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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

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EDITORIAL COMMENT

Television Demonstrations

Need for Propaganda

NOW that daily television test transmissions are taking place and we are only about a month from the date when it is proposed that the B.B.C. shall commence regular experimental television programmes, it is pertinent to ask what is being done to ensure that the public will have ample opportunities for seeing what is being done.

It may be assumed that dealers in different parts of London and the outskirts, as well as the large stores, will arrange to have television sets installed so that they can demonstrate to prospective purchasers. But this, although useful is not enough, because many people hesitate to enter a dealer's premises unless they have some intention of purchasing. Arrangements must, we feel, be made so that the public can see television demonstrations without any obligation, and to do this it seems necessary that reception points should be arranged by bodies not directly interested in the sale of particular television receivers.

Publicity Committee

One suggestion would be that a Television Publicity Committee might be formed jointly by those manufacturers who will market television sets to arrange for public demonstration rooms on the lines of the combined effort which made possible the recent television demonstrations at Olympia in connection with the Radio Show.

A year ago we said: "We hope arrangements will be made in good time so that when the transmissions start the public will be able to attend demonstrations in all parts of the service area of the station without difficulty." We believe that to-day it is still most important that these facilities should be available, since a foretaste of television has been given at Olympia. There is nothing to gain by a delay until we find out how much interest the public displays in something they have no means of seeing for themselves.

It cannot be expected that members of the public in large numbers will put down nearly a hundred pounds for a television receiver until they are reasonably satisfied as to the type of programme and entertainment which is to be offered to them.

The technical perfection and ultimate success of television must depend upon a sufficiency of sales of receivers to provide the means for meeting development expenses. The firms which are now working on the subject are expending very large sums of money, and their return will be in proportion to sales.

If the B.B.C. programmes fail to attract, sales of sets will be small and technical development will be retarded, if not stopped altogether.

It is fortunate that, in this country, the B.B.C. can put out the programmes without being concerned with the question of direct financial return. In America, as we have pointed out before, the fact that programmes are sponsored by advertisers means that television transmissions are not likely to start until the advertisers can be guaranteed a large enough "audience" of lookers-in in possession of sets—a situation which seems to promise a complete deadlock, unless manufacturers themselves are prepared to shoulder the burden of programme expenses until an audience has been created.

Parallel Wires as RF Transformers

A PRACTICAL METHOD OF MATCHING FEEDER AND AERIAL

By F. R. W. STRAFFORD
(Research Dept., Belling and Lee, Ltd.)

As the author of this article points out, the physical size of wave aerials used at television frequencies is so small that most experimenters have facilities for installing them. The use of a pair of parallel wires as a coupling transformer for linking such aerials to a feeder line is described.

IT may come as a shock to the technically complacent to learn that it is not necessary to visualise a compact coil arrangement for radio-frequency transformers. At frequencies from 30 megacycles (10 metres wavelength) upwards it is a practical proposition to erect an aerial whose lead-in system is impedance-matched by means of a transformer comprising a pair of parallel wires.

When it is practicable to erect aerials whose dimensions are not less than one-quarter of the wavelength to be received a fairly new technique in aerials and their correct impedance termination is introduced. A vertical wire approximately 3.5 metres in physical length erected well clear of the earth and other conductive surroundings will resonate sharply under the influence of a signal of which the wavelength is 7 metres. This half-wave dipole, as it is called, is highly efficient at this particular wavelength and could not be improved upon by an inverted L of maximum Post Office dimensions.

