REVISED EDITION

"The Wireless World"

1/- NET.

EVERYMAN FOUR

designed by

W. JAMES

ILIFFE & SONS LTD., LONDON

LAWS

M. Gamber

COMPLETE CONSTRUCTIONAL
DETAILS

OF

"The Wireless World"

EVERYMAN FOUR

The Receiver with a
World-wide Reputation.

BY W. JAMES

FOURTH EDITION

PUBLISHED FROM THE OFFICES OF
"THE WIRELESS WORLD"
ILIFFE & SONS LTD., DORSET HOUSE, TUDOR ST., LONDON, E.C.4

1928

ERRATA.

Page 7, Fig. 1 .. .. C_3 should be 0.01 mfd. instead of 0.005 mfd. The low-potential ends of C_5 and C_6 should be joined to L.T.— instead of to L.T.+.

Page 18, Fig. 7 .. .. When a ½in. baseboard is used the screen should be 7½in. high.

Page 22, second line .. C_3 has a value of 0.01 mfd.

ADDENDA.

Page 22, List of parts .. *Add:* 1 Potentiometer, 300 to 500 ohms, baseboard type (Igranic-Pacent).
1 Anode resistance, with holder, 250,000 ohms. (R.I.-Varley).
1 Fixed condenser 0.005 mfd.; should be 0.01 mfd.
11 Terminals; should be 14.

Page 25, 14th line .. *Add* the word "top" between "the" and "terminal," and add the word "lower" at the beginning of line 22.
Delete the sentence beginning "Just above" in the 5th line from the bottom.

Page 30 .. .. .. *Add* to the list of valves suitable for the H.F. position: Marconi or Osram H.L. 210 and D.E.L. 410.
Valves of the B.T.H., Ediswan, or Cosmos make may of course be used, but care should be taken to choose suitable types.

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INTRODUCTION

THE original "Everyman Four" receiver was described in *The Wireless World* of July 28th and August 4th, 1926, and shortly afterwards the first edition of this booklet was published in response to numerous requests. Now, after some 18 months, its popularity shows no signs of waning; on the contrary, it seems certain that a greater number of sets are being built at the present time than during the period following its introduction.

Things move quickly in the world of wireless, and few, if any, of the innumerable receivers put before the home constructor have survived for more than a few months. It is thus the more remarkable that there has been no necessity to introduce fundamental alterations into the circuit. The model described in this revised edition is, in essentials, the same as the original, but advantage has been taken of experience gained through correspondence from readers. The arrangement for obtaining "free" detector valve grid bias from the drop in voltage across a filament resistor has been abandoned in favour of potentiometer control, as many amateurs appear to prefer the use throughout of valves having the same filament rating; moreover, many modern "high-magnification" valves require fairly close adjustment of grid voltage. Furthermore, the selection of suitable resistor values seems to have presented difficulty to the less-experienced constructor.

The reason for the continued popularity of the "Everyman Four" is not difficult to discover; as its name implies, it fulfils the requirements of the average amateur. He has but two hands; there are but two main controls. He requires sensitivity; no practical arrangement has yet been put forward with definite and serious claims to better the actual figures given with regard to H.F. amplification. He must have selectivity, to an extent depending on his geographical situation; considering the present distribution of stations with respect to density of population, one may hazard a guess that Mr. Everyman lives within 7 or 8 miles of his local transmitter. In this receiver we have an almost ideal compromise between selectivity and sensitivity; the near-by station will not interfere too seriously at even shorter distances.

Constructors' Opinions

"Six American broadcasting stations on the loud-speaker."

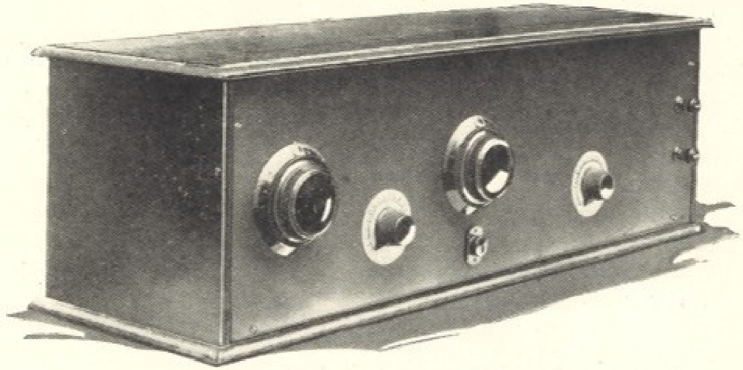
"Every station in Europe which is not actually heterodyned."

"The finest four-valve set that exists."

"Twenty-eight stations on the loud-speaker the same evening the set was finished."

"Bournemouth received with London working two miles away."

"The quality is perfect."



A "TWO CONTROL" RECEIVER OF REMARKABLE EFFICIENCY.

By W. James.

It is quite a common thing to see a two- or three-valve receiver with four or more knobs for tuning purposes, and as one of these is usually for reaction and another for coupling, tuning-in a distant broadcast station demands considerable skill and experience. Receivers of this type are still being sold by manufacturers and described in technical papers, with the result that the average man with his two hands finds tuning difficult.

The Ideal Receiver.

Many people consider the ideal receiver to be one having but two tuning controls. Such receivers have, of course, been produced, but in the majority of instances these sets are suitable for receiving the local broadcast station only, and there seems to be a very prevalent idea that it is impossible to produce a simple two-control set which will receive distant stations. It is usually thought, unless adjustable reaction is provided in a straight set, that it is necessary to use the supersonic system, with its six or seven valves, in order to make certain of receiving distant stations. But the strange thing is that designers of superheterodyne sets have a habit of adding knobs for reaction, for they find they cannot get those distant stations without it.

It is quite evident that a two-control set which is going to prove a satisfactory proposition must primarily be designed to magnify weak signals if they are to be reproduced at full loud-speaker strength, and, if we limit ourselves to four valves with relatively cheap couplings, steps must be taken to insure that each valve works at full capacity. If we decide on four valves and desire loud-speaker signals, we must necessarily use two low-frequency stages, which automatically settles the use which will be made of the two remaining valves, for one must be used as a detector and the other as a high-frequency amplifier with a tuned coupling.

Four Valves.

Our set, then, will have four valves, with one high-frequency amplifier, detector, and two low-frequency magnifiers. Now we have to tune the aerial circuit and the high-frequency valve coupling; these two tuned circuits, therefore, have variable condensers, and are the only controls on the set. Of course, it is necessary to turn the set on and off; a rheostat actuating all four valves is, therefore, used. It is also desirable to have means for reducing the strength of the local station, for it must be remembered that the set is to give strong loud-speaker signals from distant stations; a volume control should, therefore, be provided, but it must be a volume control pure and simple.

We have decided on the use to which the valves are to be put, and on the tuning controls, and it is now necessary to consider the design in detail. The set illustrated here will receive a dozen or more stations at full loud-speaker strength in daylight when used with a normal out-door aerial and earth, and we will consider its design step by step.

Main Features of the Set.

