application information

circuit information from the Philips building elements application laboratories

An all-transistor AM-FM receiver for mains supply

Issued by: Electronic Market Development Department

application information

127

An all-transistor AM-FM receiver for mains supply

by R. A. Pölzl

Date of release: July, 1965

CONTENTS

SUMMARY

In this bulletin a description is given of the circuit of a transistorised a.m. - f.m. mains radio employing 14 transistors, 7 diodes and a silicon bridge rectifier.
A non-conventional design in the h.f. section provides an aerial signal handling capability better than 1V both at a.m. and f.m. reception, as well as an excellent signal-to-noise ratio.
The audio amplifier contains a single ended push-pull output stage, which is driven by a complementary pair of driver transistors.
This circuit features low distorsion and a good frequency response. The music power output delivered into a loudspeaker of 25Ω is 2.5 W.

1 INTRODUCTION

Semiconductors in radio receivers feature instant play, small dimensions resulting in freedom of styling of the cabinet and excellent reliability, properties that are also desirable for mains operated receivers.
But mains receivers have to cope with strong aerial signals as they may operate with an outdoor aerial. Also the audio output power should be 2 W or more. The well known circuits used in portable receivers do not satisfy these requirements.
The mains receiver described in this bulletin meets the more stringent requirements on signal handling capability (both at a.m. and f.m. reception) sensitivity, spurious responses and output power. This has been achieved by virtue of delayed gain control of the a.m. mixer, a special a.g.c. circuit, a three transistor f.m. front-end and a transformerless class-B audio output stage.

2 GENERAL RECEIVER DESCRIPTION

The receiver to be discussed has been designed for operating temperatures up to 35°C. It contains 14 transistors and 7 diodes.
In addition a silicon bridge rectifier is used in the supply unit. In Fig. 1 a block diagram is given, showing the semiconductor complement of the receiver. In the following sections a survey is given of the measured performance of the various parts of the receivers. In addition some notes, concerning the circuit and the method of measurement are listed.

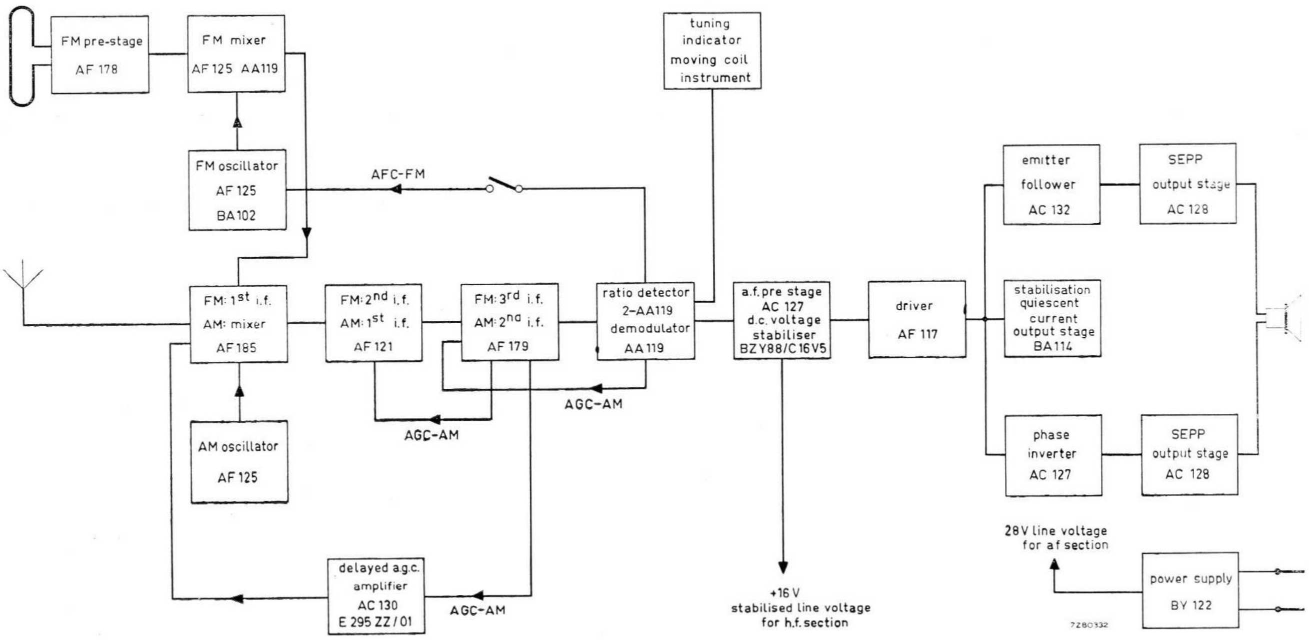


Fig. 1 Block diagram showing the various stages and the semiconductor complement of the receiver.

2.1 FM Front-End

Frequency range	87.5-108 Mc/s	
Aerial input impedance	75Ω asymmetric 300Ω symmetric	
Tuning	inductive	by means of a two gang variable inductor.
Output circuit		double tuned i.f. bandpass filter over-critically coupled.
3 dB bandwidth of output circuit	280 kc/s	
I.F. load impedance	1 kΩ	input impedance of the i.f. amplifier at the base of the first i.f. transistor.
Voltage amplification	> 6 times	ratio of i.f. voltage measured across the i.f. load impedance (1 kΩ) to aerial e.m.f. (source impedance 300Ω).
Transducer gain	> 16.3 dB	ratio of the power dissipated in the i.f. load to the available power of the aerial.
Noise figure	typ. 4 dB	
Image rejection	> 26 dB	measured at a constant output signal.
I.F. suppression	> 72 dB	a) measured at a constant output signal. b) as the input circuit is balanced, the input signal has to be applied between the aerial terminals, connected together as one pole and the earth terminal as the other pole.
Repeat spot suppression RSS[1])	> 60 dB	as reference level an i.f. output has been chosen corresponding to an aerial signal of 100μV e.m.f. (300Ω), the front-end being correctly tuned.
Double beat suppression DBS[2])	> 56 dB	
Signal handling capability	1 V	aerial e.m.f. (300Ω) for 20 kc/s oscillator frequency shift.
Radiation	< 2mV	measured at the input, terminated with 300Ω.
Selectivity S_{300}	6 times	mainly determined by the i.f. bandpass filter.
3 dB bandwidth	250 kc/s	
A.F.C. sensitivity	170 kc/s per V	measured at a reverse voltage of the diode in the region of (-)8 to (-)12 V and an oscillator frequency of 90 Mc/s.

2.1.1 R.F. Amplifier

Circuitry		AF 178 in common base connection.
Aerial circuit		single tuned circuit; pre-set at 100 Mc/s.
3dB bandwidth of the aerial circuit	80 Mc/s	loaded by the transistor and aerial as well.
R.F. interstage circuit		single tuned circuit.
3 dB bandwidth of the interstage circuit	1.5 Mc/s	measured with an aerial signal of 100 Mc/s.

2.1.2 Mixer Stage

Circuitry		AF 125 in common emitter with a trap between base and emitter tuned to 10.7 Mc/s. a diode AA 119 across the output serves for limiting of the i.f. signal.
Oscillator signal injection	70 mV	at the base of the mixer.

2.1.3 Oscillator Stage

Circuitry		AF 125 in common base with external feedback capacitance between collector and emitter.
Frequency range	76.8-97.3 Mc/s	
Oscillator voltage	250 mV	measured at the emitter.
Frequency shift	<20 kc/s	measured at a supply voltage variation from 11 V to 12 V.
Pulling	<20 kc/s	without a.f.c. and with an aerial e.m.f. from a 300Ω source ranging from 0 - 1 V.
Padding deviation	<0.5 Mc/s	

1) Repeat-spot reception of a signal occurs when its harmonics and the harmonics of the oscillator signal are such that mixing of these produces the designed intermediate frequency. Repeat-spot suppression is defined as: $RSS = 20 \log \frac{\text{aerial e.m.f. for a certain i.f. output of the front-end in repeat-spot tuning}}{\text{aerial e.m.f. for the same i.f. output when the front-end is correctly tuned}}$

2) Double-beat reception occurs when two different aerial signals (or their harmonics) together with the oscillator signal (or its harmonics) are converted to the designed intermediate frequency. Double-beat suppression is defined as:

$$DBS = 20 \log \frac{\text{aerial e.m.f. of the two interfering signals of equal strength for a certain i.f. output level of the front-end in double beat tuning}}{\text{aerial e.m.f. for the same i.f. output when the front-end is correctly tuned to one signal}}$$

2.2 AM Front End

Type of tuning		by means of a two gang variable capacitor.
Aerial		ferrite rod aerial for MW and LW with the facility of connecting an outdoor aerial. Outdoor aerial for SW. Measurements are carried out with an artificial aerial in accordance to I.E.C. standard given in Fig. 2.

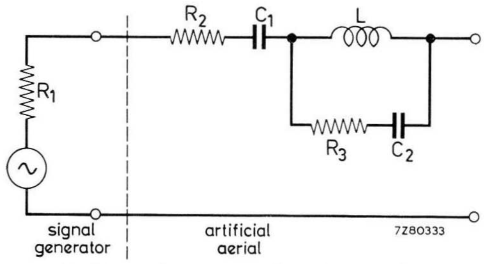


Fig. 2 Network representing the standard artificial aerial as recommended by the International Electrotechnical Commission (I.E.C. publication 69). For frequencies ranging from 150 kc/s to 26.1 Mc/s the following component values be used: $(R_1 + R_2) = 80\Omega$, $R_3 = 320\Omega$, $C_1 = 125$pF, $C_2 = 400$pF and $L = 20\mu$H.

Frequency range at:			
	LW	150- 285 kc/s	
	MW	508-1600 kc/s	
	SW	6- 16 Mc/s	
Aerial signal handling capability at:			
	LW	1.5 V	figures mentioned refer to an aerial e.m.f. (artificial aerial) measured with midband signals at a modulation distortion of 10%. Modulation depth m = 80%.
	MW	1 V	
	SW	0.9 V	
Output circuit			double tuned i.f. bandpass filter.
I.F. load impedance		3.3 kΩ	input inpedance of the i.f. amplifier at the base of the first i.f. transistor.
Voltage amplification at:			
	LW	2 times	ratio of the i.f. voltage measured across the i.f. load impedance to mid-band aerial e.m.f.
	MW	3 times	
	SW	3.5 times	

2.2.1 Aerial Circuit

Mode of outdoor aerial coupling at:	LW	common capacitive coupling	For frequency response curve at MW reception see Fig. 3.
	MW	large primary coupling	
	SW	inductive coupling	

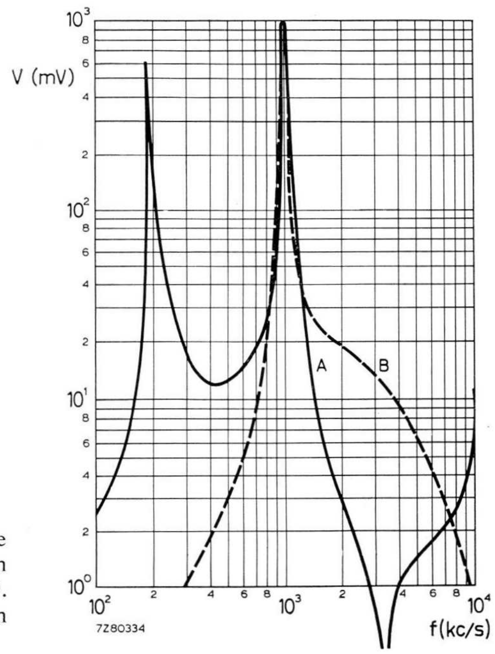


Fig. 3 Response curve of the aerial circuit for medium wave. The signal voltage at the base of the mixer at constant aerial e.m.f. has been plotted as a function of the signal frequency. Curve A has been measured in the circuit of Fig. 9. Curve B corresponds to the case of a conventional aerial circuit with common capacitive coupling.

