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D.C. AMPLIFIER GM 4530

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J.C. AMPLIFIER GM 4530

This amplifier is suitable for a great variety of purposes and possesses some specific qualities that are required for research work and laboratory measurements, such as a very great amplification and an accurately adjustable and readable balance.

It will be an appreciated item for a variety of applications where very high standards of sensitivity and stability are required. Especially for the use with a cathode-ray oscilloscope or a recorder (e.g. Kelvin & Hugnes recorder) this amplifier will meet all exigences.

SPECIFIC PROPERTIES

The GM 4530 is a D.C. amplifier with a maximum gain of over 3000. The instrument is supplied from the mains. Some of the main components are:

- a. A balanced input attenuator, which equally attenuates the voltage of both sockets of the balanced input.
- b. A 4-stage push-pull amplifier followed by a cathode-follower output stage with feed-back, the latter permitting of a low-ohmic balanced output having a rather high loading capacity.
- c. A calibrating device, by means of which a direct voltage of the desired value and polarity can be applied to each of the input terminals for calibrating the amplifier and the attenuators.
- d. A dual supply unit of high stability for supplying the amplifiers and the calibrating device.
- e. A constant positive and negative direct voltage of equal value is available to be taken up externally.

TECHNICAL DATA

Amplification: Continuously adjustable from 1000 x to far more than 3000 x (as an average the maximum gain is 10-12,000). Furthermore the amplification can be adjusted in steps of 1:1, 3:1, 10:1, 30:1, 100:1 and 300:1 by means of the built-in attenuator.

Frequency-response characteristic: For sinusoidal voltages the frequency-response characteristic lies between 0 and 250 kc/s (60%). Pulse-shaped voltages are amplified without overshoot or other distortions between 0 and 50 kc/s.

Sensitivity: When used in combination with a recorder the maximum sensitivity is better than 1 mV_{rms}/mm. When used in combination with a normal cathode-ray tube (e.g. DG 10-6) the maximum sensitivity is better than 3 mV_{rms}/cm.

Stability: At a 3000-fold amplification the output instability is less than 1% of the full output value, which corresponds to less than 300 μ V_{rms} (1 mV DC) at the input.

- Input attenuator: The dual input attenuators can be adjusted by means of a control-knob. The accuracy is better than 5 %.
- Input impedance: The input impedance between each of the input channels and earth is 1 Megohm, independent of the position of the attenuators. The input capacity depends on the position of the step attenuators and is .20 pF for the highest and .45 pF for the lowest attenuator (highest sensitivity) position.
- Input voltage: The max. permissible input voltage is 100 V_{p-p}.
- Output impedance: Dependent of the position of the control for continuous amplification, the output impedance will vary between 1 and 3 Ohms.
- Permissible output load: For a max. output voltage of 350 V_{p-p}: 0-15 mA.
For an output current of approx. 20 mA, e.g. for a recorder, the max. output voltage will amount to 200 V_{p-p}.
- Internal calibration voltage: Calibration voltages of the desired polarity can be applied to each of the non-used input channels by means of a switch. The calibration voltages available are: 10, 30, 100, 300 mV, 1, 3 and 10 V; accuracy better than 4 %.
- External supply voltage: A voltage of approx. + 100 V and approx. -100 V is available between two separate sockets and earth, for supplying photo-cells, etc. The internal resistance between sockets Bu₉ and Bu₁₀ is 50 kOhms, and between sockets Bu₈ and Bu₉, 60 kOhms.
- Output meter: The output meter, which can be switched off, has a scale for output voltages ranging from -100 V via 0 V to +100 V. By means of this meter the correct or the required balance can be adjusted or read.
- Effect of mains voltage variations: Mains voltage variations of ± 10 % produce not a single effect.
- Mains voltage: Universally adaptable for mains voltages of 125, 145, 200, 220 and 245 V, frequency 40 - 100 c/s.
- Consumption: 170 W.
- Tube complement:

Amplifier unit:	6 x UF 42
	2 x UCH 42
	2 x UL 41
Supply unit:	5 x AZ 41
	3 x UL 41
	4 x UAF 42
	3 x 85 A 1

The apparatus is equipped with a pilot lamp 8045 D, a thermal fuse for 125°C and two fuses of 2 $\frac{1}{2}$ -5 A.

