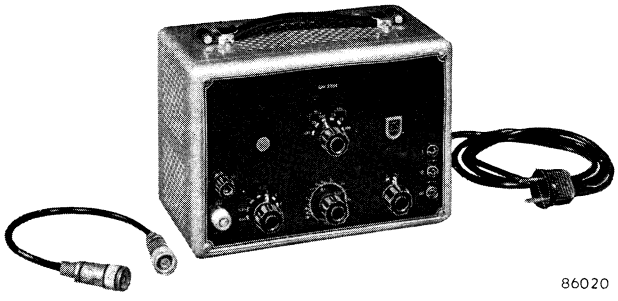
PHILIPS

DIRECTIONS FOR USE

SQUARE-WAVE GENERATOR
GM 2324

66 400 21.1-10 1/156



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CONTENTS

In case of complaints or correspondence regarding this generator always state the type and serial number as indicated on the type plate at the rear of the apparatus.

Synchronizing pulses

Synchronizing pulses, alternately positive and negative, can be taken up from Bu_2. The frequency of these pulses is also adjustable between 25 c/s and 1 Mc/s by means of Sk_1 and R_1; in the case of control with the aid of an external voltage, here too, this frequency depends on the frequency of the control voltage.
The output voltage on Bu_2 is at least 3 $V_{p\text{-}p}$.

ELECTRICAL DATA

(modifications reserved)

RESISTORS

R_1	500 kΩ (log.)	R_{16}	1 800 Ω	R_{33}	60 Ω
R_2	100 kΩ (lin.)	R_{17}	10 kΩ	R_{34}	120 Ω
R_3	1 800 Ω	R_{18}	1 MΩ	R_{35}	22 Ω
R_4	270 Ω	R_{19}	3 300 Ω	R_{36}	19,4 Ω
R_5	1 800 Ω	R_{20}	120 Ω	R_{37}	41 Ω
R_6	120 Ω	R_{21}	82 kΩ	R_{38}	82 Ω
R_7	120 Ω	R_{22}	47 Ω	R_{39}	165 Ω
R_8	4 700 Ω	R_{23}	750 Ω	R_{40}	100 kΩ
R_9	270 Ω	R_{24}	470 kΩ	R_{41}	10 MΩ
R_{10}	4 700 Ω	R_{25}	100 kΩ	R_{42}	6.8 MΩ
R_{11}	270 kΩ	R_{27}	600 Ω	R_{43}	2700 Ω
R_{12}	560 kΩ	R_{28}	82 kΩ	R_{44}	1.5 MΩ
R_{13}	270 kΩ	R_{29}	47 Ω	R_{45}	47 Ω
R_{14}	560 kΩ	R_{31}	27 Ω	R_{46}	47 Ω
R_{15}	1 MΩ	R_{32}	39 Ω		

CAPACITORS

C_1	50 μF	C_{10}	560 pF	C_{19}	8 μF
C_2	220 000 pF	C_{11}	39 pF	C_{20}	12 000 pF
C_3	27 000 pF	C_{12}	100 000 pF	C_{21}	5 pF
C_4	3 900 pF	C_{13}	100 000 pF	C_{23}	150 μF
C_5	560 pF	C_{14}	10 pF	C_{24}	100 μF
C_6	39 pF	C_{15}	100 000 pF	C_{26}	1 500 pF
C_7	220 000 pF	C_{16}	220 000 pF	C_{28}	1 500 pF
C_8	27 000 pF	C_{17}	25 pF	C_{29}	100 000 pF
C_9	3 900 pF	C_{18}	100 pF		

INTRODUCTION

The square-wave generator GM 2324 supplies symmetrical rectangular voltages of 0.12—15 $V_{p\text{-}p}$. The build-up time of the voltage pulses is very short; the repetition frequency can be adjusted from 25 c/s to 1 Mc/s.
Furthermore it is possible to take up synchronizing pulses of at least 3 $V_{p\text{-}p}$.
The generator is self-exciting, but it can also be controlled with the aid of an external voltage.
Some of the possibilities for application are:

a. measurements on wide-band amplifiers, video amplifiers, amplifiers in oscilloscopes and modulation amplifiers of wide frequency bands (frequency, phase and step-function response curves);

b. tests on electric networks and cables (transmission properties, energy reflection, tracing of cable faults);

c. trimming attenuators;

d. measuring of time constants and electrical delay phenomena;

e. testing and measuring electronic and other types of electrical counters.

WORKING PRINCIPLE

The apparatus consists of 4 parts:

MULTIVIBRATOR

The multivibrator (B_1, fig. 6) forms the voltage pulses.

