PHILIPS

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SWEEP GENERATOR
PM 5162

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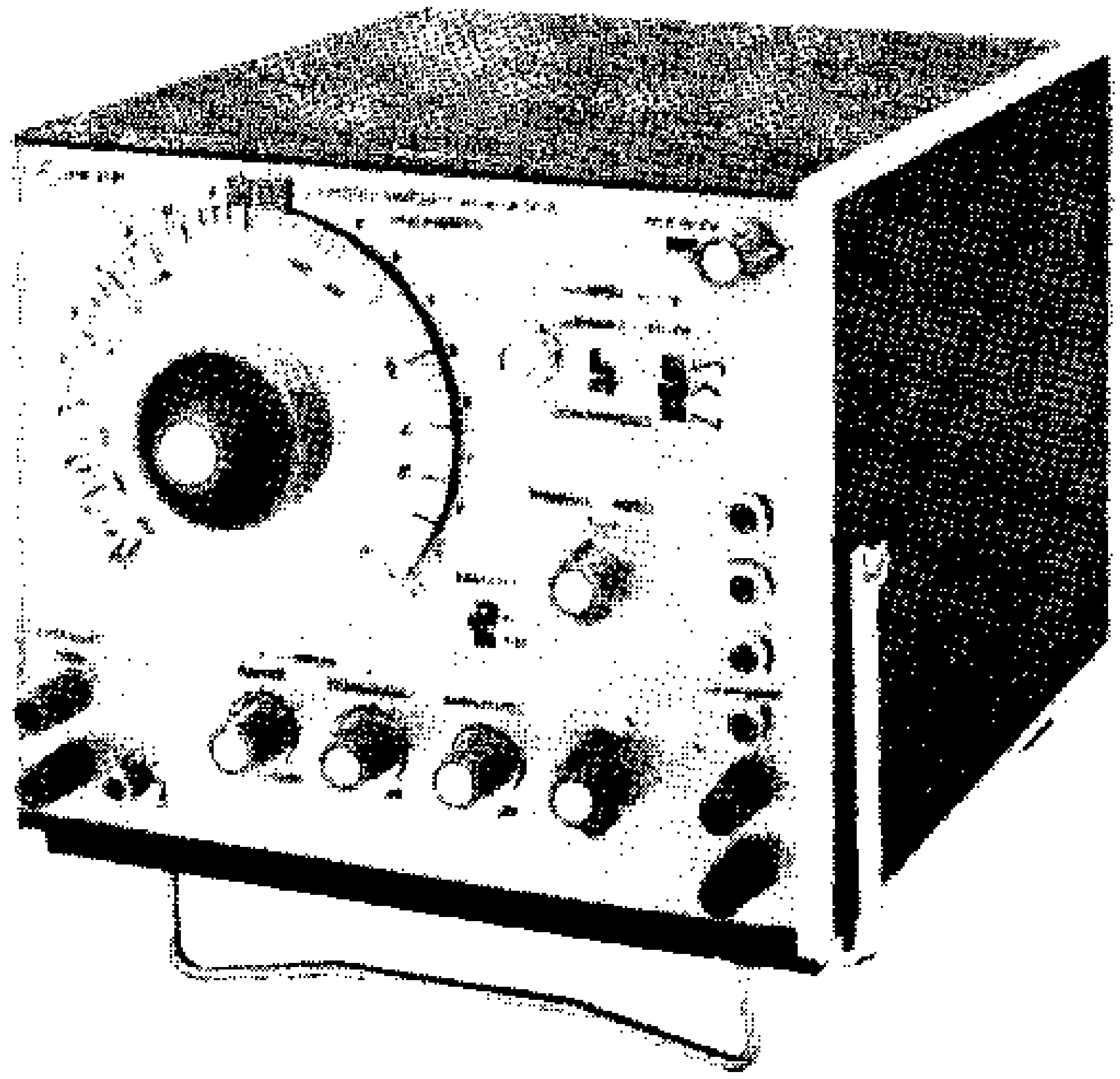

PHILIPS

Manual

SWEEP GENERATOR
PM 5162

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GENERAL

Introduction

I

Sweep oscillator PM 5162 is a function generator delivering sine, square and triangular waveforms, the frequency of which may be swept over four decades ($1 : 10^4$) in one single sweep.

Sweeping can be accomplished:
- manually
- automatically by an internal wave or
- by an external wave

Moreover, two different frequency ranges can be chosen, viz:
0.1 Hz... 1 kHz
10 Hz...100 kHz

Other facilities are:
- continuous control of the sweep width
- continuous control of the sweep speed
- fast upward sweep, fast downward sweep or equal up and down sweep times
- one single up and down sweep

The following outputs are provided:
- three output terminals, on each of which one waveform with a fixed amplitude is available
- one output terminal from which any one of the waveforms can be selected with variable amplitude
- one output socket on which a voltage is available which corresponds to the logarithm of the frequency

The output impedance of the instrument is 600 Ω; the output may be loaded with any load from open circuit to short circuit.
The circuit earth and chassis earth are separated by a 100 kΩ resistor so that a semi-floating circuit or a single-point earthing system may be used.

Technical data

II

Properties, expressed in numerical values with tolerances stated, are guaranteed by the factory.
Values without tolerances serve for information purposes only and indicate the characteristics of an average instrument.

A. FREQUENCY

Ranges	0.1 Hz... 1 kHz 10 Hz...100 kHz
Error at 25° C	$\frac{\Delta \log f}{\log f_{max}} < 1\%$
Temperature coefficient	0.7% per degree C
Long-term drift	2% in 7 hours after a warming-up period of 1 hour and at constant temperature and mains voltage

B. OUTPUTS

1. Three fixed outputs	– squarewave – triangle wave – sinewave } Amplitude 10 V_{p-p} open circuit
2. One output with a switch for selecting squarewave, triangle wave or sinewave	The amplitude of each wave form is variable up to a minimum of 3.2 V_{p-p} into 600 Ω at 20 kHz.
3. $V_0 \propto$ LOG f	Output voltage proportional to the logarithm of the frequency. Only in position AUTO of SK5

C. OUTPUT CHARACTERISTICS

1. Triangle wave

Non-linearity	< 1% of maximum amplitude
Asymmetry	< 0.5% of a period from 0.1 Hz to 80 kHz
Frequency response	Flat within 0.2 dB from 0.1 Hz to 20 kHz referred to 5 kHz A typical response curve is shown in Fig. 1

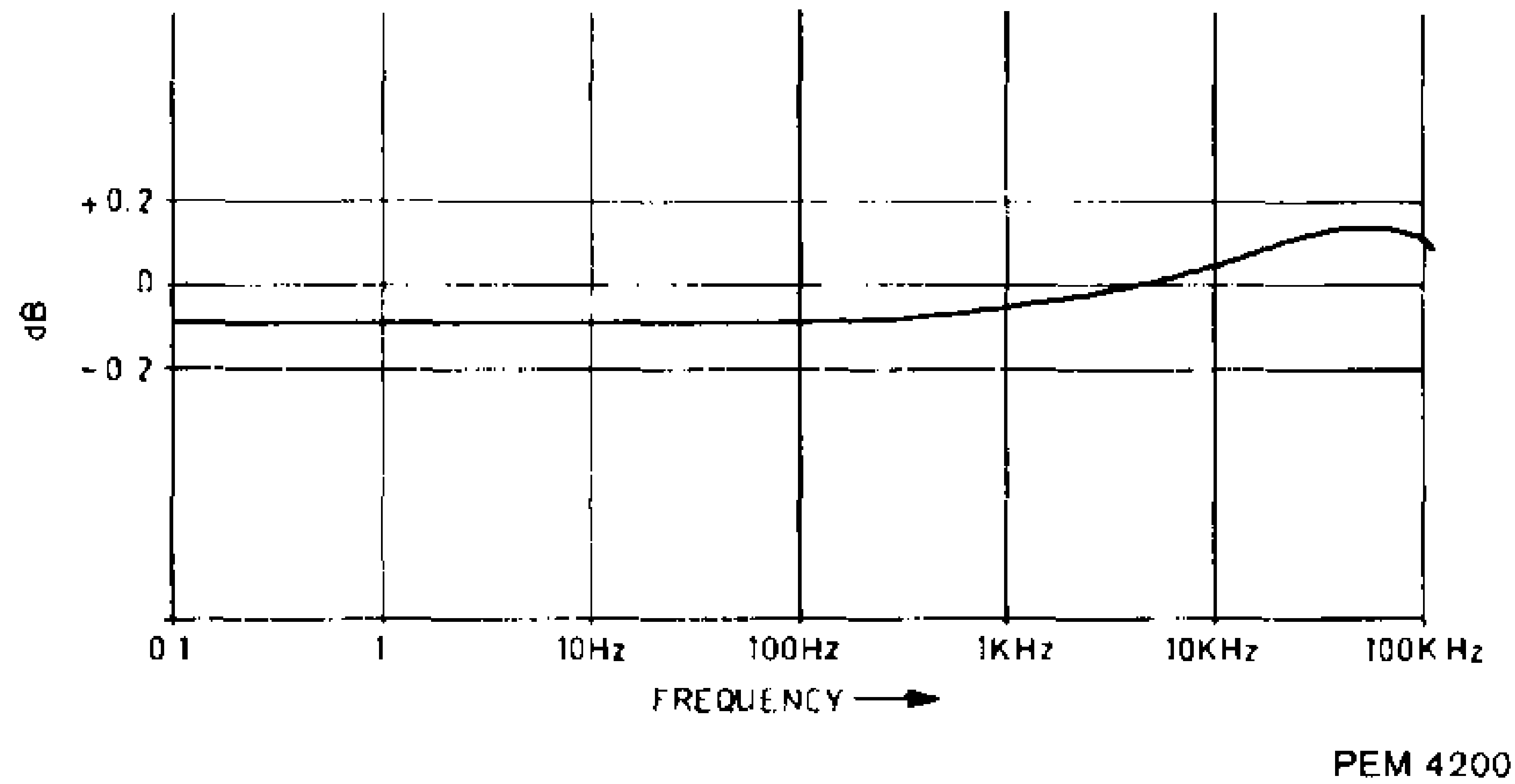


Fig. 1. Typical response curve for triangle wave

2. Sinewave

Distortion	< 1% from 0.1 Hz to 80 kHz Temperature coefficient 0.05% per degree C. A typical distortion curve is shown in Fig. 2.

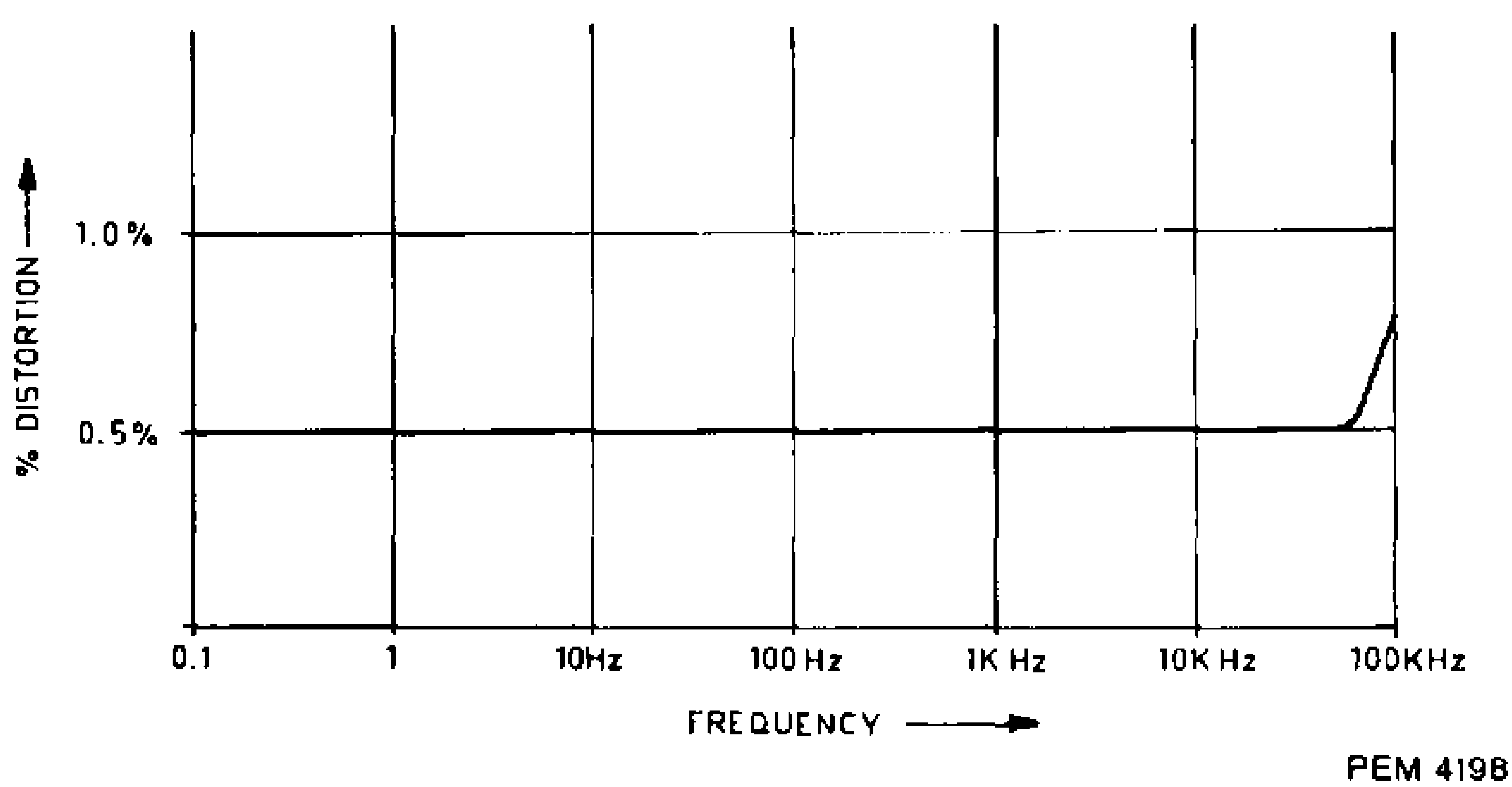


Fig. 2. Typical distortion curve

Frequency response	Flat within 0.1 dB from 0.1 Hz to 20 kHz referred to 5 kHz. A typical response curve is shown in Fig. 3.

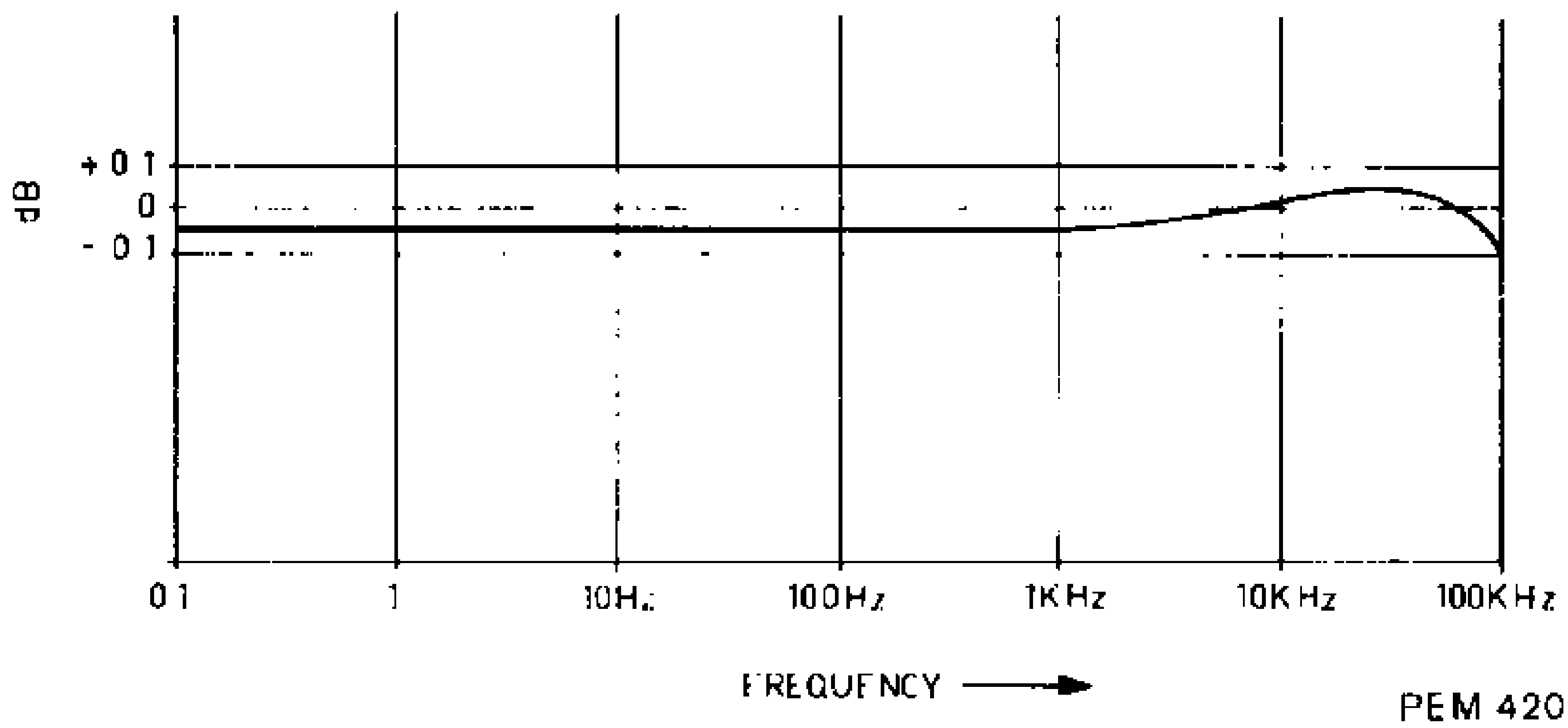


Fig. 3. Typical response curve for sinewave

3. Squarewave

Rise time	< 100 ns
Overshoot	< 2% of max. output
Sag	< 1% of max. output
Frequency response	Flat within 0.1 dB from 0.1 Hz to 20 kHz referred to 5 kHz. A typical response curve is shown in Fig. 4

4. Hum and noise — Less than 60 dB of the max. output voltage on all outputs.

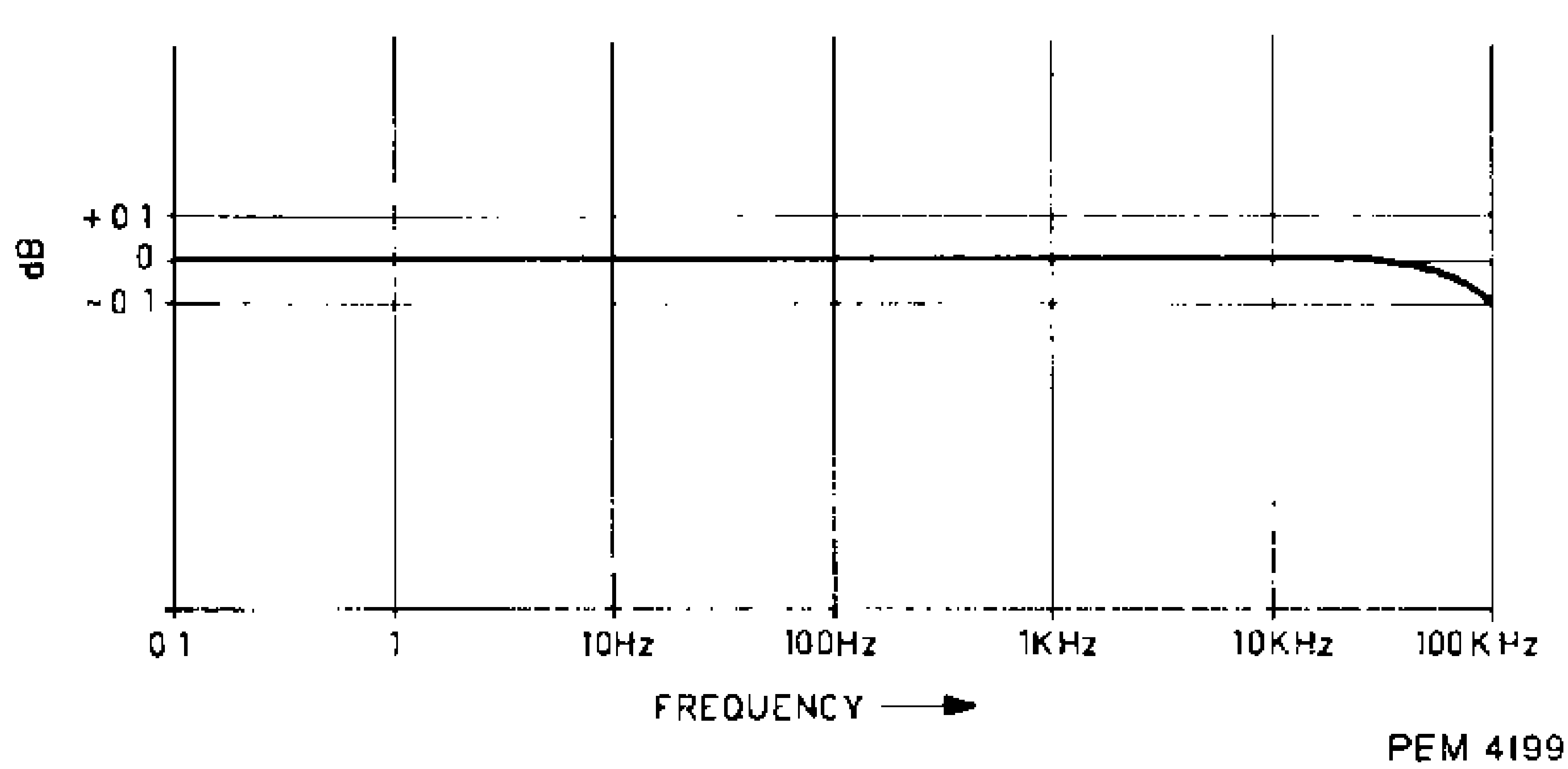


Fig. 4. Typical response curve for squarewave

D. OTHER FACILITIES

Frequency sweep	– Manual, fine and coarse control – External modulation – Automatic (10...100 sec, 3 different modes) – Single sweep (10...100 sec, 3 different modes)

E. POWER SUPPLY

Supply voltage	115 or 230 V ± 15%
Frequency	50...100 Hz
Power consumption	40 W

F. AMBIENT TEMPERATURE 10...45° C

G. MECHANICAL DATA

Dimensions	3-module cabinet (see chapter XIV)
Weight	4.5 kg (10 lbs)

Accessories

III

- Manual

Optional accessories

- coupling kit PM 9500
- 5 different cover kits, PM 9502...PM 9506.
- rack-mounting kit PM 9510 for mounting a 6-module cabinet into a 19″ rack.
- extension board for carrying out measurements on the plug-in printed wiring boards while the instrument is in operation.

The description and ordering information of these accessories are given in chapter XIV of this manual .

Description of the block diagram (see Fig. 5) IV

The triangle and squarewave generator produces waveforms with a mark-space ratio of 1 : 1.
The frequency of this generator is determined by an input voltage which is connected to an exponential current source.
In position MANUAL of switch SK5, the driving current is determined by the position of frequency control (frequency dial) R1.
In position AUTO of SK5, the input voltage is determined by the output voltage of the sweep generator and the position of R1.
The sweep generator delivers, via potentiometer R3 (SWEEP RANGE) and the control circuit, a triangular voltage wave to the current source in the triangle and squarewave generator, so that the frequency of the latter changes logarithmically. The position of frequency dial R1 determines the central frequency of the sweep.

SWEEP PERIOD, R3

The frequency of the sweep generator can be varied by means of potentiometer R3, which results in a variable sweep period of the triangle and squarewave generator.

SWEEP MODE, SK4

The mark-space ratio of the output voltage wave of the sweep generator can be:
1 : 1, giving equal "up" and "down" sweep times
100 : 1, giving a fast "up" sweep speed
1 : 100, giving a fast "down" sweep speed.

SWEEP RANGE, R2

The sweep range can be controlled by varying the amplitude of the driving triangular voltage from the sweep generator by means of potentiometer R2.

SINGLE SWEEP SK2, SK3

The single sweep mode provides one single period of the driving triangular voltage, thus producing one complete sweep of the triangle and squarewave generator.

EXTERNAL MOD., BU5

The driving voltage for the triangle and squarewave generator can also originate from an external source connected to BU5.
$V_0 \propto \mathrm{LOG}\ f$
Only in position "AUTO" of SK5 the output voltage on socket BU4 varies proportionally to the logarithm of the output frequency.
The sine shaper, consisting of an integrated network of diodes and resistors, derives a sinusoidally changing current from a linearly changing voltage. This voltage is the triangle generated in the triangle and squarewave generator.
The three generated waveforms are available on sockets BU1, BU2 and BU3. The waveform selected by SK7 can be taken from socket BU6. The amplitude of this waveform may be controlled continuously by means of potentiometer R4, AMPLITUDE.

DIRECTIONS FOR USE

Installation

V

For coupling two or more modular units, refer to chapter XIV.

A. ADJUSTING TO THE LOCAL MAINS VOLTAGE (see Fig. 7)

The instrument may be adjusted to a mains voltage of 100...130 V or 200...260 V by means of switch SK12 on the rear panel.
When the instrument is used at a mains voltage of 100...130 V, fuse VL1, having a 500-mA (slow-blow) rating, should be replaced by a 1–A (slow-blow) fuse.

B. EARTHING (see Figs. 6 and 7)

The instrument should be earthed in conformity with the local safety regulations,

a. via the 3-core mains cable supplied or
b. via earthing socket BU12, marked ⏚, on the rear panel or
c. via earthing socket BU8, marked ⊥, on the front panel.