3 dB bandwidth at:				
	LW	150 kc/s	4.5 kc/s	since the quality factor of the ferrite rod aerial may be affected by surrounding metal parts(e.g. chassis), the bandwidth has to be measured in the actual circuit.
		220 kc/s	9 kc/s	
		285 kc/s	15 kc/s	
	MW	520 kc/s	45 kc/s	
		1060 kc/s	10 kc/s	
		1600 kc/s	30 kc/s	
	SW	6 Mc/s	70 kc/s	
		11 Mc/s	120 kc/s	
		16 Mc/s	240 kc/s	
Voltage amplification at:				
	LW	0.2 times		ratio of the r.f. voltage, measured at the base of the mixer, to the mid-band aerial e.m.f.
	MW	0.3 times		
	SW	0.35 times		

2.2.2 Mixer Stage

Circuitry			AF 185 in common emitter connection.
R.F. source impedance at:			
	LW	960 Ω	base bias resistors excluded and measured in the middle of the bands.
	MW	1500 Ω	
	SW	480 Ω	
Conversion at LW, MW and SW		10 times	ratio of the i.f. voltage at the base of the first i.f. transistor to the r.f. voltage at the base of the mixer.
Oscillator signal injection at: LW, MW and SW		70 mV	measured at the emitter of the mixer.
Range of gain control		$>$45 dB	at all a.m. wave-ranges.
Type of gain control		"upward"	by increase of the operating current ("upward control").

2.2.3 Oscillator Stage

Circuitry			Hartley circuit employing an AF 125 in common base connection.
Frequency range at:			
	LW	602 - 737 kc/s	
	MW	960 - 2052 kc/s	
	SW	6.452 - 11.452 Mc/s	
Oscillator voltage at:			
	LW	420 mV	measured at the emitter of the oscillator.
	MW	470 mV	
	SW	640 mV	
Frequency shift during gain control of mixer at	LW and MW	$<$500 c/s	
	SW	$<$2.5 kc/s	
Type of padding		three points tracking	
Tracking points of the aerial circuit at:			
	LW	159 kc/s	
		217.5 kc/s	
		276 kc/s	
	MW	592.36 kc/s	
		1060 kc/s	
		1527.64 kc/s	
	SW	6.67 Mc/s	
		11 Mc/s	
		15.33 Mc/s	

2.3 I.F. Amplifier

Circuitry		a) AF 185 in common emitter either operating as a.m. mixer or i.f. amplifier at f.m. b) AF 121 and AF 179 in common emitter operating as i.f. amplifier both for a.m. and f.m.
Intermediate frequency	10.7 Mc/s at f.m. 452 kc/s at a.m.	
Interstage coupling		double tuned bandpass filter and a-periodical coupling circuit.

2.3.1 I.F. Amplifier and Detector at FM

I.F. input impedance	1 kΩ	input impedance of the i.f. amplifier at the base of the first i.f. transistor.
Voltage amplification:		
first stage	10 times	measured from base first i.f. transistor to base second i.f. transistor.
second stage	8 times	measured from base second i.f. transistor to base third i.f. transistor.
third stage	35 times	measured from base third i.f. transistor to its collector.
third stage (incl. detector)	4.3 times	measured from base third i.f. transistor to output ratio detector terminated with 8.2 kΩ.
3 dB bandwidth	>200 kc/s	the carrier has been frequency modulated with Δf = 15 kc/s and a modulation frequency of 1 kc/s.
Selectivity S_{300}	>25 times	a) measured from base of first i.f. transistor to d.c. load of the ratio detector. b) signal level at the base of final i.f. transistor has been 8.6 mV.
Onset of limiting	70 mV	measured at the base of the final i.f. transistor (operating current starts to increase).
Detector		symmetrical ratio detector.
Peak separation	>120 kc/s	separation between the peaks on the f.m. output characteristic of the ratio detector.
Input impedance of the detector	370Ω	measured at the tap of the tuned primary.
Output impedance	4 kΩ	measured at the a.f. output of the ratio detector with an audio signal of 1 kc/s.
Distortion of the ratio detector	see Fig. 4	
Maximum a.f. output	230 mV at Δf = 15 kc/s 1 V at Δf = 75 kc/s	a) measured at the a.f. output of the ratio detector terminated with 8.2 kΩ. b) mainly determined by limiting at the base of the final i.f. transistor.

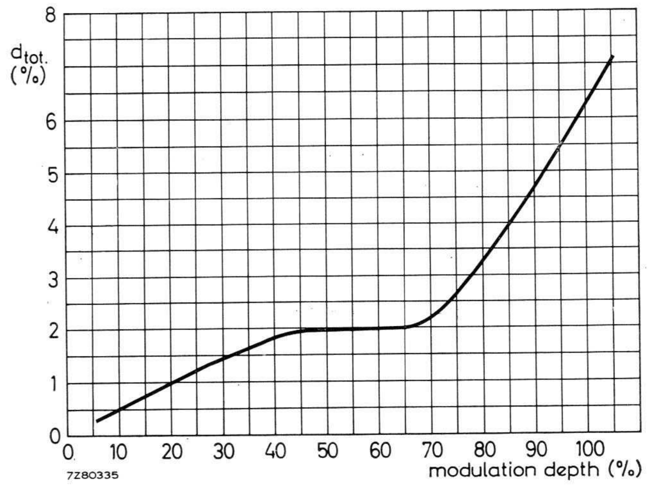
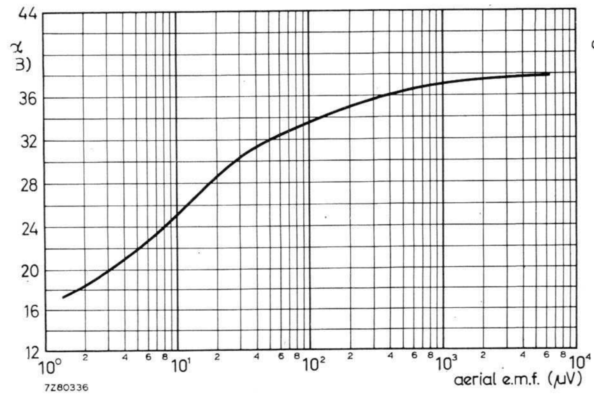


Fig. 4 Harmonic distortion at f.m.
The total harmonic distortion of the audio voltage at the output of the ratio detector, as a function of the modulation depth (100% = 75 kc/s deviation) and with an aerial e.m.f. of 10μV from a 300Ω source as parameter.



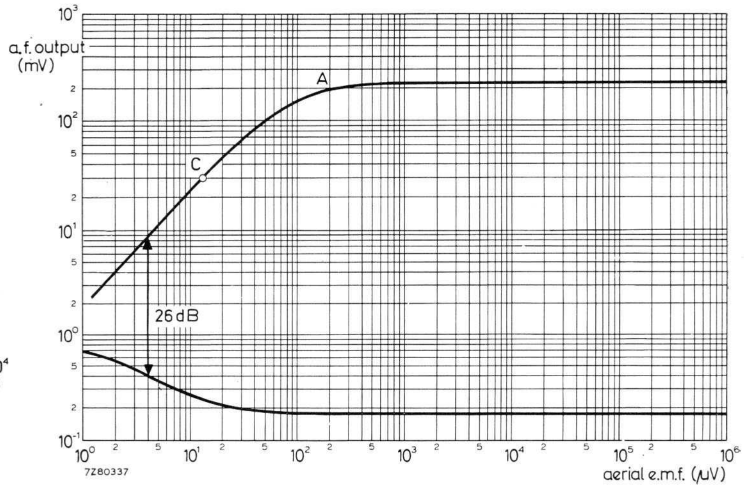


Fig. 5 AM suppression.
F.M. output over a.m. output as a function of the aerial e.m.f. from a 300Ω source connected to the corresponding input terminals of the receiver.
The test signal is frequency modulated with $\triangle f$ = 15 kc/s and 1kc/s modulation frequency and amplitude modulated with m = 0.3 and 400 c/s.

Fig. 6 Signal-to-noise ratio at f.m. Curve A represents audio voltage at the output of the ratio detector measured between contact 15 and common, as a function of the aerial e.m.f. from a 300Ω source. The frequency sweep of the input signal is 15 kc/s. Curve B represents the noise voltage at the output of the detector. Point C on curve A corresponds to an a.f. output power of the audio part of 2W.

De-emphasis	50 μs	
AM suppression	see Fig. 5	
Signal-to-noise ratio	see Fig. 6	
Figure of merit	≈ 70 dB	number of dB's by which the aerial e.m.f. from a 300Ω source has to be reduced from 100 mV, to produce a change of a.f. output power of 10 dB.

2.3.2 I.F. Amplifier and Detector at AM

I.F input impedance	3.3 kΩ	input impedance of the i.f. amplifier at the base of the first i.f. transistor.
Voltage amplification:		
first stage	75 times	measured from the base of the first i.f. transistor to the base of the second i.f. transistor.
second stage	75 times	ratio of the a.f. signal at the output of the detector terminated by 8.2 kΩ to the i.f. signal at the base of the final i.f. transistor, modulation depth = 30%.
3 dB bandwidth	4.5 kc/s	measured from the base of the mixer transistor to d.c. output of the detector with a constant input signal.
Selectivity S_9	39 dB	measured from the base of the mixer transistor to d.c. output of the detector with a constant output.
Type of gain control	reverse	on first stage.
Detector		conventional envelope detector.
Modulation handling capability	m = 80%	
Maximum a.f. output	300 mV at m = 30% 800 mV at m = 80%	measured at the detector output terminated by 8.2 kΩ.

2.4 Automatic Gain Control

Control system		detector drives final i.f. transistor to higher emitter currents rendering reverse gain control of first i.f. stage due to the long-tailed pair connection. Upward gain control of mixer stage delayed by means of an a.g.c. amplifier.
Start mixer gain control	100 to 300 μV	e.m.f. of the artificial aerial of Fig. 2.

I.F. gain reduction	40 dB	gain reduction of first i.f. transistor, its operating current varying from 1.5 to 0.002 mA, minus increase of gain of the final i.f. transistor due to its operating current variation from 3 to 6 mA.
I.F. gain reduction during mixer control	12 dB	
Mixer gain reduction	45 dB	at an operating current varying from 0.5 to 18 mA.
Figure of merit	≈ 70 dB	number of dB's by which the e.m.f. of the artificial aerial has to be reduced from 100 mV to produce a change of a.f. output power of 10 dB.

2.5 Automatic Frequency Control at FM

Control system		oscillator tuning by means of variable capacitance diode supplied from ratio detector.
Control sensitivity of the diode	170 kc/s per V	
Reference voltage	(-) 13 V	
Catching range	400 to 700 kc/s	
Holding range	< 1 Mc/s	
Correction factor	see fig. 7	

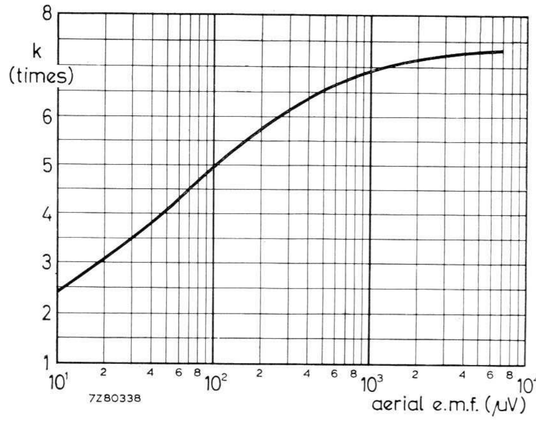


Fig. 7 Correction factor of the a.f.c. circuit. The factor k by which the detuning of the local oscillator is reduced due to the a.f.c. circuit is shown as a function of the aerial e.m.f. from a 300Ω source. These data were measured at a signal frequency of 100 Mc/s.

2.6 Tuning Indication

Circuitry		indicator is connected in series with d.c. load resistor of a.m. detector. At f.m. reception indicator is supplied from d.c. output of the ratio detector.
Type of indicator	meter	moving coil meter 300Ω/300 μA.
Aerial signal for full-scale deflection	1V	aerial e.m.f. at f.m. - and a.m. reception.