In the positions of Sk_1 and Sk_4 not indicated in fig. 6, the generator is self-exciting.
After the switching on one half of the double triode B_1 will be conducting, whilst the other half will be blocked. Which half will become conducting first depends on accidental circumstances.
If, for instance, B_1b becomes conducting, then the anode voltage of this triode decreases. Since the control grid of B_1a is connected, via a capacitance C selected with Sk_1, to the anode of B_1b, also

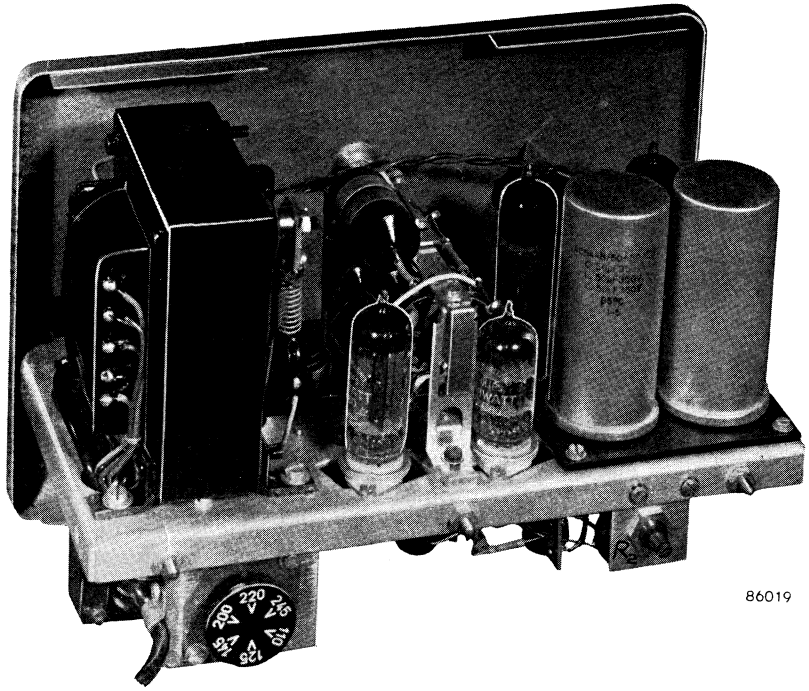

Fig. 1
Rear view

the voltage on that grid decreases: B_1a is locked. As a result of the fact that C starts discharging across the anode resistor of B_1b and the grid resistor of B_1a, the control-grid voltage of B_1a increases again; the discharge continues until the latter voltage has risen above the cut-off point of B_1a. As soon as B_1a is conducting, the grid voltage of B_1b decreases and the anode current decreases as well. The anode voltage of B_1b increases and, together with it, the control-grid voltage of B_1a. This promotes the opening of B_1a (avalanche effect). The circuit changes over and the process is repeated in opposite direction.
The moment at which B_1b becomes conducting again is determined by the duration of the discharge of the capacitance C in the grid circuit till the cut-off point of this triode and it is, therefore, primarily dependent on the value of C selected with Sk_1. At a given C, however, it is possible by means of R_1 — by continuous regulation of the RC-time of the coupling element — to advance or to delay

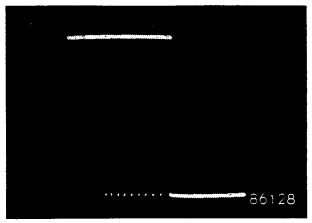

Fig. 5a

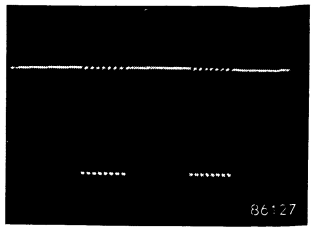

Fig. 5b

The scale of R_1 does not give absolute values, but only serves for guidance, as is shown by the indications on the front panel of the generator.

Sk_1 in position "EXT."

In this position of Sk_1 the GM 2324 can be controlled by connecting a voltage to the switch socket Bu_4. This voltage should be at least 4 V, but it is not recommended to use a control voltage of more than 30 V. (In the case of external control voltages lower than 4 V there is a danger that the generator starts oscillating in an arbitrary frequency.) For preference, use alternating voltages having a frequency within the frequency range of the generator (25 c/s ... 1 Mc/s).
The frequency of the pulses on Bu_1 and Bu_2 is now dependent on that of the external control voltage.
The control by means of an external voltage may cause disturbance of the symmetry of the square-wave voltage on Bu_1 (see fig. 5a and 5b). Therefore, if the control is effected in this way, check the shape of the squares with the aid of an oscilloscope before carrying out a measurement. Asymmetry of the square-wave voltage, if any, can be corrected by regulation with R_1 now serving as an attenuator of the external control voltage.