Note:

For operation as a single unit connect BU7 to BU8

The units of the modular system have a semi-floating circuit so that, when several units are coupled, the circuit need only be earthed at one point. Earth currents which may give rise to hum are thus avoided.
Sockets BU8 and BU12 are connected to the metal frame of the cabinet.
The signal earth is connected direct to sockets BU7 and BU9, marked ⏚, and to the cabinet via a 100–kΩ resistor.
This provides the following output possibilities:

- output from a circuit which is earthed by linking BU7 (⏚) and BU8 (⊥)
- output from a circuit which is earthed via other coupled modules or via auxiliary equipment.

Controls and sockets and their functions VI

POWER ON (SK1, LA1)	On/off switch with pilot lamp.
Frequency dial (R1)	Continuous frequency control in position "MANUAL" of SK5. R1 determines the central frequency of the sweep in position "AUTO" of SK5 (coarse and fine control).
FREQ. Hz (SK6)	Range selector. The reading of the frequency dial R1 should be multiplied by the setting of SK6.
SWEEP RANGE (R2)	Potentiometer for adjusting the sweep width. The extreme ends of the sweep can be read from the frequency dial at the points (marked in red around the dial) which coincide with the setting of R2. (Position "AUTO" of SK5).

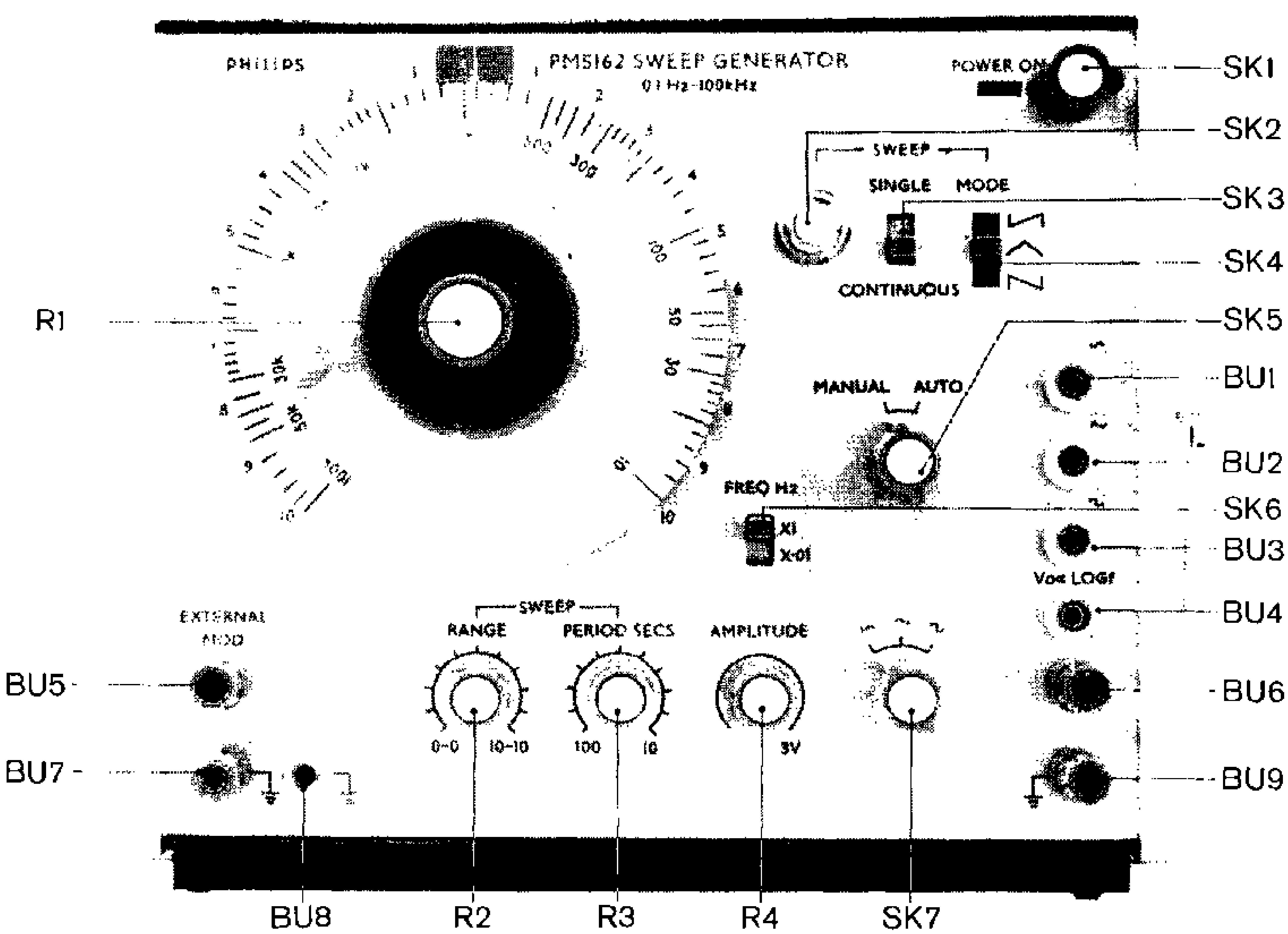


Fig. 6. Controls

SWEEP PERIOD (R3) — Potentiometer controlling the sweep speed in combination with sweep mode switch SK4.

SWEEP MODE (SK4) — Switch with which three different sweep modes can be selected:

/\/ ; equal "up" and "down" sweep times

|\| ; fast "upward" sweep

|/| ; fast "downward" sweep

SINGLE SWEEP (SK2, SK3) — In the upper position of SK3 the sweep will stop at its high frequency end. Only one complete sweep will be made on pressing button SK2.

AUTO-MANUAL (SK5) — Selector-switch with two positions:

MANUAL; for tuning the sweep frequency manually by means of R1.

AUTO; for sweeping automatically either with the internal sweep facility or with an external sweep signal applied via BU5.

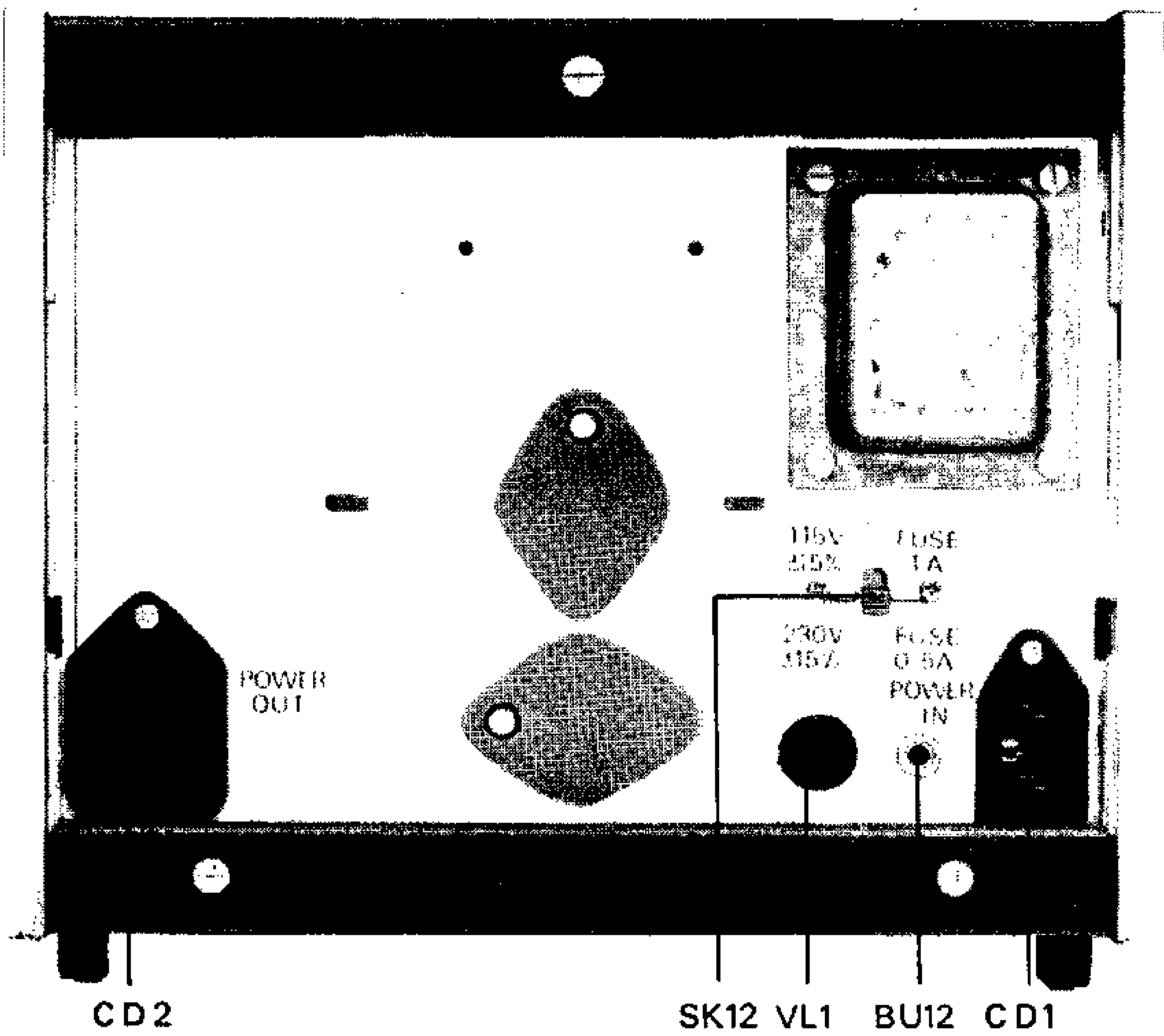


Fig. 7. Rear view

EXTERNAL MOD. (BU5)	Socket for connecting the external sweep voltage (in position "AUTO" of SK5, see chapter VII-D).
Output selector (SK7)	Switch for selecting the output wave on BU6.
Output socket (BU6)	Socket for taking off the waveform selected with SK7. The selected wave has a variable amplitude up to a minimum of 3.2 V into 600 Ω and is approx. symmetrical with respect to earth.
AMPLITUDE (R4)	Amplitude control of the output voltage on BU6.
Output socket (BU1)	Ouput for sinewave with a fixed amplitude of 10 V_{p-p}, approx. symmetrical with respect to earth.
Output socket (BU2)	Output for triangle wave with a fixed amplitude of 10 V_{p-p}, approx. symmetrical with respect to earth.
Output socket (BU3)	Output for squarewave with a fixed amplitude of 10 V_{p-p}, approx. symmetrical with respect to earth.
Output socket $V_0 \propto$ LOG f (BU4)	Socket with a voltage corresponding to the logarithm of the output frequency.
	Triangle wave from internal sweep generator, 12 V_{p-p}.
Signal earth (BU7, BU9)	Sockets to which the circuit-zero is connected.
Chassis earth (BU8, front panel) (BU12, rear panel)	Earthing sockets connected to the metal frame. The signal earth and the chassis earth may be connected by linking BU6 to BU7. Also refer to chapter V.B.
SK12, rear panel	Mains selector
CD1, rear panel	Mains input socket
CD2, rear panel	Mains output socket

Operation

VII

A. SELECTING THE FREQUENCY SWEEP

1. Frequency range

Two different frequency ranges can be selected by means of switch FREQ. HZ, SK6, viz:

0.1 Hz... 1 kHz (frequency dial reading $\times 0.01$)
10 Hz...100 kHz (frequency dial reading $\times 1$)

In position "MANUAL" of switch SK5, the frequency can be adjusted by means of frequency dial R1.
In position "AUTO" of SK5 the setting of frequency dial R1 determines the central frequency of the sweep.

2. Sweep width

The sweep width may be controlled by means of potentiometer "SWEEP RANGE", R2.
The numbers 10 to 1 and 1 to 10 marked on the text plate around the frequency dial correspond to the different positions of R2.

Note: Compare this with the setting of a camera. In this case the reading of the depth of focus depends on the aperture setting.

SWEEP RANGE potentiometer R2 should always be set to such a value that the sweep width does not exceed the upper or lower frequency limit on the frequency dial. In this way a discontinuity of the sweep is avoided.

B. SELECTING THE SWEEP PERIOD AND SWEEP MODE

The period time of the sweep can be adjusted between 10 and 100 seconds by means of potentiometer "SWEEP PERIOD", R3.
In position ⋀ of switch "SWEEP MODE", SK4, the "upward" sweep time and the "downward" sweep time are equal.
In position |/| of SK4 the downward sweep will take almost the whole period time set with R3, "SWEEP PERIOD". The upward sweep time is one hundred times shorter (i.e.: maximum 1 second in position 100 of R3).

In position |\| of SK4 the upward sweep will take almost the whole period time set with R3, while the downward sweep time is one hundred times shorter.

C. OPERATING WITH A SINGLE SWEEP

When switch SK5 is set to position "AUTO" and switch SK3 is set to the upper position, the sweep will continue to its highest frequency end and stop there.
One complete sweep, in the range set by SK6, R1 and R2 and with the speed set by R3 and SK4, will be obtained after depressing button SK2.
A second sweep will only be produced after SK2 has been released and is depressed again.

D. SWEEPING WITH AN EXTERNAL VOLTAGE APPLIED TO SOCKET BU5, EXTERNAL MOD.

The external generator to be used for sweeping the frequency of the PM 5162, should have a variable d.c. level.
Proceed as follows:

- Connect an external generator with an output voltage of 0 V a.c. to socket BU5.
- Set SK5 to position "AUTO" and set SK3 to position "SINGLE".
- Adjust the d.c. level of the output voltage of the external generator in such a way that the output frequency of the PM 5162 reaches a value, which corresponds to the setting of frequency dial R1 and range selector SK6.
- Increase the a.c. signal amplitude of the external generator until the required sweep is obtained.

Note:

The d.c. level required depends on the output impedance of the external generator.
Sweep range potentiometer R2 serves as an attenuator for the output voltage of this generator. Position 10–10 of R2 gives no attenuation, position 0–0 gives maximum attenuation.
The voltage required at BU5 in position 10–10 of R2 is approx. 12 V_{p-p} for a full sweep (frequency dial R1 in mid position).

SERVICE DATA

Circuit description

VIII

A. GENERAL

For this instrument four circuit diagrams have been drawn. Fig. 32 gives the overall diagram on which the functional printed wiring boards are shown as mere blocks.
The detail circuits of the printed wiring boards are given separately in Figs. 29, 30 and 31.
Fig. 29 shows the triangle and squarewave generator.
Fig. 30 shows the sweep generator, the sine shaper circuit and the power supply unit.
Figure 31 shows the control circuit.

B. TRIANGLE AND SQUARE WAVE GENERATOR (Fig. 29)

This circuit has been described in "Electronic Engineering" of June 1967, pages 388–390.
Figure 8 shows a schematic diagram.
The object of the circuit is to produce a triangular waveform at point A, whilst the current I_1 may be varied from 2 μA to 20 mA (10^4), in order to vary the frequency.
A symmetrical triangular waveform can only be obtained when I_2 at all times is kept equal to I_1.
Assume that switches 1 and 4 are closed as shown in Fig. 8. Main capacitor C_m is discharged with a current I_1 and the voltage at A changes linearly in negative direction. This continues until the Schmitt trigger switches to its second stable position. This closes switches 2 and 3 and opens switches 1 and 4.
Now main capacitor C_m is charged with a current I_2 and the voltage at point A changes linearly in positive direction until the Schmitt trigger switches again, and so on.
Feedback capacitor C_f serves to keep I_2 equal to I_1, while I_1 is varied over a wide range.

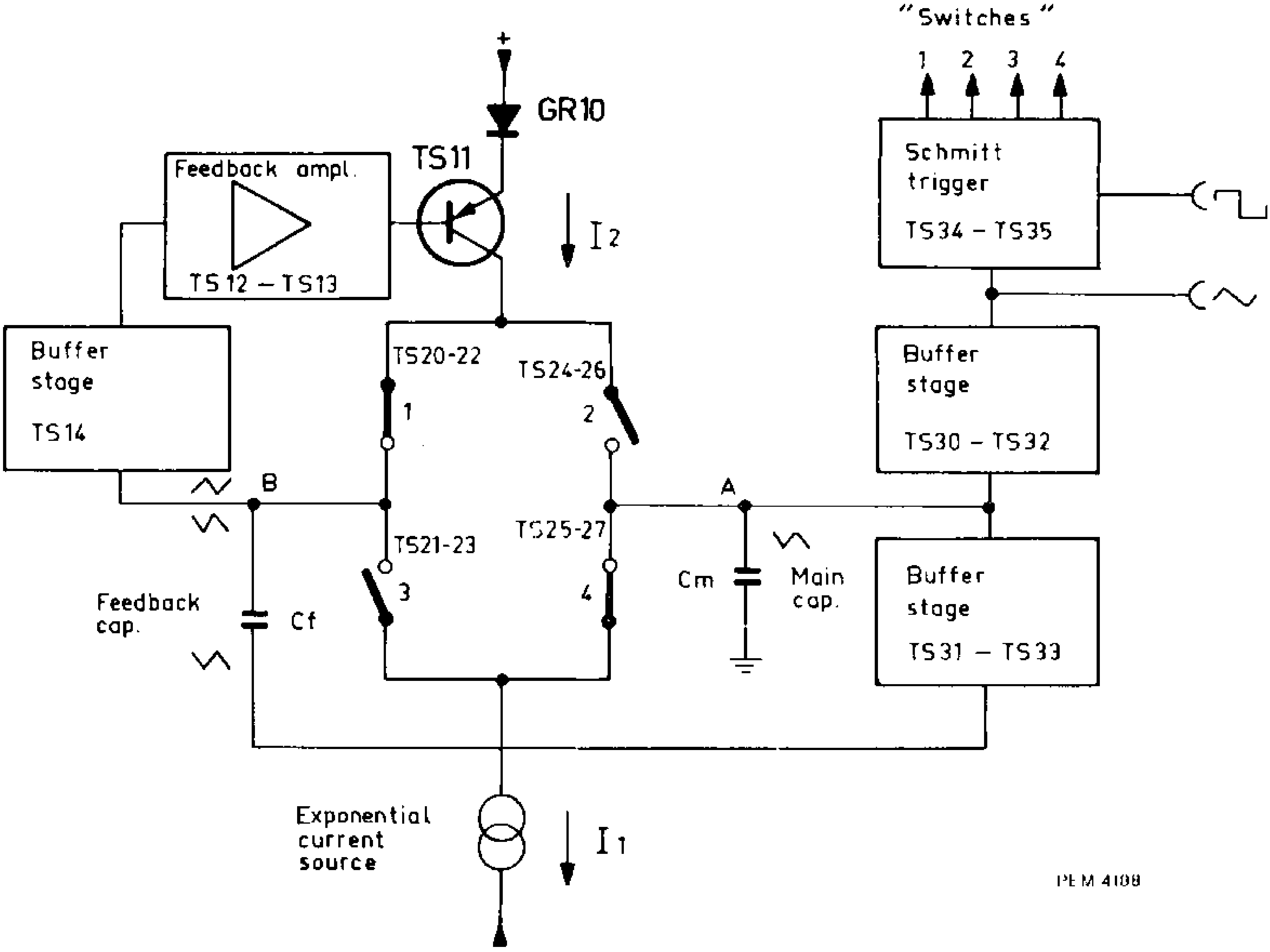


Fig. 8. Block diagram of triangle and squarewave generator

C_f is charged with a current I_2 when C_m is discharged with a current I_1.
C_f is discharged with a current I_1 when C_m is charged with a current I_2.
When $I_1 = I_2$ and $C_f = C_m$ the two capacitors are charged to the same voltage but with a phase shift of 180°.
If the voltage at point **A** is applied to the other side of C_f, the voltage at point **B** remains constant.
However, consider $I_2 > I_1$; the voltage at point B then goes positive and also the base potential of TS11 via buffer TS14 and feedback amplifier TS12–TS13, hence I_2 will be reduced.
Compensation takes place until $I_2 = I_1$. When on the other hand I_1 is varied in order to sweep the frequency, I_2 also changes thus maintaining a 1 : 1 mark space ratio of the output voltage.

Frequency range selector SK6

The main capacitors are C11 and C12, the feedback capacitors are C6 and C8.
In position ×1 of selector SK6 only C12 and C8 are in circuit.
In position ×0.01 of SK6 contacts 34 and 26 as well as contacts 30 and 25 are short-circuited to bring C11 in parallel with C12 and C6 in parallel with C8, thus increasing the value of the main capacitor and the feedback capacitor. The frequency of the generator now has decreased one hundred times.

Buffer stages

The buffer stages form very high impedances and are important because, when the switched current is only 2 μA, only a very small amount is subtracted.
The voltage on the main capacitor(s) is applied firstly to the feedback capacitor(s) via buffer stage TS31–TS33. Select-on-test capacitors C7 and C9 serve to compensate the feedback capacitance for the losses in this buffer stage.
The voltage on the feedback capacitors is applied via buffer stage TS14 to the feedback amplifier.
Secondly the triangular voltage on the main capacitor(s) is fed to Schmitt trigger TS34–TS35 via buffer stage TS30–TS32. After this buffer stage the triangular waveform is connected to output socket BU2 via contact 23, to output selector SK7 and to the sine shaper network (CD4, contact 23).

Feedback amplifier

The feedback amplifier consists of the symmetrical arrangement of TS12 and TS13, giving a gain of 1.
A voltage rise on the base of TS13 causes a voltage rise on the collector of TS12, thus reducing the current (I_2, Fig. 8) through TS11.

Schmitt trigger

The Schmitt trigger circuit TS34–TS35 is connected to three constant current sources, viz: TS36, TS37 and TS38, the bases of which are interconnected. Diode GR19 serves for temperature compensation of the emitter-base voltages of these three transistors.
Assume that TS34 is conducting and TS35 is cut off. Through R72//R73 and R74 passes a current I_1 (from source TS36) plus a current I_2 (from source TS37).

Through resistors R78//R79 passes a current I_3 (from source TS38). When TS34 is cut off and TS35 is conducting, only current I_2 flows through R72//R73 and R74, while a current $I_1 + I_3$ flows through resistors R78//R79. Currents I_1 and I_2 and resistors R72, R73, R74 and R83 determine the amplitude of the squarewave arising on the collector of TS34.

Because this amplitude directly determines the frequency of the triangle, for R72–R73–R78–R79–R82–R83–R85–R87 accurate metal-film resistors have been chosen.

Two anti-phase squarewaves which are positive with respect to earth and two which are negative with respect to earth, are used for driving the "switches" TS20...TS27.

The squarewave voltage on the base of TS35 has the same amplitude as the triangle voltage on the base of TS34.

Capacitor C15 serves to compensate the frequency response at high frequencies. The squarewave voltage on the collector of TS35 is, via emitter followers TS39–TS40 and contact 32, applied to output socket BU3 and output selector SK7.

Exponential current source

The exponential current source consists of a network of diodes and resistors. The biasing of the diodes and the values of the resistors have been selected so that the application of a linearly changing voltage produces an exponential current through the network.

Assume that a current I flows through the network. An increase of 0.5 Volt on the anodes of the diodes causes the current to increase approx. with a factor e (2.718). The current then is $2.718 \times I$.

An increase of 5 V on the anodes of the diodes thus gives a current of $e^{10} \times I$. When the initial current $I = 2\ \mu A$ the current now is $e^{10} \times 2\ \mu A \approx 22\ mA$.

The required current variation for a frequency sweep of $1 : 10^4$ is from 2 μA to 20 mA. This current variation thus is obtained by a voltage change of slightly less than 5 V.

The bias voltage across resistor chain R108...R125 is kept constant by means of zener diode GR12.

Circuit TS28, TS29 is a low impedance source which supplies the current through resistor chain R108...R125 and zener diode GR12, while keeping the voltage at junction R125–GR38 constant.

The sweep voltage from an external source or from the sweep generator and/or the voltage from frequency determining potentiometer R1 is applied to the symmetrical circuit consisting of TS15′–TS16 and TS15″–TS18 via contact 13. The same voltage as is applied to the base of TS15 will appear on the base of TS15″ and thus on the anodes of the diodes of the exponential current source.

C. SWEEP GENERATOR (Fig. 30)

The object of the sweep generator is to deliver a triangular waveform which may be

- varied in amplitude (sweep width)
- varied in mark space ratio (fast "up" or "down")
- varied in frequency (sweep period)

Moreover, the sweep generator can be made to deliver only one period on pressing a button (single sweep).
A schematic diagram is shown in Fig. 9.
The triangle wave is produced by an operational integrator with a bistable multivibrator in the feed-back loop.
The integrator amplifier consists of transistors TS45, TS46, TS47, TS48 and TS49. The feedback capacitors are C20, C21 and C22.

