	Metal film
R1428	4822 112 10155	0.22 Ω	1		Transistor resistor

CAPACITORS

<i>No.</i>	<i>Ordering code</i>	<i>Value</i>	<i>Volts</i>	<i>Description</i>
C42	4822 121 40061	220 nF	160	Polyester
C43	4822 122 70003	1.5 nF	—	Feed through
C55	4822 125 60031	25 pF	—	Trimmer
C56	4822 121 40012	100 nF	400	Polyester
C301	4822 121 30059	8.2 nF	2000	HV Capacitor
C303	4822 121 30061	20 nF	2000	HV Capacitor
C304, C305	4822 121 40095	120 nF	250	Polyester
C406, C418	4822 121 40093	56 nF	250	Polyester
C411	4822 124 20081	20 μ F	16	Electrolytic
C450	4822 125 60035	3 pF	—	Trimmer
C451	4822 121 40088	10 nF	250	Polyester
C457, C458	4822 124 20072	200 μ F	6.4	Electrolytic
C508, C510, C701 C707, C709, C710, C711	4822 125 60037	6 pF	—	Trimmer
C509	4822 120 60047	5.6 pF	500	Mica
C511, C512, C513	4822 111 30192	1 μ F + 100 nF + 10 nF	—	Box capacitor
C519	4822 121 40097	270 nF	250	Polyester
C514	4822 123 10202	990 pF	250	Mica
C520	4822 120 60079	91 pF	500	Mica
C521	4822 120 40145	27 nF	400	Polyester
C529, C31	4822 121 40023	47 nF	400	Polyester
C539, C541	4822 121 40036	100 nF	250	Polyester
C543	4822 121 40036	100 nF	250	Polyester
C1001	4822 124 70047	200 μ F	325	Electrolytic
C1003	4822 124 40058	50 μ F	200	Electrolytic
C1008	4822 124 40058	50 μ F	200	Electrolytic
C1006	4822 124 70047	200 μ F	325	Electrolytic
C1011	4822 124 70047	200 μ F	325	Electrolytic
C1013	4822 124 40058	50 μ F	200	Electrolytic
C1016	4822 124 70047	400 μ F	325	Electrolytic (2 in parallel)
C1018	4822 124 40058	50 μ F	200	Electrolytic
C1021	4822 124 70047	200 μ F	325	Electrolytic
C1022	4822 124 20094	100 μ F	64	Electrolytic
C1023	4822 124 40058	50 μ F	200	Electrolytic
C1025	4822 121 40038	27 nF	250	Polyester
C1026	4822 121 40013	1 μ F	250	Polyester
C1027	4822 121 40042	47 nF	250	Polyester
C1031	4822 124 70047	200 μ F	325	Electrolytic
C1033	4822 124 40058	50 μ F	200	Electrolytic
C1036	4822 124 70012	4,000 μ F	40	Electrolytic
C1038	4822 124 20022	40 μ F	40	Electrolytic
C1041	4822 124 70021	10,000 μ F	16	Electrolytic
C1044	4822 124 20055	50 μ F	25	Electrolytic
C1046	4822 124 70021	10,000 μ F	16	Electrolytic
C1049	4822 124 20055	50 μ F	25	Electrolytic
C1051	4822 124 70012	4,000 μ F	40	Electrolytic
C1053	4822 124 20022	50 μ F	40	Electrolytic
C1056	4822 124 70047	200 μ F	325	Electrolytic
C1057	4822 124 40058	50 μ F	200	Electrolytic
C1302	4822 124 20052	12.5 μ F	25	Electrolytic
C1303	4822 121 40166	0.47 μ F	630	Polyester
C1307	4822 122 50001	5 nF	3,000	HV Capacitor
C1308	4822 122 50001	5 nF	3,000	HV Capacitor
C1309	4822 121 30077	500 pF	10,000	HV Capacitor
C1311	4822 121 30077	500 pF	10,000	HV Capacitor
C1312	4822 121 30077	500 pF	10,000	HV Capacitor
C1313	4822 121 30077	500 pF	10,000	HV Capacitor
C1314	4822 122 50001	5 nF	3,000	HV Capacitor
C1316	4822 122 50001	5 nF	3,000	HV Capacitor
C1317	4822 50001	5 nF	3,000	HV Capacitor
C1318	4822 121 40023	47 nF	400	Polyester
C1401, C1402	4822 120 60094	330 pF	500	Mica
C1405	4822 124 20032	4 μ F	250	Electrolytic

COILS

<i>No.</i>	<i>Ordering code</i>	<i>Description</i>
L26	4822 157 50572	Coil
L27	4822 157 50253	Coil
L28	4822 157 50572	Coil
L30	4822 158 10068	Coil (0.33 μ H)
L31	4822 157 50255	Coil
L32	4822 156 20284	Coil
L33	4822 156 20283	Coil
L34	4822 157 50255	Coil
L35	4822 156 20284	Coil
L36	4822 156 20283	Coil

<i>No.</i>	<i>Ordering code</i>	<i>Description</i>
L37	4822 158 10068	Coil (0.33 μ H)
L38	4822 158 10086	Coil Coil (0.15 μ H)
L40...L49	4822 526 10011	Bead
L42, L43	4822 158 10052	Coil
L301	4822 150 10073	Coil
L401	4822 157 50318	Coil (1 μ H)
L402	4822 526 10011	Bead
L403	4822 158 10235	Coil (0.22 μ H)
L451	4822 158 10052	Coil
L453, L457	4822 526 10011	Bead
L501	4822 158 10067	Coil (100 μ H)
L502...L505	4822 526 10011	Bead

MISCELLANEOUS

<i>No.</i>	<i>Code number</i>	<i>Description</i>
T401	K3 004 97	Transformerring (furnished by Com-Dept. Elcoma)
T1001	4822 146 80047	Mains transformer
T1301	4822 142 60062	HT transformer
VL1	974/V4000	Fuse
VL2	974/V4000	Fuse
RE1001	4822 282 20004	Thermal delay switch
RE1002	4822 280 80136	Relay
RE1003	4822 282 40024	Thermostat

<i>No.</i>	<i>Code number</i>	<i>Description</i>
Unit 5	4822 216 50121	Calibration unit
Unit 6	4822 216 50035	TV sync. unit
Unit 7	4822 216 50036	X-defl. pre-amplifier
Unit 8	4822 216 50037	Rectifier unit
Unit 11	4822 216 50122	Power supply II
Unit 12	4822 216 50123	Power supply I
Unit 14	4822 216 50041	Final amplifier
Unit 16	4822 216 50042	CRT unit
Unit 17	4822 216 50043	Power supply resistor unit
Unit 18	4822 216 50044	Power supply resistor unit
Unit 21	4822 216 50124	Trigger amplifier
Unit 22	4822 216 50125	Delay line driver

VALVES, SEMI-CONDUCTORS ETC.**DIODES**

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
GR26	BAY38	4822 130 40256	Silicon diode
GR27	BAY38	4822 130 40256	Silicon diode
GR28	BZY94C11	4822 130 30307	Zener diode
GR29...			
GR32	BAX13	4822 130 40182	Silicon diode
GR301	BAX16	4822 130 30273	Silicon diode
GR401	AAZ17	4822 130 30283	Germanium diode
GR402	AEY27	4822 130 30017	Tunnel diode
GR403	AAZ15	4822 130 30229	Germanium diode
GR404	BAY38	4822 130 40256	Silicon diode
GR405	OA85	4822 130 30225	Germanium diode
GR406...			
409	BAY38	4822 130 40256	Silicon diode
GR451,			
454	BAY38	4822 130 40256	Silicon diode
GR452,			
453	AAZ15	4822 130 30229	Germanium diode
GR501	OA85	4822 130 30225	Germanium diode
GR502	OA202	4822 130 30239	Silicon diode
GR503	BAY38	4822 130 40256	Silicon diode
GR504	BAY38	4822 130 40256	Silicon diode
GR505	OA70	4822 130 30221	Germanium diode
GR506	AAZ15	4822 130 30229	Germanium diode
GR507	OA202	4822 130 30239	Silicon diode
GR508	BAY38	4822 130 40256	Silicon diode
GR509	BAY38	4822 130 40256	Silicon diode

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
GR1001	BY127	4822 130 30259	Silicon diode
GR1002	BY127	4822 130 30259	Silicon diode
GR1003	BY127	4822 130 30259	Silicon diode
GR1004	BY127	4822 130 30259	Silicon diode
GR1005	BZY88C6V8	4822 130 30079	Zener diode
GR1006	BY127	4822 130 30259	Silicon diode
GR1007	BY127	4822 130 30259	Silicon diode
GR1008	BY127	4822 130 30259	Silicon diode
GR1009	BY127	4822 130 30259	Silicon diode
GR1010	BZY88C6V8	4822 130 30079	Zener diode
GR1011	BY127	4822 130 30259	Silicon diode
GR1012	BY127	4822 130 30259	Silicon diode
GR1013	BY127	4822 130 30259	Silicon diode
GR1014	BY127	4822 130 30259	Silicon diode
GR1015	BZY88C6V8	4822 130 30079	Zener diode
GR1016	BYX38/1200	4822 130 30333	Silicon diode
GR1017	BYX38/1200	4822 130 30333	Silicon diode
GR1018	BYX38/1200	4822 130 30333	Silicon diode
GR1019	BYX38/1200	4822 130 30333	Silicon diode
GR1020	BZY88C6V8	4822 130 30079	Zener diode
GR1021	BY127	4822 130 30259	Silicon diode
GR1022	BY127	4822 130 30259	Silicon diode
GR1023	BY127	4822 130 10259	Silicon diode

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
GR1024	BY127	4822 130 30259	Silicon diode
GR1025	BZY88C6V8	4822 130 30079	Zener diode
GR1026	BZY88C6V8	4822 130 30079	Zener diode
GR1027	BY127	4822 130 30259	Silicon diode
GR1028	BY127	4822 130 30259	Silicon diode
GR1029	BY127	4822 130 30259	Silicon diode
GR1030	BY127	4822 130 30259	Silicon diode
GR1031	BY127	4822 130 30259	Silicon diode
GR1032	BZY88C12	4822 130 30346	Silicon diode
GR1036	BY127	4822 130 30259	Silicon diode
GR1037	BY127	4822 130 30259	Silicon diode
GR1038	BY127	4822 130 30259	Silicon diode
GR1039	BY127	4822 130 30259	Silicon diode
GR1041	BYX21/200	4822 130 30329	Silicon diode
GR1042	BYX21/200	4822 130 30329	Silicon diode
GR1043	BYX20/200	4822 130 30275	Silicon diode
GR1044	BYX20/200	4822 130 30275	Silicon diode
GR1045	BZZ22	4822 130 30299	Zener diode
GR1046	BYX21/200	4822 130 30329	Silicon diode
GR1047	BYX21/200	4822 130 30329	Silicon diode
GR1048	BYX20/200	4822 130 30275	Silicon diode
GR1049	BYX20/200	4822 130 10275	Silicon diode

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
GR1051	BYX21/200	4822 130 30329	Silicon diode
GR1052	BYX21/200	4822 130 30329	Silicon diode
GR1053	BYX21/200R	4822 130 30268	Silicon diode
GR1054	BYX21/200R	4822 130 30268	Silicon diode
GR1056	BYX21/200	4822 130 30329	Silicon diode
GR1057	BYX21/200	4822 130 30329	Silicon diode
GR1058	BYX21/200R	4822 130 30268	Silicon diode
GR1059	BYX21/200R	4822 130 30268	Silicon diode
GR1061	BZY88C6V8	4822 130 30079	Zener diode
GR1062	BZZ22	4822 130 30299	Zener diode
GR1063	BY127	4822 130 30259	Silicon diode
GR1064	BY127	4822 130 30259	Silicon diode
GR1065	BY127	4822 130 30259	Silicon diode
GR1066	BY127	4822 130 30259	Silicon diode
GR1067	BZY88C6V8	4822 130 30079	Zener diode
GR1301	BY140	4822 130 30296	Silicon diode
GR1302	BY140	4822 130 30296	Silicon diode
GR1303	BY140	4822 130 30296	Silicon diode
GR1304	BY140	4822 130 30296	Silicon diode
GR1305	BY140	4822 130 30296	Silicon diode
GR1401	BAY38	4822 130 40256	Silicon diode
GR1402	BAX16	4822 130 30273	Silicon diode