Dimensions and weight: width 20.5 cm, height 27 cm, depth 50 cm including knobs.
Weight approx. 18 kg.

DESCRIPTION OF THE CIRCUIT DIAGRAM

See block diagram fig.1.

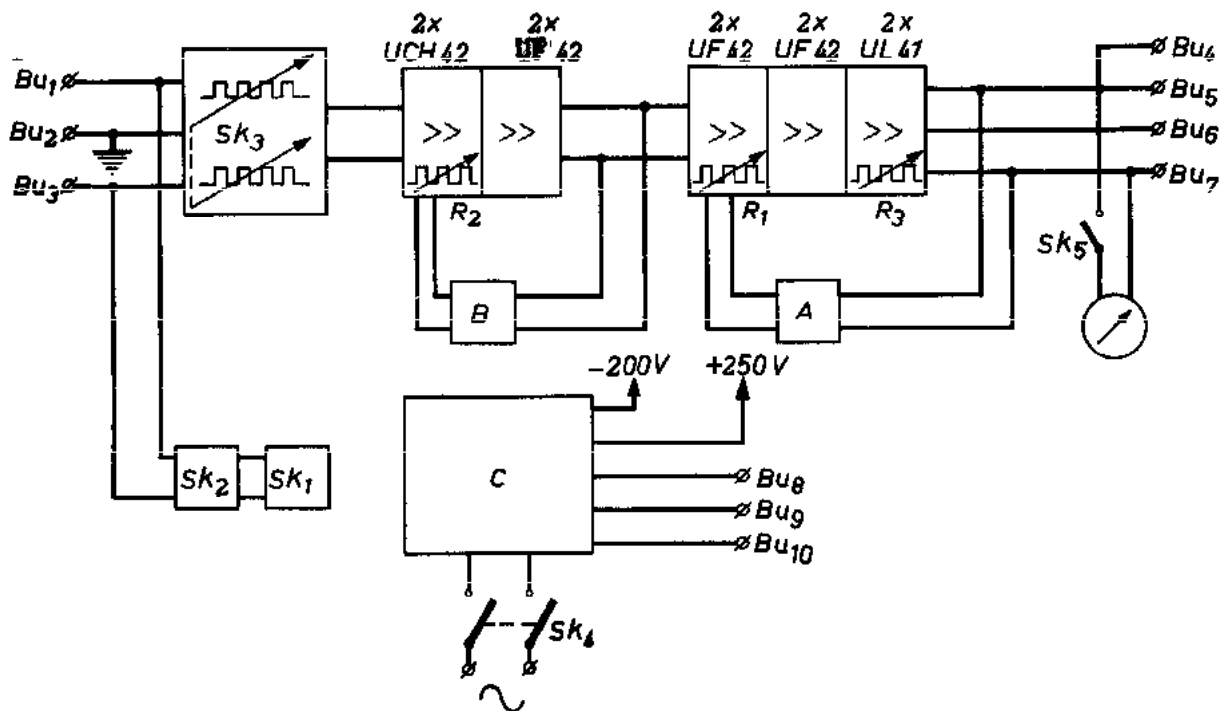


fig.1.