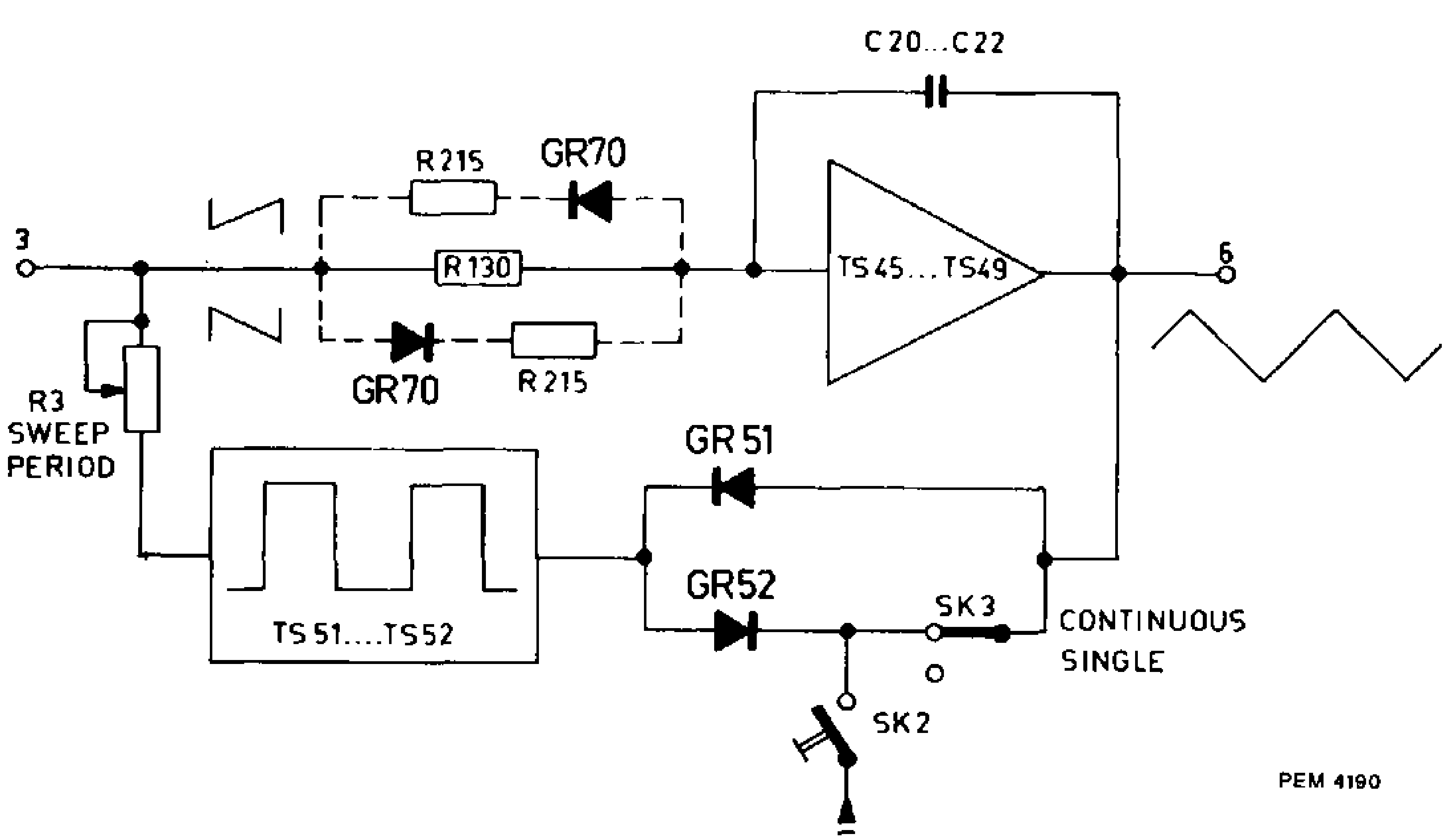


Fig. 9. Block diagram of sweep generator

Assume that a positive input voltage is applied via contact 3. This causes a negative going voltage on the emitter of TS49. The negative ramp is applied via contact 6, contact 5 (SK3 in position CONTINUOUS), GR52, R142 and R144 to the base of TS51.
At a certain value of this voltage the multivibrator TS51, TS52 will switch over such that TS51 is cut off and TS52 is conducting. The collector voltage of TS52, which is about zero volts, now is applied to contact 3 via contact 31 and sweep period potentiometer R3. This causes a positive going voltage on the emitter of TS49. This positive signal now is applied to teh base of TS51 via emitter follower TS50, diode GR51 and resistors R141 and R144.
At a certain value of this voltage the multivibrator TS51, TS52 will switch over again and the positive voltage on the collector of TS52 now again is applied to the integrator input via contact 31, sweep period potentiometer R3 and contact 3.

SWEEP PERIOD R3

By changing the current through resistor R130 of the integrator amplifier by means of sweep period potentiometer R3, the slope of the triangular waveform and thus the frequency of the sweep voltage is altered.

SWEEP MODE SK4

The squarewave voltage from bistable multivibrator TS51, TS52 is also applied to sweep mode switch SK4 via contact 31.
In the top position of SK4, diode GR70 and resistor R215 are switched in parallel with the integrator input resistor R130. The positive half-period will now cause a greater charging current of the integrator capacitors, resulting in an increased slope of the negative going ramp of the triangle.
In the bottom position of SK4 the chain GR70, R215 is reversely connected so that now the second half-period of the squarewave voltage causes a greater charging current of the integrator capacitors, resulting in an increased slope of the positive going ramp of the triangle.

SINGLE SWEEP SK3, SK2

When SK3 is set to its upper position the short-circuit between contacts 5 and 6 is broken. The negative going ramp of the integrator now will fail to switch over the bistable and the integrator will stop.

Pressing single shot button SK2 connects the —30 V supply voltage to contact 5 via capacitor C50. The bistable now switches over. First a positive going ramp and then a negative going ramp will appear on the emitter of TS49. Then the integrator will stop again. Thus only one cycle is produced.

SWEEP RANGE R2

The sweep voltage is taken from the integrator output via contact 6 and is applied to sweep range potentiometer R2 via points 16 and 15 of the control circuit board.

The sweep voltage which corresponds to the logarithm of the frequency may be taken from BU4.

D. CONTROL CIRCUIT (Fig. 31)

The object of this circuit is to connect the sweep voltage (internal or external) to the exponential current source in the triangle and squarewave generator and to ensure that the sweep will take place around the central frequency set by potentiometer R1 and with the sweep width set by potentiometer R2.

The control circuit consists of operational amplifier TS1...TS4 and of d.c.-shift circuit TS5...TS7.

A schematic diagram is shown in Fig. 10a. In position MANUAL of SK5 potentiometer R1 is connected to the voltage between points 3 and 4 of the control circuit board.

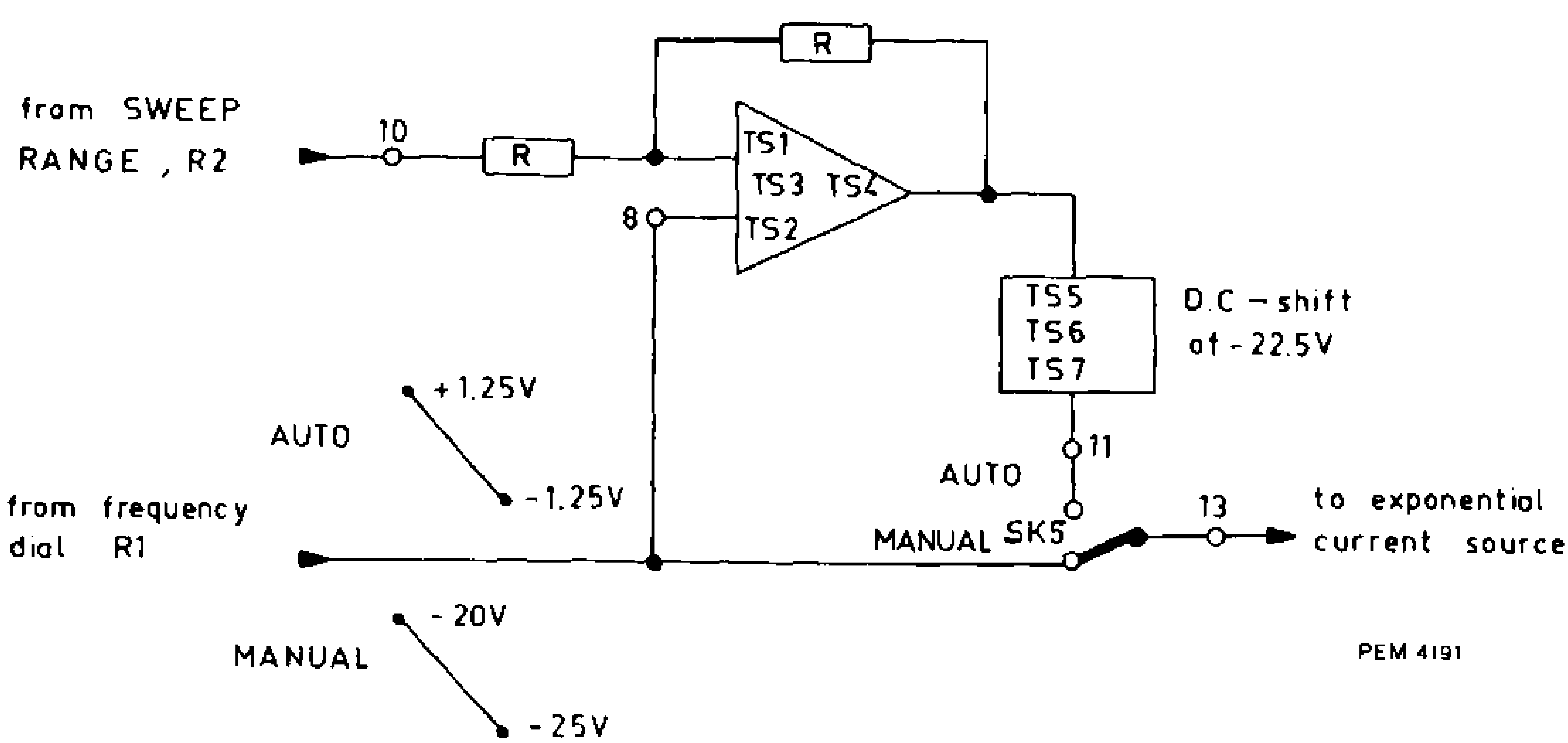


Fig. 10a. Block diagrams of control circuit

The voltage range of R1 is then from —20 to —25 V. The voltage from R1 now is connected to contact 13 of the triangle and square wave generator board, thus determining directly the output frequency.
In position AUTO of SK5, R1 is connected to the voltage between points 2 and 5 of the control circuit board. The voltage range of R1 then is from +1.25 to —1.25 V.
The voltage of R1 is now only applied to the base of TS2 via point 8, while the sweep voltage from potentiometer R2 is applied to the base of TS1 via point 10 of the control circuit board.
First assume that frequency control potentiometer R1 is set to its mid-position (1K) and sweep range potentiometer R2 to position 0-0. See schematic diagram Fig. 10b.

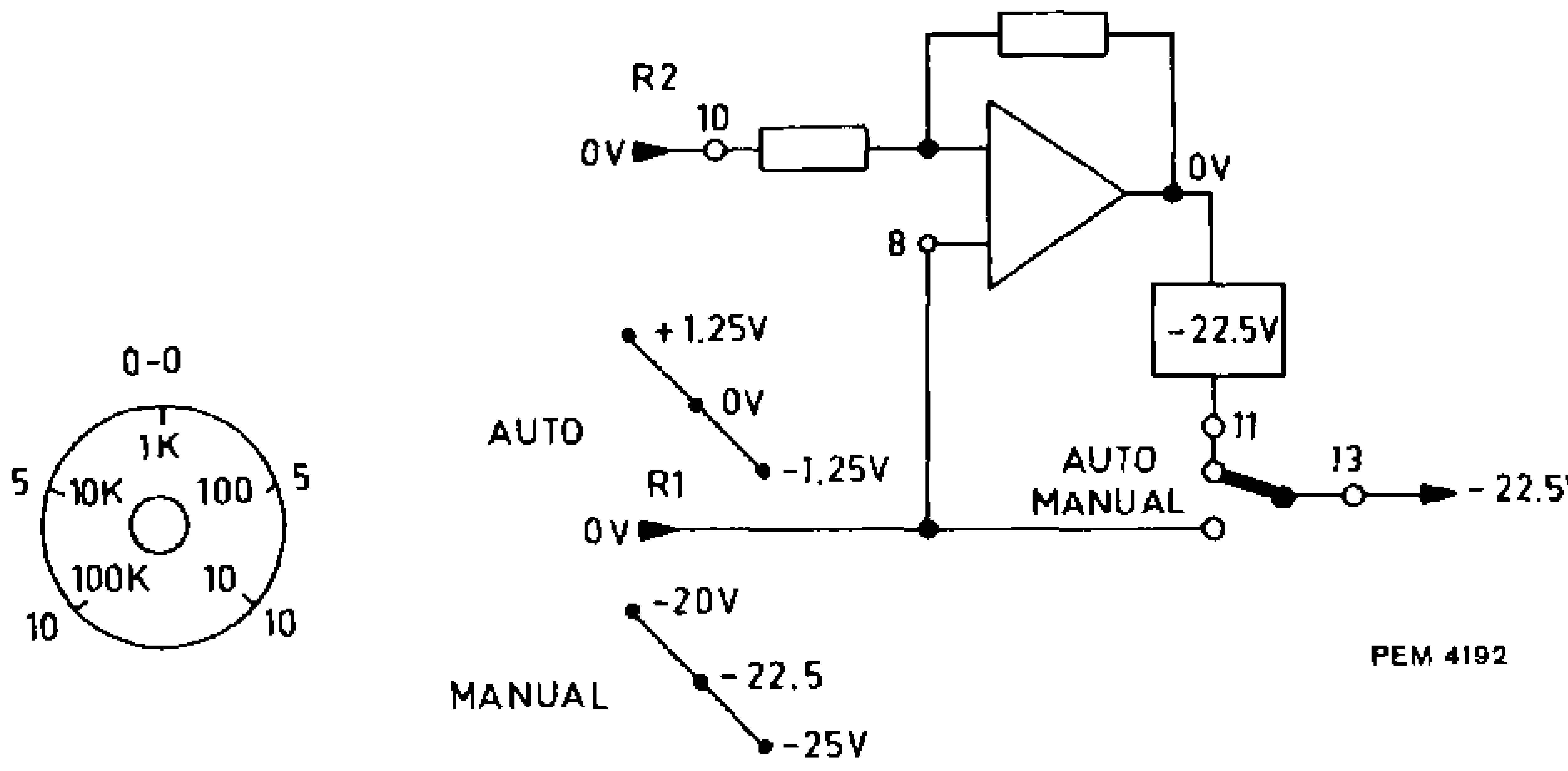


Fig. 10b

The voltage on both inputs of the operational amplifier TS1...TS4 is 0 V. The voltage on the amplifier output (the emitter of TS4) is also 0 V. Circuit TS5...TS7 gives a constant d.c. shift of —22.5 V. Thus the voltage on point 11 of the control circuit board and on contact 13 of the triangle and square wave generator board is —22.5 V, which corresponds to the voltage on the same point in position MANUAL of SK5 and mid-position of R1.
Now assume that sweep range potentiometer R2 is set to position 10–10 (see Fig. 10c).
The amplitude of the sweep voltage on the cursor of R2 is from —2.5 to +2.5 V.

A voltage of +2.5 V on one input of the operational amplifier and a voltage of 0 V on the other input gives an output voltage of —2.5 V. The output voltage applied to the triangle and squarewave generator after the d.c.-shift circuit now is: —2.5 —22.5 = —25 V.
This corresponds to the lower limit of frequency potentiometer R1 in position MANUAL of SK5, see Fig. 10c.
A voltage of —2.5 V on one input and a voltage of 0 V on the other input of the operational amplifier gives an output voltage after the d.c.-shift network of —20 V, which corresponds to the upper limit of frequency potentiometer R1 in position MANUAL of SK5, see Fig. 10d.
Finally consider that R1 is set to a position half-way between the mid position (10 K) and the upper position and R2 is set to position 5–5.

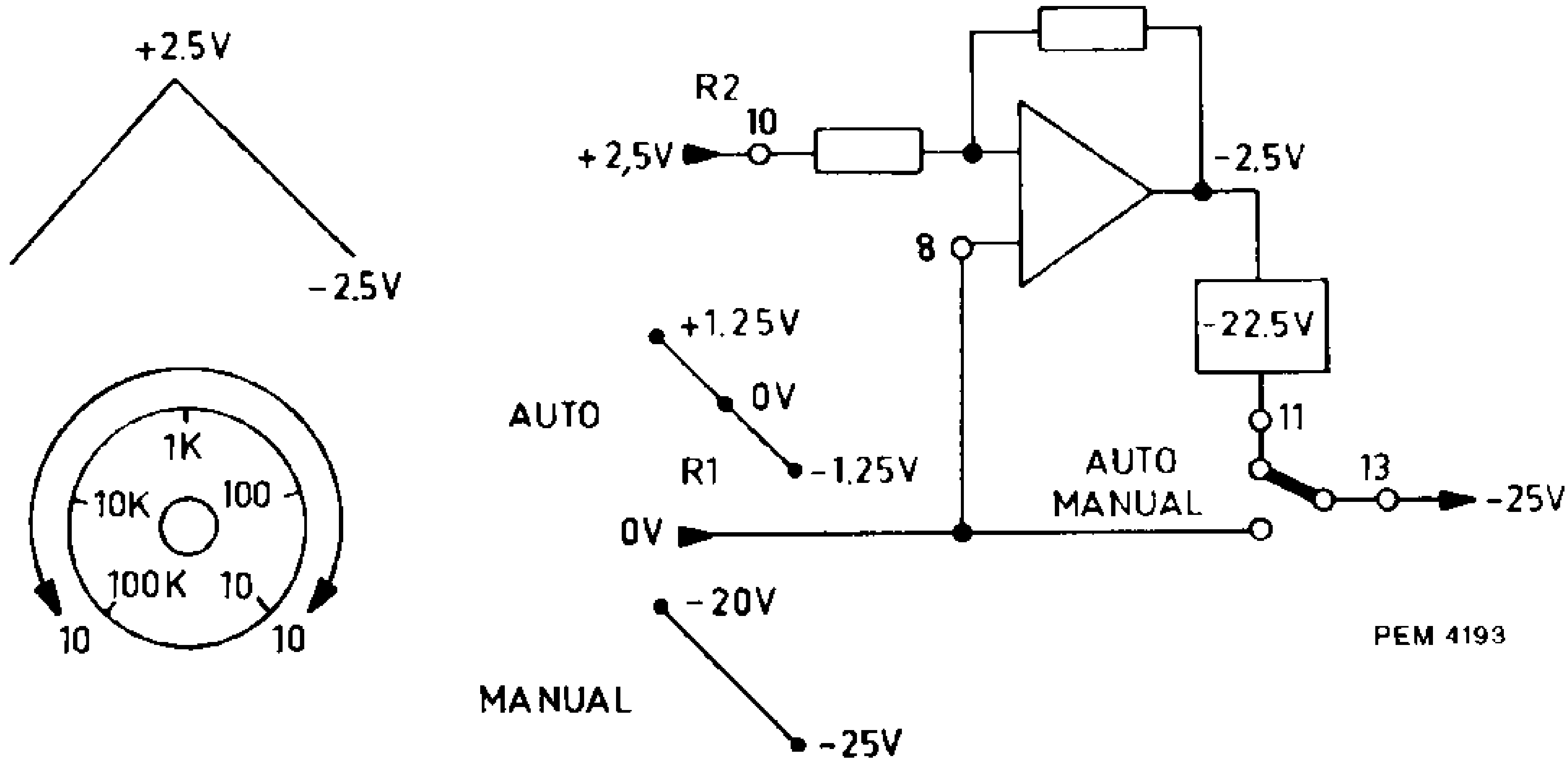


Fig. 10c

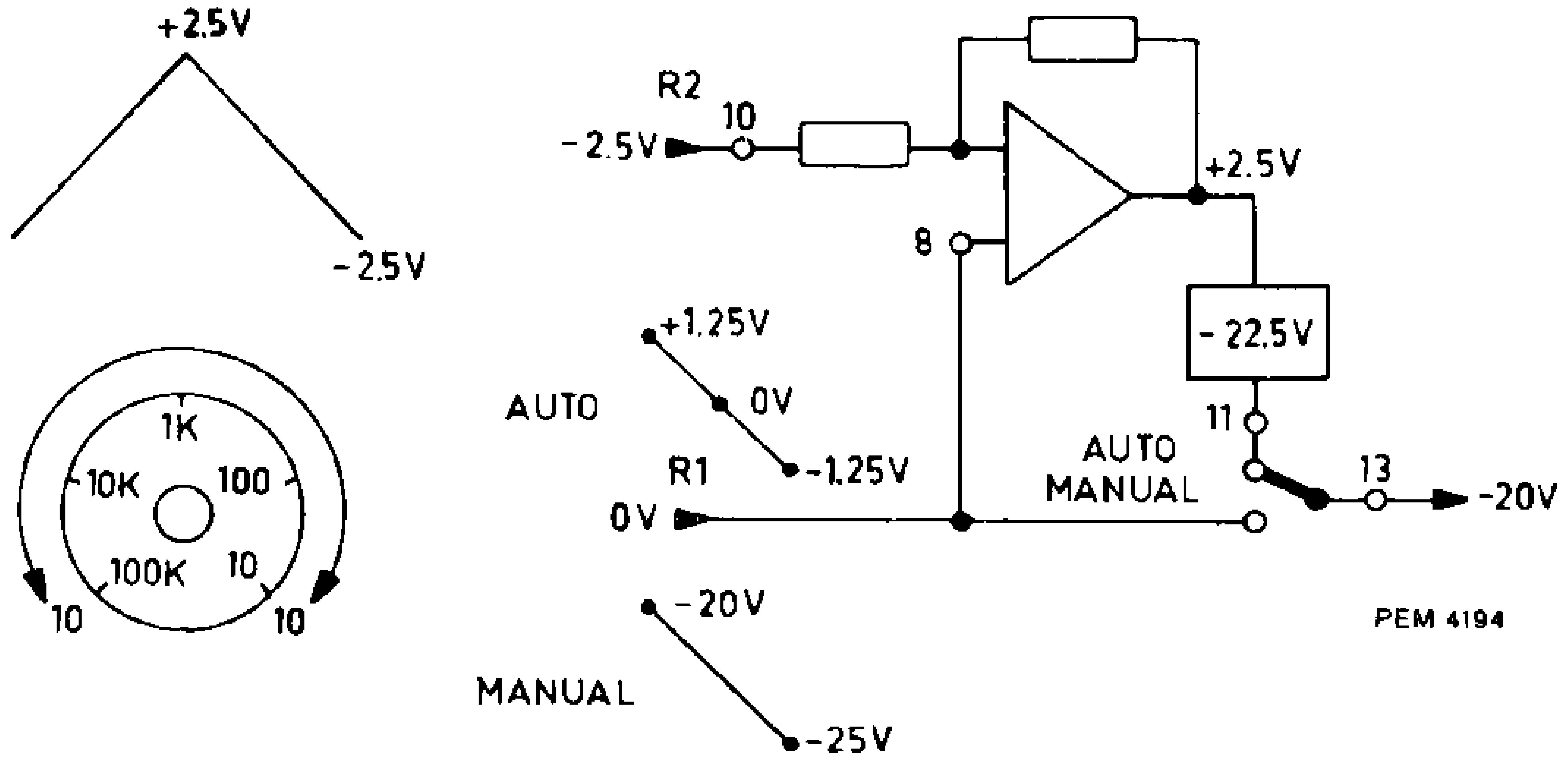


Fig. 10d

The voltage on the cursor of R1 now is 1.25/2 V. The amplitude of the sweep voltage on the cursor of R2 is from —1.25 to +1.25 V.
A voltage of +1.25 V on one input and a voltage of +1.25/2 V on the other input gives an output voltage of the operational amplifier of 0 V. After the d.c-shift circuit the output voltage is —22.5 V, which corresponds to position 1K of frequency potentiometer R1 in position MANUAL of SK5, see Fig. 10e.