The efficiency of a half-wave dipole, however, falls off very rapidly at wavelengths above and below that of the resonant condition, but this is a useful behaviour in that it reduces the strength of unwanted interference mainly located at other wavelengths. Naturally one has in mind the specific use of such a dipole at the television wavelengths, which are close enough together to enable one dipole to work efficiently on both the sound and vision wavelengths respectively. Fig. 1 depicts a simple vertical half-wave dipole (heavy line). When influenced by signalling waves of twice its linear dimension of length the dipole resonates sharply and standing waves of voltage and current are produced along it. One of the dotted lines shows the variation of HF voltage amplitude along the dipole, indicating that it is a minimum at the centre and maximum at either extremity, and in instantaneous phase opposition at any equidistant point from the centre. The other dotted line shows the current amplitude distribution, which is maximum at the centre of the dipole and falls substantially to zero at the two extremities.

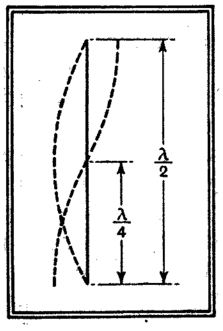

Fig. 1.—Distribution of current and voltage in a dipole aerial.

It may be proved mathematically that the impedance at the centre of a half-wave dipole remote from earth is approximately 73 ohms, but this value is liable to considerable variation when the dipole is closer than one half-wavelength to a highly conductive earth. This value of centre impedance is termed the radiation resistance of the dipole, and it is this value multiplied by the square of the current at the centre of the dipole which represents the amount of HF energy which is being dissipated in the dipole.

In order to couple a half-wave dipole to a receiver or transmitter (the technique for either is similar) it is at once clear that the impedance of the dipole must be appropriately matched to the coupling networks if maximum transference of energy is to be obtained between the aerial and the receiver. Such a system, moreover, must exert no influence upon the dipole as such, and must therefore be incapable of acting as an aerial itself. An ordinary single wire lead-in will not fulfil these requirements with half-wave dipoles, but the transmission line will.

A transmission line, perhaps better known as a feeder, consists of a pair of conducting wires of uniform cross-sectional area and spacing, insulated from one another by suitable means. Two types of feeders are in general use. There is the open wire type, consisting of two parallel wires (Fig. 2*a*) of 14-2 SWG copper wire spaced at anything from one to ten inches apart. The other type is known as the co-axial feeder (Fig. 2*b*), and consists of a wire or rod running through the centre of a metal tube and supported therein by suitable insulating spacers. Basically there is no difference in the properties of either type excepting that certain electrical characteristics are more easily obtained in one than in the other according to certain requirements which will be discussed later.

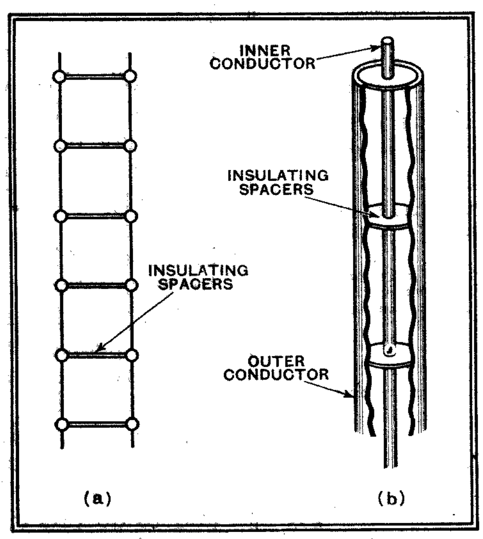

Fig. 2.—Alternative types of feeder for linking an aerial with its associated apparatus.

Now while the feeders depicted in Fig. 2*a* and Fig. 2*b* are of simple physical construction their equivalent electrical network and subsequent behaviour to alternating potentials applied at one end is extremely complex. Fig. 3*a* shows that such a feeder may be represented as an equivalent filter network in which L and R are the series inductance and resistance per unit length of the conductor, M is the mutual coupling between L, while C and R are the parallel capacity and leakage resistances between the conductors per unit length.

