Circuits of A. C. Receivers

I. 9-Valve superheterodyne receiver with balanced output stage

Valves used: EF 8, ECH 3, EF 9, EAB 1, EEP 1, 2 × EL 6, AZ 4, EM 4.

This is a design for a high-class receiver of unusually high sensitivity, having an output stage that will give ample power. On long and medium waves the sensitivity is 0.7 μV; the receiver has 4 wave-ranges, two of which are for short-wave reception, as follows:

Long waves	830—2080	m
Medium waves	200— 560	m
Short waves I	36— 90	m
Short waves II	15— 37.5	m.

The R.F. input stage includes a "silentode" valve EF 8 and the noise level is accordingly extremely low. Delayed automatic gain control using the triple-diode principle is provided, and the stage of A.F. amplification employs the secondary-emission valve EEP 1 for driving the balanced output stage, consisting of two 18 W pentodes EL 6.

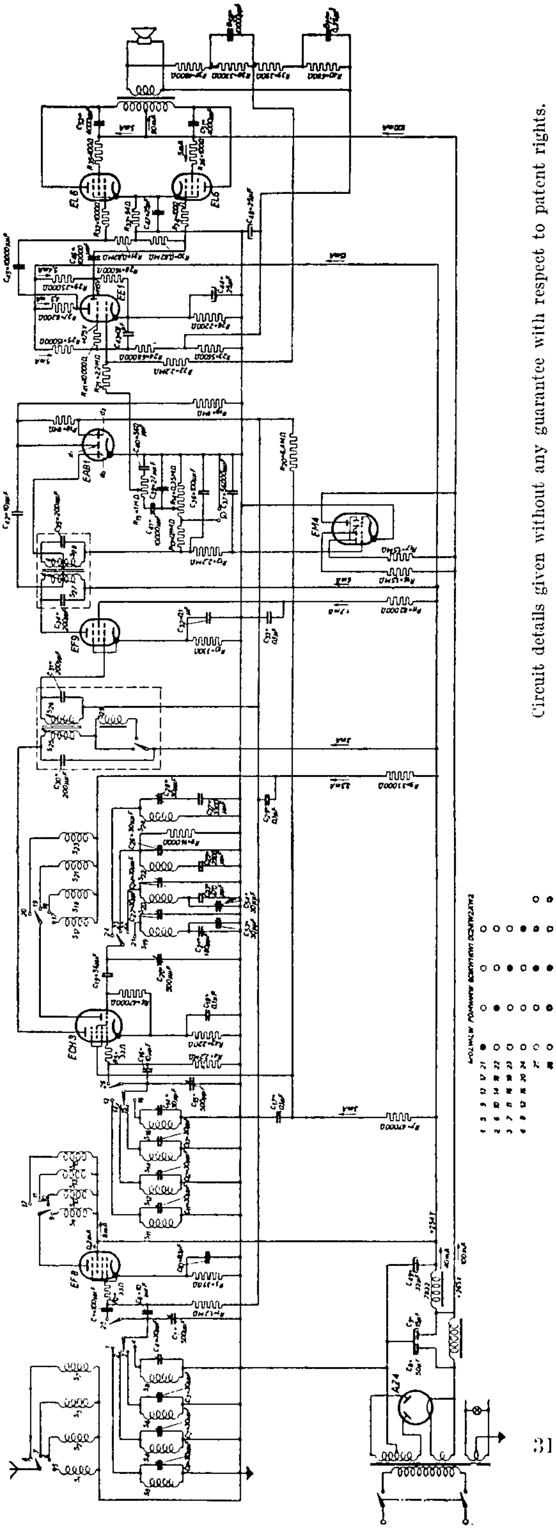
The bandwidth can be adjusted to either of two settings by varying the coupling between the circuits of the first I.F. tranformer, and as a tuning indicator the dual-sensitivity electronic indicator EM 4 is used. The R.F. circuits are based on the use of a variable capacitor of 20—500 $\mu\mu$F, the "zero"capacitance of the medium-wave range having been assessed as 50 $\mu\mu$F and that of the long-wave range at 70 $\mu\mu$F (wiring, trimmers, etc.). On medium waves the capacitive variation is accordingly 70 to 550 $\mu\mu$F and in the long-wave range 90 to 570 $\mu\mu$F; using R.F. coils of inductance 160 μH, the former range therefore covers 200 to 560 m, whilst on long waves R.F. coils of inductance 2,150 μH give a range of 830 to 2,080 metres.

It is not possible to state accurately the self-inductance of the short-wave coils, since the inductance of the wiring affects the ultimate value; the total inductance of both the coil and the wiring is therefore adjusted to the required value in the receiver, and this is done with a small copper plate adjusted at a certain distance from the coil by means of a screw, the latter being locked with solder when the adjustment has been completed. Inductance values of 4 and 0.7 μH provide ranges of 36 to 90 and 15 to 37.5 m respectively. The coupling between the aerial and R.F. circuits is inductive, and for this reason the inductances for the medium- and long-wave ranges are trimmed to the correct values with the aerial coil short-circuited. The increase in the inductance when the short-circuit is removed is then a measure of whether the coupling between aerial and tuning coil is sufficient to provide the necessary voltage gain. The coils are so proportioned as to give a voltage gain factor of the same value on all wave-ranges; when the short-circuit is removed from the aerial coil the inductance of the medium-wave tuning coil increases by 3 % and that of the long-wave coil by 7 %. Selection of the required wave-range is effected by switching the coils; this is preferable to the method, often followed, of short-circuiting certain sections of the coils, although the latter procedure does certainly entail fewer contacts on the switch. Shorted sections of coils tend to introduce various kinds of interference (erratic tuning, undesirable coupling, etc.). Coupling between the 2nd R.F. circuit and the anode circuit of the R.F. valve is inductive and, as this coupling must be as tight as possible, coils S 9 and S11, S10 and S12 are wound together on the same formers; the method of ensuring sufficiently tight coupling in the case of the short-wave coils S13/S14 and S15/S16 may be seen from the diagrams of the coils.

Due to the high signal-to-noise ratio of the "silentode" EF 8, the noise level is exceptionally low, this being an important factor in short-wave reception; in the medium and long-wave ranges the amplification of this valve is attenuated by employing capacitive tappings in the 1st and 2nd R.F. circuits so as to limit the grid input voltage to the frequency-changer; in this way overloading is avoided and whistling tones are suppressed. The capacitive tapping in the first R.F. circuit also limits the signal input to the EF 8, thus improving the cross-modulation characteristics and, due to the very low noise level of this valve, the signal-to-noise ratio is thereby not adversely affected.

The lower voltage gain and R.F. amplification in this circuit are obtained by coupling the EF 8 and ECH 3 to their input circuits through the low capacitances C6 and C16, but in the short-wave range the R.F. amplification is used to the full, a capacitor of 100 $\mu\mu$F being then connected in parallel with C6, whilst C16 is short-circuited.

Extra smoothing is provided in the form of a choke with an electrolytic capacitor, for the R.F. valve, frequency-changer, I.F. valve and A.F. pre-amplifier, to suppress modulation hum and direct ripple. Since the frequency-changer in this circuit is not provided with automatic gain control and there is therefore no risk of frequency drift, the oscillator circuit is coupled to the grid of the triode unit of the ECH 3. As is also the case with the R.F. circuits, the wave-range of the oscillator circuit is changed by switching between the coils, the advantage of this being that the coils are then quite independent of each other; the effects sometimes occurring with series-connected coils, such as jumping of the frequency in stages, are also avoided. In the first range a resistor of 16,000 ohms is connected across the oscillator circuit to ensure



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the greatest possible stability of the oscillator voltage; the padding capacitor for the long- and medium-wave ranges consists of a fixed capacitance with a trimmer in parallel, for accurate adjustment.

The frequency-changer is the ECH 3; the oscillator voltage on the 3rd grid of the hexode part of this valve and on the control grid of the triode unit should be about 8 V_{eff}, with 200 μA passing through the leak R6 of the last mentioned valve.

To suppress any tendency towards parasitic oscillation, a 33 ohm resistor is included in the lead to the hexode unit; the anode voltage of the triode part, as well as that of grids 2 and 4 of the hexode are derived directly from the supply line through series resistors, as the mixer is not controlled by the A.G.C. As already stated, the feed to the mixer valve is smoothed twice, but even without this the modulation hum becomes only slightly troublesome when very powerful transmissions are being received.

The I.F is 470 kc/s and the quality of the I.F. transformers, r/L, is equal to 15,000 $\frac{\text{ohms}}{\text{H}}$.

To align the circuits the self-inductance is varied by rotating the iron cores. The capacitance of the capacitors is fixed, at 200 $\mu\mu$F; adding to this 20 $\mu\mu$F for coil and wiring capacitances and taking into account losses in the primary circuit due to the internal resistance of the frequency-changer, the average circuit impedance of the first I.F. transformer will be 2,750,000 ohms; with a conversion conductance of 0.65 mA/V this will produce a conversion gain factor of 90. The coupling between the circuits of the first I.F. tranformer is variable from "critical" to "super-critical", a small coil being connected in series with the primary side; the coupling between this coil and the secondary side is such that when the coil is switched into the circuit an increased coupling, and therefore a wider bandwidth, is obtained. The detuning effect produced by the introduction of this coil does not greatly alter the resonance curve as a whole, displacement of the peak being only about 1 kc/s.

For one-tenth of the response at resonance the amount of detuning in the "wide" bandwidth setting is 6.5 kc/s and in the "narrow" 3.8 kc/s. The circuits of the 2nd I.F. transformer are damped by two diodes, together with the internal resistance of the I.F. valve; the diode valve EAB 1 serves as detector and also provides the A.G.C., with diode d_3 as detector. Diode d_1 is connected to the primary side of the last I.F. transformer. No delay voltage is applied to the latter diode and the distortion that would otherwise occur is thus avoided.

The delay voltage for the A.G.C. is furnished by diode d_2; as long as this diode is positive (due to its connection to R_{20}), current flows through it and there is no control on the R.F. and I.F. valves, but immediately d_1 becomes sufficiently negative to check the flow of current the A.G.C. comes into operation. Diodes d_1 and d_3 are connected to tappings on the I.F. coil in order to keep the damping effects of these diodes upon the I.F. circuits as low as possible.

A resistor, R_{13}, is placed in series with the volume control R_{14} for the purpose of reducing the difference between the A.C. and D.C. loading of the diode circuit, for, if this is not used, the difference is too great, because the tone control R_{15} is in parallel with R_{14} so far as A.C. is concerned (with the volume control turned to maximum). As is known, this would cause demodulation of the I.F. signal and also place a limit on the modulation depth that can be handled by the diode without distortion. This effect is almost entirely eliminated by the resistor R_{13}; signals of maximum modulation depth 75 % can be received and, although the sensitivity of the receiver is reduced to the extent of 22 % by this resistor, this can hardly be regarded as a disadvantage, as the sensitivity is in any case ample.

The A.F. voltage is derived from the potentiometer R_{14} and passes by way of capacitor C_{41} to the tone-control potential divider R_{15}. The latter includes a capacitor C_{40}, the signal being taken from potential divider R_{15} across a resistor of 2.2 megohms (R_{21}) to the grid of the EEP 1; the purpose of R_{21} is to render the feed-back, which is applied to the grid across another resistor of 2.2 megohms (R_{22}), independent of the setting of R_{15} and R_{14}.

The secondary-emission valve EEP 1 functions as a combined pre-amplifier and phase-inverter, the A.F. voltages being supplied in anti-phase from the anode and auxiliary cathode. Although the conductances of the anode and the cathode in question are practically equal, the resistor R_{29} has a higher value than R_{27} since the impedance in the auxiliary cathode circuit consists not only of R_{29} but also of the parallel-connected resistors R_{29} and R_{28} (so far as A.C. is concerned). The screen grid and auxiliary cathode are fed by means of potential dividers, in order to minimize D.C. voltage variations as much as possible. Grid bias is derived from the difference between the cathode voltage and a positive feed-back potential, the latter being necessary because the voltage drop across R_{26} is greater than the required bias; the variations in current between anode and cathode thereby compensate each other. The positive potential in question is taken from a tapping on the potential divider used for the screen feed; the feeds to the various electrodes of this valve have to be very effectively smoothed, to reduce hum that would otherwise occur as a result of the high amplification factor of the EEP 1, and these potentials can advantageously be taken from the twice-smoothed voltage source. A resistor of 10,000 ohms is included in the screen feed to prevent the possibility of parasitic oscillation affecting the response.

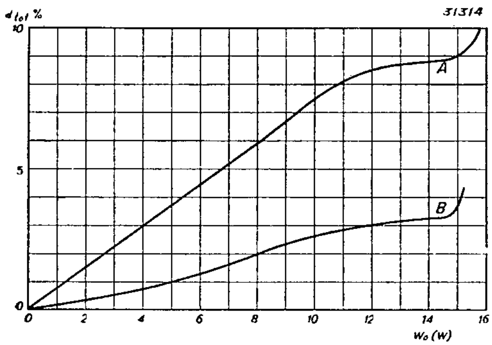


Fig. 1

Curve A. Total distortion as a function of the output power Wo of the whole A.F. section of the receiver, without negative feed-back.

Curve B. The same, but with negative feed-back.

In the output stage two EL 6 valves are used in a balanced circuit with stopper resistors in both control- and screen-grid leads, again to check parasitic oscillation, and these valves deliver 14 W with 3.5 % distortion at maximum excitation. The matching impedance between the anodes is 5,000 ohms. Fig. 1 shows the total distortion with and without negative feed-back, as a function of the output power.

Through the potential-divider circuit, consisting of the resistors R 37, 38, 39 and 40, part of the voice-coil voltage is applied through the resistor R_{22} to the grid of the EEP 1; capacitors are connected in parallel with R_{38} and R_{40}, their values being such that the feed-back is attenuated on the high and low frequencies, thus giving a very uniform response at all frequencies.

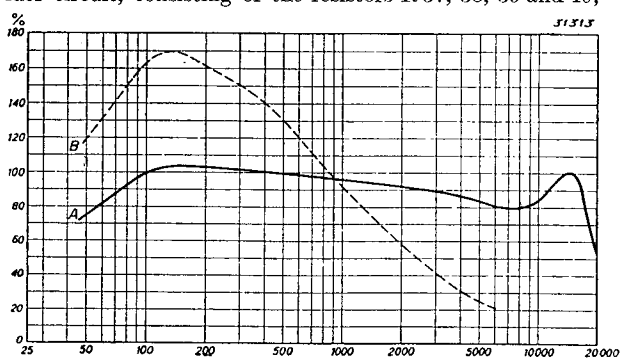


Fig. 2

Curve A. Frequency response with tone control rotated in clockwise direction.

Curve B. Frequency response with tone control rotated in anti-clockwise direction.

The frequency response of the A.F. section of the receiver is shown in Fig. 2 and relates to

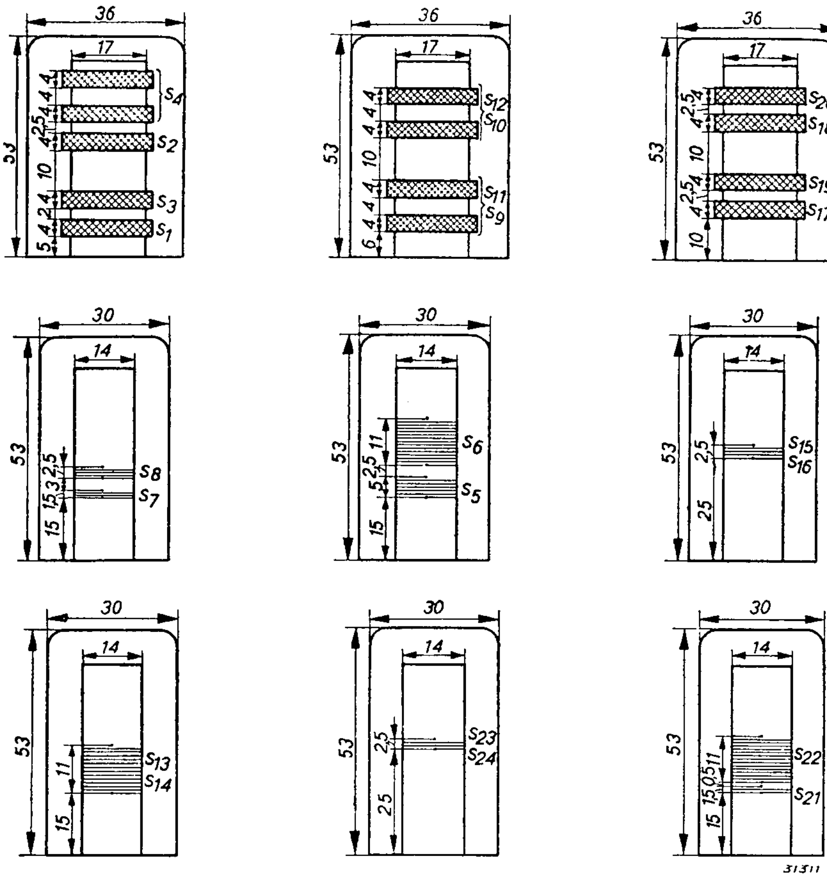


Fig. 3
R.F. and oscillator coils used in the 9-valve superheterodyne receiver.

both maximum and minimum setting of the tone control; the amount of negative feed-back equals a factor of 7.

Tuning indication is given by means of the electronic indicator EM 4, to the grid of which is applied the negative voltage produced across the grid leak of the detector diode; the A.F. voltages across this resistor are filtered out by R_{12} and C_{37}. Each of the anodes of the two triodes contained in the EM 4 is connected to a separate deflector rod within the valve.

As the gain factors of the two triodes of the EM 4 are not the same, a clear indication is obtained on weak as well as on strong signals.

The rectifying valve is the AZ 4 and the smoothing circuit consists of a double electrolytic capacitor of 50 + 15 μF with an 8-henry choke; the voltage for the earlier valves is smoothed again by means of another 8-henry choke and 32 μF electrolytic capacitor and the extra cost of this additional filter is justified when set against the saving effected by the valves. The voltage across the capacitor C_9 should be 265 V and a transformer is used of which the no-load secondary voltage is about 2 × 300 V; the total current consumed is approximately 140 mA.

Technical data

1. *Sensitivity* (for 50 mW output) on the medium- and long-wave ranges.

at the diode	0.3 $V_{(eff)}$	I.F. stage gain: 145
at the I.F. valve	2.1 $mV_{(eff)}$	Conversion gain factor: 90
at the freq. changer	24 $\mu V_{(eff)}$	R.F. stage gain: 15
at the R.F. valve	1.6 $\mu V_{(eff)}$	Voltage gain factor: 2.5
at the aerial	0.7 $\mu V_{(eff)}$	

2. *Selectivity*

"Narrow" bandwidth

Attenuation on detuning	+ 3.8 and — 3.8 kc/s:	1 : 10
,, ,, ,,	+ 7 and — 7 ,,	1 : 100
,, ,, ,,	+ 12 and — 12 ,,	1 : 1,000

"Wide" bandwidth

Attenuation on detuning	+ 6.5 and — 6.5 kc/s:	1 : 10
,, ,, ,,	+ 10 and — 10 ,,	1 : 100
,, ,, ,,	+ 15 and — 15 ,,	1 : 1,000

3. *Automatic gain control curve:*

1 ×	normal input voltage corresponds to	1 ×	normal output voltage
5 ×	,, ,, ,, ,, ,,	5 ×	,, ,, ,,
10 ×	,, ,, ,, ,, ,,	10 ×	,, ,, ,,
100 ×	,, ,, ,, ,, ,,	25 ×	,, ,, ,,
1,000 ×	,, ,, ,, ,, ,,	35 ×	,, ,, ,,
10,000 ×	,, ,, ,, ,, ,,	50 ×	,, ,, ,,

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former	Dia. of wire mm	Type of wire	Dia. of can
S1	700	—	wave	17	0.1	Enamel	36
S2	190	—	,,	17	0.1	,,	36
S3	320	2,150 μH	,,	17	0.1	,,	36
S4	2×60	160 μH	,,	17	15×0.05	Litz	36
S5	40	—	layer	14	0.1	Enamel	30
S6	20	(S5 shorted) 4 μH	,,	14	0.5	,,	30
S7	13	—	,,	14	0.1	,,	30
S8	5½	(S7 shorted) 0.9 μH	,,	14	0.5	,,	30
S9	2×208	—	wave	17	0.1	d.s.c.	36
S10	2×60	—	,,	17	0.1	,,	36
S11	2×208	2,150 μH	,,	17	0.1	,,	36
S12	2×60	160 μH	,,	17	15×0.05	Litz	36
S13	20	—	layer	14	0.1	d.s.c.	30
S14	20	4 μH	,,	14	0.5	Enamel	30
S15	5½	—	,,	14	0.1	d.s.c.	30
S16	5½	0.9 μH	,,	14	0.5	Enamel	30
S17	40	—	wave	17	0.1	,,	36
S18	35	—	,,	17	0.1	,,	36
S19	118	320 μH	,,	17	0.1	,,	36
S20	59	75 μH	,,	17	0.1	,,	36
S21	17	—	layer	14	0.1	,,	30
S22	19.5	—	,,	14	0.5	,,	30
S23	4	—	,,	14	0.1	d.s.c.	30
S24	5	—	,,	14	0.5	Enamel	30

II. 8-Valve superheterodyne receiver for 18 W output

Valves used: "Miniwatt" EF 8, ECH 3, EF 9, EAB 1, EF 9, EL 6, AZ 4, EM 1.

This is a very sensitive, high-quality receiver with 4 wave-ranges (two for short-wave reception), and a low noise-level input stage; it differs from the receiver described under section I in that the output stage is arranged on simpler lines, whilst A.F. amplification and tuning indication are obtained in a different manner. Sensitivity on the long and medium wave-ranges is 1 μV, the different ranges being as follows:

Long waves	829—2,000	m
Medium waves	200— 559	m
Short waves I	36— 90	m
Short waves II	15— 37.5	m.