A glance at the theoretical diagram, Fig. 1, will show the essential features of the set. The aerial and earth are connected to the primary winding of an input transformer T_1 and the secondary coil of this transformer, tuned by condenser C_1 of 0.0003 mfd. capacity, is joined to the grid and filament of the first valve V_1 through a grid bias battery GB_1. This valve is the high-frequency

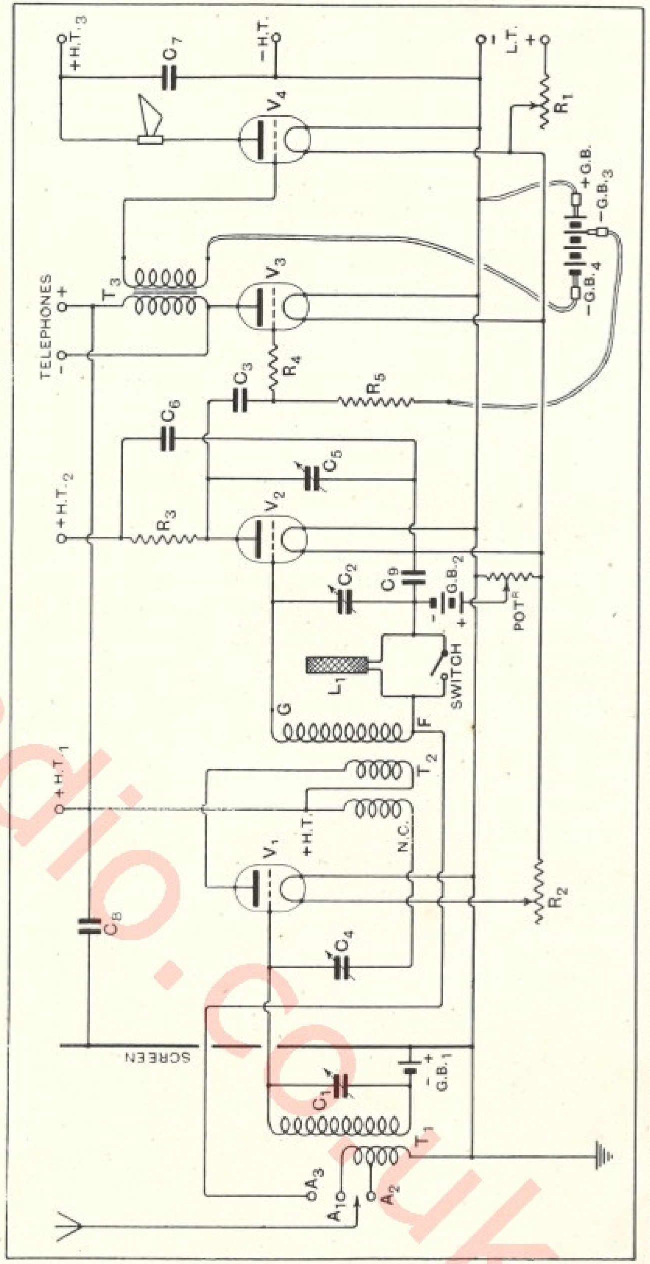


Fig. 1.—Theoretical diagram of connections. T_1, aerial-grid transformer; T_2, high-frequency intervalve transformer; T_3, Ferranti 3.5 : 1 low-frequency transformer; C_1, C_2, 0.0003 mfd. tuning condensers; C_3, 0.005 mfd.; C_4, balancing condenser; C_5, semi-variable by-pass condenser, 0.0005 mfd.; C_6, C_8, 1 mfd.; C_7, 2 mfds.; C_9, 0.25 mfd.; R_1, filament rheostat, 2 ohms; R_2, volume-control rheostat (up to 60 ohms); R_3, anode resistance, 250,000 ohms; R_4, H.F. damping resistance, 100,000 ohms; R_5, grid leak, 2 megohms; L_1, No. 200 plug-in loading coil for Daventry (5XX).

amplifying valve, and is coupled to the detector V_2 by means of a tuned transformer T_2 having a double-wound primary and a secondary tuned by the condenser C_2. One of these primary windings acts as a balancing coil. Connected to the primary winding P is the plate circuit of the first valve, and to the second primary winding NC a condenser C_4 of small capacity for stabilising the circuit.

Coil L_1 with the switch and aerial terminal A_3 are for the purpose of increasing the tuning range of T_2 so that Daventry, working on 1,600 metres, can be received at short ranges. Those who do not require Daventry should not include these parts.

For detecting, a valve set to work as an anode rectifier is used, and this is coupled to the first low-frequency valve by a resistance-condenser coupling, R_3, C_3, R_5. The third valve in turn is coupled through a low-frequency transformer T_3 to the fourth valve, which is connected direct to the loud-speaker. Rheostat R_1 controls all the valves, and R_2 is the volume control. Telephones can be connected to the terminals provided.

The Aerial-grid Circuit.

The aerial-grid circuit comprises a tuned high-frequency transformer T_1. One end of the primary winding is marked E, for the earth connection, and the top end A_1 for the aerial. An alternative connection for the aerial is provided by tapping A_2. When the aerial is connected to this point signal strength is a little less and the selectivity is better than when the aerial is connected to point A_1, it being assumed that the aerial is an outdoor one of normal size.

For a given aerial the signal will produce the largest voltages across the secondary terminals when the transformer has a low resistance and a high ratio of inductance to capacity. The secondary winding of the transformer is, therefore, wound with "Litzendraht," while the primary is wound on the outside of the earthed end of the secondary; it consists of a single wire of small diameter. These two windings are wound to have a tight magnetic coupling, and their capacitative coupling is reduced to a minimum by the use of a fine wire primary.

Now the ends of the secondary winding are connected

to the grid and filament of the high-frequency amplifying valve, and it is important to remember that the smallest possible load should be put on the transformer, for any loading will lower the applied voltage and reduce the selectivity. A single dry cell GB_1 is, therefore, connected in the grid return wire to give the grid of V_1 a negative bias and so to prevent grid current unless the amplitude of the incoming signal exceeds the voltage of the dry cell added to the normal bias of the grid. Grid current loading is not the only thing to be feared, however. Great care has to be taken to wire up with short connections and to prevent leakage paths through faulty insulation.

The High-frequency Transformer.

The high-frequency transformer T_2 is probably the most important part of the receiver, for we have to rely on it and the amplifying valve V_1 to magnify the high-frequency currents by pure high-frequency amplification and also by regeneration.

We will consider the coupling as a transformer first, and see what factors settle its operating characteristics when connected to the circuit. Now the first thing to be done is to decide on an amplifying valve V_1, and as the first requirement of this receiver is that it must receive distant stations at loud-speaker strength, it is evident that we must consider magnification first and put selectivity in the second place.

The type of valve most suitable for V_1 is easily found by examining the valve manufacturers' catalogues, bearing in mind, of course, that it is desirable to employ a valve taking a small filament current and a small anode current. Such a valve has an amplification factor of the order of 20 and an A.C. resistance of 20,000 to 30,000 ohms. There are many suitable valves; the Mullard P.M.5X valve, for instance, has an amplification factor of nearly 20 and an A.C. resistance of under 20,000 ohms.

With this valve as the starting point, we have to design a transformer which will tune over the broadcast range of wavelengths and give the highest possible magnification. Now the writer's method of designing a high-frequency transformer is to calculate the best number of turns for the primary and secondary windings, taking into account, as far as possible, the various factors which tend to make the actual amplification different from that which should be obtained according to theoretical considerations, and then with this as a starting point to put

