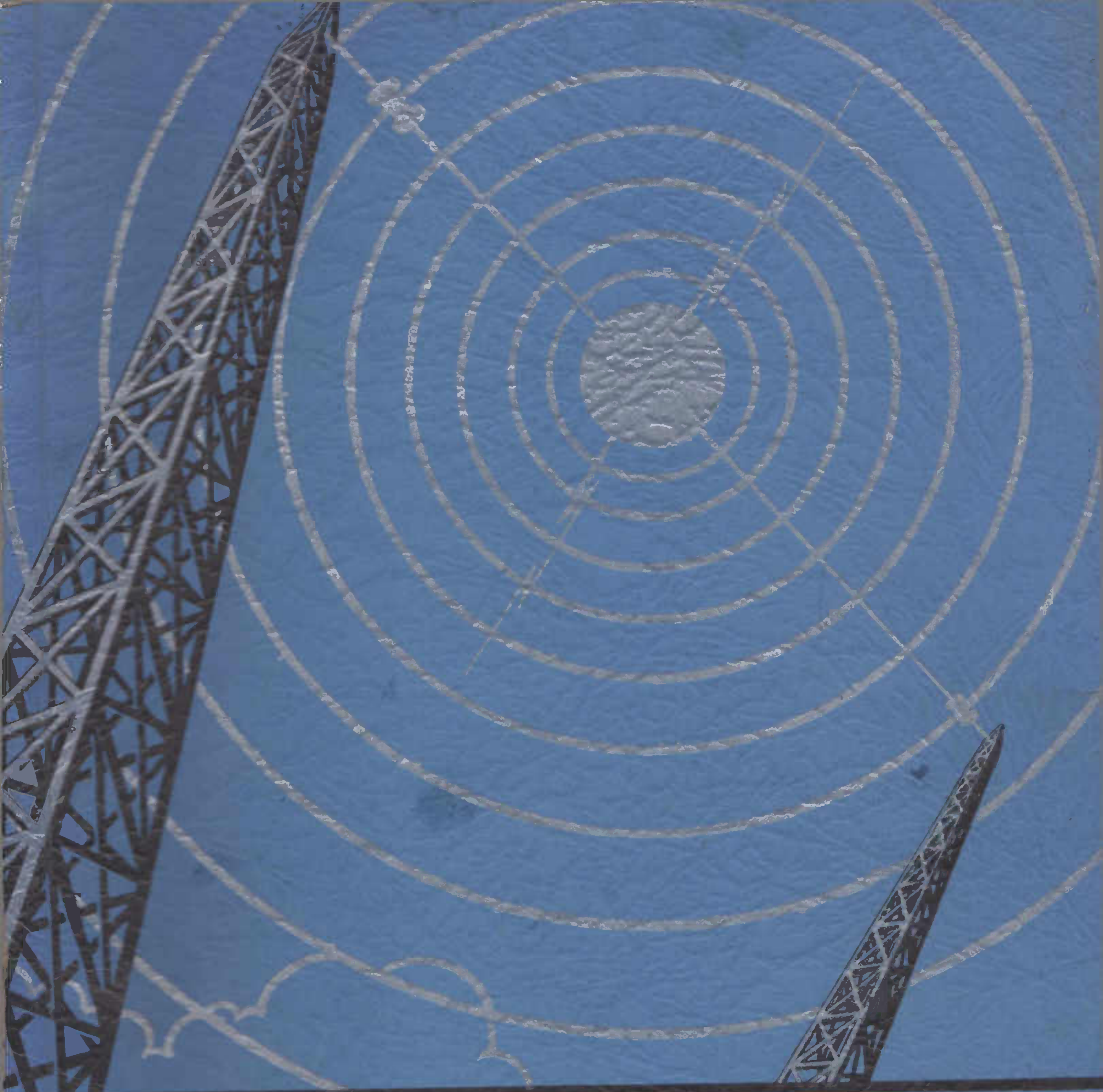

PHILIPS

TECHNICAL COMMUNICATIONS

PHILIPS TECHNICAL COMMUNICATIONS

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PHILIPS RADIO

PHILIPS TECHNICAL COMMUNICATION

No. 1

PHILIPS RADIO FREQUENCY PENTHODES TYPES E446 AND E447

The introduction of the E446 and E447 represents an important development in valve design resulting in considerable improvement to the efficiency of valve types which are responsible for the bulk of the amplification in the receiver.

The attention of the technician is directed to the outstanding characteristics of the new valves which attain the highest "figure of merit" yet achieved in the design of R.F. Penthodes.

The E446 and E447 are fitted with a new noise free cathode and heater, an exclusive Philips development, and the bulb is metallised, thus dispensing with the bothersome valve can. The metal coating is connected to a separate pin at the valve base for individual earthing.

The E446 is a "straight" R.F. Penthode designed for operation as an amplifier or detector. In particular, this valve is recommended as an autodyne in superheterodynes and also as an anode bend second detector.

The E447 is an I.F. or R.F. Amplifier with a variable mu characteristic and designed for volume control purposes.

APPLICATION

E446 as "Autodyne" Frequency Converter

With suitably designed coils the E446 operates satisfactorily and consistently as an autodyne. The conversion conductance of the E446 in this application is exceedingly high, in fact it surpasses that of all other penthode valves for the purpose.

CHARACTERISTICS.

	E446	E447
Heater voltage	4·0 V	4·0 V
Heater current	1·1 A	1·1 A
Plate voltage	250 V	250 V
Screen voltage	100 V	100 V
Plate current	3 mA. (Vg = —2V)	4·5 mA. (Vg = —2V)
Plate current	——	·01 mA (Vg = —35V)
Average Screen Current	1·1 mA	1·8 mA
Amplification factor	5,000	2,000
Mutual Conductance (normal)	2·5 mA/V	2·0 mA/V (Vg = —2V)
Mutual Conductance	——	·01 mA/V (Vg = —35V)
Plate Impedance	2 megohm	1 meg. (Vg = —2V)
Plate Impedance	——	10 meg. (Vg = —35V)
Plate—Grid capacity	·002 μμF	·002 μμF
Base	Medium 7 pin	Medium 7 pin

The maximum plate voltage under normal operating conditions is 250V, provided that an iron cored choke or transformer is not used in the plate circuit. The maximum voltage applied to the plate with the valve in a cold condition should not exceed 400V.

ADDITIONAL DATA

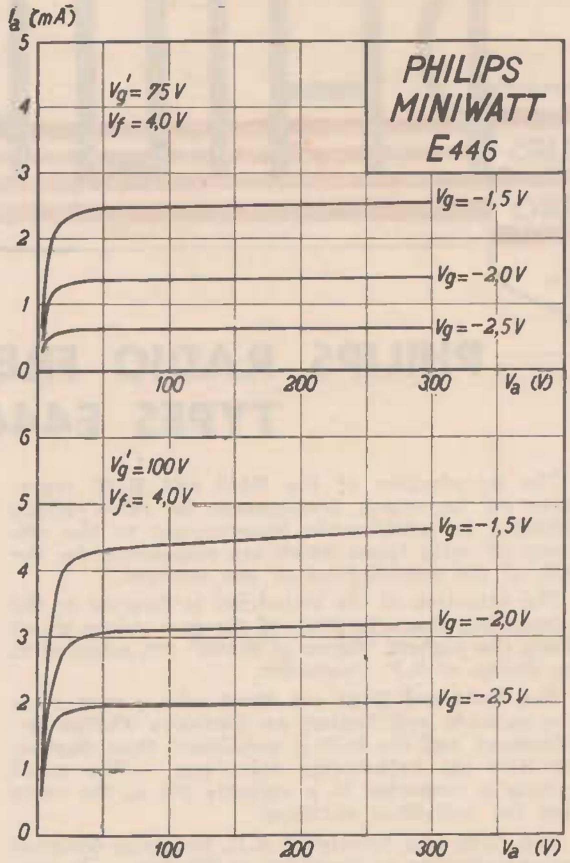
	E446	E447
Maximum plate dissipation	1·0 W	1·5 W
Maximum cathode current	10·0 mA	10·0 mA
Grid voltage for commencement of grid current (plus ·3 μA)	—1·4 V	—1·3 V
Maximum resistance in control grid circuit when bias is derived from cathode resistor (automatic bias)	1·5 megohms	4 megohms
Maximum resistance in control grid circuit with fixed negative bias	1·0 megohms	——
Output capacity	9·9 μμF	9·9 μμF
Input capacity	12·5 μμF	12·5 μμF
Maximum D.C. voltage between cathode and filament	50 V	80 V
Maximum permissible resistance between cathode and filament	20,000 ohms.	20,000 ohms

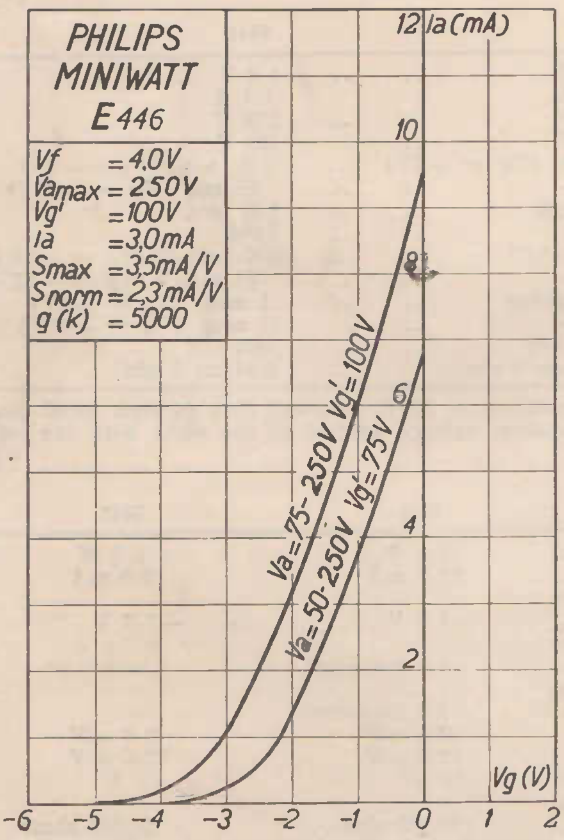
The negative bias will normally be obtained from a resistance of 1000 to 3000 ohms interposed in the cathode lead by-passed by a condenser of from 1000 to 10,000 $\mu\mu$F depending on the coils used. For maximum amplification the oscillator voltage induced in the cathode lead should preferably measure between 1 and 2 volts. Further information on the use of the E446 in this application is contained in communication No. 4.

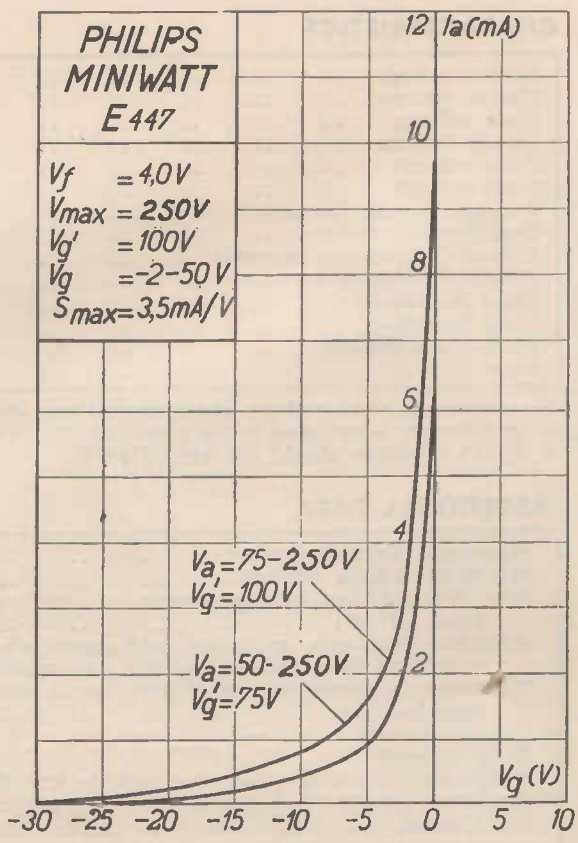
E446 as Detector

Although the E444 diode tetrode or E454 diode triode is recommended where quality of reproduction is of exceptional importance, the E446 operates particularly well as an anode bend detector. The best results are obtained at an anode supply voltage of 250V, and a screen grid voltage of 40 to 80V.

The screen voltage should be obtained from a potentiometer or voltage divider. The detector action will cause not only the plate current but also the screen grid current to vary. In the event of a series resistor being used for the screen feed, the voltage drop in this resistance will vary too, so that the valve will not continue to operate at the most favourable part of the characteristic curve. The potentiometer may be constructed from two resistances of ·1 megohm in series, the centre tap for the screen feed being by-passed to cathode by means of a 1 μF condenser. The coupling resistance in the plate circuit should have a value of ·25 to ·3 megohm whilst the recommended cathode resistance is 10,000 ohms shunted by a 1 μF condenser. The amplification obtainable from the E446 as an anode bend detector is 13·5.







E446 Audio Frequency Amplifier

The E446 is well suited for use as an audio amplifier preceding the power valve.

With a 250 V plate supply and 50 V on the screen grid the plate resistance should be ·25 to ·3 megohm, and the cathode resistor 5000 ohms shunted by a 2 uF condenser.

E447 R.F. and I.F. Amplifier

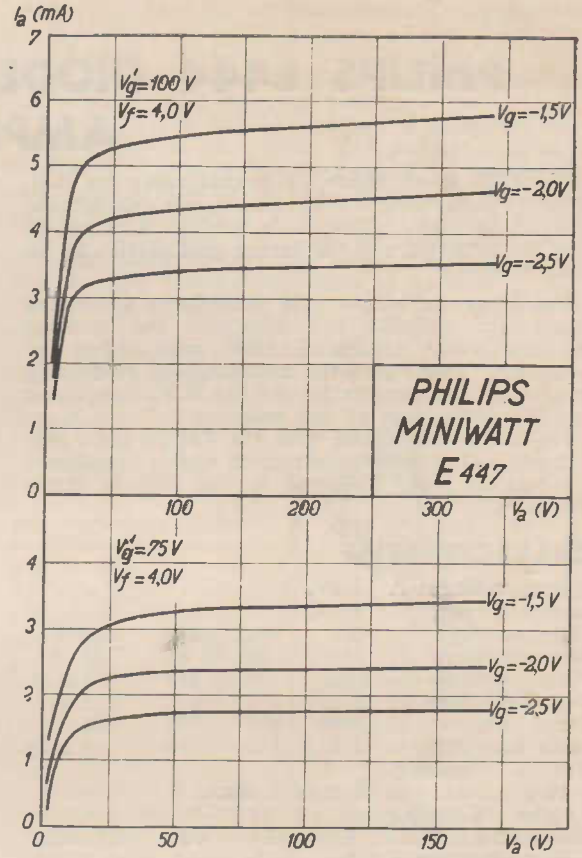
The internal resistance of the preceding valve, particularly in R.F. circuits is a very important factor. The greater this internal resistance is, the smaller the attenuation caused in the circuit. Hence the selectivity of the receiver can be improved accordingly. The internal resistance of the E447 is considerably higher in comparison with previous types, and very large stage gains are possible where high impedance tuned coupling circuits are employed.

The permissible grid swing of the E447 may be varied by an adjustment of the applied screen voltage. With a large screen potential the grid admittance is large, whereas with lower screen voltage it is small. This may be of advantage in receivers incorporating A.V.C. as in some cases the available regulating voltage is small.

E447 as Mixer in Superheterodynes with Separate Oscillator

For this purpose it is usually better to employ the E446. However, if volume control is to be effected on this stage it will be desirable to employ a valve with a variable mu characteristic such as the E447. For this application the oscillator voltage will as usual be induced into the cathode lead and for oscillator amplitudes of from 2 to 14 volts the cathode resistor will be adjusted between 600 and 5000 ohms in accordance with the circuit characteristics.

In conclusion, as an indication of merit, we furnish hereunder a comparison between the valves under discussion and other types:—



Additional types available in Philips "Super Series" of 4-volt A.C. valves:—

AK1	Octode Frequency Changer.
AF2	Variable mu R.F. Penthode (special for A.V.C.)
E444	Diode Tetrode.
E454	Duo Diode Triode.
E443H	Power Penthode (directly heated).
E463	Power Penthode (heater type).
1561	Full Wave Rectifier (directly heated).
1867	Full Wave Rectifier (heater type).

	E446	E447	57	58
Mutual Conductance (normal)	2·5	2	1·2	1·6 mA/V
Internal Resistance (Ri)	2	1·0	1·5	0·8 megohm
Grid Anode Capacity (Cag.)	·002	·002	·01	·01 μμF
Conversion Conductance (1st detector)	1·2	0·7	0·4	0·45 mA/V
Normal Anode Current	3	4·5	2	8·2 mA

No. 2

PHILIPS E444 DIODE-TETRODE DETECTOR AMPLIFIER

The E444 is an indirectly heated valve for A.C. receivers comprising a diode and screen grid tetrode in a single bulb. The diode portion is normally used for detection and the screen grid portion as an audio amplifier.

The diode and screen grid valve have a common heater and cathode, but otherwise the sections are completely separated from each other by screening. This offers the advantage of practically preventing the penetration of the R.F. component into the audio part of the receiver.

The E444 is equipped with the Philips noise-free filament and cathode construction and is metallised, the coating being anchored to the cathode inside the valve.

CHARACTERISTICS

Heater voltage ..	4·0V.			
Heater current ..	1·1A.			
Plate voltage ..	200	200	200	200 V.
Screen voltage ..	33	45	55	90 V.
Plate current ..	·35	·9	1·3	3·3 m/A.
Neg. Grid Bias ..	2·3	2·3	2·4	3·2 V.
Amp. Factor ..	1000	800	750	300
Plate Impedance ·	2·5	1·0	·8	·2 meg.
Mutual Conductance	3 mA/V. max.			
Plate Coupling Resistance	·3	·1	·06	·02 meg.

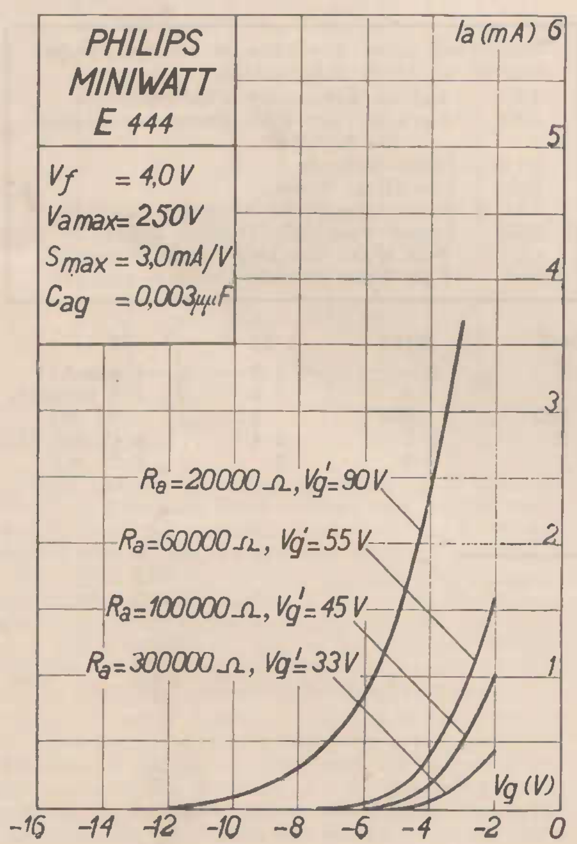
Base—medium 6 pin.

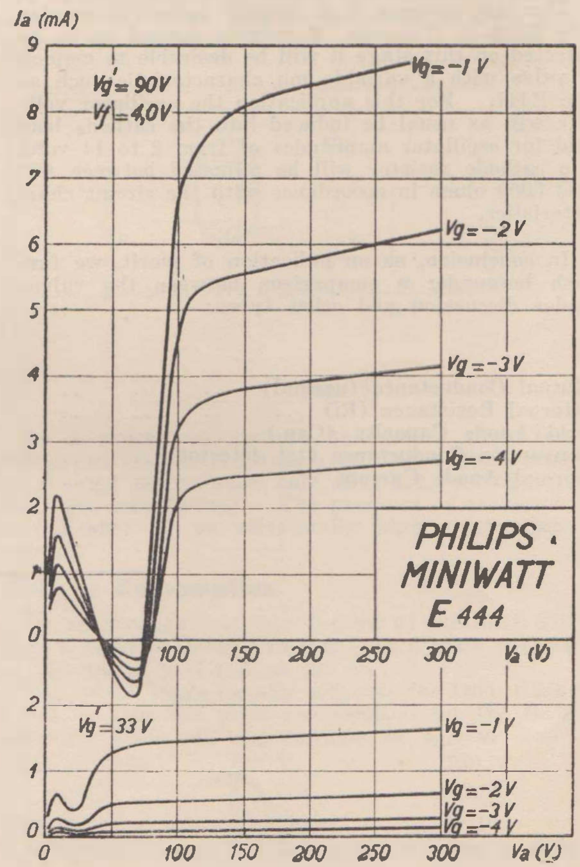
Whilst the above ratings are for 200 volts plate supply, the applied voltage may be increased to 250V. provided that an iron cored choke or transformer is not included in the plate circuit.

The voltage applied to the plate with the valve in cold condition should not exceed 400V.

ADDITIONAL DATA

Maximum plate dissipation	1·0 W
Maximum cathode current	10 mA
Maximum screen dissipation	·25 W
Negative Grid voltage for the commencement of grid current (plus ·3 μA)	1·3 V
Maximum applied voltage for diode	20 V
Maximum current for diode	·5 mA
Maximum resistance in control grid circuit when bias is derived from cathode resistor (automatic bias)	2 Megohm
Maximum resistance in control grid circuit with fixed bias	1 Megohm
Maximum permissible voltage between filament and cathode	50 V
Maximum permissible resistance between filament and cathode ..	20,000 ohms
Input capacity	10·6 μμF
Plate grid capacity	·003 μμF
Output capacity	7·0 μμF





Screen Grid Voltage. The screen grid voltage for the E444 should be obtained from a potentiometer or voltage divider and not from a series resistance. The total potentiometer resistance should not exceed ·1 megohm. As this potentiometer may also supply screen grid voltages for other valves, the value of the respective resistances cannot be specified.

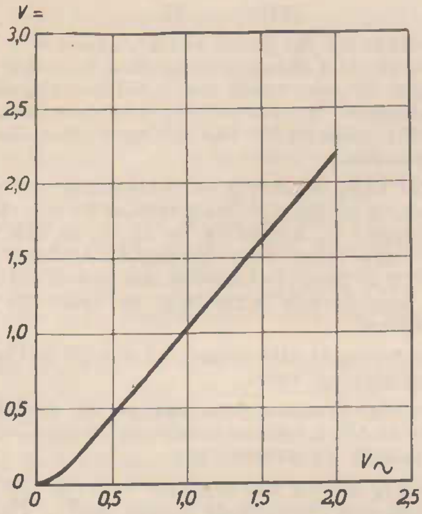


Fig. 1.

APPLICATION

In general and particularly with modern apparatus the present-day constructor requires the detector to have two properties:—

1. Absence of distortion, i.e., linear detection.
2. The possibility of supplying a fairly high L.F. voltage to the grid of the power valve without running the risk of the detector being too easily overloaded.

It is well known that anode detection causes distortion due to the parabolic curve of the anode

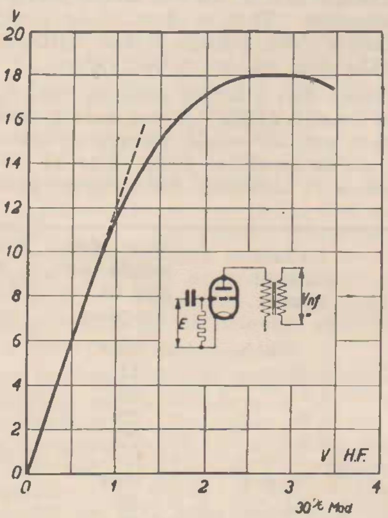


Fig. 2.

current characteristic. The grid detector gives linear detection provided it is operated on the straight part of the grid current characteristic, but for very small R.F. inputs distortion occurs, and for large inputs anode detection takes place simultaneously with grid detection, again causing distortion. This explains why it is impossible to obtain large audio voltages on the grid of the output valve without overloading the detector, unless a very high detector anode voltage is applied.

Although, in principle, diode detection is similar to grid detection, it does not have this disadvantage as is clearly seen from fig. 1 and 2.

In fig. 1, the rectified voltage is expressed as a function of the alternating R.F. voltage applied to a diode. If this rectified voltage is to remain proportional to that of the A.C. voltage for variations up to 90 per cent., it is necessary to apply an A.C. voltage of at least 1·5 volts. If the detection is to remain linear at an even deeper modulation, the initial A.C. voltage will have to be still greater. This is also applicable to a triode with grid detection.

It is generally said that for signals of ·5 volt a sufficiently linear detection is obtained, and it is assumed that very deep modulation is not very frequent.

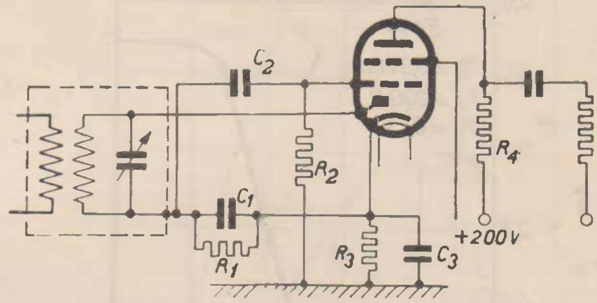


Fig. 3.

Since, with a triode using grid detection, the A.C. voltage supplied is at the same time the control voltage for the anode current, anode detection very rapidly takes place when the R.F. voltage increases (see fig. 2). Fig 2 indicates the resultant L.F. volttage in this case by the E424 with transformer 3:1, as a function of the R.F. voltage modulated by 30 per cent.

Initially, the detected signal is proportional to the R.F. voltage. When the R.F. signal exceeds ·8 volt, deviation through anode detection takes place.

The logical solution, in order to avoid these difficulties, is to separate the detection and the audio amplification, two quite different functions, and to use a diode detector.

For this purpose Philips developed the E444, which is a combination of a diode detector and a screen grid amplifier in one bulb. The diode and the amplifying valve, forming the E444, have a common cathode, i.e., the diode is formed by a small ring mounted round the cathode of the amplifying valve. This ring, which is thus the anode of the diode, is connected to one of the pins in the base of the valve. The amplifying valve is designed for use as a R.C.C. amplifier.

Fig. 3 shows the simplest circuit for use with the E444.

The R.F. signal is applied to the diode via a "grid-condenser" C1 of approx. 200$\mu\mu$F and a leak resistance R1 of ·2—2 megohms. The rectified signal obtained at R1 is supplied to the grid of the amplifying valve via a normal coupling condenser C2 of approx. 5000 $\mu\mu$F.

The negative grid voltage for the tetrode is obtained by the resistance R3, which is shunted by the condenser C3 of approx. 1 μF and supplied to the valve via the resistance R2 of 2 megohms. The value of R3 will be indicated later.

The coupling resistance R4 is connected in the anode circuit; the anode coupling to the power valve takes place in the ordinary way. The screen grid voltage can best be obtained with the aid of a potentiometer having a total resistance of ·1 megohm The diode characteristic is shown in fig. 1.

Let us assume that an unmodulated signal of ·5 volt, R.M.S., is applied, then the D.C. voltage at R1 will increase by ·43 volt. If this same R.F. signal is modulated by 50 per cent., i.e., it fluctuates between ·25 and ·75 volt the D.C. voltage will vary at R1 between ·15 and ·71 volt. The D.C. voltage thus varies with an amplitude of ·28 volt, corresponding to an A.C. voltage of ·2 volt R.M.S. value. This L.F. voltage is applied to the grid of the amplifying valve.

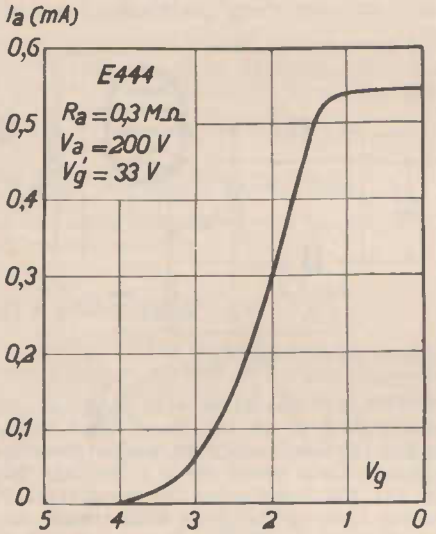


Fig. 4.

The E444 has, however, far less R.F. voltage on the grid. At first sight it might be thought that it has no R.F. voltage at all; the diode, however, has a certain capacity towards the cathode, which is approximately 2$\mu\mu$F, and parallel to this we find the capacity of the connecting wire to the diode, so that the total capacity of the diode towards the cathode will be 8 to 12 $\mu\mu$F. This capacity is in series with C1 and parallel to the tuned circuit, so that part of the R.F. voltage is transferred to C1, and thus to the grid of the tetrode.

If the capacity of the diode with wiring is 10 $\mu\mu$F, and if C1 = 200 $\mu\mu$F, the R.F. voltage on the grid of the tetrode will be:—

$$\frac{10}{210} = \frac{1}{21}$$

of the voltage on the tuned circuit, i.e., it will be 21 times less than in the case of normal grid detection. This signal is too small to produce appreciable anode detection. In view of this it is very important to keep the capacity of the wiring at the diode as low as possible.

For this same reason it is inadvisable to connect the screening of the I.F. transformer to the chassis, but to connect it, according to fig. 3, to the tuned circuit. Care must then be taken, however, that no coupling is possible between the power valve and the I.F. transformer screening, in order to avoid audio reaction.

The screening is also connected via C2 to the grid of the amplifying valve.

As the high-frequency voltage at the grid of the tetrode is small, a bypass condenser in parallel with R4 will usually be unnecessary.

As already stated, the capacity between the rectifying anode and the cathode is only 2$\mu\mu$F. The base has also been so constructed that the capacity between the pins of the rectifying anode and of the control grid is extremely low. The E444 requires altogether seven connections, the plate is led out at the top, and the valve is provided with a 6-pin base.

The amplification of the L.F. signal by the tetrode depends on the value of the coupling resistance R4.

A few values are indicated in the following table, in which the most favourable screen-grid voltages are mentioned, as well as the value for resistance R3, the approximate anode current and the A.C. anode voltage R.M.S. value, which produces 5 per cent. distortion. This is thus to be considered as the maximum A.C. voltage R.M.S. value to be supplied to the grid of the power valve.

It is known that a larger coupling resistance gives a greater amplification. Thus, with a resistance of ·3 megohm and an anode voltage of 200 volts the signal could be amplified from ·2 to 20 volts R.M.S. value, which is sufficient for a large power valve.

	R4	Screen Voltage.	R3.	Plate current approx.	Max. A.C. anode voltage to be supplied.	Effective Audio Amplification.
Plate Voltage, 250V.—	·3 megohm.	35 V.	4000 ohms.	·40 mA.	39 V.	110
	·1 „	50 „	1500 „	1·16 „	41 „	65
	·06 „	65 „	1250 „	1·8 „	36 „	50
	02 „	100 „	800 „	4·0 „	29 „	25
	·01 „	120 „	400 „	7·2 „	27 „	19
Plate Voltage, 200V.—	·3 megohm.	33 V.	5000 ohms.	·30 mA.	30 V.	100
	·1 „	45 „	2000 „	·84 „	30 „	60
	·06 „	55 „	1500 „	1·30 „	28 „	45
	·02 „	90 „	800 „	3·2 „	22 „	20
	·01 „	110 „	670 „	4·8 „	18 „	14
Plate Voltage, 150V.—	·3 megohm.	30 V.	8000 ohms.	·20 mA.	24 V.	80
	·1 „	40 „	3000 „	·60 „	23 „	50
	·06 „	50 „	2000 „	1·00 „	23 „	35
	·02 „	75 „	1000 „	2·2 „	18 „	17
	·01 „	90 „	800 „	3·2 „	12 „	10

But great amplification is not always of primary importance. It has already been stated that, in order to obtain linear detection, it is essential to have a fairly large R.F. voltage on the diode. Minimum ·5 V. R.M.S. value was the order of amplitude mentioned. If this signal is 90 per cent. modulated, an L.F.—A.C. voltage of approx. ·5 volt amplitude will result after detection.

The amplification is now chosen so that the power valve is loaded normally and yet contains a sufficient reserve for stronger signals. In that case an amplification of 30 times obtained with a coupling resistance of about 40,000 ohms is quite large enough, as the amplitude at the grid of the power valve is then 30 × ·5 = 15 volts; usually a coupling resistance of 10,000 ohms with an amplification of approx. 14 times will be quite sufficient.

In order to obtain linear detection with a diode, a large R.F. signal on the diode is essential, which necessitates a small audio amplification and a large R.F. amplification. In most of the modern "Superhets" the R.F. amplification will be more than sufficient.

It follows from the table that the E444 can also be connected as a very sensitive detector; in which case linear detection is sacrificed, but the advantages remain; these are: the detector is never overloaded, and without additional R.F. filters a small R.F. voltage is obtained in the audio part of the receiver. With a coupling resistance of ·1 megohm in the anode circuit, about the same sensitivity is obtained as with the E424 with a 3:1 transformer. With larger coupling resistances the E444 becomes more sensitive than with the latter combination, but there is a limit to the increase of the coupling resistance. The coupling resistance is not the only impedance in the anode circuit of the amplifying valve. In parallel with it we find the coupling condenser in series with the leak resistance of the power valve and sometimes also a condenser in order still further to reduce the R.F. voltage on the grid of the power valve. If, for instance, a capacity of 100 μμF. in parallel with the coupling resistance is used, the impedance for 60 kc will be ·025 megohm; if the coupling resistance is 1 megohm the R.F. will be 40 times less amplified than the L.F. For a frequency of 5000 cycles, however, the impedance of the parallel capacity is ·3 megohm, so that the high notes are also considerably subdued. In these circumstances it is not practical to increase the coupling resistance to a greater value than ·3 megohm.

The second limitation is due to the leak resistance of the power valve. For output valves of a fairly large power this resistance must not be too high. For instance, for the average power valve ·6 megohm. If R4 = 1 megohm, the total impedance in the anode circuit is ·38 megohm and the amplification is correspondingly smaller.

In order to determine the audio amplification of the amplifying valve, the Ia—Vg curve with the coupling resistance in the anode is used. Fig. 4 shows an example for R4 = ·3 megohm. The slope at —2 volts is ·33 mA/V, corresponding to an amplification of ·00033 × 300 = 100. The amplitude of the A.C. grid voltage is limited by two bends:

1. The normal lower bend where the anode current approaches zero.
2. The upper bend which results from the anode voltage becoming equal to or smaller than the screen-grid voltage. There the anode current is ·55 mA, so that the voltage drop in the coupling resistance is 165 volts and the anode voltage is then equal to the screen-grid voltage. At a lower screen-grid voltage this bend shifts in an upward direction and to the right. As the whole characteristic then shifts to the right, the grid space is finally limited by the grid current.

The screen voltage is then so chosen that the upper bend corresponds to the commencement of grid current, i.e., at approx. —1 to —1·5 volts. In this way the screen-grid voltages in the table have been found.

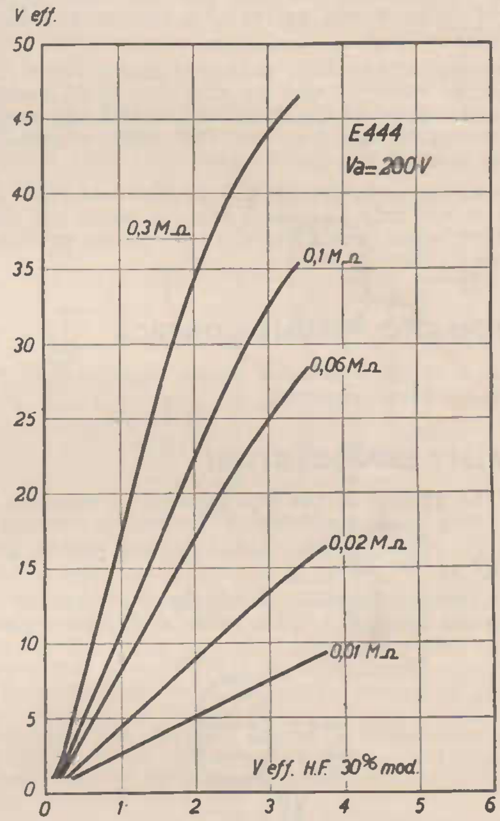


Fig. 5.

The intensity of the signal which can still be produced by the anode without distortion, depends on the two bends of the characteristic (fig. 4) and could be taken from it. However, direct measurement ensures more rapid and more reliable results. If a maximum distortion of 5% is permitted the values indicated in the table will be arrived at.

The curves of fig. 5 give an impression of the performance of the E444 as a whole. The audio voltage output measured across a leak resistance of 2 megohms for the power valve is referred to as a function of the R.F. voltage R.M.S. value at a modulation depth of 30% supplied to the "grid con-

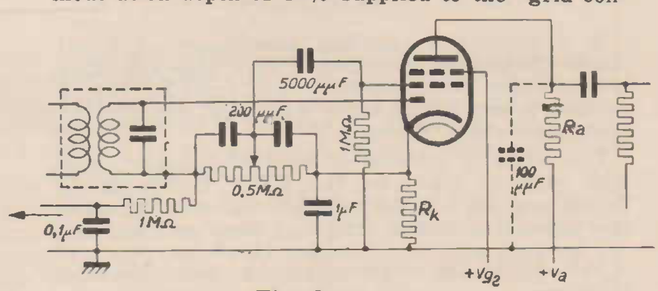


Fig. 6.

denser." The different curves relate to the various coupling resistances. These curves are obtained by direct measurement. They can also be constructed from the tetrode dynamic characteristic fig. 4. The bend in the upper part does not originate in the diode but is due to overloading of the tetrode. The audio voltage may also be determined on the basis of the diode characteristics, fig. 1, and of the different characteristics, one of which is shown in fig. 4. The maximum voltage (see table) is, however, sufficient for all cases, as the use of large power valves also entails a greater available voltage.

As long as the L.F. voltage remains below the maximum value, it may be said that it is directly proportional to the depth of modulation; the curves can therefore also be used for other modulation depths than 30%.

From the foregoing it will be observed that the E444 is not only the ideal detector valve but that it offers other possibilities, such as the provision of A.V.C., etc.

AUTOMATIC VOLUME CONTROL

Fig. 6 shows a suitable circuit applicable to the superheterodyne receiver.

QUALITY REPRODUCTION

If the quality of the reproduction is required to meet very high standards, a further improvement may be effected with regard to the screen grid portion of the E444.

The cathode resistance R3 in fig. 3 is shunted by a capacity of 1 μF. This value should be approximately 10 μF if the low notes (100 cycles) are to be amplified to the same extent as the high notes (4000 cycles).

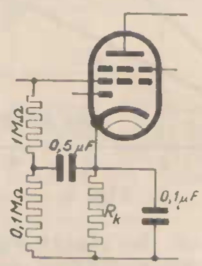


Fig. 7.

Figure 7 provides an alternative solution which dispenses with the necessity for the 10 μF condenser and yet gives adequate frequency response.

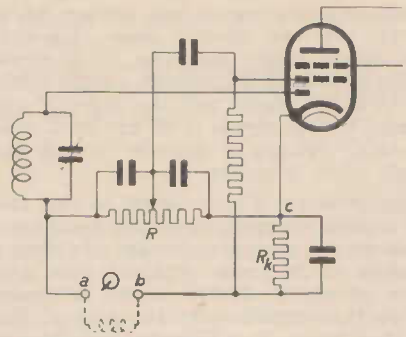


Fig. 8.

GRAMOPHONE PICKUP

A gramophone pickup may be connected to the E444 in the manner shown in fig. 8. The potentiometer R constitutes the volume control. The pickup is connected across points a and b, i.e., across resistances R and Rk. It might seem desirable to connect the pickup across the potentiometer R only, i.e., at points a and c. However, the method shown in fig. 8 offers two advantages which are as follows:

1. As the pickup affords a passage to direct current, the bias, which is automatically generated in the Resistance Rk, will be applied to the diode via the tuned circuit, and consequently any radio signals which may be received in the I.F. amplifier will not be rectified by the diode.
2. The presence of the diode in the circuit will not cause distortion to the voltage delivered by the pickup. If the diode had not been made negative with respect to the cathode, it would rectify the positive phase of the pickup output. In this circuit the pickup will of course be disconnected during radio reception.

No. 3

PHILIPS 2-VOLT BATTERY VALVES

In producing a complete new range of 2-volt valves for battery operation, Philips have succeeded in combining the robustness and dependability of existing 4 and 6 volt types with new standards of performance and efficiency.

The series is remarkably comprehensive—in fact such original types as the KBC1 Double Diode Triode and KK2 Battery Octode serve to introduce new principles to the design of Battery Receivers.