2.7 Audio Amplifier

Circuitry		two pre-stages followed by complementary driver and single ended push-pull class B output stage.
Output power	2W	continuous sine wave output power at onset of clipping.
Music power output	2.5W	the music power output denotes the single frequency power obtained at onset of clipping when measured immediately after the sudden application of a signal and during a time interval so short that supply voltages within the amplifier have not changed from their no-signal values.
Input signal:		
for 2W output	25 mV	measured at the output of the detector and at a frequency of 1 kc/s.
for 50 mW output	4 mV	

Record player sensitivity:		
for 2W output	240 mV	measured at a frequency of 1 kc/s, and an input impedance of 220 kΩ.
for 50 mW output	4 mV	

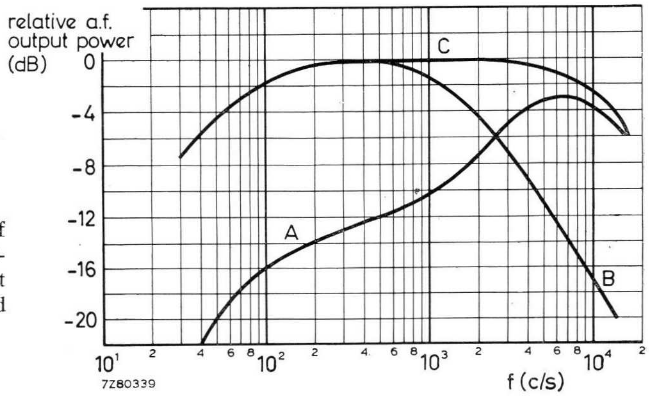


Fig. 8 Audio response curve.
The output at constant input voltage is shown as a function of the audio frequency. The 0 dB level corresponds to 2W a.f. output in the 25Ω speaker coil. Curve A is obtained at the bass-cut position of the tone control, curve B at the treble-cut position and curve C with both bass and treble response at maximum.

Input impedance	8.5 kΩ	for the detectors.
Frequency response and tone control	see Fig. 8	
Signal-to-hum ratio	62 dB	
Total harmonic distortion	1.6%	measured at onset of clipping with a signal of 1 kc/s.

2.8 Emitter Currents of the Various Stages

Measurements are carried out at an ambient temperature $T_{amb} = 25°C$.
The currents are in mA. Values between brackets relate to a maximum signal of 1V from a 300Ω aerial at f.m.- and an artificial aerial (see Fig. 2) at a.m. reception.

2.8.1 FM Front-End

RF stage	2.5 (2.5)	AF 178
Mixer stage	1 (1)	AF 125
Oscillator stage	1.7 (1.7)	AF 125

2.8.2 A.M. Front-End

Mixer stage at a.m.	0.5 (18)	AF 185
First i.f. stage at f.m.	0.5 (0.5)	
Oscillator stage	2 (2)	AF 125

2.8.3 I.F Amplifier

First i.f. stage at a.m.	1.5 (0.02)	AF 121
Second i.f. stage at f.m.	1.5 (1.2)	
Final i.f. stage at a.m.	3 (6)	AF 179
Final i.f. stage at f.m.	3 (6.6)	

2.8.4 A.F. Amplifier

Pre-stage	see Table II	AC 127
Driver stage	1.7 (1.7)	AF 117
Phase splitter and emitter follower	2.3	AC 132/AC 127
Quiescent current of SEPP output stage	5	2 — AC 128

2.9 Power Supply

2.9.1 Mains Rectifier

Type of rectifier	BY 122	bridge circuit.
Input voltage	220V-50 c/s	at primary of mains tranformer.
Power consumption from the mains	<8W	at a mains voltage of 220 V.

Direct output voltage — see Table I — measured across capacitor C_{83}.

Load current — see Table I

TABLE I

Mains voltage (V)		198		220		242	
Aerial signal condition		no signal	max.[1]) signal	no signal	max.[1]) signal	no signal	max.[1]) signal
AM (MW)	Direct output voltage (V)	24	21	28	25	30	27
	Load current (mA)	24	115	26	130	28	140
FM	Direct output voltage (V)	24	22	28	25	30	27
	Load current (mA)	28	120	30	132	32	145
Pick-up	Direct output voltage (V)	24.5	22	28.5	25	30.5	27
	Load current (mA)	10	90	13	110	15	130

2.9.2 Stabilised Supply for HF Stages

Voltage stabiliser — first audio pre-stage acting as emitter follower for d.c., the base voltage being stabilised by means of a Zener diode.

Reference voltage — 16.5V

Stabilisation factor — >24 — ratio of the relative variation of the supply voltage of the a.f. output stage $\Delta V_1/V_1$ to the relative variation of the d.c. output voltage $\Delta V_2/V_2$ at the emitter of the a.f. pre-stage transistor TR_7 with a constant load current I. condition of measurement: $V_1 = 30$ V; $\Delta V_1 = 8$ V; $V_2 = 16$ V; $\Delta V_2 = 178$ mV; I = 40 mA.

Internal resistance — <18Ω — measured at a d.c. load current varying from 17 to 40 mA.

Current consumption — see Table II

TABLE II Emitter currents of the transistor AC 127

Mains voltage (V)		198		220		242	
Aerial signal condition		no signal	max.[1]) signal	no signal	max.[1]) signal	no signal	max.[1]) signal
I_E (mA)	AM (MW)	16	40	16	40	16	40
	FM	21	23	21	23.5	21	24
	Pick-up	1		1		1	

2.10 Sensitivity of the Receiver

2.10.1 FM Reception

Sensitivity:

- for a signal-to-noise ratio of 26 dB — 4 μV
- for 50 mW a.f. output — 2 μV
- for 2W a.f. output — 11 μV

mid-band signal (e.m.f. from a 300 Ω aerial), the frequency sweep is 15 kc/s and the modulation frequency 1 kc/s.

2.10.2 AM Reception

Sensivity:

- for a signal-to-noise ratio of 26 dB — 45 μV
- for 50 mW a.f. output — 1.2 μV
- for 2W a.f. output — 8 μV

mid-band signal at all a.m. wave-ranges (e.m.f. from artificial aerial shown in Fig. 2), modulation frequency 1 kc/s and a modulation depth m of 30 %.

1) Value relates to a maximum signal of 1V from 300Ω aerial at f.m. and an artificial aerial at a.m. reception. The a.f. output is adjusted at 2W.

3 DESCRIPTION OF CIRCUIT DETAILS

The circuit diagram of the complete receiver is given in Fig. 17. In this chapter only the non-conventional parts of the receiver will be discussed in more detail.

3.1 The AM Section

3.1.1 The Aerial Circuit

In general a transistor a.m. tuner is considered to be rather apt to cause whistles, especially when receiving strong aerial signals.This difficulty is mainly due to lack of pre-selection, particularly for frequencies higher than the resonant frequency.
Increasing the selectivity, therefore, will improve the suppression of whistles considerably.
An attractive solution to this problem is the so-called large primary coupling. (see Fig. 9).

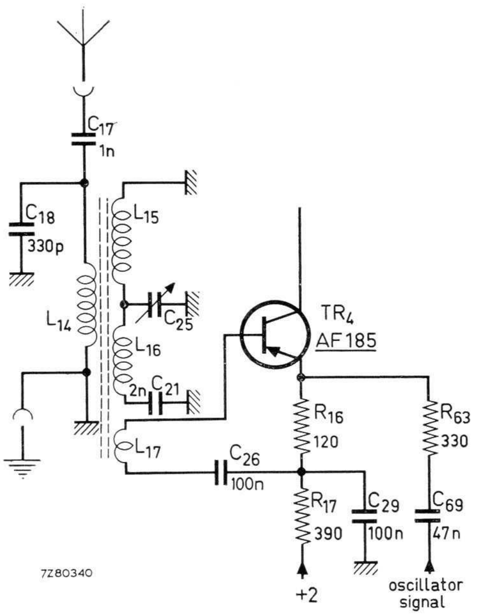


Fig. 9 Aerial input stage for medium wave.
Circuit diagram showing the connection of an outdoor aerial to the mixer input by means of the so-called large primary coupling.

Compared with a conventional aerial circuit, using common capacitive coupling, this provides a much higher selectivity - as can be seen from Fig. 3.
The large primary coupling will be used only for medium wave reception.
For long wave it would require impractically high self-inductances.
The tuning coils for medium and long wave reception (L_{15} and L_{16}) have been mounted on a ferrite rod aerial. At medium wave both coils are connected in parallel.
As a result only one coupling coil (L_{17}) is required to connect the mixer input to the aerial circuit for long wave and medium wave reception
At short wave, a large primary coupling will hardly improve the suppression of whistles. Generally the bandwidth of the aerial circuit is in the order of 100 kc/s, which is to be attributed to the maximum realisable quality factor. This already gives rise to undesired responses. Therefore at short wave reception the aerial is inductively coupled in the conventional way.

3.1.2 The Mixer Stage

In order to meet the requirements on signal handling capability a so-called „upward" controlled mixer stage TR_4 has been applied.
This mixer stage has a separate oscillator transistor TR_{13}. The emitter circuit of the mixer stage comprises a low valued non-bypassed resistor R_{16} so as to provide emitter degeneration. The „upward" a.g.c. control is mainly based on the fact that at an increase of the operating current also the amount of negative feedback with respect to the i.f. current increases.
By increasing the operating current of the mixer transistor from 0.5 mA to 18 mA a gain control range of about 50 dB can be obtained (see Fig.10).
The actual value of the non-bypassed resistor in the emitter lead is 78Ω (R_{16} in parallel with R_{63}).
The oscillator signal is supplied to the gain controlled mixer stage via a resistor of 330Ω (R_{63}). This rather loose coupling between mixer and oscillator stage ensures thas the oscillator is not affected by the varying input impedance of the mixer caused by a.g.c. action. Full details of this type of mixer circuit are given in A.I. Bulletin 119[1]).

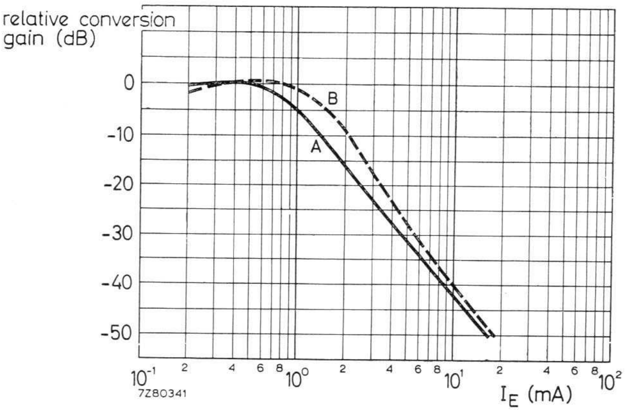


Fig. 10 Gain control characteristic of the upward controlled mixer stage. Relative conversion gain of the "upward" controlled mixer at an aerial frequency of 1 Mc/s as a function of the emitter current with the oscillator voltage as parameter.
Condition of measurement;
Curve A: oscillator voltage 50 mV
Curve B: oscillator voltage 100 mV
In both cases the oscillator voltage has been measured at the emitter of the mixer of which the emitter current was adjusted at 0.5 mA.

1) A.I. Bulletin 119 Title: High performance gain controlled a.m. mixer with AF 185. Date of Publication: March 13, 1964

3.1.3 The Oscillator Stage

In principle the oscillator stage is conventional.
However, an important point is that the oscillator voltage at the emitter of the mixer transistor has to be almost constant, (50 to 70 mV), so as to ensure the a.g.c. control of the mixer starting at the same emitter current over the entire wave range (see Fig. 10). Otherwise the signal handling as well as signal-to-noise ratio would vary with the oscillator voltage.
To avoid this, the medium-wave tank-circuit (L_{41} - L_{43}) has been equipped with a low-frequency core which causes a damping at the higher end of the frequency range. In this way the circuit impedance, and thereby the oscillator voltage, is kept almost constant.
For similar reasons the other two tank circuits have been shunted by means of the resistors R_{64} and R_{65}.
The resistor R_{62} has been inserted to avoid parasitic oscillations due to stray self-inductances of the wires to the selection switch.