OUTPUT VOLTAGES

Symmetric square-wave voltage

At Bu_1 a square-wave voltage is available, the frequency of which is adjustable between 25 c/s and 1 Mc/s by means of Sk_1 and R_1; if the control is effected with the aid of an external voltage, this frequency depends on the frequency of the control voltage.
The output voltage on Bu_1 can be regulated from 0.12 to 15 $V_{p\text{-}p}$ in 8 steps with Sk_2.

of the square-wave voltage if there is a 12" connection (30 cm) between the earth side of the output cable and the earthing point, that this measure is necessary.
Bu_5 (see fig. 2) may also be used as an earthing point, if so desired.
The earth connection must have been attached before the apparatus is connected to the mains.

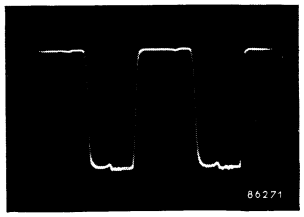

Fig. 4

If the casing of the generator has been removed and the apparatus is then connected to the mains, utmost caution is required, as several points will be under high tension with respect to the chassis (such as, e.g. the caps of the electrolytic smoothing capacitors).

OPERATION

SWITCHING ON

The apparatus is put into operation by turning the mains switch Sk_3 (see fig. 2) a little to the right; the pilot lamp at the front of the generator lights up.
About one minute after the switching on the tubes have reached their operating temperature, after which the generator is ready for use.

CONTROL

Sk_1 in position "25 c/s", "200 c/s", "1.5 kc/s", "12 kc/s" or "100 kc/s"

In these positions of Sk_1 the generator is self-exciting.
At the output sockets Bu_1 and Bu_2 voltage pulses are then available the frequency of which is adjustable within the own frequency range of the generator. This range extends from 25 c/s up to 1 Mc/s and is devided into five overlapping ranges that can be selected by means of the step switch Sk_1. Within the selected sub-range the required frequency is adjusted approximately with the aid of the continuous-control knob R_1.

the above-mentioned moment and in this way the frequency can be continuously adjusted to the required value, in addition to the gradual adjustment by means of Sk_1.
From the foregoing it follows that square-wave pulses occur on the anode of B_1b, which pulses have a repetition frequency dependent on the position of Sk_1 and R_1.

In the position of Sk_1 and Sk_4 indicated in fig. 6 the multivibrator can be controlled by an external voltage to be connected to Bu_4 and the frequency of the pulses on the anode of B_1b is determined by that of the control voltage. By means of R_1, the input voltage of the multivibrator can now be attenuated and it is thus possible to influence the moment at which the multivibrator circuit changes over and, thereby, to regulate the symmetry of the square-wave voltage.

The anodes of the double triode B_1 are uncoupled in order to avoid hum.

AMPLIFIER

This is the double triode B_2 functioning as a controlled multivibrator. The square-wave voltage originating from the anode of B_1b acts as control voltage. This voltage is supplied to the grid of B_2a via a capacitor.
Besides the fact that the anode of B_2a is coupled to the grid of B_2b, this electrode is also connected to the output socket Bu_2 via a differentiating circuit. Synchronizing pulses caused by differentiation of the square-wave voltage on the anode of B_2a can be taken up from Bu_2.

OUTPUT STAGE

The square-wave voltage of the anode of B_2b is supplied to the grid of B_3 via a capacitor, B_3 being one of the two tubes of the output stage also connected as a controlled multivibrator. Contrary to the multivibrator and the amplifier direct-voltage coupling is applied in the output stage instead of capacitive coupling. B_3 receives such a bias with the aid of the potentiometer R_2 that this tube becomes conducting at the right moment so as to obtain a symmetrical square-wave voltage of a good quality. The step attenuator for the output voltage is included in the anode circuit of B_4. The voltage is decreased by about one half per step of Sk_2. As the positive side of the supply voltage is earthed, direct-voltage coupling

is possible between the output socket and the anode of the last tube, as a result of which this anode can supply negative square-wave pulses with respect to a fixed level (earth).
In order to prevent the secondary emission from exerting an unfavourable influence — as a consequence of a direct connection between the suppressor grids and the cathodes of the final tubes — the suppressor grids are connected to the cathodes via a common resistor; moreover, they are uncoupled.
The coupling resistor between the two final tubes is bridged by an electrolytic capacitor in order to ensure a good coupling for the low frequencies as well.
The common cathode resistor of the tubes B_3 and B_4 is uncoupled for high frequencies by means of a trimmer.
If Sk_1 is adjusted for control by an external voltage, whilst this voltage is not yet connected to the switch socket Bu_4, then it might occur that tube B_3 effects coupling to the multivibrator via the supply part of the apparatus. In order to prevent this, the grid of B_3 is then connected to the negative side of the supply part via Sk_1 and Sk_4. As soon as the external control voltage is applied, the before-mentioned connection is broken again by tripping Sk_4.