The series is represented by the following types;—

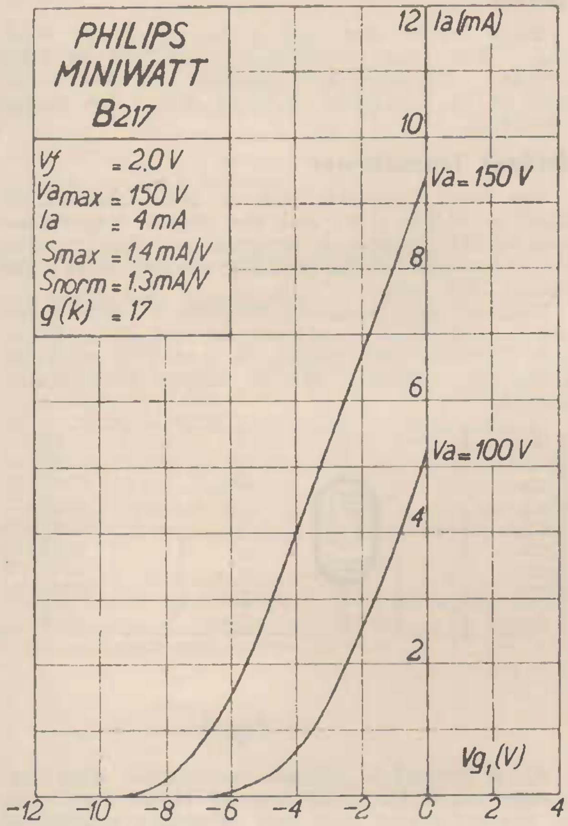
B217	General Purpose Triode and Driver.
B240	Twin Triode (Class B).
B255	Screen Grid R.F. Amplifier (variable mu).
B262	Screen Grid R.F. Amplifier.
KDD1	Twin Triode (Class B).
KBC1	Double Diode Triode.
KF1	R.F. Penthode.
KF2	R.F. Penthode (variable mu).
KK2	Battery Octode.
C243N	Output Penthode.

Data and characteristics of the B217, B240, B255 and B262 are furnished hereunder:—

B217 TRIODE GENERAL PURPOSE DETECTOR, AMPLIFIER, DRIVER, OSCILLATOR —

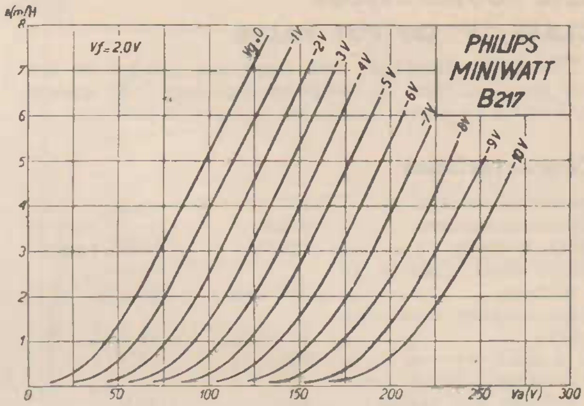
Characteristics

Filament voltage	2 V.
Filament current	0·1 A.
Plate voltage	120-150 V.
Normal plate current	4 mA.
Negative grid bias	4 V.
Voltage amplification factor	17
Mutual conductance (normal)	1·3 mA/V.
A.C. plate resistance	13,000 ohms
Base	4 pin.



Limits

Maximum plate voltage	150 V.
Maximum plate dissipation	·9 W.
Maximum cathode current	6 mA.
Starting point of grid current	—0·4 V.
Maximum resistance in control grid circuit with "automatic bias"	1·5 Megohm
Maximum resistance in control grid with "fixed bias"	1·0 Megohm
Plate grid capacity	5·3 $\mu\mu$F
Plate cathode capacity	2·1 $\mu\mu$F.
Grid cathode capacity	4·3 $\mu\mu$F.



APPLICATION

Detector with Transformer Coupling

As a grid leak detector in battery operated receivers, the B217 will be found to be sensitive and non-microphonic. The value of the grid condenser may be between ·0001 and ·0003 mfd. and the grid leak from 1 to 3 megohms.

The B217 is also particularly suited for use as a short wave detector with reaction and in this respect is comparable with the A415.

Audio Amplifier

The minimum negative bias voltages for this purpose are as follows:—

Plate voltage	Bias
150	3
100	1·5

The Philips Audio Transformer type 4003N is recommended for all straight audio circuits. As an alternative, resistance capacity coupling may be employed, in which case, a plate load resistor of 50,000 ohms is recommended.

Driver

The B217 is specified as a driver for the B240, the Philips 2 volt "Class B" output valve. For further information on "Class B" see data for B240.

Oscillator

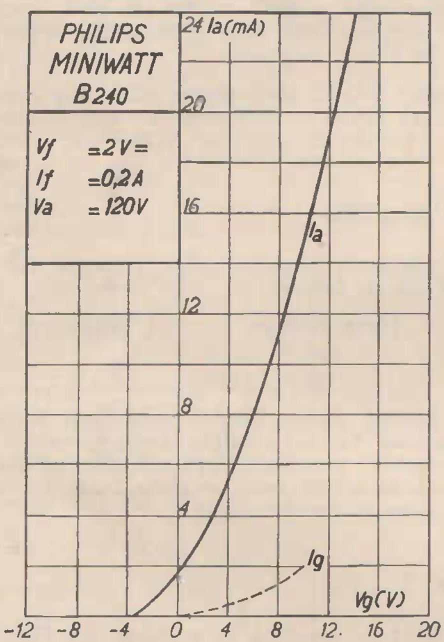
The B217 being a ready oscillator, operates satisfactorily as a separate oscillator for all wave superheterodynes.

B240 DOUBLE TRIODE CLASS "B" OUTPUT VALVE

The B240 combines two high mu triodes in the one envelope and is designed for class "B" operation in the output socket of battery receivers.

Characteristics

Filament voltage	2V.	
Filament current	0·2A.	
Plate voltage	120V.	150V. (max.)
Static plate current (2 plates)	2·5 mA.	3 mA.
Plate current max. (total)	15 mA.	21 mA.
Grid bias	0V.	0V.
Maximum signal input voltage per triode ..	14V.	14V.
Minimum input impedance (valve)	3000-5000 ohms	
Optimum load (plate to plate)	14,000 ohms	14,000 ohms
Mutual conductance (grid voltage plus 5)	2·2 mA/V.	
Output watts (2 triodes)	1·25W.	1·9W.
Base	Medium 6 pin.	



APPLICATION

Under correct operating conditions it is possible to obtain from the B240 volume and quality comparable with all electric receivers, at a current demand well within the capabilities of "B" batteries.

For Class "B" the triodes are operated in push-pull. The characteristics of the triodes are such that with no negative bias applied and the tubes in a static condition, only a small plate current will flow (2·5 to 3 mA). The grid return of both triodes should be connected to negative filament.

When a signal voltage is applied to the grids of the B240 in this circuit arrangement, the grids will alternatively become positive and grid current will flow. It is the function of the preceding valve together with the coupling transformer to supply this grid current. For this reason it is not practicable to feed the output valve directly from the detector.

Driver Stage

In common with other Class "B" valves the B240 should be preceded by a driver stage, the specified valve for the purpose being the B217.

The recommended negative bias for the B217 in this application is 4·5 V. at 150 V. plate potential and 3·0 V. with 120 V. on the plate.

To obtain the greatest output with a minimum of distortion it is necessary that a fairly high signal input be applied to the driver valve. To fully load the B240 the signal voltage applied to the grid of the B217 should approximate 3 volts (R.M.S.). The detector must be able to supply this voltage.

Audio Transformers for Class "B" are necessarily of special design and the following specifications are applicable to the abovementioned valve types.

Input Transformer Following the B217 as a Driver

Ratio 3:1 to each half of the secondary winding. The total transformer ratio will be 1·5:1 overall. To avoid grid damping the total resistance of the secondary winding should not exceed 400 ohms.

Output Transformer

The most favourable plate to plate load for the B240 is 14,000 ohms and the output transformer feeding the speaker is designed accordingly. The D.C. resistance of the primary winding should not exceed 1000 ohms.

To limit high frequency response a limiting circuit consisting of a condenser of ·005 μF in series with a 10,000 ohm resistor is generally connected across the primary of the output transformer. (See fig. 1.)

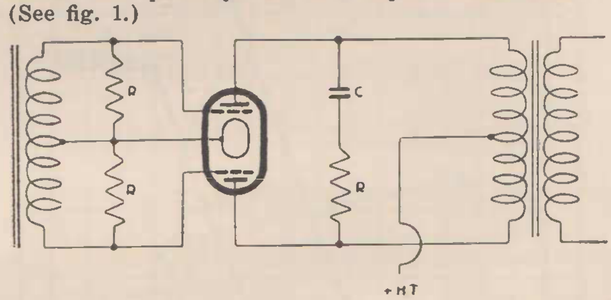


Fig. 1

As a precaution against undesirable high frequency oscillation resistances of 10,000 ohms may be shunted across each half secondary winding of the input transformer. The presence of oscillation is indicated by an abnormally high static plate current.

Battery Consumption

On an average the plate current of the B240 will have a value of from 6 to 8 mA, at a plate voltage of 150 and 4 to 5 mA at 120 V.

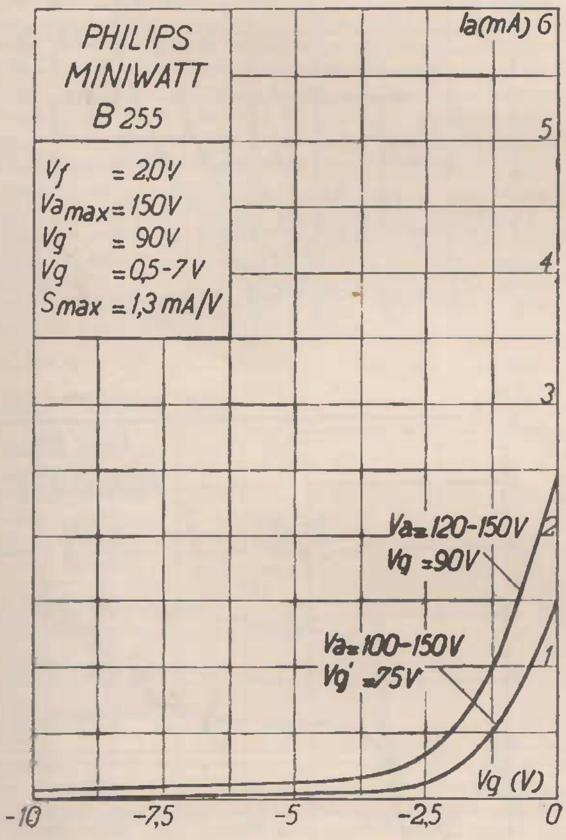
The driver stage usually accounts for from 2.5 to 3 mA so that the plate consumption for the B240 plus the B217 will approximate as follows:—

Plate voltage ..	120 V.	150 V.
No signal	4·5 mA.	6 mA.
Max signal	18·5 mA.	24 mA.
Average	6·5 to 7·5 mA.	9 to 11 mA.

B255 VARIABLE MU SCREEN GRID R.F. AMPLIFIER

Characteristics

Filament voltage	2·0
Filament current	·18 A.
Plate voltage	120-150 V.
Screen voltage	90 V.
Plate current	1·8 mA (max.)
Negative grid bias	0
Voltage amplification factor	400
Mutual conductance—	
(neg. grid bias = 0·5)	1·2 mA/V.
(neg. grid bias = 7·0)	·014 mA/V.
A.C. plate resistance	330,000 ohms
Base	4 pin



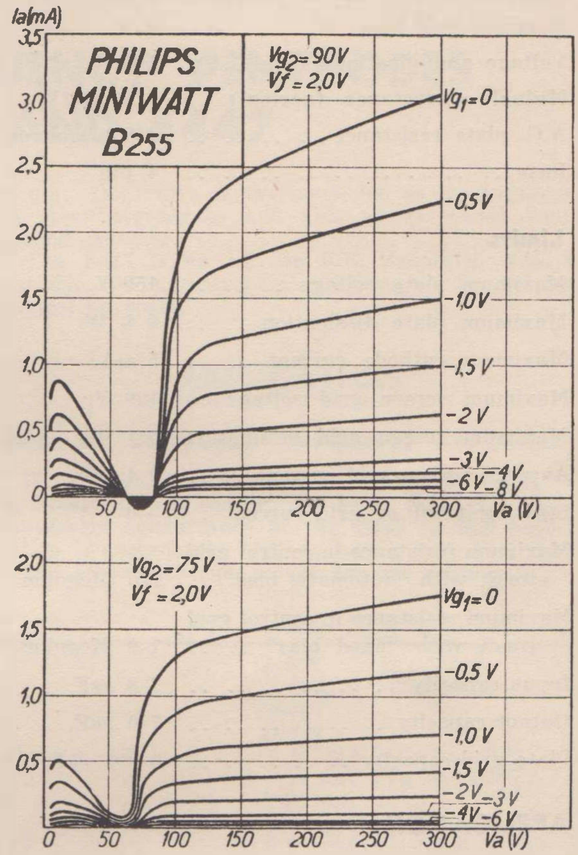
Limits

Maximum plate voltage	150 V.
Maximum plate dissipation	0·8 W.
Maximum cathode current	5 mA.
Maximum screen grid voltage	100 V.
Maximum screen grid dissipation	0·1 W.
Average screen grid current	0·4 mA.
Starting point of grid current	—0·4 V.
Maximum resistance in control grid circuit	2 megohm
Input capacity	8·2 μμF
Output capacity	6·5 μμF
Plate grid capacity	0·008 μμF

APPLICATION

Variable Mu, R.F. or I.F. Amplifier for Battery Receivers

A feature of the B255 is the fact that whilst the working value of mutual conductance varies smoothly with the negative bias applied to the grid, a bias of 9 volts is sufficient to cut off the plate current. Consequently the previous disadvantage of the necessity for a high "C" battery with variable mu valves is obviated by the use of the B255.



The grid bias for volume control purposes should be obtained from a potentiometer of 10,000 to 20,000 ohms connected across a 9 volt grid bias battery, which, incidentally, may also be used to supply bias to other valves in the receiver.

The positive return from the "C" battery will normally be connected to negative filament.

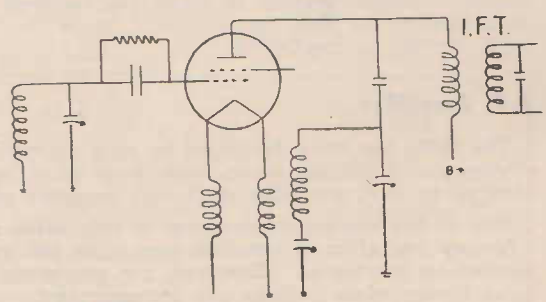


Fig. 2

B262 SCREEN GRID R.F. AMPLIFIER DETECTOR

Characteristics

Filament voltage	2·0 V.
Filament current	0·18 V.
Plate voltage	120-150 V.
Screen voltage	90 V.
Plate current	2 mA max.
Negative grid bias	0 V.
Voltage amplification factor	500
Mutual conductance (normal) ..	1·3 mA/V.
A.C. plate resistance	400,000 ohms
Base	4 pin

Limits

Maximum plate voltage	150 V.
Maximum plate dissipation	0·8 W.
Maximum cathode current	5 mA.
Maximum screen grid voltage ..	100 V.
Maximum screen grid dissipation	0·1 W.
Average screen grid current	0·4 mA.
Starting point of grid current ..	—0·4 V.
Maximum resistance in control grid circuit with "automatic bias" ..	1·5 Megohm
Maximum resistance in control grid circuit with "fixed bias"	1·0 Megohm
Input capacity	7·8 μμF.
Output capacity	7·0 μμF.
Plate grid capacity	0·008 μμF.

APPLICATION

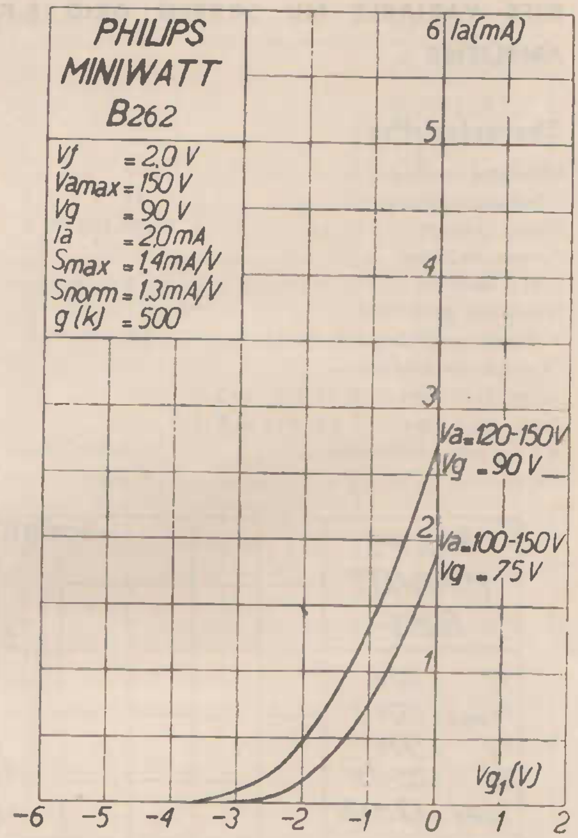
Detection

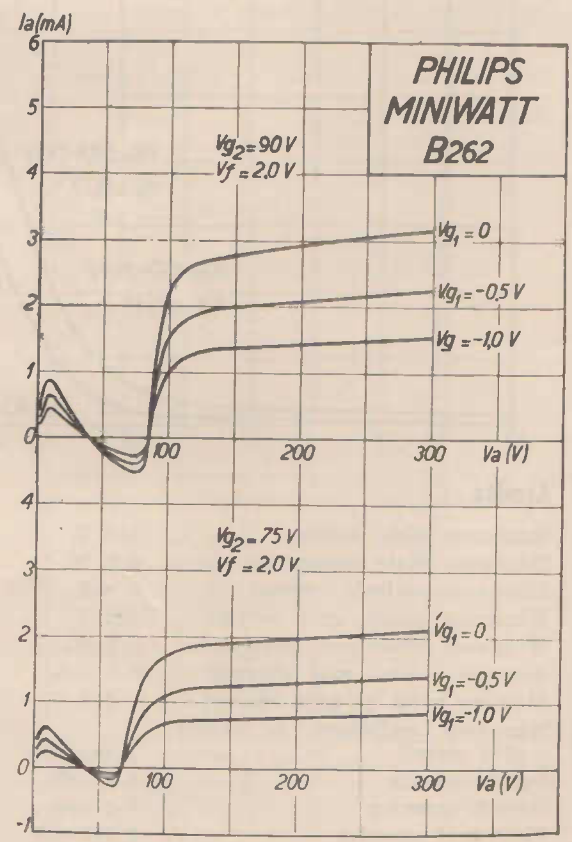
The B262 is recommended for use as an "autodyne" first detector in superheterodynes. A suggested circuit is shown in Figure 2 (see previous page), which gives satisfactory results. It will be observed that two similar reaction coils are wound in phase and coupled to the tuned oscillator circuit. Approximately 10 turns are required for each winding so that the voltage drop in the filament circuit is negligible.

R.F. Amplifier

The B262 has been developed to give exceptional efficiency and the maximum stage gain when operated as an R.F. amplifier with well designed coils.

Due to the special construction of this valve satisfactory operation is possible even with 100 volts applied to the plate. However, for maximum results higher plate ratings are recommended. No negative bias should be applied to the B262 for this application. Normally, the grid return will be taken to filament negative.





No. 4

THE "AUTODYNE" FIRST DETECTOR

Hints on the application of the Philips E446 R.F. Penthode

A wide range of valve types is available for the frequency-changing stage of modern superheterodynes.

Certain types specifically designed for the purpose, whilst possessing many advantages, are lacking in conversion conductance and in some applications considered to be responsible for low signal to noise ratio. We find, therefore, many adherents to the "autodyne" principle using an R.F. penthode and remarks concerning a new method of meeting the attendant problems should prove of interest.

The E446 by reason of its excellent characteristics is capable of exceptional results and under suitable operating conditions will be found to be superior for first detection, particularly with respect to noise level and conversion amplification.

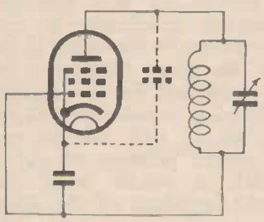


Fig 1

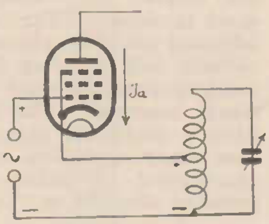


Fig 2

We furnish hereunder a survey of the points to observe when operating the E446 as an "autodyne."

(1) To obtain adequate mutual conductance (the condition in which oscillation is easily obtained), we recommend a cathode resistance of approximately 1250 ohms. The oscillator voltage induced into the cathode coil should be between 1 and 2 volts obtainable by regulating the damping of the oscillator circuit (R3 in Fig. 6), or, alternatively, by an adjustment of the number of coupling coil turns.

(2) It is well known that the value of the condenser by-passing the cathode resistance should not be too large otherwise low frequency oscillation may occur. The valve has automatic grid bias and as soon as oscillation occurs the average plate current increases and so does the grid bias.

The grid bias does not increase instantly—the condenser shunted across the bias resistance has first to be charged to the new potential. When the condenser does become charged and the bias increased, the valve ceases to oscillate for the reason that the mutual conductance has been lowered. In the absence of oscillation the plate current decreases and also the grid bias until oscillation again occurs and so on. The result is "motorboating" and as a preventative the value of the cathode resistor by-pass condenser should be as small as possible for the reason that the charging delay will then be extremely short. In some cases the capacity may be as high as ·1 μF.

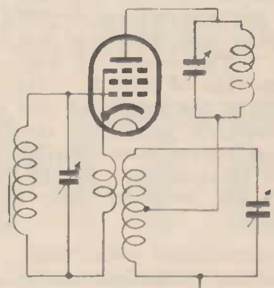


Fig 3

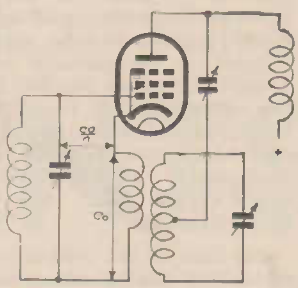


Fig. 4

On the other hand, the use of too small a capacity may cause oscillation at the Intermediate Frequency. If the cathode-plate capacity is taken into account the plate circuit can be considered as equivalent to the "Colpitts Circuit." (See Fig. 1.) It is the ratio between the cathode plate capacity and the cathode resistor shunt capacity which determines whether intermediate frequency oscillation will take place.

(3) It is the usual practice to obtain cathode coupling by means of a tap on the tuned oscillator coil (see Fig. 2), but under these conditions the impedance of the tapped portion is excessive. The voltage drop in this impedance, due to the R.F. component in the plate circuit, is in opposite phase to the incoming signal in the grid circuit.

As the tapped portion of the oscillator coil is included in both the grid and plate circuits the net result is that the incoming signal is partially suppressed. Another disadvantage is that a coupling occurs between signal frequency circuit and the oscillator circuit via the tapped portion of the oscillator coil and the grid cathode capacity which causes detuning and interlocking of the respective circuits.

It is preferable, therefore, to have a very loose coupling in the cathode circuit, but to maintain oscillation it becomes necessary to tighten the coupling in the plate circuit by tapping the tuned oscillator coil (see Fig. 3 and 4).

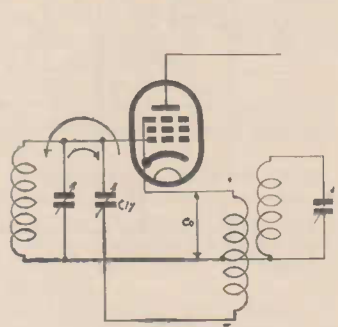


Fig.5

If the primary of the I.F. transformer is placed between the plate and the whole of the oscillator coil other difficulties occur. The minimum capacity of the oscillator circuit will be too large and adequate tracking is difficult. At the same time there is an increased tendency for intermediate frequency oscillation. If, for instance, in Fig. 3 the bottom connection of the I.F. transformer is connected to the top of the oscillator coil, there would be feed back of the intermediate frequency through the coupling with the cathode coil. If, on the other hand, the I.F. Transformer is connected to the tap on the oscillator coil and the cathode coil coupled to the top portion, the I.F. oscillation will only be predominant in the lower portion of the oscillator coil which is not coupled to the cathode coil. The circuit of Fig. 4 oscillates more readily than that of Fig. 3. On the other hand, in Fig. 4 part of the oscillator coil is introduced into the intermediate frequency circuit which can increase the damping considerably, particularly at intermediate frequencies to the order of 460 KC. For 175 KC, however, Fig. 4 is satisfactory.

(4) One of the difficulties experienced with "autodynes" is the tendency to cease oscillation at the higher frequencies (in the neighbourhood of 200 metres). As a result the sensitivity of the receiver falls off below 300 metres and oscillation may even cease completely. The reason for this is that the impedance of the grid circuit is very large for higher frequencies whereas the impedance of the grid cathode capacity is lower.

The oscillator induces an alternating voltage into the cathode coil between earth and cathode (Fig. 4). It is generally supposed that all of this voltage is applied to the grid via the grid coil. In reality only portion of this voltage reaches the grid for the reason that the capacity between cathode and grid allows a current to pass in the circuit embracing the cathode, grid, H.F. circuit, cathode coil. The result of this is that a voltage drop occurs in the tuned grid circuit which cancels out part of the original oscillator voltage which, in turn, determines the sensitivity of the valve. Consequently, in some cases at 200 metres, the oscillator voltage remaining on the grid will be too small to maintain oscillation. To prevent this the method shown in Fig. 5 is recommended to balance out the grid cathode capacity.

An additional winding is provided of exactly the same dimensions as the cathode coil, the end of which is connected by means of a small trimming condenser to the grid of the valve. The cathode and balancing windings thus become a single coil centre tapped and usually ten (10) turns are sufficient for the whole coil.

When the trimmer is adjusted to approximately the grid cathode capacity of the valve a current will flow in the signal frequency circuit in opposite phase to that induced by the reaction coil and compensation is effected. The total oscillator voltage is thus available between grid and cathode.

The coils S3 and S4 are both wound in the same direction over the oscillator coil (see Fig. 6). The most favourable position for the S3-S4 combination must be determined by experiment but the adjustment of this or the setting of the balancing condenser is not critical. It should be remembered that S3 and S4 are coupled to the top of the oscillator coil which is a reversal of the normal practice. Usually the best position for the coils is just above the centre tap of the tuned oscillator winding. For the adjustment of the balancing condenser the best procedure is to short circuit the grid tuning condenser and adjust the position of S3-S4 until approximately 1 volt is obtained across S3 over the entire waveband (measured with a vacuum tube voltmeter). If the short on the grid tuning condenser is now removed and the receiver tuned to 200 metres, the voltage across S3 will probably drop to zero. The balancing condenser is then adjusted until the normal voltage is restored in the cathode coil. After this the gang trimmers and padding condenser can be adjusted in the conventional manner. The balancing condenser should have a maximum capacity of 25 $\mu\mu$F and to prevent stray capacities and direct pickup, should be constructed of plates with a small area and mounted directly on the grid terminal of the E446.

A sample 175 KC receiver was constructed using the circuit arrangement of Fig. 6 and employing the following Philips valves: E446, E447, E444, E443H and 1561.

Constructional details of the receiver are furnished in Technical Communication No. 26.

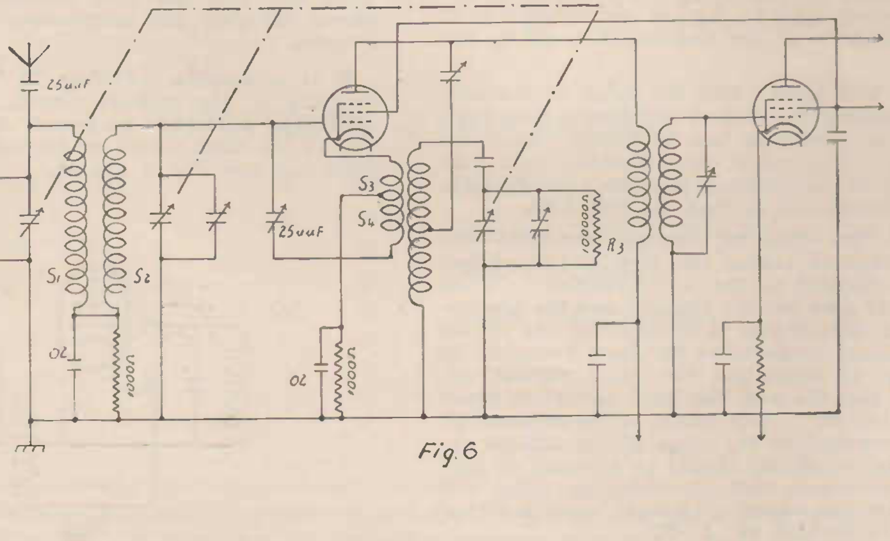


Fig. 6

No. 5

PHILIPS 1C6 PENTAGRID CONVERTER

The 1C6 is an addition to the Pentagrid family, being primarily designed for use as an electron coupled frequency changer in battery super-heterodynes.

To facilitate operation over the high frequency spectrum the mutual conductance and filament emission have been increased in comparison to the 1A6.

The mutual conductance of the oscillator portion of the 1C6 under typical voltage conditions, but when the valve is not oscillating, is 1 mA/V, whereas the corresponding value for the 1A6 is ·425 mA/V. Comparative values of anode grid current (grid No. 2) under similar conditions are:—1C6, 4·9 mA.; 1A6, 2·3 mA.

Characteristics of the 1C6 for frequency conversion are as follows:—

Filament voltage	2·0 V.	
Filament current	·12 A.	
Plate voltage	135 V.	180 V. max.
Screen voltage (grid 3 and 5)	67·5 V.	67·5 V. max.
Anode grid (grid No. 2) supply fed through 20,000 ohm resistor	135 V.	180 V. max.
Control grid negative voltage (grid No. 4)	3 V.	3 V.
Oscillator grid (grid No. 1) resistor	50,000 ohms	50,000 ohms
Plate impedance	·55 megohm	·75 megohm
Conversion conductance (normal)	·3 mA/V.	·325 mA/V.
Conversion conductance (14 volts negative bias on grid No. 4)	·004 mA V.	·004 mA/V.
Plate current	1·3 mA.	1·5 mA.
Screen current (app.)	2 mA.	2 mA.
Anode grid current	2·6 mA.	3·3 mA.
Oscillator grid current	·2 mA.	·2 mA.
Total cathode current (approx.)	6·5 mA.	7·0 mA.
Base	small 6 pin	

Socket connections equivalent to type 1A6.

No. 6

PHILIPS E454 DOUBLE DIODE-TRIODE DETECTOR AMPLIFIER

The E454 is an indirectly heated valve for A.C. Receivers comprising two diodes and a triode in a single bulb. The diodes are normally used for distortionless detection and the provision of A.V.C. voltages. The triode is employed as an audio amplifier.

The diode and triode portions have a common heater and cathode but otherwise the sections are completely separated from each other by screening. This offers the advantage of practically preventing the penetration of the R.F. component into the audio part of the receiver.

The E454 is equipped with Philips noise free heater and cathode construction and is metallised, the coating being connected to a separate pin at the base for individual "earthing."

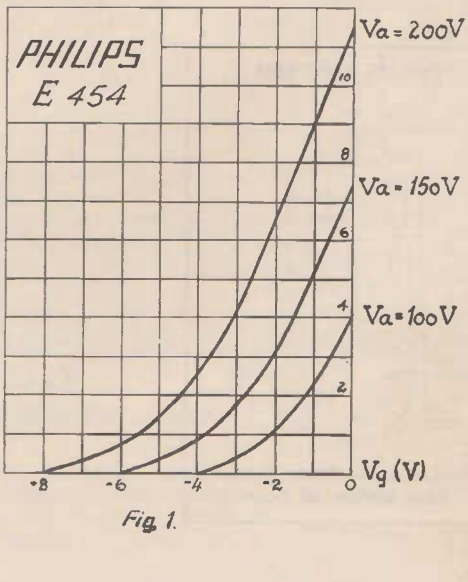


Fig. 1.

CHARACTERISTICS

Heater voltage	4·0 V.		
Heater current	1·1 A.		
Plate voltage	100 V.	150 V.	200 V.
Plate current	1·5 mA.	2·5 mA.	3·5 mA.
Negative grid bias	1·6 V.	2·5 V.	3·5 V.
Amplification factor			30
Plate impedance			19,000 ohms
Mutual conductance (normal)			1·6 mA/V.
Plate coupling resistance			75,000 ohms
Cathode resistance (for automatic bias)			1,000 ohms approx.
Base			7 pin

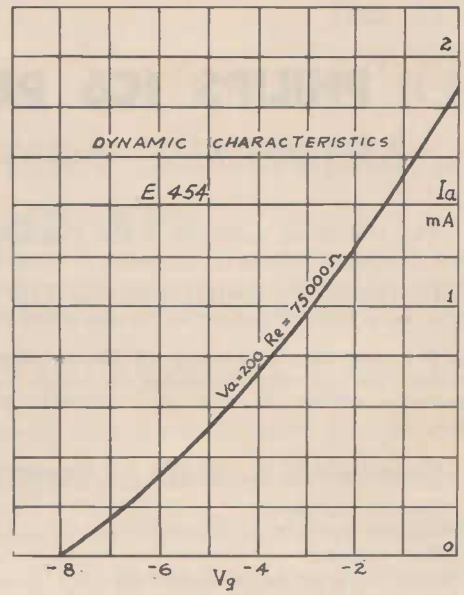


Fig. 2

APPLICATION

The double-diode portion of the E454 may be used for half or full wave detection in the conventional manner. For half wave detection the two diode plates may be connected in parallel.

When full wave detection is desired the preceding tuned circuit is centre tapped and balanced, the extremities of the coil being connected to the respective diodes.

Full wave detection offers the advantage of eliminating the carrier frequency from the grid of the amplifying triode, rendering R.F. filtering theoretically unnecessary. On the other hand, half wave rectification delivers approximately twice the signal output when compared with full wave, and due to the effective inter-electrode screening the amount of R.F. injected into the audio circuits is negligible.

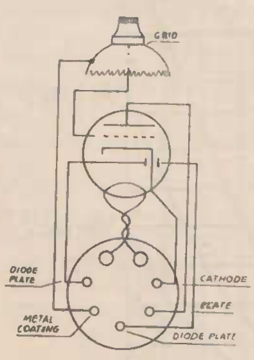
The diodes may be arranged to furnish control voltages for A.V.C. by the usual methods and a simple circuit is shown in Fig. 3.

The inclusion of a second diode permits the application of the E454 in delayed A.V.C. and amplified A.V.C. circuits.

The triode portion of the E454 normally coupled to the power amplifying stage by means of resistance-capacity coupling The optimum value for the plate coupling resistor is 75,000 ohms. A dynamic curve of the triode portion with this value of plate resistor is shown in Fig. 2.

As an alternative, transformer coupling may be employed for which purpose we recommend the Philips 4003N audio transformer.

PHILIPS TYPE E454



Socket connections viewed from bottom of base.

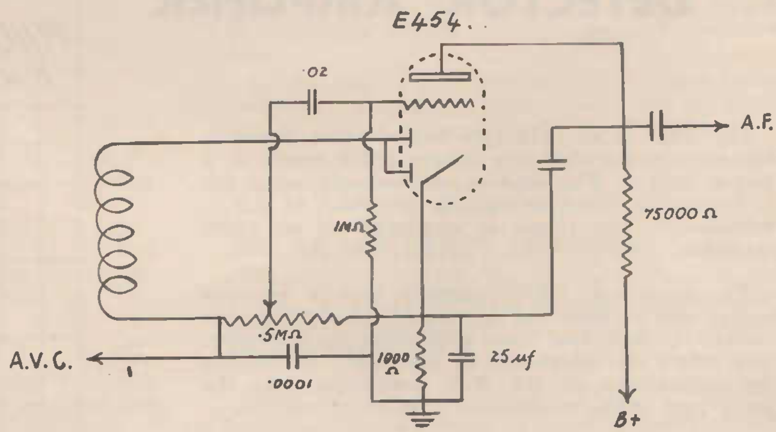


Fig. 3

No. 7

PHILIPS POWER PENTHODES TYPES E443H AND E463; PHILIPS INDIRECTLY HEATED RECTIFIER TYPE 1867

CHARACTERISTICS AND APPLICATION

Philips output Penthodes are justly famous for power handling capabilities and fidelity of reproduction possessing inherent qualities not found in the products of other manufacturers.

In keeping with the trend overseas there is a growing demand in this country for improved frequency response in broadcast receivers, and the incorporation of the E443H or E463, penthodes of the latest improved design, is recommended as a step in the right direction.

The E443H is fitted with a directly heated filament whereas the E463 is of the indirectly heated type featuring the Philips noise free heater and cathode construction.

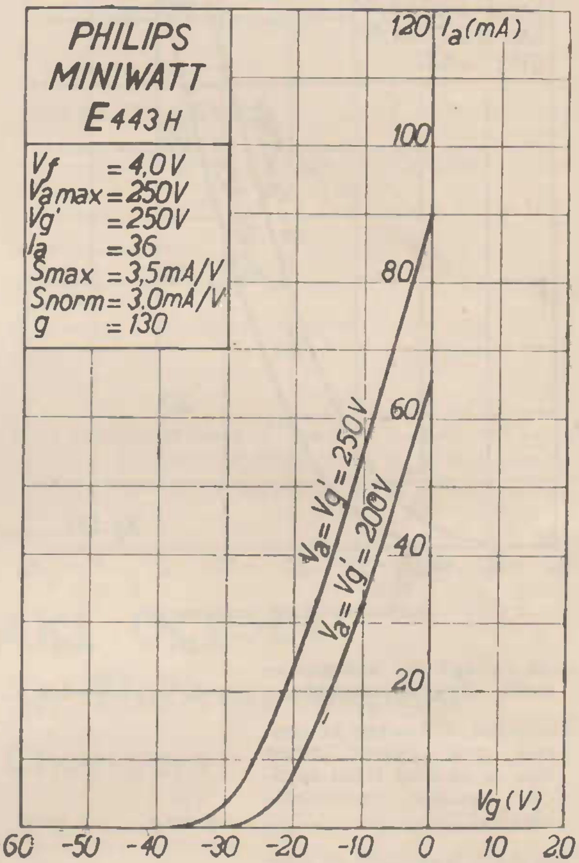
CHARACTERISTICS

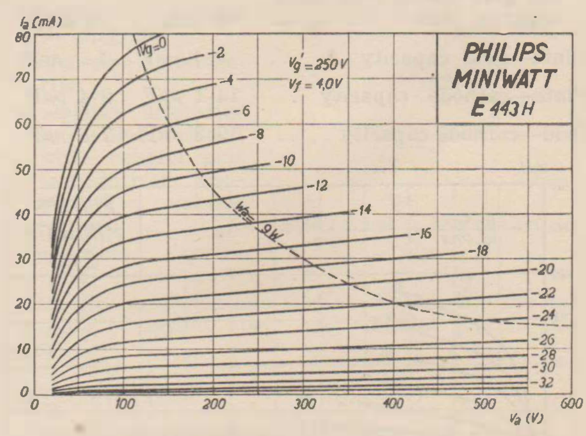
E443H POWER PENTHODE

Filament voltage	4·0 V.	
Filament current	1·1 A.	
Plate voltage	200 V.	250 V. max.
Auxiliary grid voltage	200 V.	250 V.
Plate current	22 mA.	36 mA.
Negative grid bias	14 V.	15 V.
Auxiliary grid current (approx.)		6·8 mA.
Amplification factor		130
Mutual conductance (normal)		3·0 mA/V.
Plate Impedance		43,000 ohms
Optimum load		7,000 ohms
Power output (5% distortion)		2·8 W.
Power output (10% distortion)		3·1 W.
Base		5 pin

E463 POWER PENTHODE

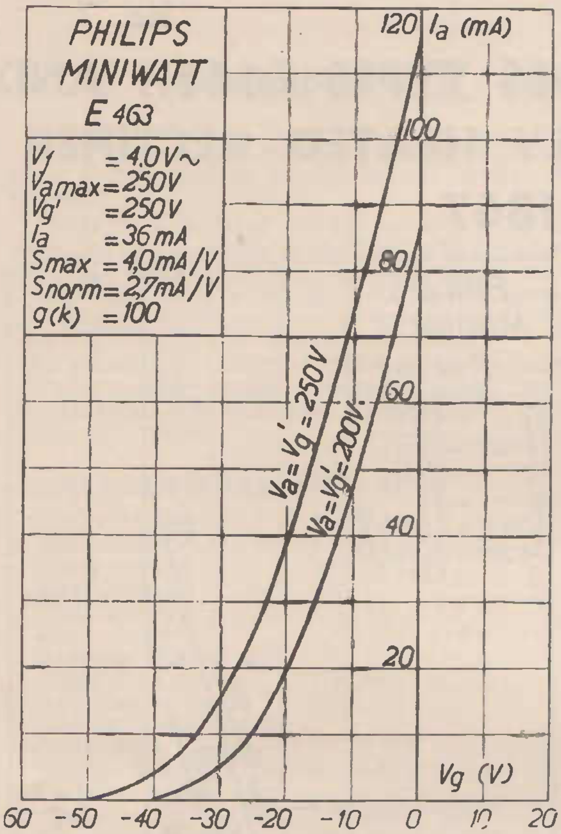
Heater voltage	4·0 V.
Heater current	1·35 A.
Plate voltage	250 V. max.
Auxiliary grid voltage	250 V.
Plate current	36 mA.
Negative grid bias	22 V.
Auxiliary grid current (approx.)	3·2 mA.
Amplification factor	100
Mutual conductance (normal)	2·7 mA/V.
Plate impedance	37,000 ohms
Optimum load	8,000 ohms
Power output (5% distortion)	2·5 W.
Power output (10% distortion)	4·1 W.
Base	medium 7 pin





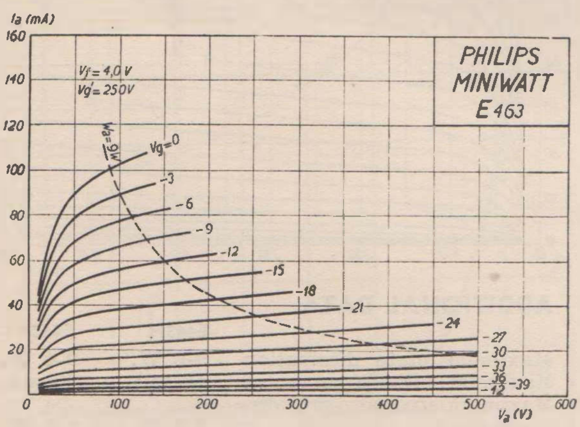
ADDITIONAL DATA

	E443H	E463
Maximum plate dissipation	9·0 W.	9·0 W.
Maximum cathode current	50 mA.	50 mA.
Maximum auxiliary grid dissipation	2·5 W.	1·5 W.