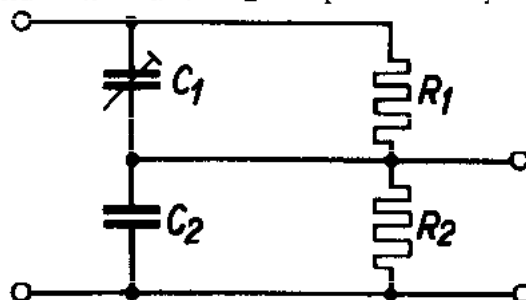
a. The input attenuator

The voltage applied to the two input sockets can be attenuated by two identical attenuator circuits with a common control, in 6 steps. The input resistance between each of the sockets and the input earth socket remains the same (1Megohm), whilst the input capacity depends to some degree on the position of the attenuator. Fig.2 represents the principle of the attenuator. The attenuation of this circuit is frequency-independent if the condition $R_1 \cdot C_1 = R_2 \cdot C_2$ is met; this is effected by making e.g. C_1 variable. Then the attenuation is determined by the ratio between the resistances of R_1 and R_2 .

In order to avoid errors due to a divided capacity, the non-used attenuator circuits are always earthed. The entire attenuator is surrounded by a metal screening for preventing any disturbing radiation reaching this high-ohmic circuit.

After humidity tests in our laboratories it was found that sometimes a disturbing e.m.f. can occur at the input and attenuator circuit, caused by charges due to condensation on the insulation material. In order to avoid this, a heating element has been placed underneath the attenuator, so that the latter is kept at the proper temperature.

This resistance also serves for limiting the anode dissipation of the output tubes B_9 and B_{10} .



b. The amplifier

The amplifier has been built-up from a two-stage push-pull pre-amplifier with feed-back (filter B) across these two stages, followed by a two-stage push-pull amplifier with behind it a cathode-follower output stage with feed-back (filter A) across the latter unit.

Special precautions have been taken to avoid instability at the amplifier output, which might be caused by instabilities of tubes of the first amplifier stage. These tubes, moreover, have been specially mounted to prevent microphon^y.

The above-mentioned instability, which is caused by fluctuations of the cathode current of the input tubes, e.g. due to a displacement of the filament inside the tubular cathode or to mutual displacements of the electrodes, has been eliminated by using a new circuit, the operation of which is based on the principle of partition of electrons between the electrodes. For this a patent has been applied.

The first amplifying tube in the GM 4530 is a UCH 42, of which only the hexode part is used. Adjustment of the balance takes place by means of potentiometer R_2 , which can adjust the voltage on the first grid.

The final amplifier consists of a two-stage push-pull amplifier with a cathode-follower output stage, with feed-back applied across the whole. The potential on the output terminals has been adjusted to zero level by an internal potentiometer. A potentiometer R_2 is available on the front plate for adjusting the shift. If the balance has been properly adjusted by potentiometer R_2 , then potentiometer R_3 will determine the shift of the output voltage, independently of the position of R_1 .

The above-mentioned output voltage is supplied by tubes UL 41 with only slight distortion, whilst the output impedance remains very low (1-3 Ohms, to some degree dependent on the position of R_1).

The anode dissipation of the output tube is limited by a resistor, as indicated above. The output tubes are, moreover, protected against an excessive voltage between control grids and cathodes by neon tubes.

A meter is connected to the output of the amplifier, via series resistors. This meter can be short-circuited by means of a switch.

c. Calibration device

Calibration voltages, the polarity and value of which can be adjusted, may be applied to the input sockets of the amplifier, for the purpose of checking the attenuators and the amplifier. The value of the calibration voltages is adjustable in 6 steps between 10 mV and 10 V, whilst the polarity applied to the input sockets can be reversed by means of a switch.