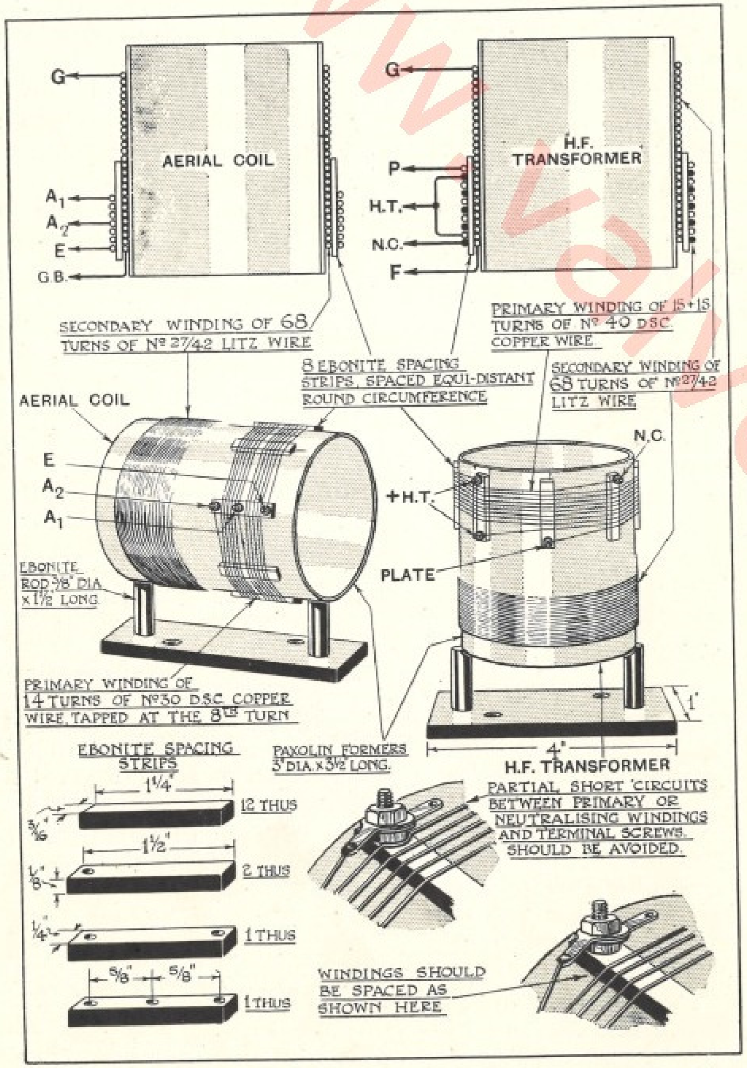


Fig. 2.—(Above) Sectional diagram showing connections to windings of H.F. transformers. The neutralising winding is shown by black dots and the primary by circles. Lettering corresponds to that in the perspective sketches (centre) and the practical wiring plan (Fig. 6). Below are shown details of spacing strips, and an important point with regard to coil winding is made clear.

the transformer in the set and measure the amplification under actual operating conditions. As we would expect, the amplification actually obtained when the transformer is connected in the receiver is less than when it is measured under ideal conditions out of the set, for a number of things act to reduce its efficiency when it is in the receiver.

When the maximum voltage amplification is desired, it is evident that the load on the secondary must be reduced to a minimum, the resistance of the transformer coil and tuning condenser must be as low as possible, and the ratio of the inductance of the secondary coil to the capacity

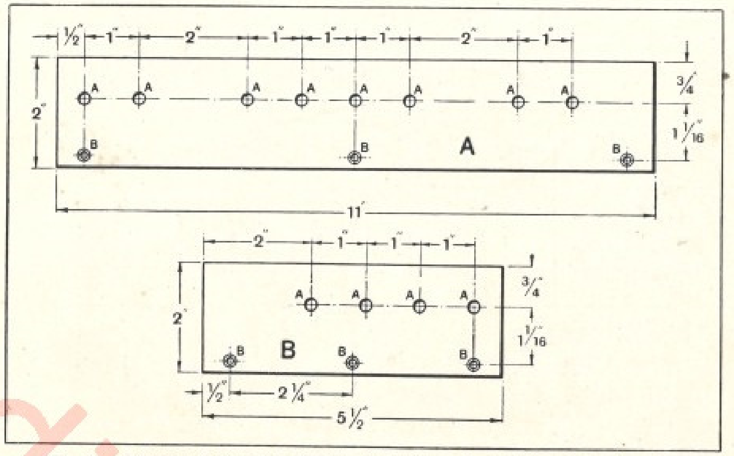


Fig. 3.—Details of ebonite terminal strips. A, 7/32in. dia.; B, 1/8in. dia., countersunk for No. 4 wood screws.

of the condenser across the secondary must be as high as possible. Another thing of considerable importance is the coupling of the primary and secondary, for it is found that there is an optimum value for the magnetic coupling, while, in general, the capacitative coupling should be made very small.

Now the writer has described in many articles in *The Wireless World* the construction of various high-frequency transformers. Each one was designed for a particular purpose, a compromise between amplification and selectivity being effected in each case to suit what were thought to be the requirements of the receiver being designed. It is of interest to compare the voltage amplification obtained with two recent transformers and their valves with the transformer constructed for the present receiver. Table I gives the amplification of a transformer having a secondary winding of 55 turns of "Litzendraht" 3in. in diameter, with a tuning condenser of 0.0005 mfd. and a primary winding of 11 turns of No. 40 D.S.C.; the amplifying valve was a Burndept L.525, having an A.C. resistance of 6,500 ohms and an amplification factor of 6.5. The amplification obtained is seen to vary between 19 and 22.5. This transformer was used in the "Long Range Three Valve Receiver" described in *The Wireless World* of May 26th and June 2nd, 1926.

TABLE I.

MEASURED AMPLIFICATION OF ONE STAGE, COMPRISING A HIGH-FREQUENCY TRANSFORMER AND VALVE OF 6,500 OHMS A.C. RESISTANCE AND AMPLIFICATION FACTOR 6.5.

Wavelength. Metres.	Voltage Amplification.	Wavelength. Metres.	Voltage Amplification.
590	20.7	350	21.6
520	22.5	290	20.0
470	22.0	230	19.3
410	21.9		

The second transformer is the one used in the "No Battery Receiver" described in the issue of June 30th, and this also has a secondary of "Litzendraht" and a primary of No. 40 D.S.C. wire, having 72 turns and 10 turns respectively with a tuning condenser of 0.0003 mfd. The valve used had an impedance of 10,000 ohms and an amplification factor of 7.5. As shown by Table II, the voltage amplification for this transformer and valve ranged from 26 to 29.

TABLE II.

MEASURED AMPLIFICATION OF ONE STAGE, COMPRISING A HIGH-FREQUENCY TRANSFORMER AND A VALVE OF 10,000 OHMS A.C. RESISTANCE AND AMPLIFICATION FACTOR 7.5.

Wavelength. Metres.	Voltage Amplification.	Wavelength. Metres.	Voltage Amplification.
540	26.0	375	28.2
480	26.5	320	29.0
430	26.5	260	29.4
400	27.3	230	28.5

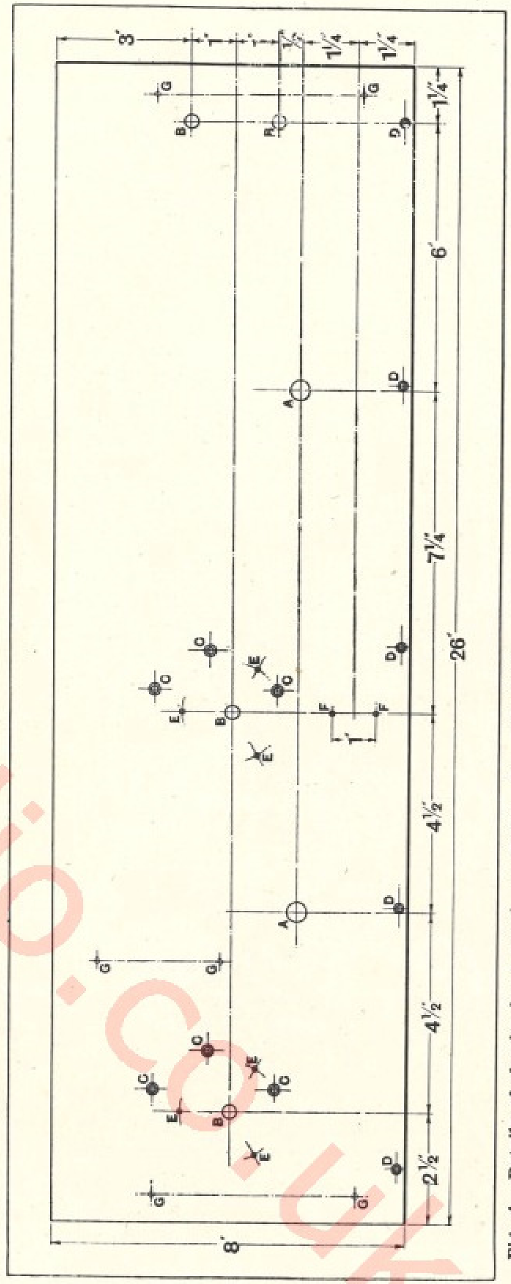


Fig. 4.—Details of ebonite front panel. A, 7/16in. dia.; B, 5/16in. dia.; C, 5/32in. dia., countersunk for No. 4 B.A. screws; D, 1/8in. dia.; countersunk for No. 4 wood screws; E, tapped holes for dials; F, 3/32in. dia.; G, tapped 6 B.A. for screws supporting brackets and screen.