SUPPLY PART

The apparatus must be fed by an alternating-voltage mains.
For rectification use is made of an EZ 80. The supply voltage of 160 V, the positive side of which is earthed, is obtained by smoothing with the aid of a choke coil and two electrolytic capacitors.

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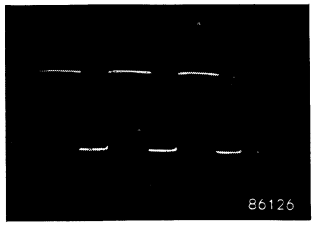

Fig. 3a

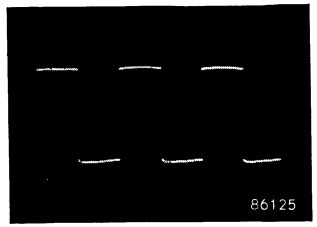

Fig. 3b

In most cases it will be found necessary to re-adjust the symmetry of the square-wave voltage after the insertion of a new tube. This re-adjustment is effected as follows:
Supply, from Bu_1, a voltage having the lowest possible frequency to the input socket of the vertical-deflection amplifier of an oscilloscope. The picture appearing on the screen of the oscilloscope will correspond to a greater or lesser extent to that shown in fig. 3a or 3b. By turning R_2 — accessible through an opening in the rear of the generator — to the left or to the right by means of a screwdriver, the shape of the voltage pulses will change, as will be seen from the oscillogram. So adjust R_2 that a good symmetric square-wave voltage is obtained.
It is recommended not to exchange or to replace the tubes, if this is not required.

THERMAL FUSE

To fit a new thermal fuse (code number 08 100 97) for the supply transformer, fasten it to the spiral spring and pull it over the little hook.

CONNECTIONS

See to it that the connections in every measuring circuit are short, as otherwise measuring errors will occur on account of self-induction in the leads.
It is most important to pay special attention to the earth connection. Connect only one point of a measuring circuit to earth and, for preference, select this point as near as possible to the point to which the square-wave voltage must be supplied. In that case only the earth plug of the output cable (see page 10) can be connected to the earthing point either directly or via the shortest possible lead. It will be found from the oscillogram in fig. 4 showing the distortion

TUBES

parts	indications	types	descriptions
multivibrator	B_1	ECC 85	double triode
amplifier	B_2	ECC 85	double triode
output stage	B_3, B_4	PL 83	pentode
supply part	B_5	EZ 80	full-wave rectifier
	La_1	7181 N	pilot lamp

OUTPUT CABLE

An accessory to the apparatus is the output cable provided with a standard plug (N-connector, 50 Ω) at both ends. A special plug fitting to the N-connector is added for the supply of square-wave voltages to apparatus which cannot possibly be connected by means of an N-connector; in this way the connection can be kept as short as possible. The pin in the axis of the plug is intended for earthing; the wire with banana plug projecting from the side is provided for transmission of the square-wave voltage.

INSTALLATION

ADAPTING TO THE LOCAL MAINS VOLTAGE

The mains voltage to which the apparatus has been adapted can be read through the round aperture in the rear. If this voltage does not correspond to that of the local mains, remove the covering plate, pull out the rotary switch a little and turn it until the required voltage is read on top. Then depress the voltage adaptor again and refit the covering plate.

TUBES

As a rule, the tubes are in the apparatus upon delivery.
For taking the apparatus out of its case, e.g. for replacement of a tube, remove the 3 nuts at the rear and the 2 screws at the bottom of the apparatus.

TECHNICAL DATA

FREQUENCY RANGES

position of Sk_1	to be regulated by R_1
25 c/s	from 25 — 250 c/s
200 c/s	from 200 — 2000 c/s
1.5 kc/s	from 1.5 — 15 kc/s
12 kc/s	from 12 — 120 kc/s
100 kc/s	from 0.1 — 1 Mc/s

The scale of R_1 does not indicate absolute values, but only serves as a guidance.
In the case of control by an external voltage the frequency of the voltage pulses on the output sockets Bu_1 and Bu_2 is dependent on the frequency of the control voltage.
The step-function response curve of the apparatus is very good. At approx. 25 c/s the square-wave pulses have a tilt of less than 3.5 % of the height of the edge. At 65 c/s the tilt has completely disappeared.