Delayed A.G.C. is provided by the triple diode EAB 1 and the control is applied to the R.F. and I.F. valves only, that is to say, the frequency-changer ECH 3 is not included. The A.F. section works with strong negative feed-back for the reduction of distortion and to improve the frequency response of the A.F. amplifier.
As this receiver differs from the 9-valve circuit only in the design of the A.F. section, reference may be made to the description of that receiver for the R.F., mixer, I.F. and detector stages.
The A.F. amplifying valve is the EF 9, the A.F. signal being taken from the volume control R_{17}, through capacitor C_{33} to the grid of this valve. As output valve, the steep-slope 18 W pentode EL 6 is used, with small stopper resistors in the control- and screen-grid leads to suppress parasitic oscillation; the cathode resistor of this valve is decoupled with a 50 μF dry electrolytic capacitor. Negative feed-back is applied to the A.F. amplifier; the speech voltage occurs across the potential divider R 33, 34, 35 and 36, and the attenuated voltage is fed back to the control grid. Capacitors are connected in parallel with R_{34} and R_{36}, of a suitable value to reduce the amount of feed-back on high and low frequencies and thus ensure uniform response throughout the whole A.F. range (see Fig. 1, curve a; full line). For comparative purposes the frequency curve showing the performance without feed-back is also given. The capacitor C_{40} may be switched out of the circuit in order to reduce amplification of the high frequencies, and the switch therefore fuctions as a tone control (curve c).
The resistors R_{28} and R_{29} together form a potential divider for both the A.F. voltage on the diode-load resistor and the feed-back voltage, and if these resistors are of equal value the amplification and the feed-back will be reduced by one half.
Visual tuning is provided by the electronic indicator EM 1, for which purpose part of

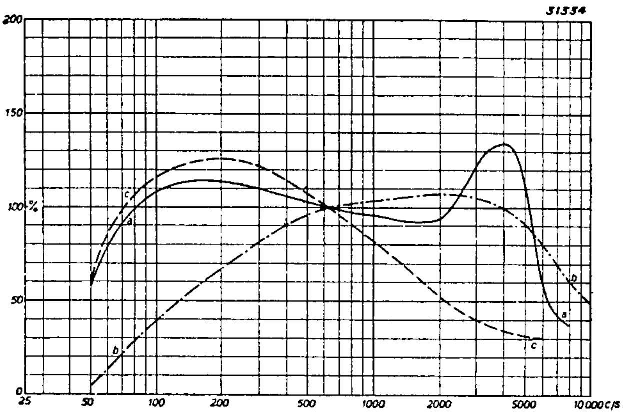
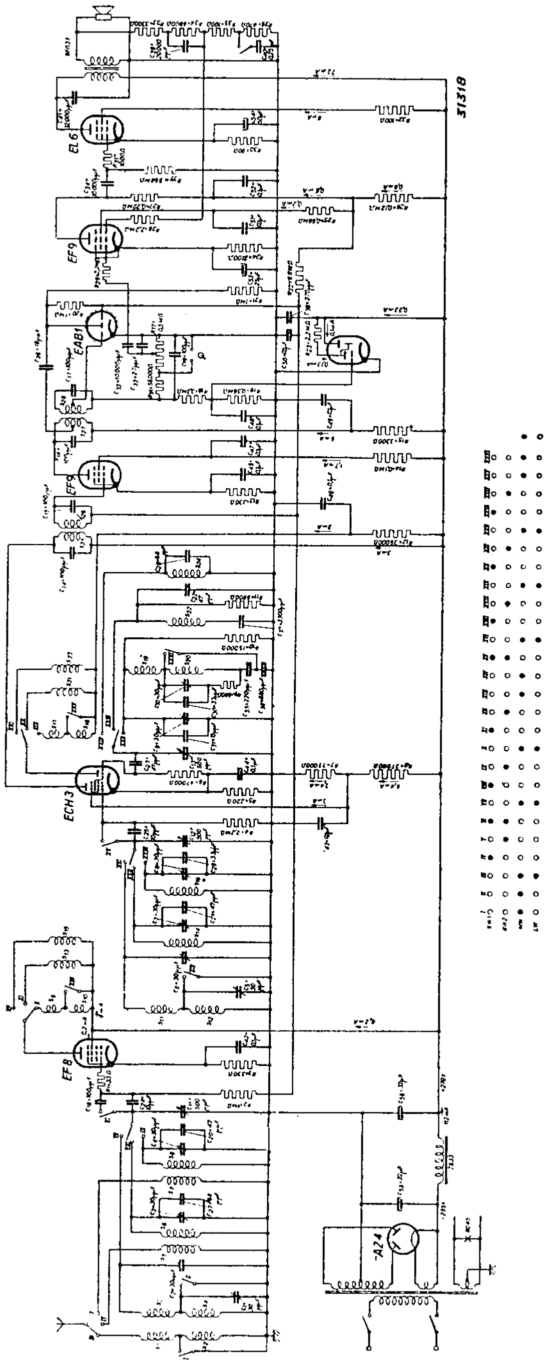


Fig. 1
Curve a. Frequency response with capacitor C 54 in circuit.
Curve b. Frequency response without feed-back.
Curve c. Frequency response with capacitor C 54 out of circuit.

the negative voltage from the detector-diode anode is taken across a potential divider R_{18}—R_{19} to the grid. The voltage from a gramophone pick-up is applied to the volume control R_{17} and a resistor, R_{16}, of 56,000 ohms is placed in series with the latter so that the detector diode of the EAB 1 will not be in parallel with the pick-up.

The rectifying valve is the AZ 4 and the smoothing comprises two electrolytic capacitors of 32 μF (320 V) and a choke of 8 H. The voltage across capacitor C_{56} should be 270 V, when the total current consumed will be approximately 112 mA.



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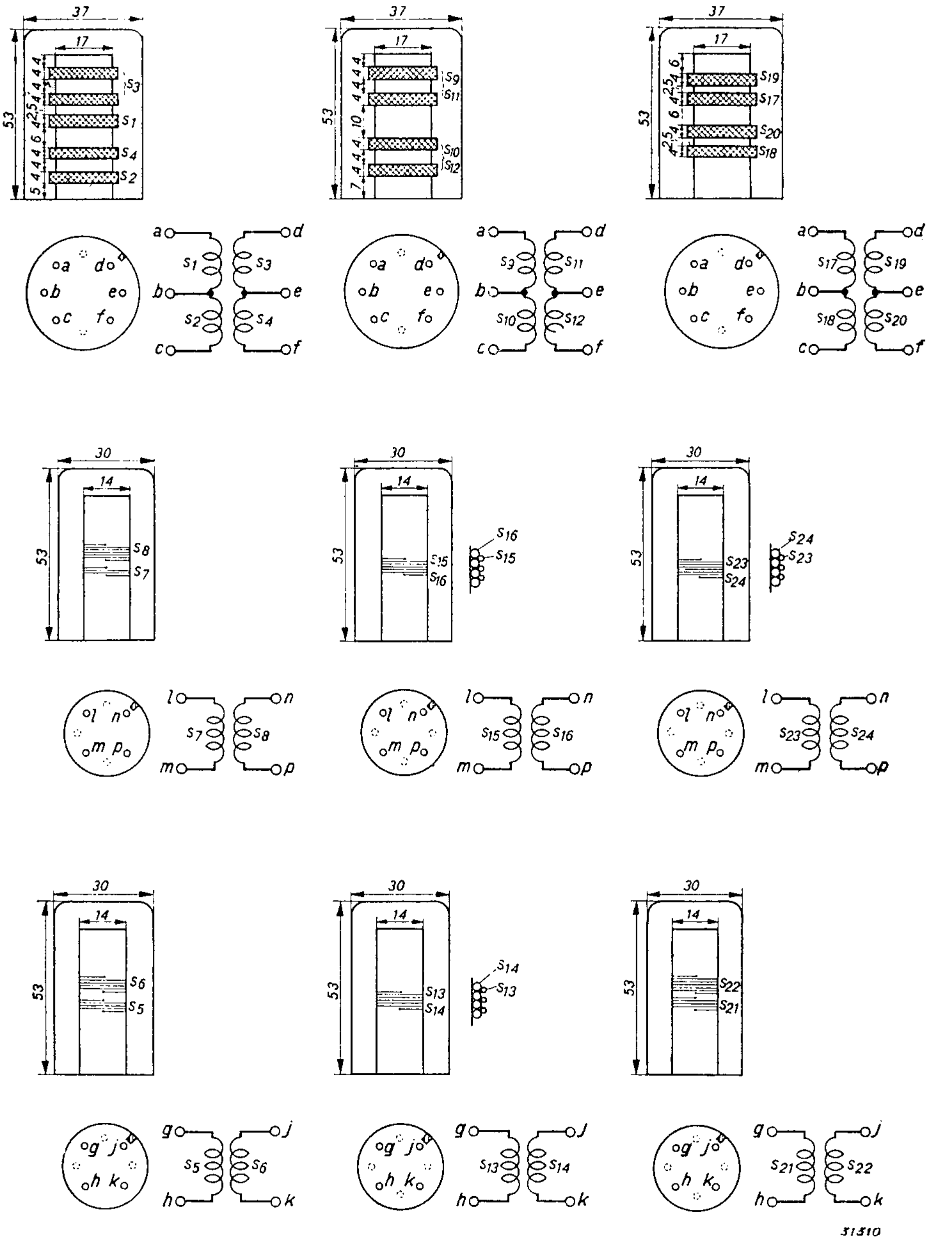


Fig. 2
Coils employed in the 8-valve receiver.
For the I.F. coils see Fig. 1 on page 324.

TECHNICAL DATA

1. *Sensitivity* (for 50 mW output) on the medium- and long-wave ranges.

at the diode	0.35 $V_{(eff)}$	
		I.F. stage gain 100
at the I.F. valve	3.5 $mV_{(eff)}$	
		Conversion gain factor 100
at the freq. changer	35 $\mu A_{(eff)}$	
		R.F. stage gain 16
at the R.F. valve	2 $\mu V_{(eff)}$	
		Voltage gain factor 2.5
at the aerial	1 $\mu V_{(eff)}$	

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5	kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8	,,	1 : 100
,, ,, ,,	+ 13 and — 13	,,	1 : 1,000

3. *Automatic gain control curve*

1 ×	normal input voltage corresponds to	1 × normal output voltage
5 ×	,, ,, ,, ,,	,, 5 × ,, ,, ,,
10 ×	,, ,, ,, ,,	,, 10 × ,, ,, ,,
100 ×	,, ,, ,, ,,	,, 25 × ,, ,, ,,
1,000 ×	,, ,, ,, ,,	,, 35 × ,, ,, ,,
10,000 ×	,, ,, ,, ,,	,, 50 × ,, ,, ,,

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former	Dia. of wire mm	Type of wire	Dia. of can
S1	180	—	wave	17	0.1	Enamel	37
S2	680	—	,,	17	0.1	,,	37
S3	2×58	S1, 2 and 4 shorted = 160 μH	,,	17	15×0.05	Litz	37
S4	306	S3 + S4 = 2,150 μH (S1 + S2 shorted in series)	,,	17	0.1	Enamel	37
S5	40	—	layer	14	0.1	,,	30
S6	20	(S5 shorted) 4 μH	,,	14	0.5	,,	30
S7	13	—	,,	14	0.1	,,	30
S8	5.5	(S7 shorted) 0.9 μH)	,,	14	0.5	,,	30
S9	2×56	—	wave	17	0.1	d.s.c.	37
S10	2×205	—	,,	17	0.1	,,	37
S11	2×56	(S12 shorted) 160 μH	,,	17	0.1	,,	37
S12	2×205	(S11+S12)= 2,150 μH	,,	17	0.1	,,	37
S13	20	—	layer	14	0.1	,,	30
S14	20	(S13 shorted) 4 μH	,,	14	0.5	Enamel	30
S15	5.5	—	,,	14	0.1	d.s.c.	30
S16	5.5	0.9 μH	,,	14	0.5	Enamel	30
S17	35	—	wave	17	0.1	,,	37
S18	40	—	,,	17	0.1	,,	37
S19	56	(S20 shorted) 75 μH	,,	17	0.1	,,	37
S20	102	S19 + S20 = 320 μH	,,	17	0.1	,,	37
S21	17	—	layer	14	0.1	,,	30
S22	19.5	—	,,	14	0.5	,,	30
S23	4	—	,,	14	0.1	,,	30
S24	5	—	,,	14	0.5	,,	30
S25 S26 S27 S28	2×130	—	wave	With 7 mm iron core	5×0.07	Litz	—

III. 8-Valve superheterodyne receiver for 9 W output

Valves used: "Miniwatt" EF 8, EK 3, EF 9, EAB 1, EF 6, EL 3, AZ 1, EM 1.

The following is a description of a highly sensitive 4-range receiver having an input stage with a very low noise level and a sensitivity of 1 μV on the medium- and long-wave ranges. There are two short-wave bands, and the different ranges are as follows:

Long waves	829—2,120	m
Medium waves	200— 559	m
Short waves I	36— 90	m
Short waves II	15— 37.5	m

The receiver incorporates automatic gain control, with the EAB 1 in a triple-diode circuit, and use is also made of strong negative feed-back to minimize distortion and ensure uniform frequency response over the whole of the A.F. range; by means of a switch, a tone control can be included in the feed-back circuit if required. Visual tuning is included, this being provided by the EM 1, which is connected to the detector diode.

The silentode EF 8 is employed for the R.F. stage to ensure a low noise level. In the short-wave ranges the full amplification of this valve is utilized, but on medium and long waves the gain is reduced by capacitors C_{49} and C_{53}, so as not to overload the grid of the EK 3.

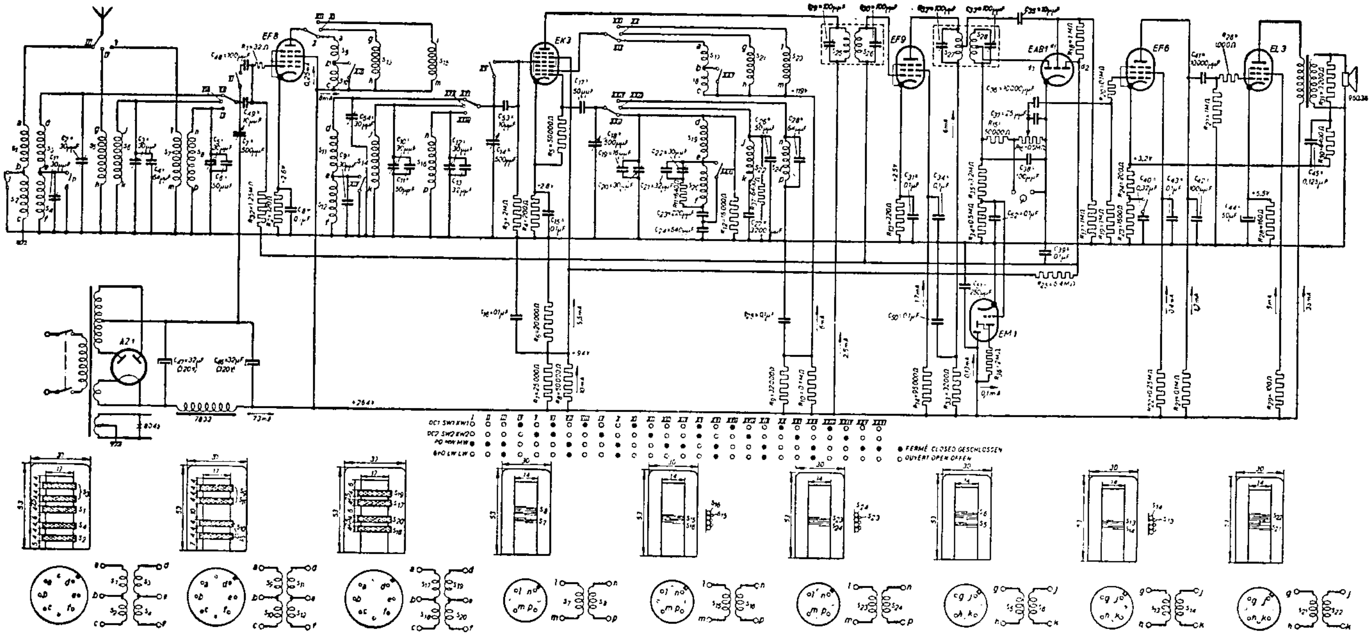
Only one tuned circuit precedes the R.F. stage in all the four wave-ranges; the R.F. medium- and long-wave coils are wound on a common former, whereas the coils for the two short-wave ranges are quite separate. The self-inductance is 160 μH on the medium and 2,150 μH on the long-wave range; for the short-wave ranges the minimum capacitance is brought up to about 70 $\mu\mu$F by means of fixed capacitors which, although somewhat reducing the range, greatly improve the accuracy of tuning, especially at the lower end of the range. The inductances for the two short-wave bands are respectively 4 and 0.9 μH, but as wiring inductances also have to be considered the coils are corrected to the required values in the receiver; this may be done by means of a small copper plate with screw, which is moved in and out of the field of the coil, being locked in its final position with solder.

The R.F. circuits are coupled inductively to the aerial; for the correction of the inductance of the medium-wave coils, the two coils S1 and S2 should be short-circuited, whilst the inductance of the long-wave coils is trimmed with these two coils shorted in series. Since the short-wave coils are corrected in the receiver itself, the effect of the aerial coils is naturally included in the inductance of the tuning coil.

A single tuned circuit is included between the R.F. and mixer valves for all the wave-bands.

The 2nd R.F. circuit is inductively coupled to the R.F. valve and, as this coupling has to be as tight as possible, coils S9 and S11, S10 and S12 are wound together: the method of winding the short-wave coils S13/S14 and S15/S16 that will ensure sufficiently tight coupling is shown in the diagrams of the coils.

The frequency-changer is the EK 3 and, as both the R.F. and I.F. valves are included in the automatic gain control system, the EK 3 is not controlled. The oscillator circuit is coupled to the first grid of the EK 3, since there is no risk of frequency drift, and the medium- and long-wave oscillator coils, moreover, are wound on the same formers. Padding capacitors are placed in series with the coils and they are also included in the switching; further, to increase uniformity of the oscillator voltage, resistors are connected in parallel with the oscillator circuits on the medium- and long-wave as well as the first short-wave ranges. The trimmers for the medium and long waves are augmented by fixed capacitors, but no trimmers are used in the short-wave oscillator circuits, because the existing capacitance can be sufficiently accurately corrected by means of the fixed capacitors.



SCHALTUNGSBEISPIEL OHNE PATENTOBLIGO UNSERERSEITS
EXEMPLE D'UN SCHÉMA DE MONTAGE DONNÉ SANS GARANTIE EN REGARD DE DROITS DE BREVETS D'INVENTION
SPECIMEN OF CIRCUIT DIAGRAM WITHOUT ANY GUARANTEE AS TO PATENTRIGHTS

50500

Circuit details given without any garantee with respect to patent rights.

A resistor R_{11} is placed in series with the long-wave trimmer to prevent any possible oscillation at undesired frequencies. The I.F. valve is the EF 9, the screen of which is fed across a resistor. The intermediate frequency is 470 kc/s and the inductance of the I.F. coils, which are fitted with iron cores, is about 1 mH; the I.F. circuits are trimmed by varying the self-inductance, this being effected by rotating the iron cores.

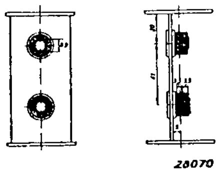
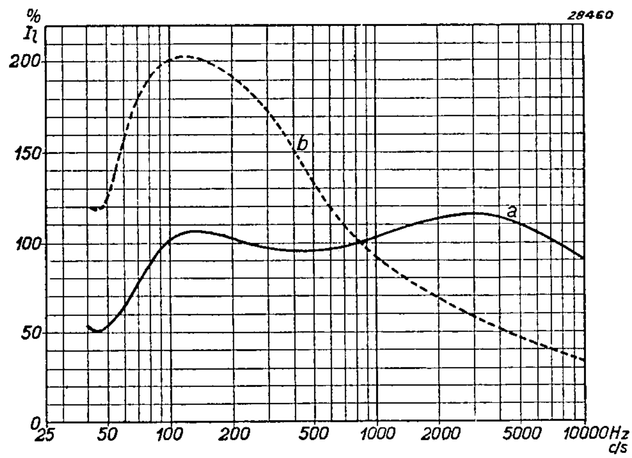


Fig. 1
I.F. coil.

Diode d_3 of the 3-diode valve EAB 1 is employed as detector, with diode d_1 for the A.G.C., this being connected to the primary circuit of the last I.F. transformer. The delay voltage of the A.G.C. is supplied by diode d_2 and so long as the latter is positive (across R_{25}) it will carry a current and the R.F. and I.F. valves will be uncontrolled. Diodes d_3 and d_1 are connected to tappings on the I.F. coils in order that losses produced by these diodes may be kept as low as possible.

The A.F. voltage across the volume control R_{16} is applied through a capacitor C_{36} to the grid of the A.F. valve EF 6 and a resistor R_{20} is employed to render the A.F. characteristic sufficiently straight. A potential divider R 23, 24, 30 and 31 is placed across the output, the values of these resistors being so chosen that they will combine to provide the correct grid bias for the EF 6; a part of the speech voltage is simultaneously fed back to the cathode of the EF 6, and the resistors R_{23} and R_{30} are by-passed by capacitors of a suitable value to reduce the amount of feed-back at the high and low frequencies, thus ensuring uniform reproduction over the whole of the A.F. range. Capacitor C_{40} is provided with a switch for purposes of tone control, the amplification of high frequencies being considerably reduced when this switch is opened.



In regard to this receiver circuit it may be said, further, that a resistor of 200 ohms, without decoupling capacitor, is included in the cathode circuit of the EF 6; under certain circumstances this arrangement might give rise to hum, but if this should be considered a drawback the connections of the ECH 3 in circuit IV may be used in preference, though then the sensitivity is slightly lower. A resistor R_{15} is connected in series with the volume control; otherwise the diode d_3 would be in parallel with the pick-up sockets.

The rectifying valve used is the AZ 1, and smoothing is by means of an 8 H choke; the total amount of direct current delivered is 73 mA.