3.1.4 A.G.C. Circuit

The basic circuit diagram of the a.g.c. is given in Fig. 11 Since a control range of 80 dB up to 90 dB is required, the gain of both the i.f. amplifier and the mixer has to be controlled. To ensure an adequate signal-to-noise ratio at low input signals, the i.f. amplifier is controlled firstly and the a.g.c. action on the mixer is delayed.
Gain reduction in an a.m. - i.f. amplifier can only be achieved by reducing the emitter current of the i.f. transistor. This is mostly obtained by means of series fed voltage feed-back from the detector to the base of the first i.f. transistor.
The control energy for the mixer cannot be taken from the controlled i.f. amplifier, because this would result in too low an available control energy for the mixer transistor.
To obtain still a sufficient control energy for the mixer stage during reverse control of the i.f. amplifier, a so-called long-tailed pair connection has been chosen for the d.c. circuit of the i.f. amplifier.
This has been obtained by using a common emitter resistor R_{23} for both i.f. transistors. The detector output voltage is smoothed and afterwards applied to the base of the final i.f. transistor TR_6. At increasing aerial signals the emitter current of TR_6 increases, rendering a slight increase in gain.
However, the emitter current of the first i.f. transistor TR_5 decreases very rapidly as a result of which the gain of this transistor is effectively reduced.
As the mixer transistor is of the PNP type, a negative going control voltage is required for the "upward" control (increasing the operating current). For this purpose the control voltage could be taken from the emitter of the final i.f. transistor, provided the reverse control of the first i.f. stage would have stopped.
But the base voltage required to control the mixer up to 18 mA, is in the order of 8 Volt which is conflicting with the required collector voltage swing of the final i.f. stage, for driving the detector stage.
This detector has to deliver d.c. control power to the final i.f. transistor and a.c. power to the audio prestage as well.
A solution is found without unduely decreasing the available collector voltage swing, by deriving the a.g.c. voltage for the mixer from a "control amplifier".

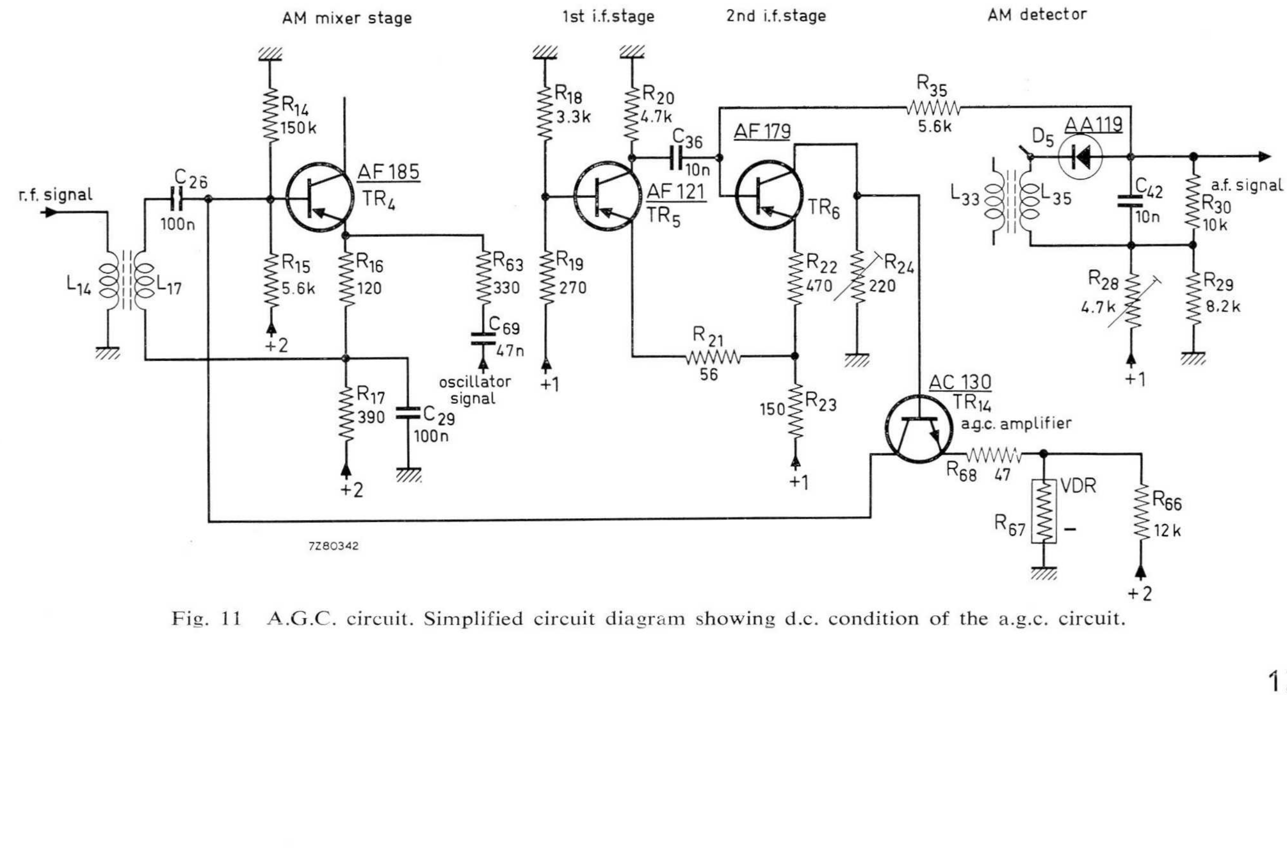


Fig. 11 A.G.C. circuit. Simplified circuit diagram showing d.c. condition of the a.g.c. circuit.

Because of the required polarity of the control voltage of the mixer the a.g.c. amplifier has to be driven from the collector circuit R_{24} of the final i.f. stage. A suitable transistor for this amplifier will be the AC 130.
Apart from the proper polarity, this transistor features a low leakage current from which thermal stability benefits.
The desired delay for the control voltage of the mixer has been obtained by incorporating an asymetric VDR (R_{67}) in the emitter lead of the a.g.c. transistor TR_{14}.
As soon as the voltage across the resistor R_{24} exceeds the emitter voltage of TR_{14}, this transistor will become conductive, thereby increasing the emitter current of the mixer transistor.
By means of the variable resistor R_{24} the d.c. loop gain of the a.g.c. circuit can be adjusted to give the designed signal handling capability. This can be done by applying an 80% modulated aerial signal of 1 Mc/s with an aerial e.m.f. of 1 Volt, and by adjusting R_{24} so that the distortion of the a.f. signal is a minimum.
The relation of the aerial e.m.f. to the gain reduction of the mixer is shown by curve B in Fig. 12. The slope of this line is not quite 20 dB per decade since part of the gain reduction in the receiver still takes place in the i.f. amplifier after a.g.c. action on the mixer has started.
Fig. 13 shows the a.g.c. characteristic of the receiver. The emitter current of the mixer and the two i.f. transistors respectively are plotted in Fig. 14 as functions of the aerial e.m.f. measured with the dummy aerial of Fig. 2.

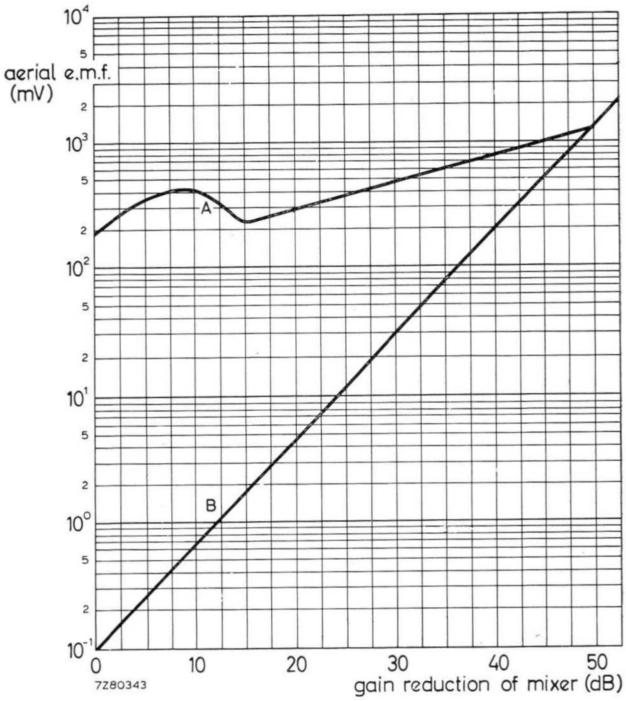


Fig. 12 Signal handling capability at a.m.
Curve A represents the aerial e.m.f. from a standard artificial aerial (Fig. 2) giving 10% modulation distortion of an 80% a.m. modulated signal, as a function of the gain reduction of the mixer, measured at 1 Mc/s.
Curve B represents the relation of the aerial e.m.f. to the gain reduction of the mixer in the circuit of Fig. 17 measured at 1 Mc/s.

3.2 The FM Section

3.2.1 FM Front-End

The f.m. front-end contains an r.f. stage, a mixer stage and a separate oscillator. By using a separate oscillator the influence of strong aerial signals on the oscillator is minimised. The signal handling capability of the tuner is, therefore, fairly high, even without using the well-known damping diode across the r.f. interstage circuit. In this way the r.f. selectivity of the tuner does not deteriorate at an increasing aerial signal.
As a result the spurious response of the tuner (i.a. repeat spot suppression) is improved considerably. This tuner has been described extensively in AI Bulletin 126[1])
The mixer transistor is operated in common emitter configuration. The oscillator voltage at the base of the mixer transistor has been chosen rather low (70 mV).
When combined with a well chosen emitter current for the mixer (1mA) this provides a good repeat spot suppression of the complete front-end.
The damping diode D_2 across the primary of the mixer bandpass filter has been used to avoid deterioration of the i.f. response curve at strong aerial signals.

3.2.2 The IF Amplifier

The a.m. mixer transistor TR_4 operates as a first i.f. amplifier at f.m. reception. The second and third i.f. stages (TR_5 and TR_6) are a-periodically coupled via R_{20}, C_{36}.
Due to this the source impedance of the final i.f. transistor is rather high. Especially for an i.f. signal of 10.7 Mc/s, this results in a low output impedance of TR_6 (about 1.5 kΩ).
In order to provide the required bandwidth the collector of TR_6 has been connected to a tap on the i.f. coil (L_{27} and L_{28}).
Consequently limiting of the f.m. - i.f. signal mainly takes place in the base circuit of TR_6.

1) A.I. Bulletin 126 (in preparation) Title: Interference effects in transistor f.m. tuners: Theory and circuitry.

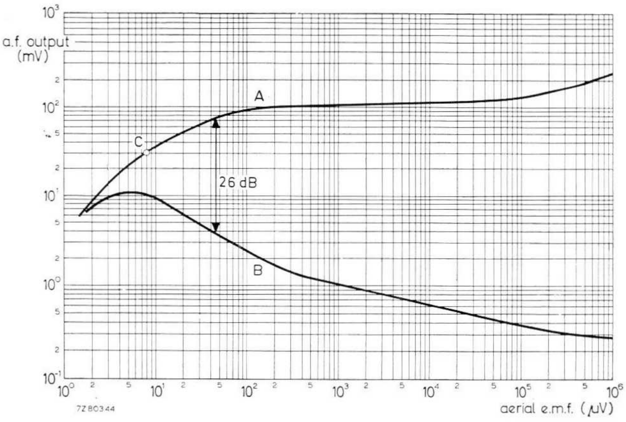


Fig. 13 A.G.C. diagram at a.m.
Curve A gives the a.f. voltage at the output of the detector, measured across R_{30} as a function of the aerial e.m.f.
Condotions of measurement: Artificial aerial of Fig. 2, signal frequency 1 Mc/s, modulation depth 30%, modulation frequency 1000 c/s. Curve B is related to the noise output voltage. Point C on curve A corresponds to an a.f. output power of the audio part of 2W.

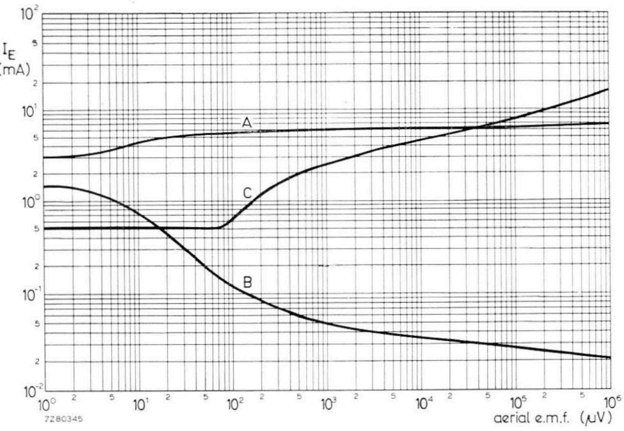


Fig. 14 Diagram showing the emitter currents of the mixer and the two i.f. transistors as functions of the aerial e.m.f., measured with the artificial aerial of Fig. 2
Condition of measurement as given for Fig. 13.
Curve A: emitter current of the final i.f. ransistor TR_6
Curve B: emitter current of the first i.f. transistor TR_5
Curve C: emitter current of the mixer transistor TR_4.