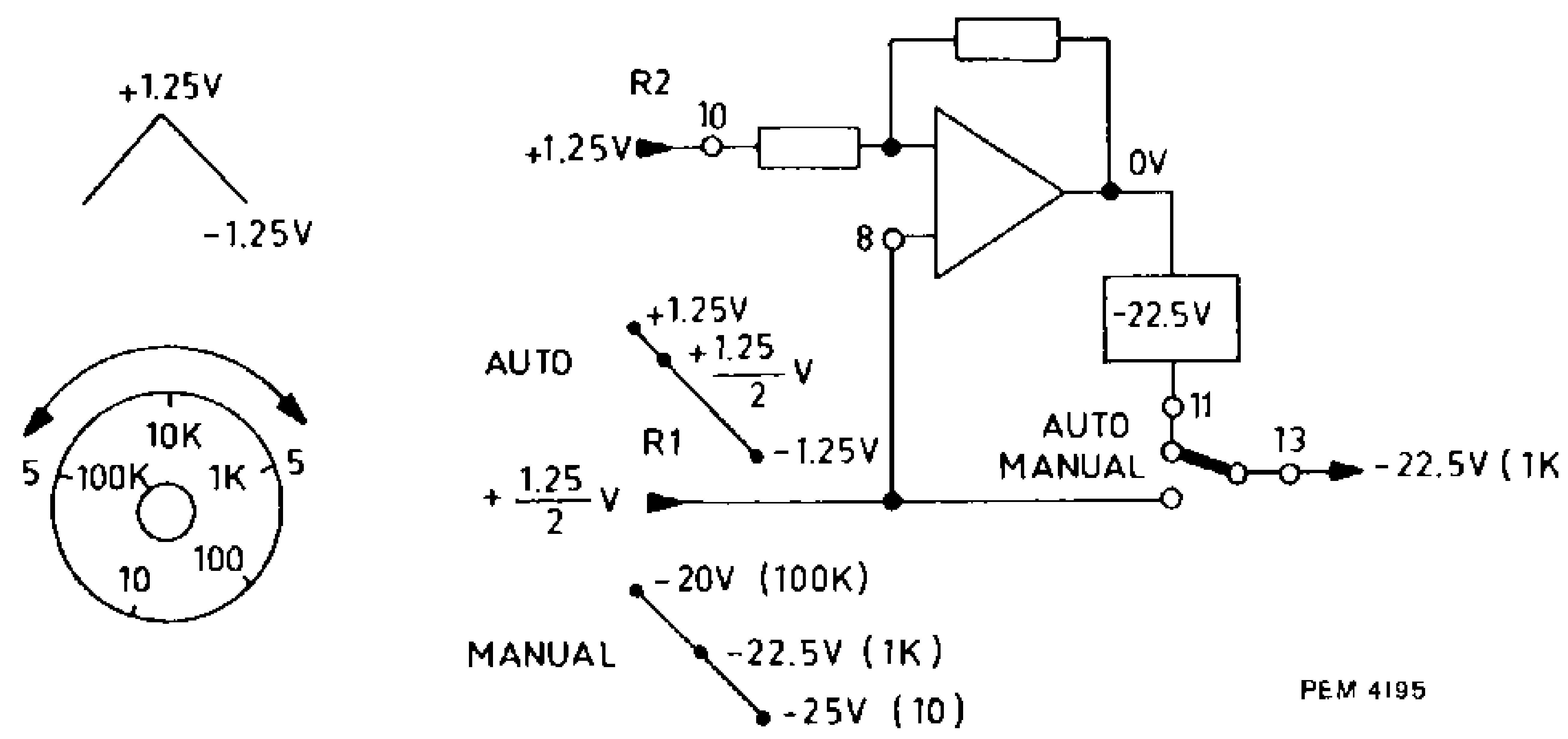


Fig. 10e

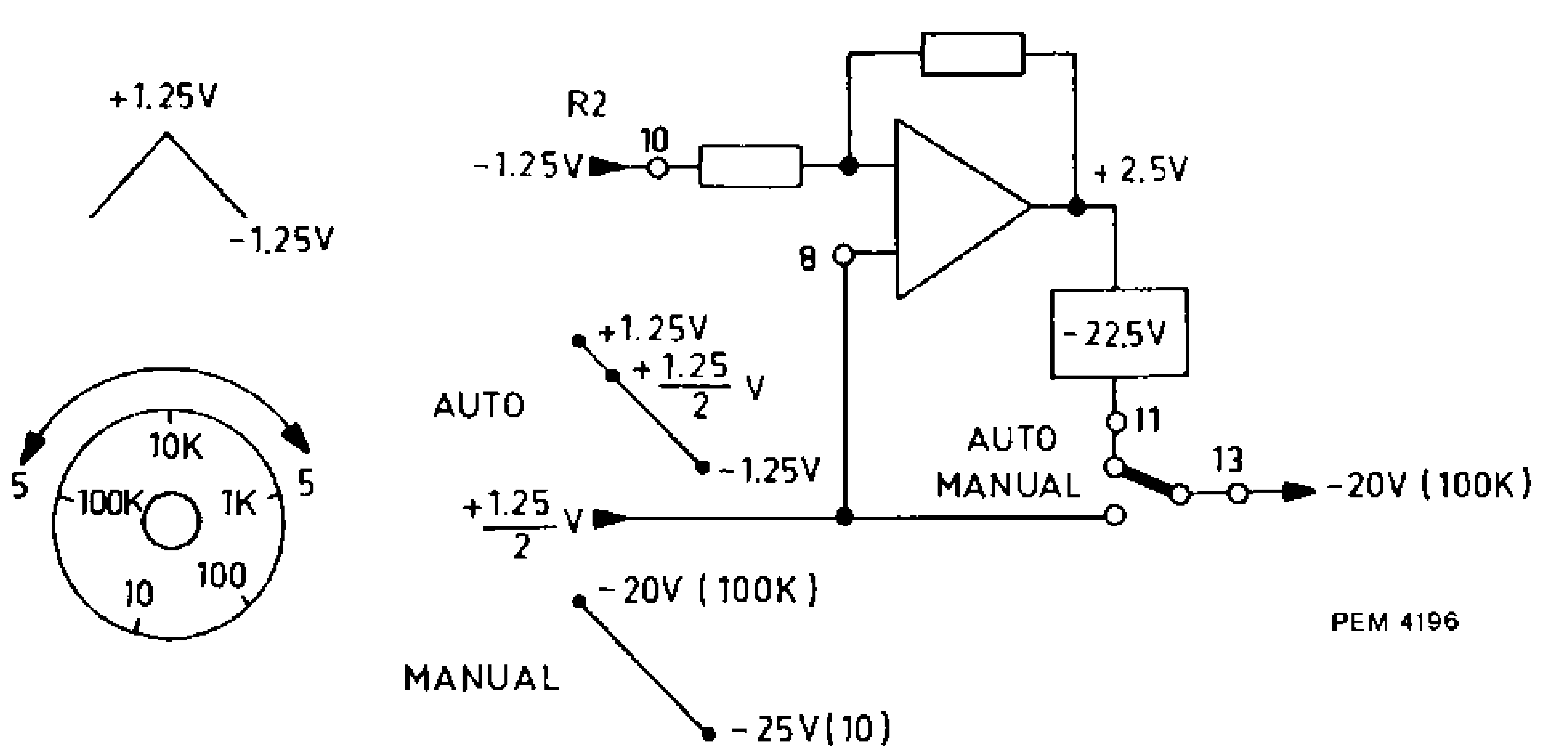


Fig. 10f

A voltage of —1.25 V and a voltage of +1.25/2 V on the inputs gives an output voltage of the operational amplifier of +2.5 V.
After d.c.-shift the output to the exponential current source is +2.5 —22.5 = —20 V which corresponds to position 100 K of frequency potentiometer R1 in position MANUAL of SK5, see Fig. 10f.

EXTERNAL MOD.

When SK3 is set tot the upper position (SINGLE) the integrator amplifier of the sweep generator will saturate after its negative going ramp. This is described in section C, paragraph SINGLE SWEEP. In position AUTO of SK5 the output voltage from the sweep generator now causes the frequency sweep to remain at its high frequency end, set by frequency dial R1 and sweep range potentiometer R2.
Short-circuiting input socket BU5 to earth has the same effect as turning R2 to position 0–0 (voltage on the cursor of R2 is 0 V). This means that when a low impedance source of 0 V is connected to BU5 the frequency sweep will return to its central frequency set by R1
Sweeping may now be effected by means of a voltage from this low impedance source, R2 serving as an attenuator for this voltage.
Position 0–0 gives maximum attenuation and position 10–10 minimum attenuation.

E. SINE SHAPER CIRCUIT (Fig. 30)

This circuit basically consists of a network of diodes and resistors in the form of an integrated circuit (U1).
The application of a linearly changing voltage produces a sinusoidal current through the network.
Assume that two anti-phase triangle waveforms are applied to the bases of long-tailed pair TS57, TS59. The waveform to TS59 is taken directly from the triangle output of the triangle and squarewave generator (contacts 23 of both boards).
The waveform to TS57 is phase-inverted by operational amplifier TS53...TS56. On the common emitter of the long-tailed pair a triangle wave appears which has twice the frequency of the input signal on contact 23.
This double frequency triangle is applied to the diode network thus producing the sinusoidal current through the network and through TS57 and TS59. However only one of the transistors of the pair is conducting at a time, hence on each collector a half-wave rectified sinewave is present.

These two waves are combined by applying them to the bases of long-tailed pair TS61, TS63.
The sinusoidal voltage is taken from the collector of TS61 and fed to output socket BU1 via emitter follower TS64 and contact 14. The sine wave voltage is applied to output selector SK7 via contact 12.
By means of SK7 one of the three output waveforms can be chosen. The selected waveform is applied to socket BU6 via amplitude control R4 and emitter follower TS8 on the control circuit board.

F. POWER SUPPLY (Fig. 30)

The a.c. voltages from supply transformer T1 are rectified by bridge circuits GR60 and GR61.

The output voltages of —30 V and +30 V are stabilised by comparing them via an amplifier (TS74, TS76 and TS75, TS77 resp.) with a reference voltage (GR64 and GR65 resp.) and using the difference to control the current through the series regulator (TS81 and TS80 resp.).
Amplification of the regulating current takes place via transistors TS72 and TS73 resp.

Gaining access to parts

IX

A. REMOVING THE TOP PLATE

The top plate can be removed after loosening the fastener at the rear of the instrument.
To refit the top plate, place the groove of the fastener in the horizontal position and push the cover home.

B. REMOVING THE SIDE PLATES

The side plates can be taken off after removing the screw on each side of the instrument.

C. REMOVING THE BOTTOM PLATE

The bottom plate can be removed after loosening the appropriate screws at the rear of the cabinet.

D. REMOVING THE STRIP WITH TILTING SUPPORT

This strip can be removed by pushing the two nylon slides "A" in the direction indicated in Fig. 11.

E. REMOVING THE PLUG-IN PRINTED WIRING BOARDS

In order to pull out the plug-in printed wiring boards, they should first be slightly bent at the top side.

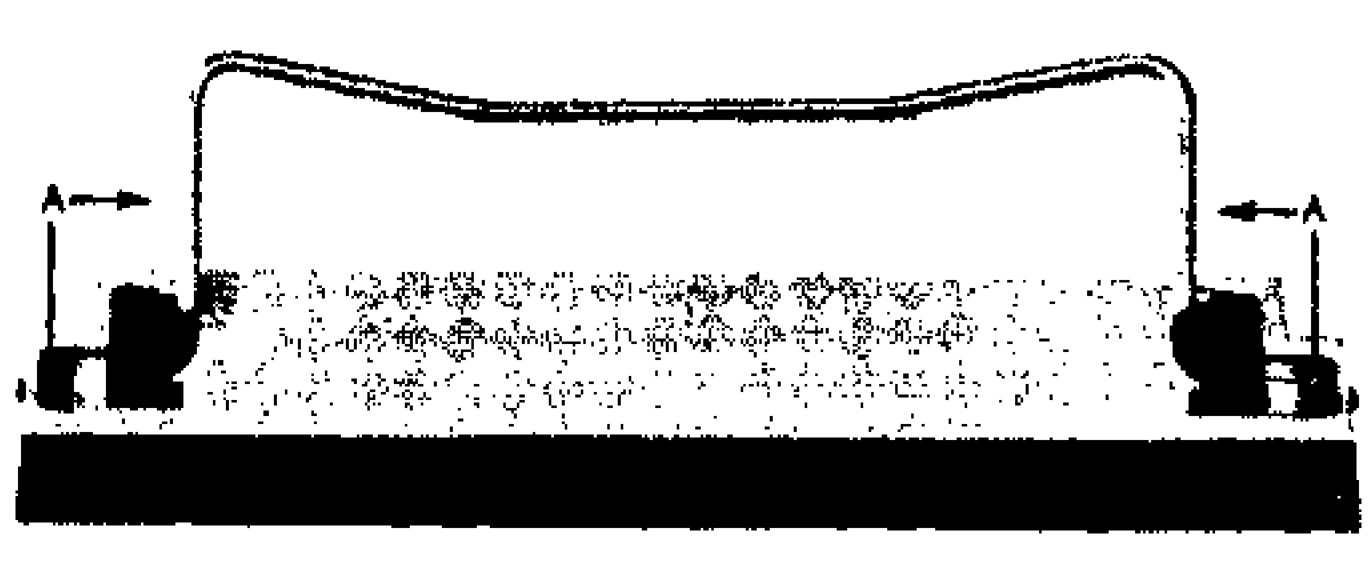


Fig. 11. Tilting assembly

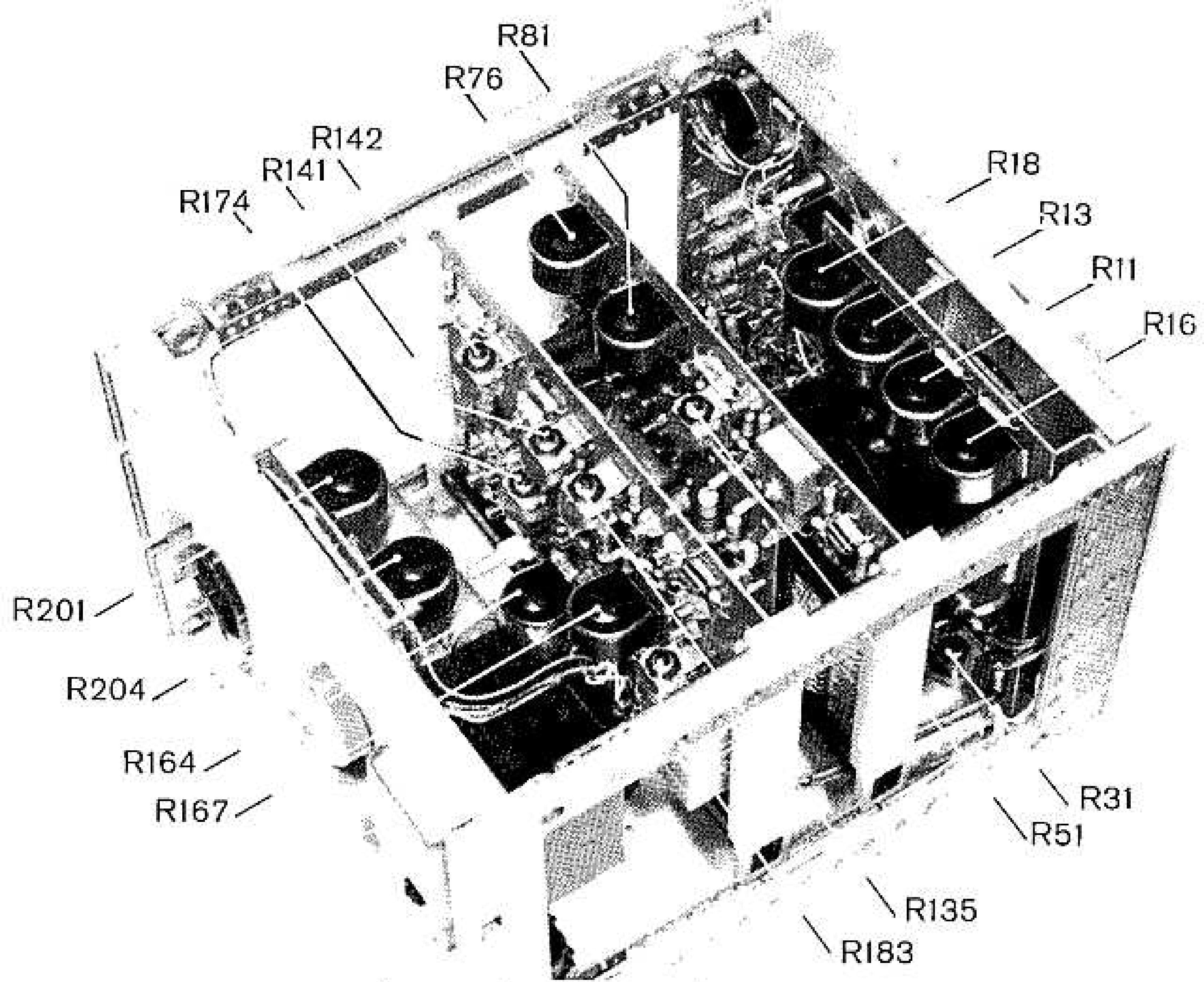


Fig. 12. Top view indicating the adjusting elements

Adjusting elements and auxiliary equipment (see Fig. 12)

X

Adjustment	*Adjusting element*	*Measuring equipment*	*Recommended PHILIPS equipment*	*Section of chapter XI*
MAINS CURRENT		ammeter	PM 2411	B
POWER SUPPLY	R201–R204	d.c. voltmeter	PM 2430	C
INITIAL ADJ.	R51–R76–R81 R164–R167–R174	oscilloscope	PM 3220	D
FREQ. ADJ. MANUAL	R11–R13	frequency counter		E
FREQ. ADJ. AUTO	R16–R18–R31– R142–R141	d.c. voltmeter frequency counter	PM 2430	F
$V_0 \propto$ LOG f	R135	oscilloscope	PM 3220	G
SQUARE WAVE OUTPUT		oscilloscope	PM 3220	H
SINE WAVE OUTPUT	R81–R164–R167– R174	distortion meter		J
OUTPUT AMPLITUDE	R183	oscilloscope	PM 3220	K
SINGLE SWEEP		oscilloscope	PM 3220	L

Checking and adjusting

XI

The tolerances mentioned in the following text apply only to a completely re-adjusted instrument. The values may differ from those given in chapter II, TECHNICAL DATA.
For optimum performance the instrument should be adjusted at the temperature at which it will be used.
The adjusting elements and the auxiliary equipment required for the adjusting procedure are indicated in chapter X.

A. GENERAL

The circuit should be earthed by connecting BU7 to BU8. All test equipment should be earthed via the instrument under test.
Accurate checking and adjusting of the frequency and the distortion according to sections E, F and J is only possible when the covers are fitted on the instrument and after a warming up period of at least one hour.
When the instrument is far out of adjustment, first carry out the adjustment with the top cover removed. Then accurate checking and readjusting can take place with the top cover fitted.

B. MAINS CURRENT

Connect the instrument to the mains and check that the current consumption does not exceed 200 mA at 230 V mains or 400 mA at 115 V mains.

C. POWER SUPPLY

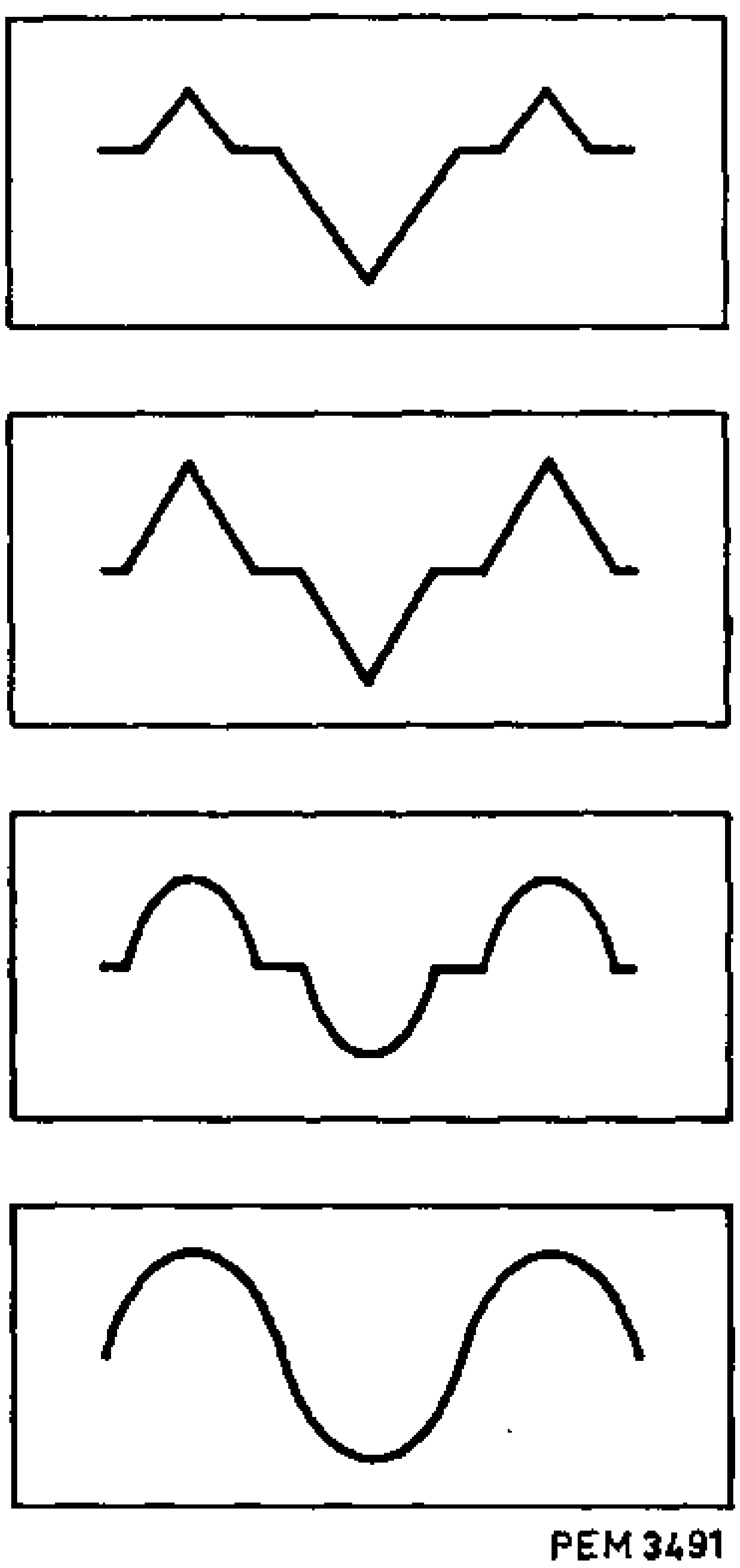
- Check that the voltage between points 54 and 55 of the power supply board is —30 V ± 10 mV.
- Adjusting element R201.
- Check that the voltage between points 51 and 46 of the power supply board is +30 V ± 10 mV.
- Adjusting element R204.

D. INITIAL ADJUSTMENT

- Check that an approximately symmetrical triangle is available on socket BU2.
- If necessary, adjust R51 to the middle of the range in which a proper triangle is obtained.
- Set the controls as follows:

SK3 (SINGLE)	CONTINUOUS
SK4 (MODE)	centre position
SK5 (MAN/AUTO)	MANUAL
SK6 (FREQ. Hz)	range × 1
SK7	triangle output
R2 (SWEEP RANGE)	position 0–0
R3 (PERIODS SECS)	position 100
R4 (AMPLITUDE)	position 3V

- Check that the amplitude of the triangle on socket BU2 is approx. 9.5 V_{p-p}.
- Adjusting element R76.
- Check visually that a proper sinewave is available on socket BU1.
- If not, follow the instructions according to Fig. 13.



Adjust R81, R164 and R167 until this output appears.
Adjust R174 until the waveform is about 0 V.

Adjust R81 until the output is symmetrical.

Adjust R167 until the peaks have just lost their triangular properties.

Adjust R164 until a pure sinewave is obtained.

Fig. 13. Distortion adjustment

E. FREQUENCY ADJUSTMENT-MANUAL

Please refer to section A, General

a. – Check that the dial movement is symmetrical with respect to the fixed cursor, i.e. equal overlaps at each end.
   – If necessary, take off the fine adjustment knob, loosen the coarse adjustment knob and turn the dial with respect to its spindle until the above condition is met.

b. – Set the scale to position 10 K
   – Check that the output frequency is 10 kHz ± 3%
   – Adjusting element R11. If not possible, start with R13 in the mid position.
   – Set the scale to position 100
   – Check that the output frequency is 100 Hz ± 3%
   – Adjusting element R13
   – If R11 and R13 have been adjusted, re-check both frequencies and readjust until they are accurate within ± 3%

c. – Check that the frequency error at scale settings 10 and 100 K is less than ± 10%.
   – If necessary readjust the frequency at scale settings 100 and 10 K, according to point b, within the limits of ± 10% in order to improve the frequency accuracy in positions 10 and 100 K. See frequency error curves in Fig. 14.
   – Check in both positions of SK6–FREQ. Hz that the frequency error at scale settings 10, 100, 1 K, 10 K and 100 K is less than ± 10%.

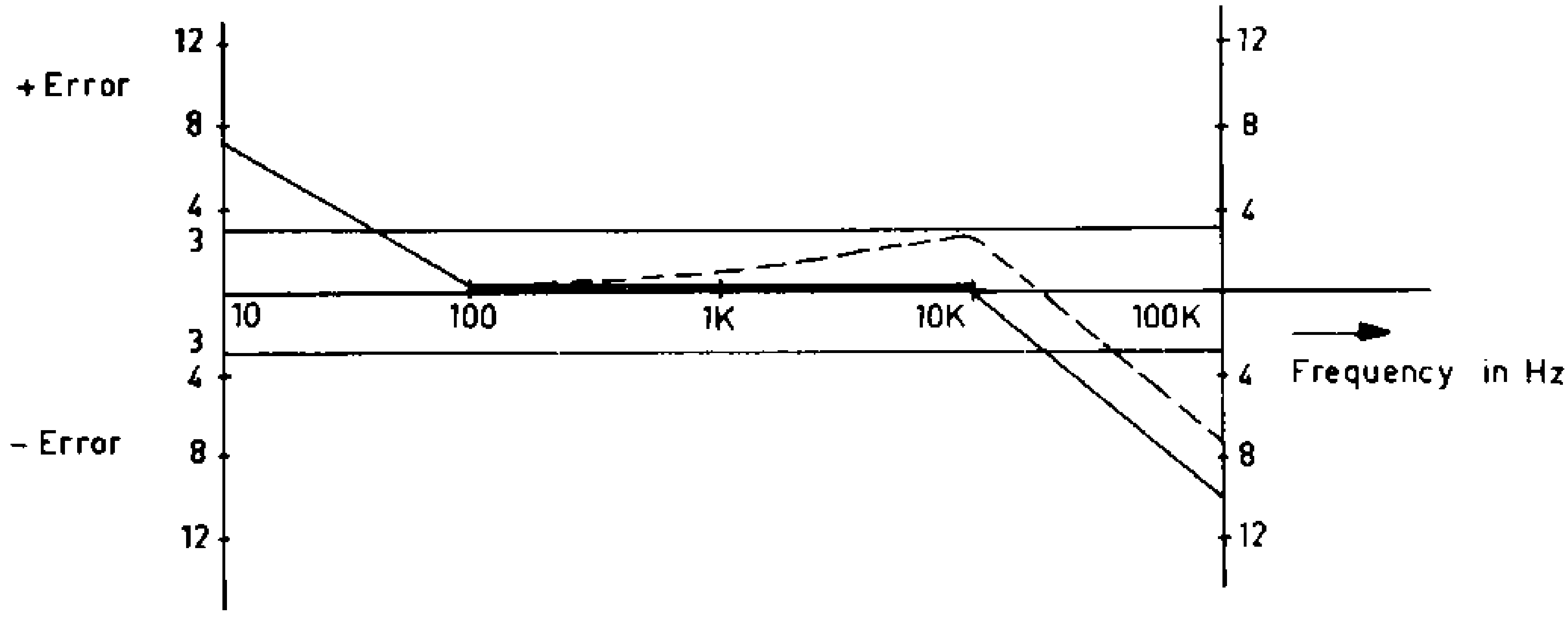


Fig. 14. Frequency error curves

F. FREQUENCY ADJUSTMENT-AUTO

Please refer to section A, General

a. – Set SK5-MAN/AUTO to position AUTO
- Set R2-RANGE to position 0–0
- Set the frequency dial to position 100 K
- Check that the voltage on the wiper of R1 is 1.25 V $\pm$ 10 mV.
- Adjusting element R16
- Next turn the dial to 10 and check that the voltage on the wiper is now —1.25 V $\pm$ 10 mV
- Adjusting element R18

b. – Set the frequency dial to position 1K.
- Check that the output frequency does not change more than 3% when SK5 is switched from position AUTO to position MANUAL.
- Adjusting element R31.

c. – Set SK5 to position AUTO.
- Set the dial to position 100K.
- Check that the output frequency is 100 kHz $\pm$ 3%.
- If necessary, readjust R16.
- Set the dial to position 10.
- Check that the output frequency is 10 Hz $\pm$ 3%.
- If necessary readjust R18.
- Re-check the output frequency at dial setting 1K.
- If the frequency error is greater than 8%, readjust R31.

d. – Set R2-RANGE to position 10–10.
- Check that the maximum attained frequency is 100 kHz $\pm$ 5%. (For a fast downward sweep set SK4 to bottom position.)
- Adjusting element R142.
- Check that the minimum attained frequency is 10 Hz $\pm$ 5%. (For a fast upward sweep set SK4 to top position.)
- Adjusting element R141.
- Set R2 in position 5–5.
- Check that the upper frequency of the sweep now is 10 kHz $\pm$ 20% and the lower frequency 100 Hz $\pm$ 20%.