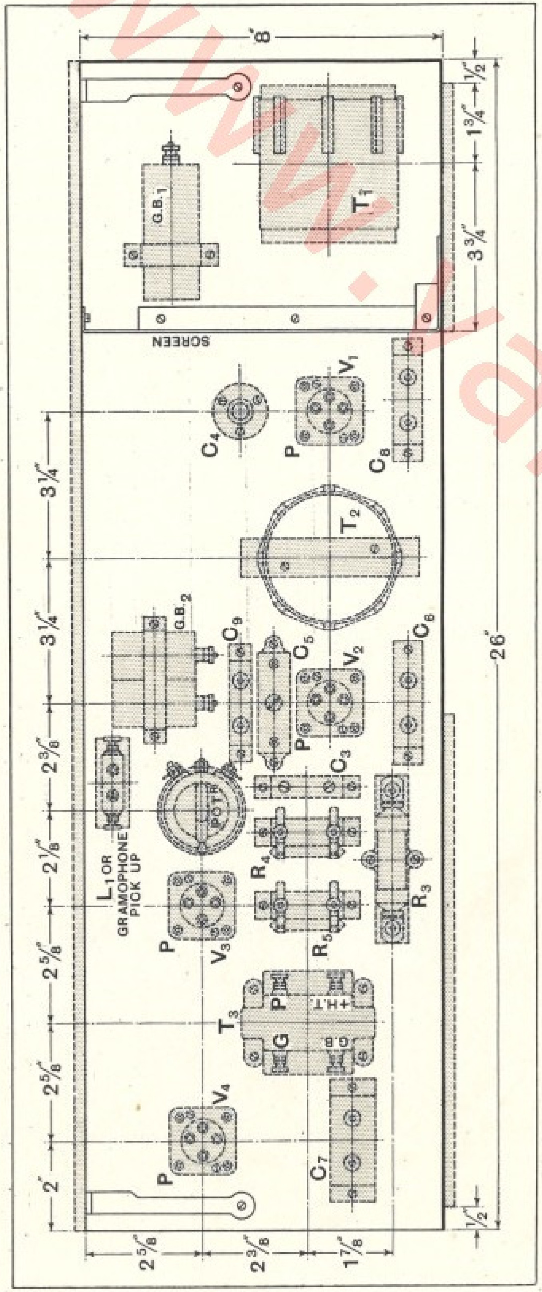


Fig. 5.—Arrangement of parts on baseboard. See Fig. 1 for values of components.

In Table III is given the amplification obtained with the transformer designed for the present receiver when used with a P.M.5 valve (old type) having a voltage factor of 20 and an A.C. resistance of 21,000 ohms. The transformer has a secondary coil of 68 turns of 27/42 "Litzendraht" 3in. in diameter and a primary of 15 turns of No. 40 D.S.C., and is tuned with a 0.0003 mfd. square law condenser. It is seen that the amplification varies between 38 and 44; this is probably the largest amplification that it is possible to obtain without using "Litzendraht" of many more strands, which is much more expensive than that used in the transformer described.

It should clearly be understood that the figures given are for pure high-frequency amplification only; the effect of reaction is to increase the total amplification as described below.

TABLE III.

Measured Amplification of One Stage, comprising a High-frequency Transformer and PM5 Valve of 21,000 Ohms A.C. Resistance and Amplification Factor 20.

Wavelength. Metres.	Voltage Amplification.	Wavelength. Metres.	Voltage Amplification.
540	38	350	43
470	41	300	44
430	42	240	43
400	44	210	41

Each of the transformers described was adjusted to give the optimum amplification with the valves used, and the reason for introducing them here is to show what can be done in the way of amplification when this is the main consideration. By way of comparison it can be shown that the pure H.F. amplification obtained from an amplifying valve and high-frequency transformer of ordinary construction, using solid wire, is 8 to 10. Many transformer-valve combinations give less than this; an amplification of 12 is considered exceptionally good.

The transformer-valve combination of Table I is, of course, much more selective than that of Table III, although the latter transformer when used in the set would be said to be quite selective when compared with the usual receiver having an ordinary tuned anode stage.

THE WIRELESS WORLD

EVERYMAN FOUR

WIRING DIAGRAM.

The plan view of the receiver shows many of the wires, and should be examined in conjunction with this diagram.

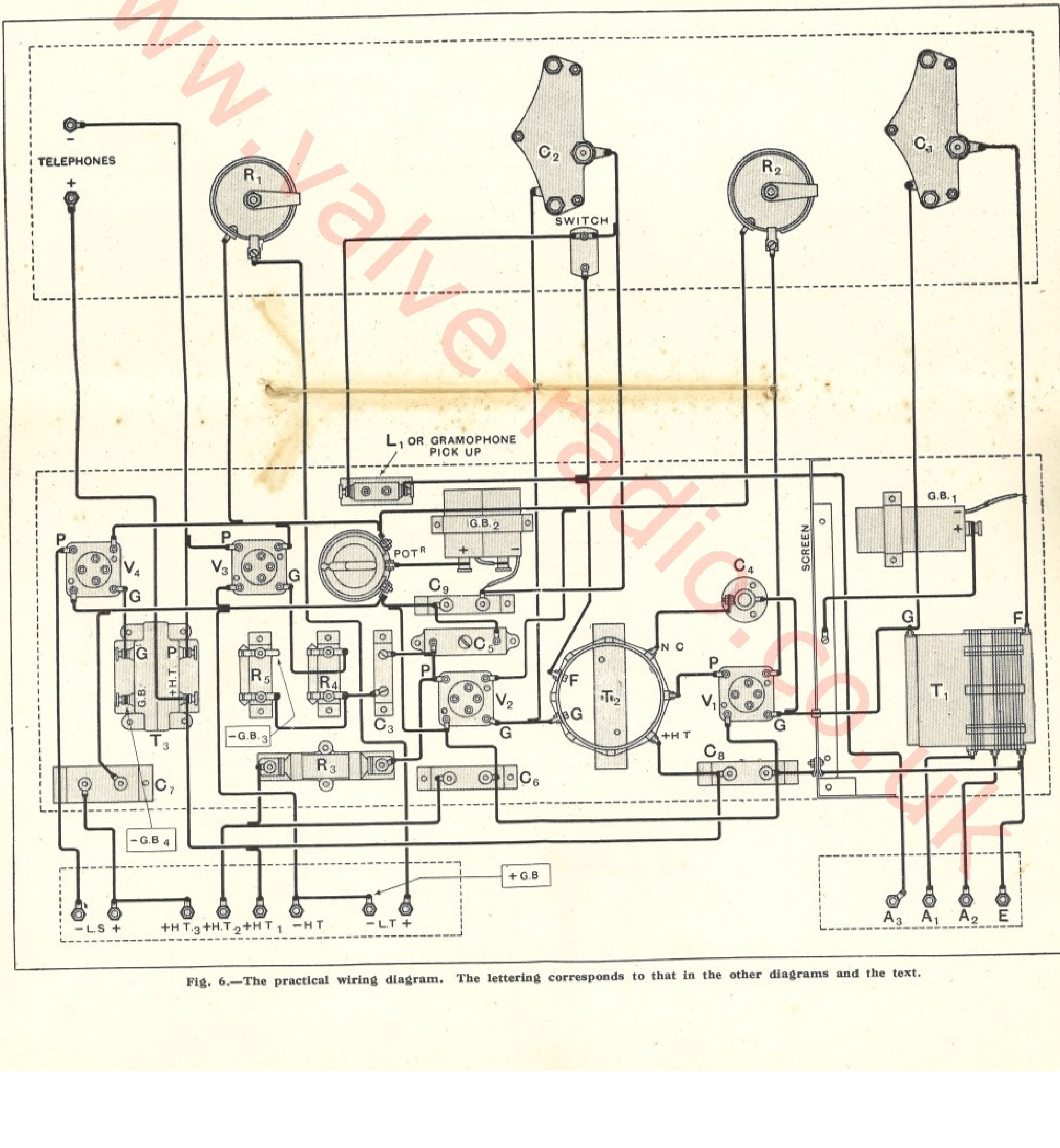


Fig. 6.—The practical wiring diagram. The lettering corresponds to that in the other diagrams and the text.