3.3 The Tuning Indication

The basic circuit diagram of the tuning indication is shown in Fig. 15. The tuning indicator M is a moving coil meter, having an internal resistance of approximately 300Ω.
Full-scale deflection will be achieved at a current of 300 μA.
At a.m. reception the tuning indicator is connected in series with the detector load resistor R_{30}. Full-scale deflection occurs at maximum signal condition (1V aerial e.m.f.). The capacitor C_{50} has been chosen so that the indicator does not react on low modulation frequencies. To prevent an unacceptable deflection of the indicator, due to the base current of the final i.f. transistor TR_6 the base bleeder of this transistor (R_{28}, R_{29}) has been connected to the interconnection of the detector load resistor R_{30} and the tuning indicator M. In this way the major part of the base current of TR_6 flows through R_{30}. A transistor having a current amplification factor β of 70 causes a deflection of the meter of only 10%.
At f.m. reception the tuning indicator is driven via the resistor R_{27}. The resistors R_{31} and R_{27} have been chosen so that the value of their parallel connection in series with the resistance of the indicator equals the value of R_{32}. In this way a symmetrical

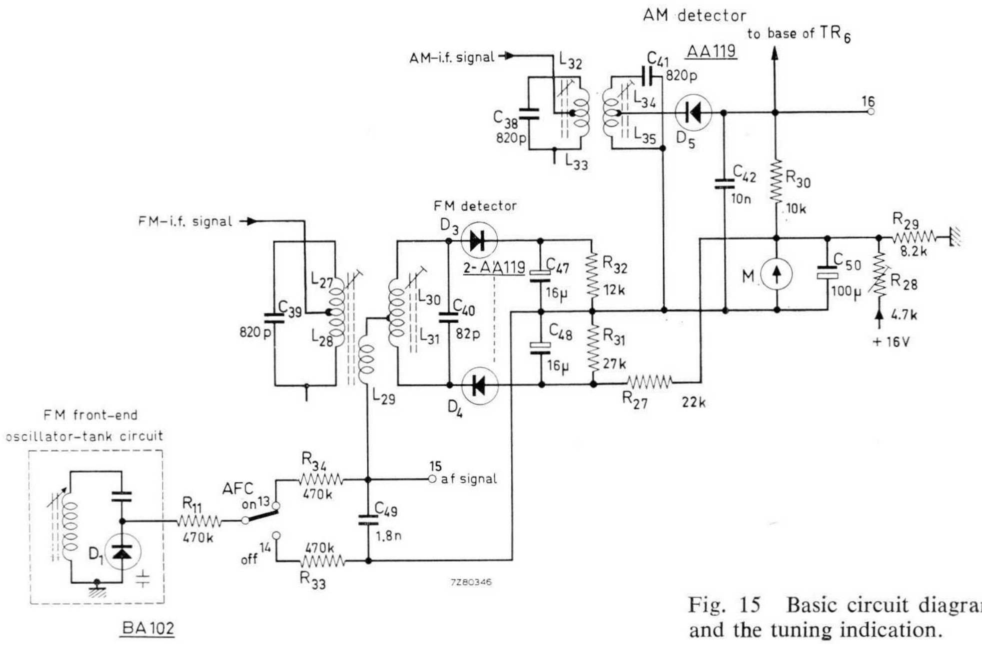


Fig. 15 Basic circuit diagram of the a.f.c. at f.m. reception and the tuning indication.

operation of the ratio detector is ensured. The influence of R_{28} can be neglected in this respect.
Full-scale deflection of the indicator has been chosen at the maximum aerial e.m.f. of 1V (300Ω) so as to provide adequate indication. This can be achieved by giving the resistors R_{27} and R_{31} a suitable value.

3.4 Audio Part

By arranging the output stage as a single-ended push-pull circuit which is driven by an npn-pnp complementary pair of transistors operating as phase-splitter, the output - as well as driver transformer can be dispensed with. This reduces both size and weight of the circuit, improves the frequency response and lowers the distortion. The type of circuit is advantageous in yet another respect. The collector-emitter voltage of each of the two output transistors is a maximum during its non-conducting period, and is then equal to the supply voltage, whereas in the conventional push-pull circuits the maximum occuring collector-emitter voltage is twice the supply voltage. Assuming the transistors to be operated up to the maximum permissible collector-emitter voltage, a single-ended push-pull output stage can thus be fed from a supply voltage which is twice that allowed in an orthodox push-pull circuit. For the same output power the current drain is thus halved, so that a smoothing circuit with smaller components can be used.

3.5 Supply-unit

Fig. 16 shows the basic circuit diagram of the supply unit, which is operated from the 220V mains voltage. The supply voltage for the receiver is obtained from a power supply, equipped with the silicon bridge rectifier BY 122.

The supply line of the a.f. amplifier excluding the a.f. pre-stage is directly connected to the power supply. In order to obtain a good signal-to-hum ratio, the supply line of the pre-stage is decoupled by means of R_{58} and C_{64}.
Due to the variable current consumption of both the class B output stage of the a.f. amplifier and the "upward" controlled mixer stage of the h.f. section the direct output voltage of the power supply can vary between 25 and 28V (mains voltage 220V).
The line voltage of the h.f. section amounts to 16 V and has been stabilised. This to prevent a reduction of the collector-to-emitter voltage of both the a.m. mixer and the final i.f. transistor due to a decrease of the direct output voltage at maximum signal condition of the receiver. The h.f. line voltage is taken from the emitter of the a.f. pre-stage transistor TR_7 and is stabilised by means of a Zener diode in the base circuit of this transistor.
To prevent shortcircuiting of the a.f. signal at the base of the pre-stage transistor due to the Zener diode, a resistor (R_{38}) has been connected between the Zener diode and the base of transistor TR_7.
At radio reception the emitter current of TR_7 can rise up to 40mA. For this reason the collector resistor of TR_7 (R_{40}) has to be rather low so as to provide sufficient collector voltage swing for driving the audio pre-driver transistor TR_8. However, such a low collector resistor would render too low an amplification when operating the a.f. amplifier from a crystal pick-up. To avoid this the amplification of the pre-stage, is increasend by switching-on an additional collector resistor R_{41} in Fig. 17. This becomes possible because the emitter current of TR_7 then amounts to only 1mA.
The f.m. front-end operates at a line voltage of 12V, obtained by means of the series resistor R_{69}.

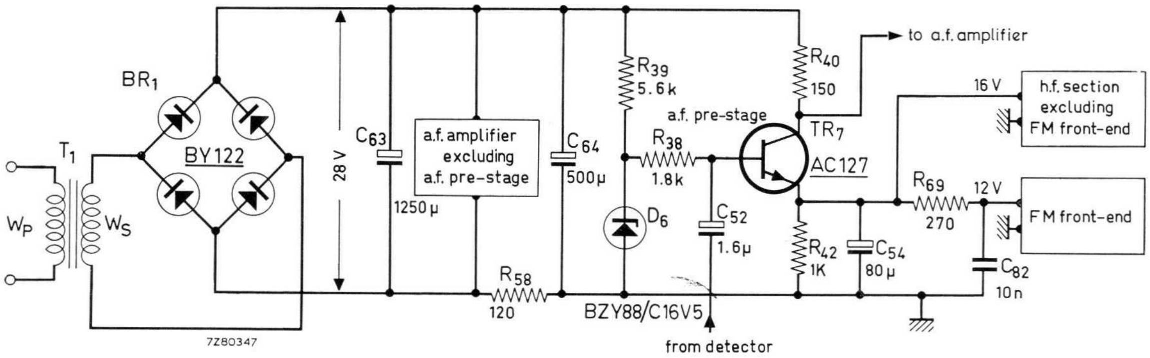


Fig. 16 Simplified circuit diagram of the power supply for the audio part and the high frequency part of the receiver. The audio pre-stage (TR_7) simultaneously acts as a voltage stabiliser for the high frequency stages. In fact this transistor operates as an emitter follower with stabilised basee voltage.

4. ALIGNMENT PROCEDURE

The alignment of the f.m. tuner and the i.f. amplifier is quite conventional.
In the parts list some notes are given concerning the position of the core in the various tuning coils.
As regards the a.m. front-end the following alignment procedure is recommended:

1. Connect a signal generator via the artificial aerial of Fig. 2 to the aerial input terminals of the receiver.

2. Connect a non-selective voltmeter to the base of the mixer transistor TR_4.
Switch-off the oscillator stage, e.g. by short circuiting the oscillator tank circuit.

3. Check that the coils L_{14}, L_{15} and L_{16} are located on the ferrite rod aerial as indicated in the parts list.

4. Switch the receiver to long wave reception and adjust the frequency range of the aerial circuit from 150 kc/s to 285 kc/s by varying the position of coil L_{15} on the ferrite rod.

5. Check the bandwidth of the LW aerial circuit at 200 kc/s. This shall be about 9 kc/s. In case of unfavourable mounting of the rod aerial (the quality factor of the tuned circuit may be affected by surrounding metal parts), the value of R_{12} (470 kΩ) may have to be changed.

6. Switch the receiver to medium wave reception and adjust the frequency range of the aerial circuit from 530 to 1600 kc/s by means of C_{22}, C_{25} and L_{15}.
During this adjustment the coupling coil L_{14} has to be at the extremity of the ferrite rod.

7. Check the bandwidth of the MW aerial circuit at 1 Mc/s. This shall be about 10 kc/s.
In case of unfavourable mounting of the rod aerial (the quality factor of the tuned circuit may be affected by surrounding metal parts), the value of R_{13} (100 kΩ) may have to be changed.

8. Adjust the voltage transfer at 1Mc/s from the aerial e.m.f. to the base of the mixer transistor to 0.3, by moving the coupling coil L_{14} towards the tuning coil L_{15}. The signal level shall be sufficiently low to avoid overloading of the mixer.
When moving L_{14} towards L_{15}, the resonant frequency of the aerial circuit becomes higher than the designed frequency. This has to be corrected my moving L_{15} across the rod aerial until maximum meter reading is again obtained. Check whether this maximum meter reading is really due to resonance of the aerial circuit by varying the frequency setting of the generator. If this is not the case, the initial displacement of L_{14} was chosen too large.
It is recommended, therefore, to adjust the voltage transfer of the aerial circuit in a few steps.

9. Switch the receiver to short wave reception and adjust the tuning range from 6 to 16 Mc/s by means of L_{12}, L_{13}, C_{20} and C_{25}.

10. Remove the short circuit of the oscillator tank circuit (refer to item 2) and adjust roughly the frequency ranges of the oscillator in the conventional way.

11. Adjust the oscillator frequency at the tracking points as given in section 2.2.3. by readjusting the tuning coils and the trimmers of the oscillator circuits. The intermediate frequency shall be 452 kc/s.

LIST OF COMPONENTS

RESISTORS

All resistors are cracked carbon types, ±5% toleranceand are rated at $^1/_8$W unless other wise stated.