G. OUTPUT VOLTAGE $V_0 \propto$ LOG F

- Check that the output voltage at socket BU4 is from +6 V $\pm$ 10% to —6 V $\pm$ 10%.

- Set R3-PERIOD SECS to position 10.
- Check that the sweep time is between 8 and 12 seconds.
- Check that the upward sweep time and the downward sweep time are approximately equal.
- Adjusting element R135.

H. SQUAREWAVE OUTPUT

- Check that the squarewave voltage on socket BU3 meets the following requirements:

amplitude	$10\ V_{p-p} \pm 1\ V_{p-p}$
rise time	< 100 ns
overshoot	$< 2\%$ of maximum output

J. SINEWAVE OUTPUT

Please refer to section A, General

a. – Set the frequency scale to position 1K.
- Set SK6–FREQ. Hz to position × 1.
- Set SK5–MAN/AUTO to position MANUAL.
- Check that the distortion of the sinewave on socket BU1 is less than 0.5%.
- If not proceed as follows:
- Adjust R164 and R81 for minimum distortion (D1).
- Check that the sinewave voltage is balanced about 0 V. If not, adjust R174.
- Next move R167 in small steps, optimising R164 and R81 each time for minimum distortion.

For example: After adjustment of R164 and R81 the distortion is D1.
Move R167 and the distortion will become D2 (D2 > D1).
Optimise R164 and R81 and the distortion will become D3 (D3 < D1).
If D3 > D1, R167 should be moved in the opposite direction.

- If a distortion of less than 0.5% cannot be obtained select another value for select-on-test capacitor C9. See chapter XII, sections B. 4 and C.

b. – Check that the distortion at 80 kHz is less than 1%.
– Check that the distortion at 100 kHz is less than 1.2%. If necessary, select another value for capacitor C15.
– Set SK6–FREQ. Hz to position ×0.01.
– Set the dial to position 1K.
– Check that the distortion at 10 Hz is less than 1%. If necessary, select another value for select-on-test capacitor C7. See chapter XII, sections B.4 and C.

K. OUTPUT AMPLITUDE

– Check that the amplitude of the sine wave on BU1 is $> 9\ V_{p\text{-}p}$.
– Set R4-AMPLITUDE to position 3 V.
– Check that the three output voltages on socket BU6, loaded with 600 Ω are $\geq 3.2\ V_{p\text{-}p}$. The sinewave amplitude can be adjusted by means of R183, if necessary.

L. SINGLE SWEEP

– Set SK3 to position SINGLE.
– Check in any position of SK4–MODE that only one sweep appears when SK2 is pressed.

Fault finding XII

A. GENERAL

To facilitate fault finding some d.c. voltages and waveforms present at various places in the circuit have been indicated in the circuit diagrams. The voltage levels given merely serve as a guide.
The circuit of the triangle and squarewave generator forms a closed loop, which complicates tracing a fault on this board.
To facilitate fault finding on the triangle and squarewave generator board several transistors at vital places in the circuit have been mounted on sockets. They can be easily plugged in and taken out of the board without soldering. Moreover a fault finding procedure for this board has been given in section B of this chapter.
When replacing parts, switch off the instrument. After replacing parts it may be necessary to readjust the instrument according to chapter XI.

Note: In case of break-downs, the assistance of the PHILIPS Service organisation can always be called upon. Whenever the instrument is to be forwarded to a PHILIPS Service Centre for repair, the following should be observed:

- Provide the instrument with a label bearing full name and address of the sender.
- Indicate as completely as possible the symptoms of the fault.
- Carefully pack the instrument in the original packing, or, if this is no longer available, in a wooden crate.
- Forward the instrument to the address provided by your local PHILIPS representative.

B. FAULT FINDING PROCEDURE OF THE TRIANGLE AND SQUAREWAVE GENERATOR BOARD

A fault on the triangle and squarewave generator board can result in:

1. No squarewave output
2. No squarewave output and no triangle output or impossible to obtain a correct output by means of R51.
3. Deterioriation of the upward and/or downward slope of the triangle output
4. High distortion of the sinewave output with a good appearance of the triangle.

In each case first check the supply voltages to be +30 V and —30 V.

Ad 1:

If the triangle and sinewave outputs are present but no squarewave output, transistor TS40 or possible TS39 is defective.

Ad 2:

If no squarewave output and no triangle output and hence no sinewave output is available or if no proper waveforms can be obtained by adjusting R51, it is recommended to follow the procedure below.

a. – Earth contacts 25 and 26.
- Unsolder the wire from point 37 of the small board.
- Remove plug-in transistors TS20, TS21, TS26, TS27 and TS31.
- Apply a d.c. voltage variable between —8 and +8 V to point 37 of the small board.
- Connect a voltmeter to contact 23.
- Check that a voltage swing from —5 V to +5 V is present on contact 23 when the voltage on point 37 is varied over the same range.
- If present, proceed with b; if not, test TS30 and TS32.

b. – Connect the voltmeter to junction R78–R82.
- Check that the voltage at this junction changes from 8 to 18 V when the voltage on point 37 is varied.
- If this is correct proceed with c; if not, test TS36, TS37, TS38 and TS39 and finally TS34 and TS35.

c. – Plug in transistors TS20, TS21, TS26 and TS27.
- Re-check the voltage transient according to b.
- If correct, plug in TS31, re-check and proceed with d.
- If not correct, test TS20, TS21, TS26 and TS27 and finally TS31.

Note: The voltage swing and the voltage transient as tested in a, b and c being correct, the fault now should be expected in the exponential current source or in the feedback amplifier including field effect transistor TS14.

d. – Test or replace transistor TS14.
- If this has no favourable result proceed as follows.
- Connect the voltmeter to junction TS11–R60.
- Check that the voltage at this point varies when R51 is turned.
- If this is correct proceed with e; if not test TS13, TS12, TS11 and GR10.

e. – Apply a d.c. voltage variable between —20 and —25 V to contact 13.
   – Check that a voltage variation on contact 13 also appears on the anodes of the current source diodes GR21...GR41.
   – If not, test TS15, TS16, TS17, TS18, TS19 and finally exponential current source GR21...GR41.

Ad 3:
A deterioriation of the upward slope of the triangle may be caused by a fault in the feedback system (TS31, TS33 and capacitors C6...C9) or by a faulty TS30 or TS31.
A deterioriation of the downward slope may originate from a fault in the current source including TS15...TS19 or from defective field effect transistors TS30 and TS31.

Ad 4:
If the triangle shape is correct but there is still a high distortion of the sine-wave not caused by the sine shaper board, this distortion is caused by an asymmetry or amplitude variation of the triangle wave.

a. High distortion at 1 kHz, frequency range × 1, after having adjusted to optimum distortion as indicated in chapter XI.
   Probable cause: incorrect value of select-on-test capacitor C9.
b. High distortion at 10 Hz, frequency range × 0.01, after having adjusted to optimum distortion as indicated in chapter XI.
   Probable cause: incorrect value of select-on-test capacitor C7.
c. High distortion at 100 kHz, frequency range × 1, after having adjusted to optimum distortion as indicated in chapter XI. (no excessive distortion at 1 kHz.)
   Probable cause: incorrect value of select-on-test capacitor C15.

C. SELECTING THE CORRECT VALUE FOR SELECT-ON-TEST CAPACITORS C7, C9 and C15

a. Selecting C7

- Set SK6 to position "× 1".
- Set R1 to the mid position.
- Select such a value for C7 that the amplitude of the waveform on point 25 of the squarewave board is minimum. (For measuring, an oscilloscope or RMS-voltmeter may be used.)

b. Selecting C9

- Set SK6 to position "$\times 0.01$".
- Set R1 to the middle position.
- Select such a value for C9 that the amplitude of the waveform on point 25 of the squarewave board is minimum. (For measuring, an oscilloscope or RMS-voltmeter may be used.)

c. Selecting C15

- Select for C15 a value of 47 nF.
- Set the frequency to 5 kHz.
- Set R4-AMPLITUDE to position 3 V.
- Observe the amplitude variation of the triangle wave (6 V_{p-p}) at no load when changing the frequency to 100 kHz.
- If the amplitude changes less than 30 mV, the value of C15 is correct.
- If the amplitude has increased more than 30 mV, increase the value of C15.
- If the amplitude has decreased more than 30 mV, reduce the value of C15.

Lists of parts

XIII

A. MECHANICAL

Item	*Number*	*Fig.*	*Code number*	*Description*
1	1	16	4822 455 70087	Text plate
2	1	16	4822 450 20078	Scale
3	1	16	4822 413 40333	Knob
4	1	16	4822 413 50397	Knob
5	1	16	4822 450 80212	Cursor
6	1	16	4822 535 70253	Ball drive
7	1	16	4822 413 70037	Cap
8	1	16	4822 413 30084	Knob
9	1	16	4822 413 70038	Cap
10	2	16	4822 502 10801	Handle screw

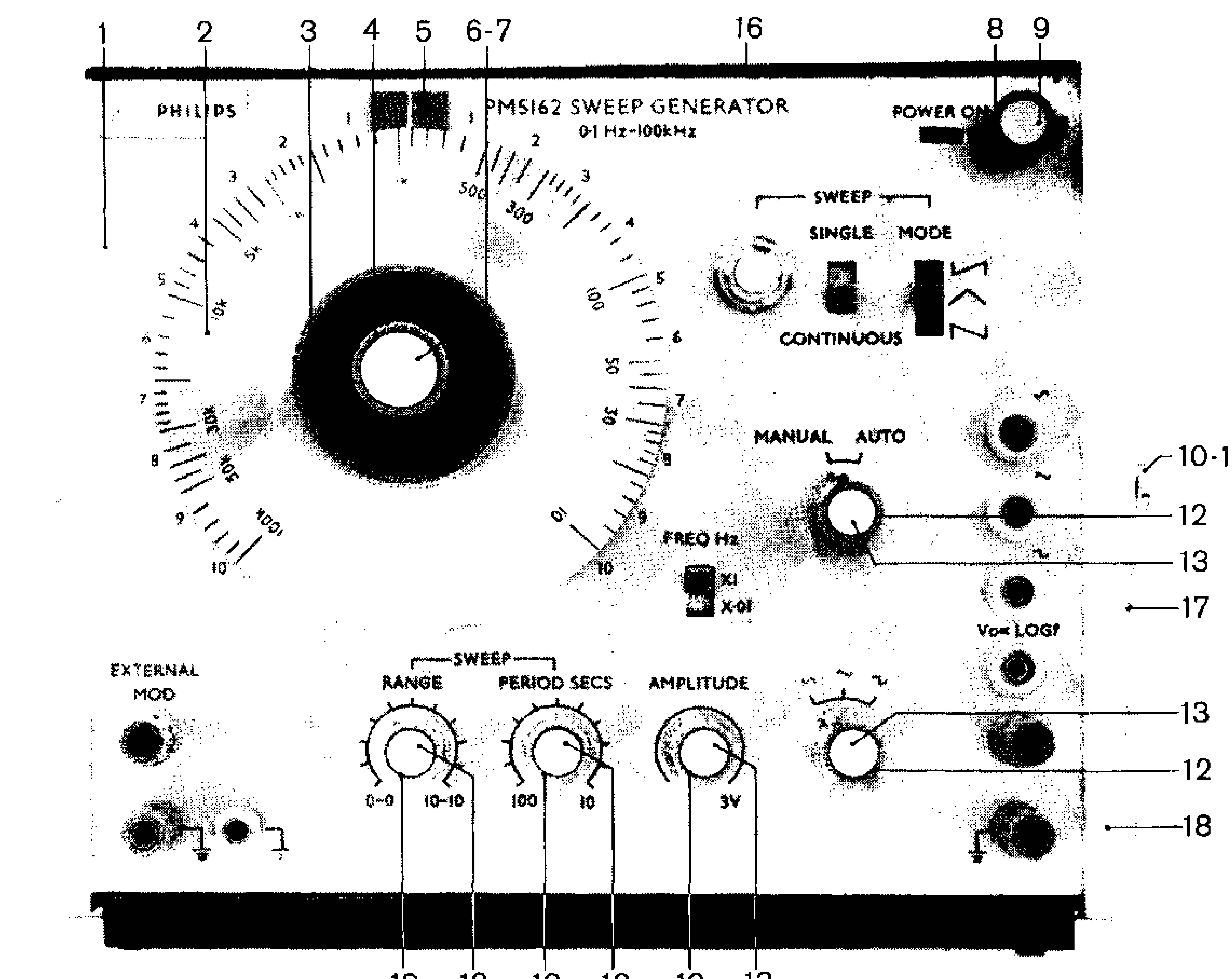


Fig. 15. Front view indicating mechanical components

Item	*Number*	*Fig.*	*Code number*	*Description*
11	2	16	4822 532 50633	Washer for handle screw
12	2	16	4822 413 30329	Knob
13	5	16	4822 413 70038	Cap
14	2	17	4822 520 10182	Bracket holder
15	2	17	4822 462 70366	Slide
16	2	17	4822 460 60017 (6-module length)	Ornamental strip
17	2	16	4822 404 50199	Handle bracket
18	2	16	4822 460 60014	Ornamental surround
19	3	16	4822 413 30082	Knob
20	2	18	4822 693 80008	Transistor cover
21	2	18	56 201 (CA)	Mica washer and bushes
22	1	18	4822 256 40017	Fuse holder
23	2	19	4822 255 40038	Transistor holder
24	2	19	4822 267 70043	Connector
25	4	19	4822 462 40157	Foot cap
26	26	19	4822 255 40006	Transistor spacer
27	5	19	4822 404 50127	Stand-off clip
28	3	19	4822 255 40017	Transistor holder
—	1	6	4822 273 40115	Switch SK1
—	1	6	4822 271 30098	Push-button switch SK2
—	3	7,6	4822 277 20014	Slide switch SK3–SK6–SK12
—	1	6	4822 277 20009	Slide switch SK4
—	1	6	4822 273 60071	Switch SK5
—	1	6	4822 273 40045	Switch SK7
—	4	6	4822 267 30045	Socket BU1–BU2–BU3–BU4
—	4	6	4822 290 40011	Socket BU5–BU6–BU7–BU9
—	2	6,7	4822 535 20023	Terminal BU8–BU12
—	2	6,7	4822 506 40016	Nut on BU8–BU12
—	1	7	4822 265 30066	Mains input socket CD1
—	1	7	4822 267 40106	Mains output socket CD2
—	1	—	4822 321 10071	Mains flex with plugs
—	1	—	4822 263 70024	Mains interconnection link

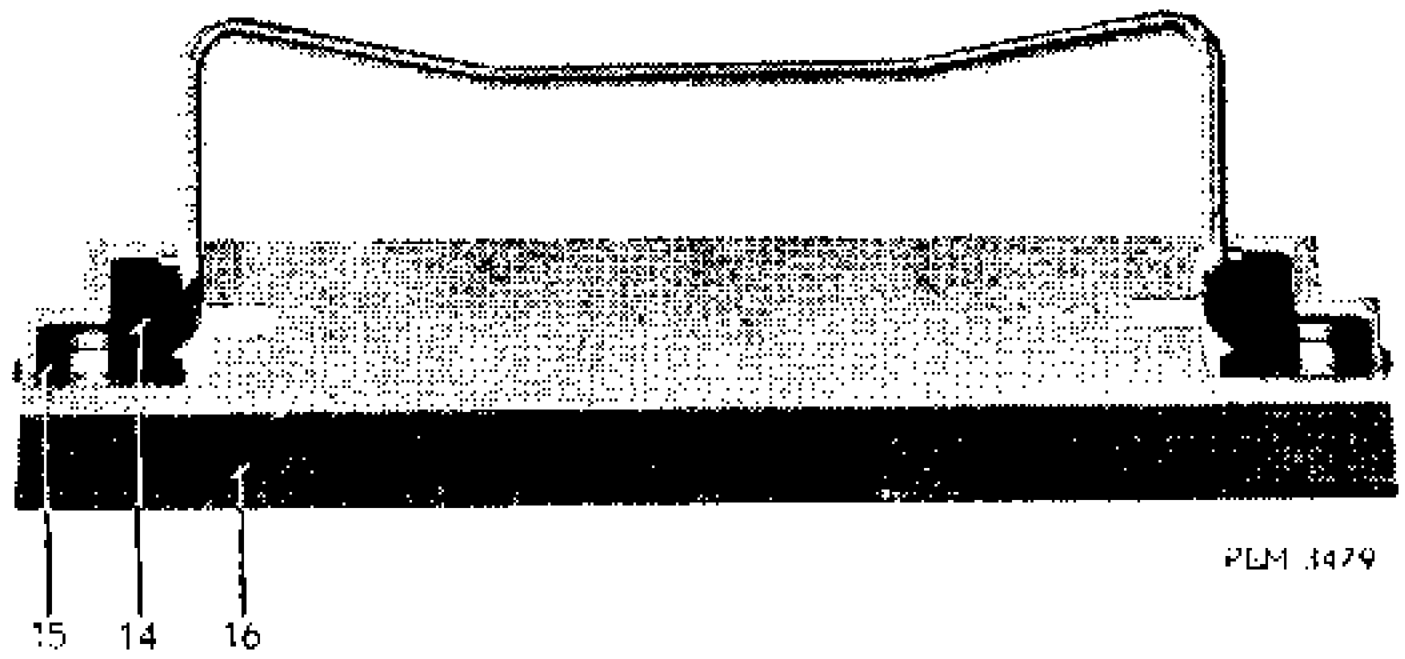


Fig. 16. Tilting assembly indicating mechanical components

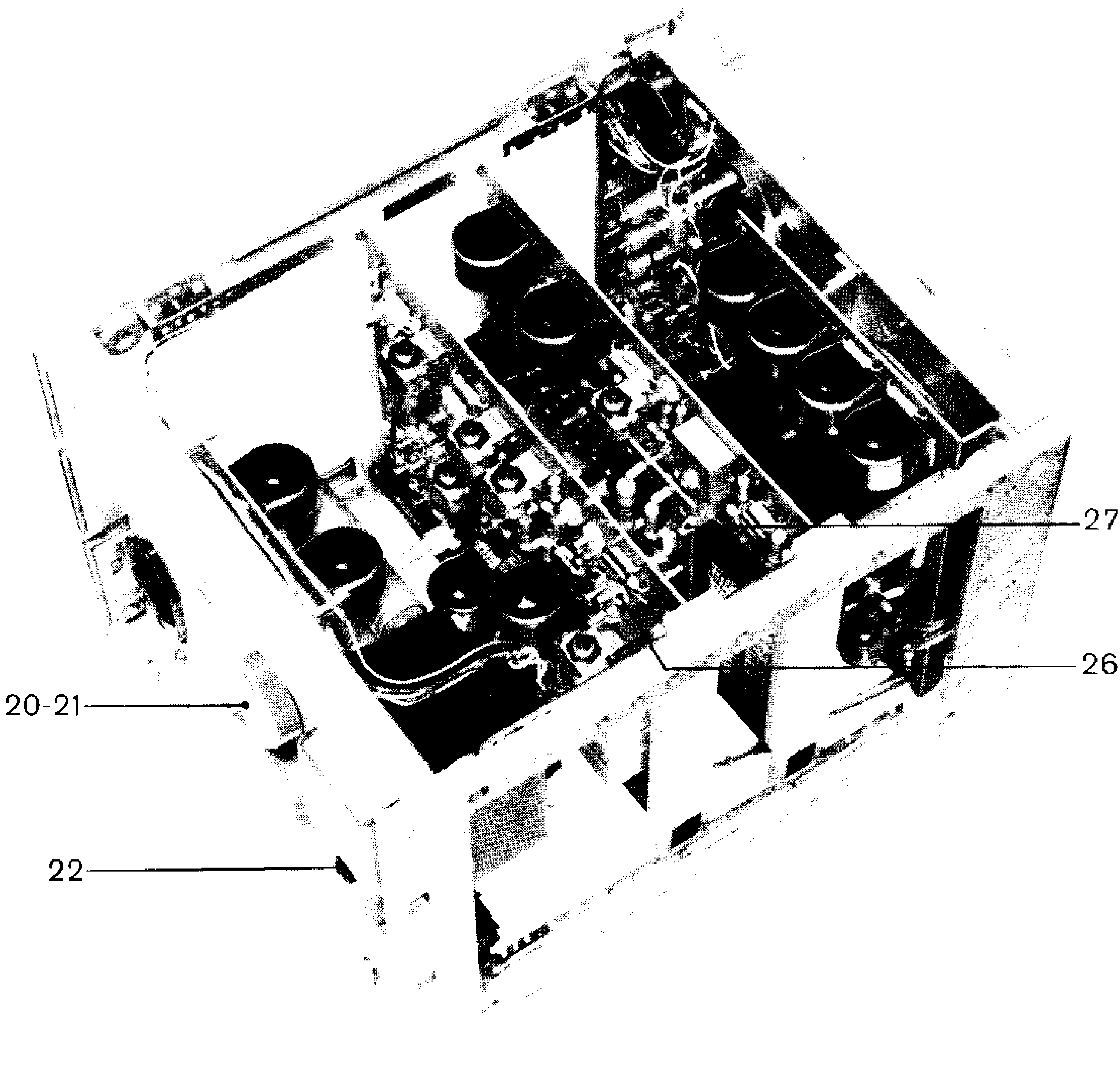


Fig. 17. Top view indicating mechanical components

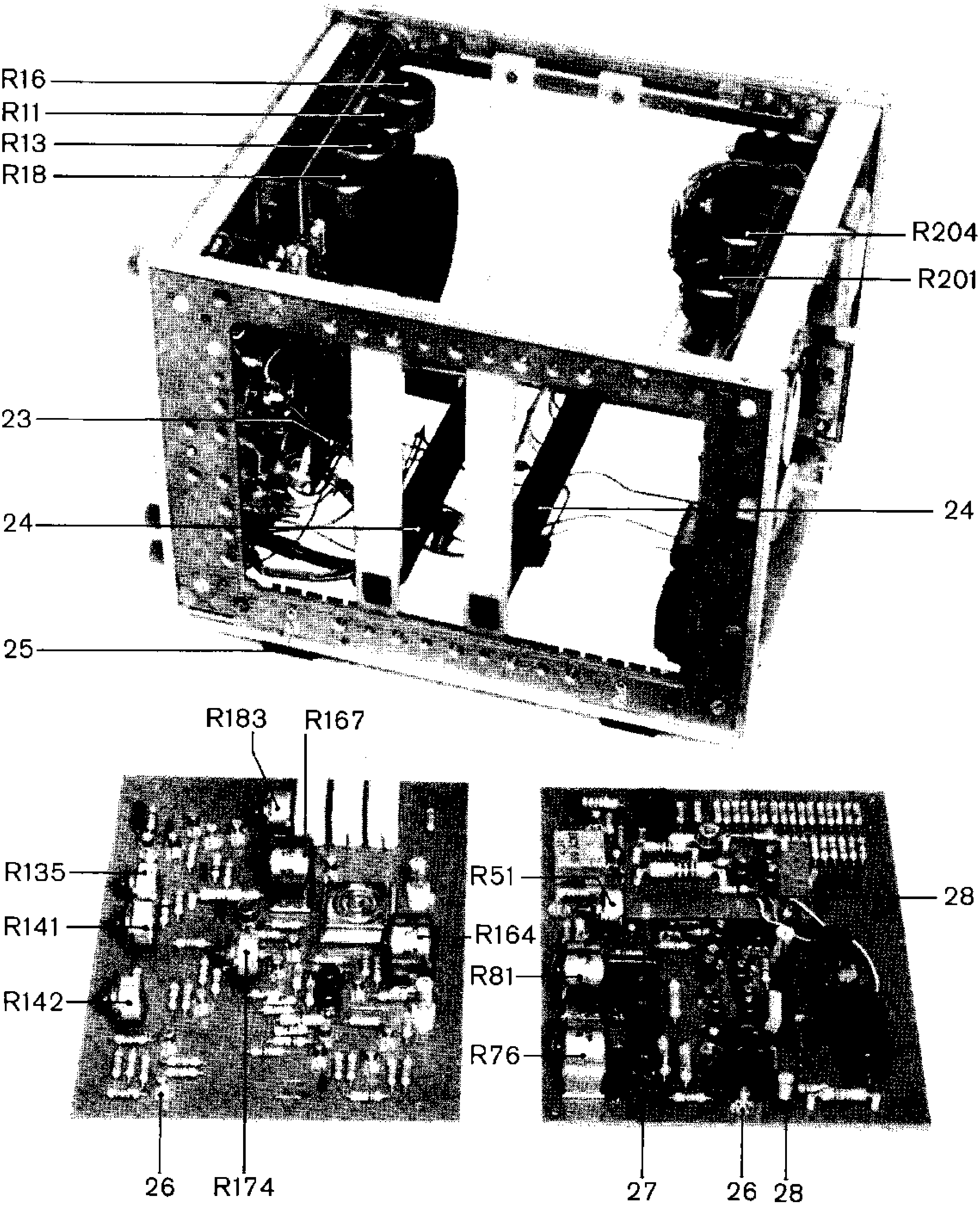


Fig. 18. Right-hand view indicating mechanical components

B. ELECTRICAL — ELEKTRISCH — ELEKTRISCH — ELECTRIQUE — ELECTRICOS

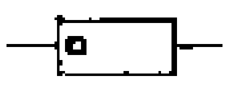
This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

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

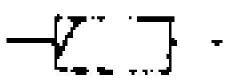
In deze stuklijst zijn geen universele en standaardonderdelen opgenomen. Deze componenten zijn in het principeschema met een merkteken aangegeven. De specificatie van deze merktekens is hieronder vermeld.