TRANSISTORS

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
TS26,27	BF184	4822 130 40461	Silicon transistor
TS28,29	BFW16	4822 130 40381	Silicon transistor
TS301	AF118	4822 130 40251	Germanium transistor
TS401	ASZ20	4822 130 40485	Germanium transistor
TS403	ASZ20	4822 130 40485	Germanium transistor
TS404	BSY39	4822 130 40125	Silicon transistor
TS451, 452	BSY38	4822 130 40138	Silicon transistor
TS453, 454	AF118	4822 130 40251	Germanium transistor
TS456, 457	AF118	4822 130 40251	Germanium transistor
TS458			
462	BFW16	4822 130 40381	Silicon transistor
TS459			
461	AF118	4822 130 40251	Germanium transistor
TS1001	ASZ15	4822 130 40091	Germ. power transistor
TS1002	ASZ15	4822 130 40091	Germ. power transistor
TS1003	AC128	4822 130 40095	Germanium transistor
TS1004	BCY31	4822 130 40452	Silicon transistor
TS1005	BCY31	4822 130 40452	Silicon transistor
TS1006	BCY31	4822 130 40452	Silicon transistor
TS1007	ASZ15	4822 130 40091	Germ. power transistor
TS1008	ASZ15	4822 130 40091	Germ. power transistor
TS1009	ASZ15	4822 130 40091	Germ. power transistor
TS1010	AC128	4822 130 40095	Germanium transistor
TS1011	BCY31	4822 130 40452	Silicon transistor
TS1012	BCY31	4822 130 40452	Silicon transistor
TS1013	BCY31	4822 130 40452	Silicon transistor
TS1014	ASZ15	4822 130 40091	Germ. power transistor
TS1015	ASZ15	4822 130 40091	Germ. power transistor

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
TS1016	AC128	4822 130 40095	Germanium transistor
TS1017	BCY31	4822 130 40452	Silicon transistor
TS1018	BCY31	4822 130 40452	Silicon transistor
TS1019	BCY31	4822 130 40452	Silicon transistor
TS1020	ASZ15	4822 130 40091	Germ. power transistor
TS1021	ASZ15	4822 130 40091	Germ. power transistor
TS1022	ASZ15	4822 130 40091	Germ. power transistor
TS1023	ASZ15	4822 130 40091	Germ. power transistor
TS1024	BCY31	4822 130 40452	Silicon transistor
TS1026	BCY31	4822 130 40452	Silicon transistor
TS1027	BCY31	4822 130 40452	Silicon transistor
TS1028	AC128	4822 130 40095	Germanium transistor
TS1029	BCY31	4822 130 40452	Silicon transistor
TS1030	BCY31	4822 130 40452	Silicon transistor
TS1031	BCY31	4822 130 40452	Silicon transistor
TS1032	ASZ15	4822 130 40091	Germ. power transistor
TS1033	ASZ15	4822 130 40091	Germ. power transistor
TS1034	ASZ15	4822 130 40091	Germ. power transistor
TS1035	ASZ15	4822 130 40091	Germ. power transistor
TS1036	AC128	4822 130 40095	Germanium transistor
TS1037	ASY80	4822 130 40261	Germanium switching transistor
TS1038	BCY31	4822 130 40452	Silicon transistor
TS1039	BCY31	4822 130 40452	Silicon transistor
TS1041	ASZ15	4822 130 40091	Germ. power transistor
TS1042	ASZ15	4822 130 40091	Germ. power transistor
TS1043	AC128	4822 130 40095	Germanium transistor
TS1044	BCY31	4822 130 40452	Silicon transistor
TS1045	BCY31	4822 130 40452	Silicon transistor
TS1046	BCY31	4822 130 40452	Silicon transistor
TS1047	ASZ16	4822 130 40279	Germ. power transistor

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
TS1048	ASY80	4822 130 40261	Germanium switching transistor
TS1049	AC128	4822 130 40095	Germanium transistor
TS1050	BCY31	4822 130 40452	Silicon transistor
TS1051	BCY31	4822 130 40452	Silicon transistor
TS1052	BCY31	4822 130 40452	Silicon transistor
TS1053	ASZ16	4822 130 40279	Germ. power transistor
TS1054	ASY80	4822 130 40261	Germanium switching transistor
TS1055	BCY31	4822 130 40452	Silicon transistor
TS1056	AC128	4822 130 40095	Germanium transistor
TS1057	BCY31	4822 130 40452	Silicon transistor
TS1058	BCY31	4822 130 40452	Silicon transistor
TS1059	ASZ16	4822 130 40279	Germ. power transistor
TS1060	ASY80	4822 130 40261	Germanium switching transistor
TS1061	BCY31	4822 130 40452	Silicon transistor

<i>No.</i>	<i>Type number</i>	<i>Ordering Code</i>	<i>Description</i>
TS1062	AC128	4822 130 40095	Germanium transistor
TS1063	BCY31	4822 130 40452	Silicon transistor
TS1064	BCY31	4822 130 40452	Silicon transistor
TS1065	ASZ16	4822 130 40279	Germ. power transistor
TS1066	ASY80	4822 130 40261	Germanium switching transistor
TS1067	AC128	4822 130 40095	Germanium transistor
TS1068	BCY31	4822 130 40452	Silicon transistor
TS1069	BCY31	4822 130 40452	Silicon transistor
TS1070	BCY31	4822 130 40452	Silicon transistor
TS1071	ASZ15	4822 130 40091	Germ. power transistor
TS1072	ASZ15	4822 130 40091	Germ. power transistor
TS1073	AC128	4822 110 40095	Germanium transistor
TS1074	BCY31	4822 130 40452	Silicon transistor
TS1075	BCY31	4822 130 40452	Silicon transistor
TS1076	BCY31	4822 130 40452	Silicon transistor
TS1401	ASZ21	4822 130 40271	Germanium transistor

VALVES

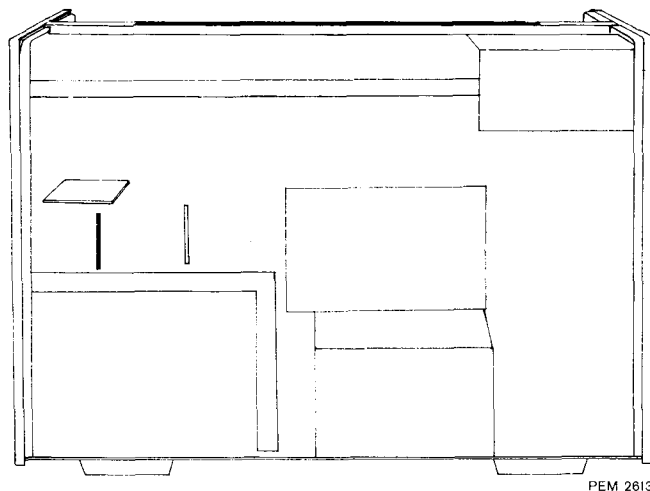
<i>No.</i>	<i>Type number</i>	<i>Description</i>
B1	E188CC	Double triode
B4	E188CC	Double triode
B5	E55L	Penthode
B6	E55L	Penthode
B301	D13-16GH/01	Cathode-ray tube
B400	E188CC	Double triode
B401	EF184	Penthode
B402	EF184	Penthode
B451	E188CC	Double triode
B501	EF184	Penthode
B502	E88CC	Double triode
B503	E88CC	Double triode
B504	5726	Double triode
B506	E81L	Penthode
B507	E88CC	Double triode
B508	E88CC	Double triode

<i>No.</i>	<i>Type number</i>	<i>Description</i>
B509	E88CC	Double triode
B511	E80CF	Triode penthode
B512	5654	Penthode
B513	E80CF	Triode penthode
B514	ZA1004	Neon stabiliser
B701	E88CC	Double triode
B702	E88CC	Double triode
B703	E810F	Penthode
B704	E810F	Penthode
B705	E88CC	Double triode
B706	E88CC	Double triode
B1001	ZZ1000	Voltage reference tube
B1301	EL86	Penthode
B1302	ECC82	Double triode
B1401	E80CF	Triode penthode
B1402	5718	Triode

LAMPS

<i>No.</i>	<i>Code number</i>	<i>Description</i>
LA1	6829	6 V-1.2 W
LA2	6829	6 V-1.2 W
LA3	6829	6 V-1.2 W
LA4	6829	6 V-1.2 W
LA5	GL8	Neon tube

<i>No.</i>	<i>Code number</i>	<i>Description</i>
LA6	GL8	Neon tube
LA7	GL8	Neon tube
LA8	955/D10 × 20	10 V-200 mA (furnished by Central Service)
LA9	8108D	25 V-50 mA



PEM 2613

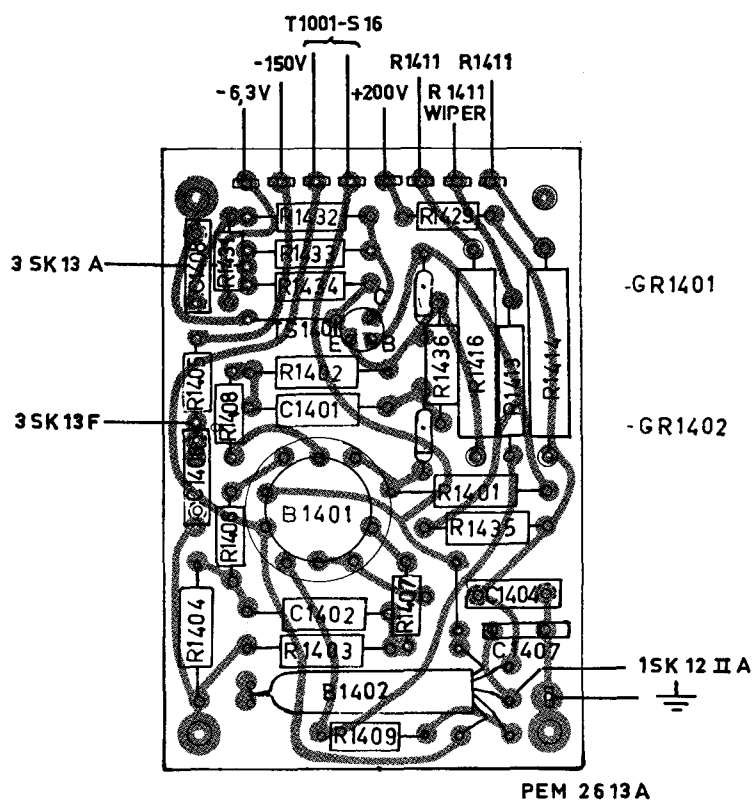


Fig. 73. Printed circuit board U5 (calibration voltage)

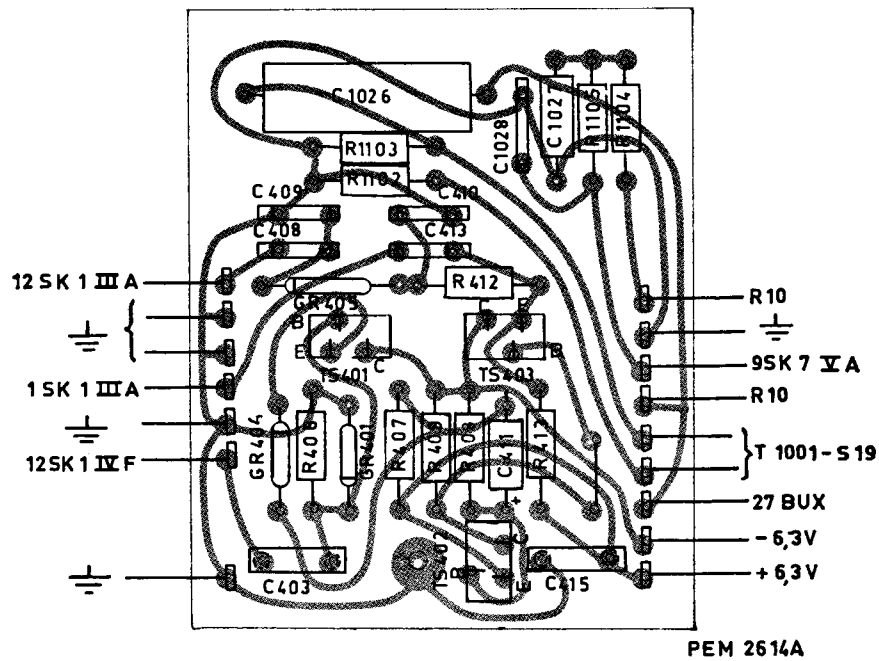
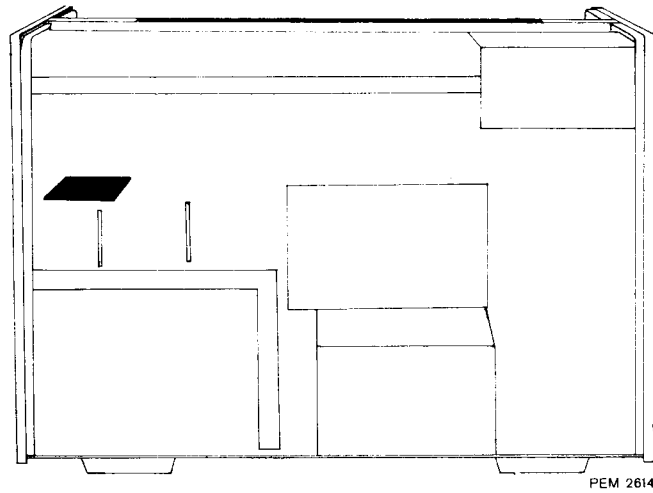


Fig. 74. Printed circuit board U6 (TV sync.)