R_1	=	820 Ω		B8 031 04B/820E
R_2	=	27 kΩ		B8 031 04B/27k
R_3	=	6.8 kΩ		B8 031 04B/6k8
R_4	=	33 kΩ		B8 031 04B/33k
R_5	=	8.2 kΩ		B8 031 04B/8k2
R_6	=	2.2 kΩ		B8 031 04B/2k2
R_7	=	100 Ω		B8 031 04B/100E
R_8	=	1.5 kΩ		B8 031 04B/1k5
R_9	=	8.2 kΩ		B8 031 04B/8k2
R_{10}	=	27 kΩ		B8 031 04B/27k
R_{11}	=	470 kΩ		B8 305 82B/470k
R_{12}	=	470 kΩ		B8 305 82B/470k
R_{13}	=	100 kΩ		B8 031 04B/100k
R_{14}	=	150 kΩ		B8 031 04B/150k
R_{15}	=	5.6 kΩ		B8 031 04B/5k6
R_{16}	=	120 Ω		B8 031 04B/120E
R_{17}	=	390 Ω		B8 031 04B/390E
R_{18}	=	3.3 kΩ		B8 031 04B/3k3
R_{19}	=	270 Ω		B8 031 04B/270E
R_{20}	=	4.7 kΩ		B8 031 04B/4k7
R_{21}	=	56 Ω		B8 031 04B/56E
R_{22}	=	470 Ω		B8 031 04B/470E
R_{23}	=	150 Ω		B8 031 04B/150E
R_{24}	=	220 Ω	carbon trimming potentiometer	E086AC/220E
R_{25}	=	390 Ω		B8 031 04B/390E
R_{26}	=	1 kΩ	carbon trimming potentiometer	E086AC/1k
R_{27}	=	22 kΩ		B8 031 04B/22k
R_{28}	=	4.7 kΩ	carbon trimming potentiometer	E086AC/4k7
R_{29}	=	8.2 kΩ		B8 031 04B/8k2
R_{30}	=	10 kΩ		B8 031 04B/10k
R_{31}	=	27 kΩ		B8 031 04B/27k
R_{32}	=	12 kΩ		B8 031 04B/12k
R_{33}	=	470 kΩ		B8 305 82B/470k
R_{34}	=	470 kΩ		B8 305 82B/470k
R_{35}	=	5.6 kΩ		B8 031 04B/5k6
R_{36}	=	8.2 kΩ		B8 031 04B/8k2
R_{37}	=	220 kΩ		B8 031 04B/220k
R_{38}	=	1.8 kΩ		B8 031 04B/1k8
R_{39}	=	5.6 kΩ		B8 031 04B/5k6
R_{40}	=	150 Ω		B8 031 04B/150E
R_{41}	=	3.3 kΩ		B8 031 04B/3k3
R_{42}	=	1 kΩ		B8 031 04B/1k
R_{43}	=	2.2 kΩ		B8 031 04B/2k2
R_{44}	=	10 kΩ	carbon logarithmic single potentiometer	E 098CG/30C29
R_{45}	=	20 kΩ	carbon linear single potentiometer	E 098CG/30C05
R_{46}	=	1 MΩ	carbon linear single potentiometer	E 098CG/30C15
R_{47}	=	6.8 kΩ		B8 031 04B/6k8
R_{48}	=	1.5 kΩ		B8 031 04B/1k5
R_{49}	=	470 Ω	carbon trimming potentiometer	E 086AC/470E
R_{50}	=	1 kΩ		B8 031 04B/1k
R_{51}	=	470 Ω	carbon trimming potentiometer	E 086AC/470E
R_{52}	=	500 Ω	NTC resistor	B8 320 01A/500E
R_{53}	=	68 Ω		B8 031 04B/68E
R_{54}	=	10 Ω		B8 031 04B/10E
R_{55}	=	68 Ω		B8 031 04B/68E
R_{56}	=	4.7 Ω	1/4 W	B8 031 05B/4E7
R_{57}	=	4.7 Ω	1/4 W	B8 031 05B/4E7
R_{58}	=	120 Ω	1/2 W	B8 031 06B/120E
R_{68}	=	2.7 kΩ		B8 031 04B/2k7
R_{60}	=	22 kΩ		B8 031 04B/22k
R_{61}	=	560 Ω		B8 031 04B/560E
R_{62}	=	22 Ω		B8 031 04B/22E
R_{63}	=	330 Ω		B8 031 04B/330E
R_{64}	=	8.2 kΩ		B8 031 04B/8k2
R_{65}	=	1 MΩ		B8 305 82B/1M
R_{66}	=	12 kΩ		B8 031 04B/12k
R_{67}			asymmetric VDR	E 295 ZZ/01
R_{63}	=	47 Ω		B8 031 04B/47E
R_{69}	=	270 Ω		B8 031 04B/270E
R_{70}	=	47 Ω		B8 031 04B/47E
R_{71}	=	3.3 kΩ		B8 031 04B/3k3
R_{72}	=	56 kΩ		B8 031 04B/56k
R_{73}	=	3.9 kΩ		B8 031 04B/3k9
R_{74}	=	330 kΩ		B8 305 82B/330k

CAPACITORS

C_{1} =	39 pF	± 2%	ceramic	C 329 BA/C39E
C_{2} =	4.7 nF	+ 100% / − 20%	ceramic	C 331 AA/R4k7
C_{3} =	4.7 nF	+ 100% / − 20%	ceramic	C 331 AA/R4k7
C_{4} =	6 pF		ceramic trimmer	C 004 ZZ/16
C_{5} =	15 pF	± 5%	ceramic	C 329 BA/B15E
C_{6} =	3.3 pF	± 0.5 pF	ceramic	C 329 BA/L3E3
C_{7} =	1.5 pF	± 0.25 pF	ceramic	C 304 GH/N1E5
C_{8} =	470 pF	± 20%	ceramic	C 322 BC/P470E
C_{9} =	4.7 nF	+ 100% / − 20%	ceramic	C 331 AA/R4k7
C_{10} =	82 pF	± 2%	ceramic	C 329 BA/C82E
C_{11} =	100 pF	± 2%	ceramic	C 329 BA/C100E
C_{12} =	10 pF	± 0.5 pF	ceramic	C 329 BA/L10E
C_{13} =	4.7 nF	+ 100% / − 20%	ceramic	C 331 AA/R4k7
C_{14} =	6 pF		ceramic trimmer	C 004 ZZ/16
C_{15} =	15 pF	± 5%	ceramic	C 329 BA/B15E
C_{16} =	12 pF	± 5%	ceramic	C 329 BA/B12E
C_{17} =	1 nF	+ 50% / − 20%	ceramic	C 322 BA/H1k
C_{18} =	330 pF	± 5%	ceramic	C 304 GH/B330E
C_{19} =	56 pF	± 3%	ceramic	C 302 CC/K56E
C_{20} =	30 pF		concentric air trimmer	C 005 CC/30E
C_{21} =	2 nF	± 5%	polystyrene	C 295 AB/B2K
C_{22} =	60 pF		concentric air trimmer	C 005 CA/60E
C_{23} =	82 pF	± 3%	ceramic	C 302 CC/K82E
C_{24} =	60 pF		concentric air trimmer	C 005 CA/60E
C_{25} = / C_{78} =	500 pF / 520 pF		variable tunning capacitor	AC 1014
C_{26} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{27} =	220 pF	± 5%	polystyrene	C 285 AA/B220E
C_{28} =	1.8 nF	± 10%	polystyrene	C 295 AA/A1K8
C_{29} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{30} =	220 pF	± 5%	polystyrene	C 285 AA/B220E
C_{31} =	820 pF	± 5%	polystyrene	C 285 AA/B820E
C_{32} =	220 pF	± 5%	polystyrene	C 285 AA/B220E
C_{33} =	820 pF	± 5%	polystyrene	C 285 AA/B820E
C_{34} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{35} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{36} =	10 nF	± 20%	polyester	C 280 AE/P10K
C_{37} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{38} =	820 pF	± 5%	polystyrene	C 285 AA/B820E
C_{39} =	220 pF	± 5%	polystyrene	C 285 AA/B220E
C_{40} =	82 pF	± 5%	polystyrene	C 285 AA/B82E
C_{41} =	820 pF	± 5%	polystyrene	C 285 AA/B820E
C_{42} =	10 nF	± 20%	polyester	C 280 AE/P10K
C_{43} =	47 nF	± 20%	polyester	C 280 AE/P47K
C_{44} =	220 nF	± 20%	polyester	C 280 AE/P220K
C_{45} =	330 pF	± 5%	ceramic	C 304 GH/B330E
C_{46} =	330 pF	± 5%	ceramic	C 304 GH/B330E
C_{47} =	16 μF	16 V	electrolytic	C 426 AR/E16
C_{48} =	16 μF	16 V	electrolytic	C 426 AR/E16
C_{49} =	18 nF	± 10%	polyester	C 281 AB/A18K
C_{50} =	100 μF	6.4 V	electrolytic	C 426 AR/C100
C_{51} =	16 μF	16 V	electrolytic	C 426 AR/E16
C_{52} =	1.6 μF	25 V	electrolytic	C 426 AR/F1.6
C_{53} =	25 μF	25 V	electrolytic	C 426 AR/F25
C_{54} =	80 μF	25 V	electrolytic	C 426 AR/F80
C_{55} =	16 μF	16 V	electrolytic	C 426 AR/E16
C_{56} =	15 nF	± 20%	polyester	C 280 AE/P15K
C_{57} =	25 μF	25 V	electrolytic	C 426 AR/F25
C_{58} =	330pF	± 20%	ceramic	C 322 BC/P330E
C_{59} =	160 μF	25 V	electrolytic	C 437 AR/F160
C_{60} =	100 μF	6.4 V	electrolytic	C 426 AR/C100
C_{61} =	1 μF	40 V	electrolytic	C 426 AR/G1
C_{62} =	500 μF	40 V	electrolytic	C 431 BR/G500
C_{63} =	1250 μF	40 V	electrolytic	C 431 BR/G1250
C_{64} =	500 μF	40 V	electrolytic	C 431 BR/G500
C_{65} =	560 pF	700 V	ceramic	C 321 GA/A560E
C_{66} =	560 pF	700 V	ceramic	C 321 GA/A560E
C_{67} =	47 nF	± 20%	polyester	C 280 AE/P47K
C_{68} =	27 nF	± 20%	polyester	C 280 AE/P27K
C_{69} =	47 nF	± 20%	polyester	C 280 AE/P47K
C_{70} =	2.2 nF	+ 50% / − 20%	ceramic	C 301 GA/H2K2
C_{71} =	700 pF	± 1%	polystyrene	C 295 AA/D700E
C_{72} =	60 pF		concentric air trimmer	C 005 CA/60E
C_{73} =	205 pF	± 1%	polystyrene	C 285 AA/D205E
C_{74} =	150 pF	± 5%	polystyrene	C 285 AA/B150E
C_{75} =	56 pF	± 5%	polystyrene	C 285 AA/B56E
C_{76} =	30 pF		concentric air trimmer	C 005 CC/30E
C_{77} =	60 pF		concentric air trimmer	C 005 CC/60E
C_{79} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{80} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{81} =	10 μF	25 V	electrolytic	C 426 AR/F10
C_{82} =	10 nF	± 20%	polyester	C 280 AE/P10K
C_{83} =	100 nF	± 20%	polyester	C 280 AE/P100K
C_{84} =	25 μF	25 V	electrolytic	C 426 AR/F25
C_{85} =	22 pF	± 20%	ceramic	C 322 BD/P22E

COILS

All coils are to be wound clockwise. For construction of the coils see adjacent figures. In the wiring diagrams of the coils the bottom view is shown. Mechanical dimensions are in mm.

FM aerial coil

L_1 $2^3/_8$ | turns of enamelled copper wire 0.22 mm diameter
L_2 $2^3/_8$
L_3 $1^6/_8$

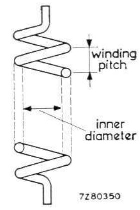
$Q_0 \approx$ 40 at 110 Mc/s — Powder iron frame K4 712 50/2P1

FM interstage coil

L_4 $1^3/_4$ | turns of tinned copper wire 1 mm diameter
L_5 $3^1/_4$ | inner diameter of coil 7.4 mm
winding pitch 4.2 mm

Q_0 = 80 at 87.5 Mc/s
Q_0 = 100 at 108 Mc/s

Coil former P 45 33 30/437 AY
Powder iron rod 32210870060
diameter 5 mm
length 22 mm
travel 15 mm



Coil of FM i.f. trap

L_6 25 | turns of enamelled copper wire 0.1 mm diameter
coil diameter $\approx$ 2 mm

$Q_0 \approx$ 30 at 10.7 Mc/s. — Coil former B 189196

FM i.f. coil primary

L_7 $17^1/_2$ | turns of stranded wire 24 x 0.03
inner diameter of coil 4.5 mm

Q_0 = 115 at 10.7 Mc/s

Coil former A3 299 07
Ferroxcube core K5 120 02/(4D)
for frequencies up to 12 Mc/s

FM oscillator coils

L_8 $1^3/_4$ | turns of tinned copper wire 1 mm diameter
L_9 $3^1/_4$ | inner diameter of coil 6.3 mm
winding pitch 3.63 mm

Q_0 = 80 at 76.8 Mc/s
Q_0 = 120 at 97.3 Mc/s
For construction see at FM interstage coil

Coil former P 45 33 30/437 AY
Powder iron rod 32210870060
diameter 5 mm
length 22 mm
travel 15 mm

L_{10} $11^1/_2$ | turns of enamelled copper wire 0.22 mm diameter
inner diameter of coil 4.5 mm
winding pitch 0.5 mm

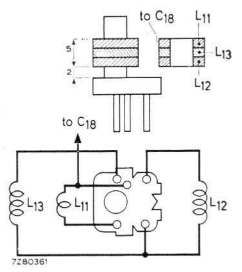
Coil former A3 238 25
Powder iron core K4 725 10/2P4
for frequencies up to 100 Mc/s

SW aerial coil

L_{11} 1 | turns of stranded wire 36 x 0.03
L_{12} 6
L_{13} 2

L = 1.24 μH
Q_0 = 110 at 11 Mc/s (measured with can)

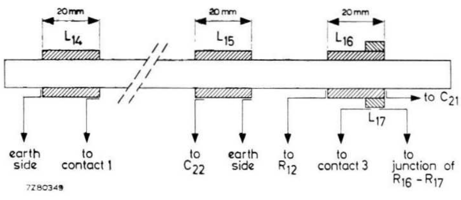
Coil former AP 3016/03
Ferroxcube frame AP 3014/02 (4D)
Ferroxcube core K5 120 02/ (4D)
Can AP 3015/02



Remark: If the core is moved into the coil from the top, the second resonance gives correct coupling between L_{11} and L_{12}, L_{13}.