The calibrating voltages are taken, via potentiometer tapplings, from the positive or negative reference voltage of 85 V of a neon reference tube 85 A 1. Connected to the input sockets are switches, which will automatically switch off any calibrating voltage as soon as a plug is inserted into Bu_1 or Bu_3 . Therefore if the calibration device is being used, no plug should be inserted into the socket involved.

d. Supply

The apparatus contains two supply circuits, one producing -200 V and one producing +250 V, connected in series. In this way a negative potential of 200 V and a positive potential of 250 V towards the chassis are obtained, by means of which the output and the input of the amplifier can be brought at zero level. The -200 V supply part mainly supplies the stabilized filament current and the anode and screengrid currents for the amplifier tubes. This is effected by the parallel connection of three full-wave rectifying tubes AZ 41. The regulated power supply contains an amplifying pentode UAF 42 with a voltage reference tube 85 A 1 and two output pentodes UL 41 connected in parallel. Also connected to the -200 V stabilized output voltage is a circuit containing an 85 A 1, supplying the negative voltage for the calibration device and for the cathodes of the first stage, as well as a potentiometer circuit for supplying a constant voltage of approx. -100 V, which can be taken off externally. (internal resistance 50 kOhms).

The 250 V stabilized supply part contains two full-wave rectifying tubes AZ 41 connected in parallel, and an output pentode UL 41. The regulated power supply contains three amplifying pentodes UAF 42, by means of which a high stability is obtained. The voltage reference tube 85 A 1 also serves as a positive-voltage source for the calibration device and for the screen grids of the first stage. The voltages of +100 V and -100 V are obtained by means of potentiometer circuits. These voltages of -100 V and +100 V are intended to be used as supply voltages for e.g. photocells. In order to avoid stray fields, the maximal self of the supply transformer has been kept low, so that its dimensions have become fairly large. The transformer has, moreover, been mounted in such a position that the stray fields come to lie outside the sensitive parts of the amplifier. The wiring has been arranged in such a way that no interfering voltages originating from the supply part can be introduced into the input circuits. It is, therefore, essential that the D.C. amplifier is properly earthed, in accordance with the directions for use.

INSTALLATION

a. Adjusting for the local mains voltage

Before connecting the GM 4530 to the mains, make sure that it has been adjusted for the local mains voltage. The voltage for which the apparatus has been adjusted is visible through the aperture in the back of the apparatus.

By changing the position of the disc of the voltage adaptor the apparatus can be set on the right mains voltage.

The apparatus has to be well earthed for preference before connecting it to the mains.

b. Replacement of tubes and fuses

The fuses $V1_2$ and $V1_3$ are located at the back of the apparatus and can easily be removed and exchanged.

When the tubes, temperature fuse or pilot lamp need replacing the apparatus has to be taken out of the case.

It is preferable when the tubes B_1 (UCH 42), B_2 (UCH 42), B_{17} (85 A 1), B_{24} (85 A 1) and B_{25} (85 A 1) have to be replaced to have the apparatus readjusted by a Philips Service Department. All other tubes can be renewed without more.

If, however, still difficulties might arise after exchange of these tubes (e.g. astigmatism which might be recorded when using an oscilloscope), then it is advisable to consult a Philips Service Department too.

OPERATION

a. Mechanical zero adjustment of the "OUTPUT-BALANCE" meter

The pointer of this meter has to be at zero when the apparatus is switched off or when the switch Sk_5 is in position "OFF". Eventual corrections can be made with the screw on the meter housing.

b. Switching on

The apparatus is switched on by turning switch Sk_4 . After approx. 3 min. the tubes will have reached their operating temperature and the amplifier is ready for use. For accurate measurements or recordings it is recommendable to use the amplifier not until 30 min. after switching on.

c. Adjustment of the balance and the shift

For this purpose no voltage is laid into the sockets Bu_1 and Bu_2 (earth) or Bu_3 and Bu_2 (earth). Switch Sk_1 (CAL. POLARITY) has to be set in position 3 (0), whilst potentiometer R_2 (SHIFT) is to be placed in the middle position (5°). The meter instrument (OUTPUT-BALANCE) has to be switched on by placing switch Sk_5 in the right hand position (ON). With potentiometer R_1 (AMPLIFICATION) in the extreme right hand position (maximum gain) the balance is adjusted by means of R_2 (BALANCE) until the meter instrument is at zero. After this any desired value of amplification and any value of the shift (R_2) can be chosen. The position of the zero level is in that case permanently determined, irrespective of the position of the gain control R_1 .

d. Adjustment of the amplification

The amplification can be adjusted by means of potentiometer R_1 in a very wide range, viz. from below 1000 times up to far more than 3000 times. At a certain input voltage the output voltage is continuously adjustable in a range 1:3 and by means of step attenuator Sk_3 in six steps in a ratio of 3:1 and 10:1.