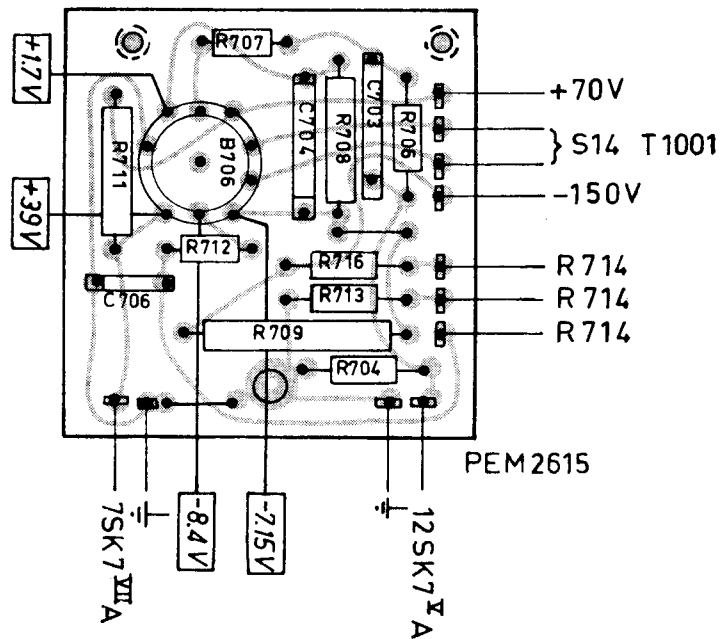
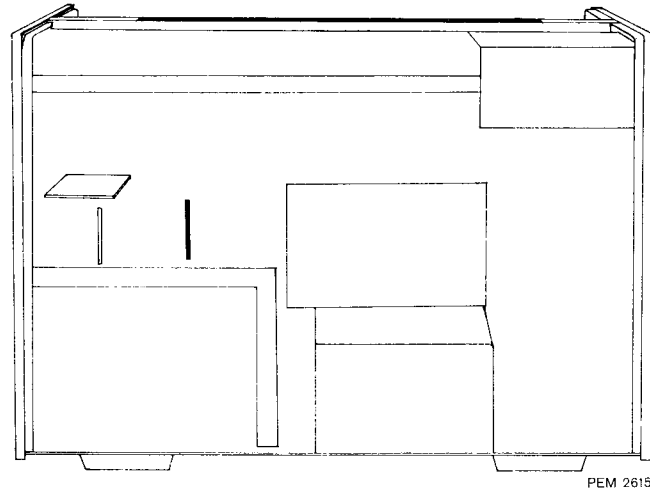
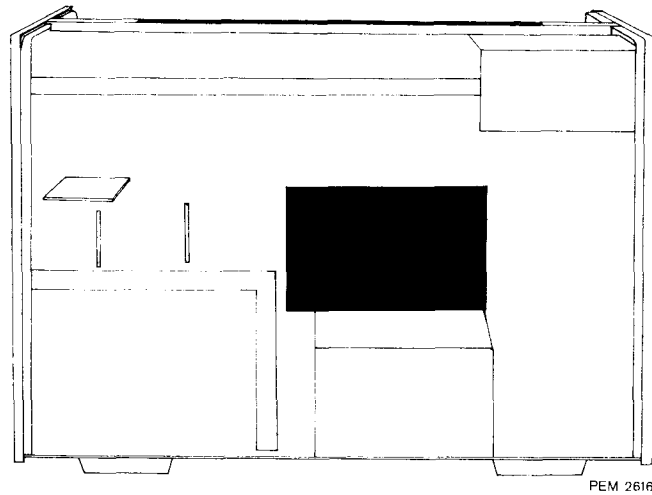
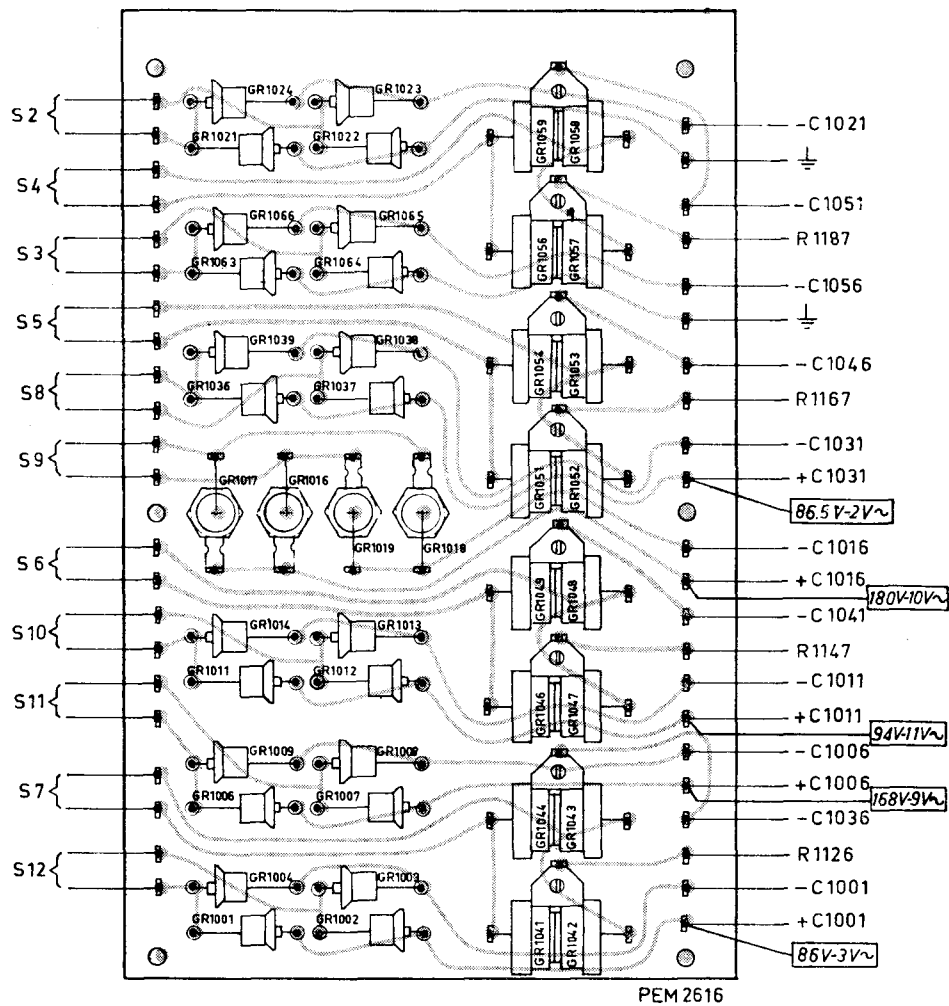


Fig. 75. Printed circuit board U7 (horizontal preamplifier)



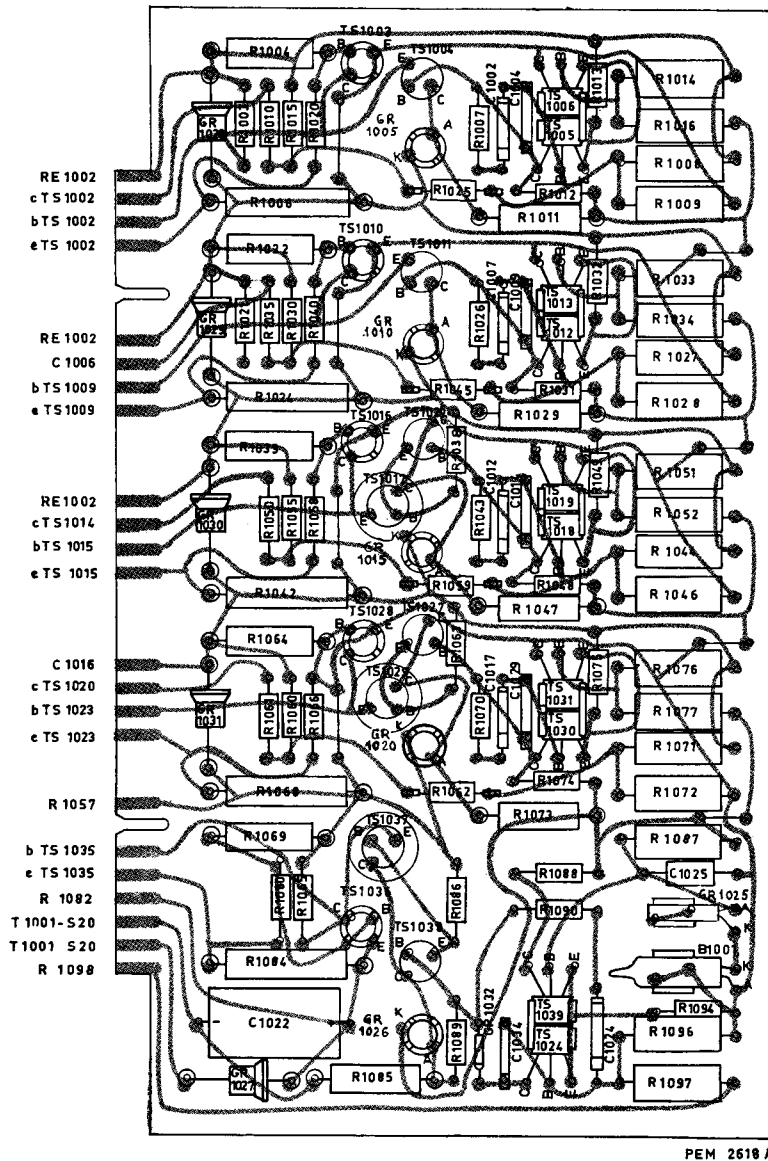
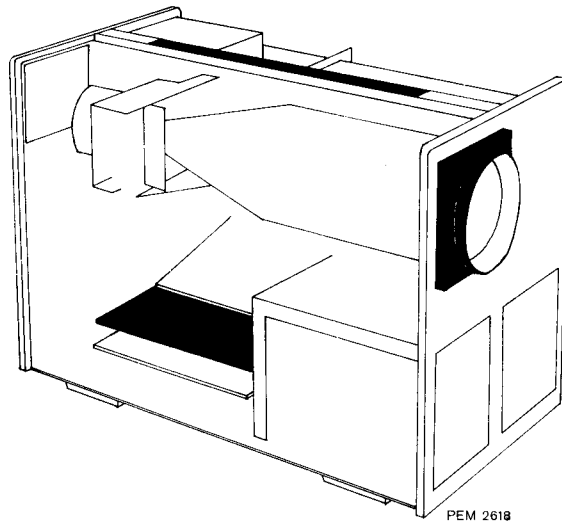
PEM 2616



PEM 2616

Fig. 76. Printed circuit board U8 (rectifiers)

Fig. 77. Printed circuit board U11 (power supply II)



Note:

The diodes GR1020, GR1015, GR1010 and GR1005 are mounted lying horizontally on the point instead of vertically as shown in fig. 78.