Additional Data (continued)

	E443H	E463
Grid voltage for commencement of grid current ..	—2 V.	—1·3 V.
Maximum resistance in control grid circuit when bias is derived from cathode resistor (automatic bias)	·8 meg.	·7 meg.
Maximum resistance in control grid circuit with fixed negative bias	·3 meg.	·3 meg.
Plate—grid capacity	1·1 $\mu\mu$F	1· $\mu\mu$F
Plate—cathode capacity ..	14·1 $\mu\mu$F	9·4 $\mu\mu$F
Grid—cathode capacity	9·3 $\mu\mu$F	7·8 $\mu\mu$F



APPLICATION

To obtain adequate reproduction of the low notes it is necessary to pay particular attention to the method of biassing.

Two methods are used in common practice, namely, automatic bias and so-called back bias. With reference to automatic bias, wherein the bias is obtained from the drop across a resistance in the cathode return, a circuit similar to figure 1 is sometimes employed. This is essentially of poor design as the A.C. component of both the grid and plate circuits returns to the cathode via the cathode resistance and its associated by-pass condenser. The respective voltages are in opposite phase and cancellation takes place resulting in impaired reproduction. A compromise may be effected by using a large value of condenser across the cathode resistor thus reducing the impedance, but to avoid loss of low notes this condenser would need to be at least 50 μF.

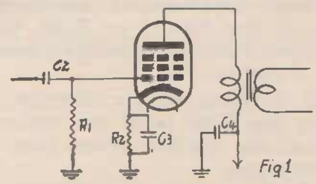


Fig 1

This circuit (Fig. 1) should therefore only be employed where parallel feed (choke condenser output) is possible so that the plate return from the loudspeaker can be taken directly to the cathode via a condenser. This results in only the A.C. component of the grid circuit traversing the cathode resistor and condenser.

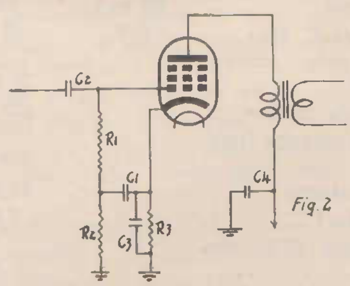


Fig. 2

In the interests of economy, however, it is not usually possible to adopt choke condenser output for the loudspeaker. As an alternative, the circuit of Fig. 2 is sometimes used.

Fig. 2 is again not to be recommended as the use of resistance capacity coupling between the previous stage and the power valve renders the de-

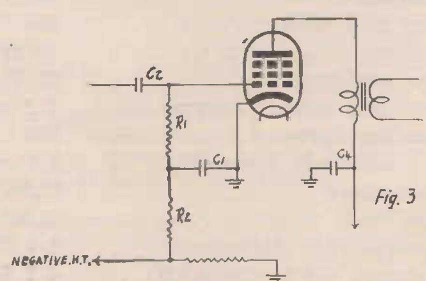


Fig. 3

coupling of the resistance R2 and the condenser C1 ineffective. On the other hand, where an audio transformer replaces R1 and C2, Fig. 2 can be regarded as satisfactory.

From the foregoing observations it would seem that a further alternative is necessary for economical manufacture using resistance coupling and this is furnished by the so-called "back biasing" method. (Fig. 3.)

In this case bias is derived from a resistor inserted between the negative high tension supply and earth. The audio component in the plate circuit is returned direct to the cathode via the 8 microfarad electrolytic filter condenser C4, the cathode being earthed.

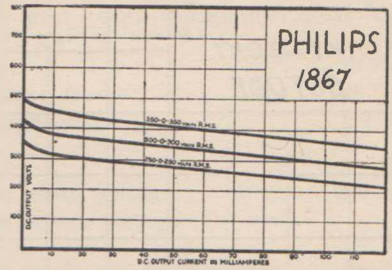
The grid circuit audio signal finds a path through C1 to the cathode and is not influenced by the plate component.

We therefore recommend the principle of Fig. 3 for all applications of the E443H and E463 where quality of reproduction is desired.

PHILIPS 1867 INDIRECTLY HEATED FULL-WAVE RECTIFIER

To solve problems associated with the design of A.C. receivers employing indirectly heated output tubes, an indirectly heated rectifying valve has been introduced by Philips.

The use of the 1867 will materially lengthen the useful life of electrolytic condensers and increase the safety margin of other components during the heating period of the output valve.



CHARACTERISTICS

1867 FULL-WAVE RECTIFIER

Heater voltage	4·0 V.
Heater current	2·4 A.
Maximum A.C. volts per plate	350 V. (R.M.S.)
Maximum D.C. output current	120 mA.
Base	4 pin

NOTE.—The cathode of the 1867 is anchored to the filament inside the tube so that a separate cathode connection is not employed.

No. 8

PHILIPS TYPE AK1 OCTODE

A new development in Electron-coupled Frequency Changers

The Octode is a development of the Philips Laboratories and represents an improvement on the existing types of pentagrid converters, i.e., Electron-coupled frequency changers.

The Octode is similar in principle to the 2A7 or 6A7 with the addition of a sixth (suppressor) grid. Thus the first detector or mixer portion of the Octode is a penthode, whereas the counterpart of the 2A7 is a tetrode.

In practice the 2A7 exhibits several disadvantages including a low signal to noise ratio, a low conversion amplification and excessive frequency shift in the oscillator circuit when the control grid is negatively biassed for volume control purposes. The latter is particularly serious on short wave.

The Philips Octode combines all the advantages of the Electron-coupled frequency changer with freedom from the abovementioned drawbacks.

The excessive background "hiss" of the pentagrid has been obviated in the octode by designing the tube in such a way that even with comparatively high conversion amplification the plate current is relatively small. The Octode also functions efficiently on short wave bands.

Comparisons of the performance of the Octode and the 2A7 are particularly interesting:—

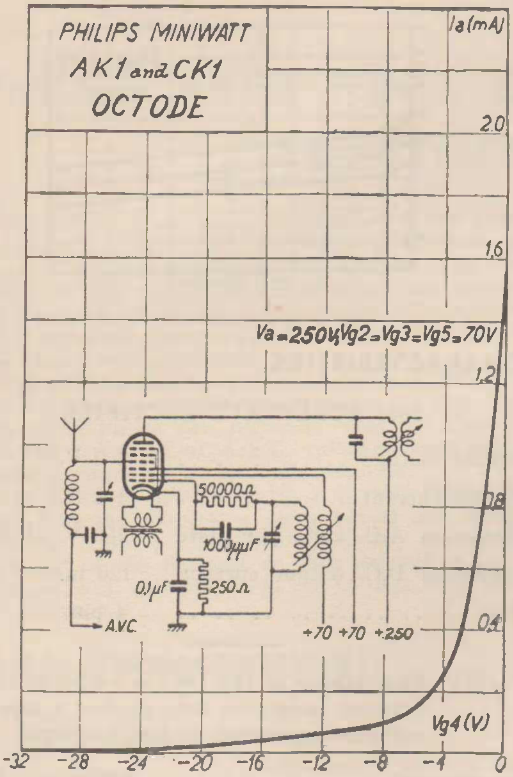
	2A7	OCTODE
Conversion conductance	520	600 micromhos
Internal resistance in megohm	·29	1·2
Conversion amplification	97	225
Frequency alteration in oscillator circuit when control grid is negatively biassed for volume control	1400 cycles	300 cycles
Background noise ratio	5	1

Special provision has also been made for the prevention of repeat spots and whistles due to harmonics.

DESCRIPTION

As the name implies, the Philips Octode is an 8 electrode valve and in the case of the AK1 is designed for operation in A.C. receivers.

The structure of the Octode can be observed from the diagram in Fig. 1a in which the various grids between the cathode and plate are numbered consecutively from 1 to 6.



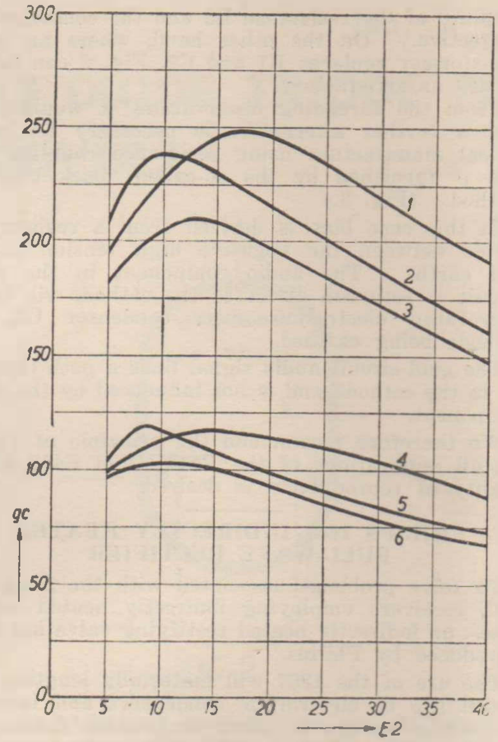


Fig. 2.

Grid 1, together with the auxiliary plate (grid 2) forms a triode.

The auxiliary plate (G2) consists of two rods mounted mostly outside the electron stream.

Grids 3 and 5 are screen grids and between them is grid 4 which is connected to the signal frequency circuit and becomes the control grid.

Grid 6 is the suppressor grid which is anchored to the cathode inside the valve.

The approximate D.C. voltages applied to the various electrodes are:—

Grids 1 and 4	1·5 volts (negative)
Grids 2, 3 and 5 ..	70 volts
Plate	200–250 volts

The functioning of the Philips Octode can be understood by imagining the valve to consist of two superimposed systems. The first system (Fig. 1b) as mentioned previously includes the cathode, grid 1 and the auxiliary plate (grid 2). Grids 1 and 2 are coupled inductively and oscillation takes place. The electronic stream in the valve is modulated by this oscillator portion and is accelerated by the positive voltage on Grid 3. A negative voltage is, however, applied to grid 4. This obstructs the electron stream and a cloud of electrons accumulates between grids 3 and 4.

When considering the second portion of the valve (see Fig. 1c). this electron cloud may be regarded as a secondary cathode, or source of electrons. It differs from the ordinary cathode, however, in that it pulsates in accordance with the oscillation frequency of the triode portion.

The part of the Octode above grid 3 may be considered as an R.F. Penthode in which grid 4 is the control grid, grid 5 the screen grid, grid 6 the suppressor, and P finally the plate.

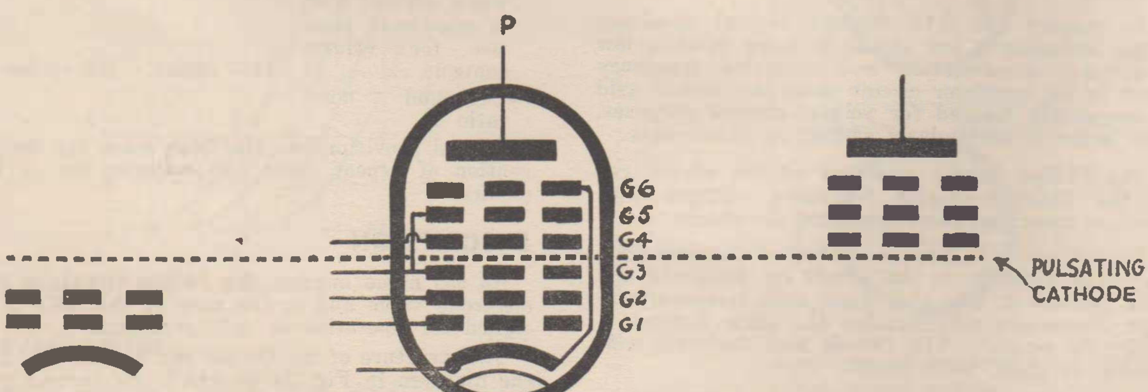


Fig. 1b. Fig. 1a. Fig. 1c.

The electron stream of the penthode portion is influenced by the signal frequency voltage on grid 4 and also by the pulsating cathode, so that the current reaching the plate combines the signal and oscillator frequencies.

CHARACTERISTICS

OCTODE TYPE AK1

Filament voltage	4 V.
Filament current	·65 A.
Plate voltage	250 V.
Screen voltage (G.3 and 5)	70 V.
Anode grid voltage (G.2)	70 V.
Control grid negative bias (G.4)	1·5 V. (min.)
Plate current	0·8 mA.
Oscillator grid negative bias (G.1)	1·5 V.
Screen current (G.3 and 5)	3·0 mA.
Anode grid current (G.2)	1·6 mA.
Cathode current	6·0 mA.
Plate impedance	1·5 megohm
Conversion conductance	·6 mA/V.
Conversion amplification	225

TRIODE OSCILLATOR (Grids 1 and 2)

(Anode grid [G.2] voltage = 75 V. Oscillator grid [G.1] bias = —2 V.)

Impedance	22,700 ohms
Amplification factor	25
Mutual conductance	1·1 mA/V.

LIMITS

Maximum plate voltage	250 V.
Maximum screen voltage (G.3 and G.5)	90 V.
Maximum anode grid voltage (G.2)	90 V.

The conversion conductance and internal resistance are dependent on the heterodyne voltage delivered by the oscillator. The maximum conversion conductance is obtained at an oscillator voltage of approximately 8·5 volts R.M.S., and decreases at higher voltages. The internal resistance increases slightly at higher oscillator voltages. The oscillator voltage at which maximum amplification is obtained, is, therefore, dependent upon the impedance of the tuned plate circuit and upon the plate voltage applied.

The conversion amplification of the AK1 has been plotted in Figure 2, as a function of the oscillator voltage for plate voltage of 250, 200 and 100 volts, assuming an impedance for the tuned output circuit of ·5 and ·2 megohm. The conversion amplification is as follows:—

Curve	Plate voltage	Grids 3 & 5 voltage	Grid 2 voltage	Grid 4 voltage	Load impedance	Conversion Amplification
1	250	80	80	—1·5	0·5 megohm	245
2	200	70	70	—1·5	0·5 „	240
3	100	70	70	—1·5	0·5 „	210
4	250	80	80	—1·5	0·2 „	120
5	200	70	70	—1·5	0·2 „	120
6	100	70	70	—1·5	0·2 „	105

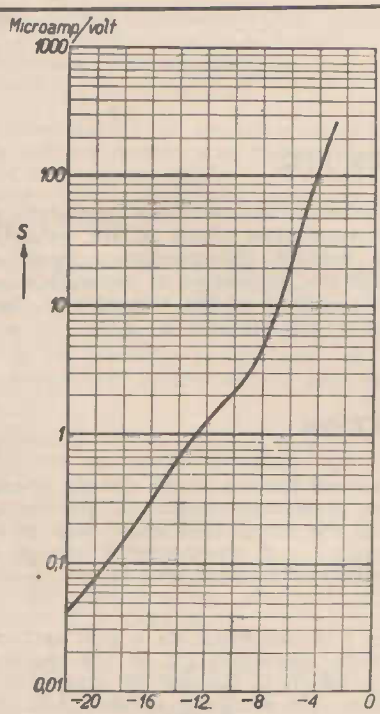


Fig. 3.

VOLUME CONTROL

The design of the AK1 is such that volume can be effectively controlled by varying the grid bias applied to the control grid (G.4). This is demonstrated by the logarithmic mutual conductance curve shown in Fig. 3 which is practically a straight line. By the application of a negative bias of 20 volts the amplification can be varied over a ratio of 1:10,000.

RE-RADIATION

The screening afforded by G.3 is very complete so that coupling between the control grid and the oscillator portion is negligible. Consequently the oscillator voltage on G.1 and 2 cannot reach the control grid G.4, and re-radiation of the oscillator into the aerial circuit is avoided. The decisive factor for this re-radiation is the capacity between grids 1 and 4 which, in the case of the Octode, is half the corresponding value of the 2A7.

OSCILLATOR FREQUENCY VARIATION

By judiciously selecting the voltage applied to grids 2 and 3 electronic coupling between grids 1 and 4 has been minimised. Thus the application of a negative bias to the control grid (G.4) for volume control purposes has very little influence on

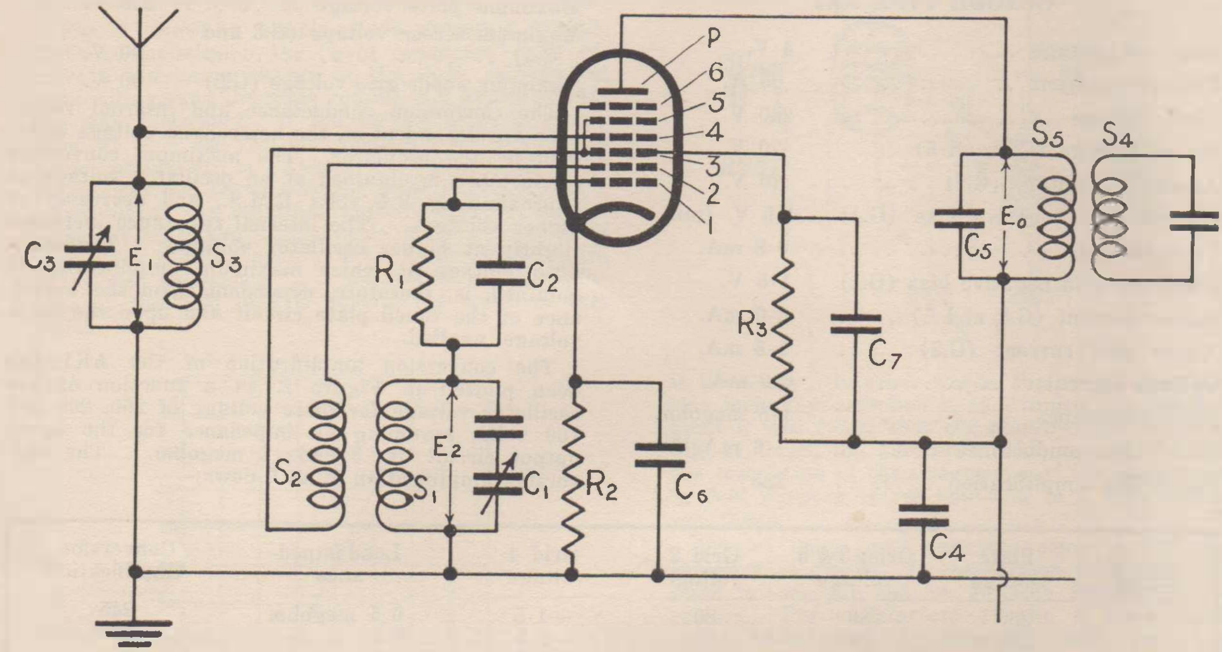


Fig. 4.

250V.

R1 = 50,000 ohms
R2 = 250 ohms
R3 = 22,000 ohms

the oscillator frequency. The frequency displacement at a wavelength of 200 metres as a result of applying 20 volts bias to G.4 is only about 300 cycles. Furthermore, the oscillator amplitude is not affected as much as in the case of the 2A7.

BACKGROUND NOISE

One of the problems of superheterodyne design is the excess of tube "hiss" or "background noise," mainly due to the frequency changer.

This hiss is proportional to the square root of the plate current in the valve.

The plate current of the Octode does not exceed 1·2 mA whereas the corresponding value for the 2A7 is 3·5 mA. Not only is the background noise correspondingly reduced in the Octode, but at the same time, a greater conversion amplification is provided, and taking both factors into consideration, the resultant background is about one-fifth of that obtained from the 2A7. This development is obviously an important advance in frequency changing technique.

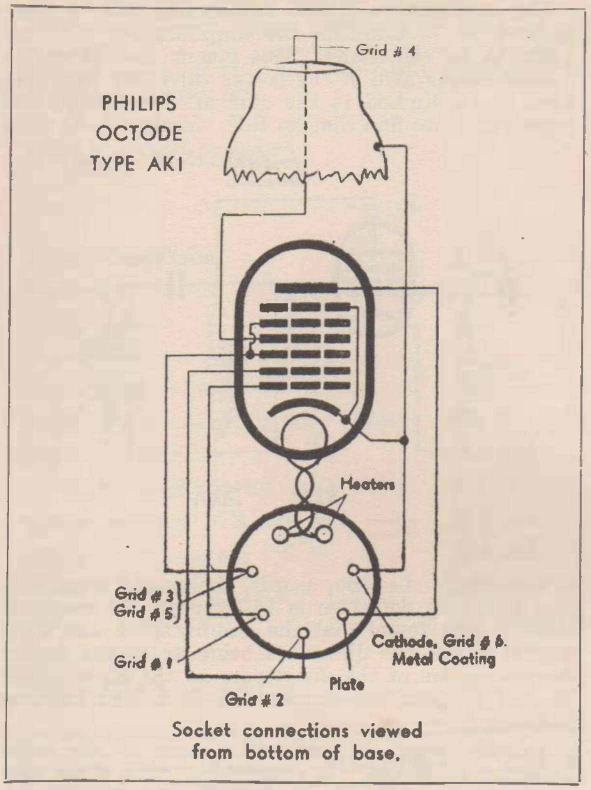
WHISTLES, ETC.

The use of moderate oscillator heterodyne voltages and the distortionless shape of the grid (4) voltage—plate current characteristic curves are responsible for the prevention of harmonics and overtones in the output of the Octode and thus oscillator whistles are minimised.

APPLICATION

As the second portion of the Octode is essentially a penthode, it is unnecessary to provide a potentiometer for the screen feed which may be a simple series resistor. A fundamental circuit for the AK1, together with component values, is shown in Figure 4.

Grid No. 1 is connected via a grid resistance R1, together with condenser C2 to the oscillator circuit S1 C1 which is coupled by means of the reaction coil to the auxiliary anode (G.2). The reaction coupling is adjusted so that an A.C. voltage



Socket connections viewed from bottom of base.

of 8 volts, R.M.S. can be measured across the oscillator circuit S1 C1 (with a vacuum tube volt meter). This value is not critical (see Figure 2). The corresponding A.C. voltage across coil S2 will be between 3 and 4 volts. Grid 1 is, therefore, controlled by an A.C. voltage of about 8 volts R.M.S. of the oscillator frequency and by a bias which is automatically developed by R2 and R1.

DEFINITIONS

The CONVERSION AMPLIFICATION of the frequency changer in a superheterodyne is expressed as the ratio between the I.F. alternating voltage in the plate circuit and the R.F. alternating voltage applied between the grid and cathode of the valve.

The CONVERSION CONDUCTANCE is the ratio between the I.F. alternating current and the applied R.F. alternating voltage.

No. 9

THE AMPLIFICATION FACTOR OF DETECTOR VALVES

In making certain calculations with regard to the sensitivity of receiving sets, it is sometimes advantageous to know the amplification factor of the various stages.

The measurement of the amplification of detectors is a fairly difficult matter, and the purpose of this article is to acquaint the reader with details of some measurements which have been carried out in the Philips Laboratories.

The amplification factor of detector valves is not a constant, but it was deemed logical to determine the amplification under standard conditions for the power valve, i.e., when the power valve is delivering an output of 50 miliwatts to the load. This is the basis for sensitivity measurements arrived at by the I.R.E.

It was assumed that an average of 2-volts applied to the grid was necessary to obtain the standard output and in making detector amplification measurements an A.C. audio frequency voltage of 2-volts in the detector plate circuit was accepted as a basis. Therefore detector amplification may be defined as being the ratio between an R.F. alternating voltage applied to the grid and the obtained audio frequency voltage of 2 volts eff.

Detectors may be classified in two groups:—

(1) Diode detectors (or grid current detectors).

(2) Plate detectors.

From the mathematical point of view this classification is perhaps unnecessary, but in practice it is helpful.

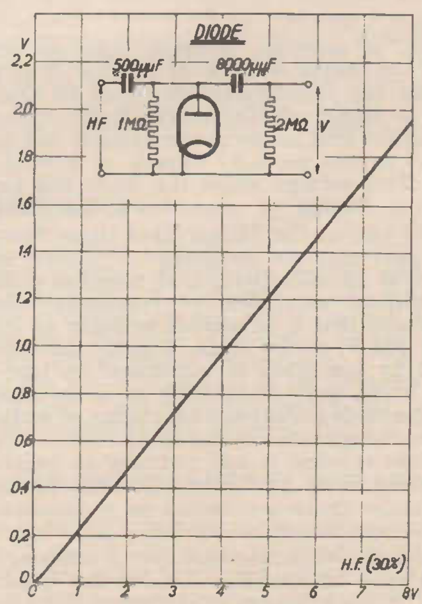


Fig. 1

1. DIODE DETECTION

Diodes can be regarded as the most elementary of detectors and grid current detection is a further development of the same principle. The results obtained under normal conditions with different types of diode valves are almost identical, and we may thus deal with diode characteristics generally, irrespective of whether we are concerned with an actual diode or with one of the electrodes of a valve.

Fig. 1 shows a simple diode detection circuit. Without modulation the "grid condenser" will receive a maximum charge at the R.F. alternating peak voltage and the same voltage will appear across the leak resistance. If the carrier wave is modulated at 30% the rectified voltage and the average audio voltage will be ·3 times the R.M.S. value. This result does not agree with the diode curve in Fig. 1 which shows the resultant audio frequency voltage to be ·24 times the R.M.S. value of the carrier. The reason for the discrepancy is the effect of the diode "grid leak resistance."' A discussion on the influence of the grid leak is beyond the scope of this article.

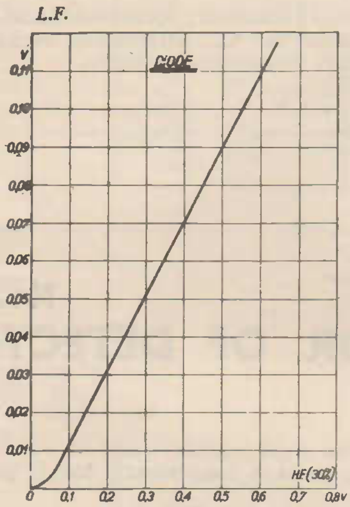


Fig. 2

It can be accepted, however, that the amplification of the simple diode is ·24 times at 30% modulation and our calculations are based on this figure. Thus, to obtain an alternating audio voltage of 2 volts on the grid of the power valve it will be necessary to supply an R.F. voltage of 8 volts to the diode. This voltage which the diode will handle is, of course, limited by saturation in the diode.

In the case of the Philips E444 Diode Tetrode, the diode part may be employed to deliver an audio voltage of 20 volts (with a ·5 megohm diode resistor) without saturation or consequent distortion. This means that it is possible to apply an R.F. voltage of 100 V. to the diode. Usually the voltage delivered by the diode is insufficient to load up the power valve, and consequently as in the case of the E444 the diode is followed by a stage of audio amplification incorporated in the same bulb. In this case the diode resistor is not virtually in parallel with the power valve grid leak, and Fig. 2 shows the diode audio frequency output as a function of the R.F. voltage modulated at 30%.

Technical Communication No. 2 contains a table of the ratio of amplification for the E444 tetrode part. This is a convenient reference for calculating the overall detector amplification.

For the most sensitive application with a plate resistor of ·3 megohm the amplification will, for example, be 100 times. This means that to obtain 2 volts on the grid of the power valve ·02 volts will have to be applied to the grid of the tetrode, and from Fig. 2 we find that an R.F. voltage of ·14 volts

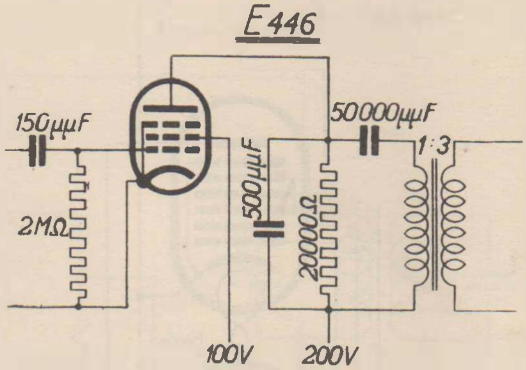


Fig. 3

is necessary. In other words, the overall amplification including detection is 14.3 times. By measurement it was found that the amplification was actually 11 times, the difference being accounted for by the restriction of the dimensions of the diode plates in dual purpose valves resulting in a high internal resistance.

Triodes using grid detection come in the same category as diodes. In comparison with other systems triodes are not as suitable for modern receivers. For satisfactory results a good quality audio transformer is necessary with consequent expense.

As an example, the E424 triode used with a 3:1 transformer gives an amplification of 72. Therefore, in order to obtain 2 volts on the grid of the power valve, ·028 volts will be required on the grid of the detector and furthermore, by referring in Fig. 2 we find that an R.F. input of ·185 volts is demanded. The amplification will thus be 11 times. Measurement indicated the actual amplification to be 14 times.

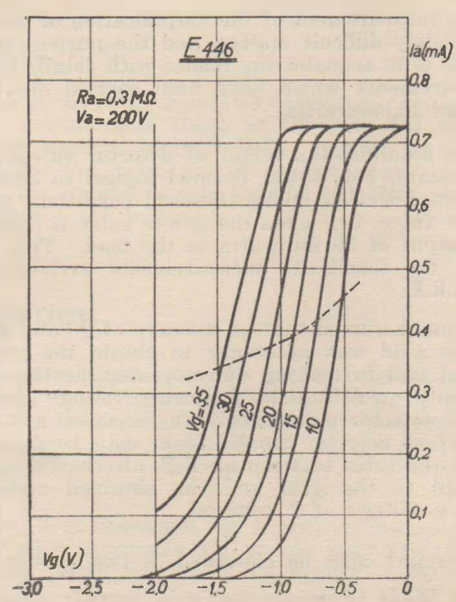


Fig. 4

The Philips new R.F. Penthode Type E446 may be used for special purposes as an extremely sensitive grid detector in accordance with the circuit shown in Fig. 3.

In this circuit the mutual conductance is about 3 mA/V and the audio amplification will consequently be to the order of 180. From this it follows that the overall detection amplification will be 20 times. The maximum audio frequency output obtainable will exceed 30 volts. Quite good quality of reproduction is possible with this circuit even with a cheap audio transformer as the core is not saturated by the D.C. plate current.

A resistance coupled triode detector gives a small audio amplification and sufficient voltage to load up the power valve can only be obtained by the use of an additional audio stage.

The E446 R.F. Penthode may be used to advantage as a grid leak detector with resistance capacity coupling in the plate circuit.

Fig. 4 gives the plate current—grid voltage curves of an E446 with a resistance of ·3 megohm in the plate circuit. The plate supply is 200 V and the different curves refer to various screen grid voltages. The mutual conductance of the curve is about 1.3 mA/V at a screen grid voltage of 10, and thus with a plate resistance of ·3 megohm the amplification will be 400 times. The corresponding overall detector amplification obtained by referring to Fig. 2 is 27 times. This value has been confirmed by measurement. This method of detection is therefore very sensitive. The higher bends in the characteristic curve are due to the fact that the greater part of the plate supply of 200V is absorbed in the plate resistance, the actual voltage on the plate of the valve being very small.

Without a signal on the grid, the grid bias automatically levels at —0·6 volts approximate, and from Fig. 4 it follows that a screen grid voltage of 10 volts is then required. When the signal arrives on the grid, the bias increases so that if the screen voltage is constant, anode bend detection will take place at the lower bend in the characteristic. This can be obviated by feeding the screen grid through a high ohmic series resistor. By this means when the bias is increased by the signal, the plate and screen currents are reduced and consequently the voltage drop in the series resistor. The screen voltage therefore rises automatically.

The dotted line in Fig. 4 shows the various working points for a resistance of 1 megohm in the screen grid lead. It will be observed that the valve works automatically on a favourable point in its characteristic. The maximum audio frequency voltage available is restricted to the straight portion of the curve between the lower and upper bends. The exact value can be measured and is found to be 9 volts.

Admittedly, the maximum audio output without distortion is limited, but this class of detector is very sensitive, and in low-priced receivers it may be used to advantage.

2. PLATE DETECTION

For plate detection valves having a sharp bend in the characteristic curve and with a high amplification factor are to be preferred.

With a fixed grid bias it will be possible to work at a favourable point on the characteristic curve so that good sensitivity is ensured. However, when receiving strong signals it will not be possible to avoid grid current.

The reason for this is that in order to get reasonable gain, a valve with a high amplification factor and restricted grid swing has to be chosen. The grid current will not necessarily exercise a bad influence on detection, but on the other hand, the preceding tuned circuit will be damped considerably.

The occurrence of grid current can be postponed by obtaining the bias from a resistor inserted in the cathode lead. With this arrangement the plate current increases when a signal is received and so does the grid bias, whilst the working point on the curve moves away from the point at which grid current occurs.

The E446 R.F. Penthode used as a plate detector offers the advantage of a large grid swing. The cathode resistance should be 10,000 ohms and the plate load resistance ·3 megohm at 200-250 volts plate supply. Under these conditions we obtain an amplification of 12·5 with 40 V applied to the screen. At a screen voltage of 80 the amplification will be 10 times and the maximum audio output 48 volts.

In the foregoing discussion we have endeavoured to explain the systems usually employed for detection. When selecting one of these systems it is not suggested that only the amplification and maximum audio output be taken into consideration. Distortion should also be taken into account, and from this point of view, diodes and R.F. Penthode exhibit a decided advantage. These valves do not cause damping brought about by the reaction of the plate circuit on the grid circuit.

No. 10

PHILIPS TYPE KBC1. DOUBLE DIODE TRIODE FOR BATTERY RECEIVERS

The KBC1 is an original invention of the Philips Laboratories, and was the first 2-volt diode combination valve to appear on this market. The availability of this valve has solved many problems for the designer, obviating the necessity to employ 6·3 types for diode detection and automatic volume control in Battery Receivers.

The Philips KBC1 consists of two separate diode rectifiers and a triode mounted in a single bulb. The diode plates are normally used for detection and the provision of A.V.C. voltages, whereas the triode is employed as an audio amplifier.

The KBC1 is provided with a directly heated filament and the respective diode plates are shielded from the triode portion and ingeniously arranged at each end of the filament so that delayed A.V.C. is automatically obtained from the voltage drop across the filament.

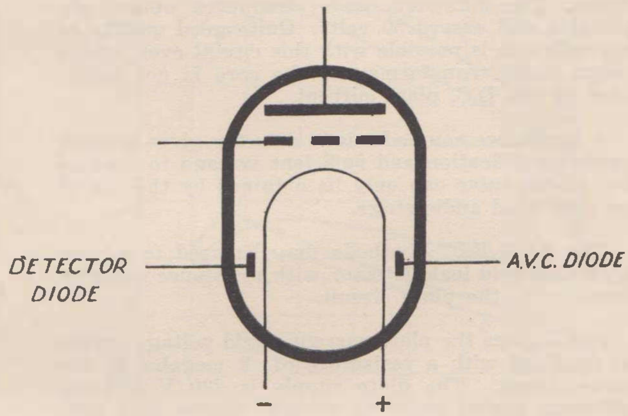


FIG 2

CHARACTERISTICS (TRIODE)

Filament voltage ..	2·0V.			
Filament current ..	0·1A.			
Plate voltage	75	100	125	150 volts.
Neg. grid bias	2·0	3·0	4·5	5·5 volts.
Plate current	1·3	1·7	2·0	2·5 mA.
Plate impedance ..			12000 ohms.	
Amplification factor ·		16·5		
Mutual conductance .			1·4 mA/V.	

The grid voltage plate current curve for the triode section is shown in Fig. 1.

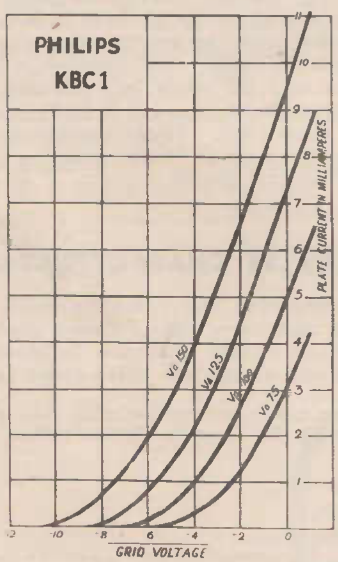
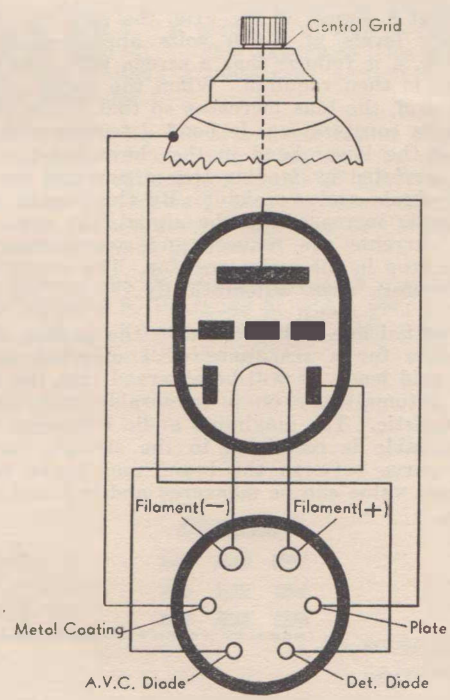


FIG.1

APPLICATION

Diode detection offers many advantages. The separation of the functions of detection and amplification practically prevent the R.F. component reaching the grid of the triode, and the triode will consequently handle a greater signal without overloading.

PHILIPS KBC1



Socket connections viewed from bottom of base.

PHILIPS KBC 1

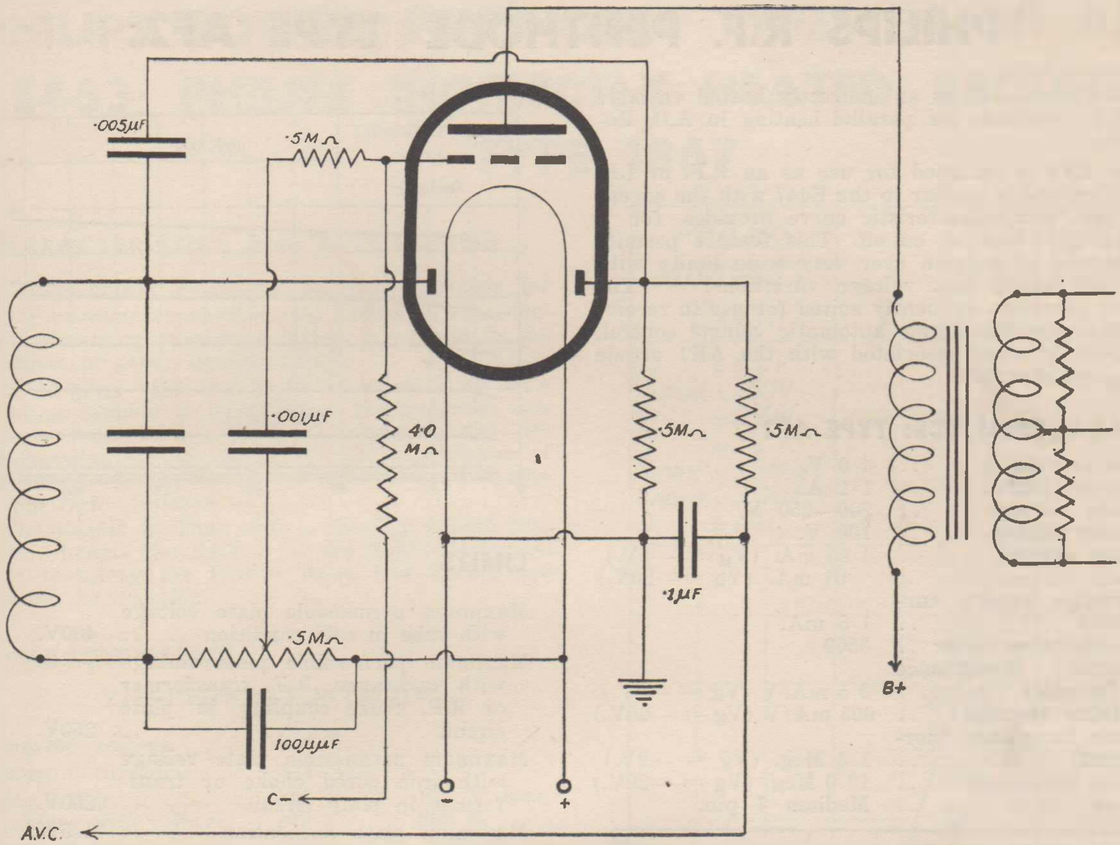


FIG.3

Diode rectification is almost linear and the diode input impedance is high.