TECHNICAL DATA

1. *Sensitivity* (for 50 mW output) on the medium- and long-wave ranges:

at the diode	0.55 V_{eff}	
at the I.F. valve	4.8 mV_{eff}	I.F. stage gain 114
at the mixer valve	40 μV_{eff}	Conversion gain factor 90
at the R.F. valve	2.5 μV_{eff}	R.F. stage gain 16
at the aerial	1 μV_{eff}	Voltage gain factor 2.5

2. *Selectivity*

Attenuation on detuning + 3.5 and — 3.5 kc/s: 1 : 10
,, ,, ,, + 5.5 and — 5.5 ,, 1 : 100
,, ,, ,, + 7.5 and — 7.5 ,, 1 : 1,000

3. *Automatic gain control curve*

1 × normal input voltage corresponds to 1 × normal output voltage
5 × ,, ,, ,, ,, ,, 5 × ,, ,, ,,
10 × ,, ,, ,, ,, ,, 10 × ,, ,, ,,
100 × ,, ,, ,, ,, ,, 25 × ,, ,, ,,
1,000 × ,, ,, ,, ,, ,, 35 × ,, ,, ,,
10,000 × ,, ,, ,, ,, ,, 50 × ,, ,, ,,

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former	Dia. of wire mm	Type of wire	Dia. of can
S1	180	—	wave	17	0.1	Enamel	37
S2	680	—	,,	17	0.1	,,	37
S3	2×58	(S1, S2 and S4 shorted) = 160 μH	,,	17	15×0.05	Litz	37
S4	306	S3 + S4 = 2,150 μH (S1 + S2 shorted in series)	,,	17	0.1	Enamel	37
S5	40	—	layer	14	0.1	,,	30
S6	20	(S5 shorted) 4 μH	,,	14	0.1	,,	30
S7	13	—	,,	14	0.1	,,	30
S8	5.5	(S7 shorted) 0.9 μH	,,	14	0.5	,,	30
S9	2×56	—	wave	17	0.1	d.s.c.	37
S10	2×205	—	,,	17	0.1	,,	37
S11	2×56	(S12 shorted) 160 μH	,,	17	0.1	,,	37
S12	2×205	S11 + S12 = 2,150 μH	,,	17	0.1	,,	37
S13	20	—	layer	14	0.1	,,	30
S14	20	(S13 shorted) 4 μH	,,	14	0.5	Enamel	30
S15	5.5	—	,,	14	0.1	d.s.c.	30
S16	5.5	(S15 shorted) 0.9 μH	,,	14	0.5	Enamel	30
S17	35	—	wave	17	0.1	,,	37
S18	40	—	,,	17	0.1	,,	37
S19	56	(S20 shorted) 75 μH	,,	17	0.1	,,	37
S20	102	S19 + S20 = 320 μH	,,	17	0.1	,,	37
S21	17	—	layer	14	0.1	,,	30
S22	19.5	(S21 shorted) 4 μH	,,	14	0.5	,,	30
S23	4	—	,,	14	0.1	,,	30
S24	5	(S23 shorted) 0.9 μH	,,	14	0.5	,,	30
S25, S26, S27, S28	2×130	—	wave	with 7 mm iron core	5×0.07	Litz	—

IV. 6-Valve superheterodyne receiver

Valves used: "Miniwatt" ECH 3, EF 9, EBC 3, EL 3N, AZ 1, EM 1.

This receiver circuit, which has a sensitivity of 16 μV on the medium- and long-wave ranges, has three ranges, viz:

Long waves	830—2,000 m
Medium waves	200— 547 m
Short waves	15— 48 m.

Delayed automatic gain control is provided. The double-diode EBC 3 is employed as detector, resistance-coupled amplifier and also to provide the delay voltage for the A.G.C. The steep-slope 9 W pentode EL 3N is used as output valve. The A.F. circuit includes negative feed-back derived from a part of the speech voltage, which is applied to the grid of the EBC 3, whilst the frequency-response curve is further improved by employing components in the feed-back circuit which are dependent of the frequency. The EM 1, coupled to the detector diode, provides visual tuning. On medium and long waves an R.F. band-pass filter with capacitive coupling is employed; the circuit calculations are based on the use of a variable capacitor of capacity 20 to 500 $\mu\mu$F, the minimum-capacitance on the medium- and long-wave ranges, including wiring, trimmers, etc., being 50 and 70 $\mu\mu$F respectively.

Taking into consideration the capacitance of the band-pass filter coupling capacitor, connected in series with the tuning capacitor, the capacitive variation for the medium-wave band is 70 to 527 $\mu\mu$F and on long waves 90 to 521 $\mu\mu$F. With coils of 160 μH, the first mentioned range covers 200 to 547 m, whilst coils of 2,150 μH give 829 to 2,000 m for the long waves. For short-wave reception only one R.F. circuit is provided, and the inductance of the short-wave coil is about 1.3 μH. On medium and long waves the coupling between the aerial and the first R.F. circuit is both capacitive and inductive, so that a constant voltage gain factor of 3 is obtained throughout the whole range; in the short-wave band the coupling is purely inductive. For the adjustment of the self-inductance of the first R.F. coil the aerial coil is short-circuited and, as coil S_3 is shorted on medium waves, trimming of the inductance for this range is carried out with the two coils S_2 and S_3 shorted; the long-wave range is trimmed with coils S_2 and S_3 shorted in series. The inductance of the short-wave coil is adjusted in the receiver by means of a small copper cylinder which is pushed into the coil and screwed in position when the correct value is obtained, and in this case the effect of the aerial coil on the inductance of the tuning coil is, of course, taken into account. In order to keep frequency drift at a minimum, the oscillator circuit is connected to the anode of the triode section of the ECH 3 and the amount of drift is, in fact, so small that the frequency-changer can be included in the A.G.C. system on short waves as well.

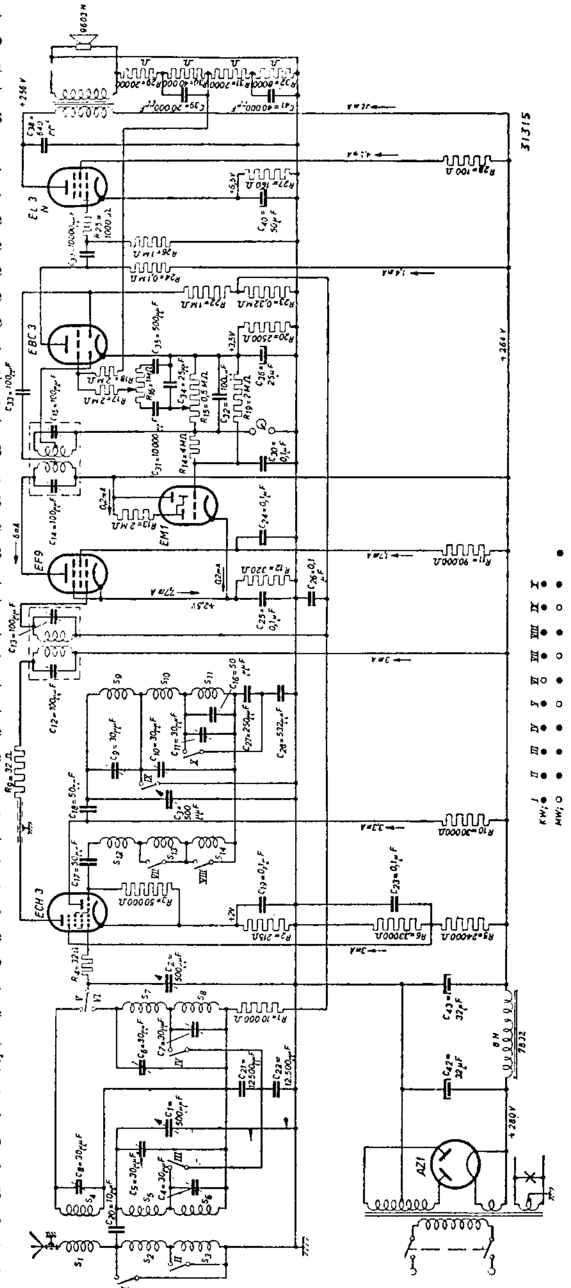
The three oscillator coils are wound on a common former (Fig. 1). The padding capacitors are arranged in series with the coils and are included in the coil switching. Constant oscillation throughout the wave ranges is ensured by connecting the lower end of the series-connected reaction coils to the upper end of the two padding capacitors also in series. The anode potential for the oscillator unit of the valve is applied through a resistor R_{10}, with capacitor C_{18} to block the direct voltage from the oscillator circuit (parallel supply).

The medium-wave padding capacitor should be about 530 $\mu\mu$F and the long-wave capacitor about 170 $\mu\mu$F, the latter value being obtained by connecting 250 $\mu\mu$F in series with the medium-wave padding capacitor; the ultimate values of these capacitors will depend on the minimum-capacitance of the respective circuits.

Capacitor C_{17} has a value of about 50 $\mu\mu$F, which ensures reliable oscillation on long waves whilst guaranteeing the least possible amount of frequency drift on the short-wave range. The voltage for the 2nd and 4th grids of the ECH 3 is obtained from a potential divider, and the values of the component resistors are so arranged that the screen voltage varies only very slightly when control is applied to the valve.

To prevent parasitic oscillation, low value resistors are included in the anode and grid circuits. The oscillator voltage on the 3rd grid of the hexode section (and grid of the triode unit) should be approximately 8 V (eff), with 200 μA flowing through R_3. The intermediate frequency is 470 kc/s and the I.F. coils are fitted with iron cores, the inductance of these coils being about 1 mH. In the I.F. circuit the capacitors are of 100 $\mu\mu$F capacity and it is necessary to use only high-quality capacitors in order to maintain the quality of these circuits, which are trimmed to the required frequency by rotating the iron cores, thus varying the inductance.

The I.F. valve is the EF 9, the screen circuit of which is arranged on the sliding-voltage principle. Both diodes of the EBC 3 are connected to tappings on the I.F. coils with a view to reducing losses in the circuit. Delay voltage for the A.G.C. diode is obtained from the cathode voltage of the EBC 3, the A.G.C. voltage being applied via the potential divider R_{22}-$_{23}$ to the valves included in the A.G.C. system; this does not provide too straight a control characteristic, however, and if better conditions are essential there is nothing against employ-



Circuit diagram given without any guarantees with respect to patent rights.

ing the full voltage for the control.

The A.F. voltage is tapped from the volume control R_{15} and is taken through C_{31} to the potential divider R_{16}, which serves as tone control; the effective tone-control circuit actually consists of R_{16} and C_{35} and the voltage is passed from the potential divider R_{16} through R_{17} to the grid of the EBC 3. The last-named resistor is included to prevent the feed-back voltage, occurring across the resistor R_{16} (also 2 megohms) on the grid of the valve, from varying with the setting of R_{15} and R_{16}.

To ensure satisfactory reproduction of the low frequencies, the cathode resistor of the EBC 3 is decoupled by an electrolytic capacitor C_{36} of 25 μF.

The output valve is the steep-slope pentode EL 3 N, the control-grid and screen-grid circuits of which include small stopper resistors to suppress parasitic oscillation. A part of the speech voltage is tapped from the potential divider R_{29}-$_{30}$-$_{31}$-$_{32}$ and is applied to the grid of the EBC 3 through a resistor R_{18}, the feed-back factor being about 4. Capacitors are connected in parallel with R_{30} and R_{32}, of suitable values to reduce the amount of feed-back on the high and low frequencies, thus ensuring uniform response over the whole A.F. range.

The EM 1 provides visual tuning indication, part of the negative potential on the detector diode being taken to the grid of this valve across the potential divider R_{14}-R_{19}; the cathode of the electronic indicator is connected to that of the I.F. valve, since, if it were earthed, the grid of the EM 1 would become positive on weak signals (cathode voltage of the EBC 3), in

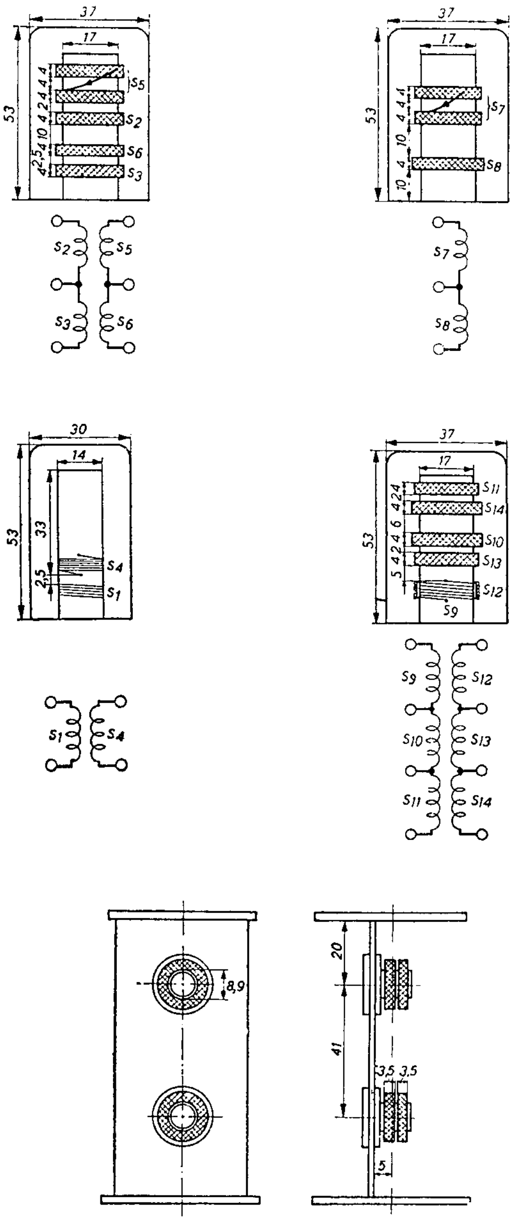


Fig. 1
Coils employed in the 6-valve receiver.

consequence of which no indication would appear. Since control is applied to the EF 9, the cathode potential of this valve falls when the signals are strong; the deflection on the screen of the indicator on strong signals is therefore smaller in proportion, and a good indication is thus ensured when the more powerful transmissions are being received.

The rectifier is the AZ 1 and the smoothing circuit consists of two electrolytic capacitors of 32 μF (320 V) with an 8 H choke. The voltage across capacitor C 43 should be 264 V, so that the transformer should deliver a no-load secondary voltage of 2 × 300 V. The total consumption is about 60 mA.

TECHNICAL DATA

1. *Sensitivity* (for an output of 50 mW) on the medium- and long-wave ranges.

at the diode	0.5 $V_{(eff)}$	I.F. stage gain: 100
at the I.F. valve	5 $mV_{(eff)}$	
at the mixer valve	50 $\mu V_{(eff)}$	Conversion gain factor: 100
at the aerial	16 $\mu V_{(eff)}$	Voltage gain factor: 3

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5 kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8 ,,	1 : 100
,, ,, ,,	+ 13 and — 13 ,,	1 : 1,000

3. *Automatic gain control curve*

1 ×	normal input voltage corresponds to	1 × normal output voltage
5 ×	,, ,, ,, ,,	,, 5 × ,, ,, ,,
10 ×	,, ,, ,, ,,	,, 8 × ,, ,, ,,
100 ×	,, ,, ,, ,,	,, 18 × ,, ,, ,,
1,000 ×	,, ,, ,, ,,	,, 30 × ,, ,, ,,
10,000 ×	,, ,, ,, ,,	,, 42 × ,, ,, ,,

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former	Dia. of wire mm	Type of wire
S1	13	—	layer	14	0.1	Enamel
S2	180	—	wave	17	0.1	,,
S3	680	—	,,	17	0.1	,,
S4	13	—	layer	14	1	,,
S5	2×58	(S2, S3 and S6 shorted) 160 μH	wave	17	15×0.05	Litz
S6	310	S5 + S6 (S2 + S3 shorted in series) = 2,150 μH	,,	17	0.1	Enamel
S7	2×57	(S8 shorted) 160 μH	,,	17	15×0.05	Litz
S8	294	S7 + S8 = 2,150 μH	,,	17	0.1	Enamel
S9	7	—	layer	17	0.5	,,
S10	54	S9 + S10 (S11 shorted) = 75 μH	wave	17	0.1	,,
S11	99	S9 + S10 + S11 = 320 μH	,,	17	0.1	,,
S12	6	—	layer	17	0.1	,,
S13	35	—	wave	17	0.1	,,
S14	40	—	,,	17	0.1	,,
S15 S16 S17 S18	2×130	—	,,	7 mm iron core.	5×0.07	Litz

V. 6-Valve superheterodyne receiver

Valves used: "Miniwatt" EK 3, EF 9, EBC 3, EL 3, AZ 1, EM 1.

This type of receiver falls within the "average" price class and it has a sensitivity of 16 μV.

The three wave-ranges employed are as follows:

Long waves	830—2,000 m
Medium waves	200— 547 m
Short waves	15— 48 m.

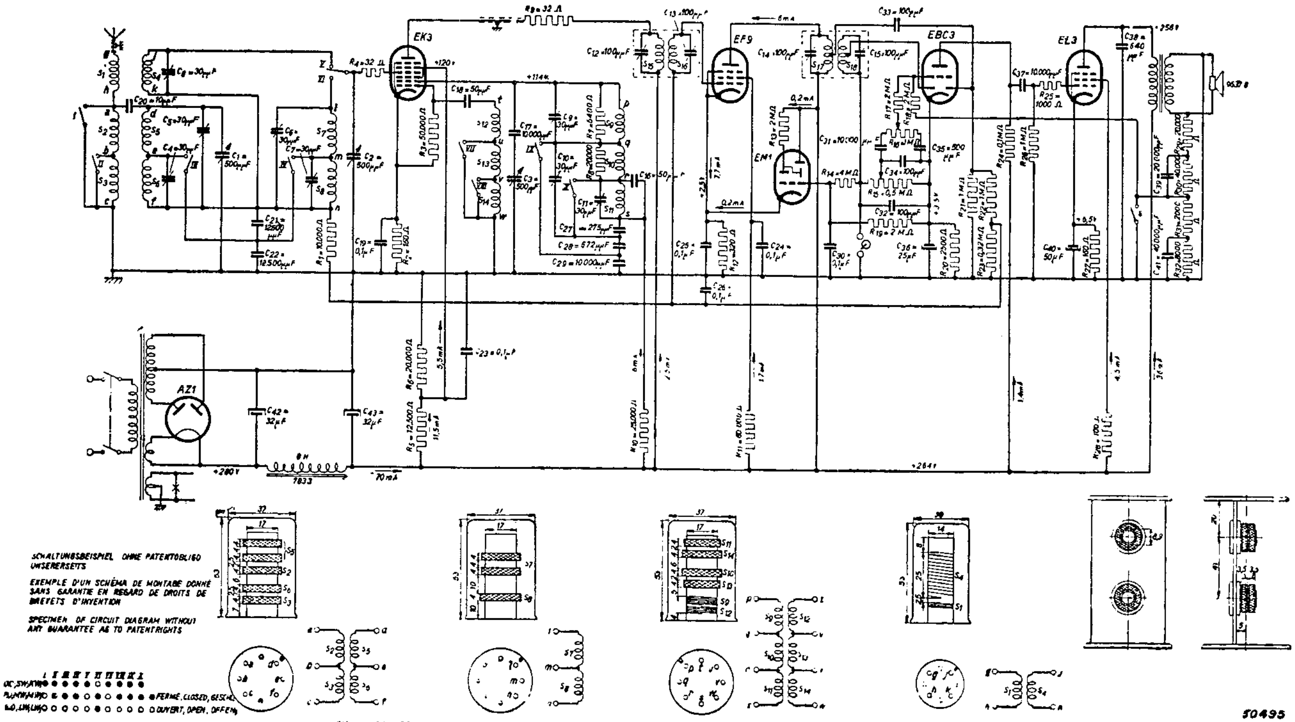
Delayed automatic gain control is provided. The double-diode EBC 3 functions as detector and A.F. amplifier and also furnishes the control voltage for the A.G.C. An EL 3, steep-slope 9 W pentode, is used in the output stage, whilst in the A.F. section a part of the speech voltage is fed back to the grid of the EBC 3; the components of the negative feed-back circuit are all independent of frequency, this being necessary to ensure a satisfactory response curve. To give visual-tuning indication the EM 1 is coupled to the detector diode. In the medium- and long-wave ranges a capacitively-coupled R.F. band-pass filter is used; the self-inductance of the medium-wave R.F. coils is 160 μH and that of the long-wave coils 2,150 μH. On short waves only one R.F. circuit is provided, the inductance of the coil being about 1.3 μH. For the medium- and long-wave bands the first tuned circuit is coupled to the aerial both inductively and capacitively, giving a voltage gain factor of 3; the short-wave aerial coupling is purely inductive.

For trimming the medium-wave inductances the two coils S_2 and S_3 are short-circuited; for the long waves these coils are shorted in series. The short-wave coil is usually trimmed in the receiver.

Frequency drift is limited as much as possible by coupling the oscillator circuit to the 2nd grid of the frequency-changer valve EK 3, and this valve is also included in the A.G.C. system. The three oscillator coils are wound on a common former. The padding capacitors are connected in series with the coils and are included in the coil switching; resistors are included in parallel with the short- and medium-wave coils to stabilize the oscillator voltage. An isolating capacitor C_{17} is employed to avoid having a "live" variable capacitor (parallel feed). The capacitance of the medium-wave padding capacitor is about 670 μμF and that of the long-wave capacitor about 195 μμF, the latter value being obtained by connecting 275 μμF in series with the medium-wave capacitor; C_{29} is an isolating capacitor which has little or no effect on the values of the padding capacitor. To prevent parasitic oscillation stopper resistors are included in the anode and 4th-grid circuits.

The intermediate frequency is 470 kc/s and the I.F. coils, which are fitted with iron cores, have an inductance value of 1 mH. The I.F. circuits are trimmed by rotating the iron cores, thus varying the self-inductance of the coils.

The I.F. valve EF 9 operates on the sliding-screen-voltage princip e. The two diodes of the EBC 3 are connected to tappings on the I.F. coil in order to reduce losses in the I.F. circuits as much as possible; the cathode potential of the EBC 3 is used as delay voltage for the A.G.C., the control voltage being applied to the relevant valves across a potential divider R_{22}, R_{23}, and it should be noted that the resultant control curve is not too straight.



Circuit diagram given without any guarantees with respect to patent rights.

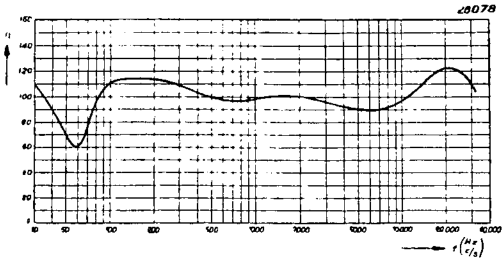


Fig. 1
Frequency-response curve for circuit including negative feed-back.

A tone control is included in the A.F. section, comprising R_{16} and C_{35}, and to ensure sufficient low-note response the cathode is decoupled by an electrolytic capacitor of 25 μF. The negative feed-back amounts to a factor of 4. Capacitors are placed in parallel with R_{50} and R_{32}, of suitable values to reduce the amount of feed-back at high and low frequencies with a view to improving the response curve.
A switch S may be added, if required, to cut out the negative feed-back on short-wave reception, which will increase the sensitivity.
The rectifier is the AZ 1; the smoothing choke should have an inductance of 8 H.
The total amount of current consumed is approx 70 mA.