REMARK.

The amplification (quotient of input and output voltage) which can be determined by calibration voltages applies for each input socket separatively and for both output sockets Bu_5 and Bu_7 together.

e. Input of the amplifier

The input of the amplifier is symmetrical, whilst control can take place both symmetrically and asymmetrically. For symmetrical control the sockets Bu_1 and Bu_3 are used, whereas for asymmetrical control one of the two channels (viz. channel I, sockets Bu_1 and Bu_2 -earth or channel II, sockets Bu_3 and Bu_2 -earth) can be used.

The input sockets are of the so-called contact switch type that cancel the action of switch Sk_1 (CAL.POLARITY) as soon as a plug is inserted into the input sockets.

REMARK.

When no plug is inserted the input sockets Bu_1 and Bu_3 are earthed via a resistor of 820 Ohms by means of switch contacts (advantage: the input being low-ohmic is insensitive for external disturbances). When inserting a plug in one of the input sockets it is recommendable to push through this plug directly avoiding too high a loading of the resistor if any.

It is possible to lay a non-earthed voltage onto the sockets Bu_1 and Bu_3 , but in many cases the disturbing voltages of equal phase which are introduced by the input circuit on these sockets are so large (relatively) that measures have to be taken to earth the input circuit capacitively or otherwise. Direct earthing of Bu_2 is always preferable.

f. Output of the amplifier

The output is symmetrical with respect to zero level. Dependent on the position of the potentiometer R_1 (AMPLIFICATION) the output impedance amounts to 1 or 3 Ohms (between the sockets Bu_5 and Bu_7). See for the maximum admissible load on the output, "Technical Data" on page 1.

g. Synchronization

If the apparatus is used in combination with a cathode-ray oscilloscope a synchronization voltage can be taken up from the sockets Bu_4 (or Bu_5) and Bu_6 (earth) for synchronizing the time base generator. If the synchronization input of the oscilloscope is not blocked for direct voltages, it is sometimes advisable to connect a coupling capacitor between the two instruments if the level of the (shifted) amplifier output should differ from zero.

h. Calibration

with the aid of the calibration device it is possible to determine the sensitivity of the D.C. amplifier in any desired position of the amplification control R_1 and of the attenuator Sk_2 . This calibration device is based on the combined action of switch Sk_1 (CAL.POLARITY) and switch Sk_2 (CAL.VOLTAGE) by means of which the value of the calibration voltage can be adjusted. In the position "0" of switch Sk_1 (3. position) the calibration device is switched off. If switch Sk_1 is set to the first or second position, a positive or negative calibration voltage is connected to the input of channel I (the same applies for channel II when choosing the positions 4 and 5 of switch Sk_1). The value of this voltage depends on the position of switch Sk_2 (CAL.VOLTAGE) unless a plug has been inserted into the input socket. The value of the output voltage, which depends on the position of the attenuator and on that of the continuous amplification control can be read from the meter instrument (OUTPUT-BALANCE) or on an externally connected voltmeter.