Fig. 78. Printed circuit board U12 (power supply I)

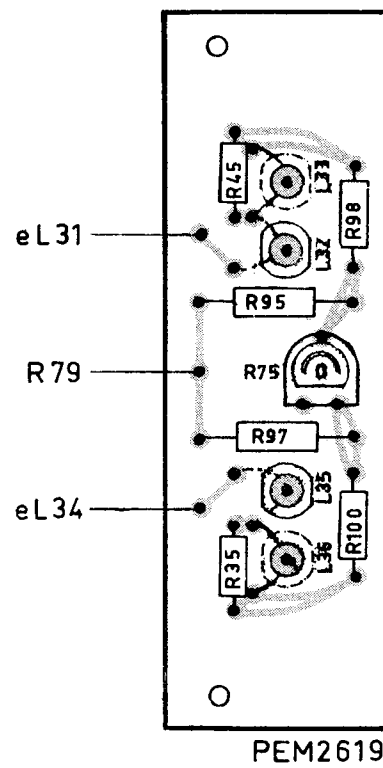
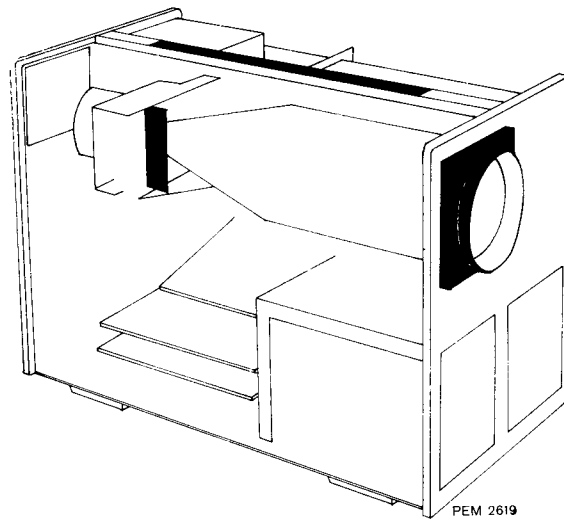


Fig. 79. Printed circuit board U14 (power amplifier)

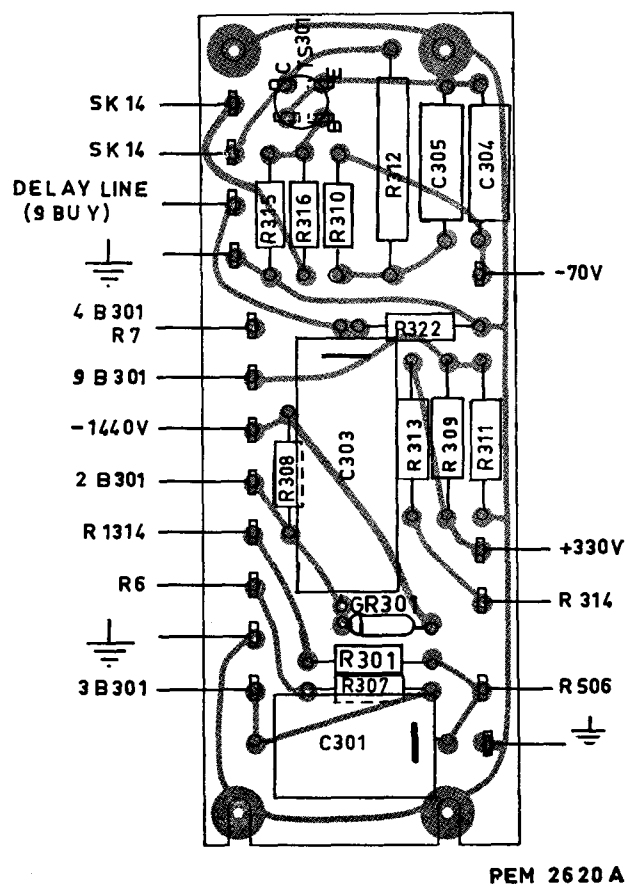
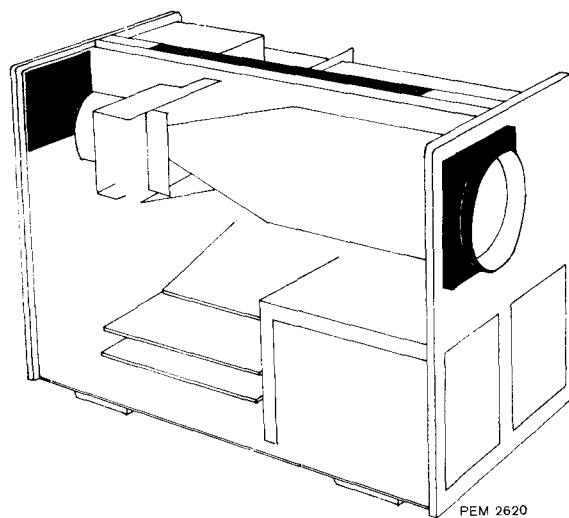


Fig. 80. Printed circuit board U16 (CRT circuit)

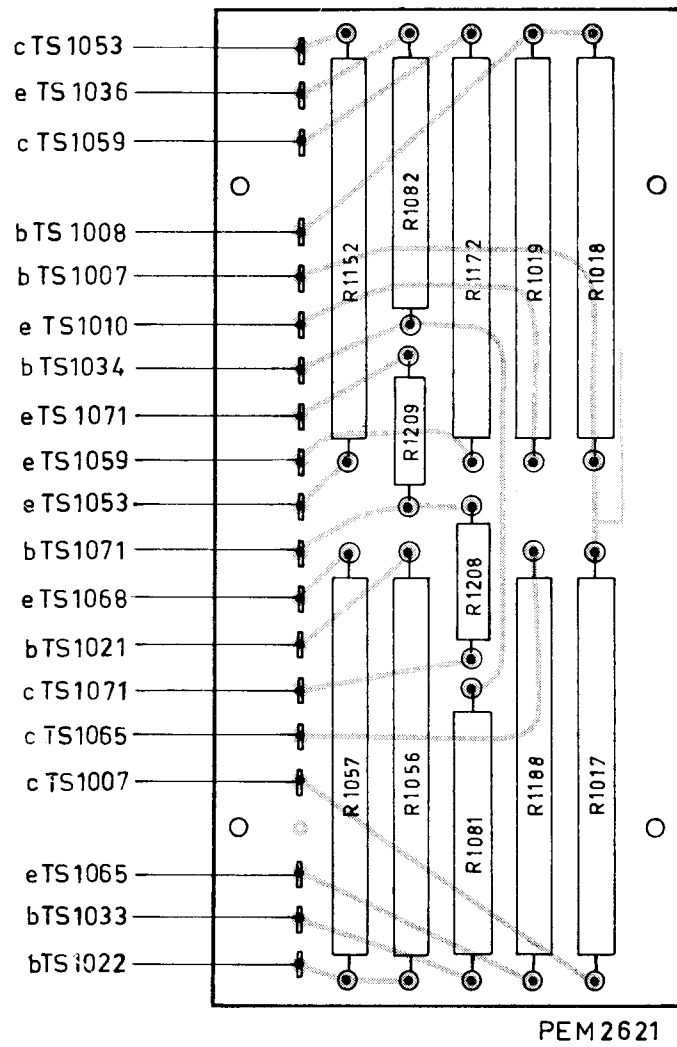
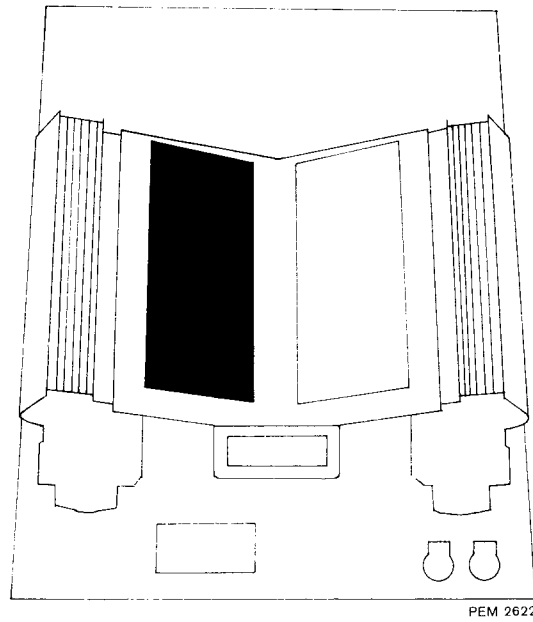


Fig. 81. Printed circuit board U17 (power supply resistors)

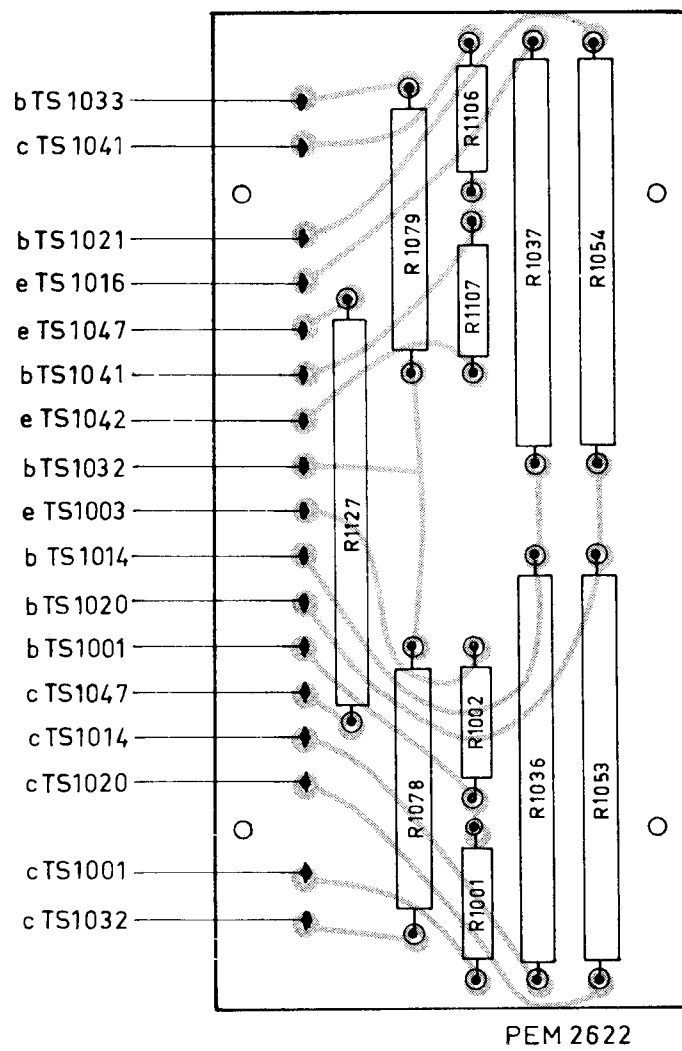
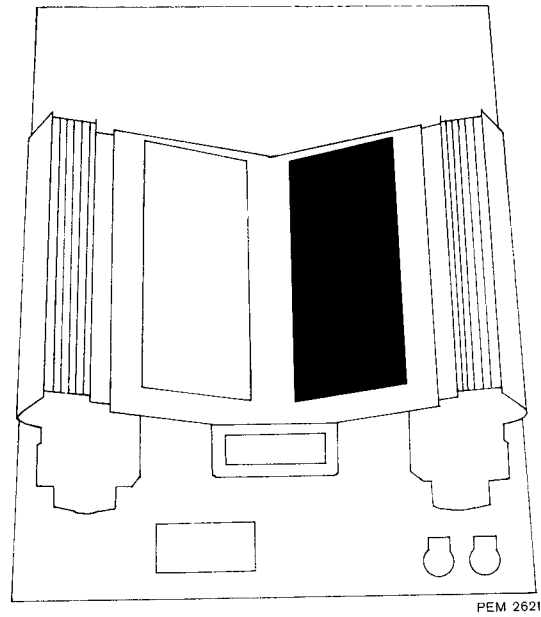


Fig. 82. Printed circuit board U18 (power supply resistors)