TECHNICAL DATA

1. *Sensitivity* (for 50 mW output) on the medium- and long-wave ranges.

at the diode	0.5 $\mu V_{(eff)}$	I.F. stage gain: 100
at the I.F. valve	6 $mV_{(eff)}$	Conversion gain factor: 100
at the mixer valve	50 $\mu V_{(eff)}$	Voltage gain factor: 3
at the aerial	16 $\mu V_{(eff)}$	

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5	kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8	,,	1 : 100
,, ,, ,,	+ 13 and — 13	,,	1 : 1,000

3. *Automatic gain control curve*

1 ×	normal input voltage corresponds to	1 ×	normal output voltage
5 ×	,, ,, ,, ,, ,,	5 ×	,, ,, ,,
10 ×	,, ,, ,, ,, ,,	8 ×	,, ,, ,,
100 ×	,, ,, ,, ,, ,,	18 ×	,, ,, ,,
1,000 ×	,, ,, ,, ,, ,,	30 ×	,, ,, ,,
10,000 ×	,, ,, ,, ,, ,,	42 ×	,, ,, ,,

TABLE OF COILS

See Circuit IV.
The coils used for Circuits IV and V are identical.

VI. 5-Valve superheterodyne receiver

Valves used: "Miniwatt" EK 3, EBF 2, EFM 1, EL 3, AZ 1.

In this receiver the combined A.F. amplifier and electronic indicator EFM 1 is used, with negative feed-back from the speech coil. The sensitivity at the aerial as well as in the medium- and long-wave bands is 16 μV and there are three wave bands, viz:

Long waves	830—2,000 m
Medium waves	200— 547 m
Short waves	15— 48 m.

The R.F., I.F. and oscillator coils are identical with those employed in Circuits IV and V for the 6-valve receivers, the only difference between the two last-named circuits and the present receiver being in the I.F. valve and the design of the A.F. section: the I.F. valve is the pentode unit in the EBF 2, which operates with sliding screen voltage. For detection and automatic gain control the two diodes in the other section of the valve are employed; these are connected to tappings on the I.F. coils in order to reduce I.F. circuit losses. Both the EK 3 and the EBF 2 are included in the A.G.C. system and the cathode voltage of the last-mentioned valve also serves as delay voltage for the control. R_{12} is the load resistor for this diode; since the required delay voltage is in excess of the grid bias needed by the pentode unit only a part of the cathode potential is applied to the EBF 2, through a potential divider formed by R 12, 13, 14 and 15, which means that only a portion of the delay voltage is applied to the I.F. valve, across R_{12}. Further, part of the positive cathode potentia of the EBF 2 is applied via the potential divider R 12—15 to the 4th grid of the EK 3, for which reason the biasing resistor is rather larger than usual.

The A.F. signal is passed from the volume control R_{17} across the tone control (R_{18}—C_{31}) to the grid of the EFM 1; a resistor, R_{31}, of 50,000 ohms is connected in series with the volume control; otherwise the detector diode would be in parallel with the pick-up when the set is used for gramophone reproduction, and this would produce considerable distortion.

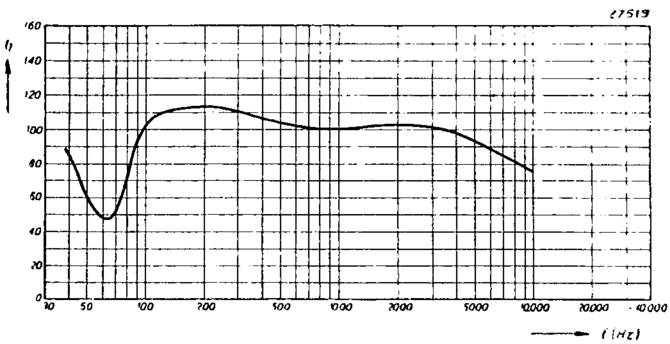


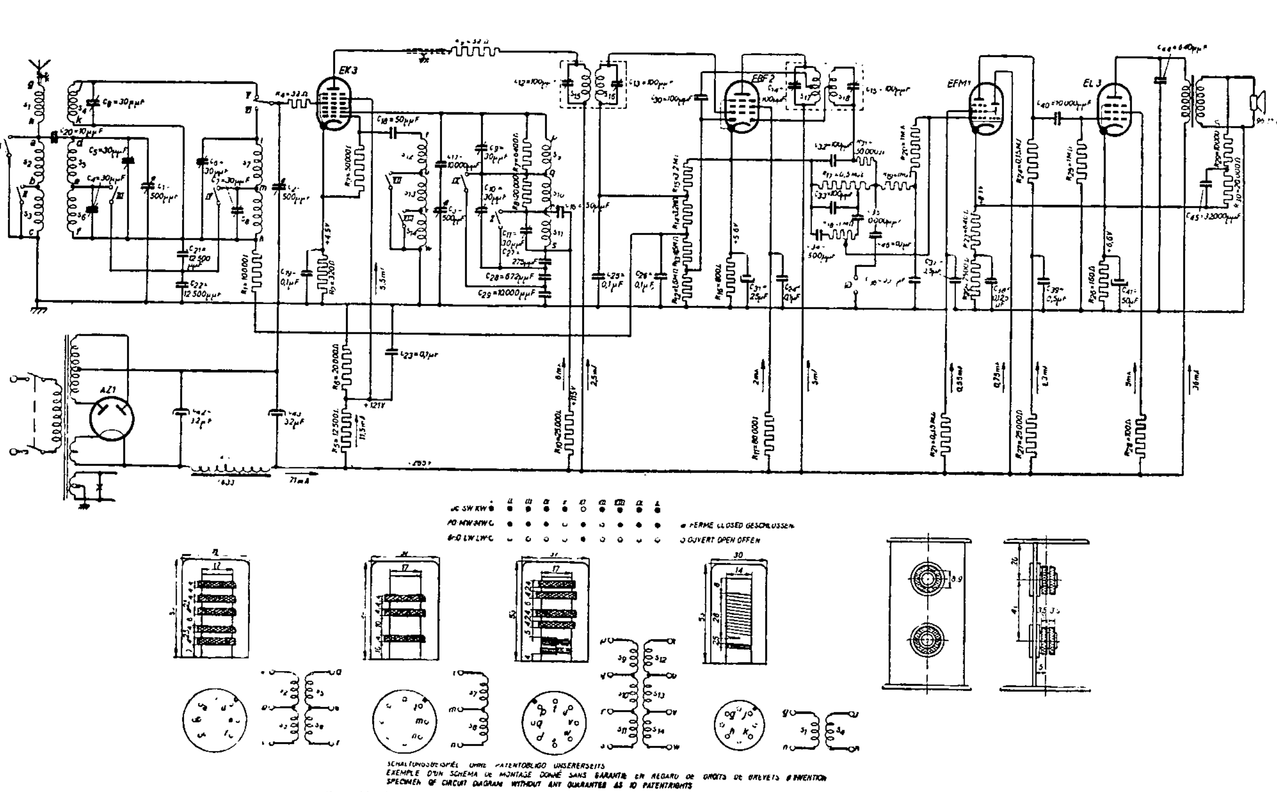
Fig. 1. Frequency-response curve

A portion of the speech voltage is tapped from the potential divider R_{29}, R_{30}, R_{23}, R_{22} for feeding back to the cathode of the EFM 1, and this is sufficient to give a feed-back factor of about 4. Capacitors are connected in parallel with R_{30} and R_{22}, the values of these being such that the amount of negative feed-back is reduced at high and low frequencies: the response is thus rendered more uniform on all frequencies.

In this circuit a resistor is connected to the cathode of the EFM 1, without a decoupling capacitor, and in certain circumstances this may give rise to hum; in this event, and if better performance is required, the circuit of the EBC 3 in diagram IV may be preferred, although the sensitivity will then be slightly less.

The negative potential occurring across the potential divider R_{17} is applied through a filter consisting of R_{19} and C_{36} to the "earth" end of the grid leak of the EFM 1 for the purpose of providing tuning indication.

The rectifying valve is the AZ 1 and the smoothing choke should have an inductance of 8 H. The total amount of current used is about 71 mA.



Circuit diagram given without any guarantees with respect to patent rights.

TECHNICAL DATA

1. *Sensitivity* (for 50 mW output) in the medium- and long-wave bands.

at the diode	0.5 V	I.F. stage gain: 100
at the I.F. valve	5 mV	Conversion gain factor: 100
at the mixer valve (octode)	50 μV	Voltage gain factor: 3
at the aerial	16 μV	

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5 kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8 ,,	1 : 100
,, ,, ,,	+ 13 and — 13 ,,	1 : 1,000

3. *Automatic gain control curve*

1 ×	normal input voltage corresponds to	1 ×	normal output voltage
5 ×	,, ,, ,, ,, ,,	5 ×	,, ,, ,,
10 ×	,, ,, ,, ,, ,,	8 ×	,, ,, ,,
100 ×	,, ,, ,, ,, ,,	18 ×	,, ,, ,,
1,000 ×	,, ,, ,, ,, ,,	30 ×	,, ,, ,,
10,000 ×	,, ,, ,, ,, ,,	42 ×	,, ,, ,,

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former	Dia. of wire mm	Type of wire
S1	13	—	layer	14	0.1	Enamel
S2	180	—	wave	17	0.1	,,
S3	680	—	,,	17	0.1	,,
S4	12	—	layer	14	1	,,
S5	2×58	(S2, S3 and S6 shorted) 160 μH	wave	17	15×0.05	Litz
S6	310	S5 + S6 (S2 + S3 shorted in series) = 2,150 μH	,,	17	0.1	Enamel
S7	2×57	(S8 shorted) 160 μH	,,	17	15×0.05	Litz
S8	294	S7 + S8 = 2,150 μH	,,	17	0.1	Enamel
S9	7	—	layer	17	0.5	,,
S10	54	S9 + S10 (S11 shorted) = 75 μH	wave	17	0.1	Enamel
S11	99	S9 + S10 + S11 = 320 μH	,,	17	0.1	,,
S12	7	—	layer	17	0.1	,,
S13	35	—	wave	17	0.1	,,
S14	40	—	,,	17	0.1	,,
S15, S16, S17, S18	2×130	—	,,	8.9 with 7 mm iron core	5×0.07	Litz

VII. 4-Valve superheterodyne receiver

Valves used: "Miniwatt" EK 3, EF 9, EBL 1, AZ 1.

The following is a description of a small, low-priced receiver which, notwithstanding the small number of valves employed, has very outstanding properties. Sensitivity on the medium- and long-wave bands is 45 μV and there are three bands, viz:

Long waves	830—2,000 m
Medium waves	200— 546 m
Short waves	15— 48 m.

In this receiver the R.F., I.F. and oscillator coils are the same as those employed in Circuit V; the difference between these two receivers is that only one valve is used in place of two others, namely the EBL 1 instead of the EBC 3 and EL 3, in consequence of which the A.F. gain is much less. Further, there is no negative feed-back or visual tuning indicator.

For detection and A.G.C. the two diodes of the EBL 1 are employed, delay voltage for the A.G.C. being derived from the cathode voltage of this valve and, as the delay voltage needs to be higher than the grid bias on the output valve, an extra resistor is connected in series with the self-biasing resistor. The control voltage is applied to the appropriate valves via a potential divider R_{21} and R_{22}.

To ensure satisfactory low-note response the bias resistor of the EBL 1 is decoupled with a 50 μF electrolytic capacitor. The tone-control circuit consists of a capacitor of 50,000 $\mu\mu$F in series with a 50,000 ohm resistor across the primary side of the output transformer.

As the amplification of the output valve is not sufficient for gramophone reproduction, the I.F. valve in this case operates as A.F. amplifier; the resistor R_{14}, which on radio reception decouples the anode voltage, functions as load resistor for record playing. The rectifier section is similar to that of the 6-valve receiver and the total current is about 70 mA.

TECHINCAL DATA

1. *Sensitivity* (for 50 mW output) on medium and long waves:

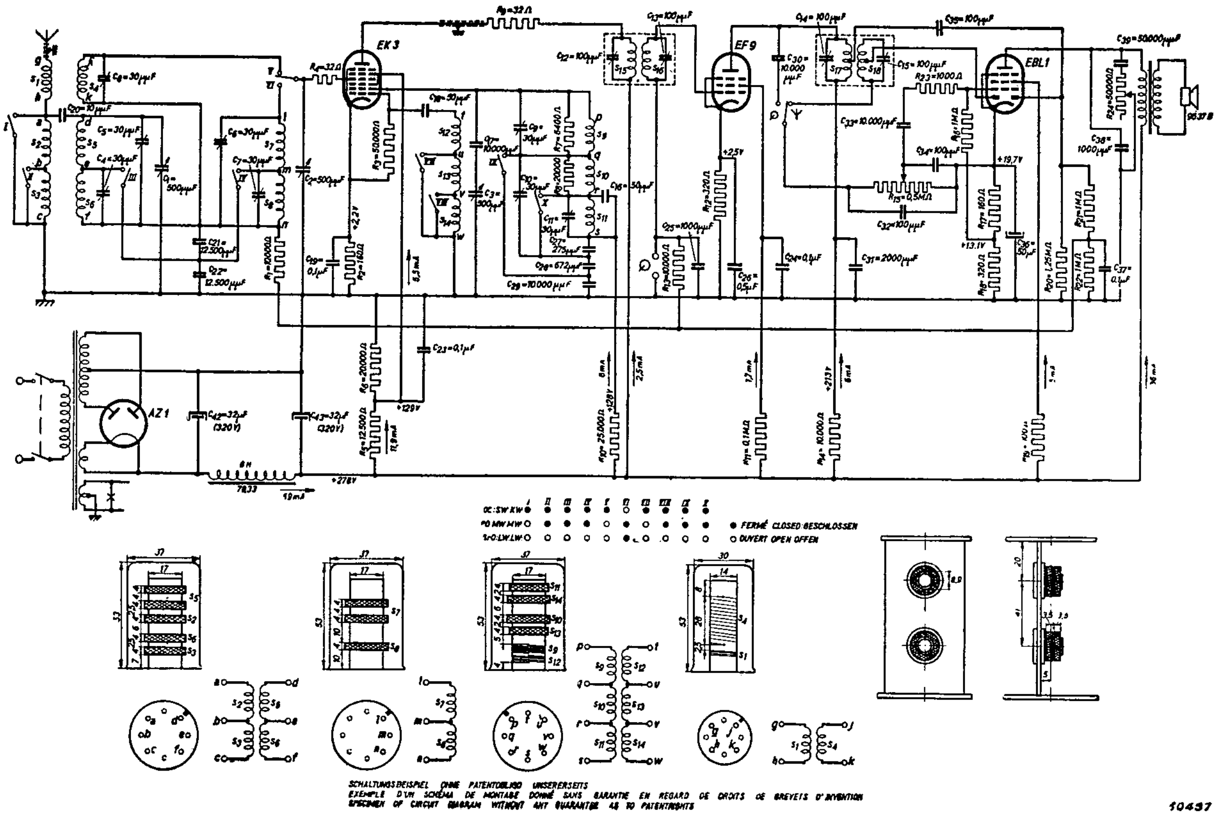
at the diode	1.4 V	
at the I.F. valve	14 mV	I.F stage gain: 100
at the mixer valve (octode)	140 μV	Conversion gain factor: 100
at the aerial	45 μV	Voltage gain factor: 3

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5 kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8 ,,	1 : 100
,, ,, ,,	+ 13 and — 13 ,,	1 : 1,000

3. *Automatic gain control curve*

1 ×	normal input voltage corresponds to	1 ×	normal output voltage
5 ×	,, ,, ,, ,, ,,	5 ×	,, ,, ,,
10 ×	,, ,, ,, ,, ,,	8 ×	,, ,, ,,
100 ×	,, ,, ,, ,, ,,	18 ×	,, ,, ,,
1,000 ×	,, ,, ,, ,, ,,	30 ×	,, ,, ,,
10,000 ×	,, ,, ,, ,, ,,	42 ×	,, ,, ,,



Circuit diagram given without any guarantees with respect to patent rights.

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former	Dia. of wire mm	Type of wire
S1	13	—	layer	14	0.1	Enamel
S2	180	—	wave	17	0.1	,,
S3	680	—	,,	17	0.1	,,
S4	12	—	layer	14	1	,,
S5	2×58	(S2, S3 and S6 shorted) 160 μH	wave	17	15×0.05	Litz
S6	310	S5 + S6 (S2 + S3 shorted in series) = 2,150 μH	,,	17	0.1	Enamel
S7	2×57	(S8 shorted) = 160 μH	,,	17	15×0.05	Litz
S8	294	S7 + S8 = 2,150 μH	,,	17	0.1	Enamel
S9	7	—	layer	17	0.5	,,
S10	54	S9 + S10 (S11 shorted) = 75 μH	wave	17	0.1	,,
S11	99	S9 + S10 + S11 = 320 μH	,,	17	0.1	,,
S12	7	—	layer	17	0.1	,,
S13	35	—	wave	17	0.1	,,
S14	40	—	,,	17	0.1	,,
S15 S16 S17 S18	2×130	—	,,	8.9 with 7 mm iron core	5×0.07	Litz

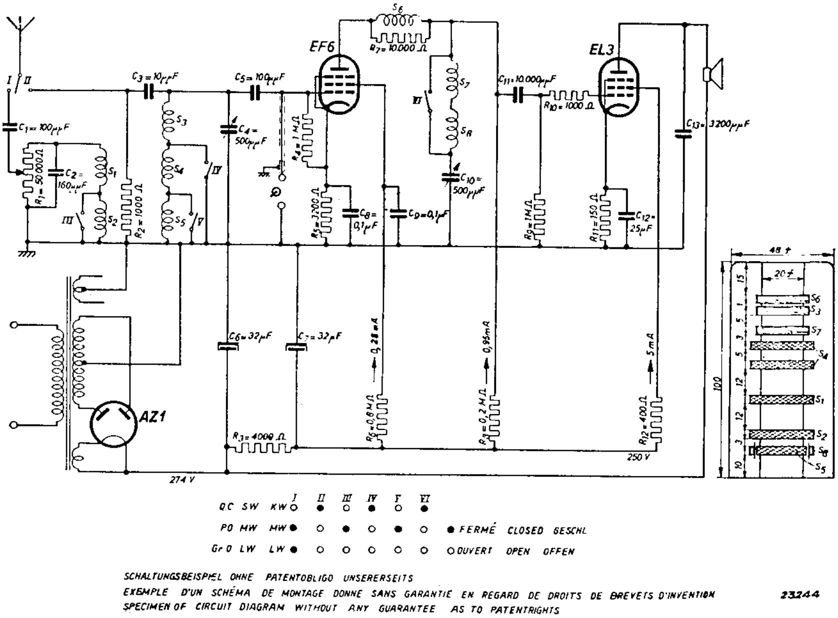
VIII. 3-Valve receiver for local stations

Valves used: "Miniwatt" EF 6, EL 3, AZ 1.

This single-circuit receiver has three wave-bands, viz:

Long waves	770—2,000	m
Medium waves	200— 550	m
Short waves	15— 63	m.

It comprises a grid detector with output stage and rectifier; tuning is but little affected by the aerial and the station dial may be calibrated.



Circuit diagram.

In the medium- and long-wave bands the aerial coupling is inductive (switch I closed); the self-inductances of the aerial coils S_1 and S_2 are such that their resonant frequencies lie below the lowest frequency in the wave band concerned (e.g., at 700 and 2,200 m). The two aerial coils have a potential divider of 5,000 ohms in parallel with them, the aerial being connected to the slider, by which means the input signal, and simultaneously the volume, can be adjusted as desired.

In the short-wave band (switch II closed) the aerial coupling is capacitive. All the coils are wound on a common former and tuning is by means of a variable capacitor of maximum capacity 500 $\mu\mu$F. Care must be taken to employ a drive having a sufficiently high ratio reduction gear to facilitate tuning on short waves.

The coils are operated by a switch that should have the lowest possible capacitance, and if the mains switch is combined with the coil switch the former must be carefully screened to avoid induced ripple on the grid of the detector; for the same reason all leads at mains potential should be properly screened.

The reaction coupling is inductive and can be controlled by a variable capacitor of at most 500 $\mu\mu$F. The anode resistor of 0.2 megohm is not connected direct to the anode but to the junction of the short and medium-wave reaction coils; in this way the input circuit of the output valve is not in parallel with the short-wave coupling coil when the receiver is operating on short waves and the reaction control functions without difficulty over the whole range. To prevent over-oscillation, this coupling coil has a 10,000 ohms resistor in parallel with it. On medium and long waves the coupling is normal, the small short-wave coil S_6 having practically no effect on reception.

In order to suppress parasitic oscillation on very short wavelengths the grid lead to the output valve EL 3 is made from a 1,000 ohm spiralized resistor, whilst a resistor of 400 ohms is included in the lead to the screen grid. The cathode of the EF 6 is connected to a 3,200 ohm resistor (R_5) with a 0.1 μF decoupling capacitor C_8 to raise it above earth potential, thus providing the necessary bias for A.F. amplification when the set is used for gramophone reproduction. When the pick-up is connected to the set the grid will be at earth potential, owing to the low internal resistance of the pick-up itself, in which case R_4 ceases to function.

As regards assembly of the chassis, it is essential to fit a screen between the detector and output valves; moreover, the pick-up sockets should not be too close to the loudspeaker sockets, since the high amplification produced by the two valves may otherwise give rise to A.F. feed-back.

The AZ 1 is employed as rectifier, and the smoothing circuit consists of two electrolytic capacitors of 32 μF each and a resistor of 4,000 ohms. The no-load voltage from the power transformer should be 2 × 240 V. The total current used is about 42 mA.

TABLE OF COILS

Coil	Number of turns	Type of winding	Diameter of former	Diameter of wire mm	Type of wire
S1	175	wave		15 × 0.05	R.F. Litz
S2	580	,,		0.1	Enamelled
S3	6	layer		0.8	d.s.c.
S4	2 × 48	wave	20 mm	15 × 0.05	R.F. Litz
S5	258	,,		0.1	Enamelled
S6	7	layer		0.3	,,
S7	8	,,		0.1	,,
S8	35	,,		0.1	,,

Diameter of can = 48 mm.

Circuits
for A.C./D.C. receivers

IX. 7-Valve superheterodyne receiver for 220 V mains

Valves used: "Miniwatt" CK 3, EF 9, EBC 3, CL 4, CY 1, EM 1, C 1.

