The resistors R27-R6 and R28 form a potentiometer circuit. The capacitor C18 (3300 pF) however forms, for practically all frequences occurring, such a small parallel impedance for R6 (2.5 MOhm) that the resistance R6 is negligible compared with C18. The branch R5 and C14/C15 in series has always at least an impedance of 2.5 MOhm and is therefore negligible compared with the branch R6/C18 with R28 in series.
A simplified diagram is given in fig. 2b.
Owing to the parallel capacitance of 220 pF the high notes are less attenuated than those in the middle and bass registers. The series capacitance of 3300 pF results in the low notes being attenuated less than those in the middle and treble registers. The whole gives a gain for the treble and bass notes compared with the middle register.

Fig. 3a shows the situation with R5 at -H and R6 at -B (minimum position). Again R6 is much greater than the impedance of C17, for practically all frequencies, and thus is negligible. The branch C13 (220 pF) in series with R5 (2.5 MOhm) is negligible compared with the branch R27 (390 KOhm) in series with R6 (2.5 MOhm) /C17 (820 uF). The circuit can then be simplified to that given in fig. 3b. Owing to the series capacitance of 820 pF the low notes are more attenuated than those in the middle and treble registers, while owing to the parallel capacitance of 1240 pF the high notes are more attenuated than the others. The whole gives an attenuation of the treble and bass notes compared with the middle register. The anode of the amplifying valve B4 (EF 40) is coupled via R42 - C23 to the upper control grid of B5 (ECC40). The filter C24/R45 has a stabilizing function.
The phase inverter B5 works as follows (see fig. 4):
The signal is amplified by the top half of B5. The common, unbypassed, cathode resistor R47 for the two triodes has been chosen very large (18000 Ohm) so that the voltage E2 across it is equal to about half the applied voltage Ei. Since the alternating voltage E1 between grid and cathode of B5 is equal to the difference between the input voltage and the cathode voltage, E1 and E2 will be equal and in opposite-phase (short-circuits the alternating voltage). Thus there are two equal voltages in opposite-phase on the anode resistors R48 and R49. The two anodes of B5 are connected to the control grids of the output valves B6 and B7 (EL 34) via the coupling capacitors C26 and C27 and the resistors R52 and R53. The negative grid voltage for the output valves is in two parts, a fixed and a variable part.
The lower part of the rectifying valve B10 gives a direct voltage across R62, which is applied via R50 and R51 as a negative grid voltage to B6 and B7. Between R62 and earth is the resistor R61. Further, in the cathode lead of the output valves there is a transformer T2, so that across the coils S1 and S1' of T2 an alternating voltage is obtained which varies according to the output of the end valves.
The voltage induced across S2 comes to lie across R60 and thus also between the cathode and anode of the upper half of B10. Under the influence of this alternating voltage a rectified voltage is obtained across the resistor R61 which has an opposite polarity to the negative grid voltage across R62. As soon as the end valves begin to deliver a certain output the negative grid voltage therefore drops.

This is necessary because if the anode current rises much then the anode voltage drops too far, and this causes the valve to operate on a diffe-

ferent curve, with the result that there would be too much distortion. Some Ia-Vg characteristics are given in fig. 5 to show what is meant. With a given anode voltage Va the valve is adjusted to a negative grid voltage -Vg1. When the anode voltage drops then the negative grid voltage must also drop to -Vg1'. Between the anodes of the output valves is a spark bridge for safeguarding the output transformer. This bridge is adjusted in the factory to 0.6 mm and then the adjusting screws are sealed.