Exemple: I Sk_1 in pos. 1 (=I/+), Sk_2 in pos. 4 (=300 mV),
 Sk_3 in pos. 3 (=30:1) and output meter +25 V.
 The gain amounts in this case to $\frac{25 \cdot 10^3}{300} \approx \text{abt. } 80$

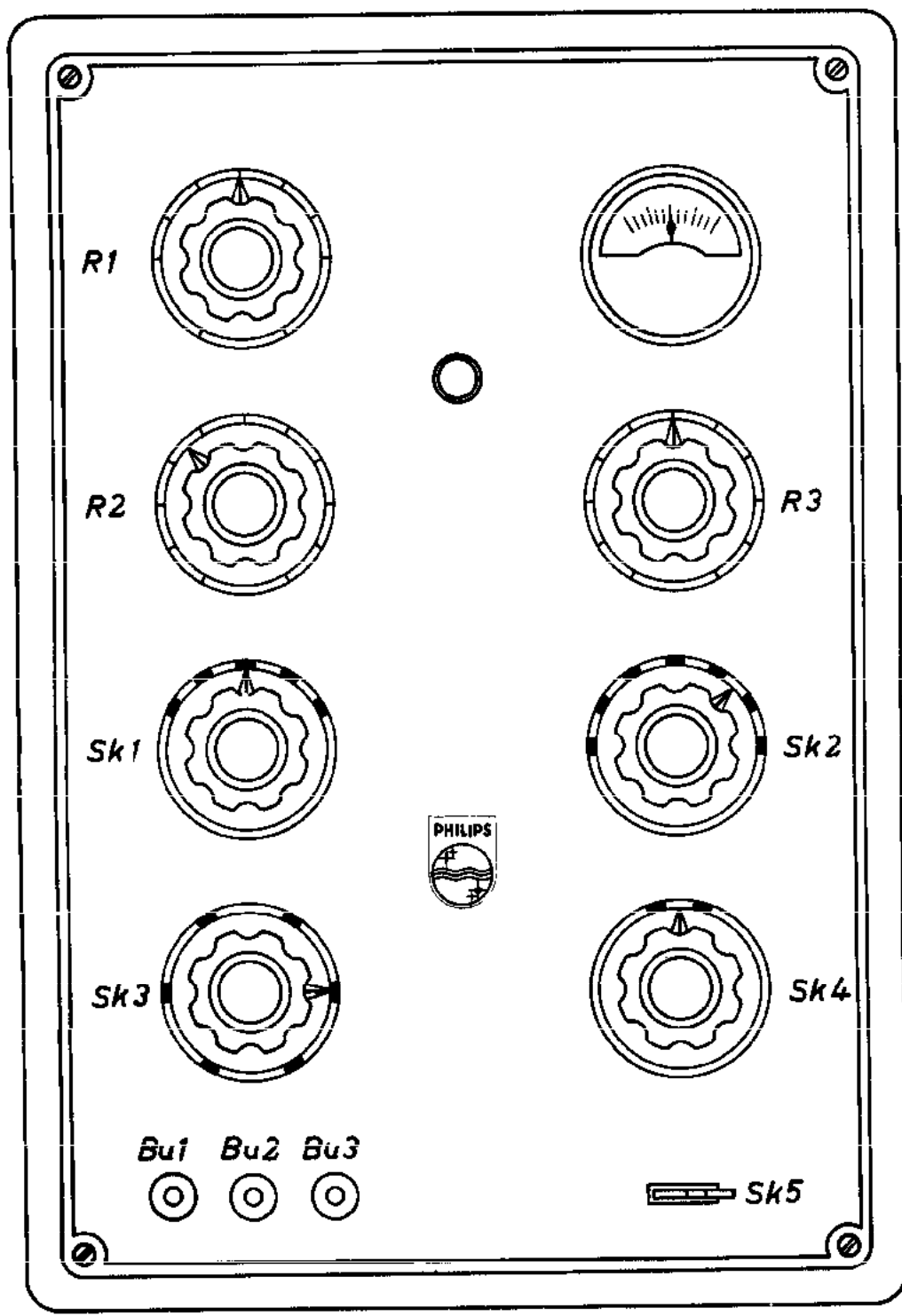
If the GM 4530 is used in combination with a recorder or in the case where the deflection plates of an oscilloscope are connected to the output sockets, the sensitivity per mm or cm can be determined in this manner.