The KBC1 will usually be operated in superheterodynes as a half-wave detector with triode amplification and with or without A.V.C.

The construction of the Philips KBC1 is shown in Fig. 2, wherein it will be observed that the diode plates are located respectively at opposite ends of the directly heated filament.

The diode plate nearest the positive end of the filament is intended for A.V.C., and when properly connected provides a delay of 3 volts.

Detection is obtained from the diode located at the negative end.

It is obvious that the KBC1 will not function correctly unless the diodes are wired in the proper relation to the filament, particularly when delayed A.V.C. is employed.

The triode portion of the KBC1 is similar in characteristics to the Philips B217 high gain triode, and will handle 4 volts (R.M.S.) input signal when 150 volts is applied to the plate.

For class A operation the triode should be resistance capacity coupled, the optimum value of load resistor being 50,000 ohms.

The triode portion may also be used as a driver stage preceding the B240 Class B output valve. In this application the negative bias should be 4·5 V. with 130 volts applied to the plate.

The driver transformer coupling the KBC1 to the B240 should be designed to have a step down ratio of 1·5:1 overall. (See Technical Communication No. 3). A typical circuit diagram incorporating the KBC1 is furnished as Fig. 3.

This arrangement will effectively control R.F. types with a short grid base such as the Philips B255 or KF2. (Technical Communications Nos. 3 and 12) and provide a delay action of approximately 3 volts.

For further information on the application of the KBC1 see Technical Communication No. 19.

No. 11

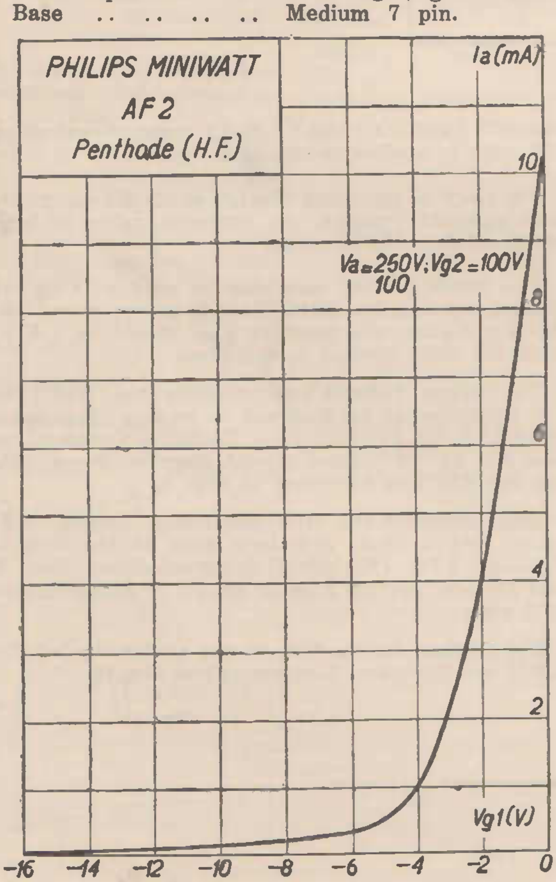
PHILIPS R.F. PENTHODE TYPE AF2.

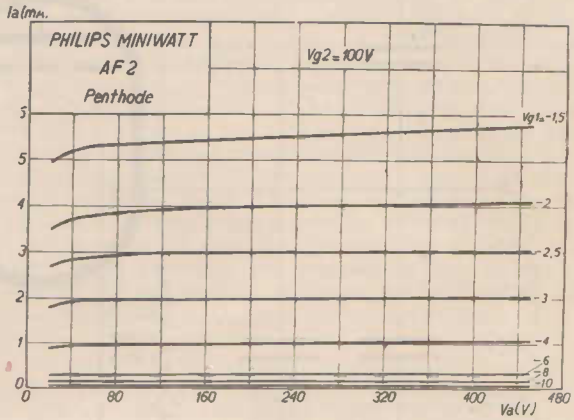
The Philips AF2 is an indirectly heated variable mu R.F. penthode for parallel heating in A.C. Receivers.

The AF2 is designed for use as an R.F. or I.F. amplifier, and is similar to the E447 with the exception that the characteristic curve provides for a shorter grid base or cut off. This feature permits the control of volume over very wide limits with relatively small bias voltage variations. The AF2 is therefore eminently suited for use in receivers incorporating simple automatic volume control, particularly when associated with the AK1 octode frequency changer.

CHARACTERISTICS: TYPE AF2

Heater voltage	4·0 V.
Heater current	1·1 A.
Plate voltage	200—250 V.
Screen voltage	100 V.
Plate current	4·25 mA. (Vg = —2V.)
Plate current	·01 mA. (Vg = —20V.)
Average screen current	1·5 mA.
Amplificator factor ..	3500
Mutual conductance (normal)	2·5 mA/V (Vg = —2V.)
Ditto (normal) ..	·005 mA/V (Vg = —20V.)
Plate impedance (normal)	1·4 Meg. (Vg = —2V.)
Plate impedance ..	10·0 Meg. (Vg = —20V.)
Base	Medium 7 pin.





LIMITS

Maximum permissible plate voltage with tube in cold condition	400V.
Maximum permissible plate voltage with resistance, R.F. transformer or R.F. choke coupling in plate circuit	250V.
Maximum permissible plate voltage with iron cored choke or transformer in plate circuit	200V.
Maximum plate dissipation	1·5W.
Maximum cathode current	10 mA.
Grid voltage for the commencement of grid current (·3 μA)	—1·3V.
Maximum screen voltage	150V.
Maximum screen dissipation	·3W.
Maximum permissible resistance in grid circuit with automatic grid bias	2 megohm
Plate grid capacity	·002 μμF
Input capacity	12·5 μμF
Output capacity	9·9 μμF
Maximum D.C. voltage between cathode and heater	80V.
Maximum permissible resistance between cathode and heater	20,000 ohms.

APPLICATION

When the AF2 is employed as an R.F. or I.F. amplifier, the usual precautions must be taken to ensure stability. Capacitive and inductive coupling between the control grid and plate circuits should be minimised. All components in the various stages should be magnetically and electrostatically separated, and the control grid leads as short as possible. In some cases it may be necessary to decouple the plate or screen grid returns by means of a condenser of at least ·1 μF capacity.

The following table furnishes various values of screen grid voltage, mutual conductance, required negative grid bias, and the effective A.C. input voltage to the grid at which 6% cross modulation occurs.

Mutual Conductance		SCREEN VOLTAGE=40V. Grid Bias.	SCREEN VOLTAGE=40V. Input Volts eff.	SCREEN VOLTAGE=60V. Grid Bias	SCREEN VOLTAGE=60V. Input Volts eff.	SCREEN VOLTAGE=80V. Grid Bias	SCREEN VOLTAGE=80V. Input Volts eff.
1000 μA/V	..	1·1	0·3	1·8	0·27	2·4	0·38
100 „	..	2·7	0·2	4·2	0·36	5·5	0·5
10 „	..	5·7	0·35	8·8	0·55	11·3	0·9
1 „	..	8·1	0·20	12·0	0·27	15·5	0·33
0·1 „	..	9·2	0·11	13·5	0·12	17·0	0·15
		SCREEN VOLTAGE=100V.		SCREEN VOLTAGE=120V.		SCREEN VOLTAGE=150V.	
1000 μA/V	..	3·0	0·45	4·1	0·5	5·1	0·58
100 „	..	6·7	0·65	8·9	0·8	11·7	1·1
10 „	..	14·0	1·1	17·5	1·1	22·5	1·3
1 „	..	18·5	0·4	23·0	0·43	30·0	0·52
0·1 „	..	20·0	0·16	25·0	0·18	32·5	0·20

This 6% cross modulation corresponds to 2·25 m% distortion where m is the modulation depth. Cross modulation and distortion are proportional to the square of the A.C. grid input voltage so that all necessary data can be obtained from the table.

A band pass filter is usually connected before the intermediate frequency amplifying valve, in which case, cross modulation is no longer of importance.

The R.M.S. input voltage which the valve can handle is then only limited when distortion occurs. We have therefore provided the following table (derived from the previous table) which indicates the A.C. (R.M.S.) grid input voltages at which 5% distortion occurs with a modulation depth of 30%:—

Mutual Conductance		SCREEN VOLTAGE=40V. Grid Bias	SCREEN VOLTAGE=40V. Input Volts. eff.	SCREEN VOLTAGE = 60V. Grid Bias	SCREEN VOLTAGE = 60V. Input volts eff.	SCREEN VOLTAGE = 80V. Grid Bias	SCREEN VOLTAGE = 80V. Input volts eff.
1000 μA/V	..	1·1	0·82	1·8	0·74	2·4	0·1
100 „	..	2·7	0·54	4·2	0·98	5·5	1·4
10 „	..	5·7	0·95	8·8	1·5	11·3	2·5
1 „	..	8·1	0·54	12·0	0·74	15·5	0·9
0·1 „	..	9·2	0·3	13·5	0.32	17·0	0·41

Mutual Conductance	SCREEN VOLTAGE = 100V.		SCREEN VOLTAGE = 120V.	
1000 μA/V.	3	1·2	4·1	1·4
100 „	6·7	1·8	8·9	2·2
10 „	14·0	3·0	17·5	3·0
1 „	18·5	1·1	23·0	1·2
0·1 „	20·0	0·44	25·0	0·5

No. 12

TECHNICAL INFORMATION ON PHILIPS R.F. PENTHODES FOR BATTERY RECEIVERS TYPES KF1 AND KF2

The KF1 and KF2 are 2-volt R.F. Penthodes of advanced design intended for use in battery receivers. In suitably designed circuits the new valves are capable of vastly superior results to the types previously available.

A glance at the characteristics will reveal that the KF1 and KF2 achieve the highest figure of merit yet attained in battery penthodes and, in this respect, are comparable with the E446 and E447 in the A.C. series.

The new valves are metallised, the coating being connected to a separate pin in the valve base for individual "earthing."

The KF1 is a "straight" R.F. penthode designed for operation as a second detector, or alternatively as an "autodyne" frequency changer in superheterodynes.

The KF2 is an R.F. or I.F. penthode amplifier with a variable mu characteristic, particularly suited for application in automatic volume control circuits.

It will be observed that both valves are true penthodes in that the same potential may be applied to both screen grid and plate, if desired.

CHARACTERISTICS

	KF1	KF2
Filament voltage	2 V.	2 V.
Filament current	·18 A.	·18 A.
Plate voltage	150 V.	150 V.
Auxiliary grid voltage	150 V.	150 V.
Plate current	2·6 mA.	3·7 mA.
Auxiliary grid current (average)	·7 mA.	1·0 mA.
Negative grid bias	0·5 V.	0·5 V. min.
Amplification factor	1300	900
Mutual conductance, (normal)	1·7 mA/V.	1·7 mA/V. (Vg = —0·5 V.)
Mutual conductance (normal)	——	·005 mA/V. (Vg = —16 V.)
Plate impedance	750,000 ohms	500,000 ohms (Vg = —0·5 V.)
Plate impedance	——	10 meg. (Vg = —16 V.)
Plate grid capacity	·01 μμF	·01 μμF
Input capacity	6·0 μμF	6·3 μμF
Output capacity	10·7 μμF	10·7 μμF

LIMITS

	KF1	KF2
Maximum plate voltage with R.F. transformer or R.F. choke in plate circuit	200 V.	200 V.
Maximum plate voltage with iron cored choke or audio transformer in plate circuit	150 V.	150 V.
Maximum plate dissipation	·8 W.	·8 W.
Maximum cathode current	7 mA.	7 mA.
Maximum auxiliary grid voltage	150	150
Maximum auxiliary grid dissipation	·3 W.	·3 W.
Negative grid voltage for commencement of grid current (plus ·3 μA)	·4 V.	·4 V.

NOTE.—For applied plate and auxiliary grid voltages of 100 or 125 volts, the negative grid bias should not be less than 0·5 volts.

KF1 AS DETECTOR

The KF1 may be employed as a plate or, alternatively, as a grid detector.

For plate detection the applied plate voltage may be between 100 and 150 volts and the auxiliary grid voltage should be approximately 100 V. The plate resistor should have a value of ·25 megohm and the bias should be adjusted to 3 volts negative.

In the case of grid leak detection a plate resistor value of ·1 megohm is recommended and the applied auxiliary grid voltage should be 50 volts.

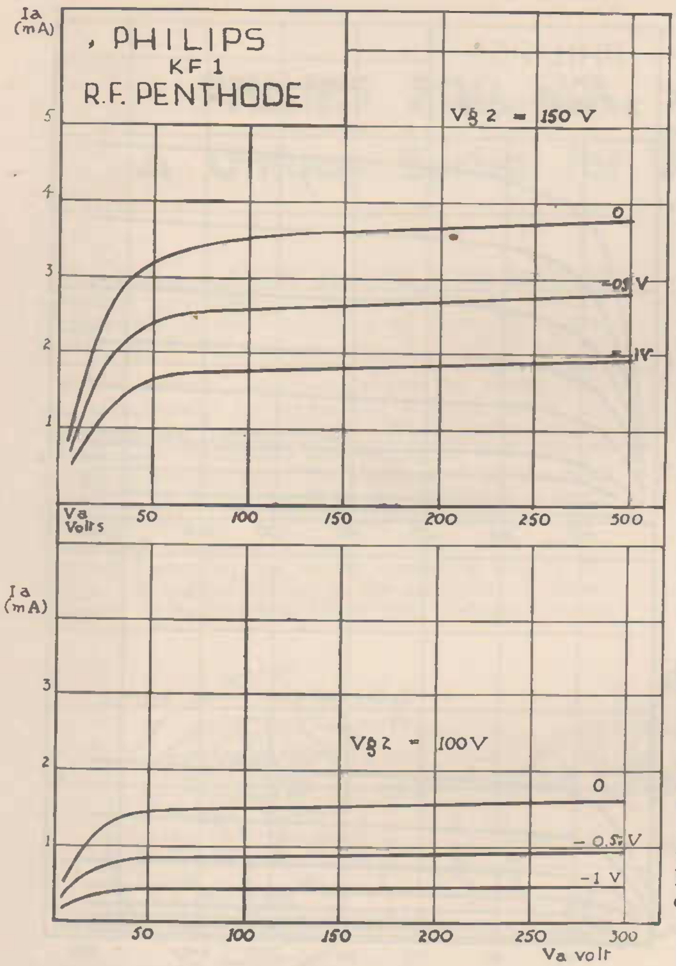
The overall detection amplification (see Technical Communication No. 9) for plate and grid detection is 10 and 12 respectively.

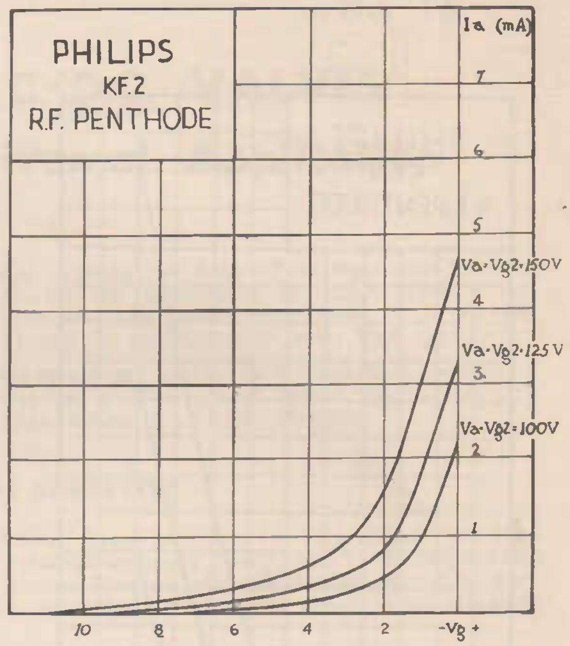
KF1 AS FREQUENCY CHANGER

The KF1 is suitable for use as an "autodyne" in superheterodynes using the filament coupling method previously suggested for the B262. (See Technical Communication No. 3.)

The number of turns on the reaction windings and the coupling should be adjusted to deliver a peak oscillator voltage of approximately 3 volts. The necessary grid bias is derived from the grid leak which has a value of from ½ to 2 megohm.

The conversion conductance of the KF1 in this arrangement is about .9 mA/V.





KF2 I.F. OR R.F. AMPLIFIER

In simple A.V.C. circuits difficulty is usually experienced in obtaining adequate control voltages for variable mu I.F. or R.F. amplifying valves.

In accordance with the latest trend in valve design, the KF2 is provided with a short grid base which facilitates volume control.

The Philips 2-volt Double Diode Triode Type KBC1 is recommended for use in conjunction with the KF2 in battery receivers incorporating A.V.C.

GENERAL REMARKS

The internal resistance and mutual conductance of the KF1 and KF2 are exceedingly high for battery types and both valves may therefore be employed to advantage for R.F. or I.F. amplification.

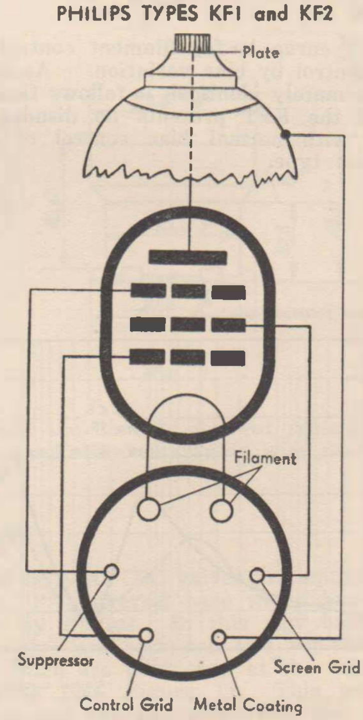
The KF1 is not a variable mu type, but, in some cases, it may be preferred for economy of design.

The volume of the receiver should not be controlled by varying the grid bias applied to the KF1, as the sharp curvature of the characteristic would produce R.F. distortion. Continuous control of volume can, however, be effected with this valve by varying the filament current with a rheostat. This arrangement offers the advantage of lower current consumption. A more important advantage, however, is that the large "C" battery normally required for the control of variable mu valves is eliminated.

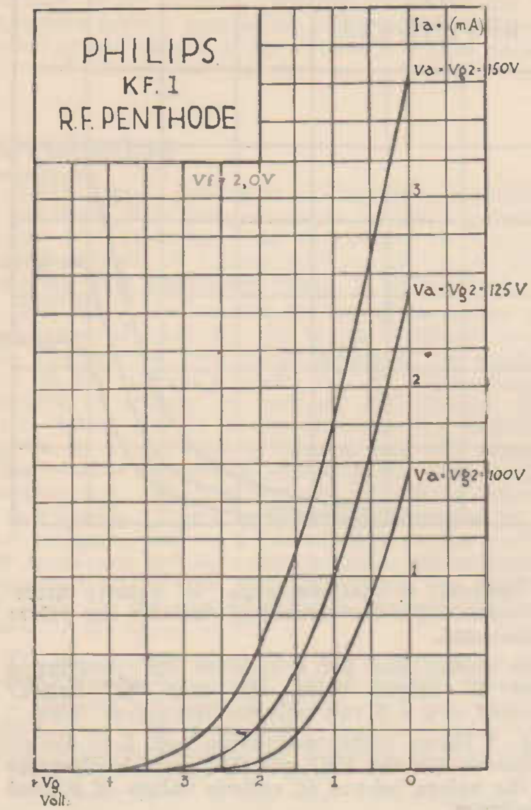
This means that for a receiver incorporating a "Class B" output valve, the only "C" battery necessary is a 4·5 volt unit for the driver valve.

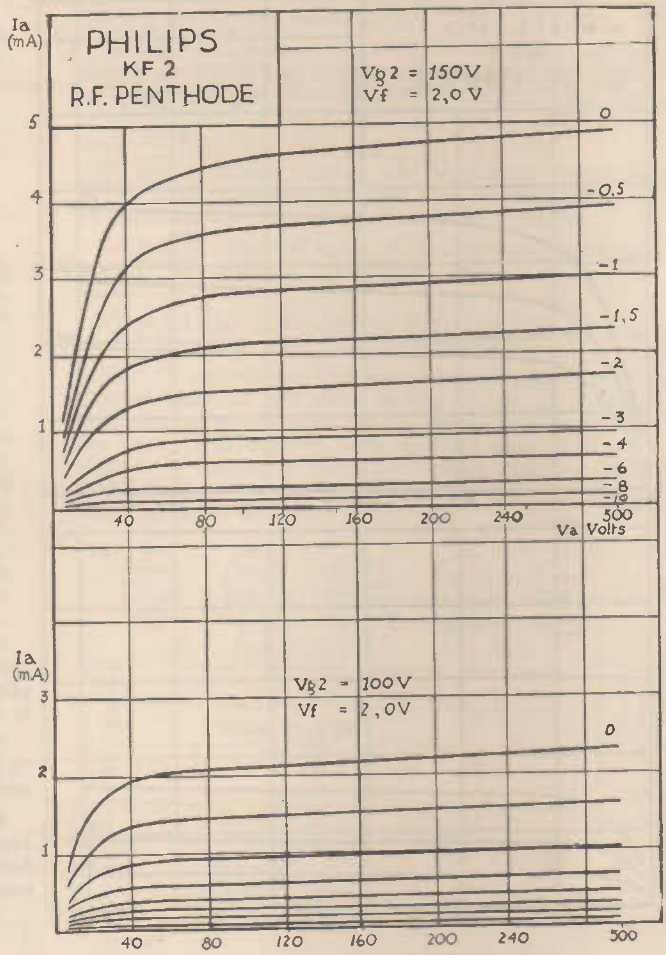
Fig. 1 shows cross modulation and R.F. distortion curves for the KF1 and KF2, which illustrate how the valves behave at various values of mutual conductance.

PHILIPS TYPES KF1 and KF2



Socket connections viewed from bottom of base.





The KF1 curve is for filament control and the KF2 for control by bias variation. As the curves are approximately identical, it follows that filament control of the KF1 presents no disadvantage as compared with normal bias control of the KF2 variable mu type.

The application of A.V.C. however, renders it necessary to employ the KF2 variable mu type. Fig. 2 depicts the mutual conductance of this valve plotted as a function of the negative grid bias from which it will be observed that the characteristics are very favourable for control purposes.

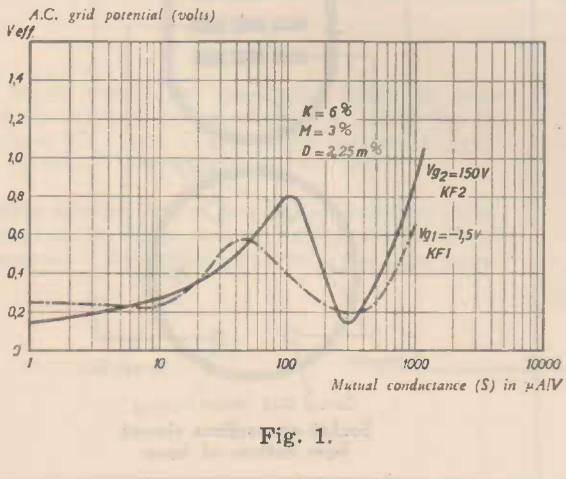


Fig. 1.

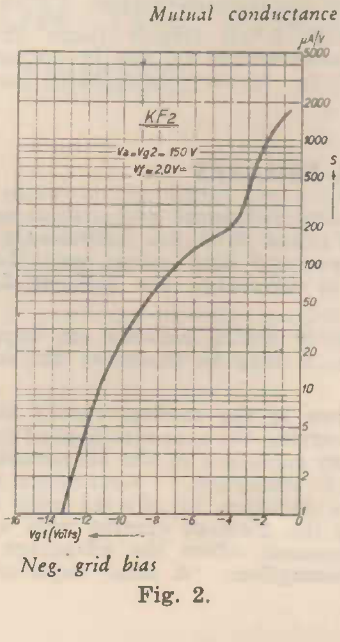


Fig. 2.

No. 13

PHILIPS 200 mA. A.C./D.C. VALVES
A Unique Series for Universal Application

The design of AC/DC receivers is not free from attendant problems, some of which are directly attributable to the limitations of valve types previously available.

For American conditions where the mains voltage is normally 110 volts, the 6·3 volt types are comparatively satisfactory. When these valves are adapted to 220-240 volt supply in this country complications ensue. The dissipation of the heat generated in the series filament resistor is a problem, particularly with restricted cabinet dimensions, and variation in mains voltage is a serious limiting factor on the useful operating life of the valves. A logical course is the adoption of higher filament voltages, but there are definite limitations in this respect. For example, if a large filament voltage is adopted only a given number of valves can be used in the receiver.

A low filament current is desirable so that the current consumption and, likewise, the development of heat in the set is minimised. Some means of regulating the filament current to take care of line variations is also an immediate necessity.

In considering the design of an ideal series of valves for this purpose, the Philips Laboratories took all these factors into consideration with the result that a range of AC/DC types literally bristling with features and possibilities was produced.

A filament current of 200 milliamperes was selected as a suitable value and, in developing a special cathode the filament voltage was fixed at 13 V., for the majority of the valve types. Exceptions are—the power valve rated at 24 V. (200 m/A) and the rectifier at 30 volts (200 mA).

We now come to the most important feature of the series, a development which has revolutionised the design of AC/DC receivers.

THE BARRETTER

Philips have produced a "Barretter" or Iron Hydrogen Regulating Lamp, which is designed for continuous filament current regulation. The Barretter entirely replaces the usual series filament resistor and the filament current remains substantially constant over remarkably wide mains voltage variations.

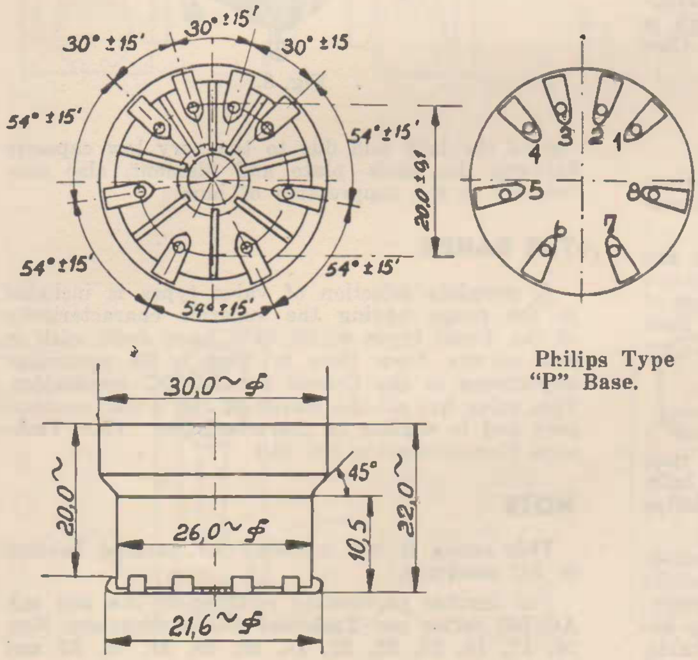


Fig. 1.

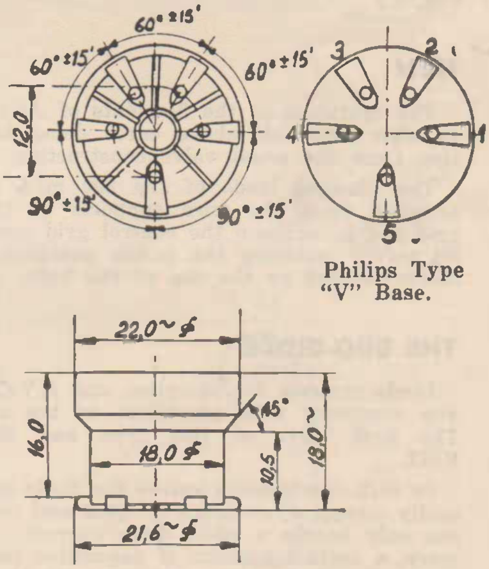


Fig. 2.

THE BASE

The 200 m/A AC/DC valves are equipped with a new type "P" universal base which has been also developed by Philips. In this new base the conventional pins are scrapped and replaced by side contacts which are positioned at the extreme edge of the base (see Figure 1). This arrangement makes possible for the first time the convenient accommodation of 8 connections in an exceedingly small space.

The "P" base has been adopted as the new universal standard in England and Europe and is creating interest in responsible quarters in America.

The new base offers many advantages from an electrical point of view. In spite of the small dimensions the distance between the various leads and contacts for the electrodes is as large as possible and the mutual capacity is consequently at a minimum. Small ribs and air gaps are provided between the contacts. The ribs increase the leakage path and the air gaps reduce the damping losses. The socket designed to accommodate the new valve base is illustrated in Fig. 3. Portion of the socket is cut away to show the principle. The contacts are formed by springs fitted at the side which grip the valve base when inserted and ensure an excellent wiping contact. Both the contact springs and the valve base contacts are silver plated.

The fitting of the valves is facilitated by a groove on the side of the valve base which can be distinctly felt by the finger. By locating a corresponding projection on the socket face, it is a simple matter to insert the valve, even in the most inaccessible position.

The new 8 contact universal base type "P" will be used for all 200 m/A valves with the exception of the duo-diode which is provided with a similar base type "V" having only 5 contacts. (See Fig. 2.)

HUM

The operation of the filaments of AC/DC valves at high potentials above earth demands a deviation from the usual valve construction.

The filament leads of the 200 m/A series are screened from the wire supports of the control grid and in addition the control grid connection of all valves including the power penthode has been accommodated on the top of the bulb.

THE DUO-DIODE

Diode systems for detection and A.V.C. are usually combined with amplifiers in the same bulb. The first valve of this type was the Philips E444.

In such combination valves the diode must necessarily occupy a minimum of space and consequently can only handle a small diode current. Furthermore, a certain amount of capacitive coupling between the diode and amplifier part is inevitable, in spite of careful screening. The result is that the R.F. component penetrates the audio portion of the valve and causes a certain amount of overload and distortion.

Likewise where A.V.C. is employed it is frequently impossible to attenuate the signal completely with an audio volume control arranged to short circuit the control grid due to this leakage of the R.F. component. The obvious solution of the various problems is the adoption of separate diode detector valves ensuring complete separation of the R.F. and audio functions in the receiver and preventing diode saturation.

There is a definite trend overseas for the use of separate diodes and a diminutive valve of this type is featured in the Philips AC/DC series. In this case the detection diode is connected at the

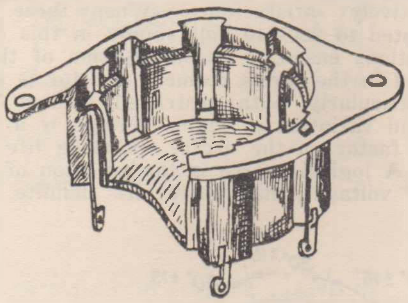


Fig. 3.

top of the bulb and due to the very low capacity between the diode plate and filament, also contributes to the suppression of hum.

THE RANGE

A complete selection of valve types is included in the range having the superior characteristics of the 4-volt types which have been dealt with in this service from time to time. Of particular importance is the Octode for AC/DC application. This valve has all the merits of the 4-volt counterpart and is similar in characteristics. (See Technical Communication No. 18.)

NOTE

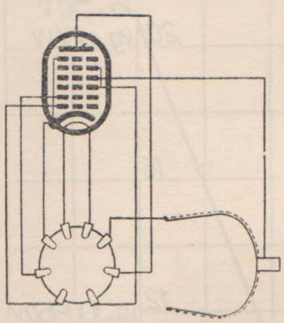
This series is not intended for parallel heating in AC receivers.

For further particulars relating to the 200 mA AC/DC series see Technical Communications Nos. 16, 17, 18, 20, 21, 22, 23, 25, 28, 31, 32, 33 and 35.

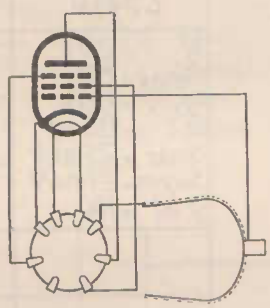
PHILIPS 200 mA. A.C./D.C. VALVES

Socket Connections viewed from bottom of base.

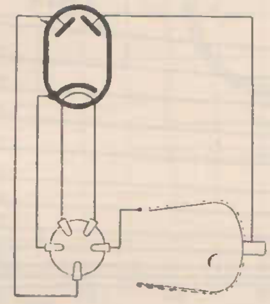
CK 1



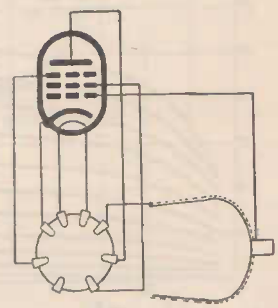
CF 2



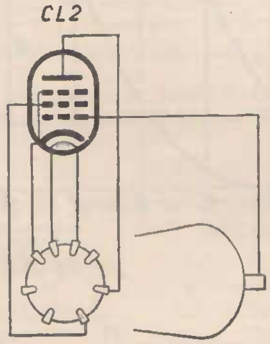
CB 1



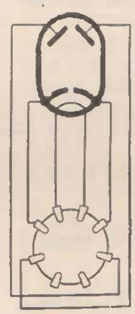
CF 1



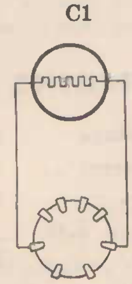
CL 2



CY 2



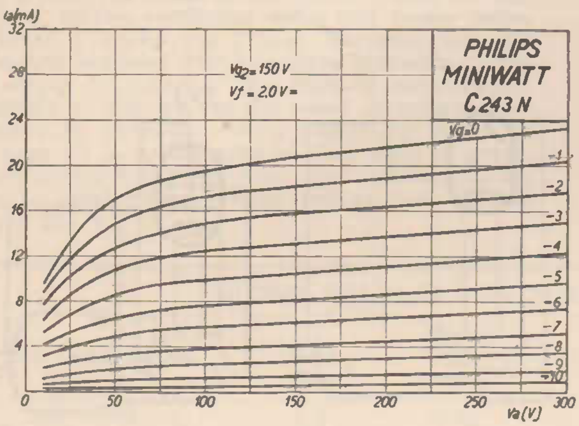
C1

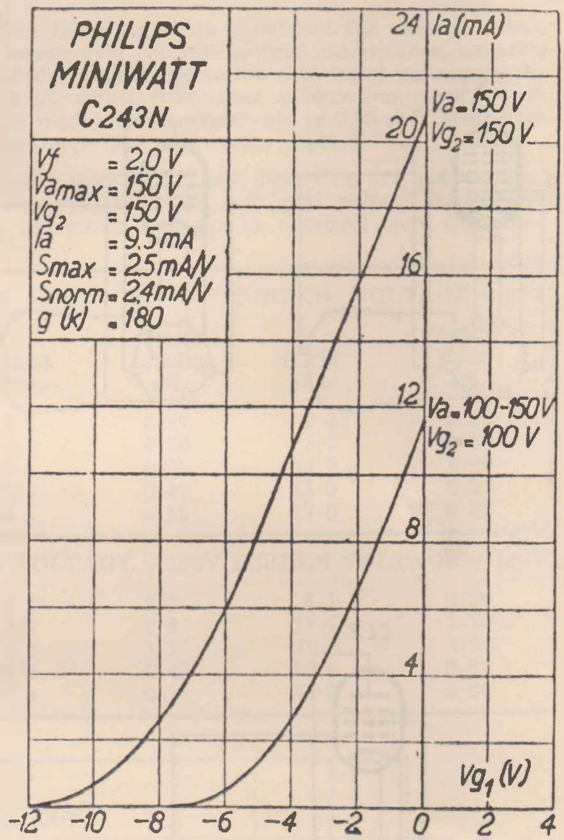


No. 14

PHILIPS TYPE C243N

Output Penthode for Battery Receivers





The C243N is a 2-volt high efficiency power penthode for use in battery receivers where economy in battery consumption is of primary importance. The valve is therefore eminently suited for incorporation in low priced battery receivers and in other applications where it is not possible to employ the B240 "Class B" twin triode.

CHARACTERISTICS

Filament voltage ..	2·0 V.	
Filament current ..	0·2 A.	
Plate voltage	100 V.	150 V. (max.)
Auxiliary grid voltage	100 V.	150 V. (max.)
Plate current	4·5 mA.	9·5 mA.
Negative grid bias	3·0 V.	4·5 V.
Average screen current		2·2 mA
Amplification factor		180
Mutual conductance normal)		2·4 mA/V.
Plate impedance ..		75,000 ohms
Optimum load		15,000 ohms
Power output (5% distortion)		·44 W.
Power output (10% distortion)		·58 W.

The maximum permissible grid input for the above mentioned conditions is 4·0 volts (R.M.S.).

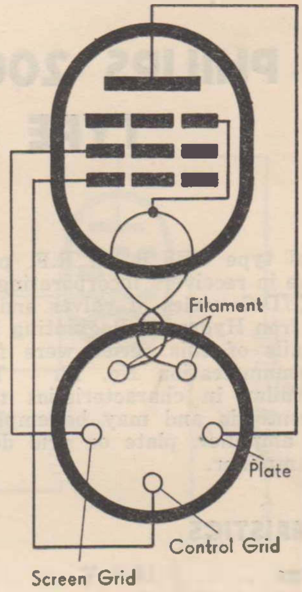
LIMITS

Maximum plate voltage	150 V.
Maximum plate dissipation	1·5 W.
Maximum cathode current	14 mA.
Maximum screen grid voltage ..	150 V.
Maximum screen grid dissipation	0·5 W.
Starting point of grid current ..	—0·4 V.
Maximum resistance in grid circuit for automatic bias	1·5 megohm
Maximum resistance in grid circuit for fixed bias	1·0 megohm
Plate grid capacity	0·6 μμF
Plate cathode capacity	10·7 μμF
Grid cathode capacity	10·2 μμF

To limit high frequency response, it is recommended that a variable resistance of 50,000 ohms in series with a ·01μF condenser be connected across the primary of the loudspeaker transformer.

QUIESCENT PUSH-PULL

For larger power outputs two type C243N Penthodes may be used to advantage in a quiescent push-pull arrangement. For this application with plate and auxiliary grid voltages of 120 V. the recommended negative grid bias is 6·0 volts. Under these conditions a pair of C243N's will deliver approximately twice the output of a single valve. The "B" battery consumption is proportional to the output, but, under most circumstances, will not exceed that of a single C243N operated as a "Class A" amplifier.



Right: PHILIPS TYPE C243N. Socket connections viewed from bottom of base.

No. 15

NEW TYPE DESIGNATION FOR PHILIPS VALVES

A new system of nomenclature has been adopted by Philips for European valves, and this has already been introduced for such types as AK1, AF2, KBC1, etc.

The type designation usually consists of two letters followed by a number. The first letter indicates the voltage and series to which the valve belongs, whilst the second letter describes the valve or defines its purpose. The two letters are followed by a number chosen in such a way that as far as is possible equivalent types' in each series carry the same number.

The key to the system is as follows:—

FIRST LETTER

A = 4 volt A.C. series.
B =
C = 200 m/A A.C./D.C. series.
D =
E = 6·3 volt series.
F =
H = 4 - volt battery series.
K = 2 - volt battery series.

SECOND LETTER

A = Diodes.
B = Duo-Diodes.
C = Triodes other than power valves
D = Power Triodes.
E = Tetrodes.
F = R.F. Penthodes.
H =
K = Octodes.
L = Power Penthodes.
Y = Half-wave Rectifiers.
Z = Full-wave Rectifiers.

NOTE.—Barretters (iron hydrogen regulating lamps) have but one letter indicating the series and one number.

EXAMPLE

AK1 represents:—
A = 4 volt
K = Octode
1 = Allotted number

Combination valves have three letters preceding the number:—

EXAMPLE

KBC1 represents:—
K = 2 volt
B = Duo-Diode
C = Triode
1 = Allotted number

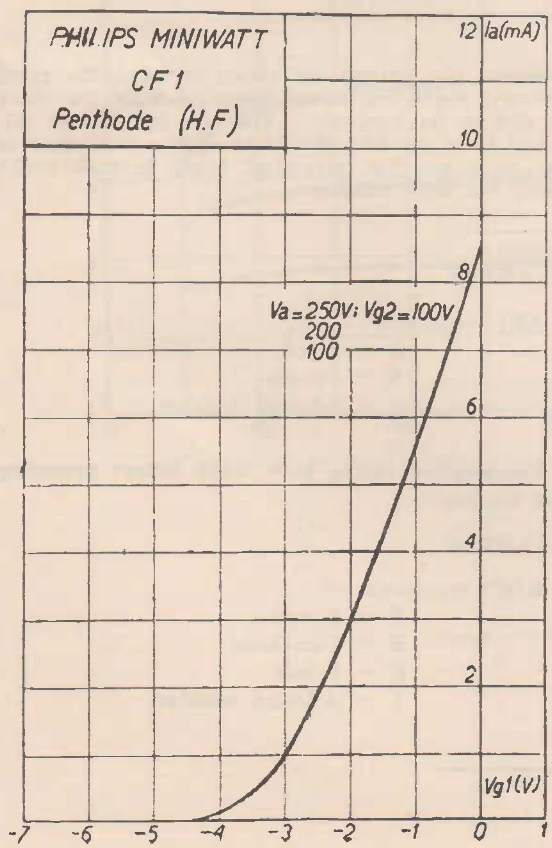
No. 16

PHILIPS 200 mA. A.C./D.C. VALVES
TYPE CF1 R.F. PENTHODE

The Philips type CF1 is an R.F. penthode designed for use in receivers incorporating the Philips 200 mA. A.C./D.C. series of valves and the Philips Barretter or Iron Hydrogen Regulating Lamp. Preliminary details of this series were furnished in Technical Communication No. 13. The CF1 is somewhat similar in characteristics to the type E446 R.F. penthode and may be employed as an R.F. or I.F. amplifier, plate or grid detector, and as an audio amplifier.