The secondary of F3 is connected according to the 100 V system.
The voltage on the feedback winding S3-S3' (p and q) is fed back via the parallel circuit C20-R40 and the resistor R39 to the resistor R38, which is in series with the cathode resistor of B4.
The alternating voltage on S4 (r and s) is led via C22 to the rectifying valve B11 (EZ40), the cathode of which receives a positive voltage (VC32) via R36. The alternating voltage from S4 is applied across the resistor R35, which is in series with R30 and R31 between the cathode and the anodes of B11. As soon as this alternating voltage reaches an amplitude greater than the positive voltage on the cathode of B", this valve begins to draw anode current and a negative voltage arises across R30 and R31. The negative voltage across R30 is applied to the control grid of the tuning indicator B12 (EM34).
As soon as the output voltage reaches a certain value the tuning indicator shows a deflection. In this way the output voltage can be determined roughly according to the deflection of the indicator.
When the limiter switch SK2 is turned on (position "Lim" fig. 1) the negative voltage across R30 and R31 is laid on the control grid of B3 (EFF22-10). Thus B3 receives more and more negative grid voltage and the amplification of this valve is reduced. When the input voltage is raised above a certain treshold value the total gain is thus reduced.
In fig. 8 the output is given as a function of the input voltage; 8a with the limiter switched off and 8b with the limiter switched on.

The anode voltage for the output valves is supplied by a voltage doubler (fig. 6).
During the negative phase of the alternating voltage on S2 of T1, thus when the cathode of B9 is negative with respect to the anode, the rectifier B9 is in action and the capacitors C29, C30 and C31 are charged to a voltage Vb. During the next phase the anode of B8 becomes positive with respect to the cathode and this valve comes into action, C28 being then charged to Vb in the direction indicated. The total voltage across R69 and R70 is then 2 Vb.
The voltage 2 Vb is led on the anodes of the output valves, the voltage Vb to the screen grids.
The mains switch SK1 has three positions:
1: off
2: heating ("standby"), in which position only the filaments are connected;
3: high tension switched on.

The purpose of position 2 is to enable the rectifier to be switched on for immediate use at any moment. When switching back from position 3 to position 2, owing to the slow discharge of the high-tension capacitors a "dying-off" sound may be heard, but this is prevented by short-circuiting the output in position 2.

CURRENTS AND VOLTAGES, measured with the GM 4257 (10000 Ω/V)

	B1-B2 EF40(1)	B3 EF22(1)	B4 EF40(1)	B5 ECC40(1)	B6-B7 EL34(1)	B6-B7 EL34(2)	B12 EL34(1)
Va	70-94	110-150	108-132	145-180	800-850	650-720	Va1=15-35
Ia	0.9-1.15	2.0-2.6	0.95-1.2	0.95-1.2	18-26	76-95	Ia1=0.13-0.21
Vg2	41-55	47-63	65-90		375-415	275-315	Va2=12-26
Ig2	0.15-0.25	0.57-0.75	0.17-0.23		1.7-2.8	14-19	Ia2=0.13-0.19
Va'				150-190			V_L =160-200
Ia'				0.65-0.85			I_L =0.95-1.2
Vk	0	1.1-1.65	1.1-2	30	-Vg=36-40 *	Vg=30-34 *	

(1) without signal
(2) at maximum output

I in mA
V in volts

* measured at the junction point R50-R51

MEASURING SENSITIVITIES PER STAGE

If a defect cannot be traced with the aid of the table of currents and voltages, the sensitivities can be measured stage for stage.

Instruments required:

A valve voltmeter, e.g. GM 4132 or GM 6005
A.F. generator, e.g. GM 2315 or GM 2307

How sensitivities are measured

Connect to the loudspeaker terminals a resistor of 143 ohms and a power rating of 20 to 50 watts. Set the loudspeaker adapter to 100 V and switch the limiter off. Tone controls B and H at 0, f = 1000 c/s.
Set the potentiometers R1 and R2 and the volume control Q1 to maximum. Apply to the microphone input Q1 a signal of such a value as to give a voltage of 50 V at the loudspeaker terminals (measured with the valve voltmeter). Disconnect the voltmeter from the loudspeaker terminals and connect it in succession to the points A, B, C, D to O (fig. 1). Compare the measurements with the voltages given in the table. In this way also the gain per stage can be determined. Deviations of more than 20% may indicate a defect in the stage concerned.

Point	Voltage measured
A	0,3 mV
B	60 mV
C	28 mV
D	1,75 mV
E	0,33 mV
F	1,2 V
G	1,15 V

Point	Voltage measured
H	0,45 V
K	11 V
L	11 V
M	10,5 V
N	10,5 V
O	35 V