SQUARE-WAVE VOLTAGES

Output socket: Bu_1

Frequencies: 25 c/s . . . 1 Mc/s, adjustable with Sk_1 and R_1; in the case of control by an external voltage the frequency is dependent on that of the control voltage.

Voltage: 0.12 . . . 15 $V_{p\text{-}p}$, adjustable with Sk_2.

Output resistance: 25—330 Ω, dependent on the adjusted voltage.

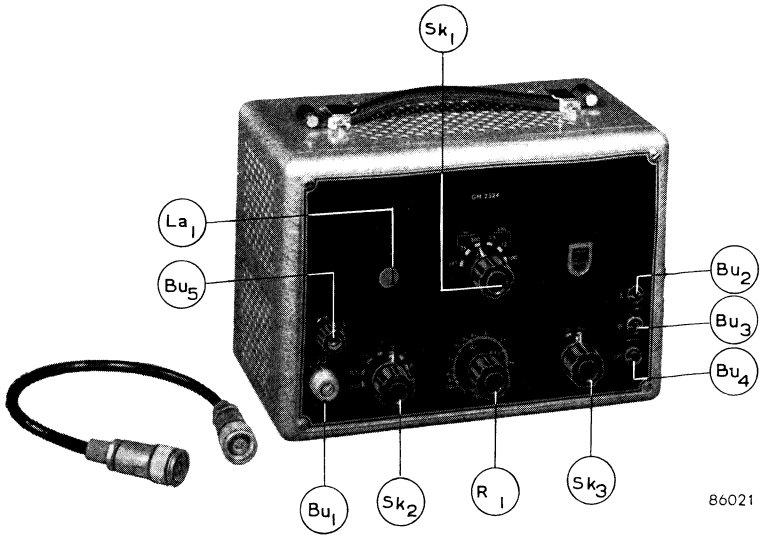

Fig. 2
Front view

R_1 : *continuous frequency adjustment/attenuation external control voltage*
Sk_1 : *step switch for the frequency sub-ranges*
Sk_2 : *adjustment of the square-wave voltage*
Sk_3 : *mains switch*
Bu_1 : *output for square-wave voltages*
Bu_2 : *output for synchronizing pulses*
Bu_3 : *earth*
Bu_4 : *input for external control voltage*
Bu_5 : *earth*

Build-up time: $<$ 0.03 μsec for voltage pulses of 4 $V_{p\text{-}p}$ and less;
$<$ 0.04 μsec for voltage pulses of 8 and 15 $V_{p\text{-}p}$.
(Build-up time is the time in which the pulse voltage increases from 0.1 to 0.9 of the peak value.)
The above values are valid up to an external load of approx. 8 pF (the total load is approx. 25 pF in that case).
For greater loads the build-up time will be longer.
Some figures will explain this matter further: At a total load of 50 or 75 pF and at an output voltage of 4 $V_{p\text{-}p}$ the build-up time will show an increase of respectively 4 or 5 % compared with the time at 25 pF. At 8 and 15 $V_{p\text{-}p}$ the percentage of the increase in build-up time will be higher.

SYNCHRONIZING PULSES

Output socket: Bu_2

Frequencies: 25 c/s . . . 1 Mc/s, adjustable with Sk_1 and R_1; in the case of control by an external voltage the frequency is dependent on that of the control voltage.

Voltage: pulses of at least 3 $V_{p\text{-}p}$, alternately positive and negative.

EXTERNAL CONTROL VOLTAGE

It is possible to control the generator by means of a voltage to be connected to the switch socket Bu_4, if Sk_1 is in the position "EXT.". This voltage should be at least 4 V and it must not exceed the value of 30 V. It is recommended to select the frequency of the control voltage within the frequency range of the generator (25 c/s—1 Mc/s).
If the control is effected in this way, then R_1 acts as an attenuator of the external control voltage and, thereby, as a regulator of the symmetry of the square-wave voltage on the output socket Bu_1.

SUPPLY

The apparatus can be adapted to alternating voltages of 110, 125, 145, 200, 220 and 245 V with frequencies from 50 to 100 c/s.
Power consumption: approx. 40 W.
The supply transformer is protected by a thermal fuse.