MW and LW aerial coils

L_{14}	L = 1.23 mH	110	turns of stranded wire 36 x 0.03
L_{15}	L = 174 μH	42	L_{14} and L_{16} cross wound.
L_{16}	L = 1.64 mH	200	gear ratio of cross winding machine 26/28, 27/79
L_{17}		24	Ferroxcube rod 56 681 23/4B
			for frequencies up to 2 Mc/s
			length 203 mm, diameter 10 mm



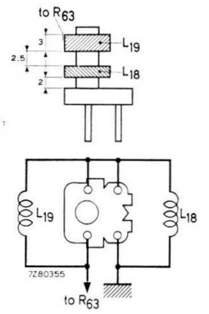
FM i.f. coil (secundary)

L_{18} 1 | turns of stranded wire 36 x 0.03
L_{19} 8

Relative coupling kQ (loaded) between L_7 and L_{19} = 1.2
L_{19}: Q_0 = 100 at 10.7 Mc/s (measured with can).

Coil former	AP 3016/02
Ferroxcube frame	AP 3014/02 (4D)
Ferroxcube core	K5 120 02/ (4D)
Can	AP 3015/02

Remark: If the core is moved into the coil from the top, the first resonance gives correct coupling between L_{18} and L_{19}.



FM i.f. coils

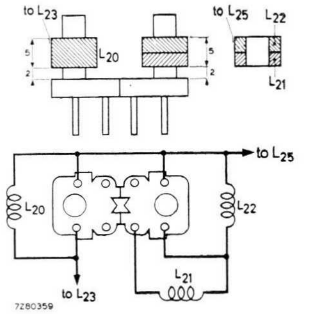
L_{20} 7 | turns of enamelled copper wire 0.16 mm diameter

L_{21} 5 | turns of enamelled copper wire 0.26 mm diameter
L_{22} 2

Q_0 = 90 at 10.7 Mc/s (measured with can)

Coilformer	AP 3016/02
Coil former	AP 3016/02
Ferroxcube frame	AP 3014/02 (4D)
Ferroxcube core	K5 120 02/ (4D)
Can	AP 3015/03
Coupling disc	AP 3018
Coupling rod	56 680 49/3B
Spacer plate	AP 3017

Remark: If the core is moved into the coil from the top, for both coils the second resonance gives the correct quality factor.



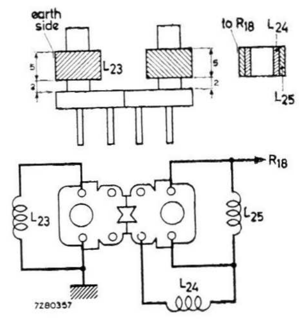
AM i.f. coils

L_{23} 80 | turns of stranded wire 12 x 0.04
L_{24} 68 | cross wound
L_{25} | gear ratio of cross winding machine 45/60, 35/40

Q_0 = 160 at 452 kc/s (measured with can)

Coilformer	AP 3016/02
Coil former	AP 3016/02
Ferroxcube frame	AP 3014/00 (3B)
Ferroxcube core	K5 120 00 (3B)
for frequencies up	to 600 kc/s
Can	AP 3015/03
Coupling disc	AP 3018
Coupling rod	56 680 49/3B
Spacer plate	AP 3017

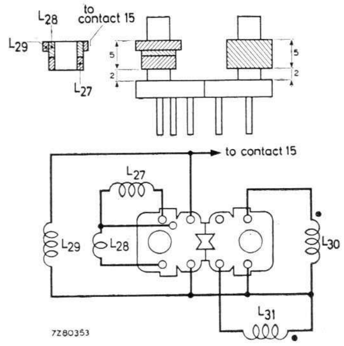
Remarks: a) The bottom of the can has to be screened so as to keep the stray field of the i.f. transformer sufficiently low.
b) If the core is moved into the coil from the top, for both coils the second resonance gives minimum stray coupling between the i.f. stages.



HF choke

L_{26} | 4 mH — d.c. resistance 20Ω A3 110 05

Coils of FM ratio detector



L_{27} 4 | turns of stranded wire 36 x 0.03
L_{28} 3 |

Q_0 = 110 at 10.7 Mc/s (measured with can and L_{29})

L_{29} 4 | turns of enamelled copper wire 0.1 mm diameter

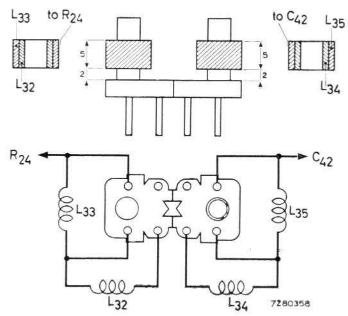
L_{30} 6 | turns of stranded wire 36 x 0.03
L_{31} 6 | bilifar wound

Q_0 = 130 at 10.7 Mc/s (measured with can)

Coil former	AP 3016/03
Coil former	AP 3016/02
Ferroxcube frame	AP 3014/02 (4D)
Ferroxcube core	K5 120 02/ (4D)
Can	AP 3015/03
Coupling disc	AP 3018
Coupling rod	56 680 49/3B
Coupling rod	56 680 49/3B
Block	AP 3019

Remarks: a) If the core is moved into the coil from the top, the second resonance gives the correct quality factor for both coils and the designed coupling between L_{27}, L_{28} and L_{29}.
b) The dot at L_{30} and L_{31} indicates the start of the windings.

AM i.f. coils



L_{32} 58 | turns of stranded wire 12 x 0.04
L_{33} 22 | cross wound
L_{34} 48 | gear ratio of cross winding machine 45/60, 35/54
L_{35} 32 |

Q_0 = 150 at 452 kc/s (measured with can)

Coilformer	AP 3016/02
Coil former	AP 3016/02
Ferroxcube frame	AP 3014/00 (3B)
Ferroxcube core	K5 120 00 (3B)
Can	AP 3015/03
Coupling disc	AP 3018
Coupling rod	56 680 49/3B
Spacer plate	AP 3017

Remarks: a) The bottom of the can has to be screened so as to keep the stray field of the i.f. transformer sufficiently low.
b) If the core is moved into the coil from the top, for both coils the second resonance gives minimum stray coupling between the i.f. stages.

HF chokes

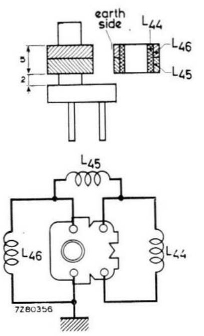
L_{36}, L_{37} | 1 mH — d.c. resistance 40Ω A3 110 68

SW oscillator coils

L_{38} 3 | turns of stranded wire 36 x 0.03
L_{39} 3 |
L_{40} 1 |
Q_0 = 100 at 11 Mc/s (measured with can)

Coil former	AP 3016/02
Ferroxcube frame	AP 3014/02 (4D)
Ferroxcube core	K5 120 02/ (4D)
Can	AP 3016/02

Remark: If the core is moved into the coil from the top, the second resonance gives correct coupling between L_{38}, L_{39} and L_{40}.

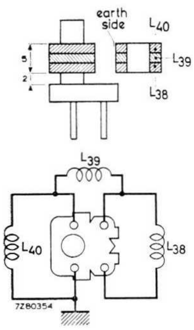


MW oscillator coil

L_{41} 59 | turns of stranded wire 8 x 0.04
L_{42} 3 | cross wound
L_{43} 4 | gear ratio of cross winding machine 28/52, 35/58
Q_0 = 100 at 1.4 Mc/s (measured with can)

Coil former	AP 3016/02
Ferroxcube frame	AP 3014/00 (3B)
Ferroxcube core	K5 120 00 (3B)
Can	AP 3015/02

Remark: If the core is moved into the coil from the top, the second resonance gives correct coupling between L_{41}, L_{42} and L_{43}.

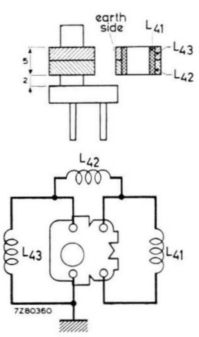


LW oscillator coil

L_{44} 130 | turns of stranded wire 8 x 0.04
L_{45} 12 | cross wound
L_{46} 1 | gear ratio of cross winding machine 28/52, 35/58
Q_0 = 110 at 660 kc/s (measured with can)

Coil former	AP 3016/02
Ferroxcube frame	AP 3014/00 (3B)
Ferroxcube core	K5 120 00 (3B)
Can	AP 3016/02

Remark: If the core is moved into the coil from the top, the second resonance gives correct coupling between L_{44}, L_{45} and L_{46}.



MISCELLANEOUS

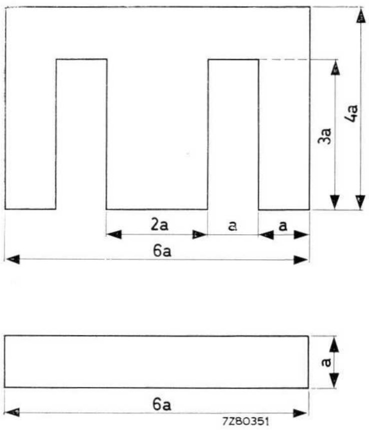
F_1	= fuse 100 mA (slow)	code no. 08 142 37
F_2	= fuse 100 mA (slow)	code no. 08 142 37
LA_1	= dial lamp 15 V 0.2A	code no. 8004 D
LA_2	= dial lamp 15 V 0.2A	code no. 8004 D
LSP	= loudspeaker 25Ω	type no. AD 3574 HX
M	= tuning indicator	current for full-scale deflection 300μA, d.c. resistance 300Ω

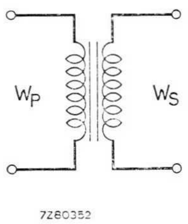
MAINSTRANSFORMER T_1

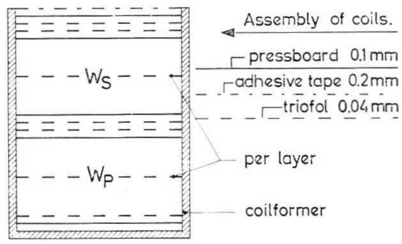
Winding	number of turns	wire diameter (mm)	winding width (mm)	turns per layer	number of layers	d.c. resistance (Ω)
W_p	1456	0.2	27.8	112	13	90
W_s	130	0.2	27.8	26	5	0.7

All windings are of enamelled copper wire. Transformer lamination Si Fe (composition: 0.8 — 2.3%, rest Fe)

stacking height : 25 mm
thickness of lamination : 0.5 mm
dimensions of lamination see adjacent Figure (a = 10 mm).