Effect of Stray Capacities.

We mentioned above that it is important to make the capacity coupling of primary to secondary as low as possible, and to show the effect of stray capacities such as might easily be introduced by bad wiring and placing of the transformer in the set, a tiny condenser having a capacity of only 10 micro-microfarads was connected between the plate end of the primary and the grid end of

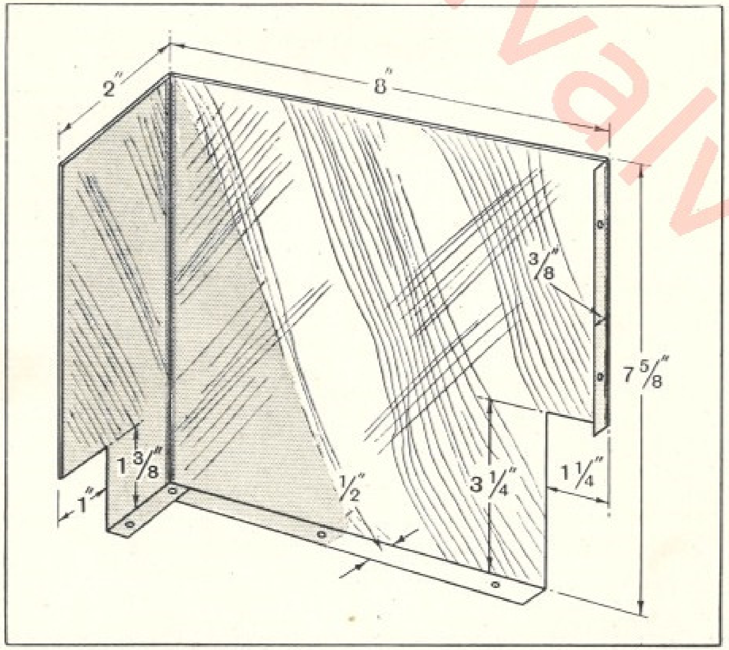


Fig. 7.—Dimensions of the copper or aluminium screen.

the secondary with thin connecting wires, and the amplification of the transformer and valve was measured with it and without it.

The experiment showed quite clearly that it is of great importance so to arrange the H.F. transformer that stray capacities be made as small as possible, and this has been taken into account when the placing of the connecting terminals of the transformer was being decided upon.

Turning now to Fig. 1, it will be seen that the transformer has a third winding marked NC, and that this is

connected to the +H.T. end of the primary winding and to the condenser C_4. This coil and condenser are used to stabilise the circuit, and it is found that condenser C_4, which may have a maximum capacity of 25 to 30 $\mu\mu$F. can be set at such a value that the receiver will not oscillate under any conditions. It is not set to balance the valve, *i.e.*, to make the valve a true one-way amplifier; it is deliberately set so that regeneration is made full use of, but the construction of the transformers T_1 and T_2 is

TABLE IV.

Characteristics of Osram D.E.5B Valve.
H.T., 156. Grid Bias—1.5.

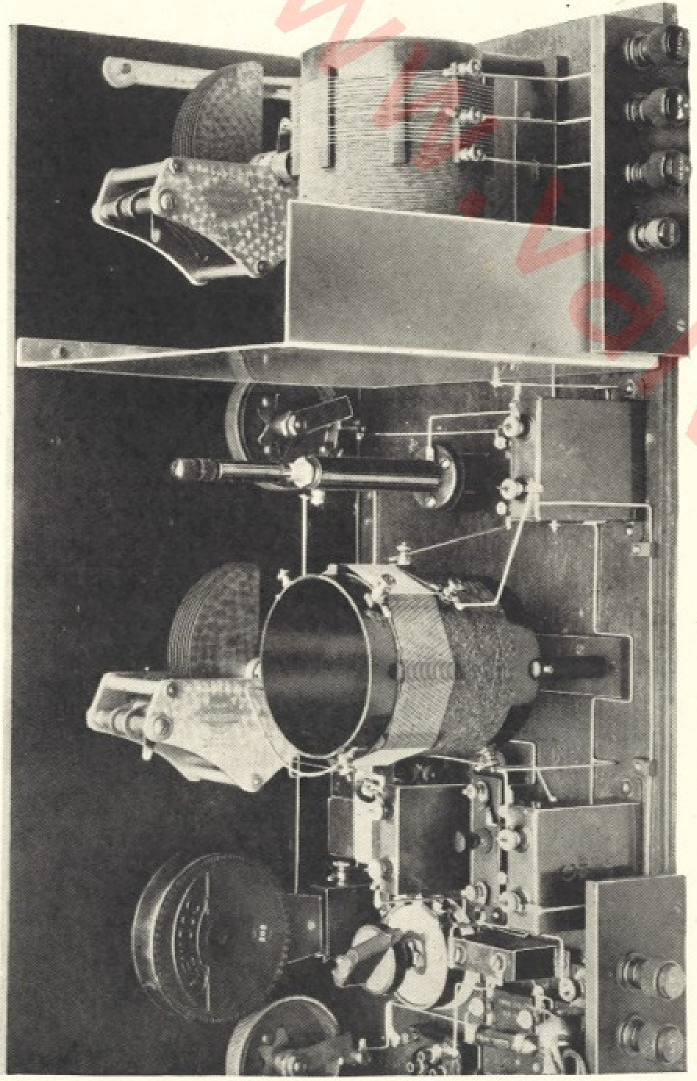
Filament Volts.	Filament Amperes.	Amplification Factor.	Anode A.C. Resistance Ohms.
5.5	0.245	18.0	20,800
5.0	0.23	18.0	21,700
4.5	0.218	18.5	23,000
4.0	0.2	18.7	25,300
3.5	0.185	19.7	35,000
3.25	0.18	17.5	85,000
3.0	0.175	16.0	155,000

such that condenser C_4 can be adjusted to give an extremely useful amount of reaction and yet allow the circuit to remain perfectly stable over the whole tuning range. This condenser C_4 is mounted inside the receiver, and it is adjusted when the receiver is first put to use; *after this there is no need to touch it.*

Combined Amplification.

The amplification of weak signals by the combined transformer and regenerative action is very great, so great, in fact, that it was found necessary to weaken the signals from distant stations such as Birmingham, Bournemouth and Brussels, as received in London, because they overloaded the set. A simple volume control is, therefore, fitted, and takes the form of a rheostat R_2, Fig. 1, connected to the first valve.