DIMENSIONS AND WEIGHT

Height: . . . . . $6^{11}/_{16}$" (170 mm),
width: . . . . . $9^{7}/_{8}$" (250 mm),
depth: . . . . . $5^{1}/_{4}$" (133 mm).
Weight: approx. 12 lbs. (5.5 kg).

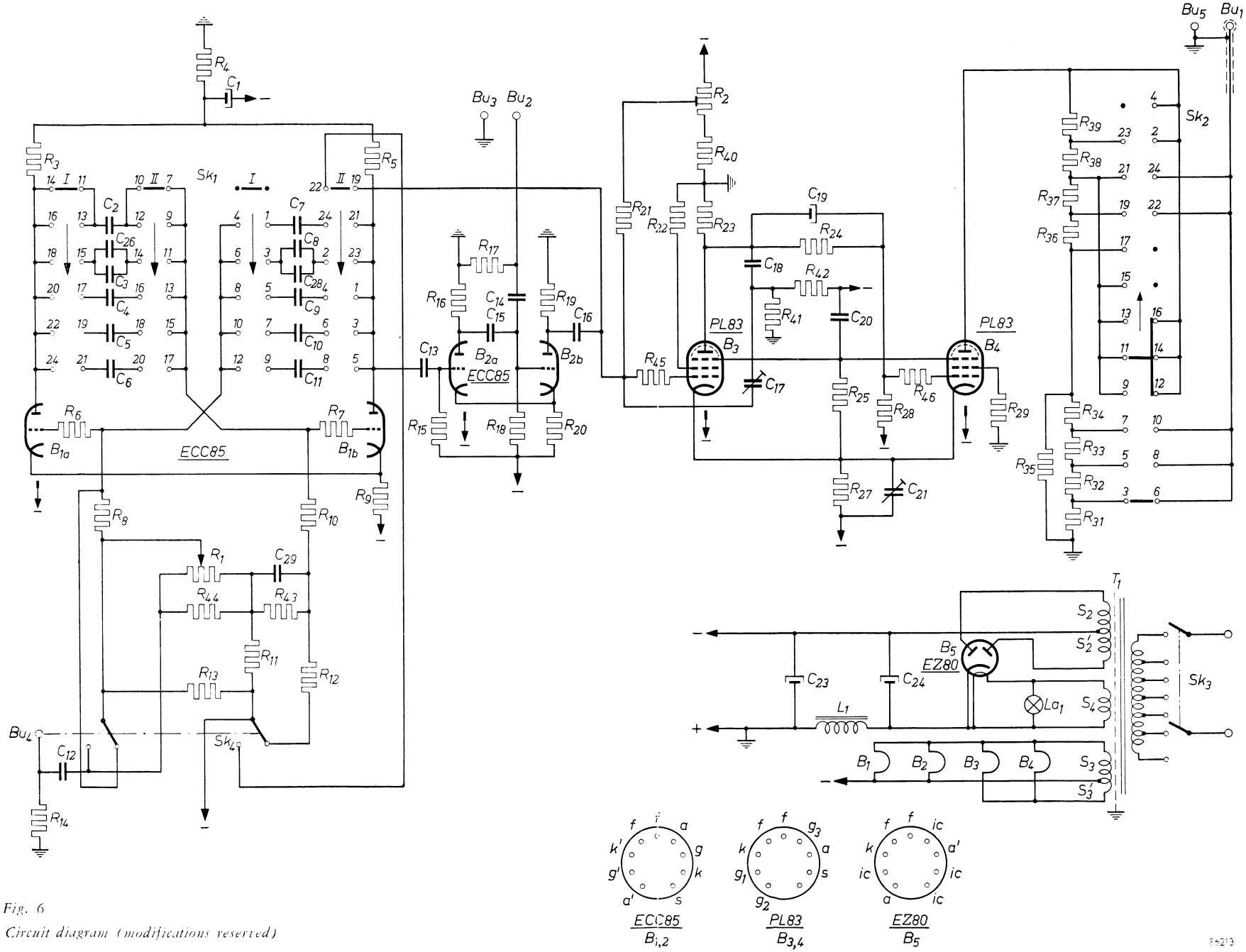

Fig. 6

Circuit diagram (modifications reserved)

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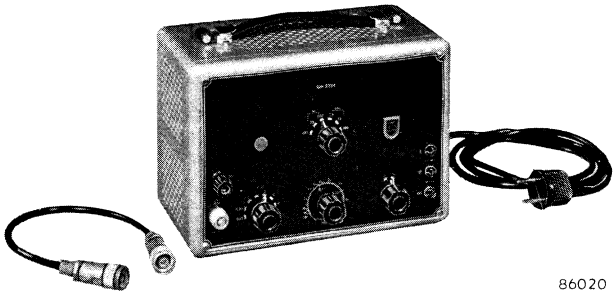