SEMICONDUCTOR COMPLEMENT

Transistors

TR_1 = AF 178 f.m.-r.f. amplifier
TR_2 = AF 125 f.m. mixer
TR_3 = AF 125 f.m. oscillator
TR_4 = AF 185 a.m. mixer
TR_5 = AF 121 first i.f. stage
TR_6 = AF 179 second i.f. stage
TR_7 = AC 127 a.f. pre-stage
TR_8 = AF 117 a.f. driver
TR_9 = AC 132 | phase-splitter
TR_{10} = AC 127 | (matched pair)
TR_{11} = AC 128 | a.f. output stage
TR_{12} = AC 128 | (matched pair)
TR_{13} = AF 125 a.m. oscillator
TR_{14} = AC 130 a.g.c. amplifier

Diodes

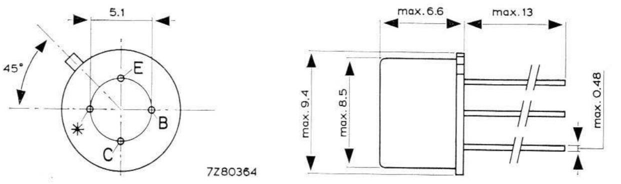
D_1 = BA 102 a.f.c. diode
D_2 = AA 119 limiter
D_3 = AA 119 | ratio detector
D_4 = AA 119 | (matched pair)
D_5 = AA 119 a.m. demodulator
D_6 = BZY 88/C16V5 d.c. stabilizer
D_7 = BA 114 d.c. stabilizer
BR_1 = BY 122 bridge rectifier

development sample data

AF 179

R.F. GERMANIUM ALLOY-DIFFUSED TRANSISTOR

The AF179 (development type V72AF) is an alloy diffused P.N.P. germanium transistor with a low thermal resistance primarily intended for application in TV-i.f. amplifier stages.



Dimensions in mm

* Interlead shield, metal case

ABSOLUTE MAXIMUM RATINGS

Collector

Voltage, base reference	$-V_{CB}$	=	25 V
Voltage, emitter reference at $\frac{R_B}{R_E} \leqslant 100$ and $R_E = 200\ \Omega$	$-V_{CE}$	=	25 V
Currents	$-I_C$	=	10 mA
	$-I_{CM}$	=	15 mA

Emitter

Currents	I_E	=	10 mA
	I_{EM}	=	15 mA
	$-I_E$	=	1 mA
Dissipation	P_C	=	150 mW

Temperatures

Storage	T_s	=	- 55°C to +75°C
Junction: continuous	T_j	=	75°C
Junction: incidentally, up to a total of 200 hrs	T_d	=	90°C

CARACTERISTICS (T_{amb} = 25°C; - V_{CB} = 10V)

$-I_{CBO}$	$\leqslant$	8 μA	
$-I_{CBO}$	$\leqslant$	150 μA	T_j = 75 °C
$-I_B$	$\leqslant$	100 μA	I_E = 3 mA
$-V_{BE}$	=	280-380 mV	I_E = 3 mA
f_1	=	270 Mc/s	I_E = 3 mA
$-C_{re}$	$\leqslant$	0.68 pF	I_E = 1 mA; f = 450 kc/s

Thermal resistance from junction to ambient $R_{th\ j\text{-}a} \leqslant 0.32$ °C/mW

SMALL SIGNAL PARAMETERS

(— V_{CB} = 10 V; I_E = 3mA; f = 35 Mc/s)

g_{ie}	=	6.5 mmho
C_{ie}	=	35 pF
$\lvert Y_{re}\rvert$	=	100 μmho
Φ_{re}	=	262°
$\lvert Y_{fe}\rvert$	=	80 mmho
Φ_{fe}	=	322°
g_{oe}	=	100 μmho
C_{oe}	=	3.6 pF

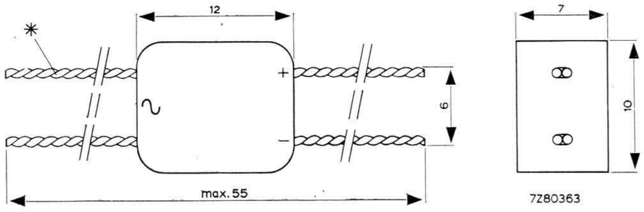
MAXIMUM UNILATERALISED POWER GAIN

Defined as $\Phi\mu_M = \frac{\lvert Y_{fe}\rvert^2}{4g_{ie}g_{oe}} = 34$ dB

BY 122 (66 BY)

SILICON BRIDGE RECTIFIER ASSEMBLY

The BY122 is a bridge rectifier assembly equipped with four silicon double diffused junction diodes for use as power supply up to 50 V and 0.5 A.



Dimensions in mm

* 2 wires 0.5 mm Ø twisted and tinned.

ABSOLUTE MAXIMUM RATINGS (with capacitive load)

Input

Input voltage	V_i	=	42 V (RMS)
Input current	I_i	=	1.1 A (RMS)
Peak inrush current	I_s	=	25 A

Output

Average output current	I_o	=	0.5 A

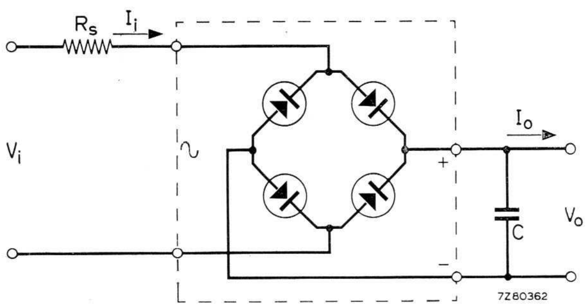
Temperature

Storage temperature	T_s	=	- 55 to + 150° C
Operating junction temperature	T_j	=	150° C
Ambient temperature at specified output current	T_a	=	60° C

CARACTERISTICS

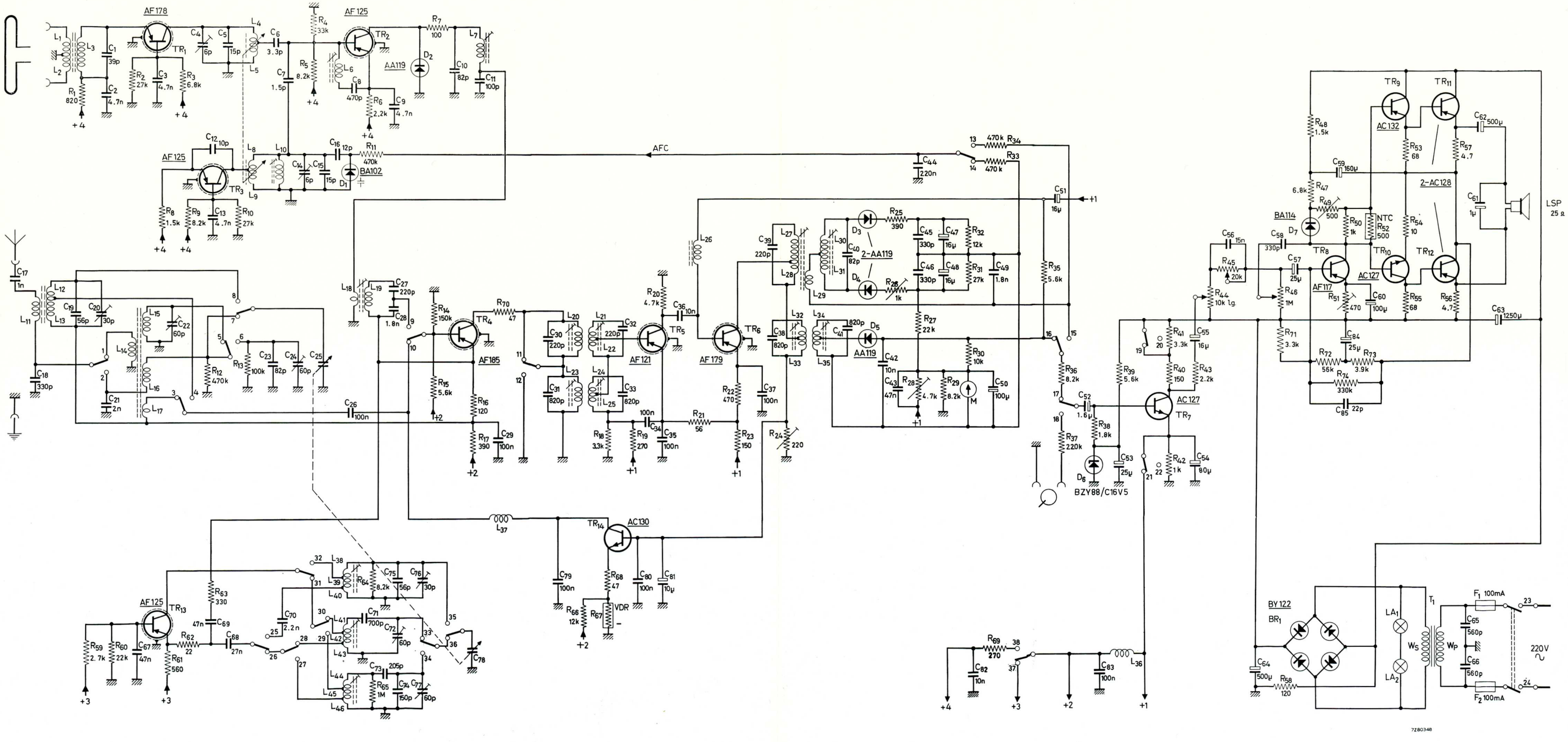
Peak forward voltage drop per diode at I_F = 2.5A; T_j = 25°C	$V_F \leqslant$	1.7 V
Peak reverse leakage current per diode at V_R = 60 V; T_j = 125° C	$I_R \leqslant$	30 μA
Thermal resistance from junction to ambient	$R_{th\ j\text{-}a} \leqslant$	55° C/W

TYPICAL OPERATIONS



Input voltage	V_i	=	23.5	39 V (RMS)
Output voltage	V_o	=	30	50 V
Output current	I_o	=	0.5	0.5 A
Capacitor	C	=	1500	1500 μF
Resistor	R_s	=	1.0 (1.1W)	1.8 (2W) Ohm

Development samples are distributed without guarantee for further supply. Development sample data represent the characteristics and ratings of development samples and are to be regarded as first indications of the ultimate performance to be achieved by the product in preparation.



SELECTION SWITCH

position	contacts																																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
LW		●	●			●	●			●	●					●	●		●		●		●	●		●	●		●		●			●		●	●	
MW	●		●		●		●			●	●					●	●		●		●		●	●		●		●		●	●		●			●	●	
SW		●		●				●		●	●					●	●		●		●		●	●	●							●			●		●	
FM									●			●		●	●		●		●		●		●	●														●
FM/AFC									●			●	●		●		●		●		●		●	●														●
PU																		●		●		●	●	●														

The dot indicates that the contact is closed

Fig. 17 Circuit diagram of the mains-operated a.m.-f.m. receiver, shown for medium wave reception.

SURVEY OF A.I. BULLETINS

The following A.I. Bulletins have been issued in this series:

*101	January 1959	Three self-oscillating mixer stages for short wave bands between 12 and 50 Mc/s with the transistor OC170
*102	April 1959	Circuits for stereophonic amplifiers
*103	July 1959	Single-ended stereophonic amplifiers
*104	July 1959	Transistorised self-oscillating mixer stages
*105	July 1959	Analysis of the non-linear distortion of transistorised amplifiers
*106	July 1959	A transistorised AM/FM receiver[1])
*107	February 1960	High-quality stereophonic amplifiers
*108	February 1960	Simple method of designing transistorised I.F. amplifiers with double tuned band pass filters
*109	March 1960	Television receiver for 110° deflection
*110	August 1960	Voltage indicator tube EM87
*111	June 1961	Nine transistor AM/FM receiver with the alloy diffused transistors AF114, AF115 and AF116 in the H.F. and I.F. stages
112	February 1962	Cooling of semiconductor elements
113	April 1962	The junction-transistor push-pull blocking oscillator
114	June 1962	The application of the alloy-diffused transistors AF124, AF125, AF126 and AF127 in an AM/FM car-radio receiver
115	July 1962	The application of transistors in a pocket size taperecorder
116	October 1962	The application of RF transistor AF102 and of AF transistors AC126 and 2-AC128 in an eight-transistor AM/FM receiver
117	May 1963	Application of the audio transistors AC125, AC126, 2-AC128
118	May 1963	NPN-PNP complementary stages with the transistors AC127/132
119	March 1964	High performance gain controlled A.M. mixer with AF185
120	June 1965	Stabilisation of radio receiver performance at low battery voltage with a VDR device
121	in preparation	Input stage of car radio
122	in preparation	Electronic organ with cold cathode tubes
123	July 1964	Stereo decoding for the F.C.C. system
**126	July 1965	Interference effects in transistor FM tuners; Theory and circuitry
128	April 1965	The integrated circuit OM200 employed as a hearing aid amplifier with 0.2 mW output

* Out of stock: dye-line prints available on request

1) Superseded by Nos 111 and 116

**125	September 1964	Audio amplifiers with AD 149

Printed in Holland

22. 145 B E