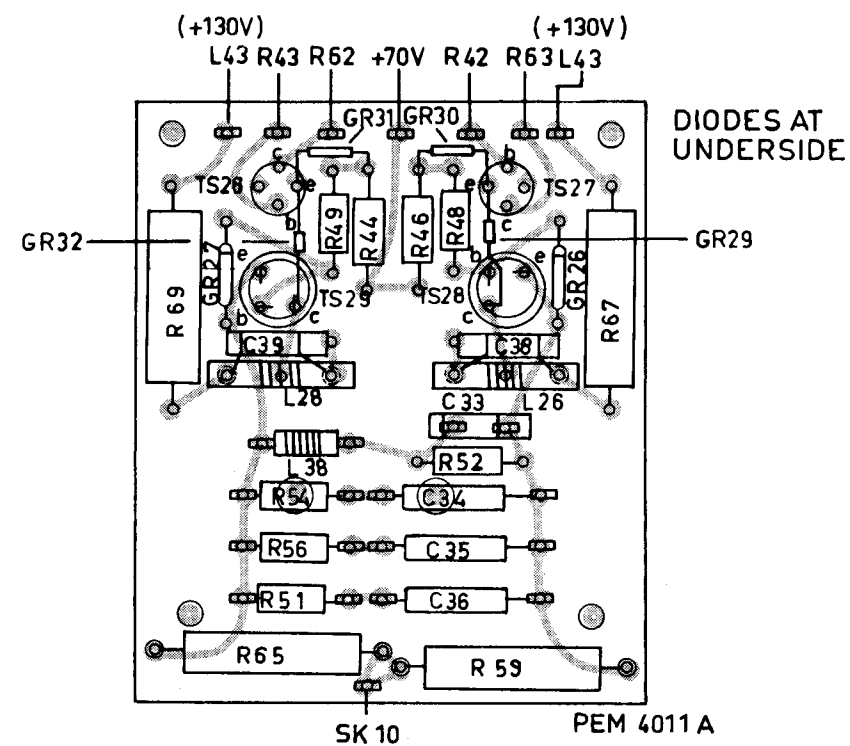
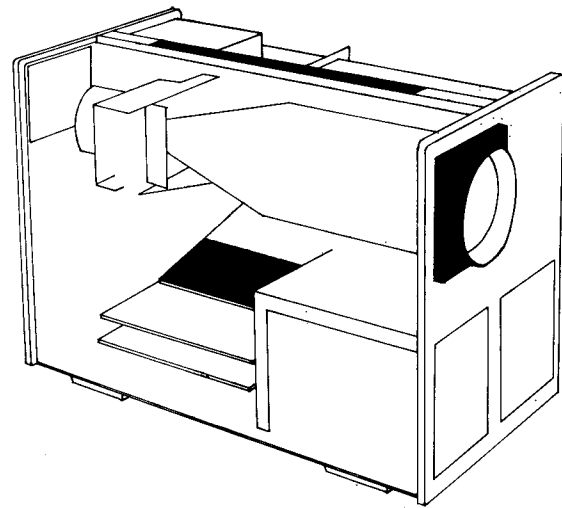
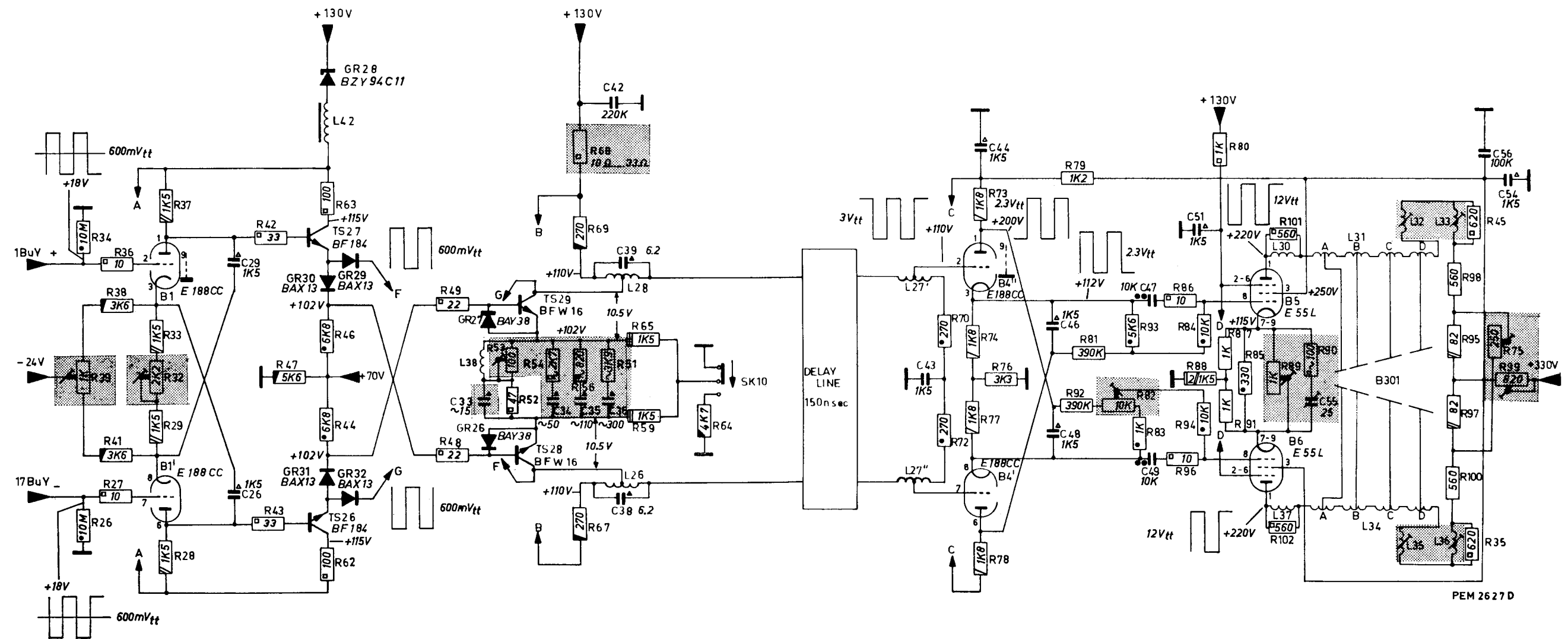


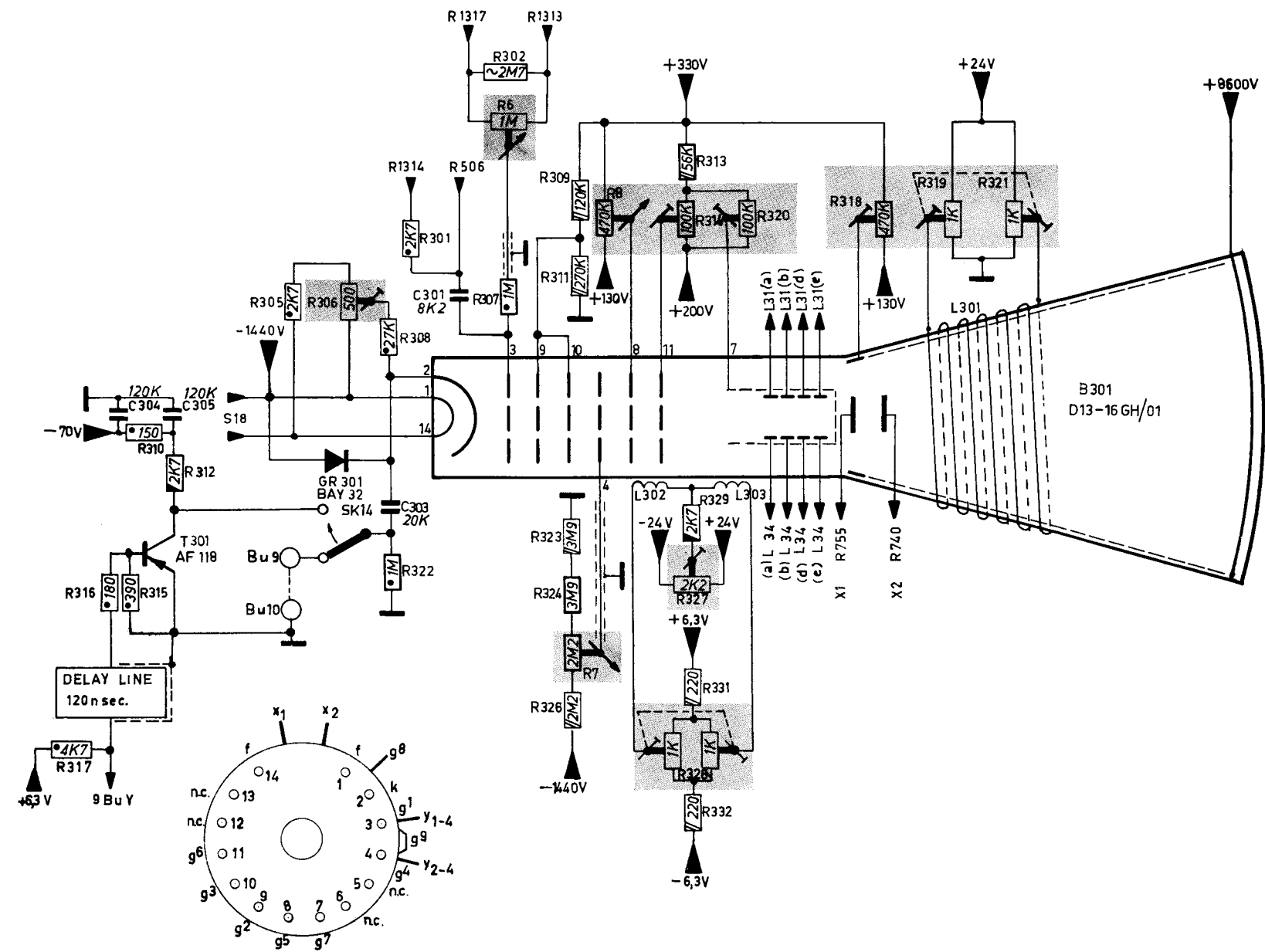
Fig. 83. Circuit diagram of the vertical amplifier and printed circuit board U22 (delay line driver)



EXPLANATION OF THE CODE

- 7BU Y means: terminal 7 of the plug at the Y-compartment
 12SK1111A means: terminal 12 of switch SK1, third (III) wafer, rear (A) side
 2SK7V1F means: terminal 2 of switch SK7, sixth (VI) wafer, front (F) side
 aB511p means: anode (a) of valve B511, pentode (p) section, front (F) side
 aB511p means: anode (a) of valve B511, pentode (p) section.
 3,8 B507 means: to terminal 3 or 8 (both interconnected) of valve B507
 eTS1075 means: to emitter (e) of transistor TS1075

Fig. 83. Circuit diagram of the vertical amplifier and printed circuit board U22 (delay line driver)



Erratum: GR301 (BAY32) should read GR301 (BAX16)

Fig. 84. Circuit diagram of the CRT circuit

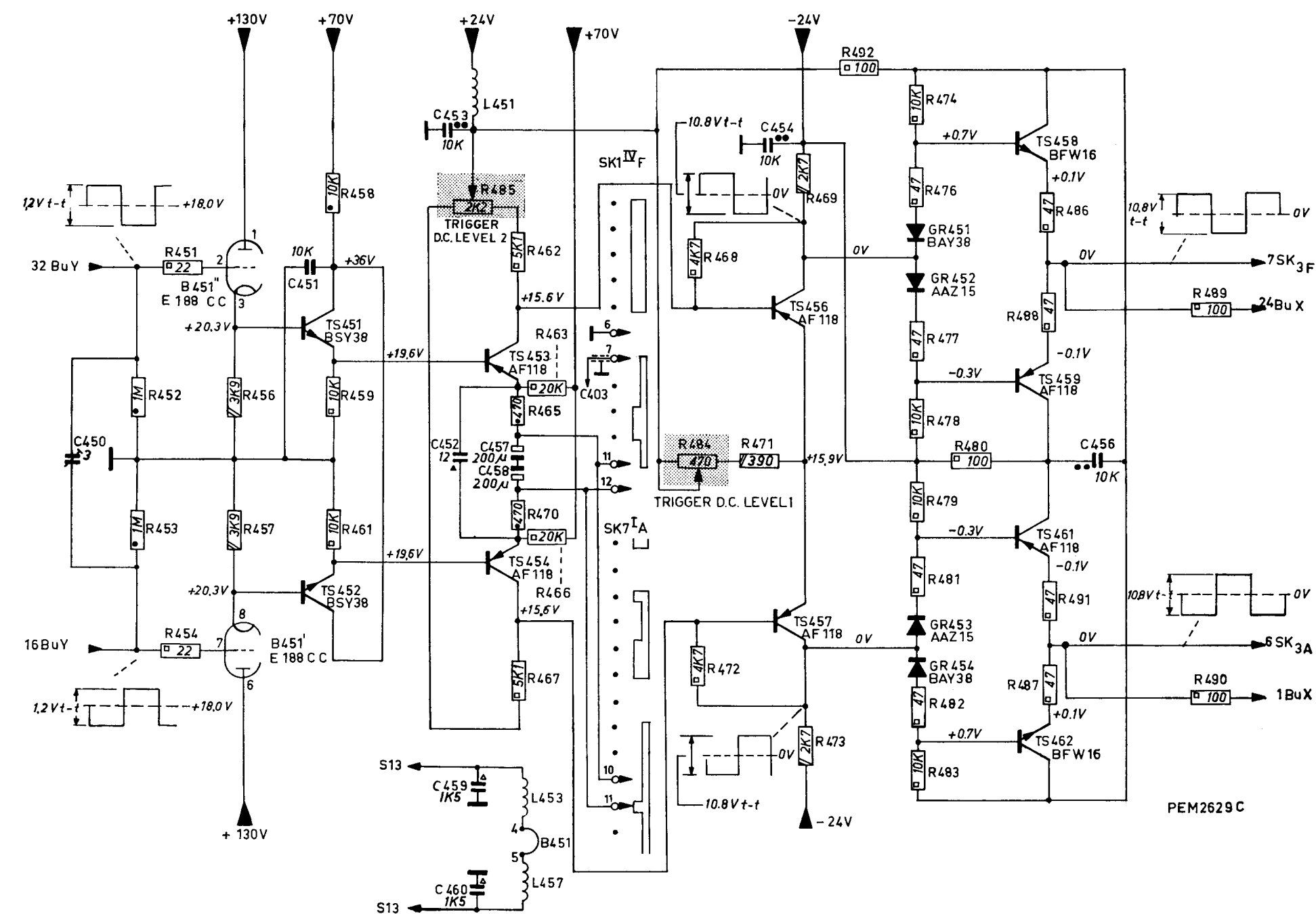
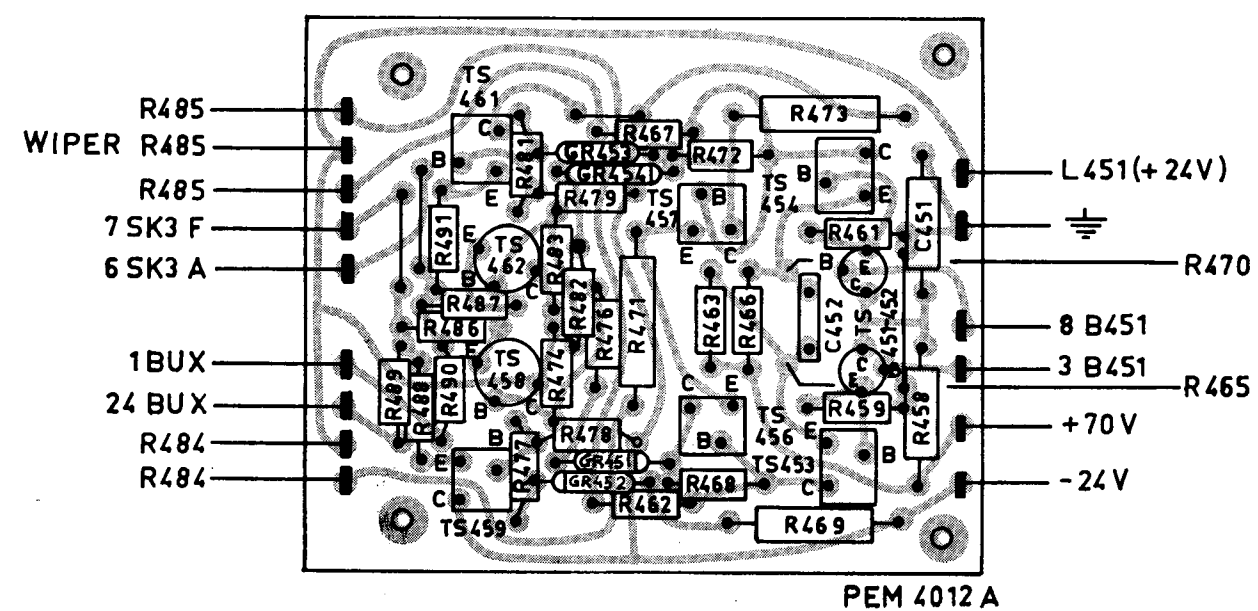
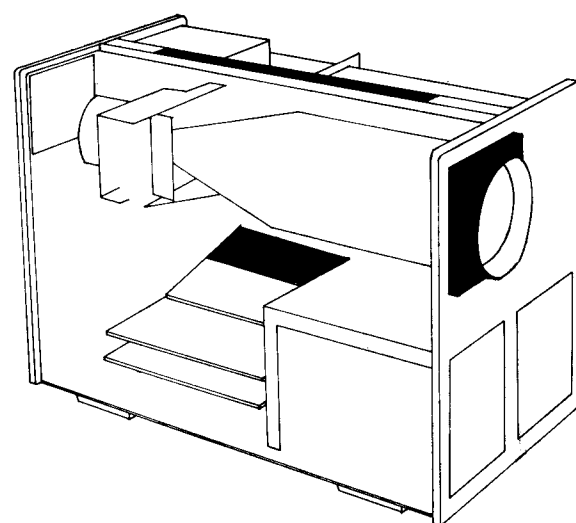