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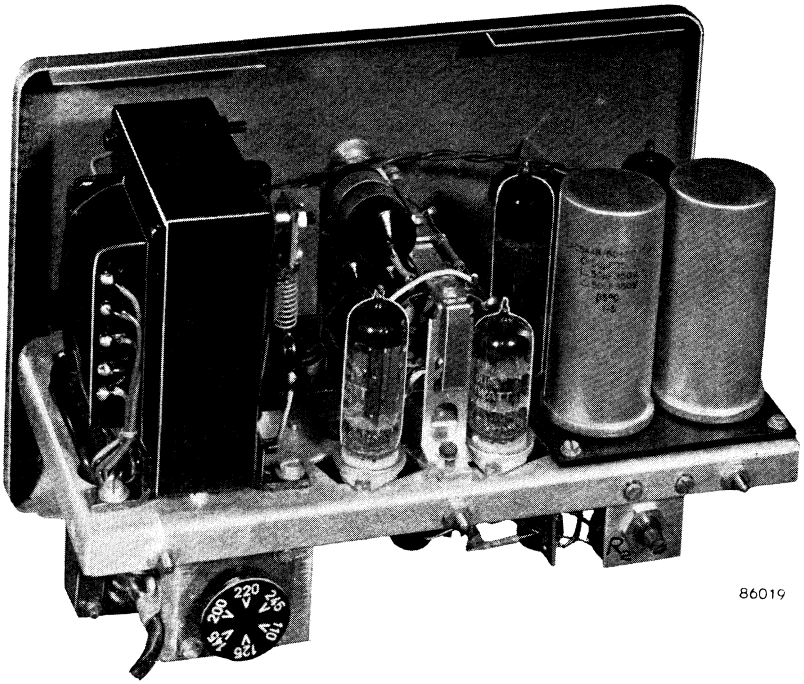

Fig. 1
Rear view

the voltage on that grid decreases: B_1a is locked. As a result of the fact that C starts discharging across the anode resistor of B_1b and the grid resistor of B_1a, the control-grid voltage of B_1a increases again; the discharge continues until the latter voltage has risen above the cut-off point of B_1a. As soon as B_1a is conducting, the grid voltage of B_1b decreases and the anode current decreases as well. The anode voltage of B_1b increases and, together with it, the control-grid voltage of B_1a. This promotes the opening of B_1a (avalanche effect). The circuit changes over and the process is repeated in opposite direction.

The moment at which B_1b becomes conducting again is determined by the duration of the discharge of the capacitance C in the grid circuit till the cut-off point of this triode and it is, therefore, primarily dependent on the value of C selected with Sk_1. At a given C, however, it is possible by means of R_1 — by continuous regulation of the RC-time of the coupling element — to advance or to delay

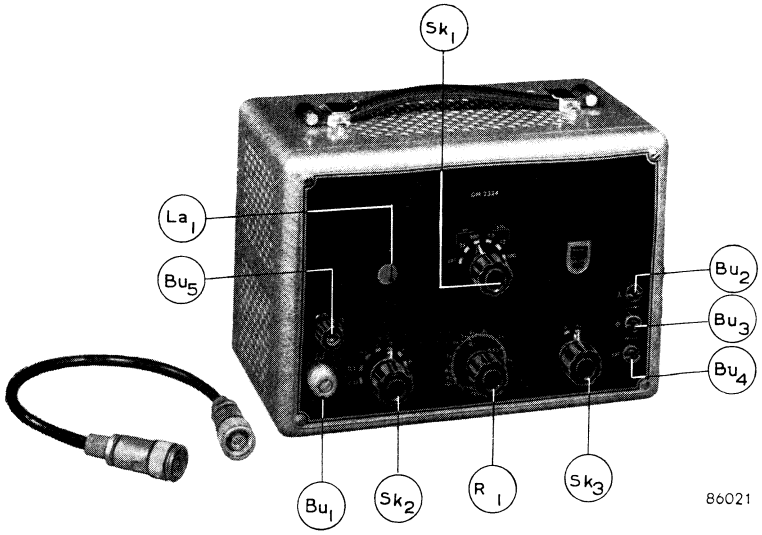

Fig. 2
Front view

R_1	:	*continuous frequency adjustment/attenuation external control voltage*
Sk_1	:	*step switch for the frequency sub-ranges*
Sk_2	:	*adjustment of the square-wave voltage*
Sk_3	:	*mains switch*
Bu_1	:	*output for square-wave voltages*
Bu_2	:	*output for synchronizing pulses*
Bu_3	:	*earth*
Bu_4	:	*input for external control voltage*
Bu_5	:	*earth*