Apart from the supply section and the valves employed, this receiver circuit is identical with the 6-valve receiver, Circuit V. The wavebands and coils are the same, as also the main features of the circuit; sensitivity is 16 μV. The wave ranges are as follows:

Long waves	830—2,000 m
Medium waves	200— 547 m
Short waves	15— 48 m.

Connection of heaters

The valve heaters and the pilot lamp are all in series with a barretter, type C 1, and the sequence of the heaters is so arranged that ripple from the mains is kept as low as possible; the heater of the EBC 3 is accordingly earthed.

Anode voltage

The rectifier is the CY 1. Since one side of the mains is applied directly to the chassis, capacitors are included in the aerial, earth and gramophone connections. The chassis as such must therefore never be earthed and has to be mounted in the cabinet in such a way that it cannot be touched when live. For the smoothing circuit two electrolytic capacitors of 32 μF (320 V) and an 8 H choke are used. The total amount of current consumed is about 77 mA.

TECHINICAL DATA

1. *Sensitivity* (for an output of 50 mW) on the medium- and long-wave bands:

at the diode	0.5 $V_{(eff)}$	I.F. stage gain: 100
at the I.F. valve	5 $mV_{(eff)}$	Conversion gain factor: 100
at the mixer valve (octode)	50 $\mu V_{(eff)}$	Voltage gain factor: 3
at the aerial	16 $\mu V_{(eff)}$	

2. *Selectivity*

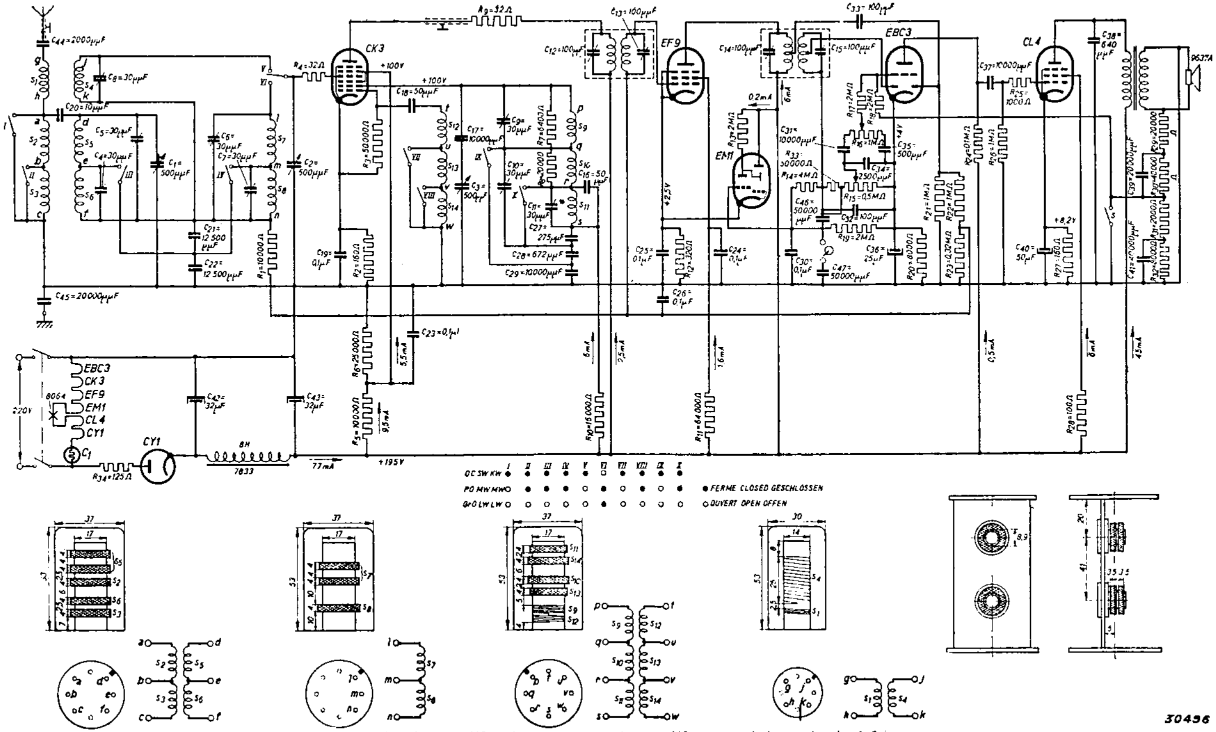
Attenuation on detuning	+ 4.5 and — 4.5	kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8	,,	1 : 100
,, ,, ,,	+ 13 and — 13	,,	1 : 1,000

3. *Automatic gain control curve*

1 ×	normal input voltage corresponds to	1 ×	normal output voltage
5 ×	,, ,, ,, ,, ,,	5 ×	,, ,, ,,
10 ×	,, ,, ,, ,, ,,	8 ×	,, ,, ,,
100 ×	,, ,, ,, ,, ,,	18 ×	,, ,, ,,
1,000 ×	,, ,, ,, ,, ,,	30 ×	,, ,, ,,
10,000 ×	,, ,, ,, ,, ,,	42 ×	,, ,, ,,

TABLE OF COILS

For details of the coils in this receiver reference may be made to Circuit IV.



Circuit given without any guarantees with respect to patent rights.

X. 5-Valve superheterodyne receiver for 110 V mains

Valves used: "Miniwatt" CK 3, EF 9, EBC 3, CL 6, CY 1.

In principle this circuit is the same as Circuit IX for a 7-valve receiver. As the operating voltage is 110 V, however, the mixer valve is connected in a different manner, and no tuning indication is provided. The power section is also different. The receiver has a sensitivity of about 18 μV.

The output valve is the CL 6, which, in spite of the low anode voltage available, delivers a relatively large amount of power. The receiver employs the same coils as those used in the 220 V model, and the wavebands are:

Long waves	830—2,000 m
Medium waves	200— 547 m
Short waves	15— 48 m.

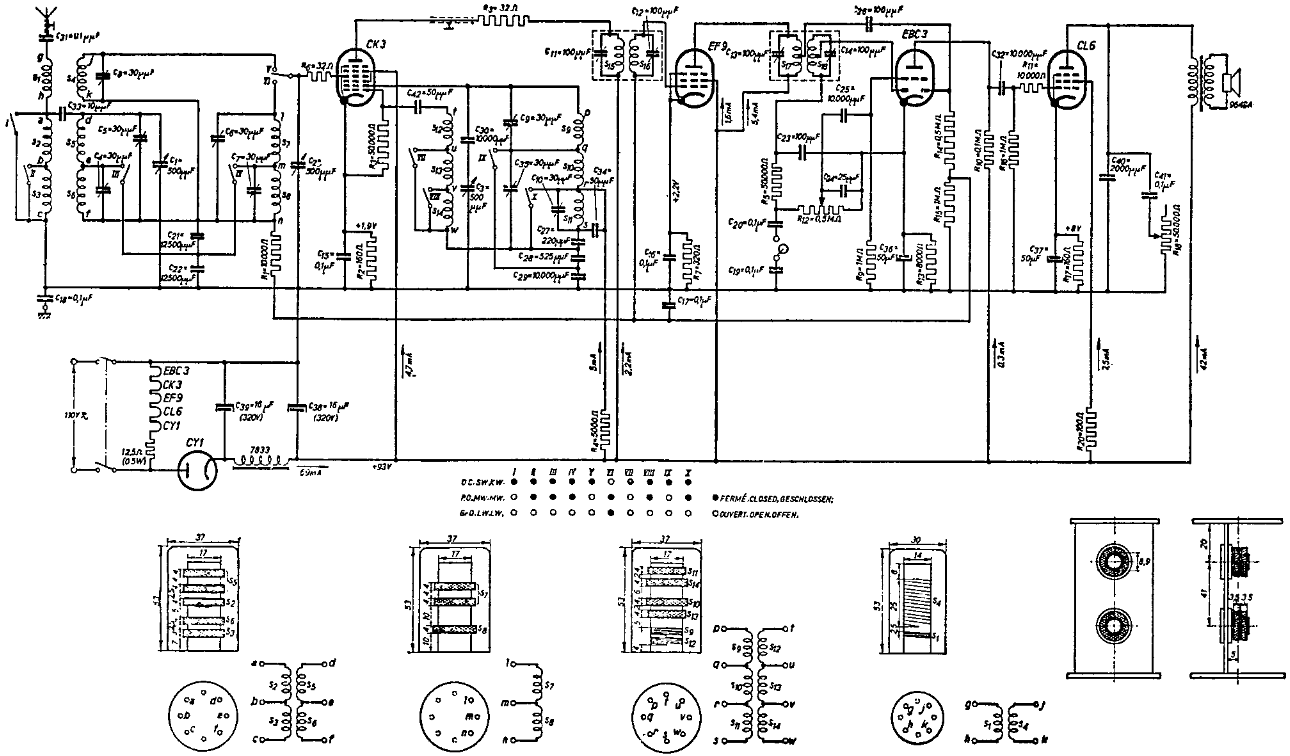
For the R.F. circuits reference may be made to the description of the 6-valve A.C. Circuit (IV).

To minimize frequency drift, the oscillator circuit is connected to the second grid of the octode CK 3, which is included in the A.G.C. system on all wave bands.

The three oscillator coils are wound on a common former. Padding capacitors are in series with the coils and are included in the coil switching. Owing to the fact that the available anode voltage is low, the resistor R_4 should not exceed 5,000 ohms and this resistor is placed between S_{10} and S_{11} in order to avoid the circuit losses that would occur if the arrangement in Circuit IX was employed. Apart from inductive reaction, capacitive coupling is also provided, the lower end of the coupling coil being connected to the padding capacitor.

As the tuning capacitor would otherwise be live, an insulating capacitor C_{30} is fitted. The values of the padding capacitors are about 525 $\mu\mu$F for the medium waveband and about 165 $\mu\mu$F for long waves, the latter value being obtained by connecting a capacitor of 220 $\mu\mu$F in series with the medium-wave padding capacitor. C_{29} is an insulating capacitor, which in no way affects the padding.

The intermediate frequency is 470 kc/s and the I.F. coils are the same as those used for Circuit VI; in the present circuit, however, the I.F. valve has a fixed screen voltage. A tone control is included in the anode circuit of the output valve and consists of a capacitor of 0.1 μF with a 50,000 ohms variable resistor in series with it. The rectifying valve is the CY 1; the smoothing choke should be of 8 H. The total current consumed is about 69 mA. In this circuit the valve heaters are in series with the pilot lamp and a resistor of 12.5 ohms (0.5 W), the sequence of the heaters being so arranged that mains ripple is kept as low as possible.



Circuit given without any guarantees with respect to patent rights.

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TECHNICAL DATA

1. *Sensitivity* (50 mW output) on the medium and long wavebands:

at the diode	0.5 $V_{(eff)}$	I.F. stage gain: 100
at the I.F. valve	5 $mV_{(eff)}$	Conversion gain factor: 100
at the mixer valve (octode)	50 $\mu V_{(eff)}$	Voltage gain factor: 3
at the aerial	18 $\mu V_{(eff)}$	

2. *Selectivity*

Attenuation on detuning + 4.5 and — 4.5 kc/s: 1 : 10
„ „ „ + 8 and — 8 „ 1 : 100
„ „ „ + 13 and — 13 „ 1 : 1,000

3. *Automatic gain control curve:*

1 × normal input voltage corresponds to 1 × normal output voltage
5 × „ „ „ „ „ 5 × „ „ „
10 × „ „ „ „ „ 18 × „ „ „
100 × „ „ „ „ „ 30 × „ „ „
1,000 × „ „ „ „ „ 42 × „ „ „

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former (mm)	Dia. of wire (mm)	Type of wire
S1	13	—	close	14	0.1	Enamel
S2	180	—	wave	17	0.1	„
S3	680	—	„	17	0.1	„
S4	12	—	close	14	1	„
S5	2×58	(S2, S3 and S6 shorted) 160 μH	wave	17	15×0.05	Litz
S6	310	S5 + S6 (S2 + S3 shorted in series) = 2,150 μH	„	17	0.1	Enamel
S7	2×57	(S8 shorted) 160 μH	„	17	15×0.05	Litz
S8	294	S7 + S8 = 2,150 μH	„	17	0.1	Enamel
S9	7	—	close	17	0.5	„
S10	54	S9 + S10 (S11 shorted) = 75 μH	wave	17	0.1	„
S11	99	S9 + S10 + S11 = 320 μH	„	17	0.1	„
S12	7	—	close	17	0.1	„
S13	35	—	wave	17	0.1	„
S14	40	—	„	17	0.1	„
S15 S16 S17 S18	2×130	—	„	8.9 with 7 mm iron core	5×0.07	Litz

XI. 5-Valve superheterodyne receiver for 110 V mains

Valves used: "Miniwatt" ECH 3, EF 9, EBC 3, CL 6, CY 1.

This receiver circuit is similar to Circuit X, also for a 5-valve receiver, but instead of the frequency-changer CK 3 the triode-hexode ECH 3 is used. The sensitivity, 18 μV, is the same.

The three wavebands are:

Long waves	830—2,000 m
Medium waves	200— 547 m
Short waves	15— 48 m.

For details of the R.F. circuits reference may be made to the description of the 6-valve A.C. receiver, Circuit IV. The oscillator circuit is connected to the grid of the triode section of the ECH 3 and, although this arrangement produces rather more frequency drift than when the circuit is coupled to the anode, it is preferable, as it simplifies the feeding of the triode anode; the coupling coil is connected directly to the source of anode voltage, and the voltage drop which a series resistor would entail, is thereby avoided. At the same time, the amount of frequency drift is still within the necessary limits, so that the mixer valve ECH 3 can be included in the A.G.C. system on short as well as other wavebands.

The oscillator coils are also indentical with those described in Circuit IV, and the padding capacitors are again placed in series with the coils and included in the coil switching; to prevent parasitic oscillation on the long-wave band, switch VII is closed when operating in this range. The grid capacitor C_{42} is 56 $\mu\mu$F, this value ensuring reliable oscillation on long waves and a minimum of frequency drift on the short-wave band. Small stopper resistors are included in the leads to the first and third grids of the hexode unit of the valve, to suppress parasitic oscillation.

The oscillator voltage on the third grid of the hexode (and grid of the triode) should be approximately 8 $V_{(eff)}$, with 200 μA passing through R_3. The I.F. is 470 kc/s and the I.F. coils are the same as in Circuit IV; the I.F. valve operates on a fixed screen potential.

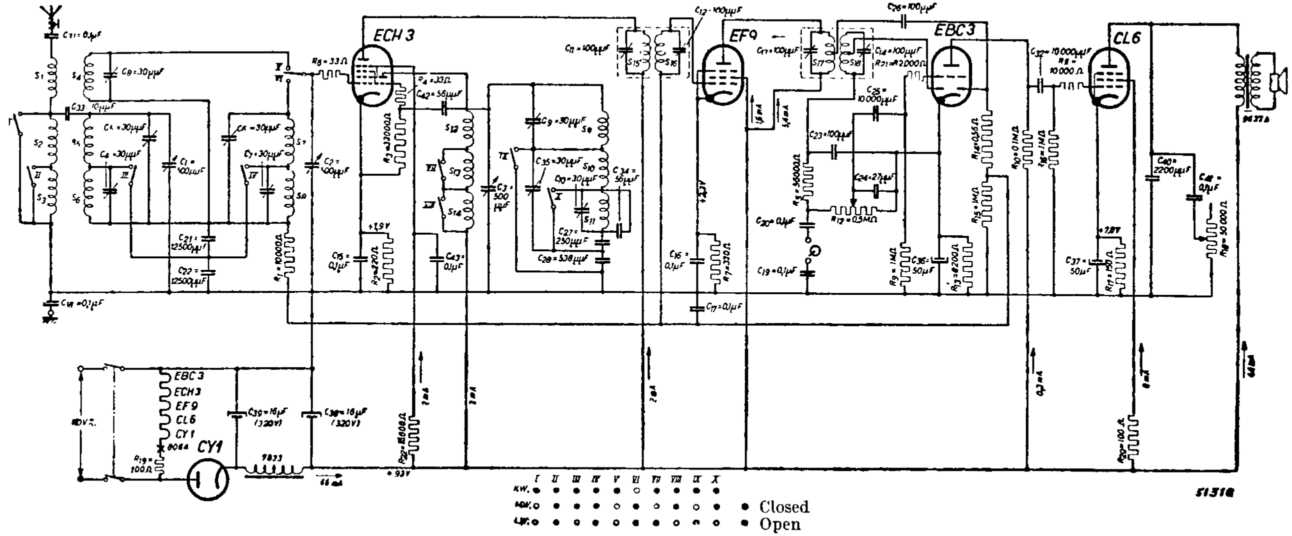
For detection, A.F. amplification, and also to provide the control voltage for the A.G.C., the double-diode triode EBC 3 is used.

The L.F. voltage is taken from the volume control R_{12}, via resistor R_{21} and capacitor C_{25} to the grid of the EBC 3, R_{21} being necessary to prevent R.F. voltages from entering the A.F. section. The control grid and screen grid of the output valve CL 6 are also provided with stopper resistors. The tone control, across the primary side of the output transformer, consists of a capacitor of 0.1 μF in series with a 50,000 ohm variable resistor.

When a pick-up is used with the receiver the voltage from the former is applied to the volume control R_{12} through capacitors C_{19} and C_{20}, and a resistor R_5 of 56,000 ohms is placed in series with the volume control to avoid the detector diode being across the pick-up.

The rectifying valve is the CY 1 and the smoothing choke should be of 8 H. The total current consumed is about 66 mA.

For sketches and table of coils see Circuit IV.



Circuit given without any guarantees with respect to patent rights.

TECHNICAL DATA

1. *Sensitivity* (for 50 mW output) on the medium and long wavebands:

at the diode	0.5 $V_{(eff)}$	I.F stage gain: 100
at the I.F. valve	5 $mV_{(eff)}$	Conversion gain factor: 100
at the mixer valve (octode)	50 $\mu V_{(eff)}$	
at the aerial	18 $\mu V_{(eff)}$	Voltage gain factor: 3

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5	kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8	,,	1 : 100
,, ,, ,,	+ 13 and — 13	,,	1 : 1,000

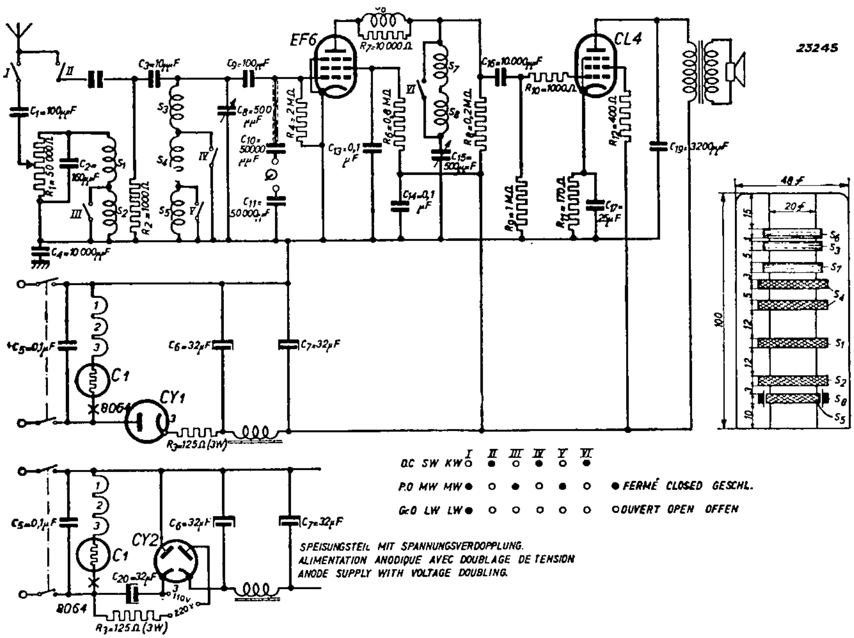
3. *Automatic gain control curve:*

1 ×	normal input voltage corresponds to	1 ×	normal output voltag
5 ×	,, ,, ,, ,, ,,	5 ×	,, ,, ,,
10 ×	,, ,, ,, ,, ,,	18 ×	,, ,, ,,
100 ×	,, ,, ,, ,, ,,	30 ×	,, ,, ,,
1,000 ×	,, ,, ,, ,, ,,	42 ×	,, ,, ,,

XII. 4-Valve receiver for reception of local stations

Valves used: "Miniwatt" EF 6, CL 4, CY 1, C 1.

This small, "straight" receiver for A.C./D.C. mains operation has three wavebands and is similar to the A.C. model, Circuit VIII, with the exception of the heater-supply and high-tension circuits. The heating circuit is as shown in the diagram. When the half-wave rectifying valve CY 1 is fitted, the receiver is suitable for A.C. and D.C. mains of 220—250 V, but details of a voltage-doubling arrangement employing the full-wave rectifying valve CY 2 are also given; in this case the receiver will also operate on 110—127 V A.C. mains when the points marked "110 V" in the diagram are short-circuited. With the points "220 V" shorted, the circuit is the same as for the CY 1 and the set can be run on A.C. and D.C. 220—250 V supplies. Where the voltage-doubling circuit is employed, that is, on 110—127 V A.C. mains, the barretter C 1 is replaced by a resistor of 175 ohms (10 W) or, if no pilot lamp is to be fitted, it is advisable to use the C 2 instead of this resistor.



Circuit given without any guarantees in respect of patent rights.

As one side of the mains is connected to the chassis, capacitors are placed in series with the aerial, earth and pick-up connections [1]; the chassis must therefore never be earthed and, moreover, should be mounted in the cabinet in such a manner that it cannot be touched without breaking the mains connection.

For gramophone reproduction the EF 6 operates without any biasing resistor or decoupling capacitor, since the pick-up is insulated from the mains by capacitors C_{10} and C_{11} and will not earth the grid; it is therefore not possible to apply bias to the grid of the EF 6.

The anode voltage is smoothed by two electrolytic capacitors of 32 μF (320 V) and an 8 H choke. For details of the coils see page 344.

[1]) In this circuit the capacitor (10,000 $\mu\mu$F) in series with switch II has been omitted in error.

CIRCUITS

for battery receivers

XIII. 6-Valve superheterodyne receiver

Valves used: "Miniwatt" KF 3, KK 2, KF 4, KB 2, KC 3, KDD 1.

This circuit possesses excellent characteristics, being equipped with an R.F. pre-amplifier and a balanced output stage delivering 2 W. The wavebands covered are as follows:

Long waves	875—2,110 m
Medium waves	200— 569 m
Short waves	17— 51 m.

Batteries

1) H.T. battery 135 V
2) Grid-bias battery 3 V
3) Accumulator 2 V.