Fig. 85. Circuit diagram of the trigger amplifier and printed circuit board U21 (trigger amplifier)

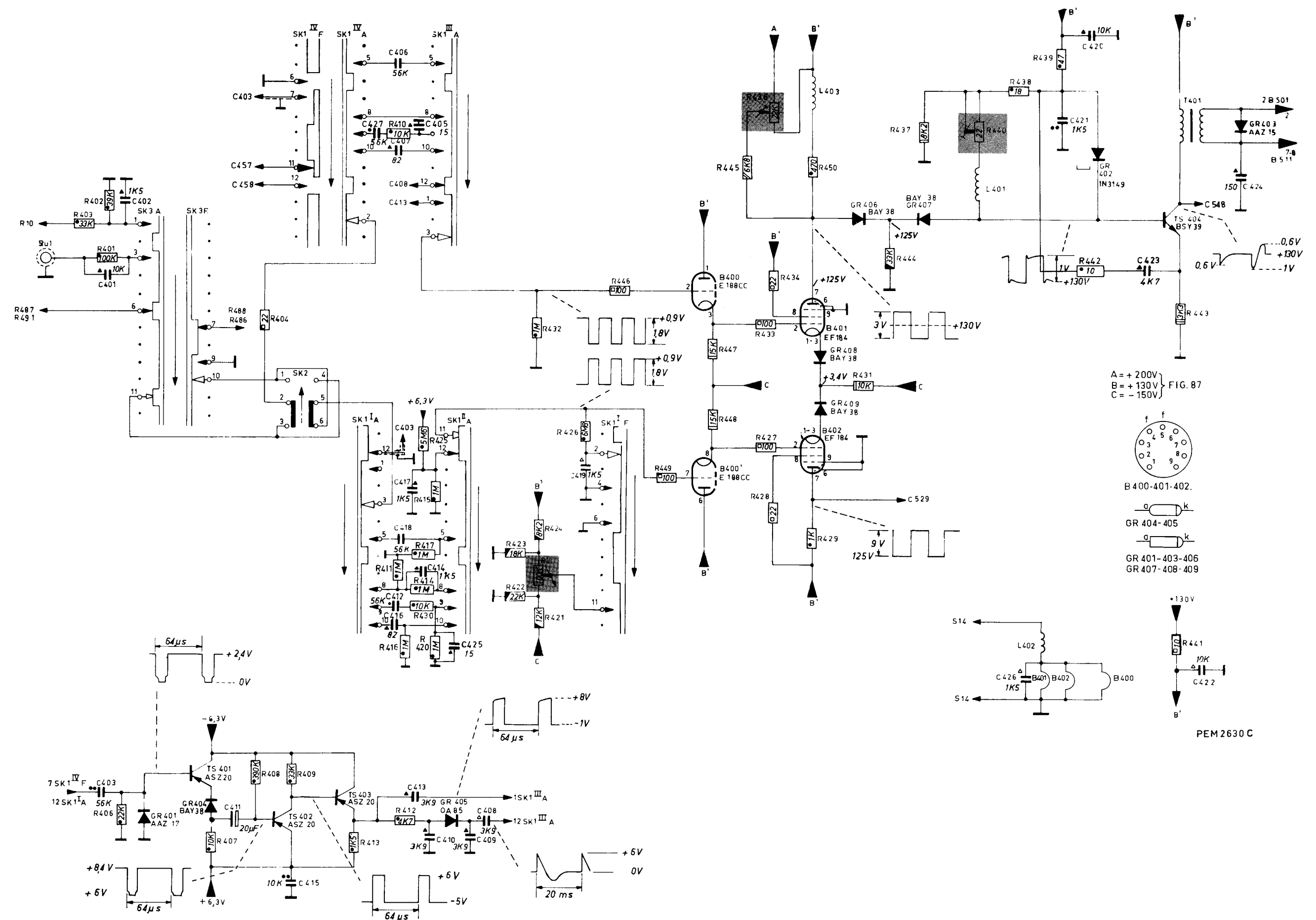


Fig. 86. Circuit diagram of the trigger unit

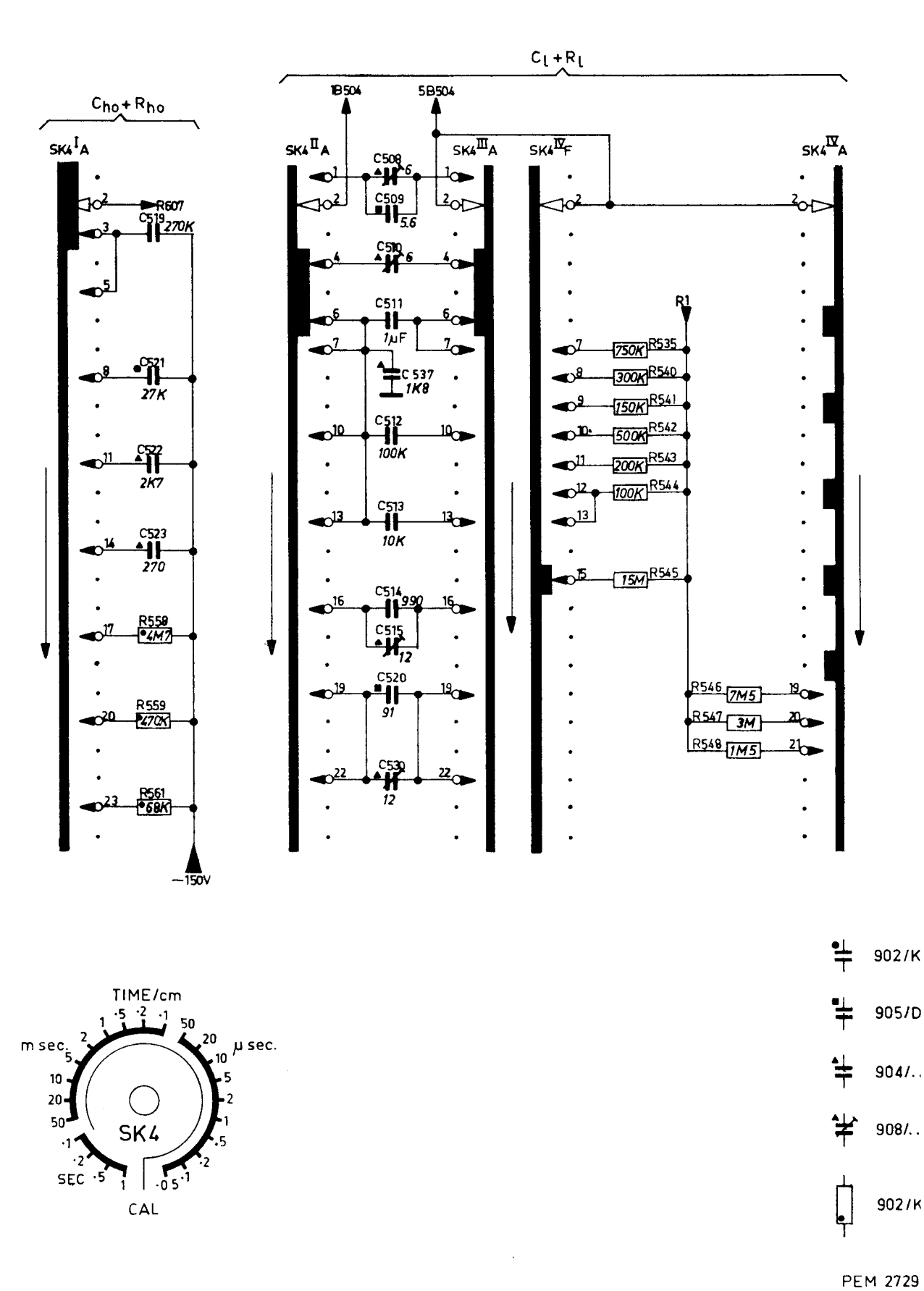


Fig. 88. Circuit diagram of the time-coefficient switch

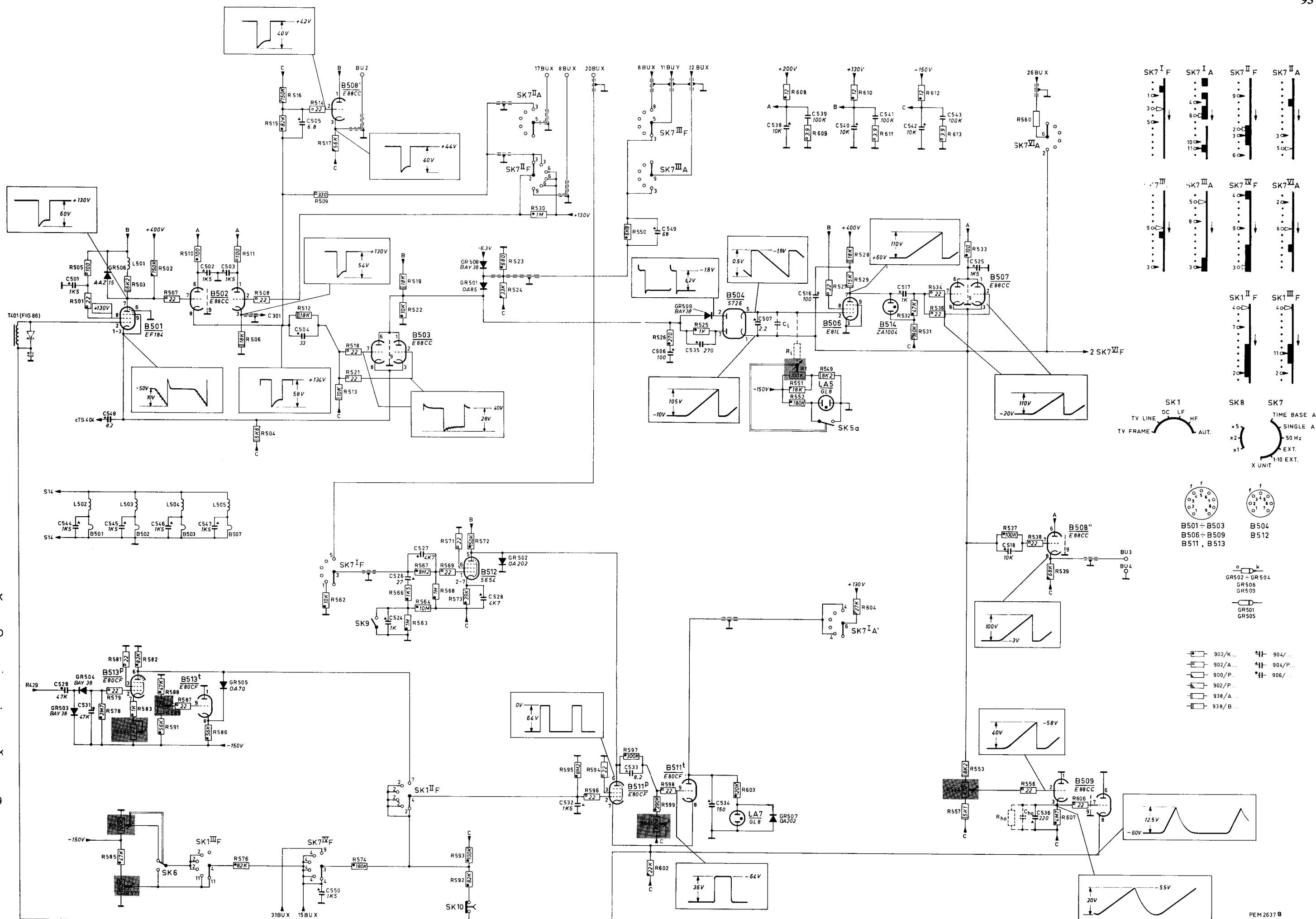