CHARACTERISTICS

Heater voltage	13·0 V.	13·0 V.
Heater current	·2 A.	·2 A.
Plate voltage	100 V.	250 V.
Screen voltage	100 V.	100 V.
Plate current	3 mA.	3 mA.
Negative grid bias ..	2 V.	2 V.
Screen current	1 mA.	1 mA.
Amplification factor ..	1100	3000
Mutual conductance ..	2·2 mA/V.	2·2 mA/V.
Plate impedance	·5 megohm	1·3 megohm



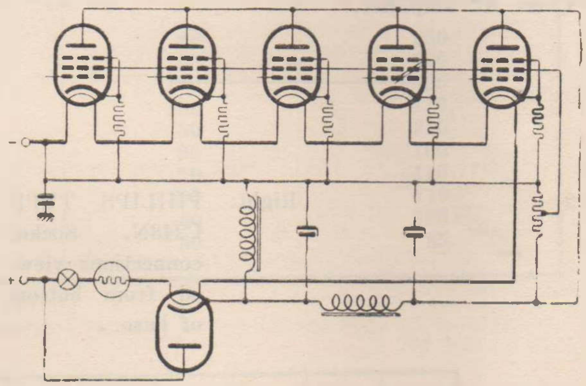


Fig. 1.

Plate-grid capacity ..	·001	μμF
Input capacity	8	μμF
Output capacity	6·8	μμF

Base—Philips type "P" universal base.

LIMITS

Maximum plate voltage with tube in cold condition	400 V.
Maximum plate voltage with resistance, R.F. transformer or R.F. choke coupling in plate circuit ..	250 V.
Maximum plate voltage with iron cored choke or transformer in plate circuit	200 V.
Maximum plate dissipation	1·0 W.
Maximum cathode current	6·0 mA.
Grid voltage for commencement of grid current (·3 μA.)	—1·3 V.
Maximum screen voltage	125 V.
Maximum screen dissipation	·25 W.
Maximum resistance in control grid circuit with automatic bias	1·5 megohm
Maximum resistance in control grid circuit with fixed bias	1 megohm
Maximum peak voltage between cathode and heater	125 V.
Maximum resistance between cathode and heater	20,000 ohm

NOTE.—The CF1 is not intended for parallel heating in A.C. receivers.

APPLICATION

The diagram shown in figure 1 is a theoretical filament circuit arrangement for an A.C./D.C. receiver. The filaments of the various valves are connected in series, the valve nearest the negative mains terminal being necessarily the detector, as this stage is critical with respect to hum.

The arrangement of the other valves depends on the maximum allowable voltage between cathode and filament. For the amplifying valves this voltage limit is 125 V., for the power valve 175 V. and for the rectifying valve 350 V.

In the circuit shown in figure 1 the peak voltage between the cathode and filament of the rectifier is equal to the sum of the rectified voltage and the total filament voltages of the receiving valves. (A.C. operation only.)

If this voltage exceeds the maximum value of 350 V. it is recommended that the rectifier filament be connected before the power valve filament. In such a case the order of the valves would be: amplifying valves, rectifying valve and power valve.

Figure 1 shows the Philips Barretter type C1 connected in series with the valve filaments. The C1 serves to maintain the filament current substantially at 200 mA. in the event of voltage fluctuations or changes. The regulating range of the type C1 is 80-200 volts so that when it is employed for example with a 5 valve receiver plus rectifier, the set may be used for all mains voltages between 190 V. and 265 V.

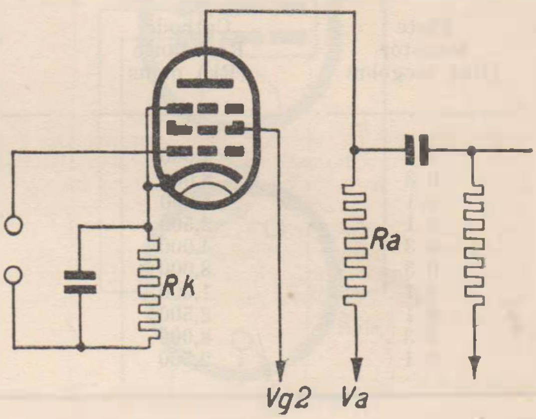


Fig. 2.

R.F. AMPLIFICATION

The CF2 variable mu R.F. penthode is normally preferred for I.F. or R.F. amplification. If, however, the CF1 is used for the purpose, the usual precautions must be taken to ensure stability. Capacitive and inductive coupling between the control grid and plate circuits should be minimised. All components in the various stages should be magnetically and electrostatically separated and the control grid leads as short as possible. In some cases it may be necessary to decouple the plate or screen grid returns by means of a condenser of at least ·1 μF capacity. A series resistor suitably by-passed may be used for the screen feed when the CF1 is employed as an R.F., I.F. or Audio Amplifier.

PLATE DETECTION

For anode bend detection the recommended plate load resistance is ·3 megohm, and the screen should be fed from a potentiometer or voltage divider, the bleeder current of which is at least 1 mA.

Data on various operating conditions for anode bend detection is given in the following table (reference Fig. 2).

Ra = ·3 megohm.

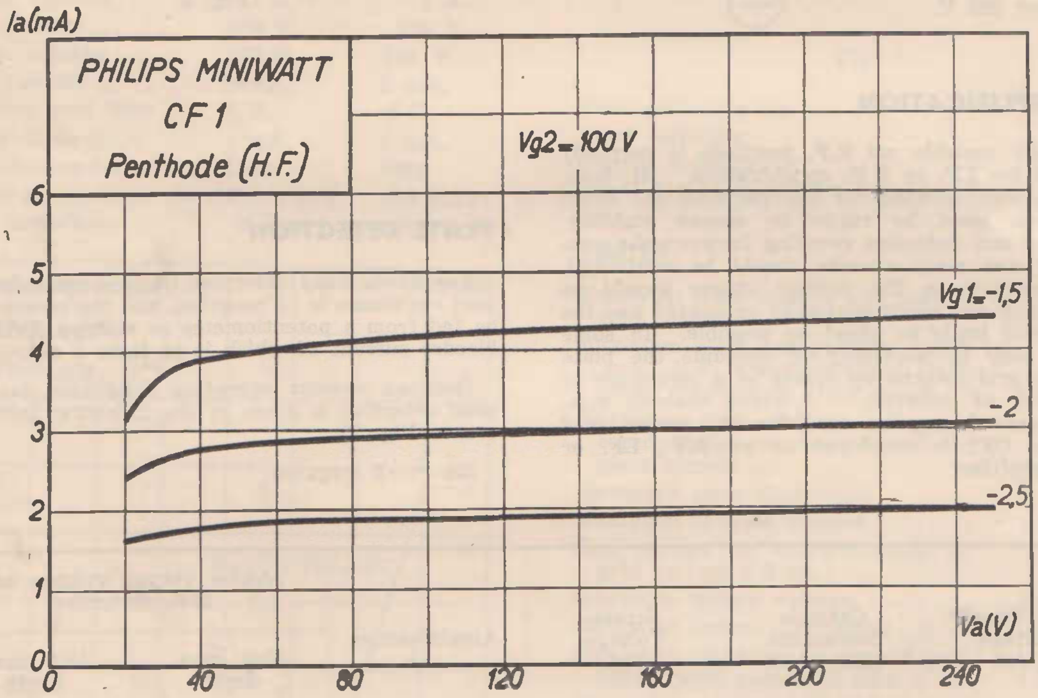
Plate Supply Voltage (Va)	Cathode Resistance (Rk) ohms	Screen Voltage (Vg2)	Amplification	Audio output voltage at 10% distortion	
				30% mod. depth	10% mod. depth
250	2500	50	11	27·5	13
	5000	70	10·5	45	18
	10000	100	9	67	30
	16000	150	7·3	70	30
200	2500	45	12	17·5	6·5
	5000	55	11·3	32	14
	10000	60	9·7	50	23
	16000	150	7·3	55	27
100	5000	35	10	9	3
	10000	40	9·6	19	9
	16000	45	8·3	24	14
	20000	100	7·2	25	13

AUDIO AMPLIFICATION

The CF1 is also adaptable for use as an audio amplifier and will usually follow the Duo-Diode type CB1 for post detector amplification before the power valve.

The effective audio amplification for various values of plate voltage and load resistor is stated hereunder. (Ref. Fig. 2):—

Plate Resistor (Ra) megohm	Cathode Resistance (Rk) ohms	Plate Voltage (Va)	Screen Voltage (Vg2)	Amplification
0·3	4,000	250	60	250
0·3	8,000	250	100	190
0·1	1,600	250	100	120
0·1	2,500	250	100	110
0·3	4,000	200	50	215
0·3	8,000	200	90	160
0·1	1,600	200	70	110
0·1	2,500	200	110	110
0·3	8,000	100	40	120
0·1	2,500	100	50	85



No. 17

PHILIPS 200 mA. A.C./D.C. VALVES
TYPE CF2 VARIABLE MU R.F. PENTHODE

The Philips type CF2 in common with the CF1 is an R.F. Penthode designed for use in receivers incorporating the Philips 200 mA. A.C./D.C. series of valves and the Philips Barretter or Iron Hydrogen Regulating Lamp.

Preliminary details of this series were furnished in Technical Communication No. 13. The CF2 is somewhat similar in characteristics to the type AF2 R.F. Penthode and is provided with a short grid base or cut-off. This feature permits the control of volume over very wide limits with relatively small bias voltage variations.

The CF2 is therefore eminently suited for use in receivers incorporating simple automatic volume control, particularly when associated with the CK1 octode frequency changer :

CHARACTERISTICS

Heater voltage	13·0 V.	13·0 V.
Heater current	·2 A.	·2 A.
Plate voltage	100 V.	250V.
Screen voltage	100 V.	100 V.
Plate current (Vg = —2 V.)	4·5 mA.	4·5 mA.
Plate current (Vg = —20 V.)	·01 mA.	·01 mA.
Screen current	1·5 mA.	1·5 mA.
Amplification factor .	650	2200
Mutual conductance (Vg = —2 V.) ..	2·2 mA/V.	2·2 mA/V.
Mutual conductance (Vg = —20 V.) ..	·005 mA/V.	·005 mA/V.
Plate impedance (Vg = —2 V.)	·3 megohm	1 megohm
Plate impedance (Vg = —20 V.)	10 megohm	10 megohm
Plate grid capacity ..	·001 μμF	·001 μμF
Input capacity	8 μμF	8 μμF
Output capacity	6·8 μμF	6·8 μμF

Base—Philips new type "P" universal base.

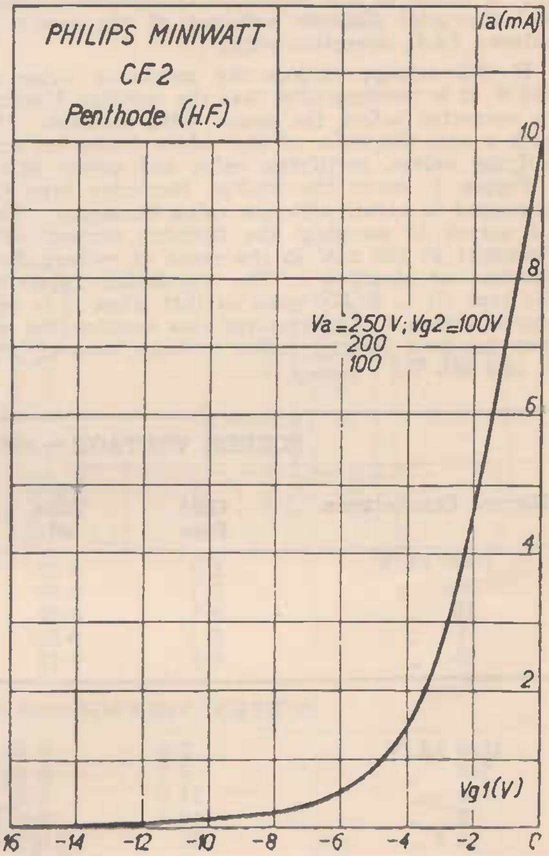
LIMITS

The limits for the CF2 are the same as for CF1 with the following exceptions:—

Maximum plate dissipation	1·5 W.
Maximum cathode current	8·0 mA.
Maximum permissible resistance in control grid circuit with automatic bias	2 megohm

NOTE.—The CF2 is not intended for parallel heating in A.C. receivers.

The rated maximum screen voltage for the CF2 is 125 V. When this valve is biased to a low value of mutual conductance and the plate current decreases below 1 mA. the screen voltage may be allowed to approach 150 V. Thus by judiciously selecting the voltage divider or series resistance for the screen feed, it is possible to give the valve an even sharper cut-off if necessary.



APPLICATION

The diagram shown in figure 1 is a theoretical filament circuit arrangement for an A.C./D.C. receiver. The filaments of the various valves are connected in series, the valve nearest the negative mains terminal being necessarily the detector, as this stage is critical with respect to hum.

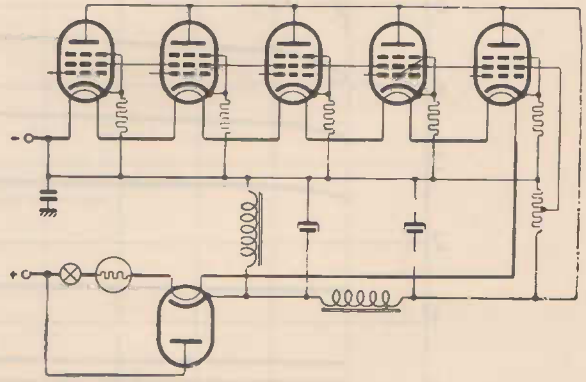


Fig. 1

The arrangement of the other valves depends on the maximum allowable voltage between cathode and filament. For the amplifying valves this voltage limit is 125 V., for the power valve 175 V. and for the rectifying valve 350 V.

In the circuit shown in figure 1 the peak voltage between the cathode and filament of the rectifier is equal to the sum of the rectified voltage and the total filament voltages of the receiving valves. (A.C. operation only.)

If this voltage exceeds the maximum value of 350 V. it is recommended that the rectifier filament be connected before the power valve filament. In such a case the order of the valves would be: amplifying valves, rectifying valve and power valve.

Figure 1 shows the Philips Barretter type C1 connected in series with the valve filaments. The C1 serves to maintain the filament current substantially at 200 mA. in the event of voltage fluctuations or changes. The regulating range of the type C1 is 80-200 volts so that when it is employed with a 5 valve receiver plus rectifier, the set may be used for all mains voltage between 190 V. and 265 V.

I.F. AND R.F. AMPLIFICATION

When the CF2 is employed as an I.F. or R.F. amplifier the usual precautions must be taken to ensure stability. Capacitive and inductive coupling between the control grid and plate circuits should be minimised.

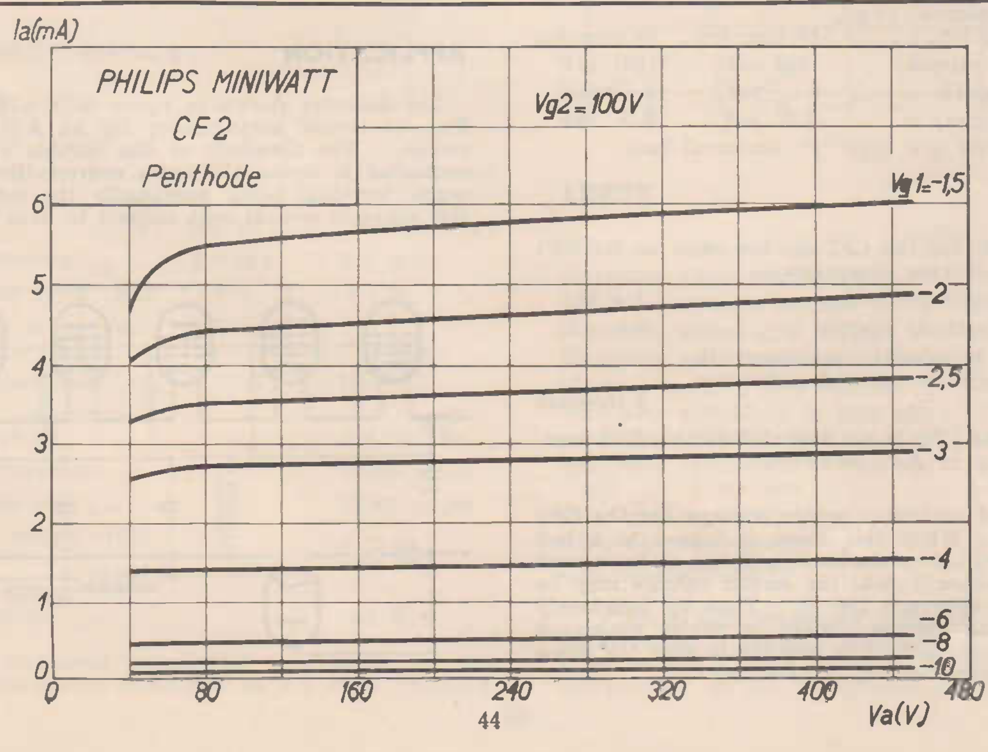
All components in the various stages should be magnetically and electrostatically separated and the control grid leads as short as possible. In some cases it may be necessary to decouple the plate or screen grid returns by means of a condenser of at least ·1 μF capacity.

The following table furnishes for various values of screen grid voltage, mutual conductance, negative grid bias, and the effective A.C. input voltage to the grid at which 6% cross modulation occurs (6% cross modulation corresponds to 2.25 m% distortion where m is the modulation depth.)

Cross modulation and distortion are proportional to the square of the A.C. grid voltage so that all the necessary data can be obtained from the table.

	SCREEN VOLTAGE = 40V.		SCREEN VOLTAGE = 60V.		SCREEN VOLTAGE = 80V.	
Mutual Conductance.	Grid Bias	Input Volts eff.	Grid Bias	Input Volts eff.	Grid Bias	Input Volts eff.
1000 μA/V.	1·1	0·30	1·8	0·27	2·4	0·38
100 „	2·7	0·20	4·2	0·36	5·5	0·50
10 „	5·7	0·35	8·8	0·55	11·3	0·90
1 „	8·1	0·20	12·0	0·27	15·5	0·33
0·1 „	9·2	0·11	13·5	0·12	17·0	0·15

	SCREEN VOLTAGE=100V.		SCREEN VOLTAGE = 120V.		SCREEN VOLTAGE = 150V.	
1000 μA/V.	3·0	0·45	4·1	0·5	5·1	0·58
100 „	6·7	0·65	8·9	0·8	11·7	1·10
10 „	14·0	1·1	17·5	1·1	22·5	1·30
1 „	18·5	0·4	23·0	0·43	30·0	0·52
0·1 „	20	0·16	25·0	0·18	32·5	0·20



No. 18

PHILIPS 200 mA. A.C./D.C. VALVES TYPE CK1 OCTODE FREQUENCY CHANGER

The Philips type CK1 OCTODE is an Electron Coupled frequency changer designed for use in receivers incorporating the Philips 200 mA AC/DC series of valves and the Philips Barretter or Iron Hydrogen-regulating Lamp. Preliminary details of this series were furnished in Technical Communication No. 13.

The OCTODE is a development of the Philips Laboratories and represents an improvement on the existing types of pentagrid converters, i.e.. Electron-coupled frequency changers. The OCTODE is similar in principle to the 2A7 or 6A7 with the addition of a sixth (suppressor) grid. Thus the first detector or mixer portion of the OCTODE is a penthode, whereas the counterpart of the 2A7 is a tetrode.

In practice the 2A7 exhibits several disadvantages, including a low signal to noise ratio, a low conversion amplification and excessive frequency shift in the oscillator circuit when the control grid is negatively biased for volume control purposes. The latter is particularly serious on short wave.

The Philips OCTODE combines all the advantages of the Electron-coupled frequency changer with freedom from the abovementioned drawbacks.

The excessive background "hiss" of the pentagrid has been obviated in the octode by designing the tube in such a way that even with comparatively high conversion amplification the plate current is relatively small. The Octode also functions efficiently on short wave bands.

Comparisons of the performance of the Octode and the 2A7 are particularly interesting:—

	2A7	Octode
Conversion conductance	520	600 micromhos
Internal resistance in megohm	·29	1·2
Conversion amplification	97	225
Frequency alteration in oscillator circuit when control grid is negatively biased for volume control	1400	300 cycles
Background noise ratio	5	1

Special provision has also been made for the prevention of repeat spots and whistles due to harmonics.

DESCRIPTION

As the name implies, the Philips Octode is an 8 electrode valve, and in the case of the CK1 is designed for operation in AC/DC receivers.

The structure of the Octode can be observed from the diagram in Fig. 1a, in which the various grids between the cathode and plate are numbered consecutively from 1 to 6.

Grid 1 together with the auxiliary plate (grid 2) forms a triode.

The auxiliary plate (G2) consists of two rods mounted mostly outside the electron stream.

Grids 3 and 5 are screen grids, and between them is grid 4, which is connected to the signal frequency circuit and becomes the control grid.

Grid 6 is the suppressor grid which is anchored to the cathode inside the valve.

The approximate D.C. voltages applied to the various electrodes are:—

Grids 1 and 4	1·5 volts (negative)
Grids 2, 3 and 5 ..	70 volts
Plate	200-250 volts

The functioning of the Philips Octode can be understood by imagining the valve to consist of two superimposed systems. The first system (Fig. 1b) as mentioned previously includes the cathode, grid 1 and the auxiliary plate (grid 2). Grids 1 and 2 are coupled inductively and oscillation takes place. The electronic stream in the valve is modulated by this oscillator portion and is accelerated by the positive voltage on grid 3. A negative voltage is, however, applied to Grid 4. This obstructs the electron stream, and a cloud of electrons accumulates between grids 3 and 4.

When considering the second portion of the valve (see Fig 1c), this electron cloud may be regarded as a secondary cathode, or source of electrons. It differs from the ordinary cathode, however, in that it pulsates in accordance with the oscillation frequency of the triode portion.

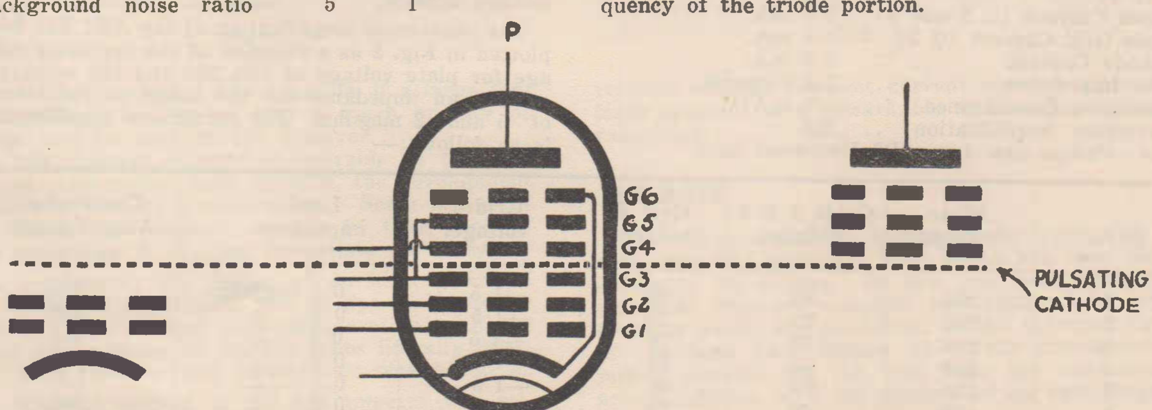


Fig. 1b. Fig. 1a. Fig. 1c.

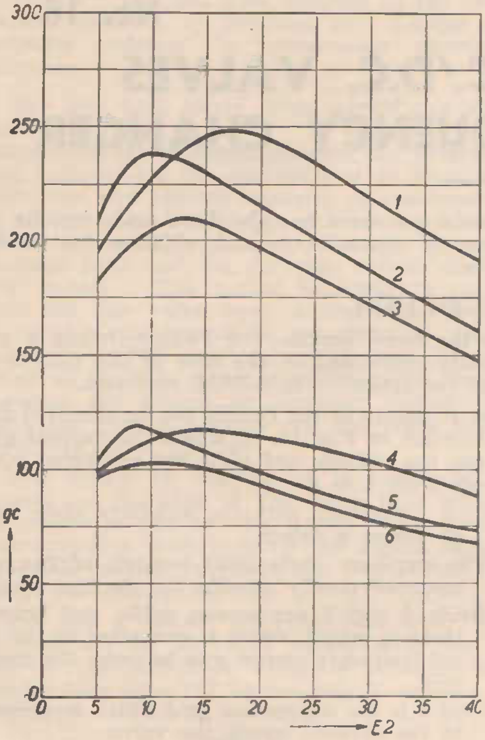


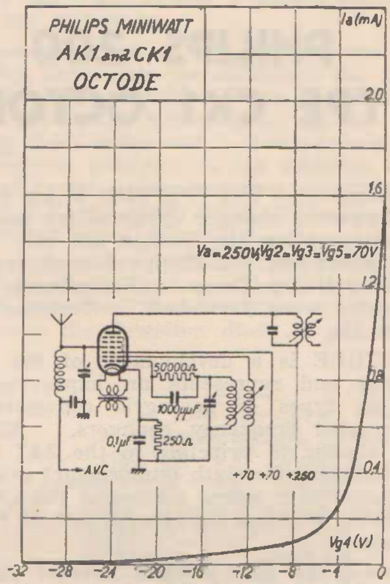
Fig. 2

The part of the Octode above grid 3 may be considered as an R.F. Penthode in which grid 4 is the control grid, grid 5 the screen grid, grid 6 the suppressor, and P finally the plate.

The electron stream of the penthode portion is influenced by the signal frequency voltage on grid 4 and also by the pulsating cathode, so that the current reaching the plate combines the signal and oscillator frequencies.

CHARACTERISTICS	OCTODE TYPE CK1
Heater voltage	13 V.
Heater current	·2 A.
Plate voltage	200-250 V.
Screen voltage (G. 3 and 5).	70 V.
Anode Grid voltage (G 2) ..	70 V.
Control grid Negative bias (G 4)	1·5 V. (minimum)
Plate current	0·8 mA.
Oscillator grid negative bias (G 1)	1·5 V.
Screen Current (G 3 and 5).	3·0 mA.
Anode Grid Current (G 2) ..	1·6 mA.
Cathode Current	6·0 mA.
Plate Impedance	1·5 megohm
Conversion Conductance . . .	·6 mA/V.
Conversion Amplification ..	225

Base—Philips new type "P" Universal base.



TRIODE OSCILLATOR (GRIDS 1 AND 2)

(Anode grid [G.2] voltage = 75 V. Oscillator grid [G.1] bias = —2 V.)

Impedance	22,700 ohms
Amplification factor	25
Mutual conductance	1·1 mA V.

LIMITS

Maximum plate voltage	250 V.
Maximum screen voltage (G.3 and G.5)	90 V.
Maximum anode grid voltage (G.2)	90 V.

Note.—The CK1 is not intended for parallel heating in AC Receivers.

The conversion conductance and internal resistance are dependent on the heterodyne voltage delivered by the oscillator. The maximum conversion conductance is obtained at an oscillator voltage of approximately 8·5 volts R.M.S. and decreases at higher voltages. The internal resistance increases slightly at higher oscillator voltages. The oscillator voltage at which maximum amplification is obtained is, therefore, dependent upon the impedance of the tuned plate circuit and upon the plate voltage applied.

The conversion amplification of the AK1 has been plotted in Fig. 2 as a function of the oscillator voltage for plate voltage of 250, 200 and 100 volts, assuming an impedance for the tuned output circuit of ·5 and ·2 megohm. The conversion amplification is as follows:—

Curve.	Plate voltage	Grids 3 & 5 voltage.	Grid 2 voltage.	Grid 4 voltage.	Load impedance.	Conversion Amplification.
1	250	80	80	—1·5	0·5 megohm.	245
2	200	70	70	—1·5	0·5 ,,	240
3	100	70	70	—1·5	0·5 ,,	210
4	250	80	80	—1·5	0·2 ,,	120
5	200	70	70	—1·5	0·2 ,,	120
6	100	70	70	—1·5	0·2 ,,	105

VOLUME CONTROL

The design of the CK1 is such that volume can be effectively controlled by varying the grid bias applied to the control grid (G. 4). This is demonstrated by the logarithmic mutual conductance curve shown in fig. 3 which is practically a straight line. By the application of a negative bias of 20 volts the amplification can be varied over a ratio of 1:10,000.

RE-RADIATION

The screening afforded by G. 3 is very complete so that coupling between the control grid and the oscillator portion is negligible. Consequently the oscillator voltage on G. 1 and 2 cannot reach the control grid G. 4, and re-radiation of the oscillator into the aerial circuit is avoided. The decisive factor for this re-radiation is the capacity between grids 1 and 4 which, in the case of the Octode, is half the corresponding value of the 2A7.

OSCILLATOR FREQUENCY VARIATION

By judiciously selecting the voltage applied to grids 2 and 3 electronic coupling between grids 1 and 4 has been minimised. Thus the application of a negative bias to the control grid (G. 4) for volume control purposes has very little influence on the oscillator frequency. The frequency displacement at a wavelength of 200 metres as a result of applying 20 volts bias to G. 4 is only about 300 cycles. Furthermore, the oscillator amplitude is not affected as much as in the case of the 2A7.

BACKGROUND NOISE

One of the problems of superheterodyne design is the excess of tube "hiss" or "background noise," mainly due to the frequency changer. This hiss is proportional to the square root of the plate current in the valve. The plate current of the Octode does not exceed 1·2 mA, whereas the corresponding value for the 2A7 is 3·5 mA. Not only is the background noise correspondingly reduced in the Octode, but at the same time, a greater conversion amplification is provided, and taking both factors into consideration, the resultant background noise is about one-fifth of that obtained from the 2A7. This development is obviously an important advance in frequency changing technique.

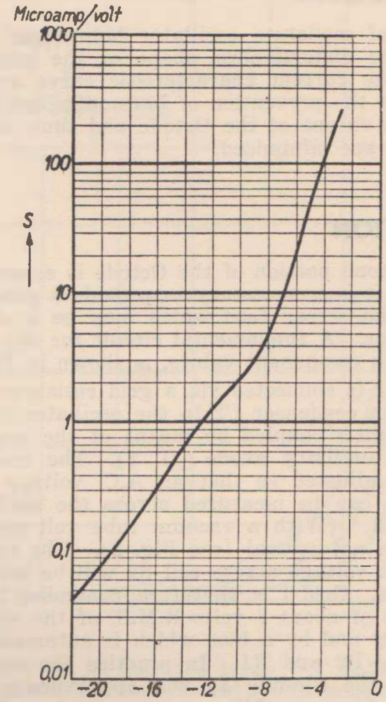


Fig. 3.

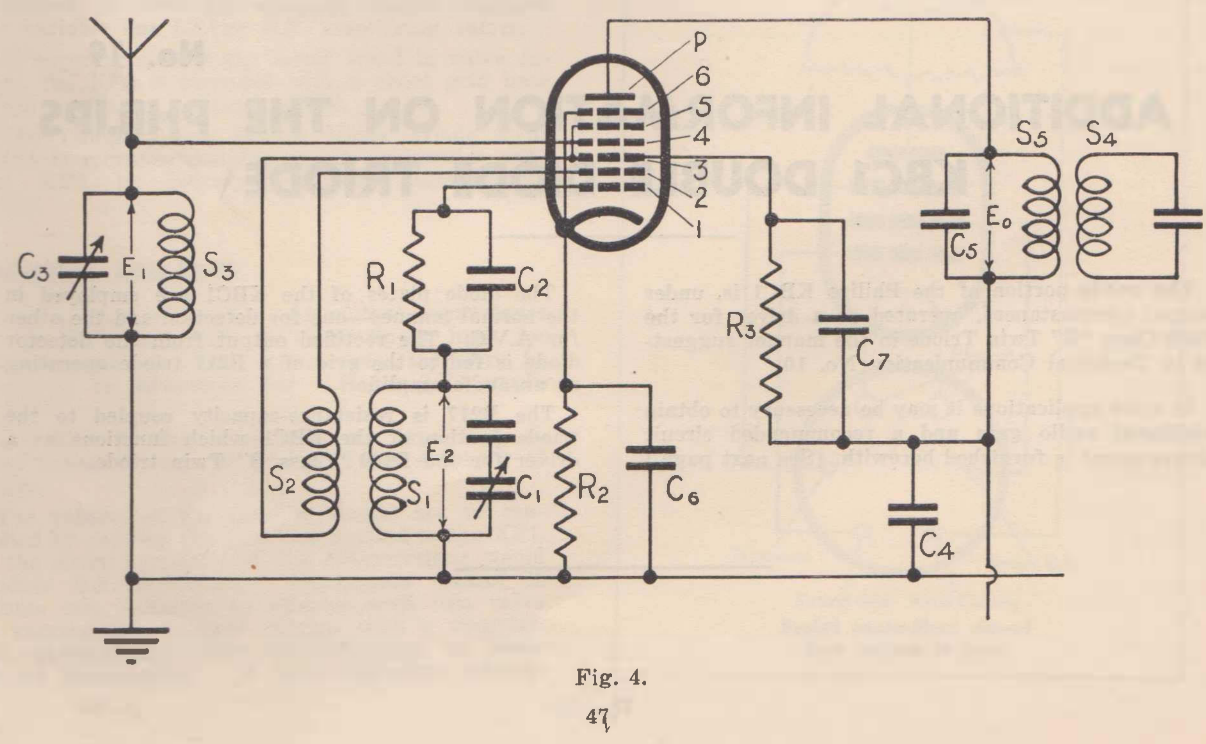


Fig. 4.

WHISTLES, ETC.

The use of moderate oscillator heterodyne voltages and the distortionless shape of the grid (4) voltage—plate current characteristic curve are responsible for the prevention of harmonics and overtones in the output of the Octode and thus oscillator whistles are minimised.

APPLICATION

As the second portion of the Octode is essentially a penthode. it is unnecessary to provide a potentiometer for the screen feed which may be a simple series resistor. A fundamental circuit for the CK1, together with component values, is shown in Fig. 4.

Grid No. 1 is connected via a grid resistance R1, together with condenser C2 to the oscillator circuit S1, C1, which is coupled by means of the reaction coil to the auxiliary anode (G. 2). The reaction coupling is adjusted so that an A.C, voltage of 8 volts R.M.S. can be measured across the oscillator circuit S1 C1. (With a vacuum tube volt meter). This value is not critical (see Fig. 2). The corresponding A.C. voltage across coil S2 will be between 3 and 4 volts. Grid 1 is, therefore, controlled by an A.C. voltage of about 8 volts R.M.S. of the oscillator frequency and by a bias which is automatically developed by R2 and R1. In practice the number of turns on the winding S2 will approximate one-third of the turns on S1.

The diagram shown in Fig. 1 is a theoretical filament circuit arrangement for an AC/DC receiver. The filament of the various valves are connected in series, the valve nearest the negative mains terminal being necessarily the detector, as this stage is critical with respect to hum:

The arrangement of the other valves depends on the maximum allowable voltage between cathode and filament: For the amplifying valves this voltage limit is 125V, for the power valve 175V, and for the rectifying valve 350V.

In the circuit shown in Fig. 1 the peak voltage between cathode and heater of the rectifier is equal to the sum of the rectified voltage and the total filament voltages of the receiving valves: (A.C. operation only):

If this voltage exceeds the maximum value of 350V. it is recommended that the rectifier filament be connected before the power valve filament:

In such a case the order of the valves should be: amplifying valves, rectifying valve and power valve:

Figure 1 shows the Philips Barretter type C1 connected in series with the valve filaments:

The C1 serves to maintain the filament current substantially at 200 mA. in the event of voltage fluctuations or changes. The regulating range of the type C1 is 80—200 volts so that when it is employed for example with a 5-valve receiver plus rectifier, the set may be used for all mains voltages between 190V. and 265V.

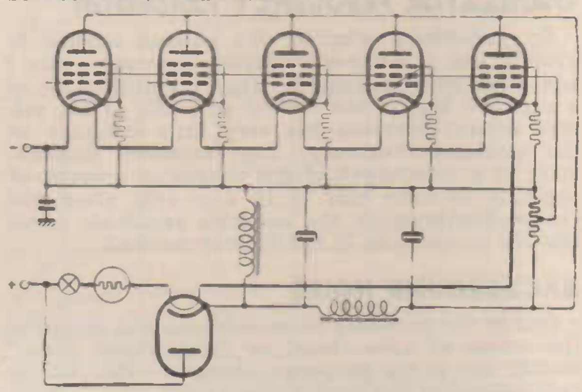


Fig. 1

No. 19

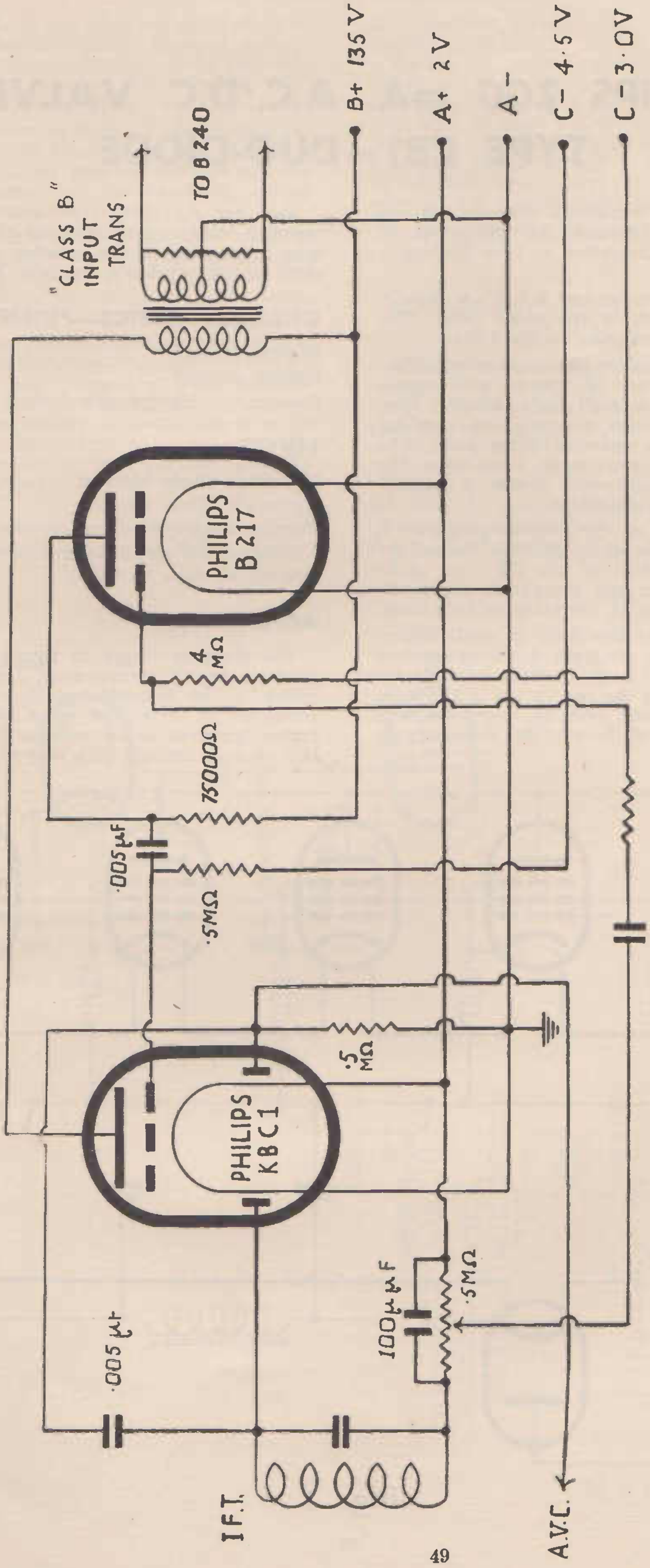
ADDITIONAL INFORMATION ON THE PHILIPS KBC1 DOUBLE DIODE TRIODE

The triode portion of the Philips KBC1 is, under normal circumstances, operated as a driver for the B240 Class "B" Twin Triode in the manner suggested in Technical Communication No. 10.

In some applications it may be necessary to obtain additional audio gain and a recommended circuit arrangement is furnished herewith. (See next page.)

The diode plates of the KBC1 are employed in the normal manner—one for detection and the other for A.V.C. The rectified output from the detector diode is fed to the grid of a B217 triode operating as an audio amplifier.

The B217 is resistance-capacity coupled to the triode portion of the KBC1 which functions as a driver for the B240 "Class B" Twin triode.


B+ 135 V
A+ 2V
A –
C– 4·5 V
C– 3·0V
"CLASS B" INPUT TRANS.
TO B240
PHILIPS B217
4 MΩ
75000Ω
·005µF
·5MΩ
·25 MΩ
·001µF
·5 MΩ
PHILIPS KBC1
100µµF
·5MΩ
·005 µF
I.F.T.
A.V.C.