Now the circuits of the first valve are adjusted with rheostat R_2 short circuited, and when it is desired to reduce the strength of the signal, R_2 is turned so as to lower the filament current. The effect of reducing the filament current is clearly shown in Table IV, which gives the measured values of amplification and A.C. resist-



The high-frequency and detector circuits: on the right is the aerial coil, tuning condenser, connection strip and screen. Behind the right-hand valve holder is the balancing condenser and volume-control rheostat, while to the left can be seen the Daventry plug-in type coil.

ance for various filament currents. It is seen that as the filament current is reduced the anode A.C. resistance increases, whilst the amplification factor also varies a

little. Thus the amplification is reduced as the filament current is reduced, and a very steady adjustment of volume is had by this simple method.

The reason for the lowering of amplification with reduction in filament current is not hard to understand if the transformer coupling is considered as a resistance connected in the anode circuit of the valve, for the amplification depends on the ratio of anode circuit resistance to the valve's anode resistance. As this ratio is reduced by dimming the filament the amplification is reduced.

This form of volume control has the secondary effect of increasing the selectivity, but the effect is slight, because the increased selectivity of transformer T_2 is practically offset by the decreased selectivity of T_1.

Detector Connections.

The next item of interest in the set is the detector. When considerable trouble is taken to make transformer T_2 so that it has low losses, great care is necessary in setting up the detector or it will load the transformer and lower the amplification. A rectifier of the grid condenser and leak type is out of the question, and we have to use an anode detector because, in the first place, it can be so adjusted that a normal signal will not produce grid current, and, secondly, its output circuit can be so arranged that no appreciable load is introduced to the grid circuit.

One of the main requirements of a valve for use as an anode rectifier is that it should have a high amplification factor. Many are suitable for this purpose, as given in the table below. Precise adjustment of the grid bias voltage of this valve is obtained by means of a potentiometer in conjunction with two dry cells. A condenser C_9 by-passes the high-frequency component.

Now when a valve is set to rectify as an anode bend detector, its anode impedance is much higher than the normal value quoted by the makers. Transformer coupling, therefore, cannot be used, and it is necessary to employ either a choke or resistance-condenser coupling.

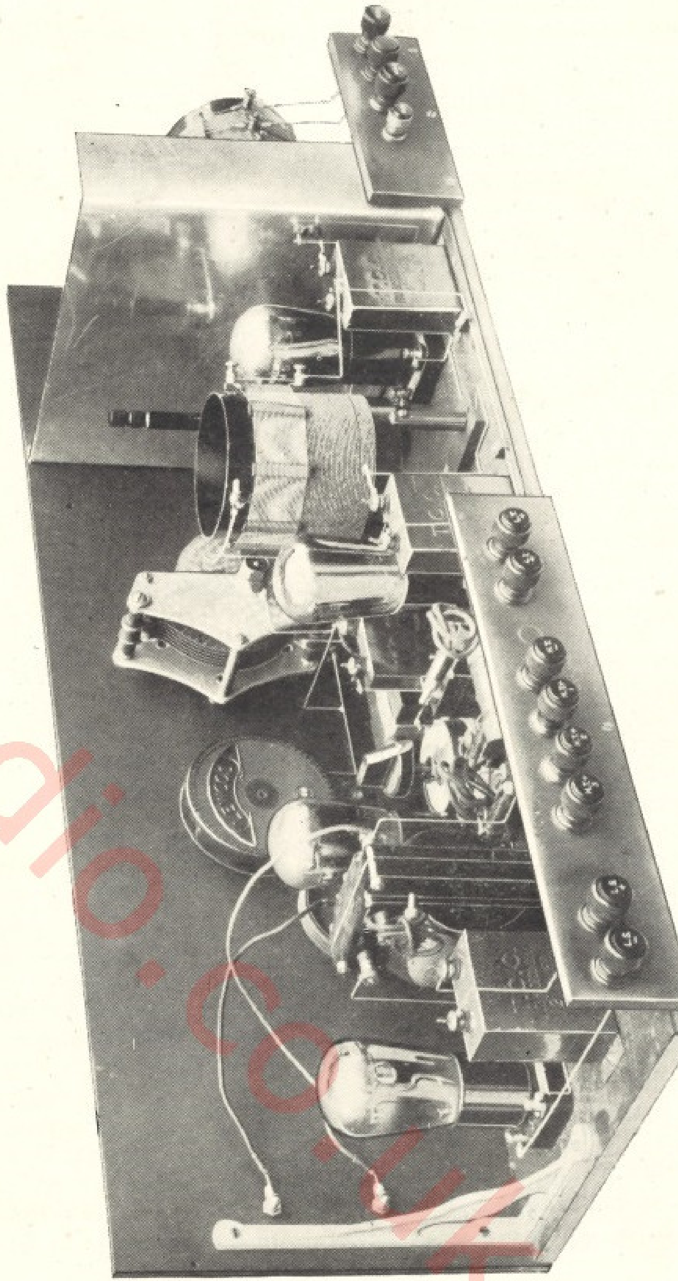
The resistance-capacity method offers the best solution of the problem of coupling the high-impedance detector valve to the L.F. amplifier. Due to the fact that improved valves are now available, it has been found possible to reduce the anode resistance R_3 to 250,000 ohms, and at the same time to retain ample magnification. Coupling condenser C_3 has a value of 0.005 mfd., and the grid leak R_5 is of 2 megohms. This combination gives high amplification, and low-frequencies are amplified to practically the same extent as the frequencies of about 1,000 cycles. The interesting thing here is the amplification of the higher frequencies, for when high resistances are used the effect of stray and valve capacities is of considerable importance.

LIST OF PARTS.

- 2 Variable condensers, 0.0003 mfd. (Igranic).
- 2 Vernier condenser dials (Burndept).
- 2 Rheostats, 2 ohms and 30 to 60 ohms (Burndept).
- 1 Potentiometer, baseboard mounting (Igranic).
- 2 Condensers, 1 mfd. (T.C.C.).
- 1 Condenser, 0.25 mfd. (T.C.C.).
- 1 Condenser, 2 mfd. (T.C.C.).
- 1 Balancing condenser (Gambrell Neutrovernia).
- 1 L.F. transformer (Ferranti A.F.3).
- 1 Dry cell, T. size (Siemens).
- 2 Dry cells, O. size (Ever-Ready).
- 1 Semi-variable condenser, 0.0005 mfd. (Formo).
- 1 Fixed condenser, 0.005 mfd. (Dubilier).
- 1 Grid leak, 2 megohms (Dubilier).
- 2 Grid leak holders (Dubilier).
- 1 Resistance, 100,000 ohms (Ediswan).
- 1 16-volt grid bias battery.
- 50 yds. Litzendraht wire, 27/42 S.S.C. and D.S.C. overall.
- 4 Valve holders (Bowyer-Lowe).
- 2 Paxolin tubes.
- 11 Ebonite-shrouded terminals (Belling Lee).
- 2 Dial indicators (Belling Lee).
- 1 Ebonite panel, $26 \times 8 \times \frac{1}{4}$in.
- 2 Panel brackets.
- 1 Cabinet and baseboard (Camco).
- 1 On-off switch (Wearite).
- 1 Plug-in coil, No. 200 (Lewcos).

(Other components may be used, provided they have similar characteristics.)

The stray and valve capacities shunting the resistance are much greater under working conditions than the static values of the capacities because of the amplifying property of the valve; further, it is necessary to shunt the plate circuit resistance with a condenser C_6 to limit the amount of high-frequency current which passes to the next low-frequency amplifying valve and also to improve the rectification efficiency of the detector. We would, therefore, expect to find that the higher notes of audio-frequency are reduced in strength. This is certainly the case, as can be seen by calculation, but it was also found that the effect of connecting a fairly large condenser across R_6 increased signal strength to a very marked extent. This strengthening of signals increases with increase of shunting capacity up to some 0.0005 mfd., so it was decided to fit a semi-variable condenser which may be set at a comparatively low value for short-distance work, giving maximum response on the higher audible frequencies, and increased to full capacity when the utmost sensitivity is required for long-distance reception. Generally speaking, however, it will be possible to find an all-round adjustment which will give more than sufficient sensitivity,



View of the completed set from the output end.

and at the same time will not lower the treble enough to be aurally perceptible. In any case, the adjustable by-pass condenser affords the most convenient method of making a happy compromise between even response and high sensitivity. Two other methods are open to us; we can use a fixed condenser of from 0.0001 to 0.0005 mfd., chosen to suit our taste and requirements, or else fit a plug-in condenser, which may be changed to meet the needs of the moment.