Fig. 87. Circuit diagram of the time-base generator A

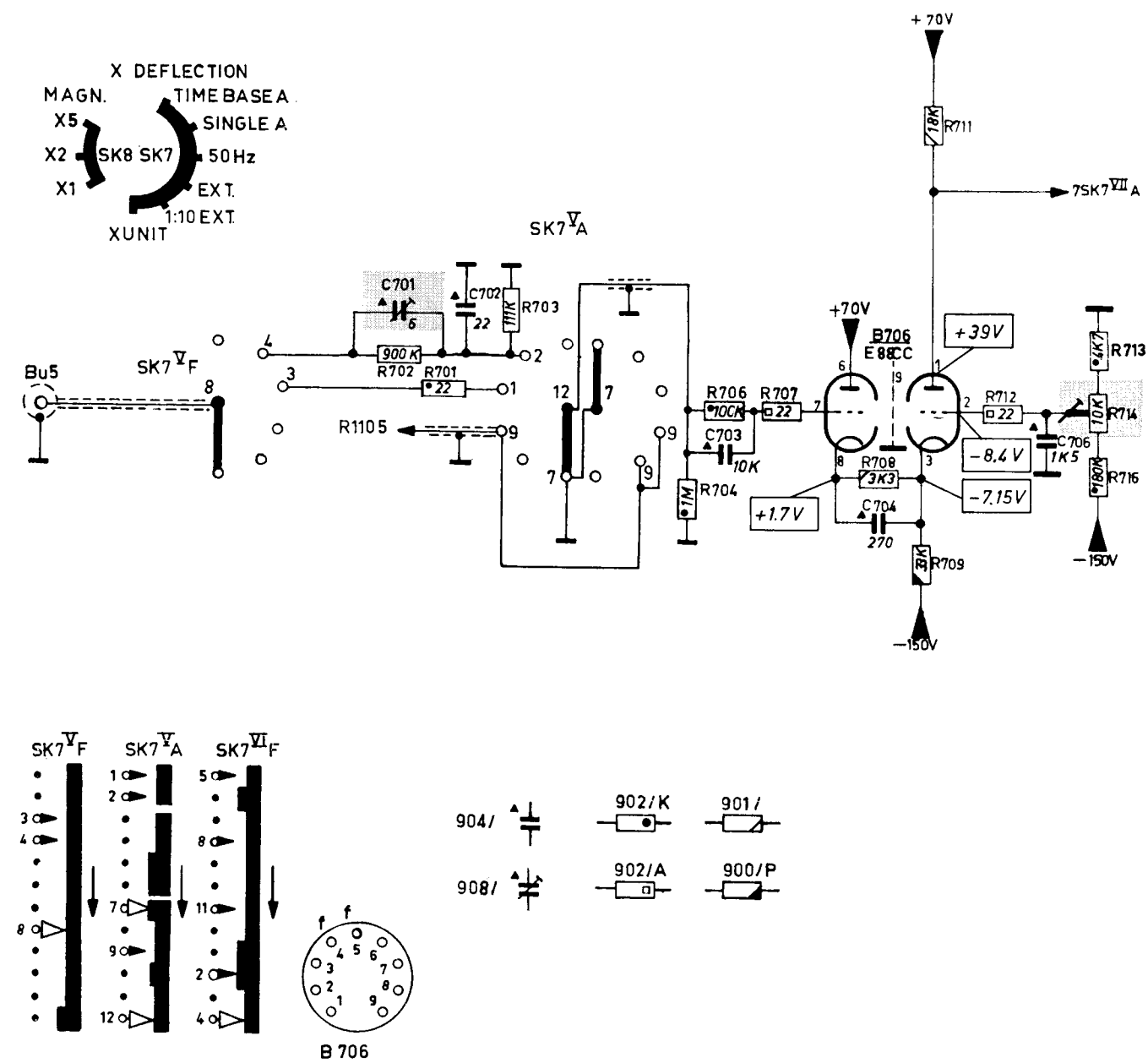


Fig. 89. Circuit diagram of the pre-amplifier

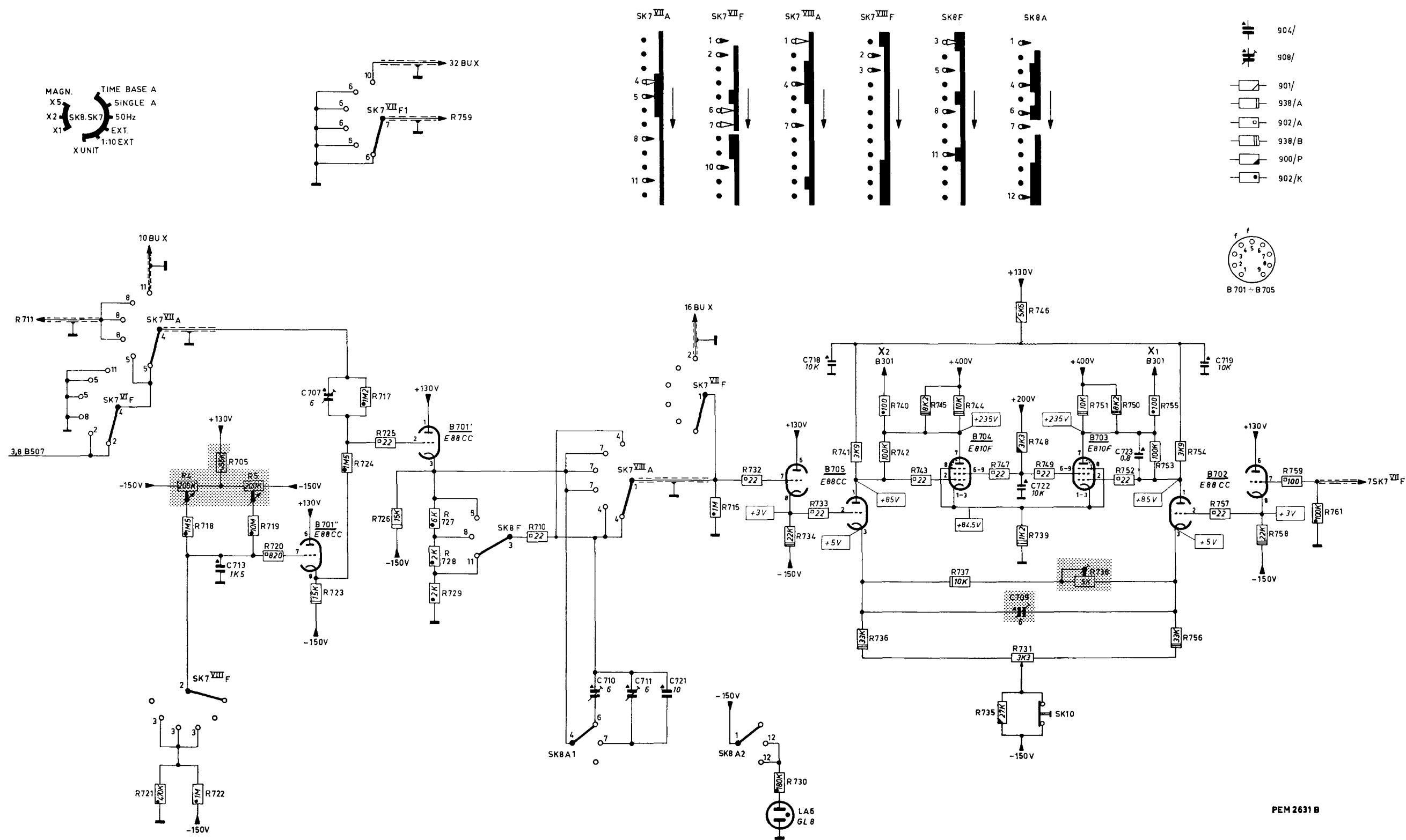


Fig. 90. Circuit diagram of the horizontal amplifier

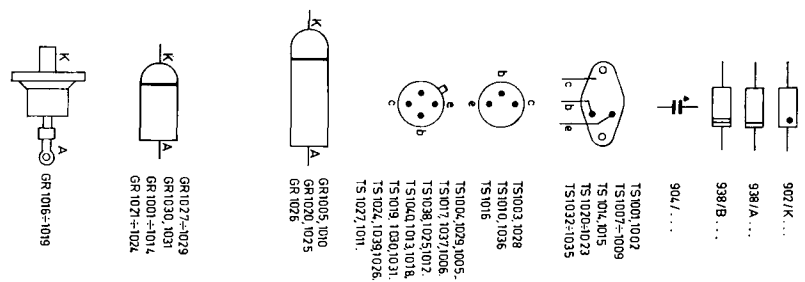
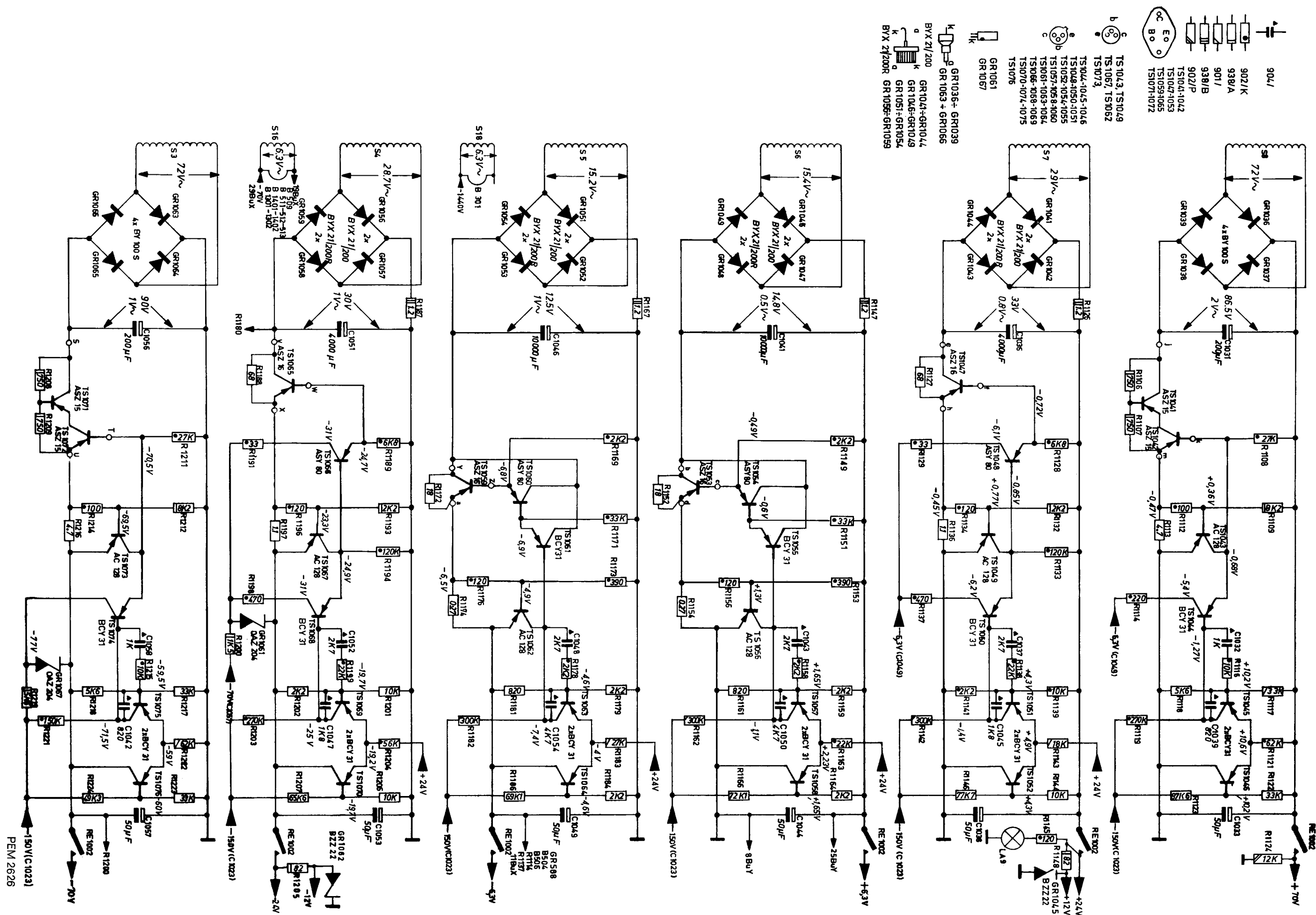