No. 20

PHILIPS 200 mA. A.C./D.C. VALVES TYPE CB1—DUO-DIODE

The Philips CB1 is a Duo-Diode designed for use with the Philips new 200 mA. AC/DC series of valves and the Philips Barretter or Iron Hydrogen Regulating Lamp.

Diode systems for detection and A.V.C. are usually combined with amplifiers in the same bulb. The first valve of this type was the Philips E444.

In such combination valves the diode must necessarily occupy a minimum of space, and consequently can only handle a small diode current. Furthermore, a certain amount of capacitive coupling exists between the diode and amplifying part. The result is that the R.F. component penetrates the audio portion of the valve and causes a certain amount of overload and distortion.

The obvious solution of the various problems is the adoption of separate diode detector valves ensuring complete separation of the R.F. and audio functions in the receiver and preventing diode saturation by the provision of adequate cathode area.

The CB1 is a separate duo-diode of small dimensions and provided with adequate shielding between the respective diodes. The diode plate intended for detection is connected to the cap on top of the bulb. The input capacity of this diode is, therefore, very small and the damping of the previous tuned circuit is accordingly reduced.

Also, for A.C./D.C. receivers, the use of a low capacity diode contributes to the suppression of hum originating in the detector. The A.V.C. diode plate is connected via the tube base.

CHARACTERISTICS—PHILIPS TYPE CB1

Heater voltage .. .. 13 V.
Heater current .. .. ·2 A
Base .. .. Philips new type "V" universal base

LIMITS

Maximum Diode voltage .. .. 200 V.
Maximum Diode current .. .. ·8 mA
Maximum voltage between heater and cathode 125 V.

Note.—This series is not intended for parallel heating in A.C. receivers.

APPLICATION

The diagram shown in figure 1 is a theoretical filament circuit arrangement for an A.C./D.C. receiver. : The filaments of the various valves are connected in series, the valve nearest the negative mains terminal being necessarily the detector, as this stage is critical with respect to hum.

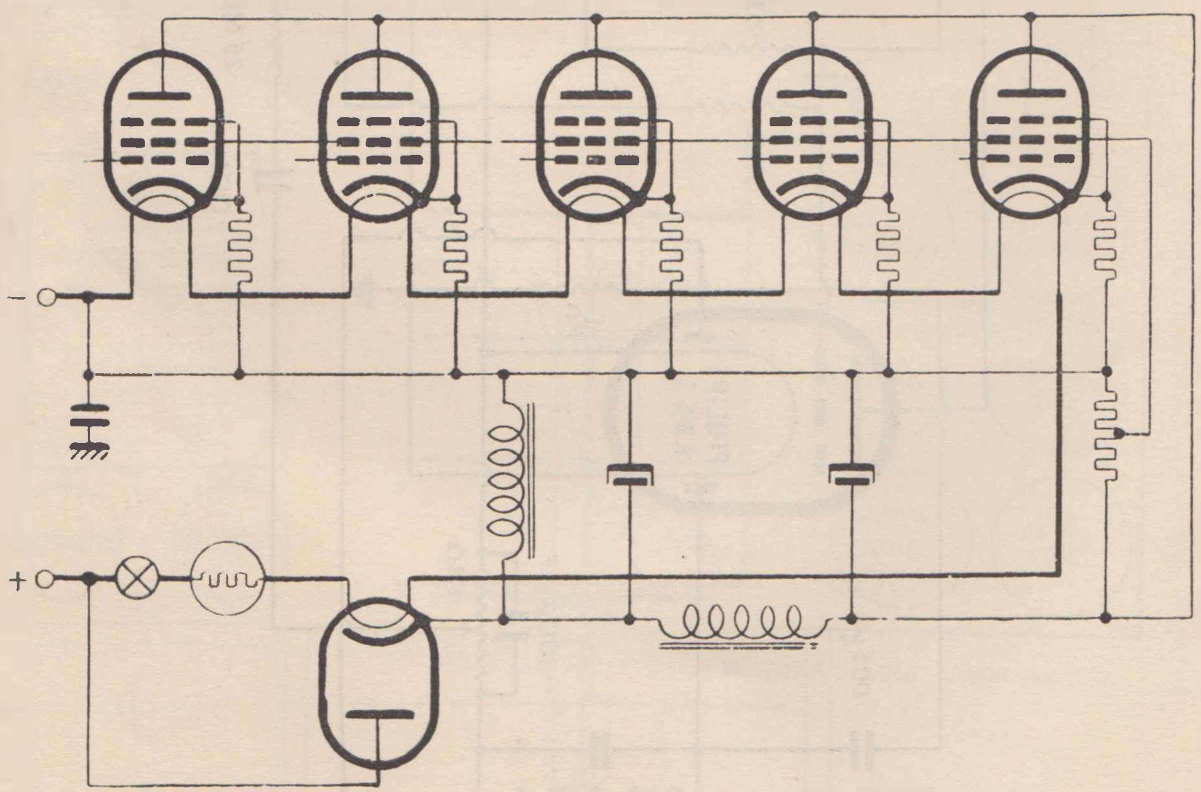


Fig. 1

The arrangements of the other valves depends on the maximum allowable voltage between cathode and filament. For the amplifying valves this voltage limit is 125V., for the power valve 175V. and for the rectifying valve 350V.

In the circuit shown in figure 1 the voltage between the cathode and filament of the rectifier is equal to the sum of the rectified voltage and the total filament voltages of the receiving valves. (A.C. operation only.)

If this voltage exceeds the maximum value of 350V. it is recommended that the rectifier filament be connected before the power valve filament. In such a case the order of the valves would be : amplifying valve, rectifying valve and power valve.

Figure 1 shows the Philips Barretter type C1 connected in series with the valve filaments. : The C1 serves to maintain the filament current substantially at 200 mA. in the event of voltage fluctuations or changes. The regulating range of the type C1 is 80-200 volts, so that when it is, for example, employed with a 5-valve receiver plus rectifier, the set may be used for all mains voltages between 190V. and 265V.

The maximum peak value of the signal voltage applied to the C1 should not exceed 200V., and the D.C. current through the diode load resistor is limited to ·8 mA.

As the D.C. voltage on the diode resistor is equal to the amplitude of the modulated carrier wave, the maximum permissible value of the R.F. signal for any value of diode resistor can be easily calculated. Assuming the modulation depth to be 100%, the maximum Radio frequency A.C. voltage which can be admitted when using, for example, a load resistance of 0·1 megohm will be:

$$\frac{100{,}000 \times 0{\cdot}0008}{\sqrt{2}} = 56 \text{ V. R.M.S.}$$

The peak voltage in this case amounts to:

$$2 \times 56 \times \sqrt{2} = \text{approx. } 160\text{V.}$$

With a diode resistor of ·2 megohm the peak voltage at a current of 0·8 mA. would amount to 320V. This is, of course, beyond the rating of 200V. peak for the valve, and for this and higher values of diode resistor, the maximum signal voltage is limited by the voltage rating and not the current.

Figure 2 shows a typical detection hookup for the CB1, the audio amplifying valve being the type CF1 R.F. Penthode which is in turn followed by the Power Penthode type CL2.

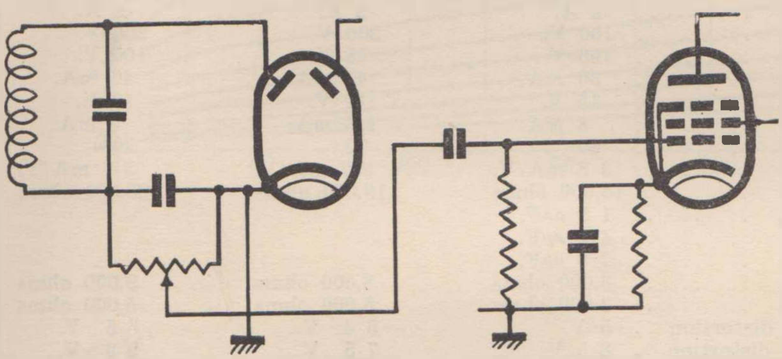


Fig. 2.

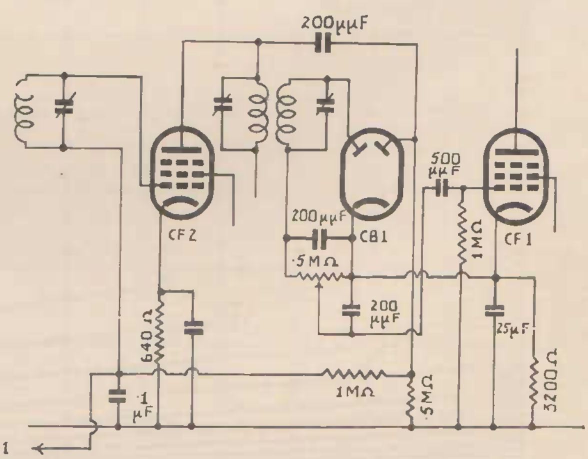


FIG. 3

A delayed A.V.C. action may be obtained from the other diode in the manner suggested in Figure 3.

The cathode of the diode receives a positive bias from the voltage drop in the cathode resistor of the CF1, providing a delay of approx. 2.5 volts. This means that the A.V.C. diode plate has initially a negative potential of 2·5V. with respect to the cathode.

As long as the peak signal voltage on the diode does not exceed this value, the diode will not function, and the set will retain its full sensitivity for weak signals. At the same time, it will be possible to obtain a greater undistorted output from strong signals before the diode takes charge than is the case for simple A.V.C.

The CB1 is equipped with the new type "V" small universal base which has been developed by Philips.

No. 21

PHILIPS 200 mA. A.C./D.C. VALVES
TYPE CL2 POWER PENTHODE

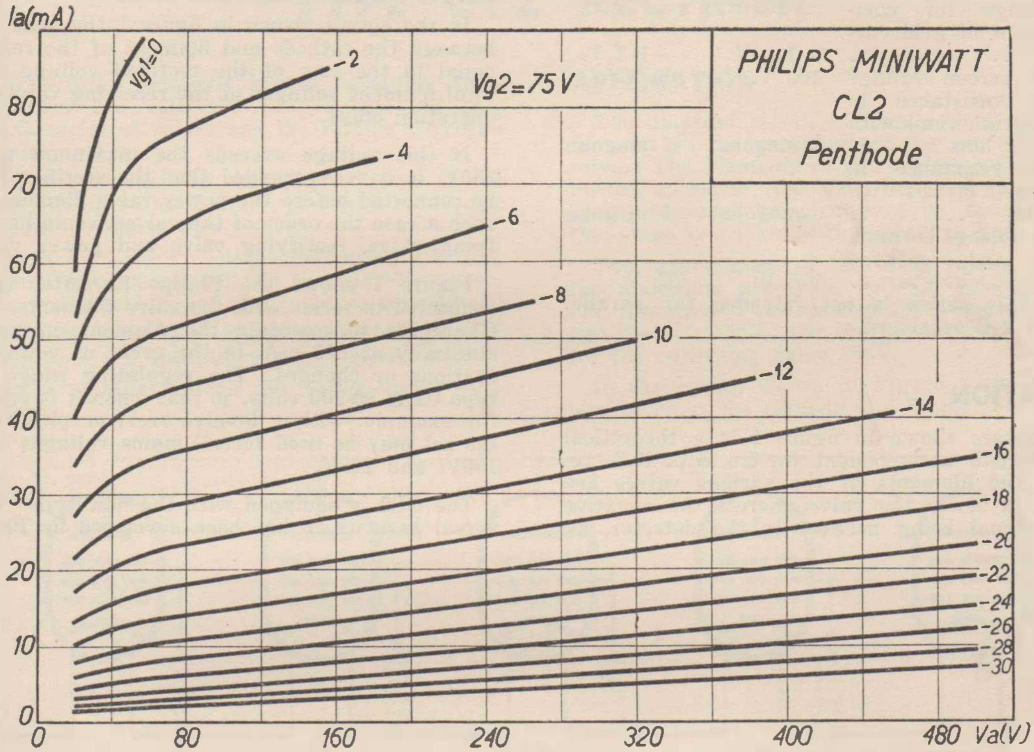
The CL2 is a power penthode designed for use in conjunction with the Philips new 200 mA. A.C./-D.C. series of valves and the Philips Barretter or Iron Hydrogen Regulating Lamp.

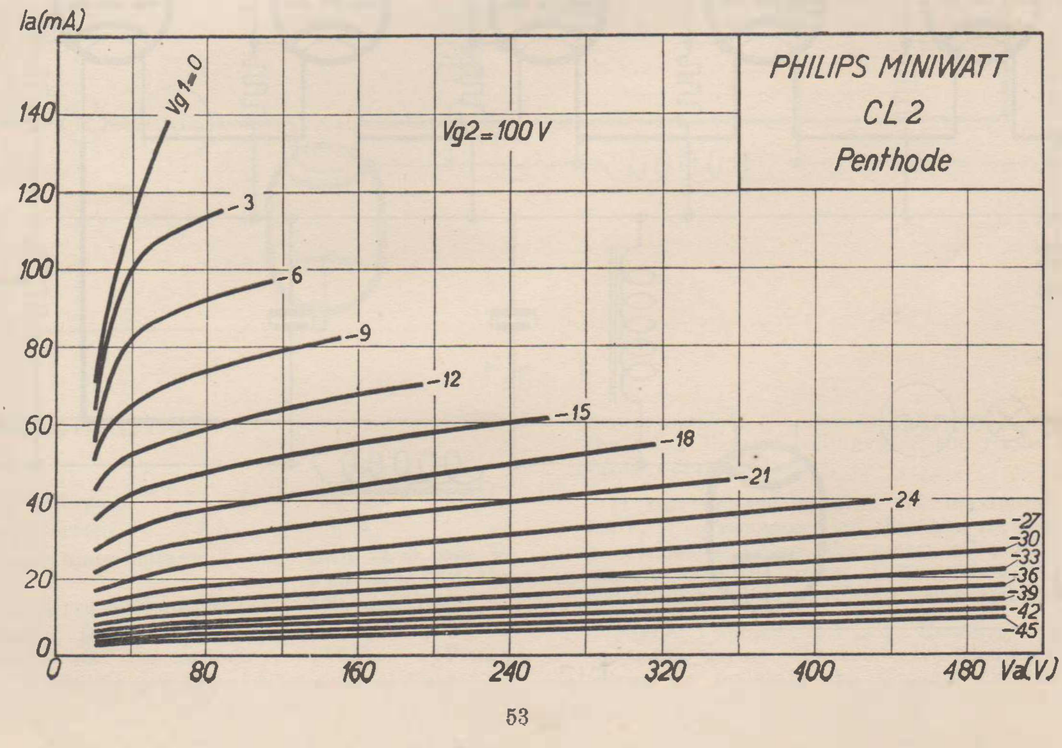
The CL2 has been constructed so that even at a plate potential of 100 volts the output is adequate. The maximum plate and screen voltages for the CL2 are 250V. and 100V. respectively. The maximum plate dissipation for this rating is 8 watts.

CHARACTERISTICS TYPE CL2

Heater voltage	24 V.	24 V.	24 V.
Heater current	·2 A.	·2 A.	·2 A.
Plate voltage	100 V.	200 V.	200 V.
Screen voltage	100 V.	75 V.	100 V.
Plate current	50 mA.	40 mA.	40 mA.
Negative grid bias	15 V.	11 V.	19 V.
Screen current	8 mA.	4·5 mA.	5 mA.
Amplification factor	60	70	70
Mutual conductance (normal)	3·8 mA/V.	3·7 mA/V.	3·1 mA/V.
Plate Impedance	16,000 ohms	19,000 ohms	23,000 ohms
Plate grid capacity	1·2 μμF.		
Plate cathode capacity	4·2 μμF.		
Grid cathode capacity	7·0 μμF.		
Optimum load (5% distortion)	3,000 ohms	8,000 ohms	9,000 ohms
Optimum load (10% distortion)	2,000 ohms	5,000 ohms	5,000 ohms
Effective A.C. grid input for 5% distortion	5 V.	5·4 V.	6·5 V.
Effective A.C. grid input for 10% distortion	8·5 V.	7·5 V.	9·9 V.
Watts output (5% distortion)	·6 W.	1·95 W.	2·0 W.
Watts output (10% distortion)	1·8 W.	3·15 W.	3·55 W.

Base : Philips new type "P" universal base.


Ia(mA)
PHILIPS MINIWATT
CL2
Penthode
Vg2=75V
Vg1=0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
80
70
60
50
40
30
20
10
0
0
80
160
240
320
400
480
Va(V)


Ia(mA)
PHILIPS MINIWATT
CL 2
Penthode
Vg2=100V
Vg1=0
-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
-42
-45
140
120
100
80
60
40
20
0
0
80
160
240
320
400
480
Va(V)

LIMITS

Maximum plate voltage	100 V.	250 V.
Maximum plate dissipation	5 W	8 W.
Maximum cathode current	70 m.A.	70 m.A.
Grid voltage for commencement of grid current	—1·3 V	—1·3 V.
Maximum screen voltage	100 V.	100 V.
Maximum resistance in control grid circuit with automatic bias	1 megohm	·7 megohm
Maximum resistance in control grid circuit with fixed bias	·6 megohm	·3 megohm
Maximum voltage between heater and cathode (Peak)	175 V.	175 V.

Note.—This series is not intended for parallel heating in A.C. receivers.

APPLICATION

The diagram shown in figure 1 is a theoretical filament circuit arrangement for an A.C./D.C. receiver. : The filaments of the various valves are connected in series the valve nearest the negative mains terminal being necessarily the detector, as this stage is critical with respect to hum.

The arrangement of the other valves depends on the maximum allowable voltage between cathode and filament. : For the amplifying valves this voltage limit is 125V., for the power valve 175V. and for the rectifying valve 350V.

In the circuit shown in figure 1 the peak voltage between the cathode and filament of the rectifier is equal to the sum of the rectified voltage and the total filament voltages of the receiving valves. (A.C. operation only).

If this voltage exceeds the maximum value of 350V. it is recommended that the rectifier filament be connected before the power valve filament. : In such a case the order of the valves would be: amplifying valve, rectifying valve and power valve.

Figure 1 shows the Philips Barretter type C1 connected in series with the valve filaments. : The C1 serves to maintain the filament current substantially at 200 mA. in the event of voltage fluctuations or changes. The regulating range of the type C1 is 80-200 volts, so that when it is employed, for example, with a 5-valve receiver plus rectifier. the set may be used for all mains voltages between 190V. and 265V.

The CL2 is equipped with the new type "P" universal base which has been developed by Philips.

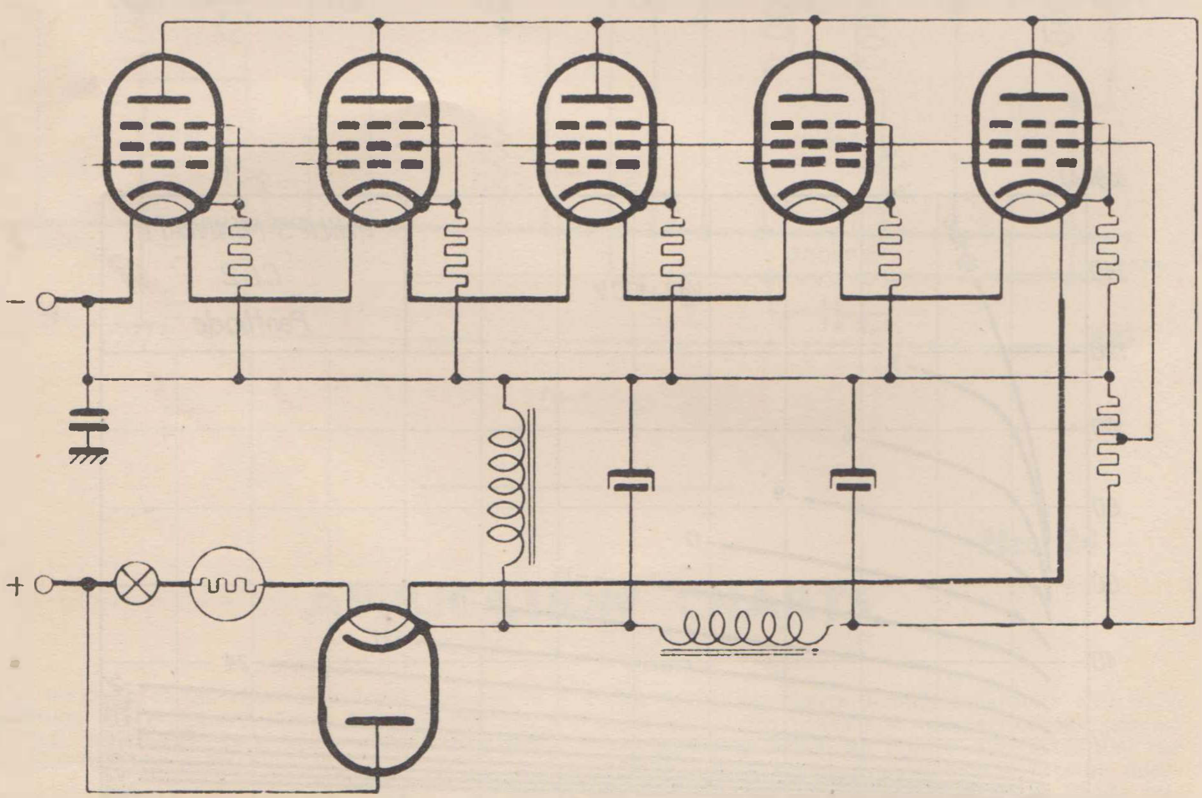


Fig. 1

No. 22

PHILIPS 200 mA. A.C./D.C. VALVES
TYPE CY2 RECTIFIER

The CY2 is an indirectly heated rectifying valve designed for use with the Philips new 250 mA. A.C./D.C. series of valves and the Philips Barretter or Regulating Lamp.

The CY2 contains two separate rectifiers in the one bulb having series heaters, and may be used in the following applications:—

1. As a half wave rectifier delivering 120 mA. (In this arrangement the two plates are connected together, and the cathodes are joined.)
2. Full wave rectifier—the cathodes being joined together and the plates used separately.
3. As a voltage doubler for lower mains voltages.

APPLICATION

The diagram shown in Figure 1 is a theoretical filament circuit arrangement for an A.C./D.C. receiver: The filaments of the various valves are connected in series, the valve nearest the negative mains terminal being necessarily the detector, as this stage is critical with respect to hum.

The arrangement of the other valves depends on the maximum allowable voltage between cathode and filament: For the amplifying valves this voltage limit is 125V., for the power valve 175V., and for the rectifying valve 350V.

In the circuit shown in Figure 1 the peak voltage between the cathode and filament of the rectifier is equal to the sum of the rectified voltage and the total filament voltages of the receiving valves (A.C. operation only).

If this voltage exceeds the maximum value of 350V. it is recommended that the rectifier filament be connected before the power-valve filament: In such a case the order of the valves would be:— amplifying valve, rectifying valve and power valve.

Figure 1 shows the Philips Barretter type C1 connected in series with the valve filaments. The C1 serves to maintain the filament current substan-

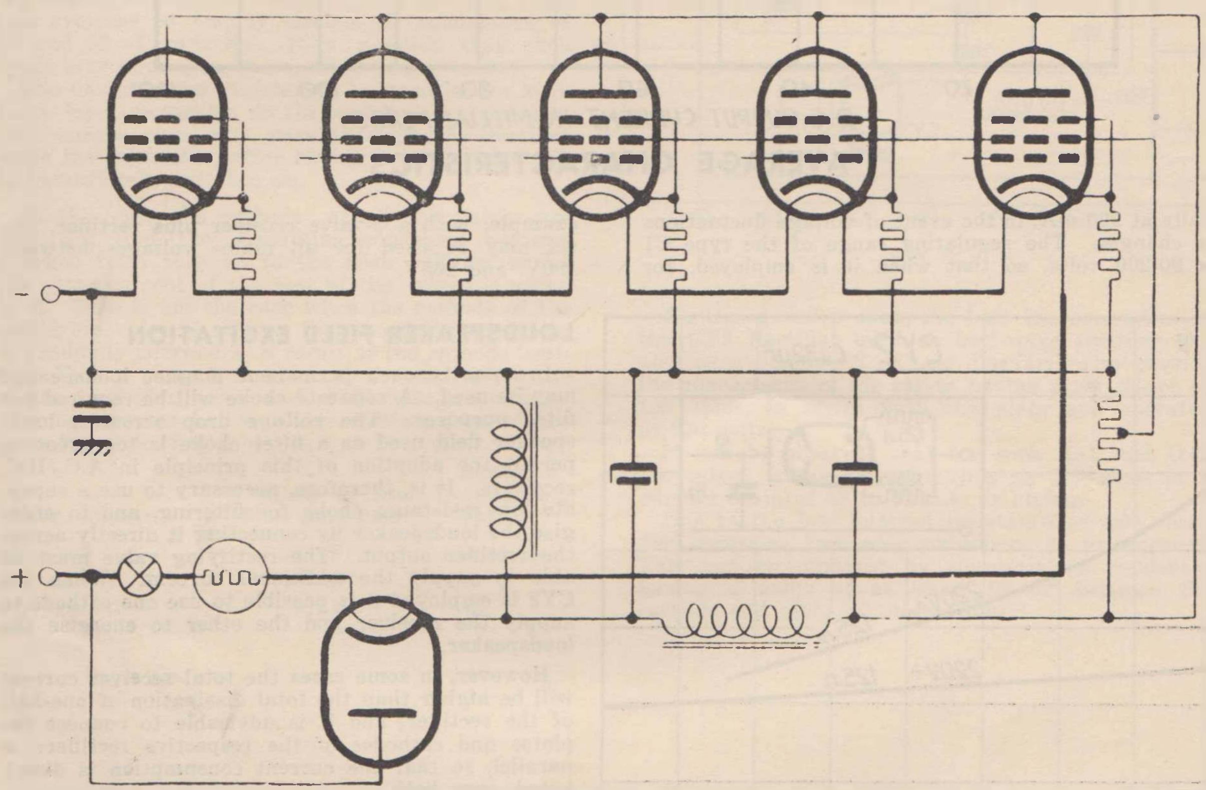
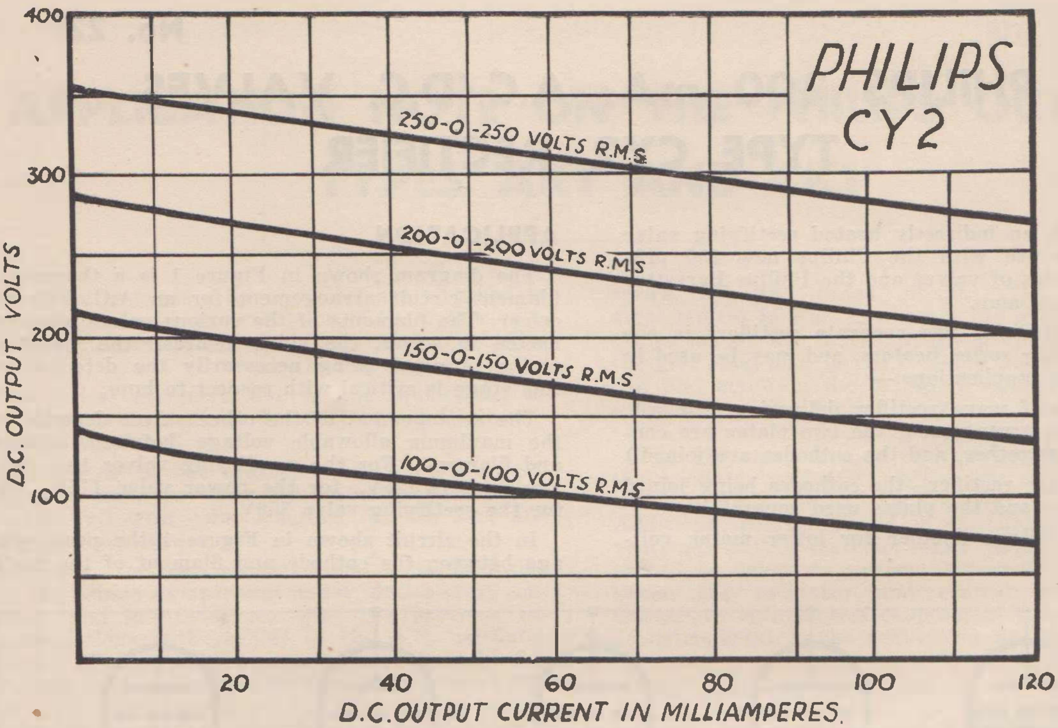


Fig. 1

CHARACTERISTICS

	CY2
Heater voltage	30 V.
Heater Current	·2 A.
Maximum plate voltage	Half-wave 250 V. Full-wave 125 V.
Maximum rectified output ..	120 mA. (D.C.).
Maximum D.C. voltage between heater and cathode ..	350 V. (Peak)

Base : Philips new type "P" universal Base.



AVERAGE CHARACTERISTICS

tially at 200 mA. in the event of voltage fluctuations or changes. The regulating range of the type C1 is 80-200 volts, so that when it is employed, for example, with a 5-valve receiver plus rectifier, the set may be used for all mains voltages between 190V. and 265V.

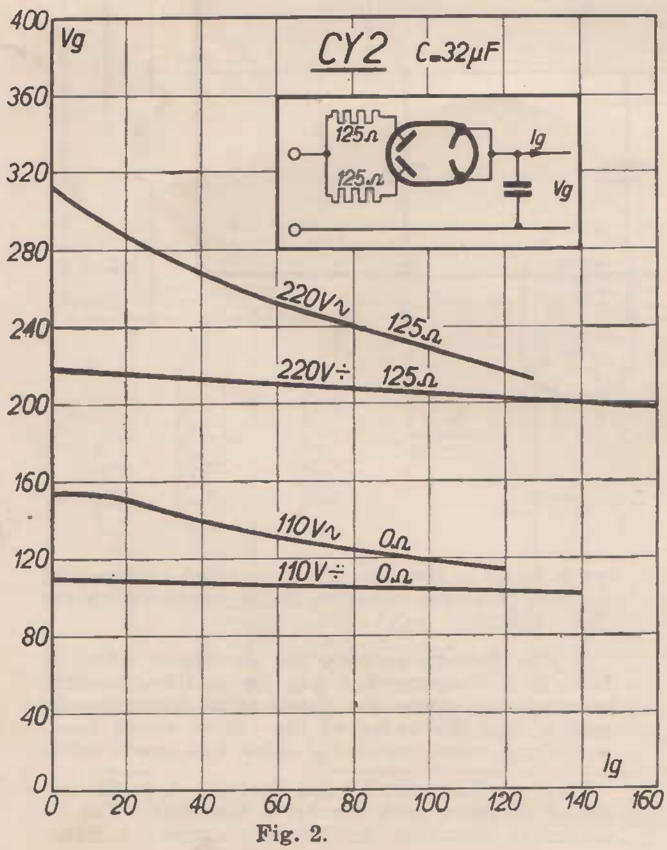


Fig. 2.

LOUDSPEAKER FIELD EXCITATION

In some cases a permanent magnet loudspeaker may be used. A separate choke will be required for filter purposes. The voltage drop across a loudspeaker field used as a filter choke is too great to permit the adoption of this principle in A.C./D.C. receivers. It is, therefore, necessary to use a separate low resistance choke for filtering, and to energise the loudspeaker by connecting it directly across the rectifier output. The rectifying valve must be able to supply the additional current. When the CY2 is employed it is possible to use one cathode to supply the receiver and the other to energise the loudspeaker.

However, in some cases the total receiver current will be higher than the total dissipation of one-half of the rectifier, and it is advisable to connect the plates and cathodes of the respective rectifiers in parallel, so that the current consumption is distributed over both.

A.C. VERSUS D.C.

One of the problems associated with the design of A.C./D.C. receivers arises from the fact that the available plate voltage is much higher when using A.C. than is the case when D.C. mains are employed. The difference in the voltage delivered depends on the current drain on the rectifier and also on the capacity of the condenser connected across the filter input.

For example, given a mains voltage of 220V. A.C., the actual peak voltage is 220 x $\sqrt{2} = 310$V. Thus, during each positive half-cycle the smoothing condenser is charged to this peak value less the drop across the rectifying valve. Due to the discharge of the condenser during the negative half-cycle this voltage drops until the new positive half-cycle re-charges the condenser. The resultant mean voltage is considerably higher than is the case for 220V. D.C.

If the internal resistance of the valve were high, the maximum value of the re-charging voltage would be considerably reduced as a result of the voltage drop, so that the rectified voltage would adjust itself to a much lower value.

The rectifying valves for A.C./D.C. however, are designed to have a very low internal resistance in order that a maximum plate voltage may be obtained from the low voltage mains. For this reason it is advisable to include a resistance in series with the rectifier plates when operating on comparatively high mains voltages, particularly when a large capacity filter input condenser is employed.

For D.C. this resistance gives a much lower voltage drop since the plate current flows evenly and the charging current impulses for the condenser are eliminated.

To obtain better filtering, particularly when using chokes of small dimensions, it is common practice overseas to employ electrolytic condensers of 16 and 32 μF capacity. It is possible that such types may appear on this market in due course.

The use of series resistances is essential for such large input capacities as the resistors restrict current surges that may pass through the rectifier when the apparatus, after having been switched off, is immediately switched on.

In this case the cathodes of all the valves are still hot and the smoothing condenser becomes charged from zero up to the peak voltage, whilst the plate current of the rest of the valves is added to it. This is not the case when the cathode of the rectifying valve is cold as the smoothing condenser is gradually charged as a result of the cathode heating. Violent current surges may jeopardise the life of the rectifying valve and resistances must therefore be inserted in the plate circuit in accordance with the following table:—

Mains voltage.		Capacity of first filter condenser.	Series Resistance Value.
170—250 V.	..	32 μF	125 ohms.
170—250 V.	..	16 μF	75 „
170—250 V	..	8 μF	0 „

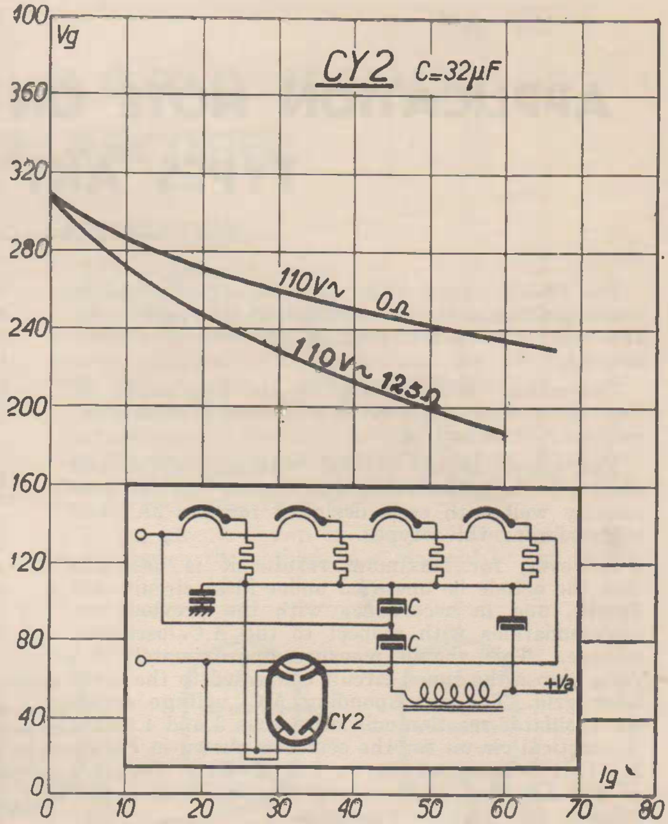


Fig. 3.

Figures 2 and 3 show the load characteristics of the CY2 Rectifier used as half-wave rectifier and also as a "doubler." These diagrams also provide the characteristics for valves having a resistance of 125 ohms, in series with the plate and operated at 220 volts.

It will be observed that for both A.C. and D.C. the output voltage is approximately the same at a current drain of 60 to 70 mA. or higher.

Due to the low internal resistance of this rectifier, excessive hum may sometimes be experienced. This can be obviated by connecting a condenser having a value of at least ·01 μF between the cathode and plate of the rectifier.

No. 23

APPLICATION NOTE ON THE PHILIPS OCTODE TYPES AK1 AND CK1

The Philips types AK1 and CK1 are identical in characteristics with the exception of the heater voltage and current, and may be operated in similar circuits.

Theoretical considerations in the application of the valves were dealt with in Technical Communications Nos. 8 and 18.

The octode is not critical with respect to coil design, in fact, the valve will usually operate reasonably well with coils designed for the 2A7 and other similar valve types.

However, for maximum results it is desirable that the octode be operated under ideal circuit conditions, and in accordance with the previous recommendations with respect to the A.C. oscillator voltage. This should measure approximately 8·5 volts across the tuned circuit connected to the oscillator grid. The corresponding A.C. voltage across the oscillator reaction coil is between 3 and 4 volts.; A practical circuit for the octode is shown in Figure 1. This is designed for an intermediate frequency of 175 K.C. and is therefore provided with a preselector for image suppression.

In the original theoretical circuit (see Tech. Comm. No. 8) the oscillator grid leak was connected in series with the tuned circuit. The alternative arrangement in Fig. 1, wherein the gridleak is connected across the tuned circuit, is recommended, as the grid leak, also serves to damp the oscillator circuit and maintain the oscillator voltage reasonably constant over the tuning range.

The 320 ohm. cathode resistor provides bias for the oscillator grid (G1) and at the same time furnishes a minimum bias for the control grid (G4). : Additional control of G4 is accomplished by conventional A.V.C. methods.—The usual precautions should be taken to prevent external coupling between the oscillator and control grid circuits. Capacitive or inductive coupling of this nature will be detrimental to the conversion conductance.

The connecting wire between the plate of the Octode and the "hot" end of the I.F. Transformer should be carefully arranged to avoid coupling with the oscillator circuit or its associated components such as the padder. Coupling of this nature will be responsible for the production of whistles, etc. It may be advisable in some cases to screen this lead but to avoid damping it is essential that the braiding be of low capacity.

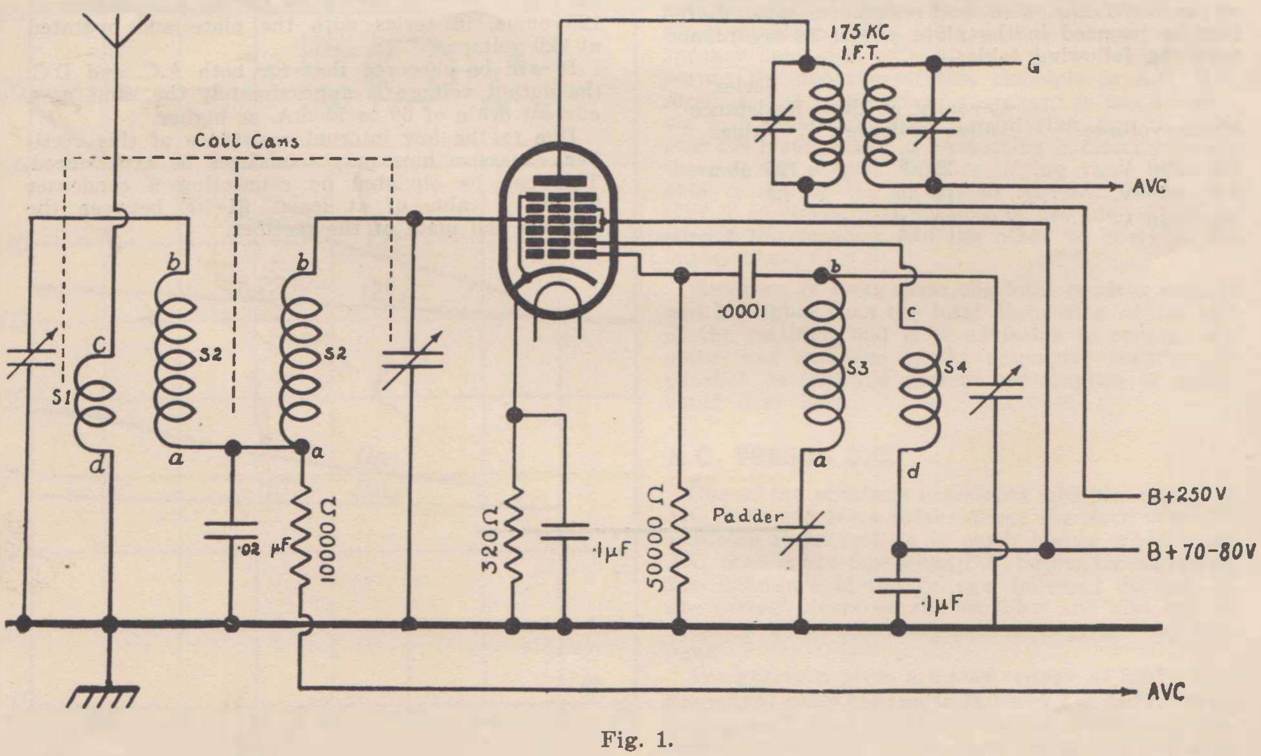


Fig. 1.

The lead to the control grid (G4) on top of the bulb should be as short as possible, and if this lead is screened to avoid direct pickup at signal frequencies, it is again necessary to employ low capacity braiding.

Suitable coils for the circuit are illustrated in Fig. 2. These coil specifications are subject to modification depending on the tuning condensers employed and local chassis conditions, and are merely indicated as a guide. Coil S1 is a bobbin type aerial coupling coil.