Example: II Let us suppose that the cathode-ray tube DG 10-6 is connected to the output of the GM 4530. Sk_3 in pos. 4 (=10:1), R_1 at random, Sk_2 in pos. 4 (=0,3 V). If, after disconnecting the calibration voltage by means of inserting a plug into the input socket, or by setting Sk_1 in the third position (=0), one finds that the shift of the light-spot or the line is e.g. 3 cm, then the overall sensitivity is 0,1 V/cm. Without calibration voltage, moreover, the shift to either side of the line should be approximately equal for both channels. This will serve as a check on the two attenuators.

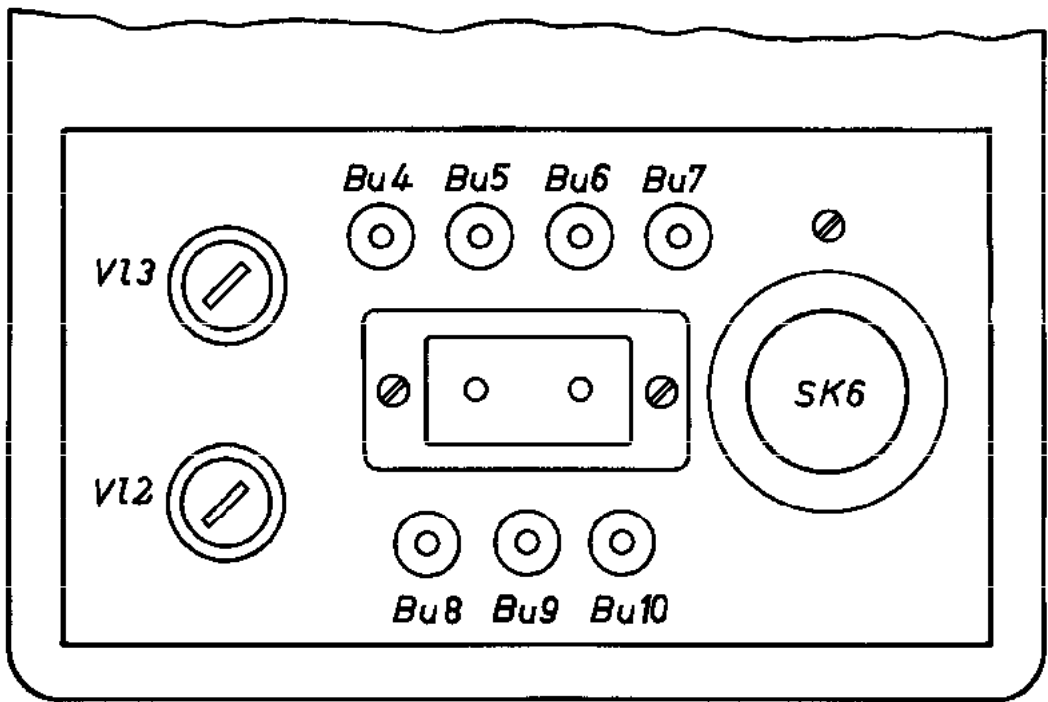
i. Output-Balance meter

This meter instrument (OUTPUT-BALANCE) is connected via high-ohmic resistors to the output sockets Bu_5 and Bu_7 . The output voltage is directly readable in volts approx. The zero point is in the middle of the scale. The meter can be short-circuited by means of the meter switch Sk_5 when the output voltage exceeds 100 V or when A.C. voltages in a very low frequency range are applied.

-0-0-0-0-0-0-0-0-0-



Front view of the D.C. Amplifier GM 4530
Vorderansicht des Gleichstromverstärkers GM 4530.



Rear view of the D.C. Amplifier GM 4530
Hinteransicht des Gleichstromverstärkers GM 4530.