Build-up time:

$<$ 0.03 μsec for voltage pulses of 4 $V_{p\text{-}p}$ and less;
$<$ 0.04 μsec for voltage pulses of 8 and 15 $V_{p\text{-}p}$.
(Build-up time is the time in which the pulse voltage increases from 0.1 to 0.9 of the peak value.)
The above values are valid up to an external load of approx. 8 pF (the total load is approx. 25 pF in that case).
For greater loads the build-up time will be longer.
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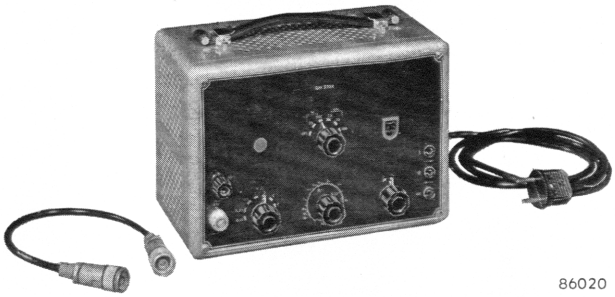

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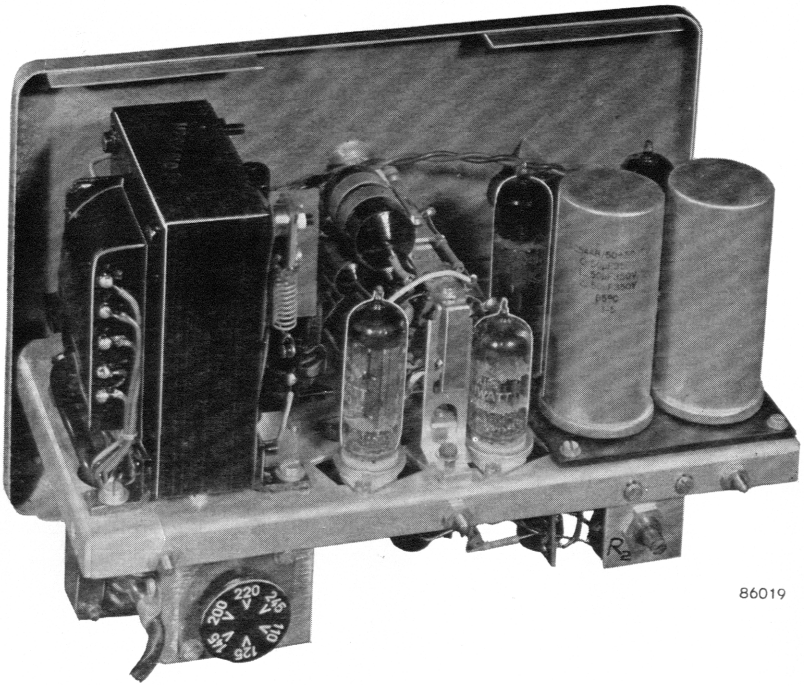

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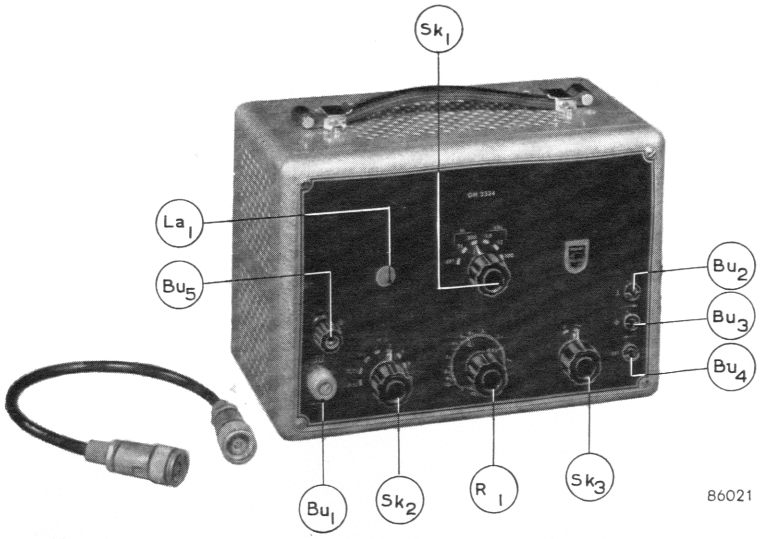

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