Coils S2 consist of 135 turns of 30 S.W.G. enamel wire.

Coil S3 consists of 100 turns of 30 S.W.G. enamel wire.

Coil S4 consists of 25 turns of 30 S.W.G. enamel wire.

Tuning condenser capacity, 18 to 385 μμF.

For initial adjustments of the oscillator voltage, it is recommended that the coil S4 be wound on a paper tube to permit the sliding of the winding over the oscillator tuned winding.

If a vacuum tube voltmeter is not available for measurement of the oscillator voltage, this may be conveniently determined by measuring the direct current flowing in the 50,000 ohm. grid leak. An 0—1 milliameter or a micro-ammeter may be connected between the bottom of this resistor and earth, and a direct current of 190 microamperes or approximately ·2 milliamperes corresponds to an amplitude of 8 volts in the oscillator circuit. : If necessary, the number of turns on the reaction winding may be altered to obtain the desired result.

SHORT-WAVE RECEPTION

As mentioned in our previous communication, the frequency displacement of the oscillator circuit when the control grid bias is varied for volume control purposes, is negligible on normal broadcast frequencies.

However, on short waves in the neighbourhood of 20 metres this frequency displacement may amount to several thousand cycles, and some means of compensation is recommended. For this purpose the modified circuit arrangement of Fig. 3 may be employed to advantage. In this circuit the return of the intermediate transformer primary is taken through portion of the oscillator reaction winding to the high voltage supply. The value of the grid condenser has also been reduced.

A separate feed resistance is provided for the anode grid (G2) and for the screen grid (G3 and 5). : If the control grid (G4) is biased negatively, the plate current decreases and at the same time the screen current (G3 and 5) increases. : Thus a measure of compensation is effected, and not only does the oscillator voltage remain substantially constant, but also the frequency. The various values for the circuit are indicated. At a wavelength of 20 metres the acual frequency displacement was only 1400 cycles when the control grid was biased from —1·5 to —15 volts.

A practical hookup for Broadcast and Shortwave reception incorporating the abovementioned principle is shown in Fig. 4. For simplicity only one shortwave band is included. An optional preselector is used for the broadcast band, but this is dispensed with for short wave. : The shortwave grid coil S3 is accommodated in a separate coil can. The short-

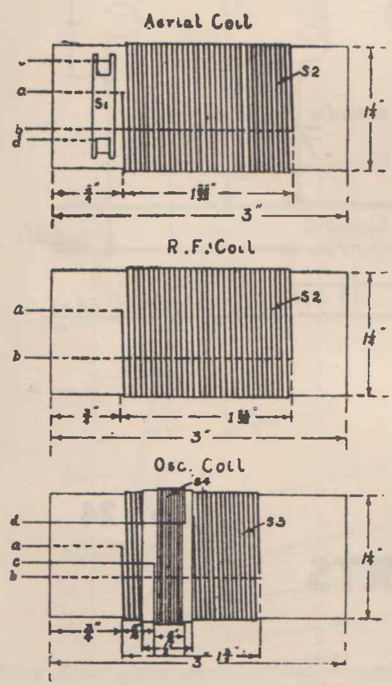


Fig. 2

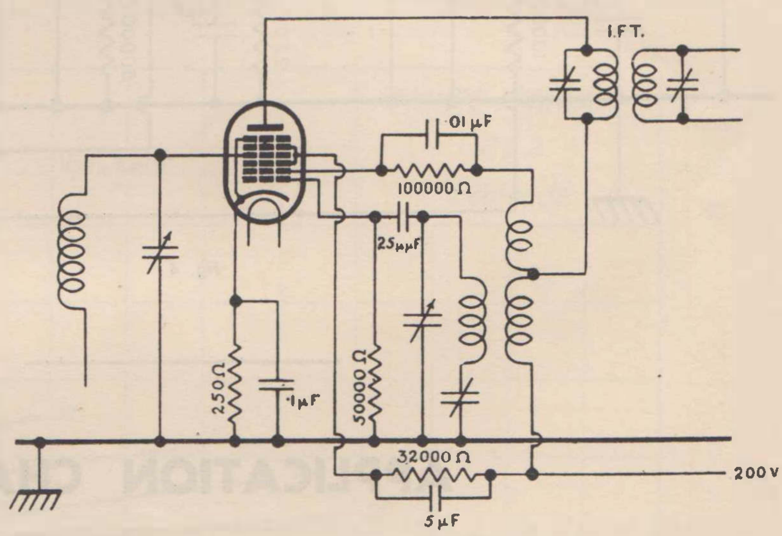


Fig. 3

wave tuned oscillator winding S6, together with the reaction windings S9 and S10, which are wound concentrically with same, are also isolated in a separate can. The switching arrangement provides for the entire disconnection of S6 when receiving on the broadcast band, as otherwise the stray capacity will be excessive. The grid coil S3 is left in circuit and will not create difficulty.

The design of the broadcast band coils S1, S4 and S7 will, with suitable modifications for the intermediate frequency employed, be constructed in accordance with the previous recommendations.

The key to the switch positions is as follows:—

Broadcast Band.

Switches 1 and 5 closed.
Switch 2, 3, 4 and 6 open.

Shortwave Band.

Switches 2, 3, 4 and 6 closed.
Switches 1 and 5 open.

Note.—If required, additional R.F. stages may be added for shortwave reception.

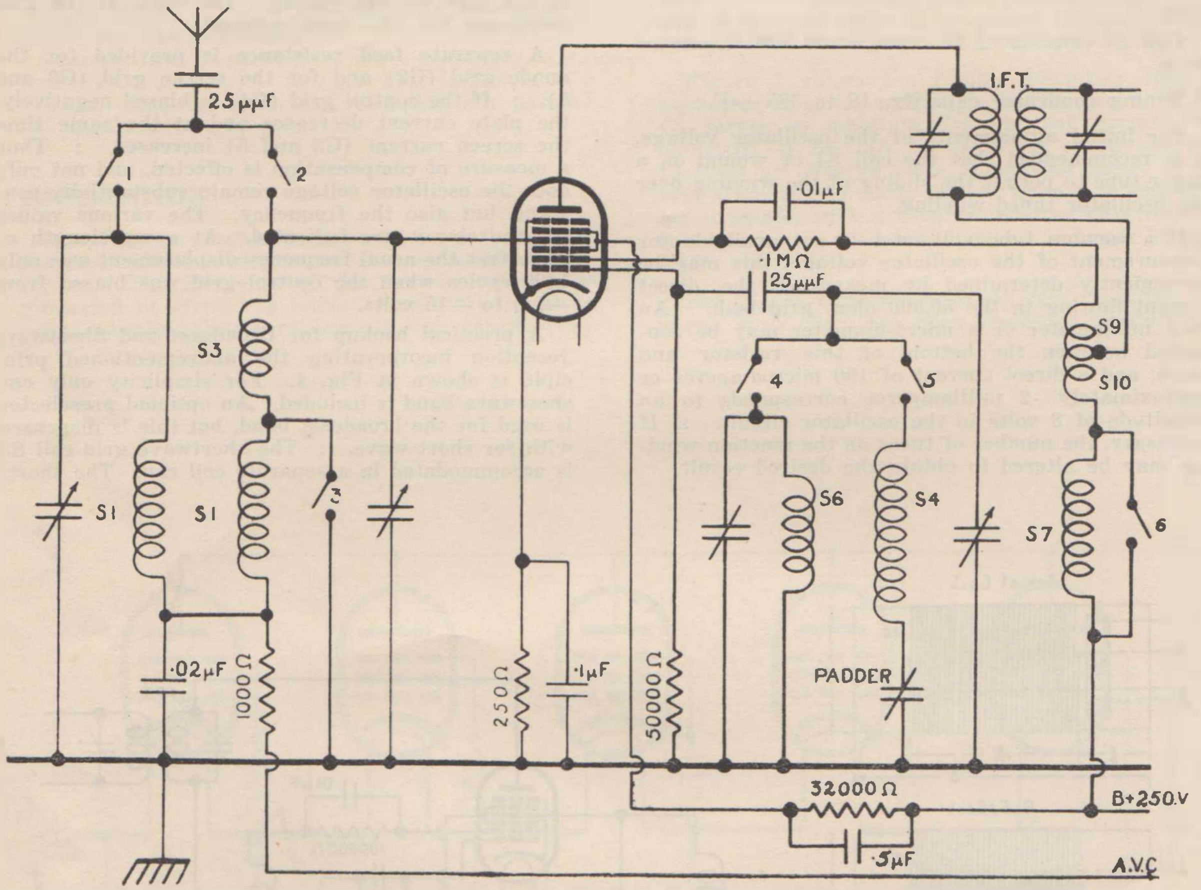


Fig. 4

No. 24

APPLICATION CHARTS

The majority of the new valve types included in the Philips 2-volt battery, 4-volt A.C. and 200 mA. A.C./D.C. series have been dealt with in this service from time to time.

As a guide to the technician in determining the application of the respective valve types, we provide hereunder charts dealing separately with each series. : For convenient comparison the nearest corresponding American type is also listed and the technical data already issued on the type in question can be readily located by referring to the column indicating the Technical Communication number.

APPLICATION CHART—PHILIPS BATTERY VALVES

Purpose	Valve construction	Philips New 2V Type	Described in Tech. No.	Nearest American Type
Variable Mu R.F. Amplifier	Penthode Screen Grid	KF2 B255	12 3	34 —
Frequency Changer (1st Detector)	Penthode Screen Grid OCTODE	KF1 B262 KK2	12 3 —	— 32 1C6
Variable Mu Intermediate Frequency Amplifier	Penthode Screen Grid	KF2 B255	12 3	34 —
Demodulator (2nd Detector)	Penthode Screen Grid Triode Duo Diode-Triode	KF1 B262 B217 KBC1	12 3 3 10 & 19	— 32 30 —
"Class B" Driver Audio Amplifier, also separate oscillator	Triode	B217	3	30
"Class B" Power	Twin Triode	B240	3	19
"Class A" Output	Penthode	C243N	14	33

Note.—The American types mentioned are not necessarily interchangeable with the Philips 2-volt Battery Types and are only indicated as a guide to the application of the various types.

APPLICATION CHART—PHILIPS 4-VOLT A.C. VALVES.

Purpose	Valve construction	Philips new 4v. Type	Described in Tech. No.	Nearest American Type
Variable Mu R.F. Amplifier	Penthode Penthode	E447 AF2	1 11	58 —
Frequency Changer (1st Detector)	R.F. Penthode OCTODE	E446 AK1	1 & 4 8 & 23	57 2A7
Variable Mu Intermediate Frequency Amplifier	R.F. Penthode Penthode	E447 AF2	1 11	58 —
Demodulator (2nd Detector)	Penthode Diode-Tetrode Diode-Triode	E446 E444 E454	1 2 6	57 2B7 2A6
"Class A" Output.	Penthode Penthode Triode	E443H E463 E406	7 7 —	247 2A5 245
Audio Amplifier, also separate oscillator	Triode	E424N	—	56
Rectifiers	Full-wave Full-wave (Indirectly Heated)	1561 1867	— 7	80 —

Note.—The American types mentioned above are not interchangeable with the Philips 4-volt A.C. series and are only indicated as a guide to the application of the various types.

APPLICATION CHART —PHILIPS 200 mA A.C./D.C. VALVES

Purpose	Valve construction	Philips New 200 mA AC/DC Type	Described in Tech. No.	Nearest American Type
Variable Mu R.F. Amplifier	Penthode	CF2	17	6D6
Frequency Changer (1st Detector)	OCTODE	CK1	18	6A7
Variable Mu Intermediate Frequency Amplifier	Penthode	CF2	17	6D6
Demodulator (2nd Detector)	Separate Duo Diode Penthode	CB1 CF1	20 16	— 6C6
Audio Amplifier	Penthode Triode	CF1 CC1	16 —	6C6 76
"Class A" Output	Penthode	CL2	21	43
Rectifier	Half-wave, full-wave or doubler	CY2	22	25Z5
Barretter	Iron Hydrogen Resistance Lamp	C1	—	—

Note. — The American types mentioned are not interchangeable with the Philips 200 mA A.C./D.C. series and are only indicated as a guide to the application of the various types.

No. 25

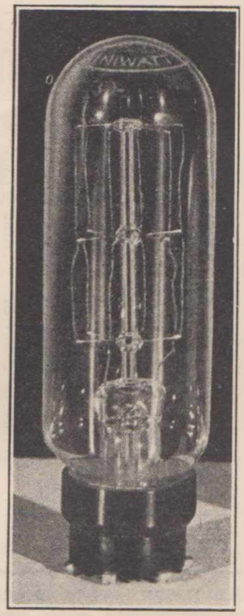
PHILIPS 200 mA. A.C./D.C. SERIES BARRETTER TYPE C1

The type C1 is an Iron Hydrogen resistance lamp designed for continuous filament current regulation in A.C./D.C. receivers employing the Philips 200 mA. series of valves and is fitted with the Philips type "P" universal base.

The Barretter replaces entirely the usual series filament resistor, and the filament current remains substantially constant over remarkably wide mains voltage variations.

The regulating range of the C1 is from 80 to 200 volts. Where the voltage drop across the filaments of all the valves is at least 50 volts, the C1 may be used on mains voltages up to 250 volts. Furthermore, when the filament voltage drop is 70 volts the maximum permissible mains voltage is 265. It is, therefore, possible to apply the C1 in the following combinations:—

	Total filament voltage drop	Permissible mains voltage application
2 valve receiver plus rectifier	63 V.	143–260 V.
3 valve receiver plus rectifier	76 V.	156–265 V.
4 valve receiver plus rectifier	89 V.	169–265 V.
5 valve receiver plus rectifier	102 V.	182–265 V.



No. 26

A 4/5 SUPERHETERODYNE RECEIVER FOR A.C. OPERATION

VALVE EQUIPMENT

Autodyne Frequency Changer	E446 R.F. Penthode
Intermediate Frequency Amplifier	E447 R.F. Penthode
Detector Amplifier	E444 Diode Tetrode
Power Amplifier	E443H Penthode
Rectifier	1561

This receiver has been designed to take advantage of the superior characteristics of Philips new R.F. Penthodes, and features extreme sensitivity coupled with excellent tone quality.

A value of 175 K.C. was selected for the Intermediate Frequency and the set was accordingly provided with a pre-selector for image suppression. A suitable circuit is shown in Fig. 1 which is similar to that used in the Model A Radioplayer.

The E446 is employed as an "autodyne" frequency changer in the arrangement described in Technical Communication No. 4. The balancing condenser C5 serves to neutralize the input capacity of the E446 and thus obviates the normal tendency of the autodyne to cease oscillation at the higher frequency end of the tuning spectrum. The condenser C5 is a small padder type unit of 25 $\mu\mu$F maximum capacity. To minimise stray capacity and direct pick-up C5 should be mounted directly on the grid terminal of the E446.

The E447 variable mu R.F. Penthode is incorporated as a high gain I.F. amplifier and the bias of this valve is varied for volume control purposes. The 2500 ohm potentiometer used to vary the bias also controls the input in the aerial circuit.

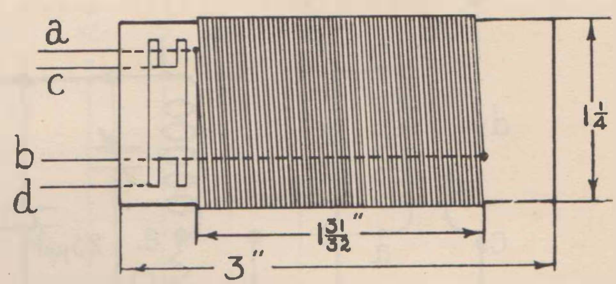
Diode detection is accomplished on the diode portion of the Philips E444 Diode Tetrode, and the tetrode serves for audio amplification. The screen voltage of the E444 should be adjusted to approximately 35 volts for best results.

An E443H power penthode delivers adequate output in the final power stage and the 1561 is used for rectification.

Suitable coils for this circuit are illustrated herewith together with a "close up" of the associated circuit. These coil specifications are subject to modification depending on the tuning condensers employed and local chassis conditions.

The aerial and preselector coils "A" and "B" are identical and consist of 135 turns of 30 S.W.G. enamelled wire wound on a 1¼ inch former. A bobbin type primary coil "A" provides the aerial coupling. Coil "C" is the oscillator coil and is wound with 100 turns of 30 S.W.G. enamelled wire on a 1¼ inch former tapped in the centre for connection to the I.F. Transformer trimming condenser. The cathode and neutralising coils are a continuous winding of 12 turns of 42 S.W.G. D.S.C. wire wound over the 100 turn coil just above the centre tap of same. The tap "f" is taken at the sixth turn. The latter coil may be mounted on a sliding cardboard former for the initial adjustments.

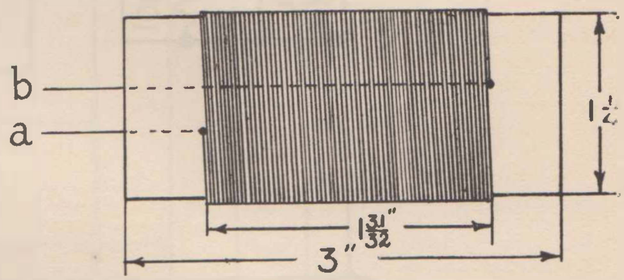
"A"



ADJUSTMENT OF CIRCUITS

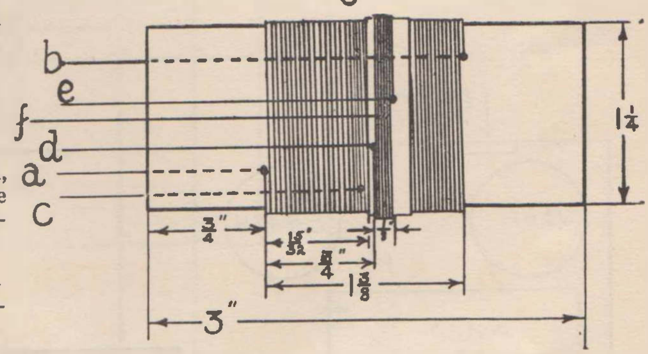
The I.F. circuits should first be aligned to 175 K.C. The next adjustment should consist of neutralizing the input capacity of the E446. The best procedure is to short circuit the grid tuning condenser and adjust the position of the sliding cathode and neutralizing coils until an oscillator heterodyne voltage of approximately 1 volt is obtained between the cathode and chassis over the entire waveband. (Measured with a vacuum tube voltmeter.)

"B"



If difficulty is experienced in obtaining approximately 1 volt evenly over the band it may be necessary to connect a damping resistance of ·25 megohm across the oscillator tuning condenser C3 (not including the padder). If the short on the grid tuning condenser is now removed and the receiver tuned to 200 metres the oscillator heterodyne voltage between cathode and chassis will probably drop to zero. The neutralizing condenser C5 is then adjusted until the normal heterodyne voltage is restored in the cathode circuit. After this the gang trimmers and padding condenser can be adjusted in the conventional manner.

"C"

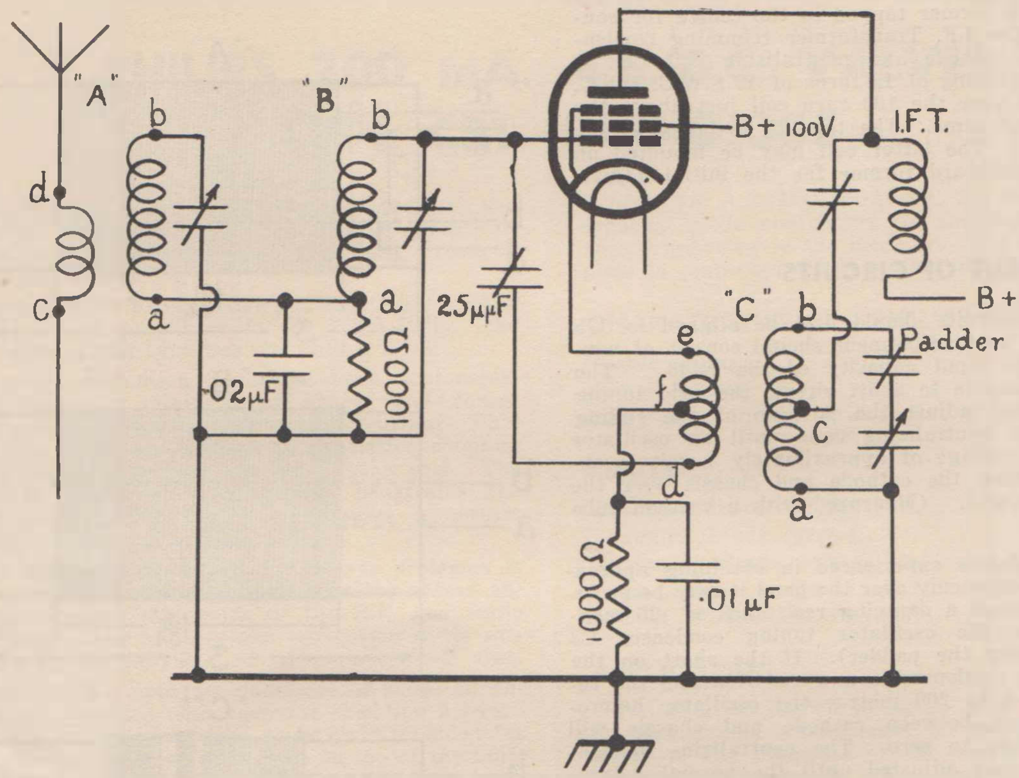


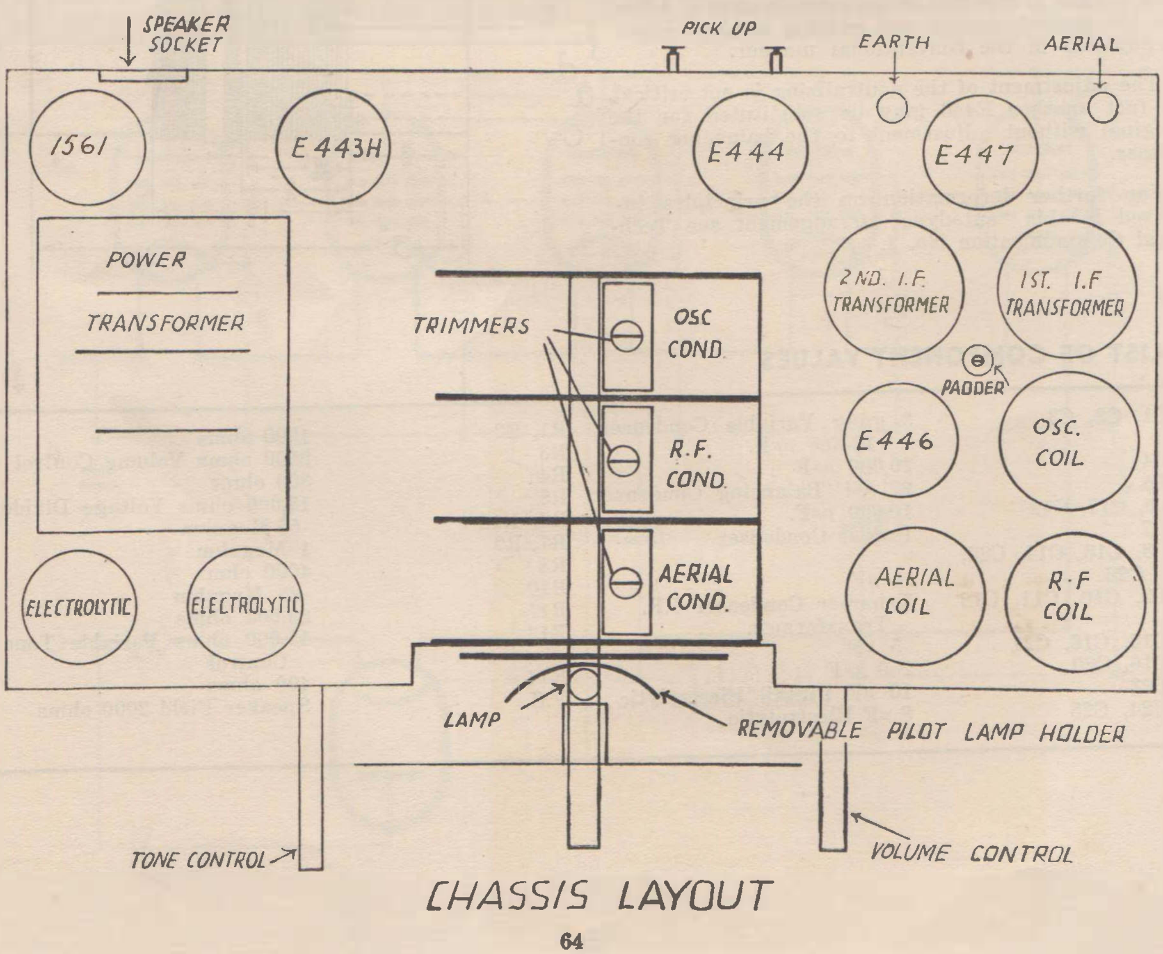
The adjustment of the neutralizing is not critical, in fact another E446 may be substituted for the original without adjustment to the balancing condenser.

For further information on the principles involved in this "autodyne" arrangement see Technical Communication No. 4.

LIST OF COMPONENT VALUES

C1, C2, C3	3 gang Variable Condenser, 18-385 μμF.	R1, R2	1000 ohms
C4	20,000 μμF	R3	2500 ohms Volume Control
C5	27 μμF Balancing Condenser	R4	300 ohms
C6, C17, C19	10,000 μμF.	R5	15,000 ohms Voltage Divider
C7	Padder Condenser	R6, R12	·5 Megohm
C8, C13, C14, C22, C26	·1 μF	R7, R9	1 Megohm
C9, C10, C11, C12	Trimmer Condenser I.F. Transformer.	R8	4000 ohms
C15, C18, C21	·5 μF	R10	·25 Megohm
C16, C20	250 μμF	R11	25,000 ohms
C23	10 μF Pigtail Electrolytic	R13	15,000 ohms Variable Tone Control
C24, C25	8 μF Electrolytic	R14	400 ohms
		F.C.	Speaker Field 2000 ohms





CHASSIS LAYOUT

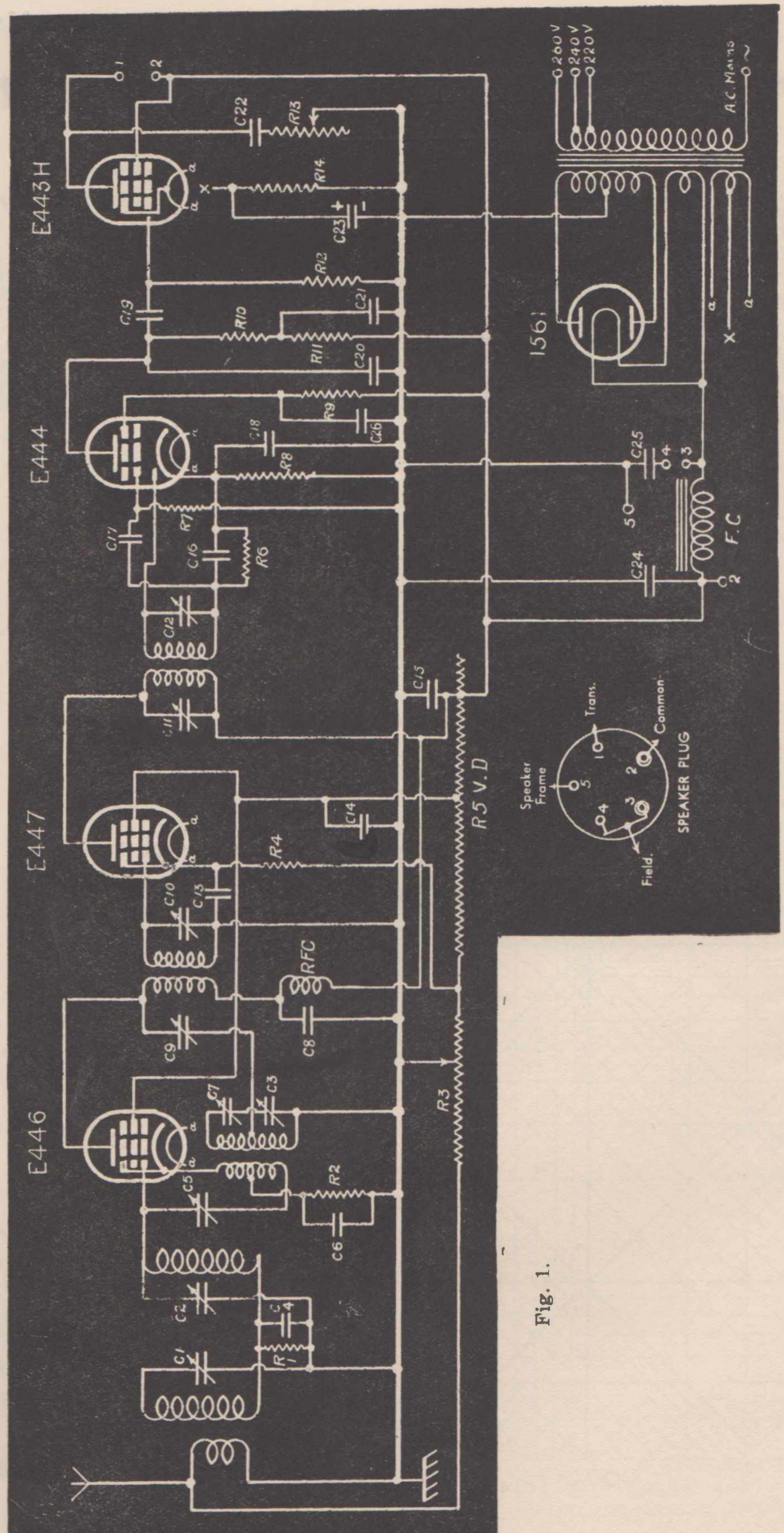

E443H
E444
E447
E446
1561
R5 V.D
F.C
SPEAKER PLUG
Speaker Frame
Trans.
Common
Field.
RFC
A.C. Mains
260 V
240 V
220 V

Fig. 1.

No. 27

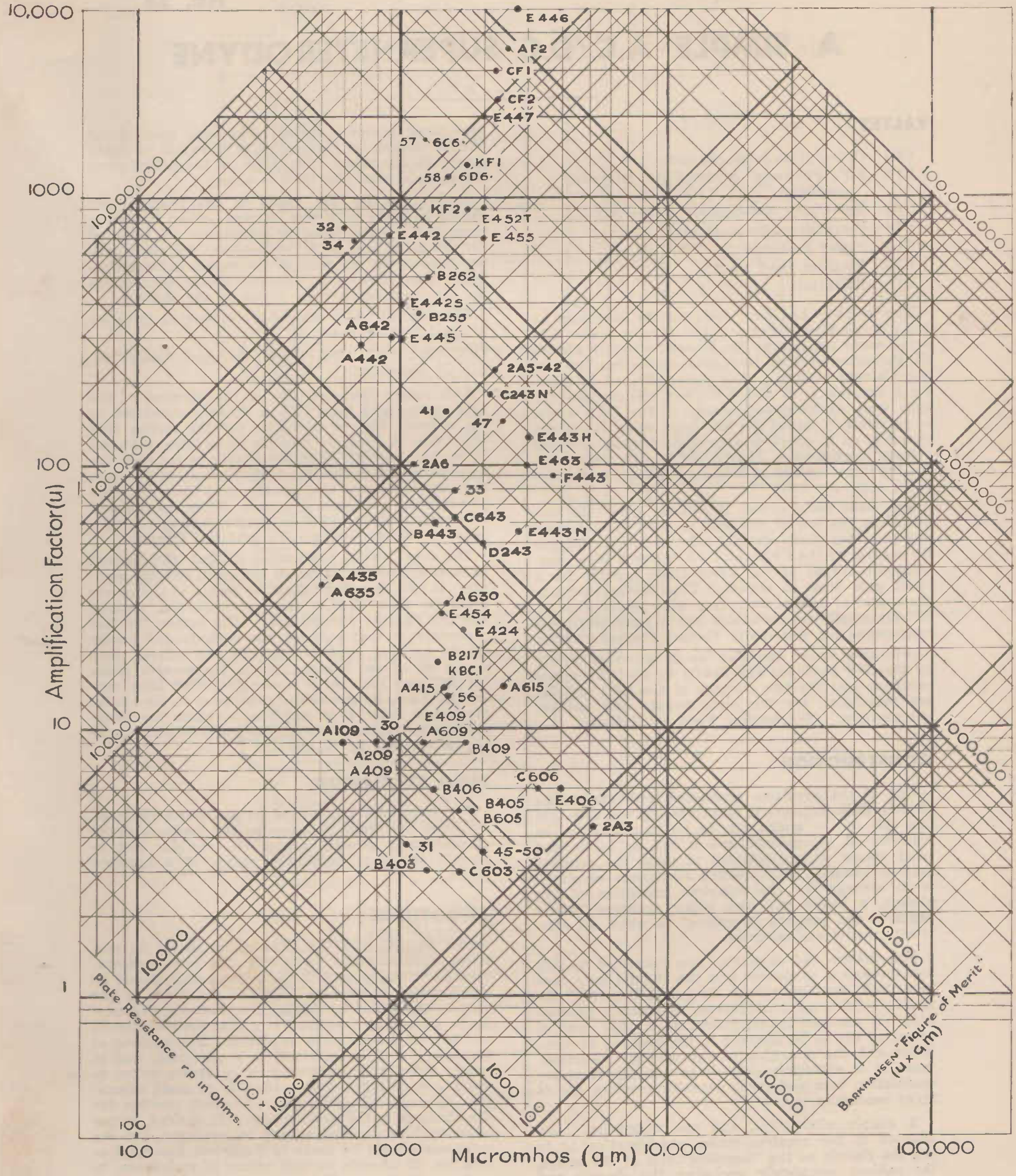
THE BARKHAUSEN "FIGURE OF MERIT"

In the May, 1934, issue of "Electronics," an extremely interesting chart was published based on a system of European origin and classifying various American valve types.

The respective valves are plotted as a single point on the chart and from the various logarithmic coordinates may be obtained direct reference to amplification factor, plate resistance, mutual conductance and finally the Barkhausen "Figure of Merit" under rated conditions. This latter quantity is defined as "a measure of the merit of the tube as a voltage amplifier in connection with a tuned transformer. In general it characterises the effectiveness of the tube for a number of common applications."

The "Figure of Merit" is calculated for individual tube types by multiplying the amplification factor by the mutual conductance in micromhos.

This system of valve classification affords an excellent graphical means of comparison, and the chart furnished herewith demonstrates in no uncertain manner the superiority of the Philips European types.


10,000
1000
100
10
1
Amplification Factor (u)
Micromhos (g m)
100
1000
10,000
100,000
10,000,000
1,000,000
100,000
10,000
100,000,000
10,000,000
1,000,000
100,000
Plate Resistance rp in Ohms.
100
1000
10,000
Barkhausen "Figure of Merit" (u x G m)
E 446
AF2
CF1
CF2
E447
57
6C6
KF1
58
6D6
KF2
E452T
32
34
E442
E 455
B262
E442S
B255
A642
E445
A442
2A5-42
C243N
41
47
E443H
2A6
E463
F443
33
C643
B443
E443N
D243
A435
A635
A630
E454
E424
B217
KBC1
A415
A615
56
E409
A109
30
A609
B409
A209
A409
C606
B406
E406
B405
B605
2A3
31
45-50
B403
C603

No. 28

A SIMPLE A.C./D.C. SUPERHETERODYNE

VALVES

- CK1 Octode frequency changer.
- CF2 R.F. Penthode intermediate frequency amplifier.
- CB1 Duo-Diode demodulator (also A.V.C.).
- CF1 Penthode audio amplifier.
- CL2 Power Penthode.
- CY2 Rectifier (half wave).
- C1 Barretter.

This receiver has been designed for operation on 180-265 volt alternating or direct current mains, this being made possible by the incorporation of Philips C1 Barretter or Iron Hydrogen regulating lamp in the filament circuit. For simplicity, an intermediate frequency of 460 K.C. was chosen and the coils were designed accordingly. The CK1 octode is particularly suited for the function of frequency changer, as it operates consistently under varying voltage conditions. The octode is also responsible for the uncanny lack of background noise in the finished receiver.

The diode plate of the Duo-Diode type CB1 connected to the top of the bulb is used for detection and the other diode provides delayed A.V.C. voltages for control of the CK1 and CF2 valves. The characteristic curves of the latter types provide for a short grid base or cut-off. This feature permits the contol of volume over very wide limits with relatively small bias variations and is particularly advantageous for Automatic Volume Control circuits.

Adequate audio amplification is provided firstly by the CF1 penthode and finally by the CL2 power penthode and the two sections of the CY2 rectifier are parallelled for the plate supply and speaker energisation. (See heading Field Excitation.)

CONSTRUCTION

One of the problems associated with the design of A.C./D.C. receivers is occasioned by the fact that one side of the mains has to be connected to the majority of components and it has to be decided what means will be adopted to make the receiver safe to handle. One method sometimes employed is to arrange for the complete insulation of the chassis, a heavy bus wire being arranged underneath as the common "negative" to which all electrical circuits are returned.

The chassis and cans, etc., are connected to this bus through a condenser and the chassis may thus be actually earthed without danger of "blowing" the fuses. Such an arrangement is entirely practicable but necessarily expensive, as a good deal of attention has to be directed to the problem of insulation and the screening of the wiring. Furthermore, it is extremely difficult to entirely eliminate modulation hum and other parasitic troubles due to stray capacities, etc.

A simple alternative, and one which has been adopted in the receiver under consideration is to use the chassis as the "negative" side of the mains, the cabinet completely enclosing the chassis and preventing personal contact. The rear door of the cabinet should be provided with a switch or other device to disconnect both poles of the mains from the chassis when the door is open.

Grubscrews for the knobs on the front of set should be filled with wax or some other insulating compound. Series isolating condensers are required for the aerial and earth connections. No valve cans are needed, the majority of the valves being metalised. The respective separate socket connections for the metallisation are joined to the chassis.

The heaters of the valves are connected in series in the following order:—

CF1, CB1, CK1, CF2, CY2, CL2, and, finally, the C1 Barretter.

This means that one side of the filament of the first audio valve type CF1 is directly connected to the chassis. This is advisable for the reason that this valve is likely to amplify stray hum voltages. If we have a high alternating voltage between the filament and cathode, this will be distributed across the impedance provided by the grid filament capacity and the grid leak in series. When the filament of the CF1 is connected to chassis, there is practically no voltage between the grid and filament.

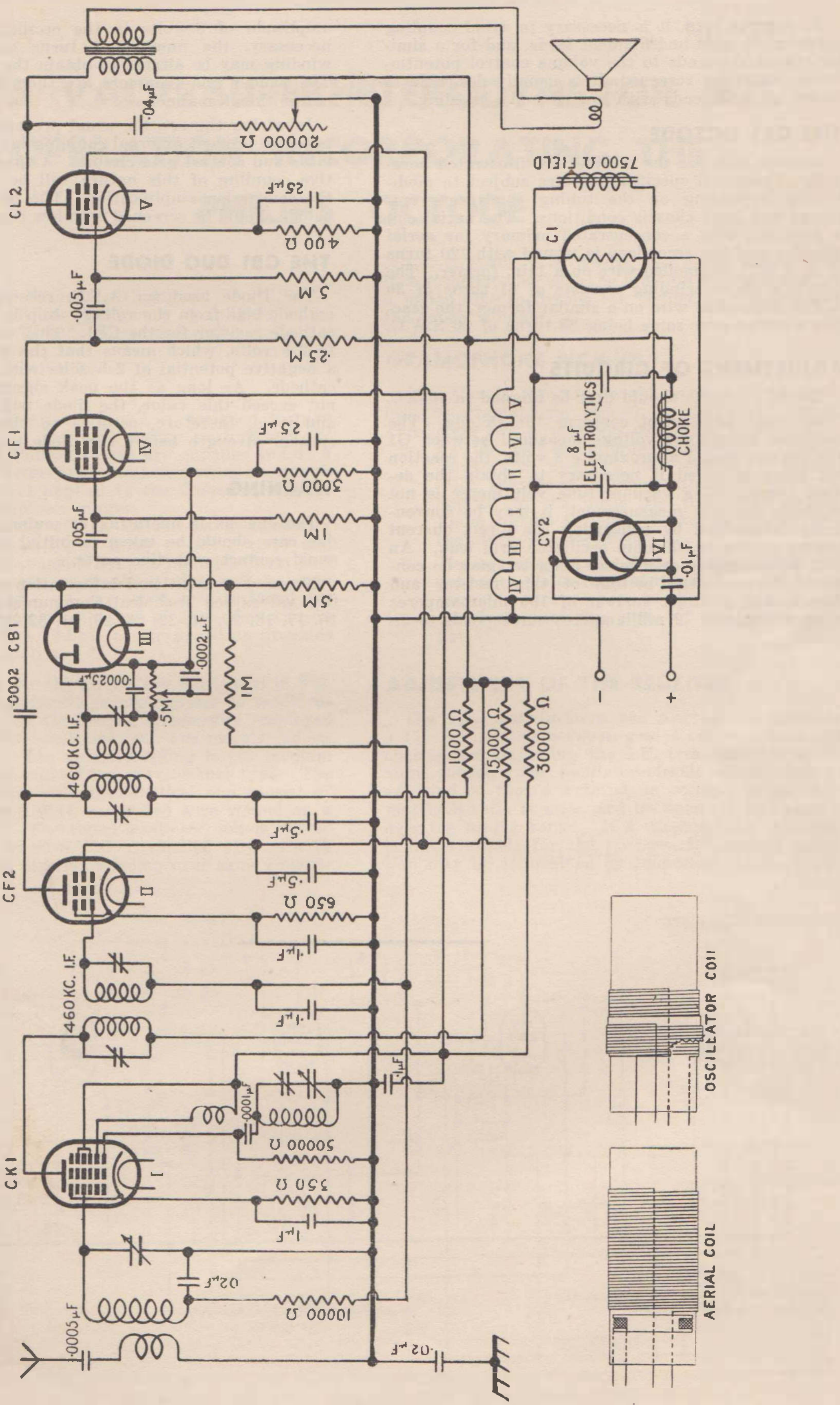
The other valves are not so critical with respect to hum and are arranged in the most suitable manner. It will be noticed that the heater of the power penthode type CL2 is farthest from the chassis, and the rectifier second last. The reason for this procedure is that between the cathode and heater of the rectifier appears not only the voltage drop across all of the heaters but on the reverse phase for AC, also the charge across the input filter condenser. Thus, by connecting the valves in the abovementioned order, it is possible to reduce the maximum peak voltage between the cathode and heater of the rectifier by 24 volts.