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

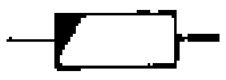
Esta lista de componentes no comprende componentes universales ni standard. Estos componentes están provistos en el esquema de principio de una marca. El significado de estas marcas se indica a continuación.

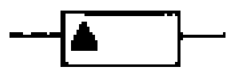

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
— 0,125 W 5%

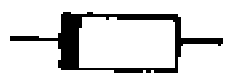

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 0,25 W ≤ 1 MΩ, 5%; > 1 MΩ, 10%

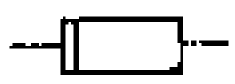

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
— 0,5 W ≤ 5 MΩ, 1%; > 5 ≤ 10 MΩ, 2%; > 10 MΩ, 5%

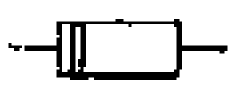

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 0,5 W ≤ 1,5 MΩ, 5%; > 1,5 MΩ, 10%

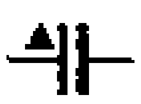

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 1 W ≤ 2,2 MΩ, 5%; > 2,2 MΩ, 10%

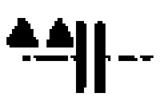

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
— 2 W 5%

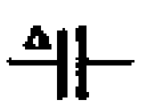

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
— 0,4 – 1,8 W 0,5%


Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
— 5,5 W ≤ 200 Ω, 10%; > 200 Ω, 5%

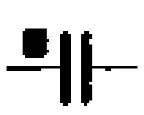

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
— 10 W 5%

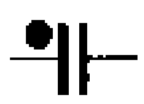

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
— 500 V

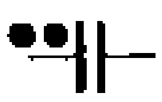

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
— 700 V

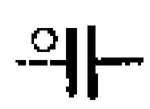

Ceramic capacitor, "pin-up"
Keramikkondensator "Pin-up" (Perltyp)
Keramische kondensator "Pin-up" type
Condensateur céramique, type perle
Condensador cerámico, versión "colgable"
— 500 V

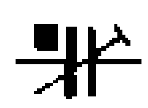

"Microplate" ceramic capacitor
Miniatur-Scheibenkondensator
"Microplate" keramische kondensator
Condensateur céramique "microplate"
Condensador cerámico "microplaca"
— 30 V


Mica capacitor
Glimmerkondensator
Micakondensator
Condensateur au mica
Condensador de mica
— 500 V


Polyester capacitor
Polyesterkondensator
Polyesterkondensator
Condensateur au polyester
Condensador polyester
— 400 V


Flat-foil polyester capacitor
Miniatur-Polyesterkondensator (flach)
Platte miniatuur polyesterkondensator
Condensateur au polyester, type plat
Condensador polyester, tipo de placas planas
— 250 V


Paper capacitor
Papierkondensator
Papierkondensator
Condensateur au papier
Condensador de papel
— 1000 V


Wire-wound trimmer
Drahttrimmer
Draadgewonden trimmer
Trimmer à fil
Trimmer bobinado


Tubular ceramic trimmer
Rohrtrimmer
Buisvormige keramische trimmer
Trimmer céramique tubulaire
Trimmer cerámico tubular

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.
Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.
Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.
Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.
Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

RESISTORS

No.	*Code number*	*Value*	*Watt*	*%*	*Description*
R1	4822 103 30085	10 kΩ			Potentiometer
R2	4822 101 20122	2.2 kΩ			Potentiometer
R3	4822 101 20257	4.7 MΩ			Potentiometer
R4	4822 101 30053	1 kΩ			Potentiometer
R11	4822 103 10058	250 Ω			Potentiometer Colvern
R12	4822 110 30094	330 Ω	1/8	1	Carbon
R13	4822 103 10058	250 Ω			Potentiometer Colvern
R16	4822 103 10058	250 Ω			Potentiometer Colvern
R17	4822 110 30091	240 Ω	1/8	1	Carbon
R18	4822 103 10058	250 Ω			Potentiometer Colvern
R28	4822 111 20044	27 kΩ	1/8	1	Carbon
R29	4822 110 30122	3.6 kΩ	1/8	1	Carbon
R30	4822 110 30142	20 kΩ	1/8	1	Carbon
R31	4822 101 20074	2.2 kΩ			Potentiometer
R32	4822 111 20019	3 kΩ	1/8	1	Carbon
R51	4822 101 20239	22 kΩ			Potentiometer
R66	4822 111 20019	3 kΩ	1/8	1	Carbon
R67	4822 110 30128	6.2 kΩ	1/8	1	Carbon
R72	4822 116 50424	1 kΩ		1	Metal film
R73	4822 116 50424	1 kΩ		1	Metal film
R74	4822 110 30073	51 Ω	1/8	1	Carbon
R76	4822 103 10059	50 Ω			Potentiometer Colvern
R77	4822 116 50425	240 Ω		1	Metal film
R78	4822 116 50424	1 kΩ		1	Metal film
R79	4822 116 50424	1 kΩ		1	Metal film
R81	4822 103 10061	20 Ω			Potentiometer Colvern
R82	4822 116 50225	590 Ω		1	Metal film
R83	4822 116 50426	560 Ω		1	Metal film
R85	4822 116 50377	220 Ω		1	Metal film
R87	4822 116 50377	220 Ω		1	Metal film
R130	4822 110 30176	390 kΩ	1/8	1	Carbon
R135	4822 101 20002	4.7 kΩ			Potentiometer
R141	4822 101 20002	4.7 kΩ			Potentiometer
R142	4822 101 20074	2.2 kΩ			Potentiometer
R162	4822 110 30125	4.7 kΩ	1/8	1	Carbon
R164	4822 103 10062	5 kΩ			Potentiometer Colvern

No.	*Code number*	*Value*		*Watt*	*%*	*Description*
R167	4822 103 10063	1	kΩ			Potentiometer Colvern
R168	4822 110 30135	11	kΩ	1/8	1	Carbon
R174	4822 101 20241	1	kΩ			Potentiometer
R177	4822 110 30136	12	kΩ	1/8	1	Carbon
R178	4822 110 30125	4.7	kΩ	1/8	1	Carbon
R183	4822 101 20241	1	kΩ			Potentiometer
R201	4822 103 10064	100	Ω			Potentiometer Colvern
R202	4822 111 20005	390	Ω	1/8	1	Carbon
R204	4822 103 10064	100	Ω			Potentiometer Colvern
R205	4822 111 20005	390	Ω	1/8	1	Carbon

CAPACITORS

No.	*Code number*	*Value*		*Volt*	*Description*
C6	4822 121 50376	1	μF	160 V	Polyester
C8	4822 121 50097	10	nF	63 V	Polystyrene
C11	4822 121 50376	1	μF	160 V	Polyester
C12	4822 121 50097	10	nF	63 V	Polystyrene
C20	4822 121 40184	3.3	μF	100 V	Polyester
C21	4822 121 40184	3.3	μF	100 V	Polyester
C22	4822 121 40184	3.3	μF	100 V	Polyester
C24	4822 124 20359	16	μF	40 V	Electroyltic
C25	4822 124 20359	16	μF	40 V	Electrolytic
C35	4822 124 20396	250	μF	64 V	Electrolytic
C36	4822 124 20396	250	μF	64 V	Electrolytic
C39	4822 124 20359	16	μF	40 V	Electrolytic
C40	4822 124 20359	16	μF	40 V	Electrolytic
C41	4822 124 20026	400	μF	40 V	Electrolytic
C42	4822 124 20026	400	μF	40 V	Electrolytic
C53	4822 120 60101	560	pF		Mica
C54	4822 120 60101	560	pF		Mica

DIODES

No.	Type number	Description
GR1	BZY 95/C18	Zener
GR2	OA 202	Silicon
GR10	OA 202	Silicon
GR11	BZY 94/C15	Zener
GR12	BZY 78	Zener
GR13	BZY 88/C8V2	Zener
GR14	BZY 88/C6V2	Zener
GR15	BZY 95/C15	Zener
GR16, GR17	AAZ 15	Germanium
GR18	BZY 78	Zener
GR19... GR26	OA 202	Silicon
GR27... GR42	OA 202	Silicon
GR50	BZY 88/C9V1	Zener
GR51, GR52	OA 202	Silicon
GR53	BZY 88/C9V1	Zener
GR54	OA 202	Silicon
GR60, GR61	BY 123	Bridge diode stack
GR62, GR63	BZY 88/C3V9	Zener
GR64, GR65	BZY 78	Reference diode

TRANSISTORS

No.	Type number	Description
TS1... TS7	BC 107	Silicon
TS8	BCY 52	Silicon
TS11	BCY 70	Silicon
TS12, TS13	BC 107	Silicon

No.	*Type number*	*Description*
TS14	BFW 10	Field-effect
TS15	BCY 55	Silicon, pair
TS16... TS18	BC 107	Silicon
TS19	2N930	Silicon
TS20	BCY 71	Silicon
TS21	2N930	Silicon
TS22	BCY 71	Silicon
TS23	2N930	Silicon
TS24	BCY 71	Silicon
TS25	2N930	Silicon
TS26	BCY 71	Silicon
TS27	2N930	Silicon
TS28 TS29	BC 107	Silicon
TS30 TS31	BFW 10	Field-effect
TS32 TS33	BFY 52	Silicon
TS45	2N930	Silicon
TS46 TS56	BC 107	Silicon
TS57	ASY 29	Germanium
TS58	BC 107	Silicon
TS59	ASY 29	Germanium
TS60 TS61 TS62 TS63	BC 107	Silicon
TS64	BFY 52	Silicon
TS70 TS71	BC 107	Silicon
TS72... TS77	BCY 70	Silicon
TS80 TS81	OC 29	Silicon

MISCELLANEOUS

No.	*Code number*	*Description*
T1	4822 146 20343	Mains transformer
U1	4822 209 80005	Integrated circuit
VL1	4822 253 30017	Fuse 500 mA
	4822 253 30021	Fuse 1 A
—	4822 216 60104	Printed wiring board of emitter follower assembly with components (without plug-in transistors)
—	4822 216 60105	Printed wiring board of triangle generator with components (without plug-in transistors)
—	4822 216 60106	Printed wiring board of frequency control with components (without plug-in transistors)
—	4822 216 60107	Printed wiring board of power supply with components
—	4822 216 60108	Printed wiring board of sine shaper with components

Information on the modular system and optional accessories

XIV

A. GENERAL

Power amplifier PM 5162 is part of the modular L.F. system, which consists of various units, which can be easily linked, thus forming several alternative L.F. systems for a wide field of applications. (Refer to PHILIPS publication: "Instrument and Application"). The width of the various units is expressed in modules, one module having the following dimensions:

width:	70 mm
height:	178 mm
depth:	250 mm

The units have a width of one, two or three modules. They can be linked to a maximum width of six modules.
The instruments are suitable for rack-mounting.
The following units are, amongst others, suitable for use with the PM5162.

PM5160-Oscillator

Frequency range	1 Hz...1 MHz
Output voltage	1 $V_{r.m.s.}$ into 600 Ω
Attenuator	continuous (logarithmic)
Width	2 modules

Suitable for use with:

Wide-band amplifier	PM 5170 (width: 1 module)
Power amplifier	PM 5175 (width: 2 modules)
Monitored atnuattor	PM 5180 (width: 2 modules)

PM 5168-Function generator

Frequency range	0.5 mHz...5 kHz
Output voltage	3 V_{p-p} into 600 Ω
Attenuator	continuous (logarithmic)
Waveforms	– triangle wave – squarewave – sinewave

Facilities	– single shot – external triggering
Width	3 modules

Suitable for use in combination with:

Wide-band amplifier	PM 5170 (width: 1 module)
Power amplifier	PM 5175 (width: 2 modules)
Monitored attenuator	PM 5180 (width: 2 modules)

PM 5170-Wide-band amplifier

Frequency range	DC...1 MHz
Maximum output	10 $V_{r.m.s.}$ into 600 Ω
Input impedance	– 600 Ω and – high impedance (100 kΩ)
Width	1 module

Suitable for use in combination with:

Oscillator	PM 5160 (width: 2 modules)
Sweep oscillator	PM 5162 (width: 3 modules)
Function generator	PM 5168 (width: 3 modules)
Monitored attenuator	PM 5180 (width: 2 modules)

PM 5175-Power amplifier

Frequency range	DC...1 MHz
Maximum output	10 W_p
Input impedance	– 600 Ω and – high impedance (100 kΩ)
Attenuator	steps of 10 dB
Width	2 modules

Suitable for use in combination with:

Oscillator	PM 5160 (width: 2 modules)
Sweep oscillator	PM 5162 (width: 3 modules)
Function generator	PM 5168 (width: 3 modules)

PM 5180-Monitored attenuator

Attenuation	0...99.9 dB in 10 – 1 and 0.1 dB steps
Outputs	– 600 Ω unbalanced – 600 or 150 Ω balanced (floating)

Maximum input voltage	10 $V_{r.m.s.}$
Frequency ranges	
a. attenuator	DC...1 MHz
b. meter	10 Hz...1 MHz
c. transformer output	20 Hz...20 kHz
Width	2 modules

Suitable for use in combination with:

Oscillator	PM 5160 (width: 2 modules)
Sweep oscillator	PM 5162 (width: 3 modules)
Function generator	PM 5168 (width: 3 modules)
Wide-band amplifier	PM 5170 (width: 1 module)

B. COUPLING ACCESSORIES

For coupling the various units to form one complete instrument, coupling accessories are available for every chosen combination up to a width of six modules.
These accessories comprise one coupling kit and five different cover kits. With the aid of the parts provided in the *coupling kit* any two modular units can be linked to each other.
A *cover kit* contains a top cover, a tilting assembly and an extension piece for the carrying handle; with these parts the coupled units can be equipped to form one complete instrument.

Ordering information

One coupling kit PM 9500 should be ordered for each coupling connection to be made. Depending on the total width of the coupled units, one of the following cover kits should also be ordered.

Type number	*Cover kit for a total width of*
PM 9502	2 modules
PM 9503	3 modules
PM 9504	4 modules
PM 9505	5 modules
PM 9506	6 modules

For example:

To be coupled	one 2-module unit two 1-module units
Required coupling accessories	two coupling kits PM 9500 one cover kit PM 9504

The coupling kit PM 9500 includes: (Fig. 19)

a. 4 coupling screws with nuts
b. 2 fixing screws for handle
c. 1 inter-unit screen
d. 1 mains interconnection link
e. 2 signal interconnection links

A cover kit PM 9502...PM 9506 includes: (Fig. 20)

a. 1 n-module top cover
b. 1 n-module tilting assembly
c. 1 n-module handle bar

Further optional accessories available

a. Coupling parts for one-module units

When an equipment is to be made up from 1-module units only, coupling parts additional to the coupling kit and cover kit are required.
This is because 1-module units are not equipped with a carrying handle.
These additional parts are:

Number	*Description*	*Ordering number*
2	Handle bracket	4822 404 50199
2	Handle screw	4822 502 10801
2	Washer for handle screw	4822 532 50653
2	Screw for handle bar	4822 502 10555

b. PM 9510, rack-mounting kit (See exploded view, Fig. 22)

Adaptation set for mounting a 6-module cabinet into a 19″ rack, including:
- 2 brackets
- 2 handles
- 4 fixing screws
- 2 inter-unit screens

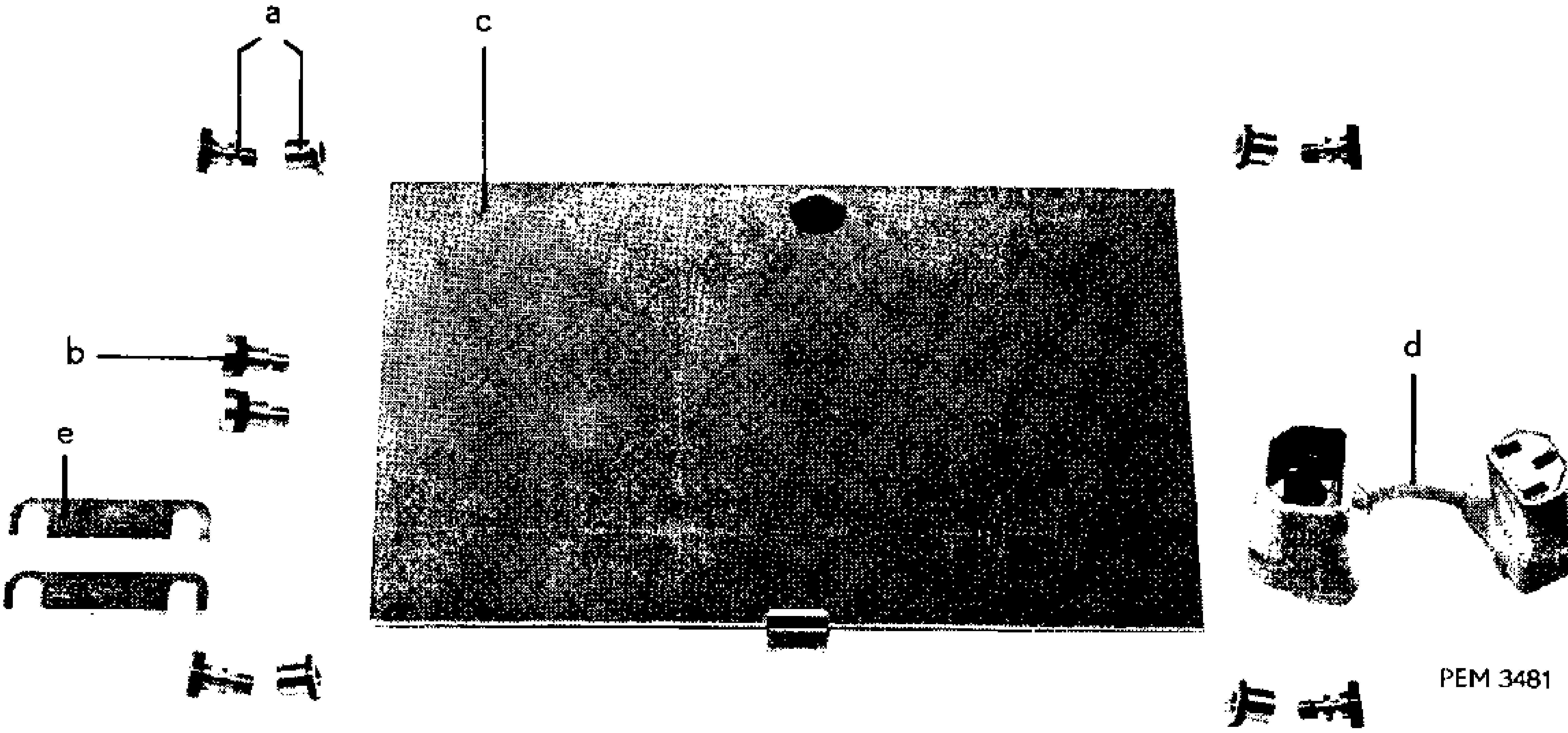


Fig. 19. Coupling kit

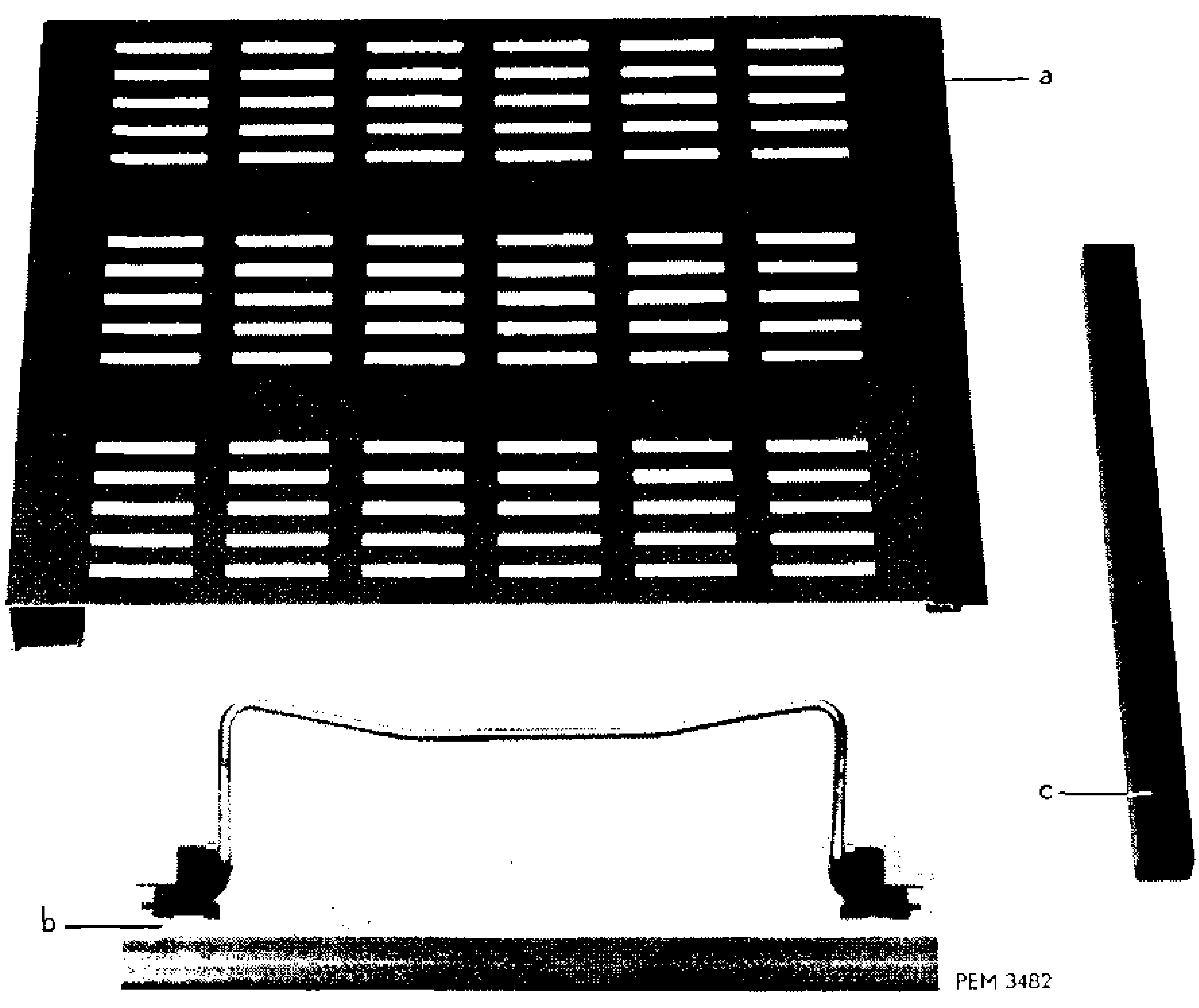


Fig. 20. Cover kit

C. COUPLING INSTRUCTIONS (also see Fig. 23)

1. Detach the carrying handles by removing the screws on both sides of each unit. Next remove the handle bar and replace it by the bar, provided in the cover kit.

   Note: When two or more 1-module units have to be coupled a handle should be composed and fixed to the instrument by means of the additional coupling parts mentioned in the preceding section under point "a".

2. The side covers should be removed from the sides which are to be connected together and the inter-unit screen from the coupling kit should be fitted to one of the exposed side frames.
3. Remove the top covers by loosening the fastener at the rear of each unit.
4. Detach the bottom covers by removing the appropriate screw(s) at the rear of the units.

   N.B.: Ensure that the bottom covers are refitted to the units from which they have been taken. (See point 9.)

5. Remove the tilting assembly at the bottom of each unit by pushing the two nylon slides "A" in the direction indicated in figure 21.
6. Remove the two feet at the coupling sides of each unit. First loosen the grub screws which hold the surround.
7. Couple the units to each other by means of the nuts and bolts provided in the coupling kit.
8. Fit the tilting assembly, which is provided in the cover kit, to the bottom of the instrument by means of the two nylon slides.
9. Refit the appropriate bottom cover of each unit. (See point 4).