For the grid bias part of the voltage from the H.T. battery may be tapped, instead of using a separate battery.

Current consumption

The filament current is 0.77 A: when the set is used for gramophone reproduction the KF 3, KK 2 and KB 2 are switched off and the filament current is then only 0.5 A. Without an aerial input signal the H.T. current is about 12 mA, whilst with maximum excitation of the output valve the consumption is roughly 36 mA. When the set is used as a gramophone amplifier the anode current without a signal is 8 mA and with full excitation 32 mA.

Coils, capacitors and circuits

The medium-wave R.F. coils have a self-inductance of 160 μH and the long-wave coils 2,150 μH; the inductance of the short-wave coils is adjusted to approximately 1.3 μH in the receiver.

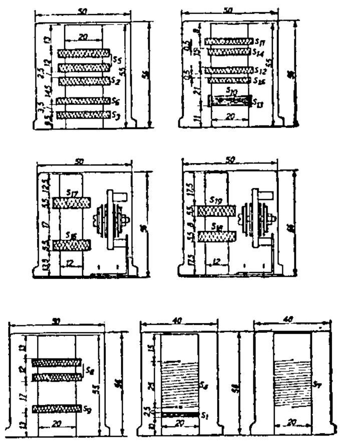


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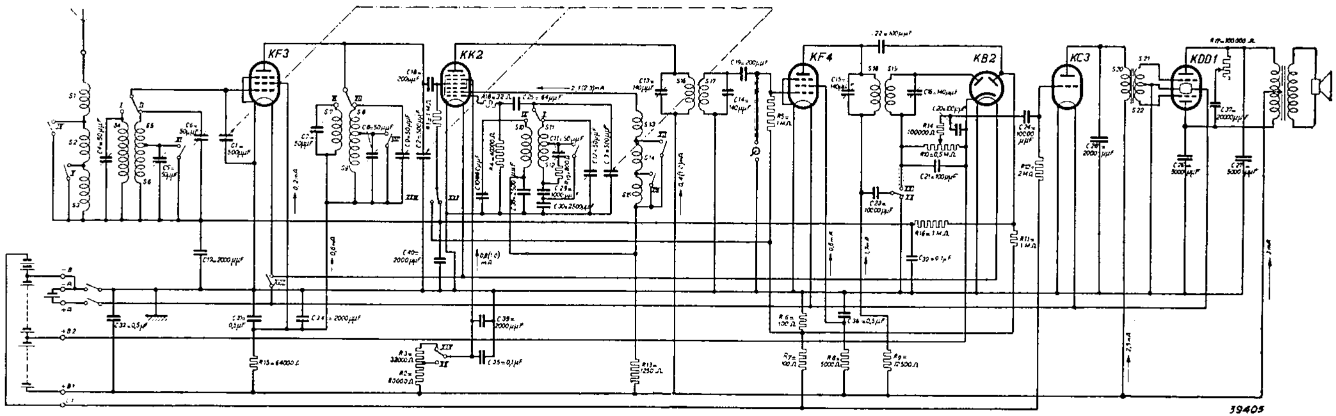
Fig. 1
Sketches of the coils used.

The R.F. coils are wound on a 20 mm diameter former, the wire used for the medium waveband being 15 × 0.05 Litz, whilst for the long waves enamelled copper wire of 0.1 mm is employed. The short-wave coils are wound on separate formers with 1 mm enamelled wire. The numbers of turns on the coils for the first and second R.F. circuits



			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVIII	XX	XXI
OC	SW	KW	●	○	○	●	●	●	○	●	●	○	●	●	●	○	●	●	●	○
PO	MW	MW	○	●	●	○	●	○	●	●	○	●	●	○	●	●	○	●	●	○
GrO	LW	LW	○	●	○	○	○	○	●	○	○	●	○	○	○	●	○	●	●	○
		Q	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●

● FERMÉ CLOSED GESCHL.
○ OUVERT OPEN OFFEN

Circuit given without any guarantees with respect to patent rights.

are not the same, as the self-inductance values should be similar under varying conditions. The first coil is inductively coupled to the aerial and trimming in the medium- and long-wave bands is carried out with the two coils S_1 and S_2 short-circuited; in both ranges the voltage gain amounts to a factor of about 5. The second R.F. coil is connected directly to the anode circuit of the R.F. valve, which means that the anode voltage occurs across the plates of the tuning capacitor, and if the latter is not suitable for this purpose an insulating capacitor of sufficiently high capacitance must be used.

Stray capacitance between the R.F. circuits should be kept as low as possible. On the medium waveband an oscillator coil of 128 μH is used and on long waves a coil of 987 μH, the long-wave padding capacitor being shorted simultaneously with the coil. Resistor R_{19} is a damping resistor for the suppression of parasitic oscillation. The short-wave oscillator coil is wound on the same former as the medium and long-wave oscillator coils. Padding capacitor values are approximately 2,500 $\mu\mu$F for the medium waves and 700 $\mu\mu$F for the long waves, the latter value being obtained by connecting about 1,000 $\mu\mu$F in series with the medium-wave capacitor; the padding capacitor C_{38} in the short-wave oscillator circuit also serves to provide capacitive reaction.

The wave-change switch should be so arranged that when the receiver is switched from the long to the medium-wave band, the tuning coil S_{12} cannot be shorted in advance of the coupling coil S_{15}.

The intermediate frequency is 125 kc/s and the self-inductance of the I.F. coils is about 17.5 mH, tuning to 125 kc/s being affected by variable capacitors of approximately 140 $\mu\mu$F. Coupling between the two circuits is critical in the case of both the I.F. transformers and, since the two circuits of the second of these transformers are damped by the double-diode KB 2, the coupling between these two coils has to be tighter than in the first transformer; this explains why the spacing of the coils in the first transformer is 17 mm and that of the second 8 mm.

Calculating from the aerial to the control grid of the octode, the gain to be obtained in this receiver amounts to a factor of about one hundred on both medium and long-wave bands. Normally such a high gain would not be practicable in view of the higher harmonics of the signal frequency, which would produce too much interference in the form of whistles, but due to the high sensitivity of the circuit and the very flat A.G.C. characteristic the conductance of the R.F. valve is reduced by such a high grid bias on reception of practically all the stations concerned that the maximum R.F. gain is seldom obtained. However, on very weak stations which hardly come into consideration for general reception, when the R.F. amplification is at its highest faint whistles will be audible.

Valves

The R.F. valve has 80 V applied to both anode and screen, the total current passing through the valve thus being only 0.8 mA; a resistor, R_{15}, of 64,000 ohms is used to reduce the battery voltage to the required 80 V.

The R.F. voltage is transformed into an I.F. voltage by the octode KK 2, the current consumption of which on the medium and long-wave bands is only 3.3 mA. A potential of only 45 V is therefore applied to grids 3 and 5. To ensure reliable oscillation on the short-wave band, the voltage on these grids has to be increased to 60 V on that band and the current consumption is then 4.3 mA. In order to dispense with the switch necessitated by this arrangement, it is possible, however, to run the octode with 60 V on the 3rd and 5th grids on medium and long waves as well, but the current consumption is then naturally higher.

Automatic gain control is applied to the octode in the medium and long-wave ranges whereas on short waves a fixed potential of —1.5 V is applied to grid 4; this potential is used as the minimum grid bias for the octode on the medium and long-wave bands, as well as for the R.F. and I.F. amplifying valves. A lower bias can of course be used to increase sensitivity, but the anode current will then be somewhat higher.

The R.F. pentode KF 4 serves as I.F. amplifier, taking a total current of 2.3 mA with a grid bias of —1.5 V; this valve is not included in the A.G.C. system. The intermediate frequency is rectified by one of the diodes of the KB 2, the other diode being employed for A.G.C. purposes. The cathode of the KB 2 is connected to a tapping on the H.T. battery and the load resistor of the A.G.C. diode is at a potential of —1.5 V, so that the controlled valves also receive this bias when the control is not in operation. Consequently, the A.G.C. diode is held at a certain threshold potential which delays the control. If a voltage of 12 V (+ B 2 in the circuit diagram) is applied to the cathode of the double-diode, the control will commence working, roughly speaking, when the output valve is fully excited, assuming a signal modulated to 30 %. Owing to the strong signals occurring on the diode, the control characteristic, as from the threshold point, is extremely flat.

To drive the Class B output stage the triode KC 3 is used, this valve taking a current of 2.5 mA on a grid bias of —3 V. Two resistors, R_6 and R_7, each of 100 ohms, are connected across the bias battery; the latter therefore has to deliver a current of $\frac{3}{200} \cdot 10^3 = 15$ mA, so that when the anode current falls the grid bias is also reduced, thus preventing the KC 3 from operating on the curved part of the characteristic, with consequent serious distortion. The accumulator switch should be of the double-pole type as shown in the circuit, to break the grid-bias current when the set is switched off.

The resistors R_6 and R_7 serve also as a potential divider for the bias to be applied to the other valves.

Current from the bias battery—as also the anode current — flows in the lead marked —B, but in the opposite direction, and a milliammeter used for measuring the anode current of the receiver must not therefore be connected in that lead, but in the lead marked +B 1.

The different leads connected to the grid of the driver valve KC 3 must be as short as possible, to avoid A.F. oscillation; should they be at all lengthy, they should be screened and the screening adequately earthed. The driver transformer should have a ratio of 2 : (1 + 1); if this is any higher the maximum obtainable output is less, whilst if it is smaller the distortion is increased. Care should be taken, further, to ensure that the inductance of the primary winding is high enough to guarantee satisfactory low-note response. The correct number of turns for the primary is 2,500, with 2 × 1,250 turns on the secondary and a cross-sectional area of the iron core of 2.5 cm^2. The primary inductance is 14 H at 50 c/s, with a primary direct current of 2.5 mA.

The output valve KDD 1 comprises two matched, high-gain triodes, the anode current, of which without a grid input signal or bias, is extremely low, being only 3 mA for the two triodes together; as soon as a signal is received at the grid, the current rises, reaching 28 mA at the maximum output of 2.2 W. Practically speaking, therefore, this valve constitutes an appreciable load on the H.T. battery only when signals are being received and not in the intervals between signals.

The output transformer should be designed to give a matching resistance of 10,000 ohms between the anodes of the output valve and, to suppress any tendency towards accentuated treble response, capacitors of 5,000 $\mu\mu$F are connected across the primary windings. Capacitor C_{37}, which in conjunction with the variable resistor R_{17} is placed across the whole primary winding, serves as a tone control. Resistor R_{17} should be at least 0.1 megohm; otherwise too much of the power delivered by the KDD 1 will be absorbed.

The amplification of the KC 3 is not sufficient for gramophone reproduction and the I.F. valve KF 4 is therefore used alternatively as an A.F. amplifying valve. Resistor R_9, which decouples the anode voltage on radio reception, functions as a load resistor for gram. reproduction, whilst C_{23} is a decoupling capacitor on radio and a blocking capacitor on gram.

As the leads to the pick-up sockets are usually fairly long, they should be screened. The signal from the pick-up is applied to the grid of the KF 4; capacitor C_{19}, of 200 $\mu\mu$F, provides a sufficiently high impedance to the A.F. voltages to prevent the pick-up from being shorted by the coil S_{17}, and this capacitor is also large enough to allow the I.F. voltage present during radio reception to pass without attenuation to the grid of the KF 4, so that it is not necessary to employ a separate switch. It is essential, however, when changing back from gramophone to radio reception, to remove the pick-up plugs from the set, although if it is found preferable to leave them connected a separate switch can be provided to break the connection.

On gramophone reproduction the KF 4 receives no bias, since the pick-up is connected to the chassis, in consequence of which the gain, and also the anode current of this valve, will be slightly higher.

TECHNICAL DATA

1. *Sensitivity* (for 50 mW output) on the medium and long-wave bands:

I.F. signal:		
at the diode	0.9 $V_{(eff)}$	I.F. stage gain: 30
at the grid of the I.F. valve	30 $mV_{(eff)}$	
R.F. signal:		Conversion gain factor: 30
at 4th grid of octode	1 $mV_{(eff)}$	R.F. stage gain: 20
at the grid of the R.F. valve	50 $\mu V_{(eff)}$	Voltage gain factor: 5.
at the aerial	10 $\mu V_{(eff)}$	

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5	kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8	,,	1 : 100
,, ,, ,,	+ 13 and — 13	,,	1 : 1,000

3. *Automatic gain control curve:* (+B 2 = 12 V).

The following points are taken from the control characteristic.

1 × normal input voltage corresponds to	1 × normal output voltage
5 × ,, ,, ,, ,,	5 × ,, ,, ,,
10 × ,, ,, ,, ,,	9 × ,, ,, ,,
100 × ,, ,, ,, ,,	14 × ,, ,, ,,
1,000 × ,, ,, ,, ,,	20 × ,, ,, ,,
10,000 × ,, ,, ,, ,,	25 × ,, ,, ,,

TABLE OF COILS

Coil	Number of turns	Self-inductance	Dia. of wire (mm)	Type of wire
S1	13	Approx. 8 μH	0.1	Enamelled
S2	160	Approx. 800 μH	0.1	,,
S3	570	S2 + S3 = appr. 10.5 mH	0.1	,,
S4	10	Approx. 1.3 μH *)	1	,,
S5	2 × 49	160 μH *)	15 × 0.05	Litz
S6	263	S5 + S6 = 2,150 μH *)	0.1	Enamelled
S7	9	approx. 1.3 μH	1	,,
S8	2 × 48	160 μH	15 × 0.05	Litz
S9	249	S8 + S9 = 2,150 μH	0.1	Enamelled
S10	6	approx. 1.3 μH	0.5	,,
S11	67	128 μH	0.1	,,
S12	165	S11 + S12 = 987 μH	0.1	,,
S13	6	—	0.1	,,
S14	40	—	0.1	,,
S15	67	—	0.1	,,
S16, S17, S18, S19	1,080	approx. 17.5 μH	0.1	,,

*) measured with shorted coupling coil.

XIV. 6-Valve superheterodyne receiver

Valves used: "Miniwatt" KF 3, KK 2, KF 3, KBC 1, 2 × KL 4.

This is a modified version of Circuit XIII for a 6-valve battery receiver; in place of the double-triode KDD 1 in the output stage, two output pentodes KL 4 are used in Class B. The maximum output delivered is slightly lower, but the quality of reproduction is better, owing to the absence of grid current in the output stage.

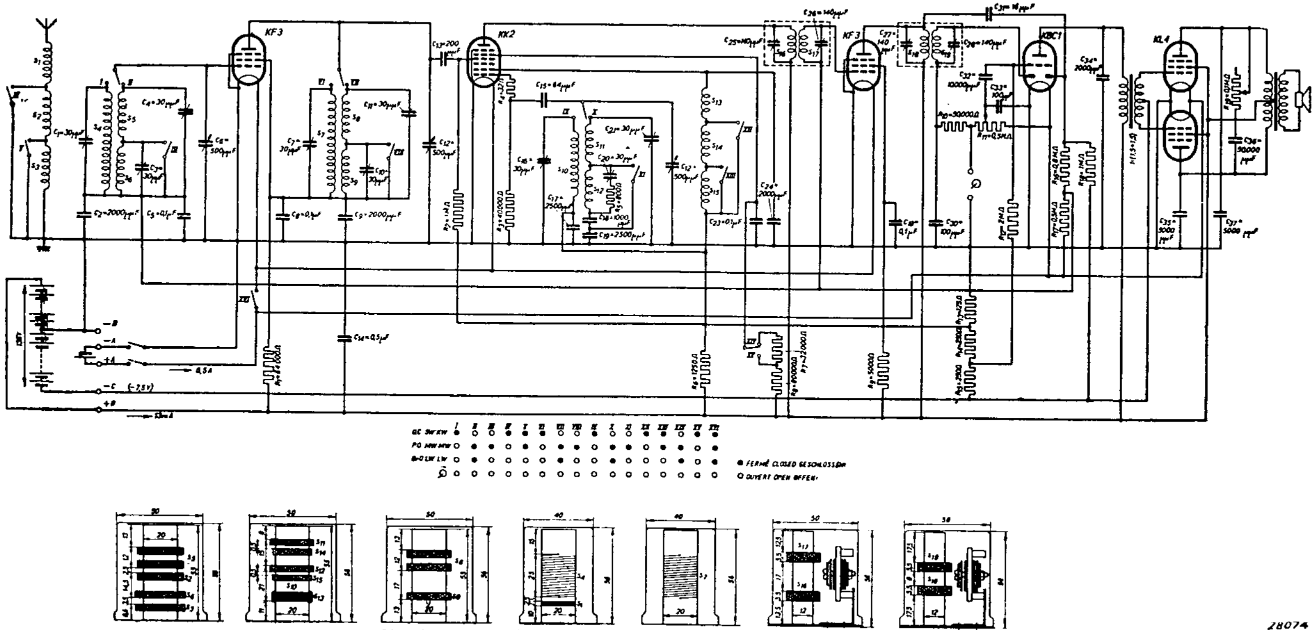
The KBC 1 is used as driver, the anodes of this valve being employed for detection and delayed A.G.C. respectively. A 7.5 V grid-bias battery is required for the output stage.

Delay for the A.G.C. system is obtained from the potential divider, consisting of R_{18}, R_{16} and R_{17} and connected between the negative side of the G.B. battery and L.T. positive. As the diode anode used for the A.G.C. is located near the positive end of the filament, the delay is about $\frac{1.3}{2.3}$ (7.5 + 2) = 5.4 V.

Obviously the potential divider R_{16}-R_{17} reduces the control voltage somewhat, but the A.G.C. is nevertheless sufficiently effective. As the A.F. sensitivity of this circuit is higher than that of the receiver employing the KDD 1, the variations in the alternating voltages in the anode circuit of the I.F. valve are not so great and this valve can be included in the A.G.C. circuit; it is thus possible to use the KF 3 instead of the KF 4. In view of the fact that the R.F. valve is also controlled, it is not necessary to control the frequency-changer and the inevitable frequency drift is avoided. The A.F. sensitivity is adequate for record playing and in this case the I.F. valve need not function as pre-amplifier for that purpose.

For data regarding the tuned circuits, reference may be made to the receiver incorporating the KDD 1.

A driver transformer wiht a ratio of 1 : (1.5 + 1.5) is used in the output stage.



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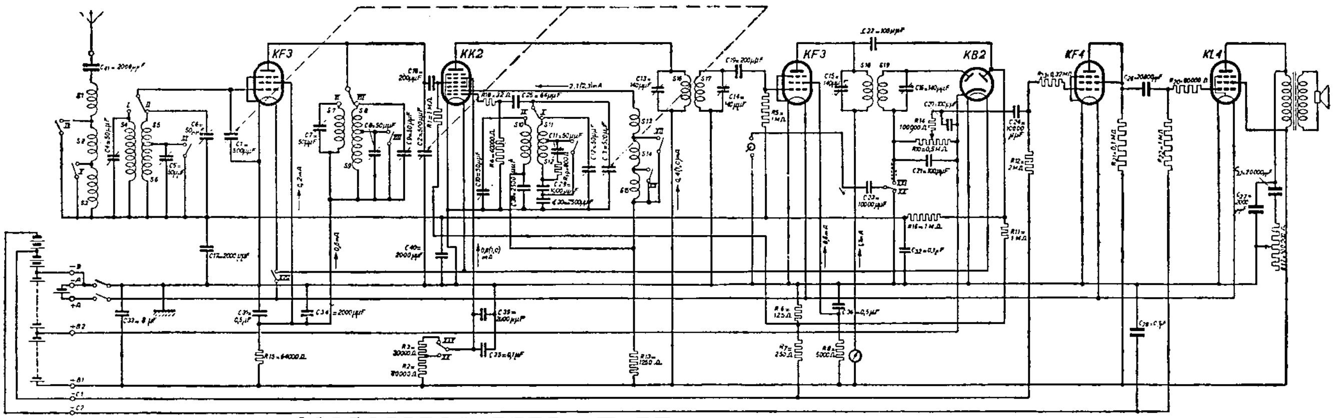
XV. 6-Valve superheterodyne receiver

Valves used: "Miniwatt" KF 3, KK 2, KF 3, KB 2, KF 4, KL 4.

This circuit differs from Circuit XIV in the arrangement of the output, detector and A.F. amplifier stages; only one pentode KL 4 is used instead of two in Class B, with the KF 4 as resistance-coupled pre-amplifying valve.



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			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVIII	XX	XXI
OC	SW	KW	●	○	○	●	●	●	○	●	●	○	●	●	●	○	●	●	●	○
PO	MW	MW	○	●	●	○	●	○	●	●	○	●	●	○	●	●	○	●	●	○
Gr.O	LW	LW	○	●	○	○	○	○	●	○	○	●	○	○	○	●	○	●	●	○
		⚲	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●

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○ OUVERT OPEN. OFFEN

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XVI. 4-Valve superheterodyne receiver

Valves used: "Miniwatt" KK 2, KF 3, KBC 1, KL 4.

This is an extremely simple receiver without an R.F. stage, the sensitivity being, therefore, relatively low. The three wavebands covered are as follows:

Long waves	875—2,100 m
Medium waves	200— 559 m
Short waves	17— 51 m.

Batteries

1) H.T. battery 135 V
2) Grid-bias battery 7.5 V
3) Accumulator 2 V.

Instead of a separate grid-bias battery, a tapping on the H.T. battery may be used.

Coils, capacitors and circuits

In the medium and long-wave bands the frequency-changer is preceded by a band-pass filter, but on short waves this gives place to a single tuned circuit. The self-inductance values of the R.F. coils are 160 μH for the medium-wave band and 2,150 μH for the long waves; the inductance of the short-wave coil is adjusted to about 1.3 μH in the receiver. The R.F. coils are wound on a former 20 mm in diameter, with Litz wire 15 × 0.05 mm for the medium-wave range and 0.1 mm enamelled copper wire for the long waves; the short-wave coil is separate.