FIELD EXCITATION

For maximum undistorted output, particularly on DC, it is preferable to energise the loudspeaker by connecting it directly across the rectifier and to smooth the plate supply by means of a separate choke.

SMOOTHING

For AC/DC sets, the filter choke should be specially dimensioned. To obtain the best performance particularly on DC, the voltage drop should be small, which means that the DC resistance of the choke should also be small. Furthermore, for adequate smoothing it is important that the core should not become magnetically saturated. The number of turns is therefore restricted to a minimum, and to obtain sufficient inductance it is necessary either to use a core of large cross-section or to avoid saturation by means of an air gap. The best position for the choke is in the positive lead. If desired, larger capacity filter condensers may be employed, but due reference should be made to Technical Communication No. 22 wherein various values of resistances in series with the rectifier are recommended.


CL2
CF1
CB1
CF2
CK1
CY2
C1
7500 Ω FIELD
8 μF ELECTROLYTICS
CHOKE
460 KC. I.F.
460 KC. I.F.
20000 Ω
400 Ω
5 M
·25 M
3000 Ω
1 M
·5 M
1M
1000 Ω
15000 Ω
30000 Ω
650 Ω
50000 Ω
550 Ω
10000 Ω
·04 μF
25 μF
·005 μF
·0002
·0002 μF
·00025 μF
·01 μF
·5 μF
·1 μF
·02 μF
·0005 μF
OSCILLATOR COIL
AERIAL COIL

To prevent hum, it is necessary to avoid coupling between the grid and filament leads, and for a similar reason the leads to the volume control potentiometer should be screened. It is usually desirable to screen all grid leads with low capacity braiding.

THE CK1 OCTODE

Suitable coils for the receiver are illustrated herewith. These coil specifications are subject to modification depending on the tuning condensers employed and local chassis conditions. The aerial coil is provided with a concentrated primary for aerial coupling and the secondary is wound with 120 turns of 30 S.W.G. enamelled wire on a 1¼in. former. The tuned oscillator winding consists of 61 turns of 30 S.W.G. enamelled wire on a similar former, the reaction winding over same being 25 turns of 30 S.W.G.

ADJUSTMENT OF CIRCUITS

The I.F. circuits should first be aligned to 460KC.

The next adjustment concerns the Octode. The oscillator heterodyne voltage measured between G1 and chassis should approximate 8 volts, the reaction coil being adjusted if necessary to obtain the desired result. If a vacuum tube volt meter is not available for this measurement, it may be conveniently determined by measuring the direct current flowing in the 50,000 ohm oscillator grid leak. An 0—1 milliammeter or a micro-ammeter may be connected between the bottom of this resistor and chassis, and a direct current of 190 microamperes or approximately ·2 milliamperes corresponds to an amplitude of 8 volts in the oscillator circuit. If necessary, the number of turns on the reaction winding may be altered to obtain the desired result. The padder and trimmers are then adjusted in the conventional manner.

In wiring the set, the usual precautions should be taken to prevent external coupling between the oscillator and control grid circuits. Capacitive or inductive coupling of this nature will be detrimental to the conversion amplification. The plate lead to the octode should be screened with low capacity braiding.

THE CB1 DUO DIODE

The Diode used for A.V.C. receives its positive cathode bias from the voltage drop in the 3000 ohm. cathode resistor for the CF1. This voltage amounts to 2·5 volts, which means that the diode plate has a negative potential of 2·5 volts with respect to its cathode. As long as the peak signal voltage does not exceed this value, the diode will not function, and it is, therefore, possible to obtain full loudspeaker strength before the diode takes charge.

WARNING

The chassis is operating at mains potential, and due care should be taken in initial adjustments to avoid contact with live parts.

Note.—For additional information on the respective valves see Technical Communications Nos. 13, 16, 17, 18, 20, 21, 22, 23, 25, 31, 32, 33.

No. 29

A 4/5 VALVE SUPERHETERODYNE FOR A.C. OPERATION INCORPORATING THE PHILIPS OCTODE

VALVES

AK1 Octode Frequency Changer.
AF2 Intermediate Frequency Amplifier.
E444 Diode Tetrode demodulator and audio amplifier.
E443H Power Penthode.
1561 Rectifier.

The circuit shown in Fig. 1 is designed to take full advantage of the outstanding performance of which the new Philips valves are capable and is a 175 K.C. superheterodyne featuring simple automatic volume control applied to the frequency changing and I.F. amplifier stages.

The employment of the Octode as a frequency changer ensures a high signal to noise ratio and exceedingly high sensitivity is obtainable from this circuit arrangement, particularly with well-designed I.F. transformers. A pre-selector is included for image suppression and the use of diode detection in association with a Philips power penthode provides excellent tone quality.

Suitable coils for the circuit are illustrated in Fig 3. These coil specifications are subject to modification depending on the tuning condensers employed and local chassis conditions, and are merely indicated as a guide. The aerial coupling is per medium of a bobbin type coil of the conventional type. The tuned pre-selector coils are identical and consist of 135 turns of 30 S.W.G. enamelled wire wound on a 1¼ inch former. The tuned oscillator coil is wound with 100 turns of 30 S.W.G. enamelled wire on a 1¼ inch former, the reaction winding over same consisting of 25 turns of 30 S.W.G. For initial adjustments it is recommended that the reaction coil be wound on a paper tube to permit the sliding of the coil over the tuned winding.

GRAMOPHONE PICK-UP

Attention is directed to the method of connecting the gramophone pick-up to the diode circuit. This offers two advantages which are as follows:—

1. As the pick-up affords a passage to direct current, the negative bias, which is automatically developed in the cathode resistor, is applied to the diode via the tuned circuit. Radio signals arriving on the diode plate are, therefore, not rectified.
2. The presence of the diode in the circuit will not cause distortion. If the diode is not made negative with respect to the cathode, it will rectify the positive phase of the pick-up output.

ADJUSTMENT OF THE RECEIVER

The I.F. transformers are aligned by applying a 175 K.C. signal between grid 4 of the octode and chassis and adjusting the I.F. trimmers for maximum output. The oscillator circuit should then be adjusted so that a heterodyne voltage of approximately 8 volts is measured between G1 and chassis over the tuning range. If a vacuum tube voltmeter is not available for the purpose, the correct condition may be determined by connecting an 0—1 mil-

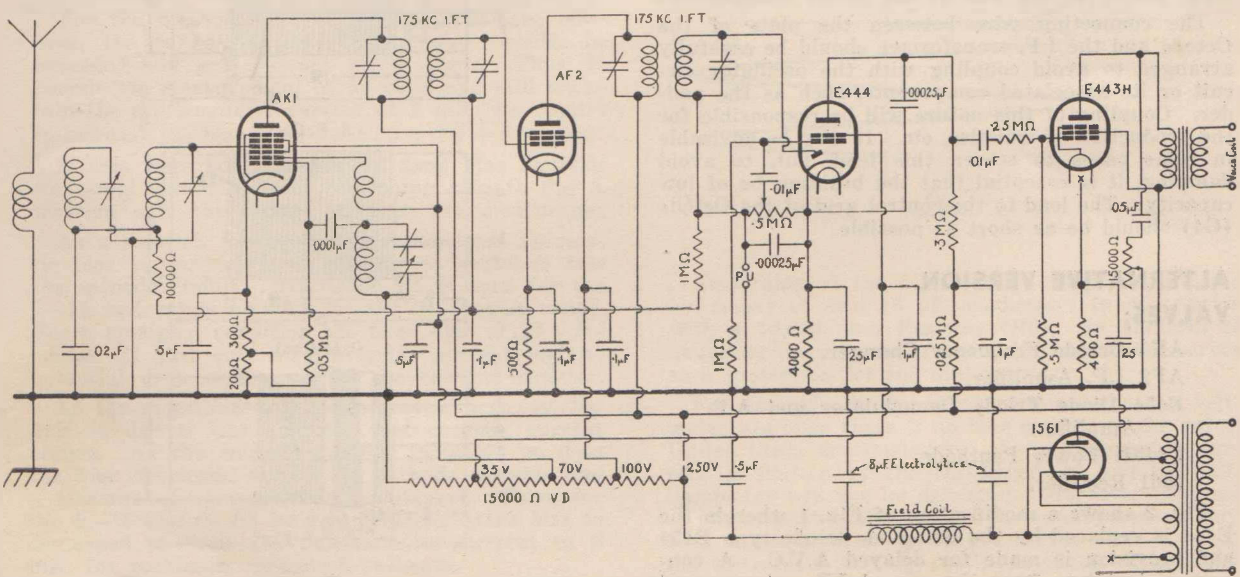


Fig. 1.

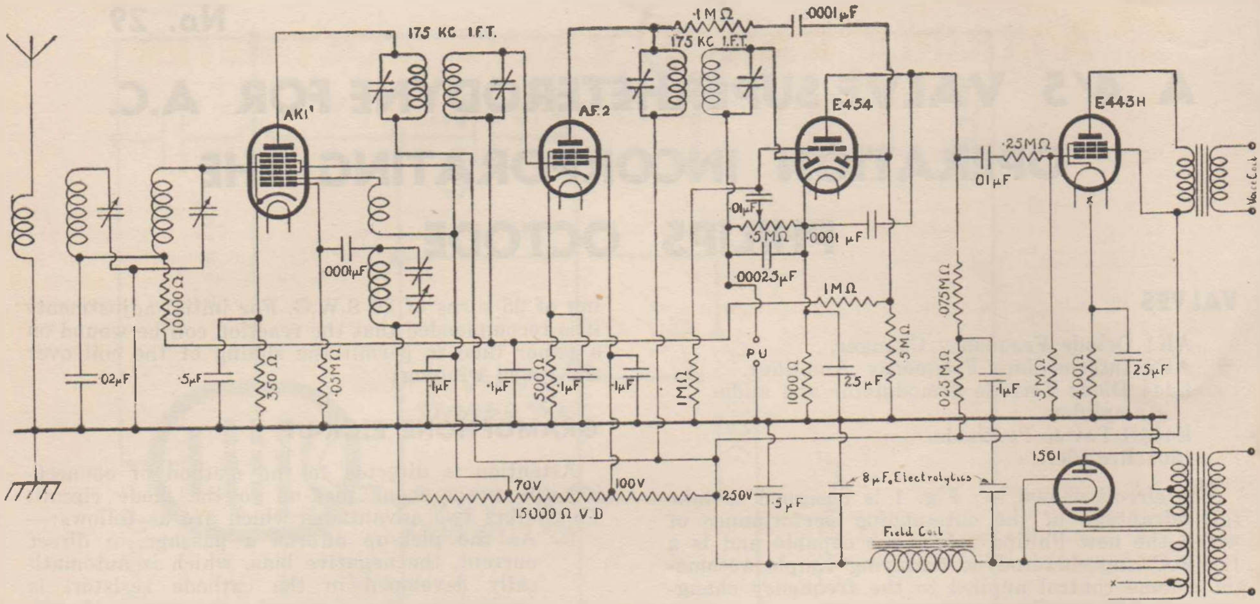


Fig. 2.

liammeter or microammeter between the bottom of the 50,000 grid leak and chassis. A direct current of 190 microamperes or approximately ·2 milliamperes corresponds to an amplitude of 8 volts in the oscillator circuit. If necessary, the position of the reaction winding or the number of turns on same may be varied to obtain the desired result. The tuning condenser trimmers and the padder are then adjusted in the conventional manner.

CONSTRUCTIONAL NOTES

The value of the grid leak should not be varied. as 50,000 ohms will give the best results. Other values may be responsible for increased background noise.

The leads to the ·5 megohm volume control potentiometer should be screened to avoid hum and undesirable coupling. For a similar reason the axis of the second I.F. transformer should be mounted at right angles to the axis of the power transformer.

The connecting wire between the plate of the Octode and the I.F. transformer should be carefully arranged to avoid coupling with the oscillator circuit or its associated components, such as the padder. Coupling of this nature will be responsible for the production of whistles, etc. It may be advisable in some cases to screen this lead, but, to avoid damping, it is essential that the braiding be of low capacity. The lead to the control grid of the Octode (G4) should be as short as possible.

ALTERNATIVE VERSION

VALVES:

- AK1 Octode Frequency Changer.
- AF2 I.F. Amplifier.
- E454 Diode Triode Demodulator and A.F. Amplifier.
- E443H Power Penthode.
- 1561 Rectifier.

Fig. 2 shows a modification of Fig. 1 wherein the E444 is replaced by the duo-diode triode type E454 and provision is made for delayed A.V.C. A connection is taken from the second I.F. primary and fed through an 0·1 megohm resistor in series with an 0·0001 μF condenser to the A.V.C. diode plate.

The diode load resistor (0·5 megohm) is returned to chassis. It will be observed that the E454 cathode is positive by the amount of voltage developed in the cathode resistor. It follows therefore that current cannot flow in the A.V.C. diode circuit until the R.F. signal equals the cathode voltage. Thus a measure of delay is provided and weak signals are not attenuated by the A.V.C. action.

Furthermore an adequate undistorted output is achieved before the A.V.C. takes charge.

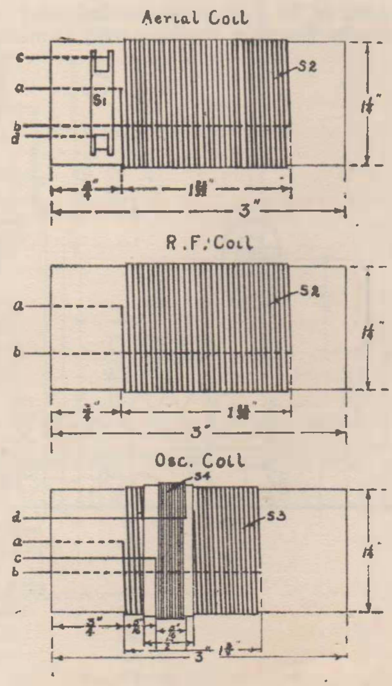


Fig. 3.

No. 30

A TRIPLE RANGE VALVE VOLTMETER 5, 15, AND 50 VOLTS

This instrument has been designed with the intention of producing a measuring apparatus which, whilst it is simple and cheap to construct, provides sufficient precision for most practical purposes.

An 0—2 milliameter is usually available, and this was adopted as a convenient indicating instrument for the voltmeter. To be effective the voltmeter must therefore meet with the following specifications:—

1. It must have three ranges, viz., 0—5, 0—15 and 0—50 volts.
2. The maximum milliammeter current for the maximum measured voltage in each range is to be approximately 2 mA.
3. The minimum milliammeter current for zero measured voltage in each range is 0 mA. (Note: The milliammeter current should not cut-off before zero measured voltage is reached.)
4. The input circuit of the voltmeter should not damp the circuit on which the measurement is made. In other words, grid current is not permissible in the voltmeter valve.

Fig. 1 shows the circuit which was finally adopted.

The instrument is A.C. operated and an E446 R.F. Penthode is employed as an anode bend detector. A fixed negative bias of 13 volts is developed across the resistance R1 which forms part of a voltage divider connected across the high voltage supply. The voltage divider has a comparatively low resistance, so that the bias remains substantially constant when the plate current of the valve increases.

For this particular circuit a negative bias of 13 volts is just sufficient to cut off the plate current, and for the 0—5 range the valve is thus adjusted to the most favourable part of its characteristic curve (see Fig. 2). If 5 volts is measured the milliammeter current will be 2mA.

For the measurement of higher potentials, however, the range of the milliammeter would be exceeded and grid current would occur. Thus, to permit the measurement of 50 volts and still maintain the milliammeter current at 2 mA. we require to increase the bias to at least 50 x $\sqrt{2}$ = 70 volts.

If this were accomplished by fixed bias methods we would obtain a result something akin to Fig 3, wherein only the higher voltages are measurable.

As a solution to the problem additional automatic bias is derived from resistances switched into the cathode circuit. Resistance R5 is used for the 0—15 volt range and R4 for the 0—50 volt range. For a no-signal condition the fixed bias of 13 volts across R1 just cuts off the plate current and no potential drop occurs across the cathode resistor.

As the measured voltage increases, however, the grid is driven less negative and cathode current occurs. As the cathode current increases so does the bias developed across the cathode resistor and a measure of compensation is effected. Thus, for the 0—15 and 0—50 ranges sufficient extra bias is developed to limit the milliammeter current to 2 mA. for maximum measured voltages.

To obtain a suitable operating characteristic it became necessary to join the plate and screen grid together and also to operate these elements at a potential in excess of the normal rating for the valve. Since the plate current will not exceed 2 mA. the use of a high plate voltage is permissible, and as the valve is a penthode, no secondary emission will result from joining the plate and screen.

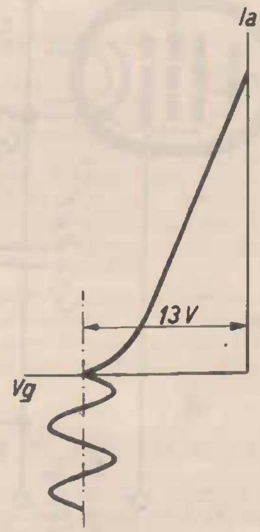


Fig. 2

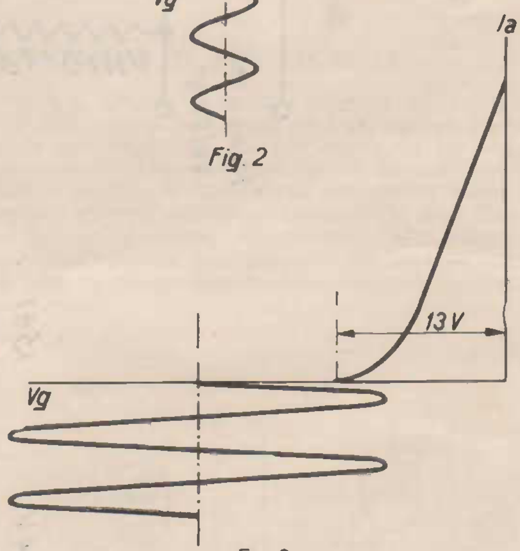


Fig 3

Smoothing of the high voltage supply is effected by means of two 16 μF condensers in association with a 10,000 ohm Resistor (R6). In addition to obviating the need for a choke, this resistance serves as a protection for the milliammeter.

For example, if the input terminals to the voltmeter are open there is no bias applied to the valve. Under these circumstances, the milliammeter current is limited by the resistance R6 and the milliammeter will not be damaged. Moreover, the use of the resistance R6 permits the employment of any 0—2 milliammeter, for the internal resistance of the instrument is very small compared with 10,000 ohms.

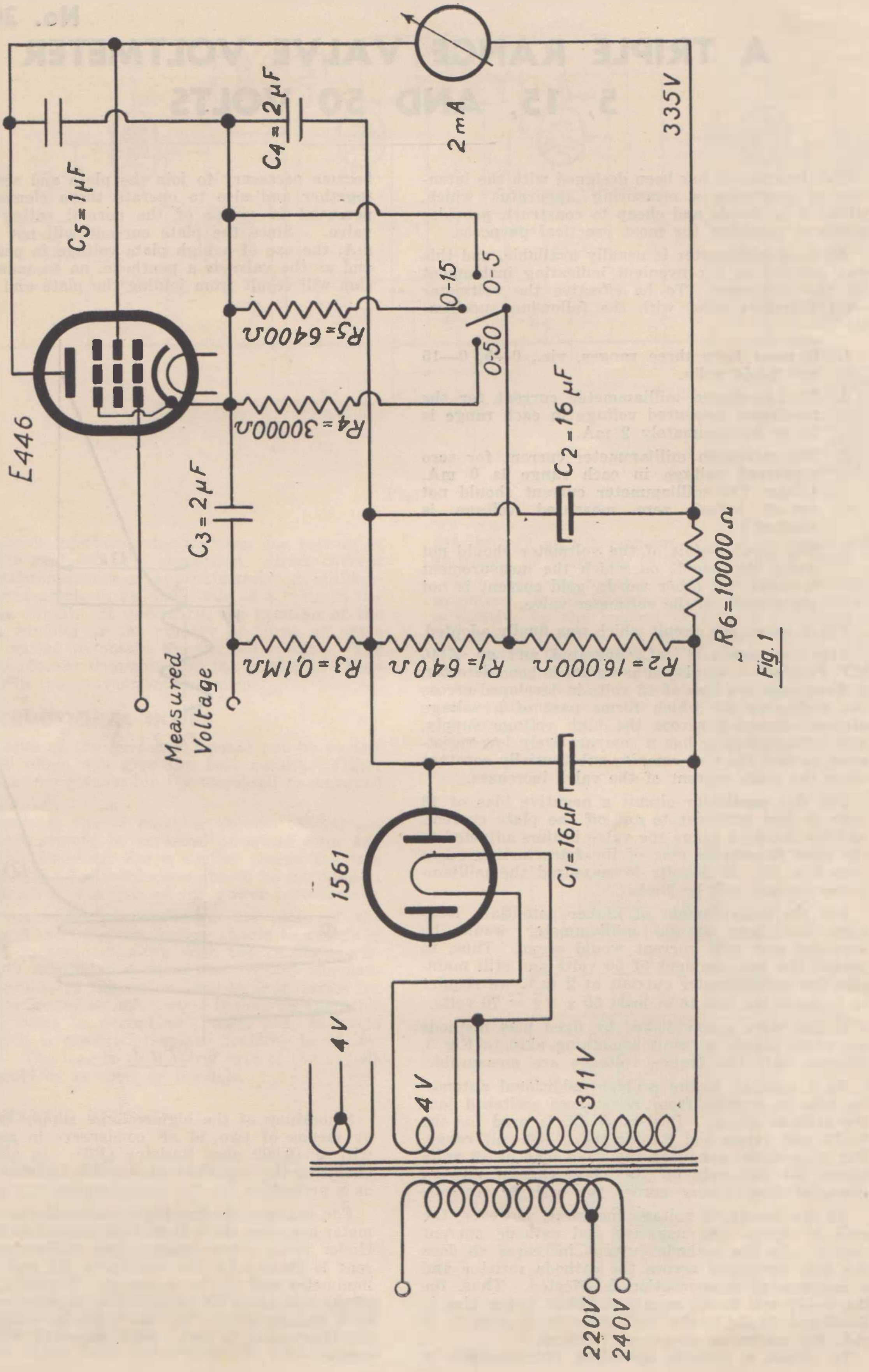

C5=1μF
C4=2μF
2mA
335V
0-15
0-5
0-50
R5=6400Ω
R4=30000Ω
C2=16μF
E446
C3=2μF
R6=10000Ω
R3=0,1MΩ
R1=640Ω
R2=16000Ω
Measured Voltage
1561
C1=16μF
4V
4V
311V
220V
240V

Fig. 1

The milliammeter is bypassed to cathode by a 1μF condenser (C5), so that when measuring high frequencies the impedance of the instrument will not cause a voltage drop. This condenser should be non-inductive and offer a very small series resistance to A.C.

In the measuring ranges of 0—15 and 0—50 volts the valve voltmeter is practically independent of mains voltage fluctuations. If the mains voltage increases the plate voltage will rise accordingly, and hence also the plate current will tend to increase. The higher plate current will give a greater drop across the cathode biasing resistor, and the plate current will return to its original value.

This is not the case, however, for the 0—5 range, for this range is not provided with a cathode resistor. Thus a variation of 10% in the mains voltage corresponds to an error of 8% in the reading of the milliammeter. It will, therefore, be necessary to adhere to the original mains voltage on the 0—5 range for accurate results.

When using this voltmeter care should be taken that there is always a conductive connection between the input terminals, as otherwise the valve will not receive negative bias.

If, for example, we wish to measure a voltage via a condenser, the terminals of the voltmeter must be shunted by a grid leak resistance of from 1 to 2 megohm.

CALIBRATION

Although this voltmeter is not an instrument of great precision, it has considerable practical value, particularly as the majority of measurements made are only for comparison.

Each voltmeter must, of course, be separately calibrated. The curves of the original experimental instrument are shown in Fig. 4. 50 cycle A.C. mains will usually be employed for the calibration, and for extreme accuracy it would normally be necessary to determine whether the supply is reasonably free from harmonics. Suitable filtering could be employed to eliminate such harmonics.

For the most practical purposes, however, it will be sufficient to calibrate the vacuum tube voltmeter directly from the supply, using a step-down transformer or other means of reducing the mains voltage to suitable values.

Actual calibration is carried out by comparing the V.T. voltmeter readings with those of a moving iron or current operated type of A.C. meter.

MEASUREMENT OF STANDARD OUTPUT IN RADIO RECEIVERS

The instrument under discussion may be employed as an output meter for the testing or servicing of radio sets, a suitable hook-up being shown in Fig. 5.

The resistance "R" would have a value equal to that quoted by the tube manufacturer as optimum load for the power valve. For power penthodes this would normally be 7000 ohms.

The condensers "C" should be at least 4 μF, thus having a small impedance in comparison with 7000 ohms at audio frequencies. The inductance of the audio choke should be as high as practicable, as the A.C. output of the valve is divided between the choke and the resistor. The standard output of ·05 watts corresponds to 18·7 volts measured across the 7000 ohm resistor.

D.C. MEASUREMENTS

The voltmeter may also be used for the measurement of D.C. voltages such as, for example, the effect of A.V.C. on the bias of the controlled valves. The instrument should be separately calibrated for D.C. measurements, and the positive side of the voltage to be measured is connected to the grid of the E446.

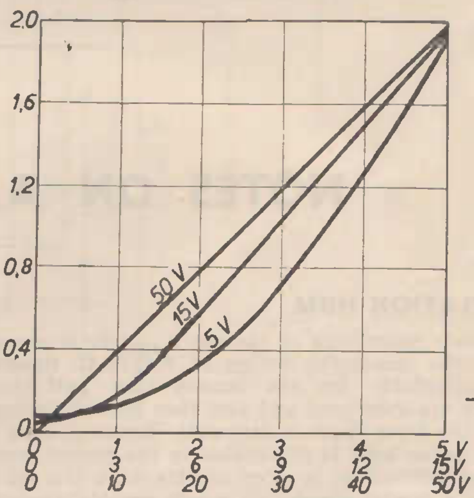


Fig. 4

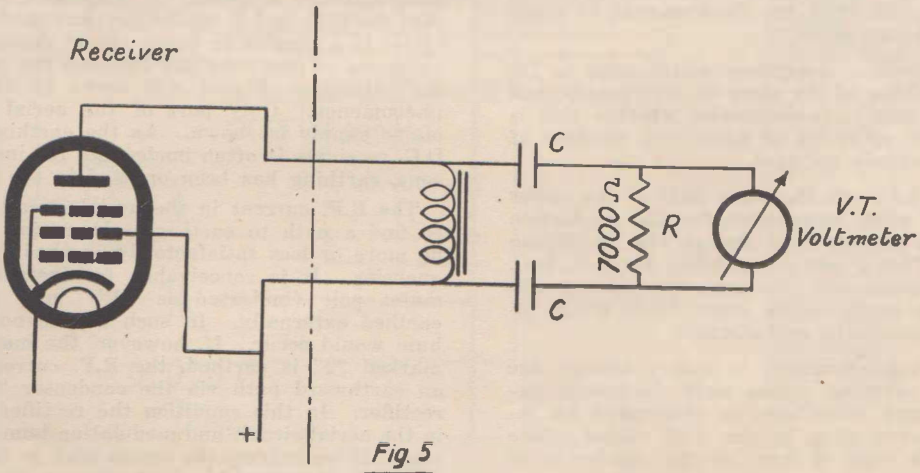


Fig. 5

No. 31

PHILIPS 200 mA. A.C./D.C. SERIES DIAL LAMP TYPE 8064

In considering the design of AC/DC Receivers, it becomes necessary to provide for the illumination of a dial. One solution of the problem is the use of a small 240-volt Pilot Lamp wired in parallel with the mains input to the receiver. A smaller lamp than this is usually preferable, and it is convenient to wire a lamp in series with the valve heaters.

Ordinary Radio Panel Lamps are not suitable for the purpose for the reason that when the set is first switched on there is a heavy surge of current due to the low resistance of the valve heaters when cold. This condition is quickly compensated for by the action of the Barretter, but the normal type of dial lamp will not meet with the demands imposed momentarily upon it.

A special lamp (Philips Type 8064) of robust construction has been developed for this application.

This lamp is equipped with a miniature bayonet base similar to the standard Auto lamp and the filament rating is 18 volts 200 mA.

The use of a lamp of this rating is also advantageous for the reason that it adds to the voltage drop in the filament circuit, thus dissipating heat which would otherwise be radiated by the Barretter. The heat developed in the Barretter is, in any case, negligible when compared with that normally radiated from wire wound resistances in A.C./D.C. receivers.

This is evident when it is remembered that the Philips new valves are rated at 200 mA., whereas competitive valves require 300 mA. filament current. The higher filament voltages (13, 24 and 30 volts) are also useful in this respect. It is, nevertheless, advisable to mount the Barretter in a position where adequate ventilation is ensured. This precaution is instrumental in preventing too great a temperature rise in the receiver which may prove detrimental to cabinet work or rubber insulation.

No. 32

NOTES ON A.C./D.C. RECEIVERS

MODULATION HUM

Adequate smoothing of the plate supply is essential for the successful design of A.C./D.C. Receivers, particularly for the reason that half-wave rectifiers are employed and also that limited voltage drop in the filter choke is desirable. However, even if normal mains hum is eliminated in the proper manner, modulation hum is often audible when the set is tuned to a carrier wave. As a rule modulation hum has a higher pitch than the fundamental 50 cycle and is easily recognisable.

Modulation hum is sometimes attributable to insufficient smoothing of the plate or bias supply, and the first procedure is to determine whether this is the case by the provision of additional filtering of the various electrode voltages.

In ordinary A.C. sets the stray field of the power transformer is often responsible for the production of hum in the output, even though the smoothing be adequate. This is not a possibility for A.C./D.C. sets as the transformer is absent, but the smoothing choke may easily create stray fields which induce hum voltages into grid circuits.

Modulation hum, however, is nearly always due to inadequate earthing of the radio frequency circuits, and it may sometimes be eliminated by reversing the power plug in the wall socket. The reason for this type of hum on the carrier is as follows:—

Every rectifier is in effect a resistance between cathode and anode, which resistance during operation becomes alternately infinitely high (blocking) and declines to a definite but not constant value (free passage to current). When this variable resistance, represented by the rectifier, is coupled more or less tightly to one of the tuned circuits of the receiver. a part of the R.F. or I.F. oscillations existent is periodically absorbed in this resistance in accordance with the frequency of the mains. This means that the R.F. or I.F. oscillations are modulated at 50 cycles to a greater or lesser extent dependent on the tightness of the coupling between the rectifier and R.F. circuits. Fig. 1 will serve to illustrate the phenomenon. Only part of the aerial circuit and mains supply is shown. As the earthing of A.C./D.C. receivers is often inadequate for inevitable reasons, earthing has been omitted in the figure.

The R.F. current in the aerial circuit endeavours to find a path to earth via the mains, which may be more or less satisfactorily earthed for high frequencies. It is conceivable, for instance, that the mains pole (indicated as "1") may be directly earthed externally. In such a case no modulation hum would occur. If, however, the mains terminal marked "2" is earthed, the R.F. current will seek an earthward path via the condenser "C" and the rectifier. In this condition the rectifier is included in the aerial circuit and modulation hum will be present. If we reverse the mains plug in its socket we eliminate the trouble. Nevertheless, the possibility exists that the hum will be present for one position of the plug.

In many cases neither pole "1" or pole "2" will be completely earthed for the return of R.F. current. Portion of the R.F. current will, in any case, seek a path via the rectifier, and we cannot remedy the trouble by reversing the mains plug. We can, however, create a shorter path for the R.F. by shunting a ·1 μF condenser across the poles "1" and "2." The condenser must, of course, have a sufficiently high voltage rating for the mains in question. A second possibility is to shunt the rectifier with a condenser (between cathode and plate).

This condenser must be able to take care of higher voltages than the first example, as during the negative half-cycle, the positive voltage stored in the filter condenser will be added to the peak value of the mains voltage, and the whole will appear across the rectifier. This second method will thus be necessarily more expensive than the first.

If the smoothing choke appears in the negative lead (between the aerial circuit and pole "1"), the only effective solution is the second, i.e., to shunt the rectifier by a condenser. Consequently, it is preferable to insert the choke in the positive lead. In cases where a shunt condenser of ample capacity (·1 μF) fails to effect an improvement the fault will have to be traced elsewhere.

It will be usually found that there is a path whereby the 50 cycle mains voltage reaches a grid, this being occasioned by the fact that the circuit in question is directly connected to a pole of the mains which has a potential of 240 volts with respect to earth.

In tracing hum the position of the Barretter should not be disregarded. Should the regulating lamp be located in close proximity to the audio amplifying valves, stray hum voltages may be induced into the grid leads. In such cases it may be necessary to adopt iron shielding or to alter the position of the Barretter which in common with other valves in the series is equipped with the universal type "P" base.

CONNECTION OF THE METAL COATING

It is usual in designing A.C./D.C. Receivers to arrange for the connection of the chassis directly to one pole of the mains, the earth terminal being insulated from the chassis and connected thereto only by a condenser. Under such circumstances, the metal coating of the valves should be connected to chassis.

If, for any reason, the chassis is directly earthed and separated from the mains it is advisable to join the metal coating of the valves to the respective cathodes. The reason for this is that under certain conditions on D.C. mains it is possible for the chassis (when separately earthed) to assume a large positive potential with respect to the cathodes. If the metal coating also receives this positive potential it will attract the electrons emitted from the cathode, resulting in detrimental secondary emission. The remedy is to connect the coating directly to the cathode.

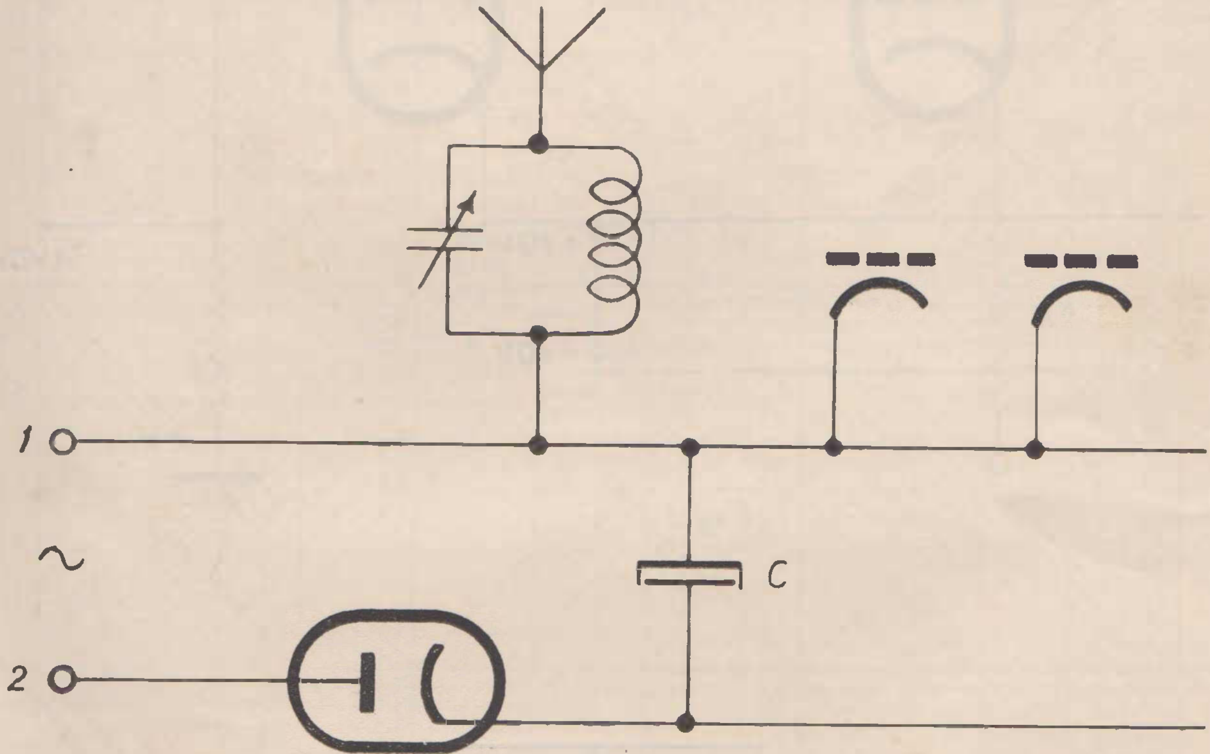


Fig. 1.

No. 33

THE DUO DIODE TYPE CB1

This valve which has been previously described in Technical Communications No. 20 consists of two entirely separated diode sections, one of which is normally employed for detection and the other for A.V.C. The respective diodes are carefully screened from each other, and the screen is joined to the cathode internally. At first sight it would appear that it would be preferable to connect the screening to chassis, in other words, to the metal coating.

In designing this valve, however, it was realised that where amplified A.V.C. is employed (see Fig. 1), the cathodes of the duo-diode and control valve are likely to become considerably negative when receiving strong signals.

If we assume, for example, that the cathode voltage fluctuates between plus 10 volts and minus 10 volts it will be obvious that when the cathodes fall below zero potential they would become negative with respect to the screening, that is if the screening were connected to chassis. The screening being in close proximity to the cathode would then act as an anode, and current would flow via the chassis and the cathode resistance Rk. The net result would be that the cathode would become less negative than was originally intended, and the A.V.C. would be less effective. The connection of the screening to the cathode, however, ensures that it will always remain at the same potential as the cathode whilst the screening is nevertheless effective. The metal coating, as distinct from the screening, is, however, provided with a separate socket connection.

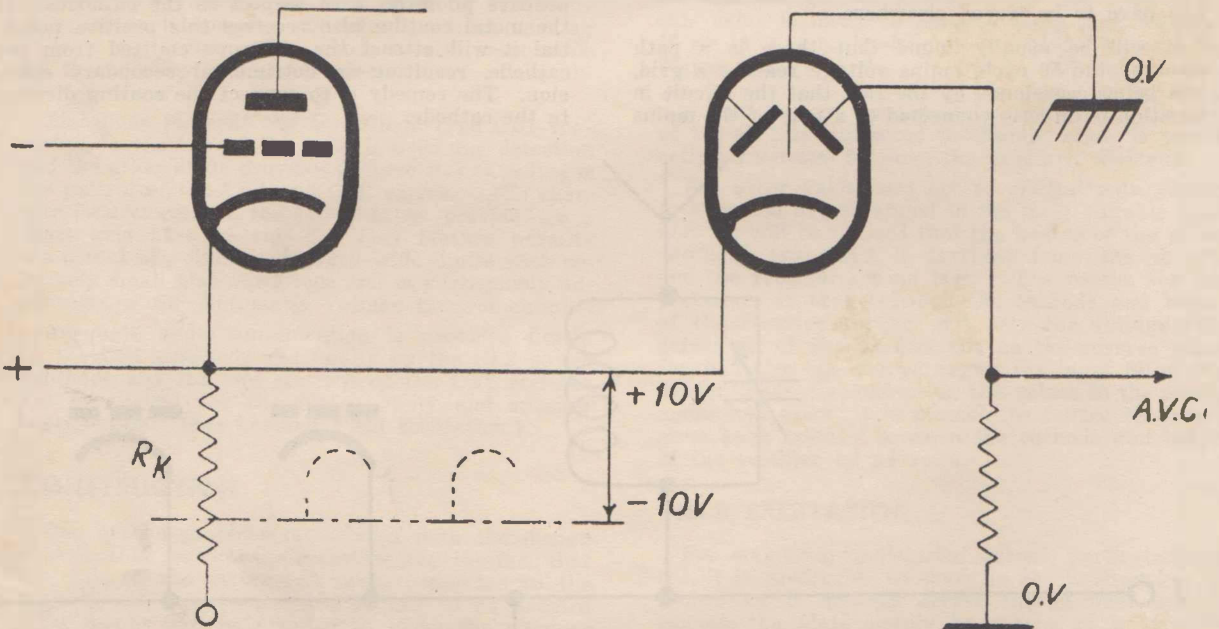


Fig 1

PHILIPS
RADIO