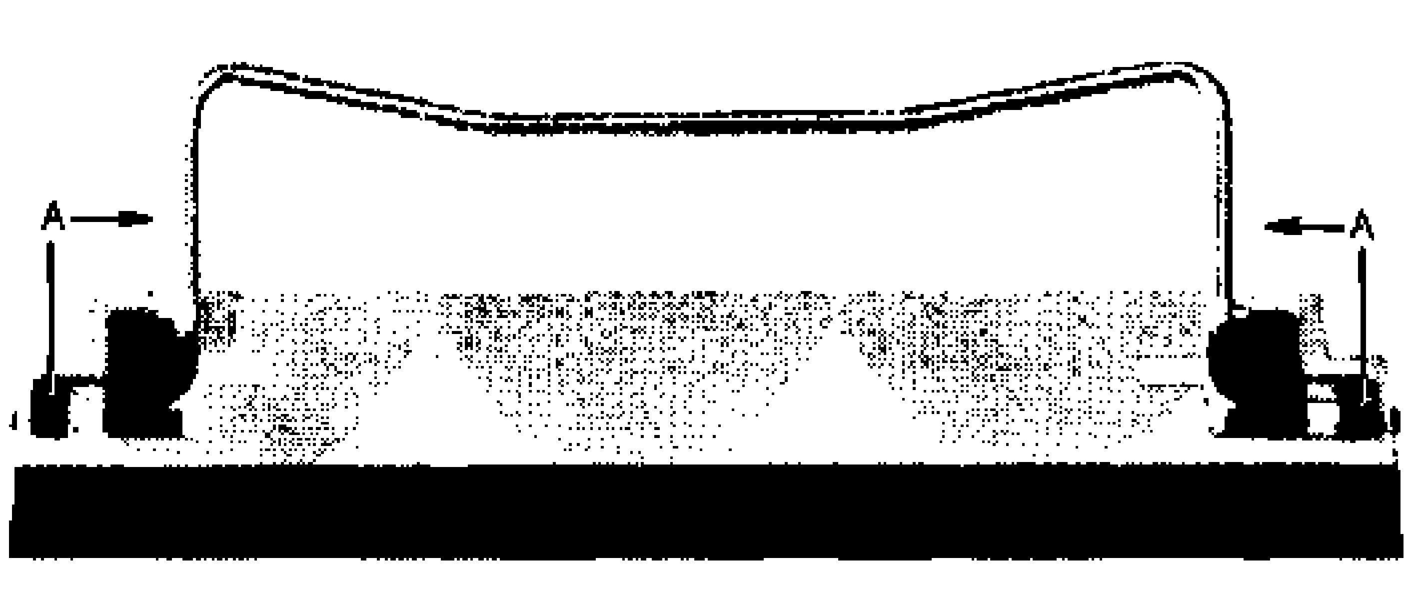


Fig. 21. Tilting assembly

10. Fit the new top cover on the instrument, by placing the groove of the quick fastener in a horizontal position and pushing the cover towards the front of the instrument.
11. Screw the extended carrying handle to the instrument.
12. Finally fit the mains link on the rear of the instrument and the signal links on the front of the instrument.

Note:

- Always earth the coupled circuits at one point only by interconnecting the circuit earth (⏚) and the cabinet earth (⊥) of only one of the coupled units.
- Coupling two or more units may involve a temperature rise in the units. Make sure that the ambient temperature as mentioned in the TECHNICAL DATA of the manual will not be exceeded.