When using a low value of anode by-pass capacity, an appreciable and undesirable H.F. voltage may be applied to the L.F. amplifier; this is prevented by the insertion of a damping resistance R_4 of 100,000 ohms—an addition to the original design made necessary by the use of a semi-variable capacity at C_5.

The third valve is of the type having an amplification factor of about 20, and its grid has a negative bias of 1.5 volts from GB_3, the anode voltage being 120. In its anode circuit is connected a Ferranti 3.5 : 1 transformer, the inductance of the primary winding of this transformer being 80 henries. The anode current is less than 2 milliamperes, and an amplification of about 70 is obtained. This is a very high amplification, and it should be noted that the amplification-frequency curve will be rather better at the low-frequency end of the scale than that shown by the makers if we use a valve of below 30,000 ohms A.C. resistance. Valve V_4 should be a "super" power valve working with a high plate voltage and a grid bias of at least negative 12 volts.

Construction of the High-frequency Coils.

Coil T_1 stands horizontally in the set, and comprises a base of wood 4in. × 1in. × ¼in., with two ebonite supports ⅜in. in diameter and 1½in. long. These supports are drilled and tapped 4B.A. at each end. The coil itself is wound on a Paxolin former 3in. in diameter × 3½in. long, and has 68 turns of 27/42 Litzendraht wire wound with the turns touching; the ends are terminated at tags held by small screws and nuts. Over this winding and at the earth end are placed 8 ebonite spacers (Fig. 2), cut from a length of ebonite tube 3in. in diameter with ⅛in. wall. These can be held by a rubber band; one of the spacers has three No. 8B.A. countersunk headed screws, which

are held in position by nuts. The primary winding is wound of No. 30 D.S.C. copper wire in the same direction as the secondary, and has 14 turns, with a tap at the eighth turn. Details are given in Fig. 2.

The high-frequency transformer shown in Fig. 2 is also mounted on a wooden base, 4in. × 1in. × ¼in., carrying two ebonite supports ⅜in. in diameter and 1⅝in. long. The secondary winding is of 68 turns of No. 27/42 Litz wire and eight ebonite spacing strips are placed over its low-potential end. Reference to Fig. 2 will show that three of these strips have small screws attached, one strip having a screw at either end and two strips having a screw at one end. The primary winding commences at the terminal marked +H.T., Fig. 2, and has 15 turns of No. 40 D.S.C. wound in the same direction as the secondary, the end of this winding being terminated at the screw marked "Plate." The turns are wound 16 to the inch. The neutralising winding is now put on; this winding is commenced at the screw marked NC. The wire is passed round the former and runs in the space between the turns of the primary winding, and terminates at the screw marked +H.T. The two primary windings have 15 turns each of No. 40 D.S.C. copper wire. Great care must be taken not to short-circuit the primary and balancing windings, or to allow a contact between the heads of the connection screws and the Litzendraht wire; the screws must be well countersunk.

The Ebonite Front Panel.

This panel measures 26in. long × 8in. high and is ¼in. thick. On it are mounted the two square law tuning condensers of 0.0003 mfd. capacity, and the two filament rheostats R_1 and R_2 of 2 and 30 ohms respectively (50 ohms if V_1 takes a filament current of 0.1 ampere); the 2 ohms rheostat is the one mounted on the right-hand side of the panel, and the 30 ohms rheostat is mounted between the two tuning condensers. On the extreme right-hand side two terminals for the telephone connections are mounted. Just above the two tuning condensers will be seen two holes; these are to take a name plate and pointer.

The Baseboard.

With the high-frequency transformers made and the parts assembled on the ebonite front panel, as described above, it only remains to screw the parts to the baseboard before the wiring can be started. The baseboard measures 26in. × 8in. × ½in.

In addition to the components, such as transformers, condensers, and resistances, which are screwed to the baseboard, it is necessary to fix a screen of copper or aluminium, Fig. 7, between the two high-frequency transformers. This screen can be made from a sheet of about No. 24 gauge. Its lower edge is turned over so that it can easily be screwed to the baseboard, and the top is bent over to remove the sharp edge; also, one end is bent over so that it can be screwed to the panel. A hole is drilled opposite the grid connection of V_1, further holes being drilled to take a 4B.A. screw for earthing and to pass the wire from A_3, as shown in the wiring diagram, Fig. 6.

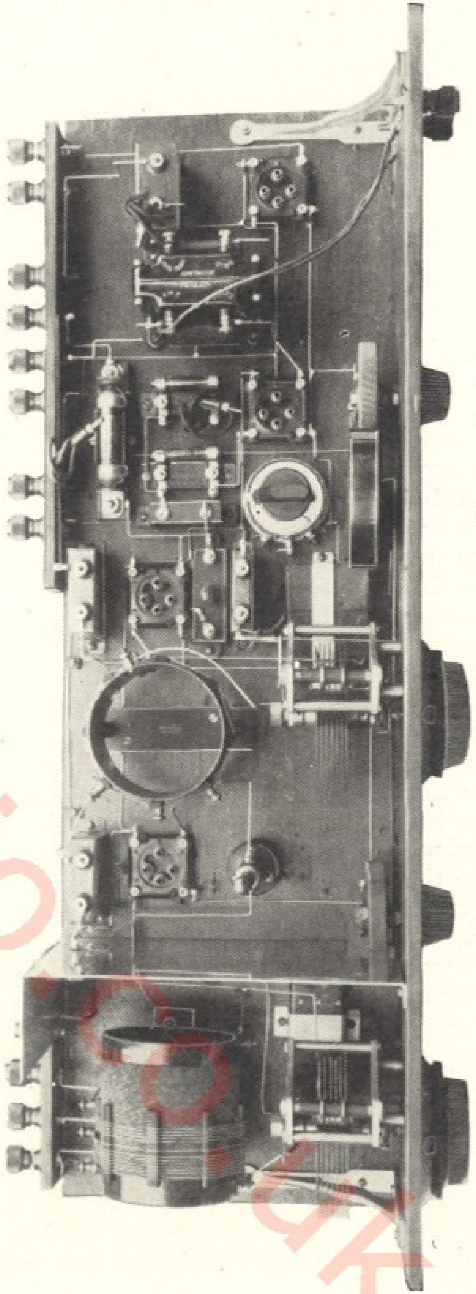
It is necessary to cut a small piece out of the edge resting against the ebonite panel to clear the rheostat used as the volume control.

The balancing condenser is raised above the level of the baseboard by three short lengths of ebonite tube, ¾in. long and ½in. in outside diameter, through which the securing screws are passed into the wood. This is a refinement which is not strictly necessary, but it is of advantage to raise the operating handle of the condenser to a more convenient position.

Finally, a piece of wood about ½in. thick, or pieces of ebonite may be placed below each valve holder; this is to raise the valve holder connections well above the baseboard, and is a great convenience, as it enables the filament wires to be run along the baseboard in a neat and orderly fashion.

Wiring Hints.

The important thing in a set of this type is to run the wires in such a way that there is no risk of moving them when inserting or withdrawing valves. It is, therefore, convenient to put all the filament wires and other power wires in Systoflex, and to run them along the baseboard and to bring them up at the valve contacts, rheostats, etc. Wires connecting the filament side of the condensers, the earth, and battery wires should also, as far as possible, be run along the baseboard. Only the wires connected to the grids of the valves and the high-frequency portions of the receiver should be run clear and in straight paths.