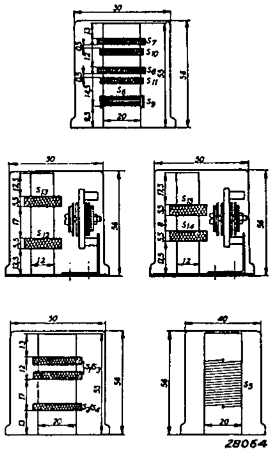
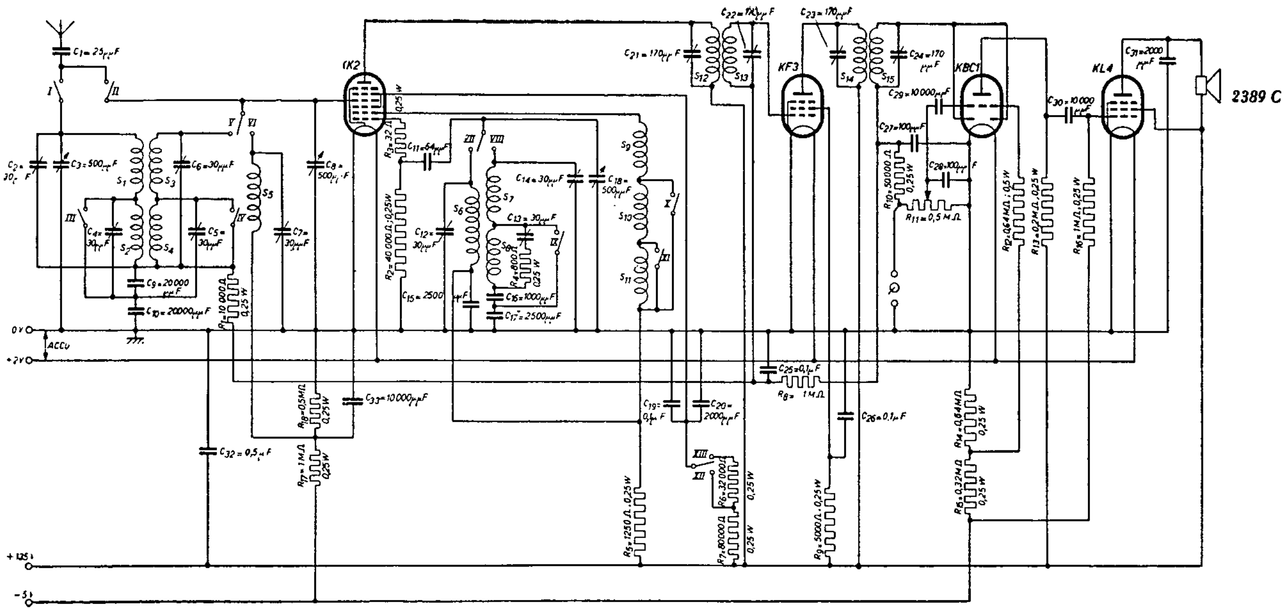


Fig. 1
Sketches of the coils.

In the medium-wave band the oscillator-coil inductance is 128 μH and in the long-wave range 987 μH, the padding capacitor for the latter waveband being switched simultaneously with the coil. R_4 is a damping resistor for suppressing parasitic oscillation. The short-wave oscillator coil is wound on the same former as the other oscillator coils. Padding capacitor values should be approximately 2,500 $\mu\mu$F for the medium-wave band and about 700 $\mu\mu$F for the long waves, the latter value being obtained by connecting roughly 1,000 $\mu\mu$F in series with the medium-wave padding capacitor.

C_{13} fulfils a double function in serving also to establish capacitive coupling. The wave-change switch should be so arranged that when the receiver is switched from the long-wave to the medium band, there is no chance of shorting-out the tuning



			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
OC	SW	KW	○	●	○	○	○	●	●	○	○	●	●	●	○	
PO	MW	MW	●	○	●	●	●	○	○	●	●	○	●	○	●	○ OUVERT OPEN OFFEN
GO	LW	LW	●	○	○	○	●	○	○	●	○	○	○	○	●	● FERMÉ CLOSED GESCHL

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coil S_8 in advance of the coupling coil S_{11}. The intermediate frequency is 125 kc/s and the inductance of the I.F. coils is about 17.5 mH, the I.F. being adjusted to 125 kc/s by means of variable capacitors of capacitance about 170 $\mu\mu$F; the coupling between the circuits of both I.F. transformers is critical. The secondary side of the 2nd I.F. transformer is damped by the detector diode and the coupling of the two coils of this transformer should therefore be tighter than in the first transformer; hence the spacing of 17 mm between the coils in the first and only 8 mm in the second I.F. transformer.

Valves

The mixer valve is the KK 2, grids 3 and 5 of which are at a voltage of only 45 V on the medium and long-wave bands; on short waves this is increased to 60 V. On the former wavebands the octode is included in the automatic gain control circuit, but for short-wave operation a fixed bias of —1.5 V is applied to grid 4.

The KF 3 is used as the I.F. valve and is controlled by the A.G.C.; the intermediate-frequency signal is rectified by the parallel-connected diodes of the KBC 1.

The A.G.C. is not delayed, the control voltage being derived from the load resistor in the detector circuit; a negative potential exists across this resistor even in the absence of a signal, so that it is not necessary to provide a separate bias for the KK 2 and KF 3 valves. The output valve KL 4 is resistance-coupled to the triode section of the KBC 1.

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former (mm)	Dia. of wire (mm)	Type of wire
S1	2×48	160 μH [1])	wave	20	15×0.05	Litz
S2	249	S1 + S2 = 2,150 μH	,,	20	0.1	Enamel
S3	2×48	160 μH [2])	,,	20	15×0.05	Litz
S4	249	S3 + S4 = 2,150 μH	,,	20	0.1	Enamel
S5	9	approx. 1.3 μH	close	20	1	,,
S6	6	approx. 1.3 μH	,,	20	0.5	,,
S7	67	128 μH [3])	wave	20	0.1	,,
S8	165	S7 + S8 = 987 μH	,,	20	0.1	,,
S9	6	—	close	—	0.1	,,
S10	40	—	wave	20	0.1	,,
S11	67	—	,,	20	0.1	,,
S12, S13, S14, S15	1,080	approx. 17.5 mH	,,	12	0.1	,,

[1]) S2 shorted. [2]) S4 shorted. [3]) S8 shorted.

XVII. 4-Valve superheterodyne receiver

Valves used: "Miniwatt": KCH 1, KF 3, KBC 1, KL 5.

This is a simple battery superhet. of relatively low sensitivity, namely 180 μV on the medium- and long-wave bands. It has three ranges, viz:

Long waves	830—2,000 m
Medium waves	200— 547 m
Short waves	15— 48 m.

Automatic gain control is applied to the frequency-changer and I.F. valve on all the wavebands.

Batteries

1) H.T. battery 120 V.
2) Accumulator 2 V.

The A.F. and output valves are self-biased by means of resistors.

Coils, capacitors and circuits

On the medium- and long-wave ranges the mixer valve is preceded by a capacitively-coupled band-pass filter. The variable capacitor is of 20 to 500 $\mu\mu$F and, taking into account a minimum capacitance on the medium and long-wave bands of 50 and 70 $\mu\mu$F respectively (trimmers, wiring, etc.) and also the capacitance of the band-pass filter coupling capacitor which is in series with the tuning capacitor, the capacitive variation on the medium-wave band is 70 to 527 $\mu\mu$F and on long waves 90 to 521 $\mu\mu$F. R.F. coils of inductance 160 μH and 2,150 μH then give a medium-wave band of 199.5—547 m and a long-wave band of 829—2,000 m respectively.
On short waves a single R.F. circuit only is employed; the inductance of the short-wave coil is about 1.3 μH.
The tuned R.F. circuit, on medium and long waves, is coupled to the aerial both inductively and capacitively, giving a fairly constant voltage gain factor of 3 throughout the ranges; on short waves the aerial coupling is purely inductive.
To minimize frequency drift, the oscillator circuit is connected to the anode of the triode part of the KCH 1, thus permitting the mixer valve to be controlled also on the short-wave band.
The medium and long-wave oscillator coils are wound on the same former (see Fig. 1) and the padding capacitors are in series with the coils; on the medium and long-wave bands, moreover, the "lower" end of the coupling coil is connected to the "upper" end of the padding capacitor to ensure a more uniform oscillator voltage over the whole of the wave-range.
No padding capacitor is fitted on the short-wave band.
The anode feed is applied through a resistor R_4, the voltage being blocked from the oscillator circuit by capacitor C_{13} (parallel feed). On the medium-wave band the value of the padding capacitor should be about 538 $\mu\mu$F and on long waves approximately 180 $\mu\mu$F, but the ultimate values depend on the minimum capacitance of the circuits. The grid capacitor C_{12} is 56 $\mu\mu$F, this giving reliable oscillation on the long-wave band, with a minimum of frequency drift on short waves.
The intermediate frequency is 470 kc/s. Iron-cored coils are fitted in the I.F. circuits and the quality of these circuits is accordingly very high; the inductance of the coils is about 1 mH and the value of the capacitors in the I.F. circuit should be 100 $\mu\mu$F; these capacitors should be of the best low-loss type if the required quality of the circuit is to be attained. These circuits are trimmed by means of iron cores, which are rotated to vary the self-inductance.

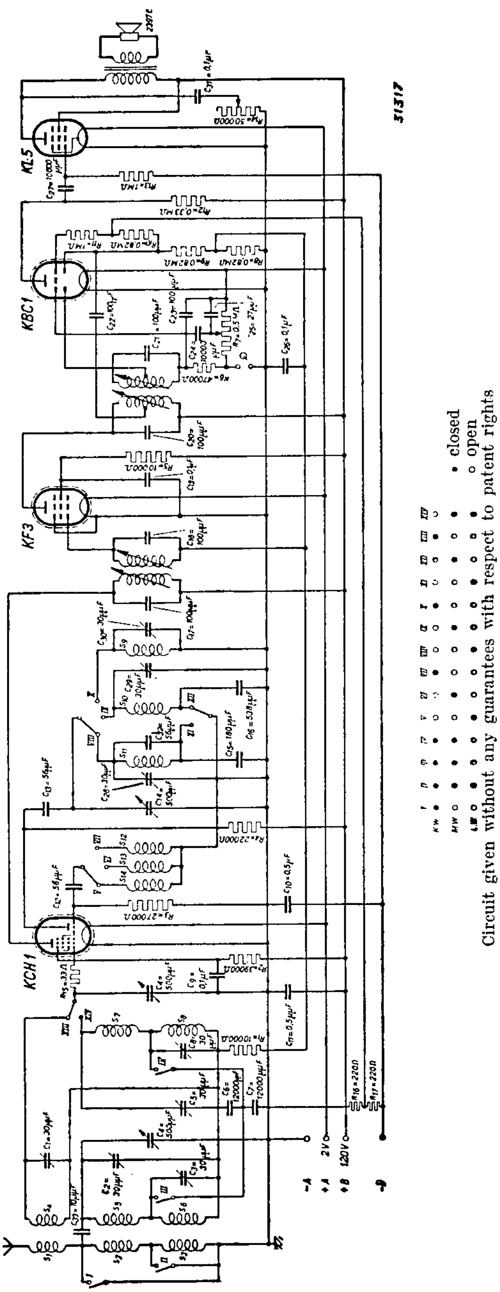
Valves

The frequency-changer is the triode-hexode KCH 1, the 2nd and 4th grids of which are fed through the resistor R_2 to suppress frequency drift.

To avoid possible parasitic oscillation a stopper resistor R_{15} is connected to the 1st grid of this valve. The oscillator voltage on the 3rd grid of the hexode section (and grid of the triode) should be 8 $V_{(eff)}$, with 180 μA passing through R_3.

The KF 3 is used as the I.F. valve, the screen being fed through a resistor; this valve is controlled by the A.G.C. For detection and A.G.C., the two diodes of the KBC 1 are employed, each of these diodes being connected to a tapping on the I.F. coils to reduce circuit losses. Delay for the A.G.C. is established in the first place by the fact that the diode anode used for this purpose is located near the positive end of the filament and, secondly, by the negative potential applied to this diode anode and obtained from the potential-divider R_8, R_9, R_{10}. The valves controlled by the A.G.C. also receive their respective bias from this potential divider when the control is not operating. It is true that only one half of the available control voltage is obtained across R_8—R_9, but this is quite sufficient to ensure a reasonably straight control characteristic.

The A.F. voltage is applied to the grid of the KBC 1 through the volume control R_7, and capacitor C_{24}. The output valve is the KL 5, which operates on a filament current of only 0.1 A; with 120 V on anode and screen, this valve will deliver an output of 0.38 W. The total current to be supplied by the H.T. battery is approximately 14 mA.



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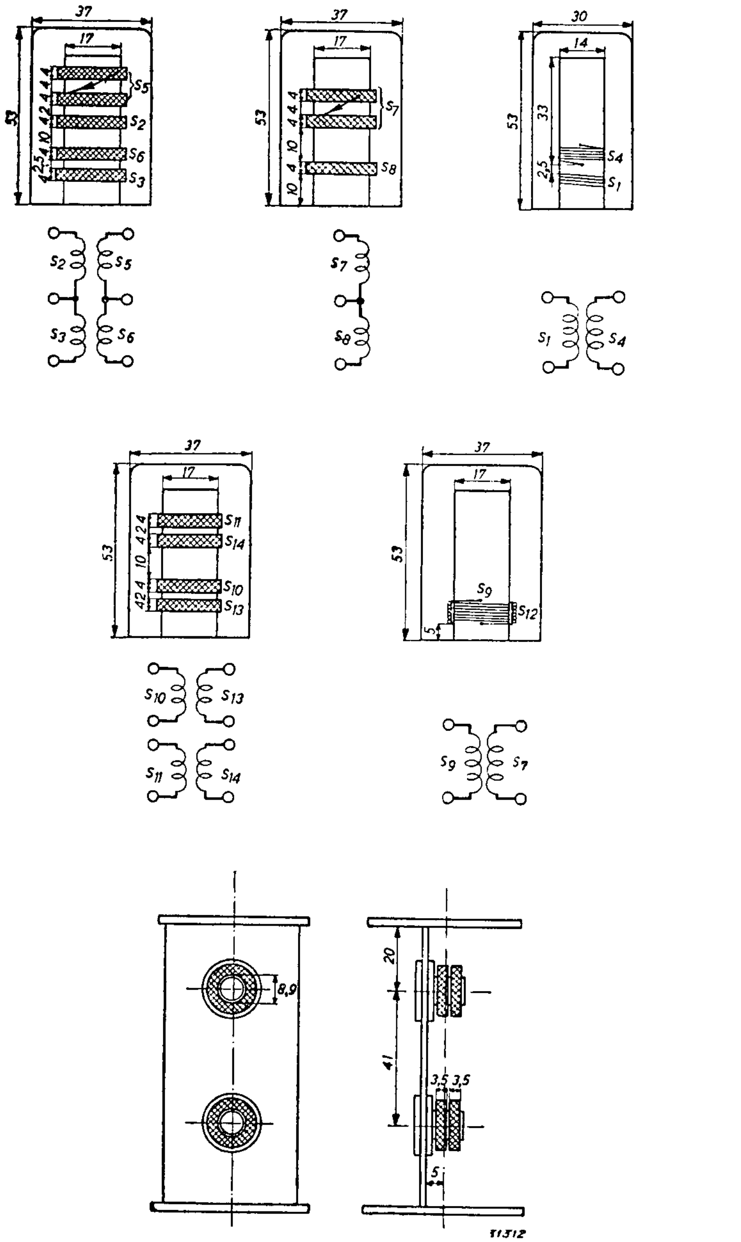


Fig. 1
Sketches of the coils used in the 4-valve receiver.

TECHNICAL DATA

1. *Sensitivity* (for 50 mW output) in the medium and long-wave bands:

at the diode	0.6 $V_{(eff)}$	I.F. stage gain: 30
at the I.F. valve	20 $mV_{(eff)}$	Conversion gain factor: 40
at the mixer valve	500 $\mu V_{(eff)}$	Voltage gain factor: 3
at the aerial	180 $\mu V_{(eff)}$	

2. *Selectivity*

Attenuation on detuning	+ 4.5 and — 4.5 kc/s:	1 : 10
,, ,, ,,	+ 8 and — 8 ,,	1 : 100
,, ,, ,,	+ 13 and — 13 ,,	1 : 1,000

3. *Automatic gain control curve*

1 × normal input voltage	corresponds to	1 × normal output voltage
5 × ,, ,,	,, ,,	3 × ,, ,,
10 × ,, ,,	,, ,,	4 × ,, ,,
100 × ,, ,,	,, ,,	8 × ,, ,,
1,000 × ,, ,,	,, ,,	16 × ,, ,,

TABLE OF COILS

Coil	Number of turns	Self-inductance	Type of winding	Dia. of former (mm)	Dia. of wire (mm)	Type of wire
S1	13	—	close	14	0.1	Enamel
S2	180	—	wave	17	0.1	,,
S3	680	—	,,	17	0.1	,,
S4	13	approx. 1.3 μH	close	14	1	,,
S5	2×58	160 μH [1]	wave	17	15×0.05	Litz
S6	310	S5 + S6 = 2,150 μH [2]	,,	17	0.1	Enamel
S7	2×57	160 μH [3]	,,	17	15×0.05	Litz
S8	294	S7 + S8 = 2,150 μH [3]	,,	17	0.1	Enamel
S9	7	approx. 1.3 μH	close	17	0.5	,,
S10	59	75 μH	wave	17	0.1	,,
S11	118	320 μH	,,	17	0.1	,,
S12	7	—	close	17	0.1	,,
S13	35	—	wave	17	0.1	,,
S14	40	—	,,	17	0.1	,,
S15, S16, S17, S18	2×130	—	,,	Iron core 7 mm	5×0.07	Litz

1) S2, S3 and S6 shorted.
2) S2 + S3 shorted in series
3) S8 shorted.

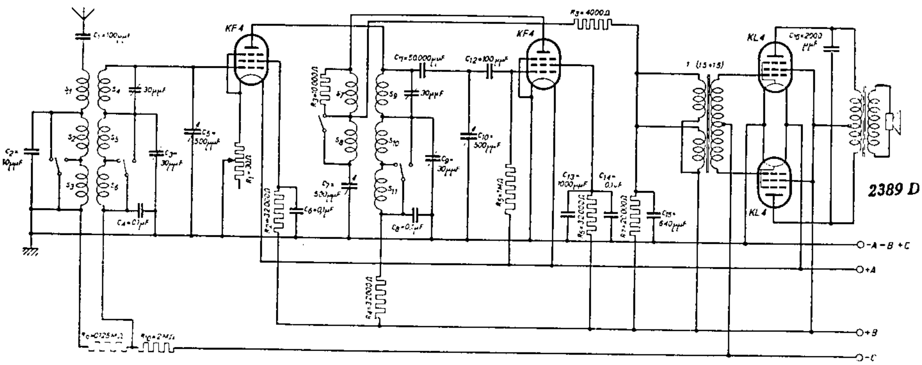
XVIII. 4-Valve, 2-circuit cascade receiver

Valves used: "Miniwatt" KF 4, KF 4, 2 × KL 4.

This is a simple receiver circuit employing an R.F. stage and grid detector with reaction. The three wavebands are as follows:

Long waves	805—2,080 m
Medium waves	199— 558 m
Short waves	15— 50 m.

Needless to say, the requirements to be imposed on a receiver of this type must not be too severe; if the set is to be used in the vicinity of a local transmitter it will be necessary to include a wavetrap in the aerial.



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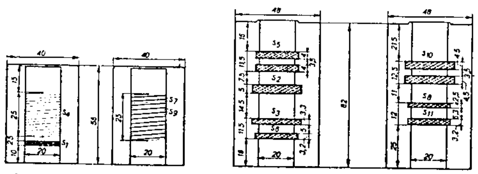
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Inductive coupling of the aerial is adopted in order to provide uniform sensitivity throughout the wavebands and to minimize the effect of the aerial upon the losses and tuning of the circuit.

Capacitors of 20 to 500 $\mu\mu$F, in conjunction with a self-inductance of 160 μH, will give a medium waveband of 199 to 558 m, and with 2,150 μH a long-wave range of 805—2,050 m. The inductance values of the aerial coils S_2 and S_3 are 800 and 10,750 μH respectively. As the wiring affects the short-wave inductances, it is not possible to give an exact figure for that waveband, but the number of turns indicated in the Table of Coils will give roughly the required range; the inductance values may be corrected in the receiver by adjusting the spacing of the turns on the coils.

The R.F. valve is the KF 4 and the volume is controlled by varying the filament current of this valve, which, moreover, operates on a fixed grid bias of —1.5 V. In the second circuit the same self-inductances are employed as in the first, although the numbers of turns are slightly fewer, since there are no coupling coils in this circuit. The same coupling coil serves both the medium and long-wave bands.

Pentode KF 4 is used as grid detector and the output stage is coupled to it by a driver transformer of ratio 1 : (1.5 + 1.5).
As shown in the circuit diagram, the winding of the latter is in two equal sections, with the two primary windings in parallel. This ensures a symmetrical arrangement, with equal capacitances of the windings on the grids of the valves. A resistor of 20,000 ohms is connected across the primary side of the transformer, to ensure uniform frequency response. The grid bias for the output valve should be adjusted so as to give a total combined current on the two output valves of about 3 mA, with no signal. Sensitivity depends on the setting of the reaction control, but averages about 400 μV.

TABLE OF COILS

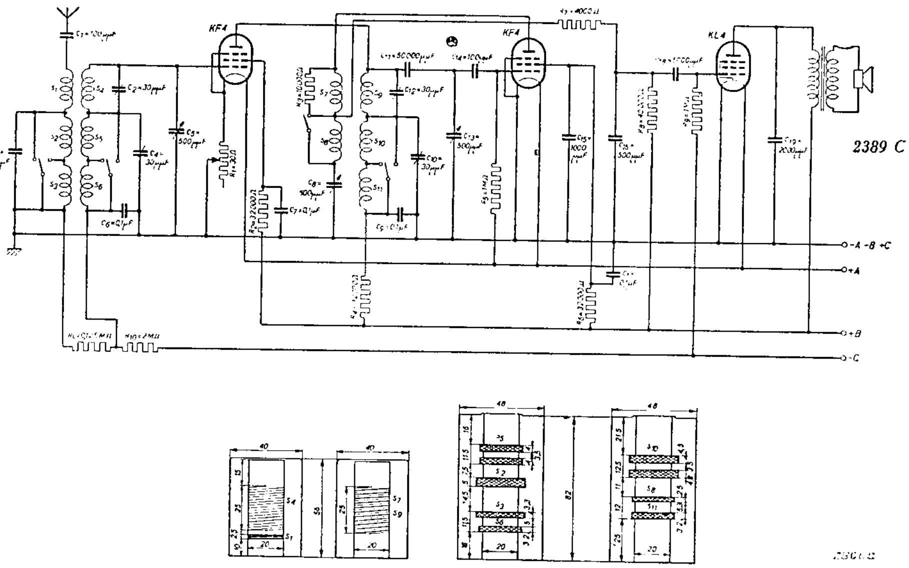
Coil	Number of turns	Self-inductance	Type of winding	Dia. of former (mm)	Dia. of wire (mm)	Type of wire
S1	13	—	close	20	0.1	Enamel
S2	175	approx. 800 μH	wave	20	15×0.05	Litz
S3	580	approx. 10,750 μH	,,	20	0.1	Enamel
S4	9	—	close	20	1	,,
S5	2×48	160 μH [1])	wave	20	15×0.05	Litz
S6	258	S5 + S6 = 2,150 μH [2])	,,	20	0.1	Enamel
S7	9	—	close	20	0.15	,,
S8	28	—	wave	20	0.1	,,
S9	8	—	close	20	1	,,
S10	2×47	160 μH [3])	wave	20	15×0.05	Litz
S11	250	S10 + S11 = 2,150 μH	,,	20	0.1	Enamel

[1]) S2, S3 and S6 shorted.
[2]) S2 and S3 shorted in series.
[3]) S11 shorted.