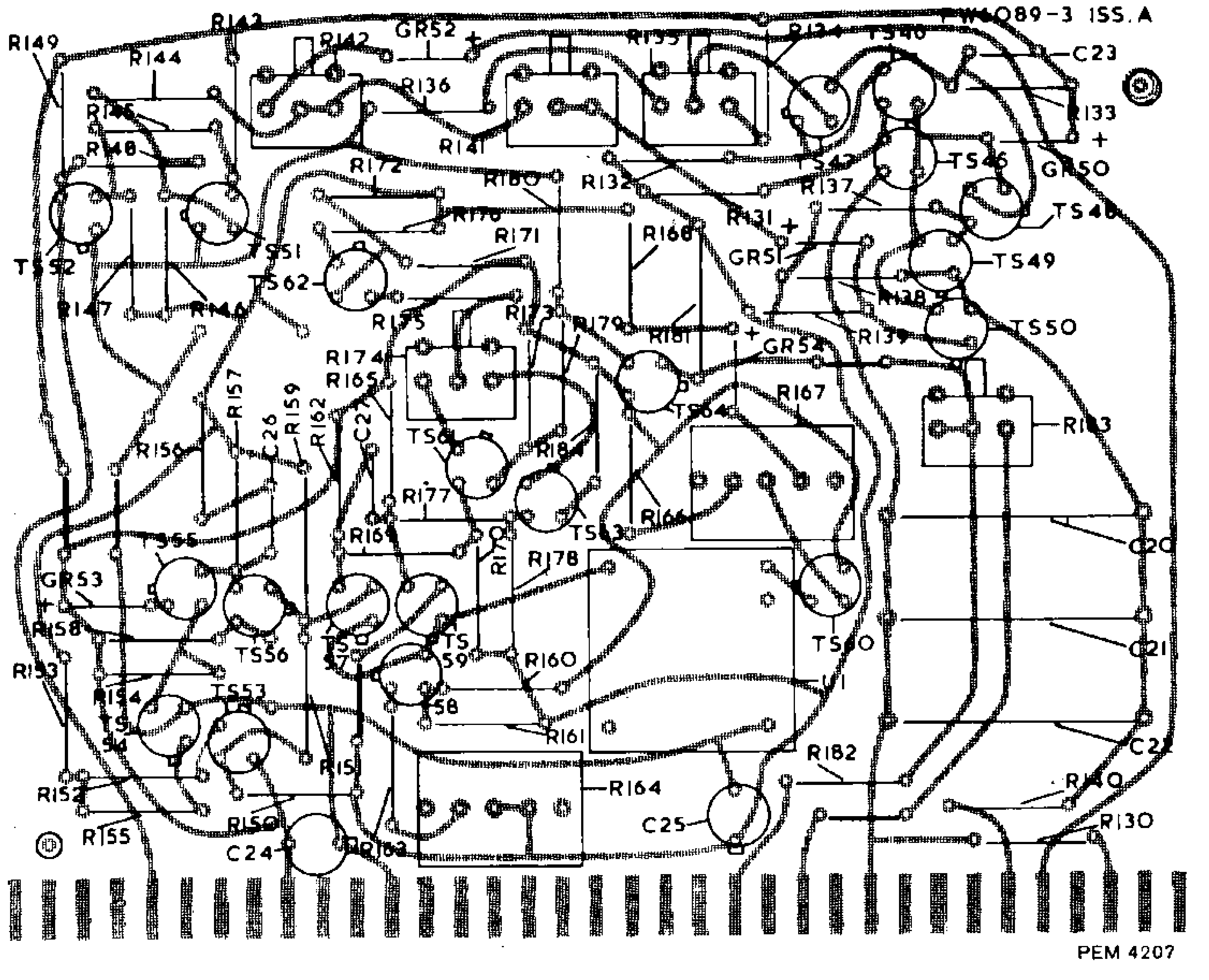


Fig. 24. Printed wiring board of sine shaper

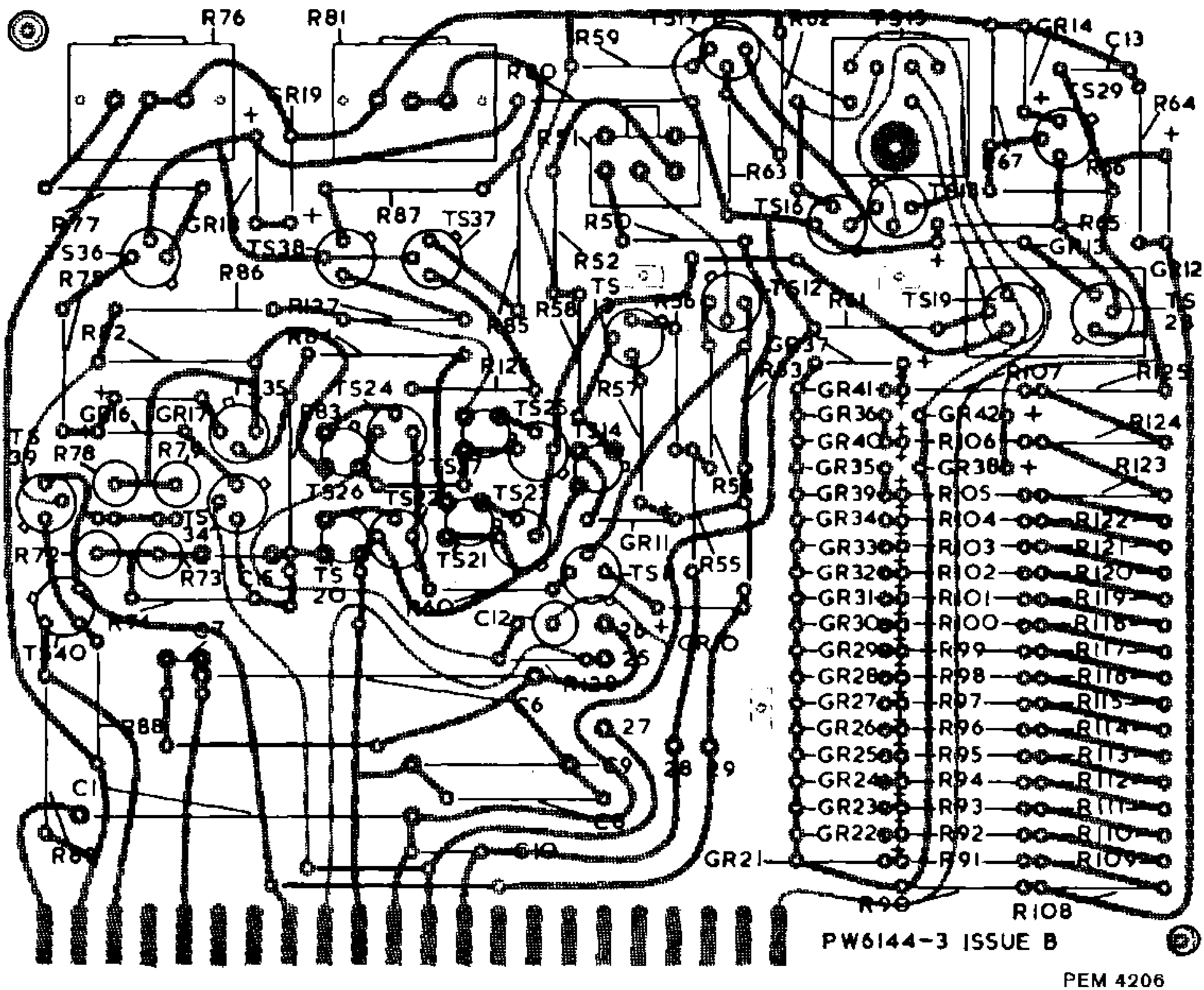


Fig. 25. Printed wiring board of triangle and squarewave generator

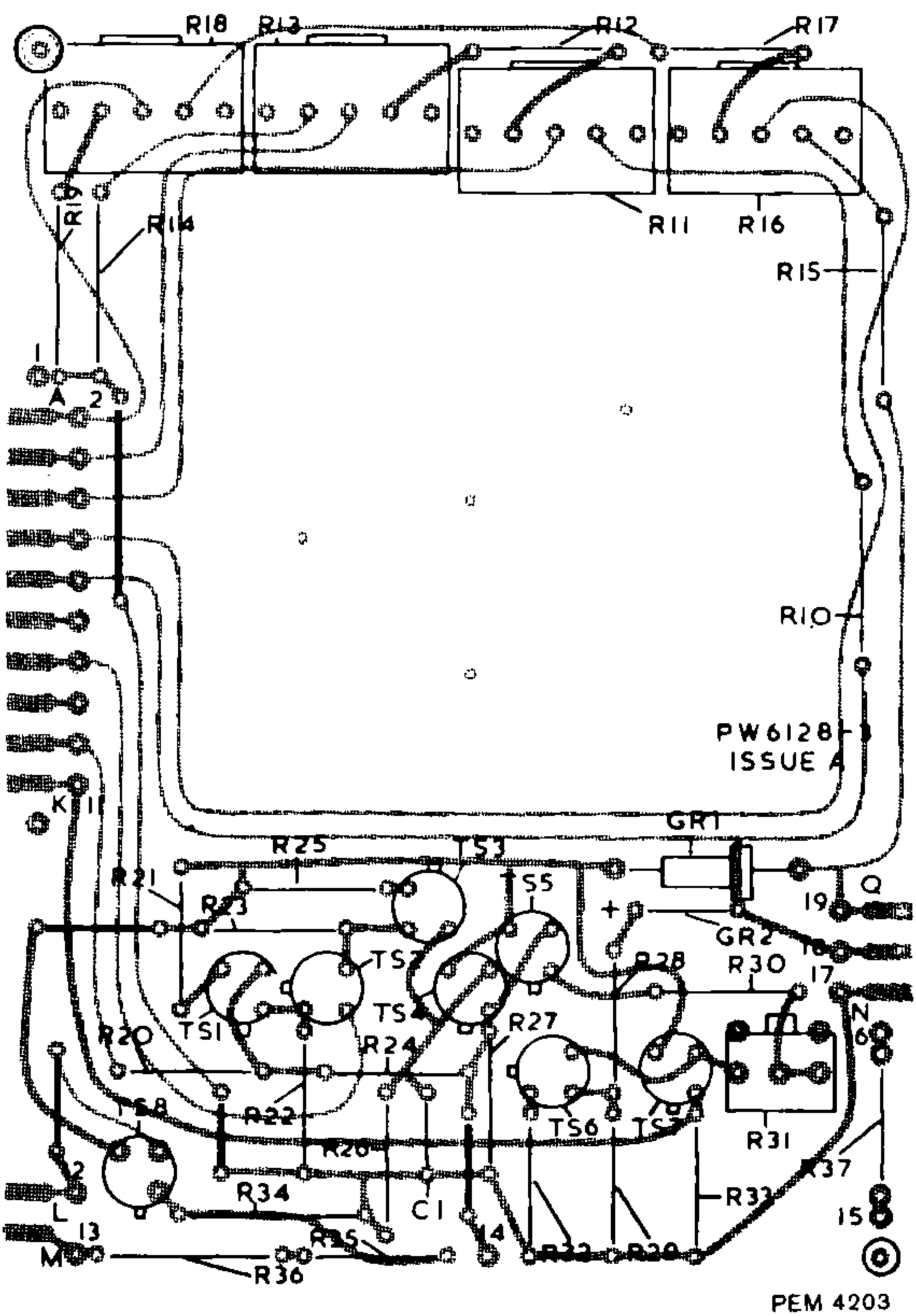


Fig. 26. Printed wiring board of control circuit

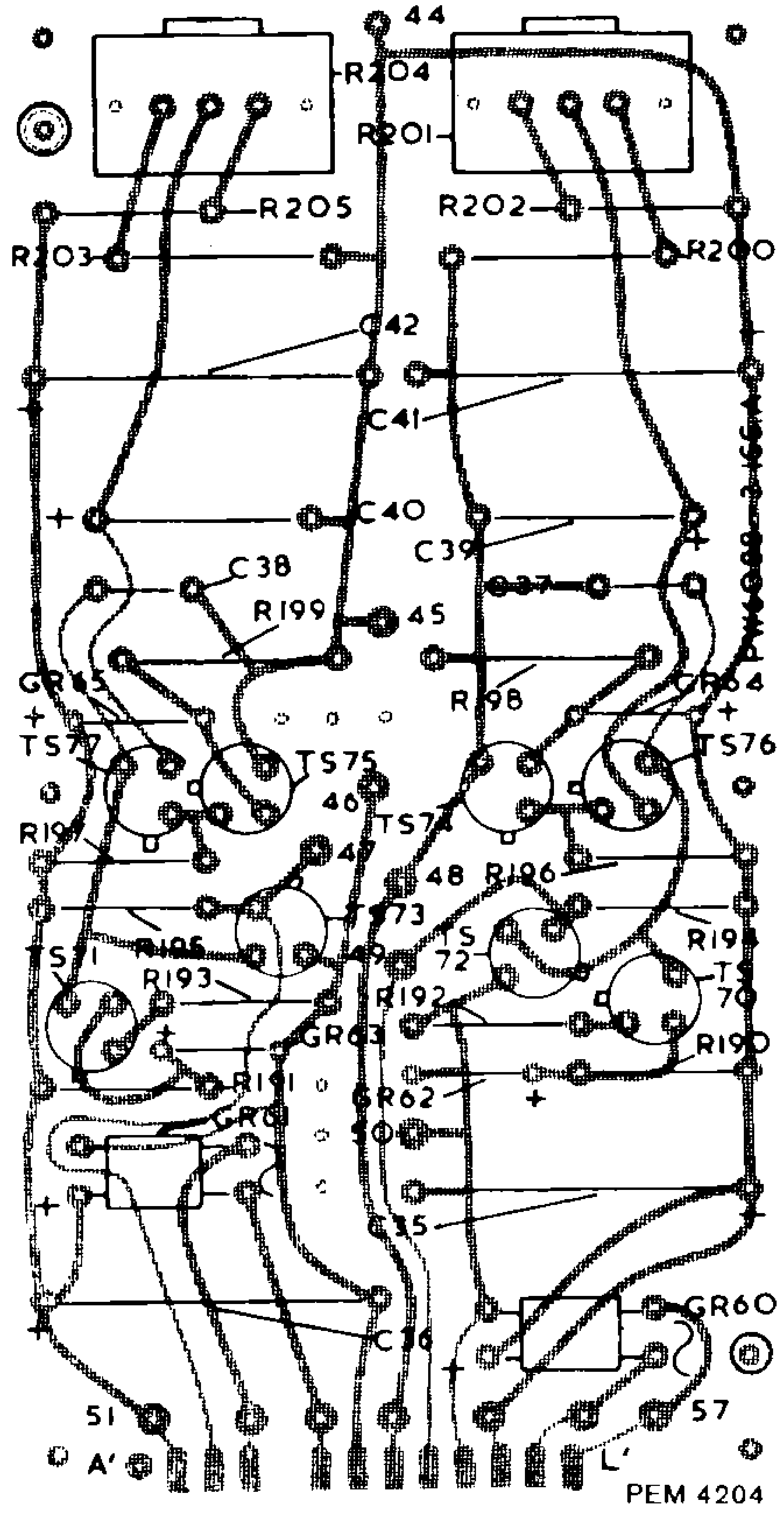


Fig. 27. Printed wiring board of power supply

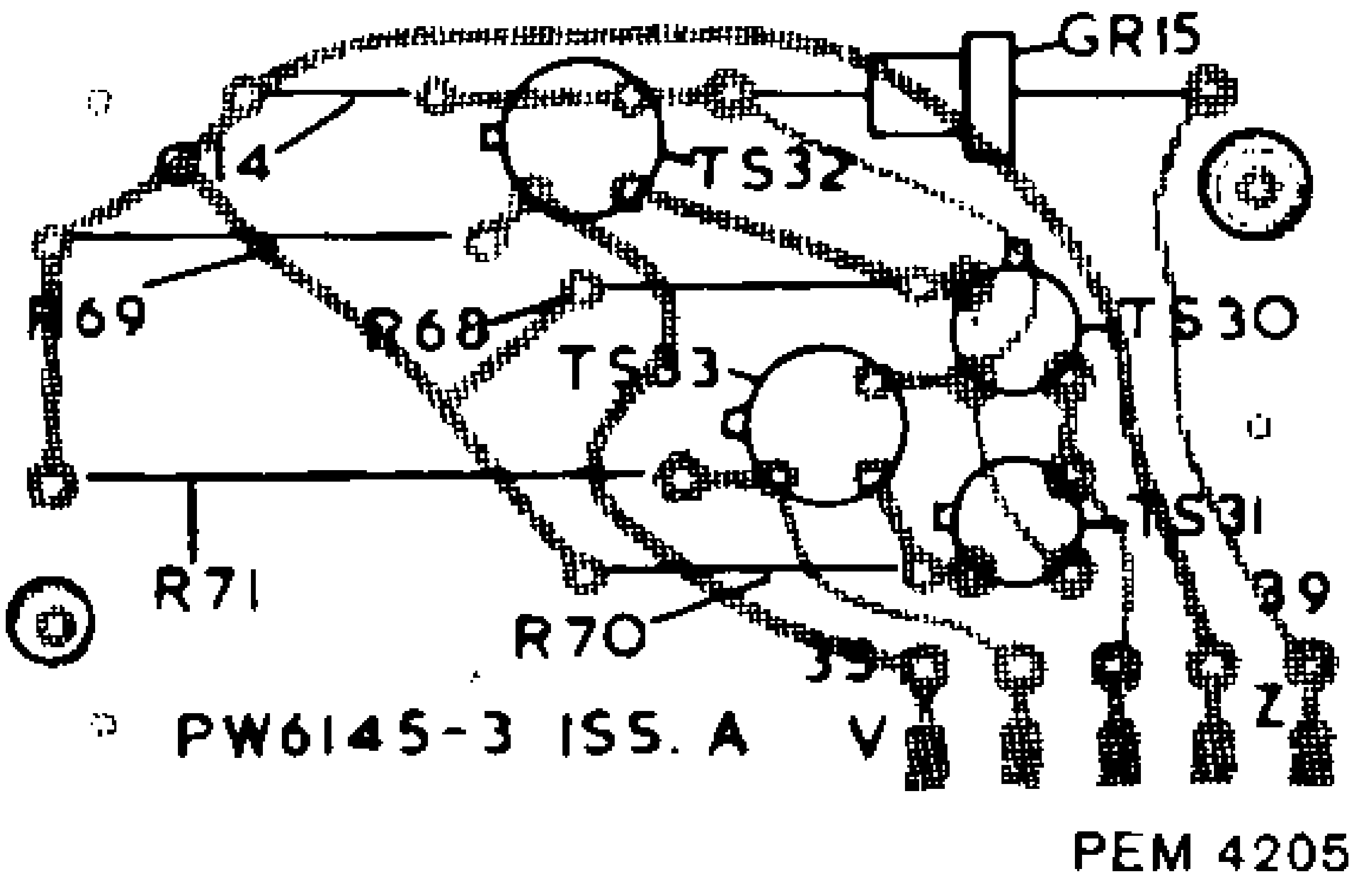


Fig. 28. Printed wiring board of buffer stage

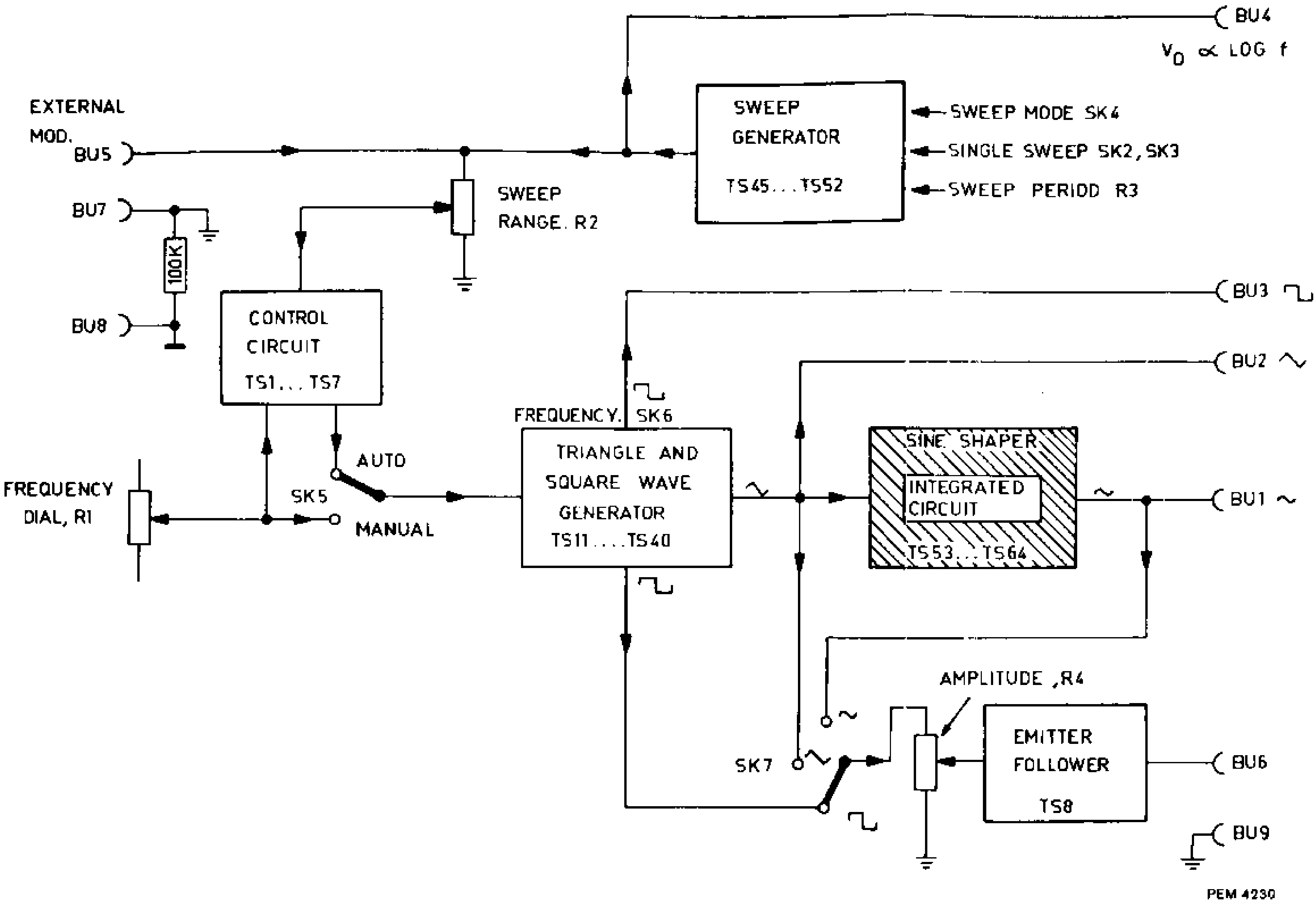
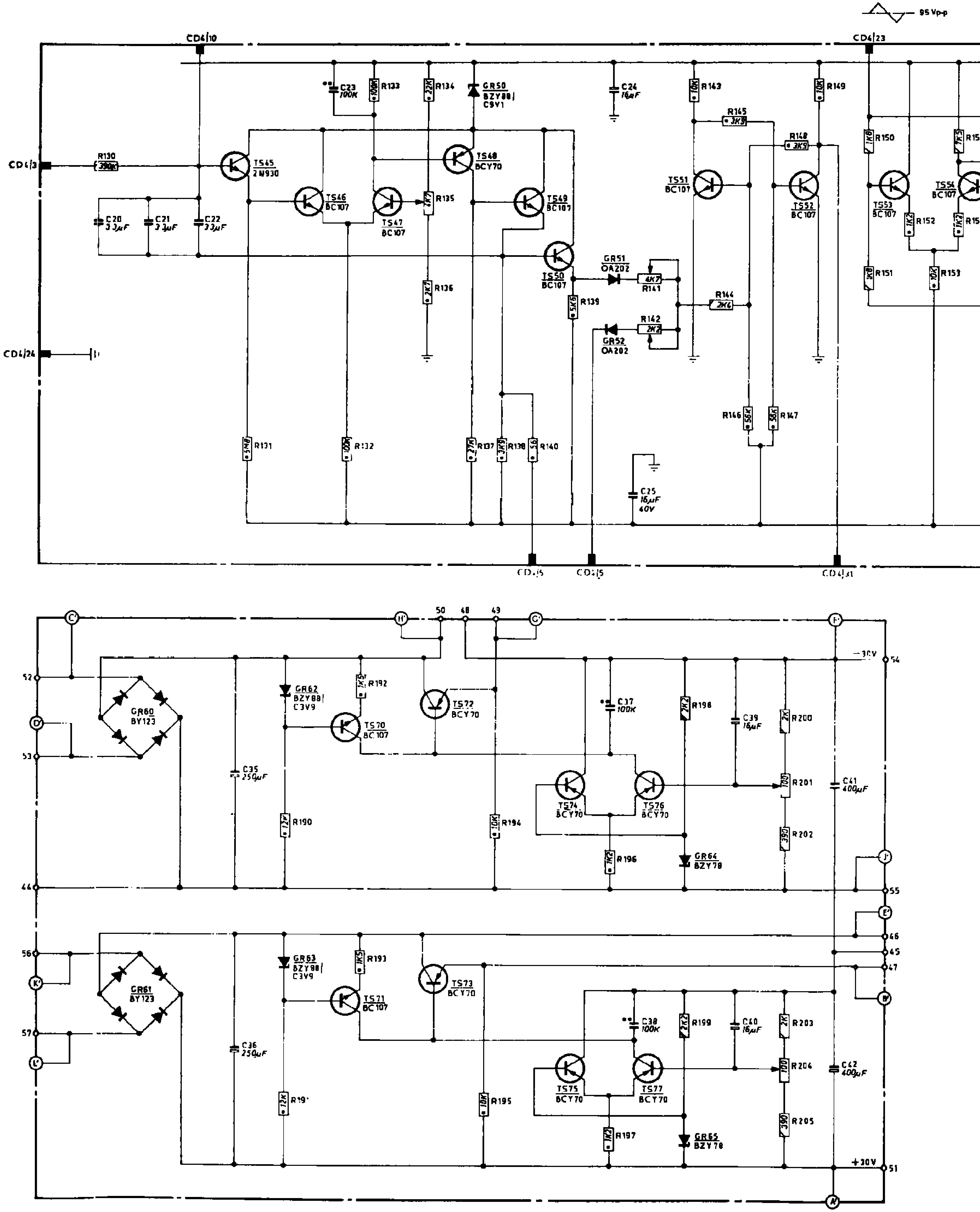
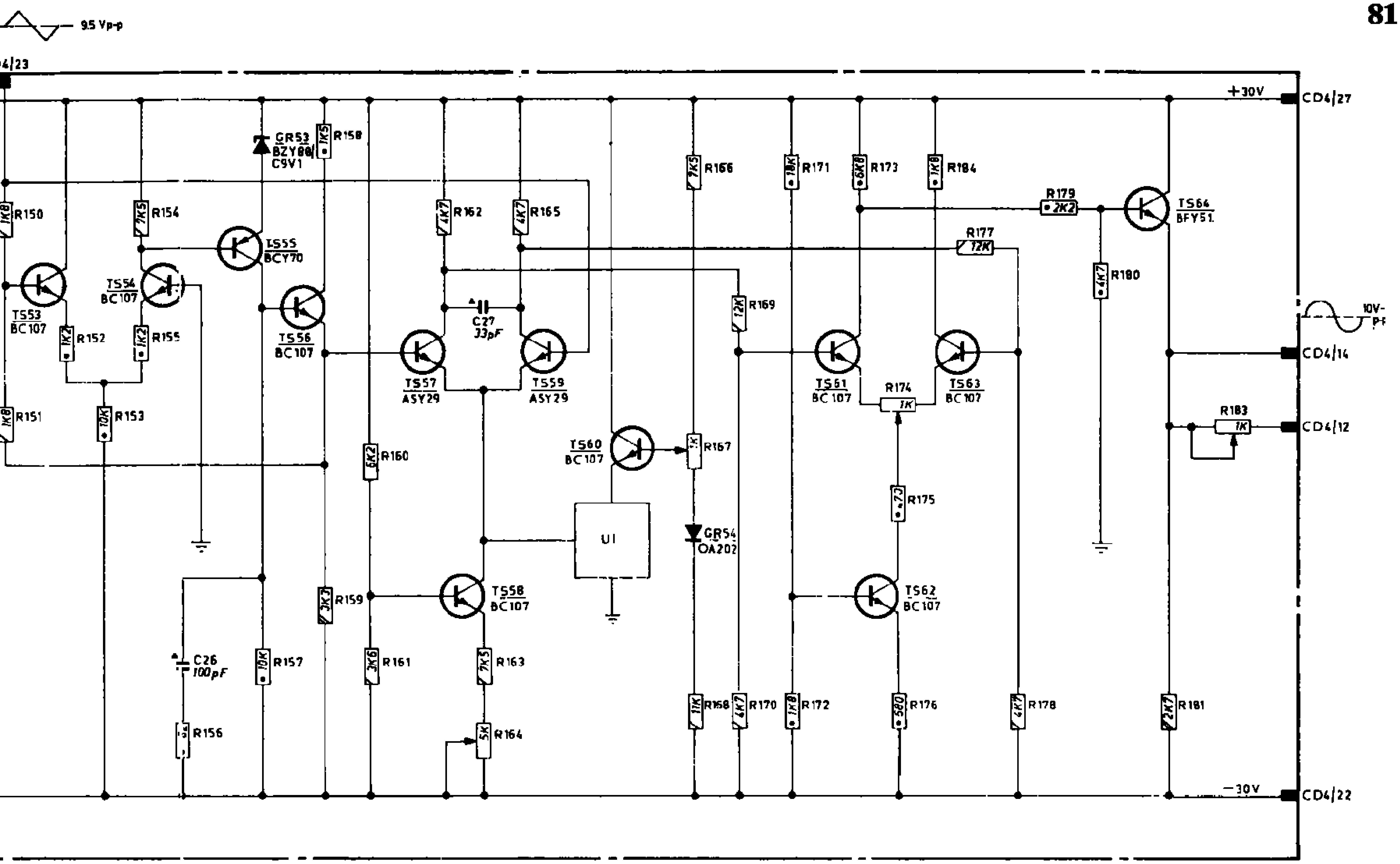


Fig. 5. Block diagram



95 Vp-p
CD4/10
CD4/23
CD4/3
CD4/24
CD4/5
CD4/31
R130 390K
C20 3.3μF
C21 3.3μF
C22 3.3μF
TS45 2N930
TS46 BC107
TS47 BC107
TS48 BCY70
TS49 BC107
TS50 BC107
C23 100K
R133 100K
R134 22K
GR50 BZY88/C5V1
R135 1K7
R136 2K7
C24 16μF
R143 10K
R149 10K
R145 3K9
R148 3K9
TS51 BC107
TS52 BC107
TS53 BC107
TS54 BC107
R150 1K8
R151 1K8
R152 1K2
R153 10K
GR51 OA202
R141 4K7
R144 2K6
R142 2K2
GR52 OA202
R139 5K6
R146 56K
R147 56K
R131 5M6
R132 100K
R137 27K
R138 3K9
R140 56
C25 16μF 40V
C'
H'
G'
F'
D'
J'
E'
K'
L'
B'
N'
50
48
49
52
53
44
55
56
57
46
45
47
51
54
-30V
+30V
GR60 BY123
GR61 BY123
C35 250μF
C36 250μF
GR62 BZY88/C3V9
GR63 BZY88/C3V9
R190 12K
R191 12K
R192 1K5
R193 1K5
TS70 BC107
TS71 BC107
TS72 BCY70
TS73 BCY70
R194 10K
R195 10K
C37 100K
C38 100K
R198 2K2
R199 2K2
C39 16μF
C40 16μF
R200 2K
R201 100
R202 390
R203 2K
R204 100
R205 390
TS74 BCY70
TS76 BCY70
TS75 BCY70
TS77 BCY70
R196 1K2
R197 1K2
GR64 BZY78
GR65 BZY78
C41 400μF
C42 400μF



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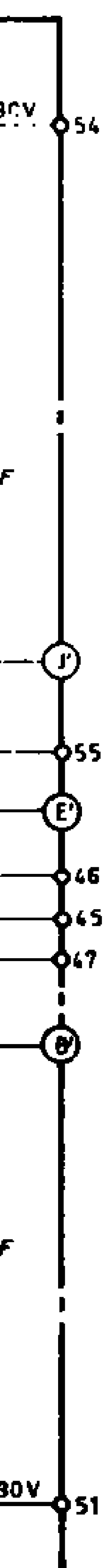
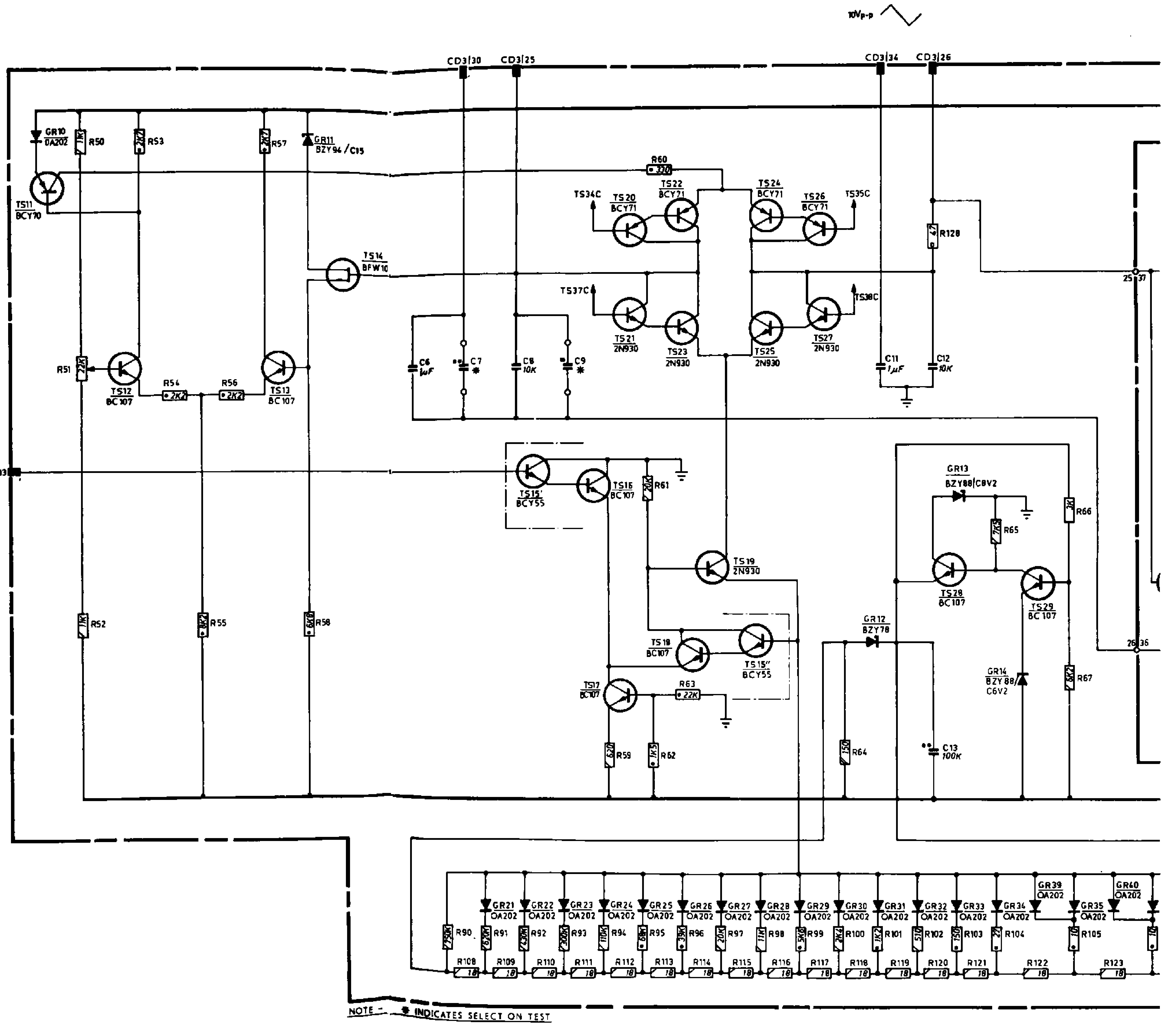


Fig. 30. Circuit diagram of sine shaper and power supply


10Vp-p
CD3|30
CD3|25
CD3|34
CD3|26
GR10 0A202
R50
R53
R57
GR11 BZY94/C15
R60 220
TS11 BCY70
TS14 BFW10
TS34C
TS20 BCY71
TS22 BCY71
TS24 BCY71
TS26 BCY71
TS35C
R128 47
TS37C
TS21 2N930
TS23 2N930
TS25 2N930
TS27 2N930
TS38C
R51 22K
TS12 BC107
R54 2K2
R56 2K2
TS13 BC107
C6 1µF
C7 *
C8 10K
C9 *
C11 1µF
C12 10K
TS15' BCY55
TS16 BC107
R61 20K
GR13 BZY88/C8V2
R65 7K5
R66 3K
TS19 2N930
TS28 BC107
TS29 BC107
R52 1K
R55 8K2
R58 6K8
GR12 BZY78
TS18 BC107
TS15" BCY55
GR14 BZY88/C6V2
R67 6K2
TS17 BC107
R63 22K
R59 620
R62 1K5
R64 150
C13 100K
25|37
26|36
GR21 OA202
GR22 OA202
GR23 OA202
GR24 OA202
GR25 OA202
GR26 OA202
GR27 OA202
GR28 OA202
GR29 OA202
GR30 OA202
GR31 OA202
GR32 OA202
GR33 OA202
GR34 OA202
GR35 OA202
GR39 OA202
GR40 OA202
R90 750K
R91 620K
R92 430K
R93 300K
R94 110K
R95 68K
R96 39K
R97 20K
R98 11K
R99 5K6
R100 2K4
R101 1K2
R102 510
R103 150
R104 27
R105 10
R108 18
R109 18
R110 18
R111 18
R112 18
R113 18
R114 18
R115 18
R116 18
R117 18
R118 18
R119 18
R120 18
R121 18
R122 18
R123 18
NOTE - * INDICATES SELECT ON TEST

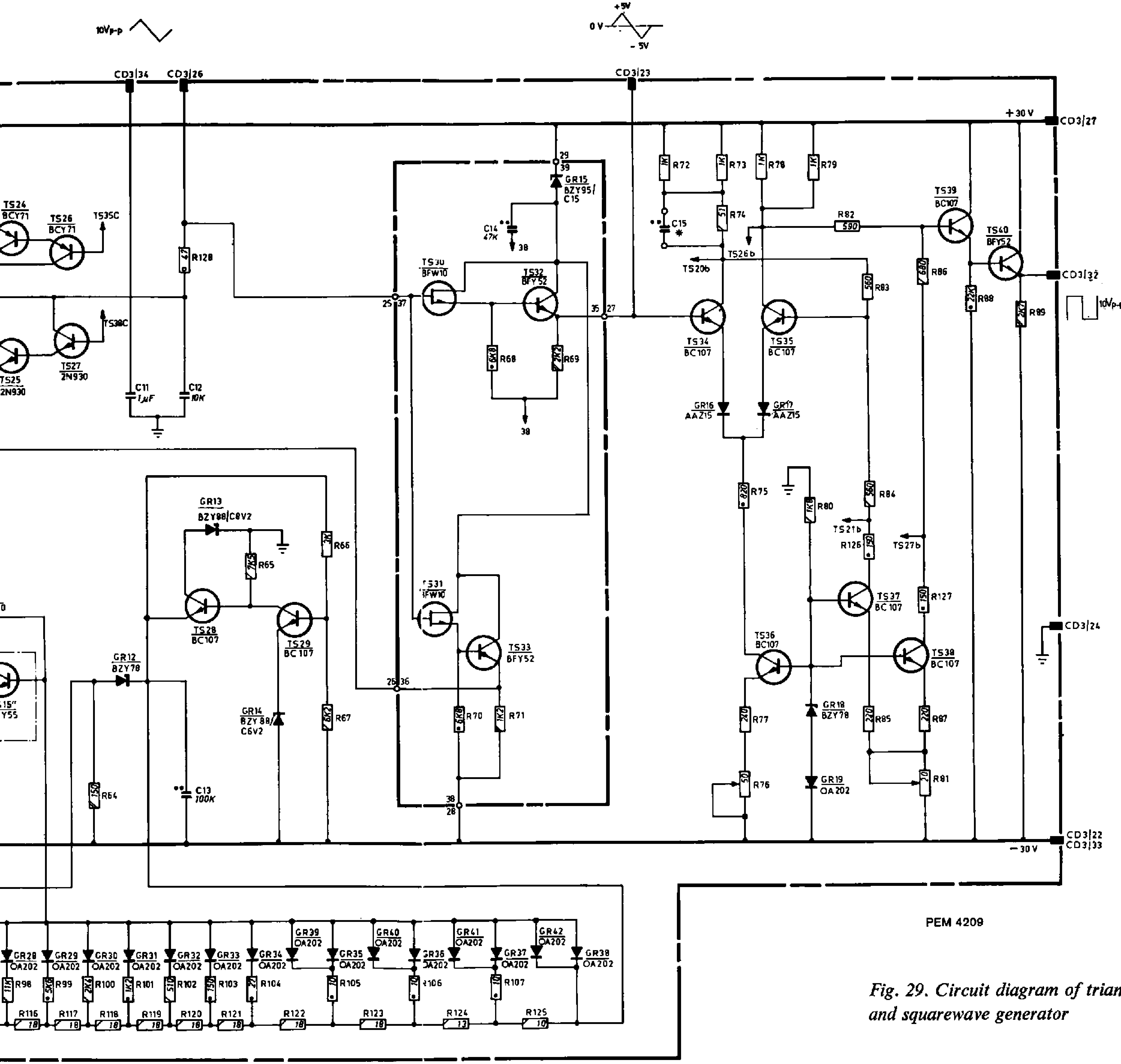
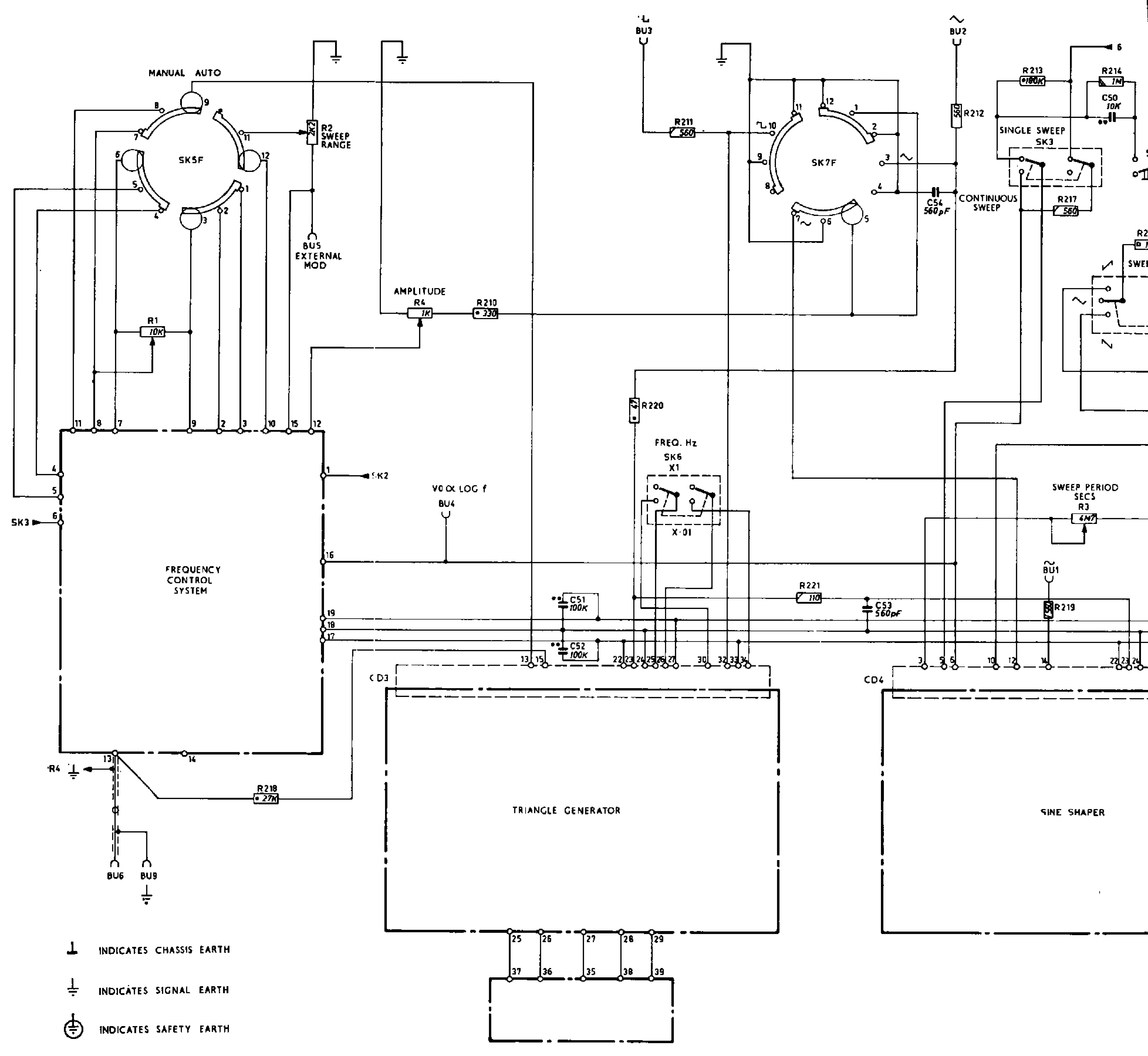


Fig. 29. Circuit diagram of triangle and squarewave generator



INDICATES CHASSIS EARTH

INDICATES SIGNAL EARTH

INDICATES SAFETY EARTH

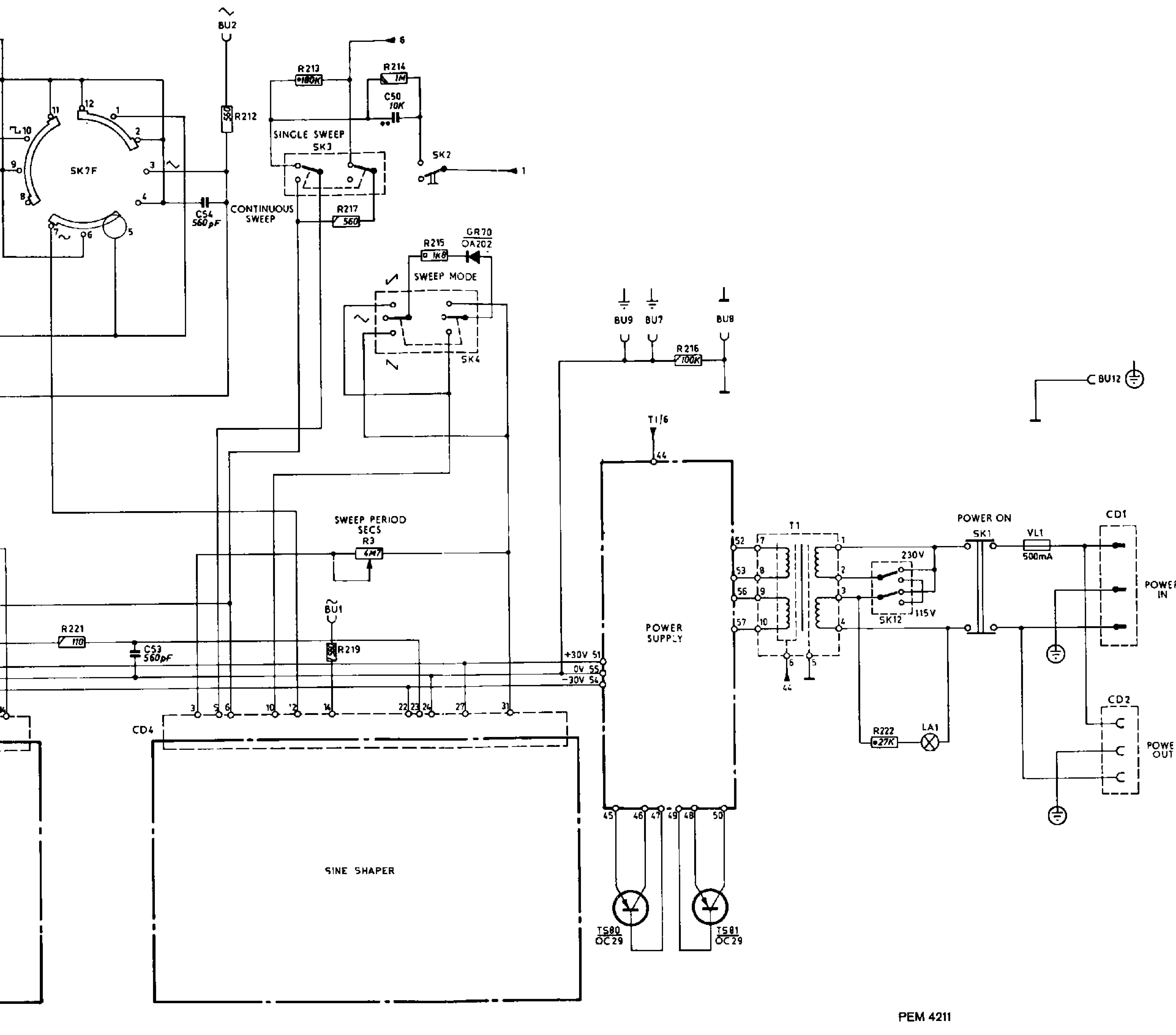


Fig. 32. Overall circuit diagram

Fig. 31. Circuit diagram of control circuit