Plan view of the receiver which shows the wiring very clearly.

It should be noticed that the grid wire for V_1 passes through the copper screen, so that it must be insulated, and that the screen has three other (earth) wires connected to it. The cases of all by-pass condensers may be earthed.

There are three flexible wires, which are for connecting the grid bias battery. This battery is fastened, by means of two brass straps, or in any convenient manner, to the back of the cabinet just above the battery connection strip. These three wires, which are shown in the wiring diagram, are marked $+GB$, $-GB_3$, and $-GB_4$, and can be cut to the correct length after the set is placed in the cabinet.

Testing.

The H.F. valve and the first-stage L.F. amplifier are supplied with high-tension through terminal $H.T.+_1$, the detector through $H.T.+_2$, and the output valve through $H.T.+_3$. It is essential, if performance is to equal that of which the set is capable, that the valves should be carefully chosen in accordance with the information given below. The L.T. battery voltage applied will of course depend on filament characteristics; it should be noted here that 6-volt valves are, in the nature of things, better than those with 2-volt filaments.

For the H.F. transformer described, a valve having an A.C. resistance of 20,000 to 30,000 ohms should be used in the H.F. position, that is at V_1, and this valve should have the highest amplification factor for the best results. As an example, a valve of 25,000 ohms A.C. resistance with an amplification factor of 20 will give exactly twice the H.F. amplification for equal selectivity as another valve of 25,000 ohms having an amplification factor of 10.

For the detector position a valve having a high amplification factor is required; by high is meant 30 or more, although it is realised that a valve having a lower amplification factor such as 12 or 15 can be used successfully. But, generally speaking, the strongest signals will be obtained when a valve having an amplification factor of more than 25 is used.

In the first low-frequency position, at V_3, a valve having an A.C. resistance of not over 30,000 ohms should be used; this is because a low-frequency transformer is employed, and the particular instrument used was designed to work

with a valve of 30,000 ohms or less. Here again it is important to choose a valve with a high amplification factor as this directly affects the amplification obtained, and, therefore, the signal strength. As an example, if a Marconi D.E.R. is used (this valve has an amplification factor of 10), the low-frequency amplification obtained is 35, whereas if a Marconi D.E.5b is employed (amplification factor 20) the low-frequency amplification is 70.

Connect the earth to terminal E and the aerial to terminal A_2, and tune in the local station. Adjust the voltage applied to the detector; about 90 volts is usually satisfactory. Probably the set will oscillate. To stop this it is only necessary to adjust C_4, the filament rheostat and volume-control rheostat being full on.

This condenser should be so set that the receiver does *not* oscillate at any wavelength, and a very good method to adopt is this. Tune in the local station and turn off the first valve by means of the volume-control rheostat. This station will probably still be heard at good strength. Now adjust the balancing condenser until the signal disappears. At this position of the balancing condenser the set is perfectly balanced. Now we do not wish to have a perfect balance; we wish to take advantage of the regenerative effects of the high-frequency inter-valve transformer, and yet not allow the input circuit to oscillate.

This can be done by turning on the volume control rheostat and tuning in a distant station; now slightly reset the balancing condenser, and notice whether the receiver oscillates. If it does not, make a further adjustment until the set is in its most sensitive state, *but not oscillating*. Tune in a signal at the lower as well as the higher wavelength end of the tuning dials, and make sure that there is no sign of self-oscillation. This adjustment is quite a simple one to make, and should only take a few minutes; *once it is made there is no further need to touch the balancing condenser unless the first valve is changed.*

The set will be found to be perfectly stable when the balancing condenser is correctly set; in fact, absolute stability can be obtained with the aerial and earth removed from the set.

The potentiometer must now be adjusted to give maximum response; this operation is best carried out when listening to weak signals; those from the local station may be artificially weakened for this purpose by detuning.

To receive Daventry, transfer the aerial to terminal A_3, open the switch, and tune with condenser C_2. This is the right-hand one. Rheostat R_2 can be turned off, as the first valve is not used when receiving Daventry.

If the receiver is turned full on when receiving the local station the valves are almost certain to be grossly overloaded. It is usually necessary to detune the aerial circuit and to turn down the volume control to avoid overloading, which has the effect of making the quality very bad. The strength of the signals which can be satisfactorily handled depends almost entirely on the fourth valve, assuming the loud-speaker to be a good one. For this reason the fourth valve should be given ample H.T. and grid bias. The H.T. should never be less than 120 if really satisfactory loud-speaker signals are required.

Among suitable valves are the following :—

Make.	H.F. (V_1).	Det. (V_2).	1st L.F.(V_3).	Output (V_4).
Two-Volt Valves.				
Cossor	210 H.F.	210 R.C.	210 H.F.	215 P.
Marconi-Osram .	—	D.E.H.210	D.E.L.210	D.E.P.215 or D.E.P.240
Mullard	P.M.1 H.F.	P.M.1A.	P.M.1 H.F.	P.M.2 or P.M.252
Four-Volt Valves.				
Cossor	410 H.F.	410 R.C.	410 H.F.	410 P.
Marconi-Osram .	—	D.E.H.410	D.E.L.410	D.E.P.410
Mullard	P.M.3	P.M.3A.	P.M.3	P.M.4 or P.M.254
Six-Volt Valves.				
Cossor	610 H.F.	610 R.C.	610 H.F.	610 P.
Marconi-Osram .	D.E.5b	D.E.H.610	D.E.L.610	D.E.P.610 or D.E.5a
Mullard	P.M.5X.	P.M.5a	P.M.5X.	P.M.6 or P.M.256

Valves of an impedance closely approximating to that for which the H.F. transformer is designed should always be used under normal conditions, but at distances of five miles or less from a powerful broadcasting station it is recommended that a so-called "R.C." valve should be used as a high-frequency amplifier, in order that greater selectivity may be obtained. Such valves need ample H.T. voltage, and seldom more than ¾-volt grid bias. The Cosmos S.P.50b, which is particularly suitable, requires no bias; thus G.B.1 may be omitted.

It is advisable to employ an anode battery of ample size, and in all cases the best results will be obtained when the voltage applied to the anode of the fourth (output valve) is of the order of 150. The manufacturers' instructions regarding the proper grid bias should be adhered to in most cases, but it has been found by experience that many manufacturers indicate too large a grid bias for a given anode voltage; they assume that the effect of the load in the anode circuit is to make the working characteristic longer and straighter than the static characteristic. This is so provided the load in the anode circuit is of sufficient magnitude, but if low tones are to be reproduced and the loud-speaker connected in the output circuit is of normal design, the straightening effect at the lower frequencies is very small indeed, and it is advisable to choose a grid bias which is only slightly more than half the permissible grid swing as shown by the static characteristic curve.

Really loud, undistorted results cannot be obtained if the anode battery is of small size, having, say, a voltage of 100. Neither will the set be used to the best advantage with a small type loud-speaker. Such an instrument is easily overloaded and cannot possibly do justice to the set.

When receiving the local broadcast station it is easy to overload even a "super" power valve connected in the output stage. For this reason it is necessary to tune very carefully; sometimes it is essential to turn the aerial tuning condenser—that is, the left-hand one—to 180°; to turn down the volume control; and to set the right-hand tuning condenser for the best quality. In other words, the latter condenser is set to tune the high-frequency transformer to the wavelength of the station, but the aerial circuit is suitably de-tuned and the volume-control rheostat is turned down. The object of this is to prevent the high-frequency valve rectifying and to stop overloading the last valve in the set.

A gramophone pick-up may be used with this receiver in a very simple manner. It is connected by a flexible lead to a standard coil plug, which is inserted in place of the Daventry loading coil L_1. The H.F. valve is extinguished, and the negative bias applied to the detector valve (which now becomes an L.F. amplifier) is reduced to half its previous value by rotating the potentiometer slider towards that end of the winding which is connected to L.T.+.