XIX. 3-Valve, 2-circuit cascade receiver

Valves used: "Miniwatt" KF 4, KF 4, KL 4.

This circuit differs from Circuit XVIII only in the output stage, which incorporates a single pentode instead of two of these valves in Class B. The output valve is resistance-coupled to the grid of the KF 4.



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Circuit.

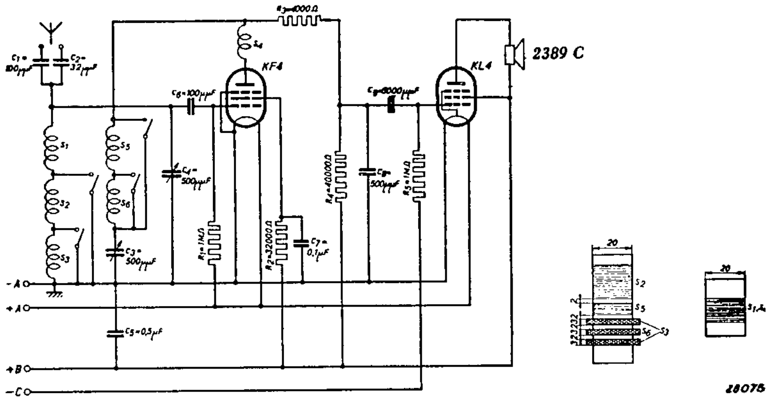
XX. 2-Valve receiver for local stations

Valves used: "Miniwatt" KF 4, KL 4.

This simple little circuit is intended for the reception of local transmitters only. It has three wavebands, viz:

Long waves:	approx.	900—2,000 m
Medium waves:	,,	200— 550 m
Short waves:	,,	15— 50 m.

The KF 4, as grid detector, is followed by a resistance-coupled output pentode KL 4.



Circuit.

TABLE OF COILS

Coil	Number of turns	Type of winding	Diameter of former (mm)	Diameter of wire (mm)	Type of wire
S1	8	close	20	0.5	Enamelled
S2	108	,,	20	0.15	,,
S3	2 × 132	wave	20	0.15	,,
S4	11	close	20	0.15	,,
S5	60	,,	20	0.1	,,
S6	80	wave	20	0.1	,,

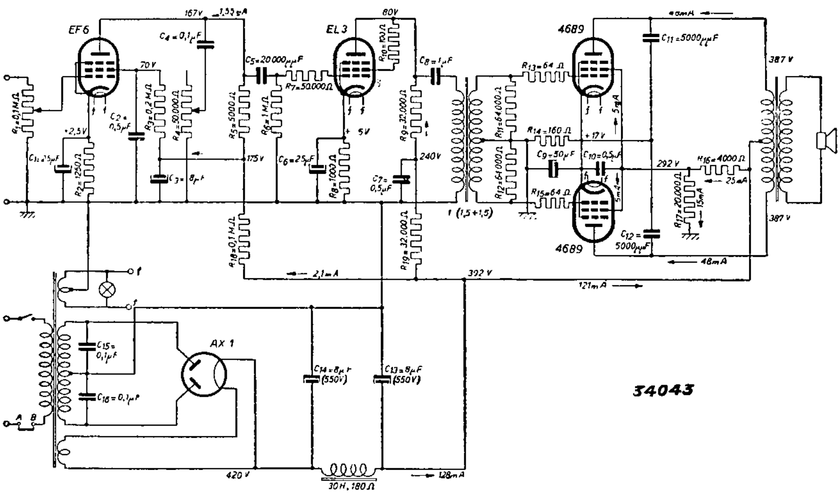
CIRCUITS
for small gramophone amplifiers

XXI. 25-Watt gramophone amplifier for A.C. mains operation

Valves used: "Miniwatt" EF 6, EL 3, 2 × 4689, AX 1.

This amplifier is equipped with Class A/B output, this stage comprising two type 4689 valves. The first pre-amplifying valve is the EF 6 and the second the EL 3, connected as a triode. No separate rectifier is needed for the bias on the output valves, as these are self-biasing.

The loudspeaker matching impedance between anodes is 6,500 ohms and the EL 3, connected as a tridoe, appears to be the best valve for the purpose from the point of view of freedom from distortion; the anode of this valve is fed through a resistor in parallel with the primary winding of the driver transformer, and a blocking capacitor is fitted to prevent the D.C. from flowing through and pre-magnetizing the transformer. The screen is connected through a 100 ohm resistor to the anode, the object of this, as also of the 50,000 ohm resistor connected to the control grid, being to prevent R.F. oscillation of this steep-slope valve. As the high gain in this circuit may give rise to hum, the anodes of the EL 3 and EF 6 are decoupled by an R-C filter.



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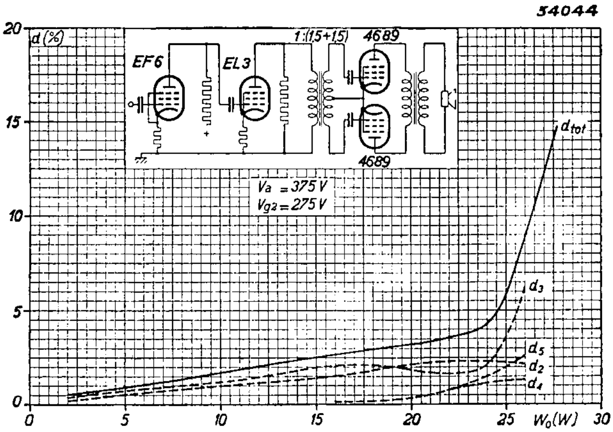
The screen voltage for the output valves is tapped from a potential divider which itself consumes 15 mA. The two halves of the A.F. transformer have resistors of 64,000 ohms in parallel with them for the purpose of smoothing the frequency response curve, but these resistors are superfluous if a very high quality transformer is used, namely with high inductance on no-load and low leakage. Capacitors of 5,000 $\mu\mu$F are connected across the anodes, also to improve the frequency response. The first pre-amplifier stage, using the EF 6, provides a stage gain of about 10, but greater amplification is not necessary, seeing that in this circuit an input signal of about 0.1 $V_{(eff)}$ is sufficient for maximum excitation of the output valves. This voltage is in excess of what the average pick-up will deliver.

The rectifier section employs the gas-filled rectifying valve AX 1, connected for full-wave rectification, and capacitors are fitted across the secondary side of the power transformer to suppress any interference that may originate in the valve. The smoothing choke should be as large as possible, say 30 H, with a D.C. resistance of 180 ohms. A lamp is connected in parallel with the heaters of the valves to serve as a signal light. With a view to the acoustic properties of the amplifier, the loudspeaker is not mounted on the amplifier chassis and, in order to avoid the possibility of damage to the output valves when the speaker lead is disconnected from the amplifier sockets, a 4-pole jack should be used; two of the contacts are for the speaker itself and the other two make the connection between points A and B, so that when the plug is withdrawn the mains connection is simultaneously opened.

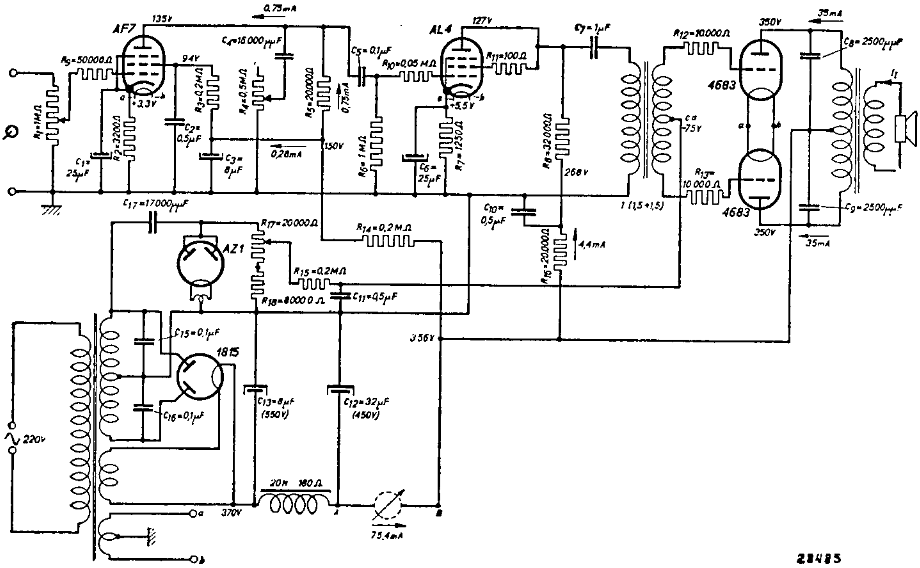


Total distortion, 2nd, 3rd, 4th and 5th harmonic distortion, as functions of the power measured at the loudspeaker.

XXII. 15-W gramophone amplifier for A.C. mains operation

Valves used: "Miniwatt" AF 7, AL 4, 2 × 4683, AZ 1, 1815.

The output stage of this amplifier comprises two 15 W triodes type 4683 in Class B, with fixed bias; the second pre-amplifying valve is the AL 4, connected as a triode and coupled to the output stage by a driver transformer having a ratio of 1 : (1.5 + 1.5). The AF 7 is used as first pre-amplifying valve, with a volume control in the grid circuit and a tone control in the anode circuit.



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The output triodes 4683 are given a fixed bias, since the optimum output power with automatic bias would be about 4.5 W less; the required bias is about —75 V, this being supplied by another rectifying valve, the AZ 1, connected for half-wave rectification and operating on one half of the secondary winding of the power transformer. Together with the internal resistance of the AZ 1, capacitor C_{17} forms a potential divider which reduces the voltage across the secondary winding to the required level of 75 V D.C., and the voltage can be further adjusted by means of R_{17}, of 20,000 ohms. With 350 V on the anode and V_g = —75 V, the internal resistance of the 4683 is about 800 ohms, which means that the anode current is to a great extent dependent on variations in the anode voltage, i.e. about 1.3 mA per volt anode-voltage variation for each valve. It is therefore always advisable to adjust the bias on the output valves so that the total current consumed by the amplifier, with no signal, will be about 75—80 mA, as measured with the milliammeter connected across points A and B. The resistor R_{15}, of 0.2 megohm, and capacitor C_{11}, of 0.5 μF, are for smoothing the grid bias.

The driver transformer, the ratio of which, as stated, is 1 : (1.5 + 1.5), is so connected that it does not carry any current.

The value of capacitor C_7 is 1 μF, this being a suitable value to favour the bass response. The first pre-amplifying valve is the AF 7, with the volume control R_1 of

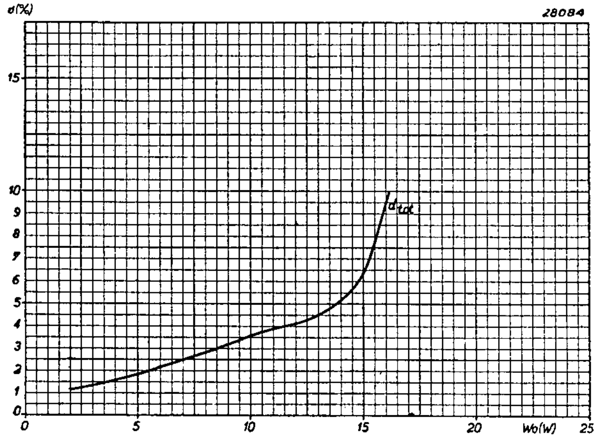


Fig. 1
Distortion in the output stage o the amplifier as a function of the power, measured at the loudspeaker

1 megohm in the grid circuit; a tone control, consisting of a potential divider R_4 (0.5 megohm) and capacitor C_4 (16,000 $\mu\mu$F), is connected across the anode circuit. The value of the coupling resistor of the AF 7 has been so selected that an alternating voltage of 0.15 V_{eff} applied to the input terminals of the amplifier will fully load the output valves.

For the valve feeds, the full-wave rectifying valve 1815 is used, with an electrolytic capacitor C_{13} of 8 μF (550 V), a choke of 20 H (180 ohms) and a second electrolytic capacitor C_{12} of 32 μF (450 V) for the smoothing. Anode voltages for the two pre-amplifying valves AF 7 and AL 4 are smoothed separately by filters $R_{14} = 0.2$ megohm, $C_3 = 8$ μF and $R_{16} = 20{,}000$ ohms, $C_{10} = 0.5$ μF.

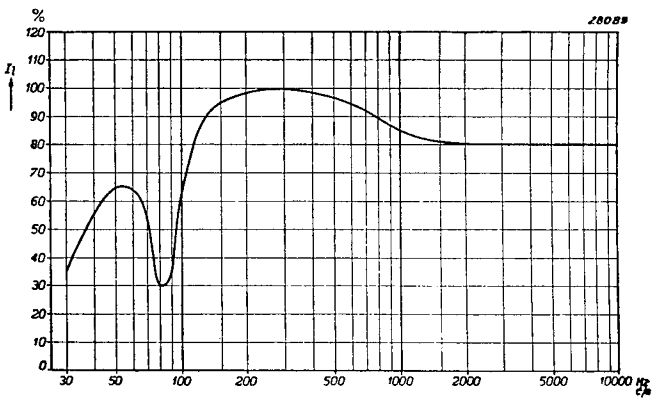
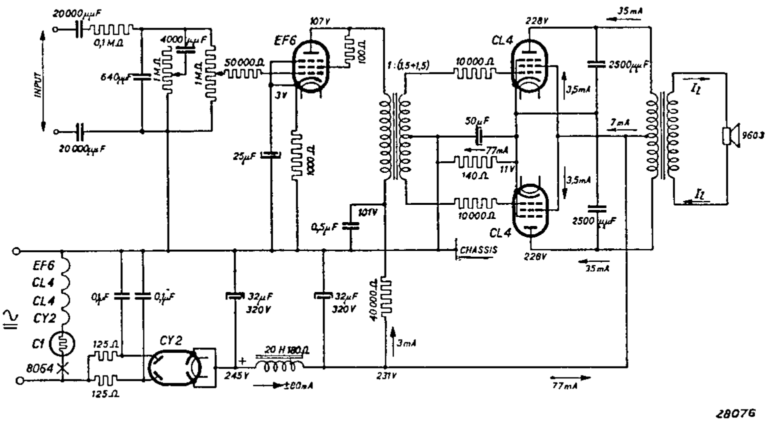


Fig. 2
Frequency response of the amplifier.

XXIII. 6-Watt gramophone amplifier for 220 V A.C./D.C. mains

Valves used: "Miniwatt" EF 6, 2 × CL 4, CY 2, C 1.

This 220 V A.C./D.C. amplifier circuit is of simple design, employing only three amplifying valves, viz. the pentode EF 6 and two output pentodes CL 4; the first of these is the pre-amplifier, connected as triode, with a resistor of 100 ohms between the anode and the screen grid to suppress parasitic oscillation. The volume and tone controls are both in the grid circuit of this valve, the former consisting of a logarithmic potential divider of 1 megohm and the latter a logarithmic potential divider with a 4,000 $\mu\mu$F capacitor. A filter is also included in the input circuit, comprising a resistor of 0.1 megohm and 640 $\mu\mu$F capacitor, for the purpose of flattening out



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the frequency response characteristic, which is fairly straight up to 7,000 c/s. The output stage, comprising two output pentodes operating in Class A/B, is coupled to the EF 6 by a driver transformer the ratio of which is 1 : (1.5 + 1.5).

The valve heaters are connected in series, as shown in the circuit diagram, i.e. from the chassis end, the EF 6, the two CL 4 valves, rectifying valve CY 2, barretter C 1 and a signal lamp 8064; this sequence will ensure the least possible amount of hum. Resistors of 125 ohms are connected to the anodes of the CY 2 to protect the rectifying valve, and smoothing is provided by two electrolytic capacitors of 32 μF (320 V), with a choke of 20 H (180 ohms). The anode voltage of the pre-amplifying valve EF 6 is further smoothed by a resistor of 40,000 ohms with a 0.5 μF decoupling capacitor. The effective output as measured at the loudspeaker is 6.2 W with 5 % distortion on an input of about 0.27 V_{eff} to the amplifier.

The input terminals of the amplifier are connected through capacitors of 20,000 $\mu\mu$F, and as they are therefore isolated from the mains they can be safely handled. On the other hand, the chassis is at mains potential and should for the sake of safety be mounted in a suitable cabinet. It is advisable to locate the input terminals as far as possible from the speaker terminals.

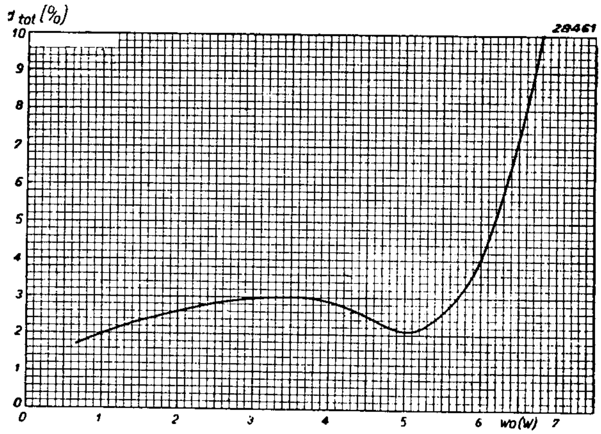


Fig. 1
Distortion in the output stage of the amplifier as a function of the output power measured at the loudspeaker.

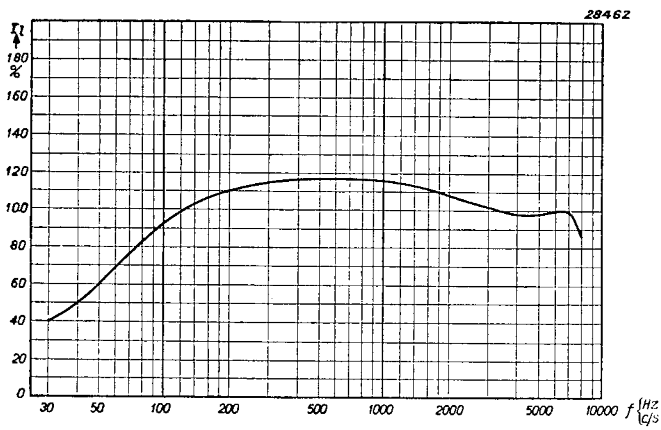
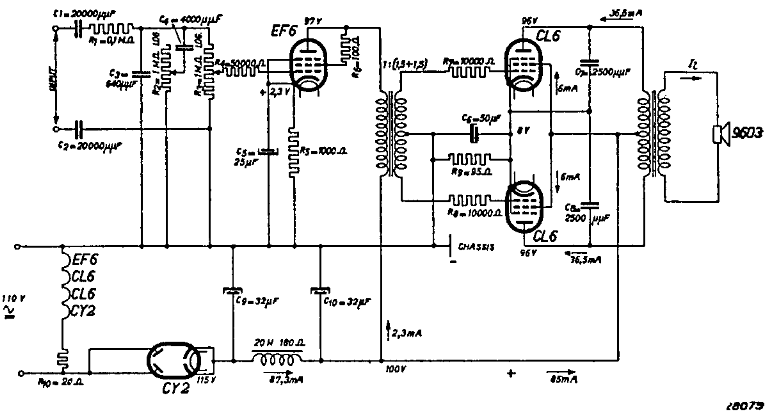


Fig. 2
Frequency response characteristic of the amplifier.
A.F current passing through the loudspeaker as a function of the frequency.

XXIV. 2-Watt gramophone amplifier for 110 V A.C./D.C. mains

Valves used: "Miniwatt" EF 6, 2 × CL 6, CY 2.

This circuit is for 110 V A.C. or D.C. mains operation. Owing to the fact that the anode voltage of the output stage is lower, the optimum output is not so great as in the case of Circuit XXIII. The output stage comprises two CL 6 valves in a balanced circuit.



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The pentode EL 6, connected as a triode, serves as pre-amplifying valve; to conserve voltage, the anode voltage of this valve is not separately smoothed, but this does not result in any noticeable hum.

The 125 ohm resistors in series with the anodes of the rectifying valve in Circuit XXIII are omitted here, in view of the lower voltage. Otherwise, the frequency-response curve is the same as that of Circuit XXIII and the output power measured on a mains supply of 110 V is shown against the distortion in Fig. 1. The power at the loudspeaker is 2.2 W with 10 % distortion, the input required to produce this being about 0.27 V_{eff}. The matching resistance in the output stage, measured between anodes, is 3,000 ohms.

The common biasing resistor for the output valves should be 95 ohms and this can be made up by using one 1 W, 100 ohm resistor and one 0.5 W, 2,000 ohm resistor in parallel. In place of the baretter in the previous circuit, a resistor of 20 ohms, 1 W, is employed,

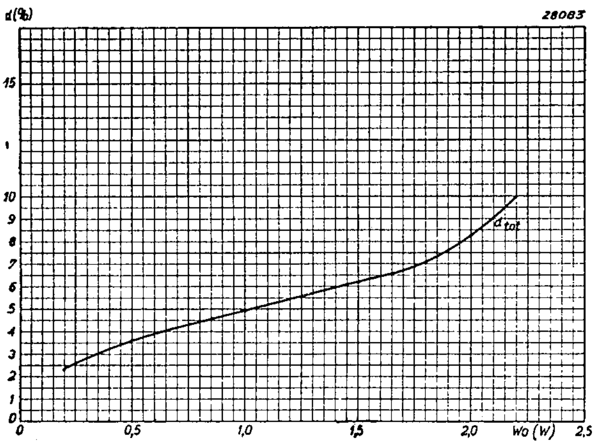

Fig. 1
Distortion in the output stage as a function of the power as measured at the loudspeaker.