Fig. 91. Circuit diagram of the power supply I



Errata: GR 1036... GR 1039 and GR 1063... GR 1066 should be of type BY127
 GR 1061 and GR 1067 should be of type BZY88C6V8

Fig. 92. Circuit diagram of the power supply II

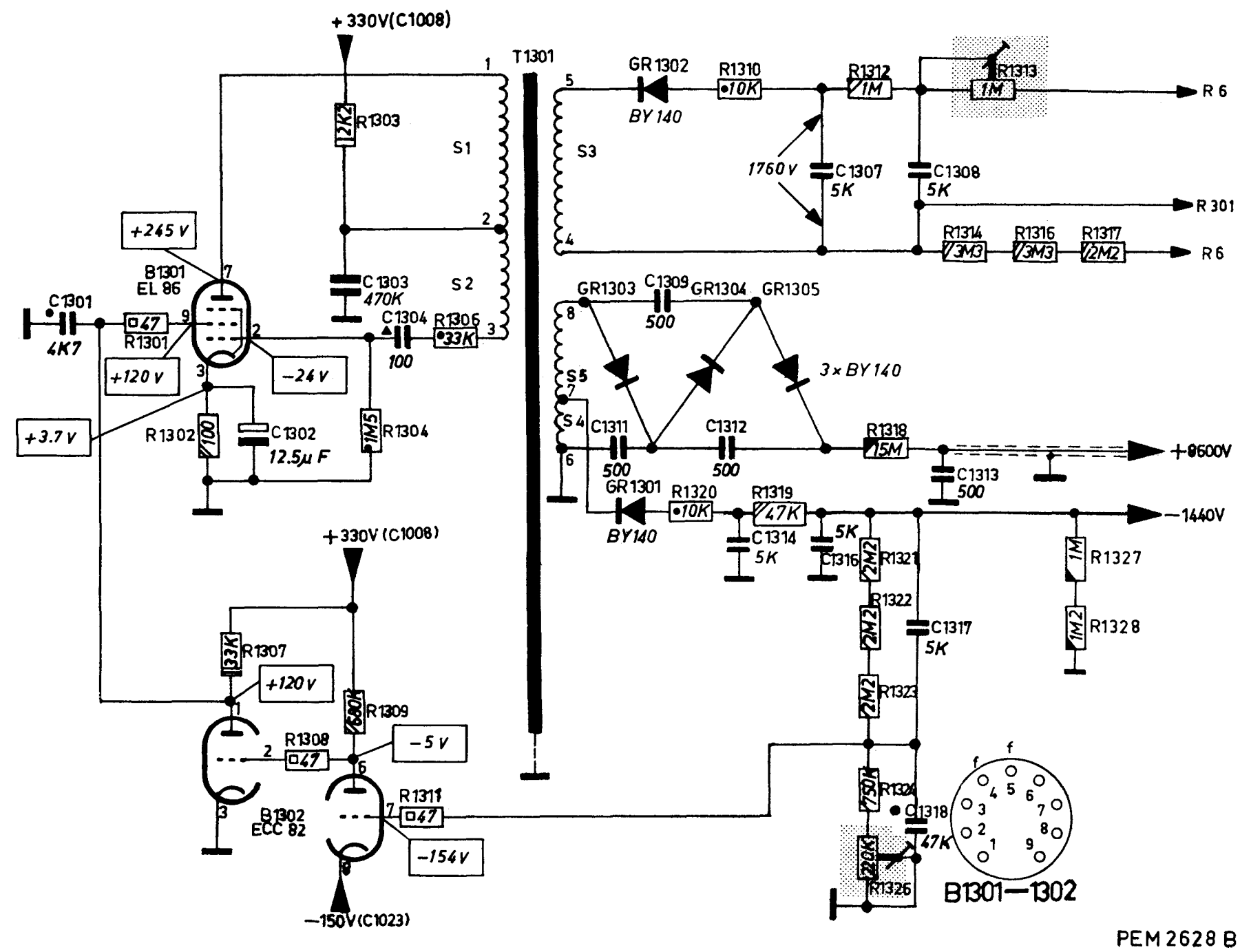


Fig. 93. Circuit diagram of the high voltage unit

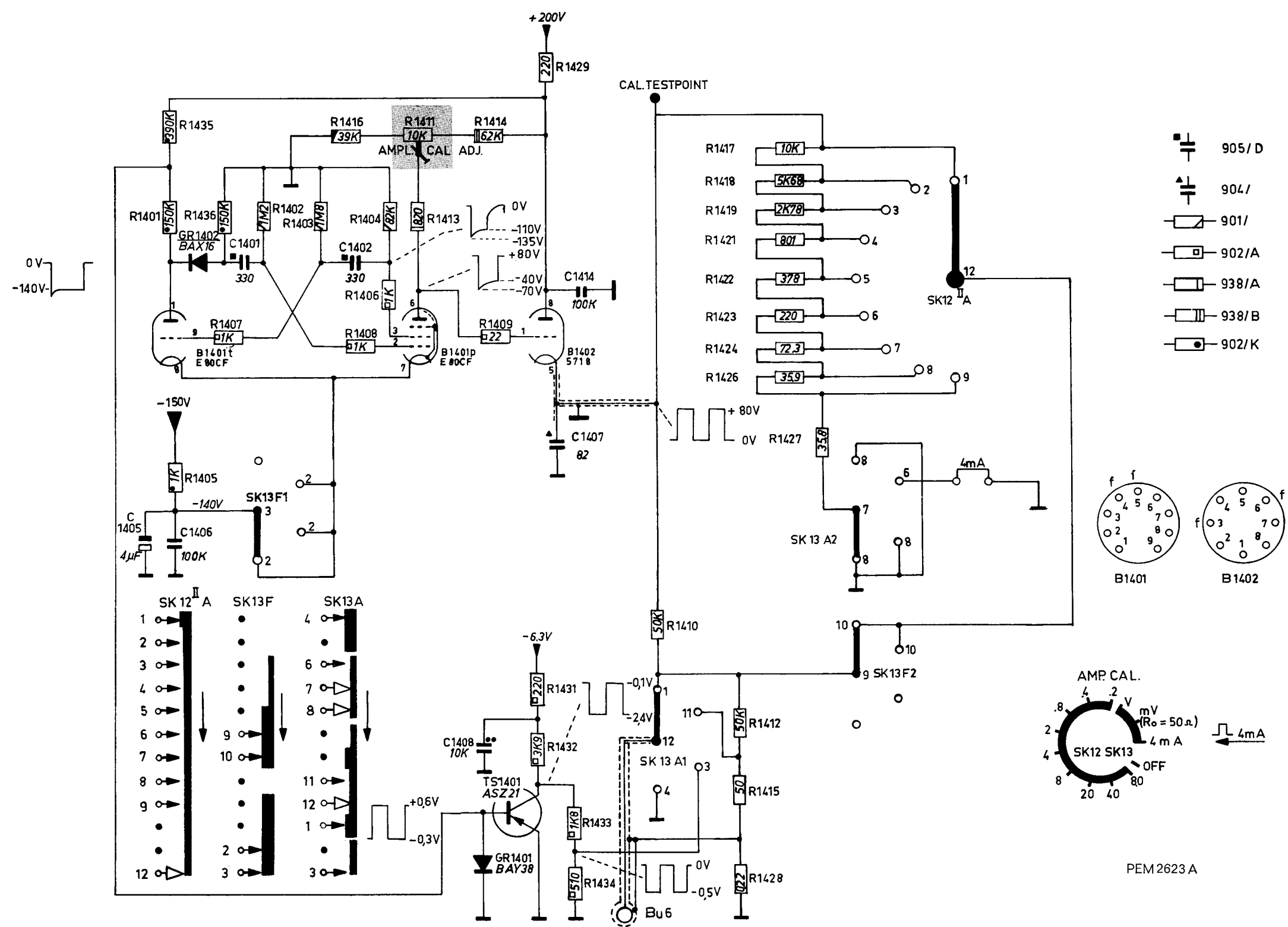


Fig. 94. Circuit diagram of the calibration unit

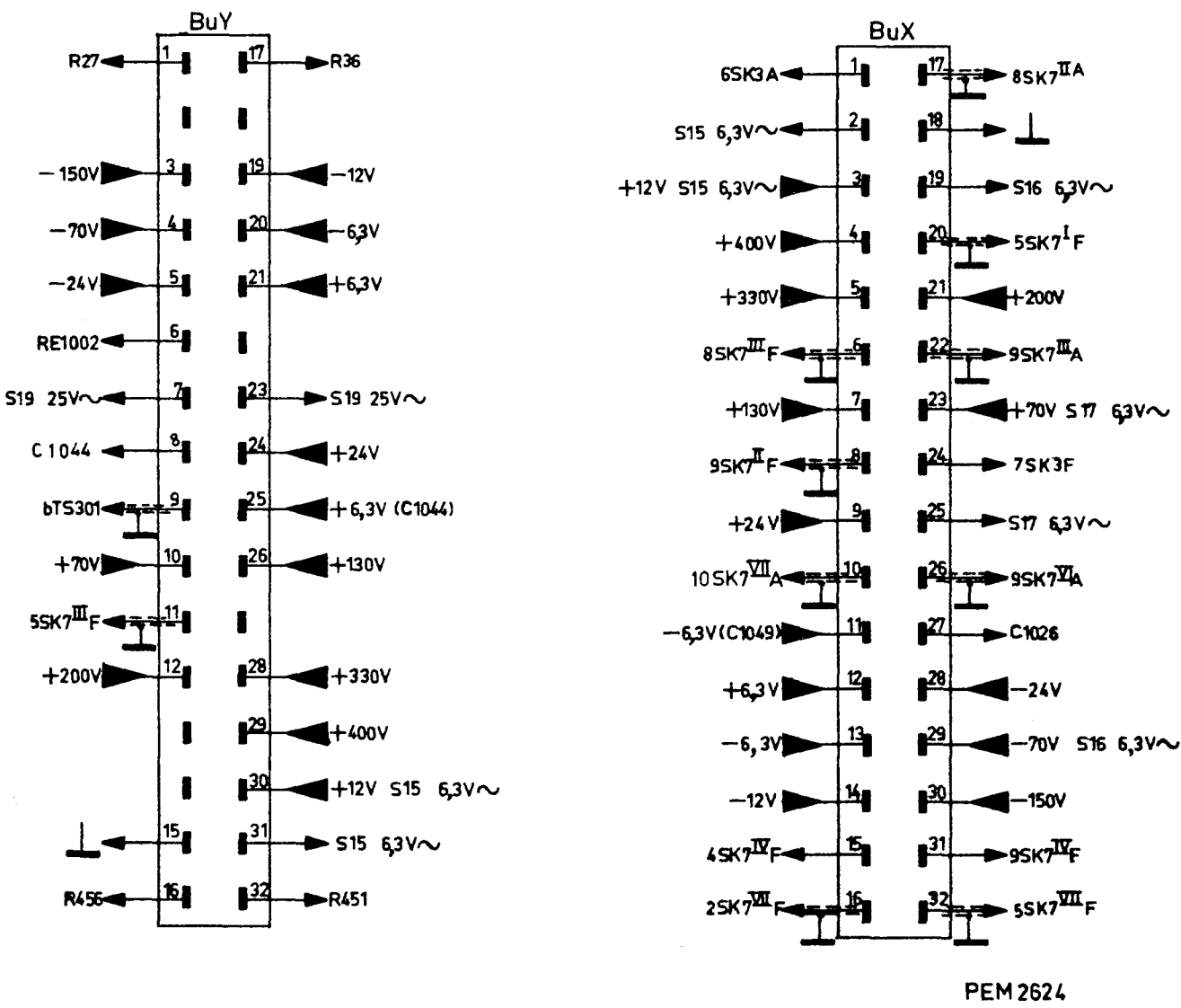


Fig. 95. Plug connections

ERRATUM: 17 BUX is connected to
5 SK7^{II}A instead of
8 SK7^{II}A

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