When an alternating EMF is applied across one end of a feeder it is thus quite obvious that the same amplitude of EMF is unlikely to appear across a valve voltmeter at the other extremity, particularly if such a feeder is, say, 1,000 feet in length and the frequency of the applied EMF is as high as, say, 50 megacycles (6 metres). Each condenser is charged and discharged across R, and through its neighbouring L, R and C, so that one must visualise a wave of EMF surging along the

Parallel Wires as RF Transformers—

line at some finite speed. An interesting experiment which clearly indicates the behaviour of feeders whose length is greater than the wavelengths of applied EMF's may be conducted by using the circuit arrangement in Fig. 3*b*. A number of flashlamp bulbs of equal rating are placed at random distances along the feeder, which must be long compared with the wavelengths of the oscillations from the generator V*g*. These bulbs must, however, be opposite in pairs. The resistance R must be substantially non-reactive and variable between 50 and 1,000 ohms. The feeder wires should be about 20 SWG copper wire spaced approximately four inches apart. With R set to 1,000 ohms the output of V*g* is adjusted until the lamps glow.

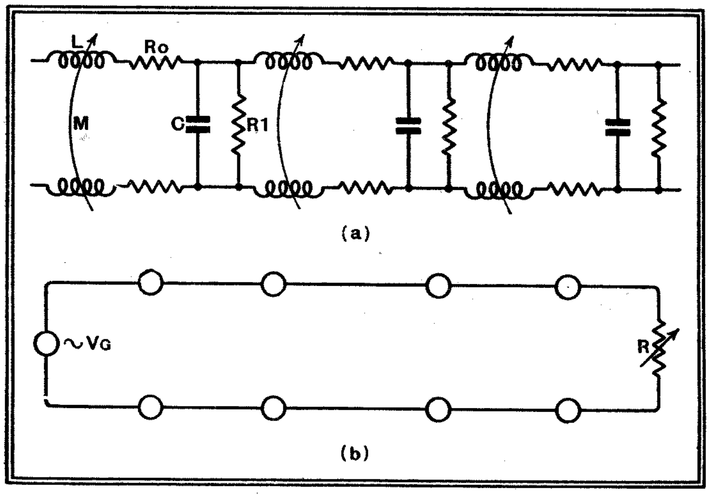

Fig. 3.—A feeder may be represented as a filter network, as in diagram (*a*). Diagram (*b*) in which the circles represent flashlamp bulbs inserted in the lines, shows a method of experimentally determining the behaviour of a feeder.

Indication of Matching

It will then be noted that while opposite pairs of lamps glow with uniform brightness there is quite a random distribution of brightness along the line. For example, a pair of lamps in the centre of the line may be dimly glowing, while pairs situated at either extremity may be glowing brightly. It is quite obvious that the current through the feeder is by no means uniform throughout its length. If the resistance R is now reduced slowly a critical value will be found at which all lamps glow at approximately equal brilliance, there being a slight but progressive diminution of intensity as the distance from the generator increases. Under this condition of resistance termination to the feeder is said to be non-reflecting and matched to the load resistances. It may be shown mathematically that the value of this resistance is very nearly equal to $\sqrt{\frac{L}{C}}$ of the feeder, Fig. 3*a*. This value is termed the surge impedance or characteristic impedance of the feeder. Naturally this varies with the linear dimensions of the feeders, so that there is a correct value of terminating impedance for every feeder such that this value is equal to the surge impedance of the feeder. Under these conditions the current flows uniformly down the feeders with a slight but progressive diminution in intensity which depends mainly upon R, and the frequency of the EMF it is desired to transmit. Naturally as R becomes lower and the frequency higher the attenuation constant for the feeder becomes greater. It is possible, however, to design an open-wire feeder to have an attenuation of less than 1 decibel per hundred feet of length at 6 metres (50 megacycles), while the same value may be obtained with co-axial feeders by very careful design. In general, the attenuation per unit length of a co-axial feeder will be greater than that of the open-wire type.

The value of the surge impedance Z_o of any feeder which is air spaced may readily be calculated from the formula:—

$Z_o = 276 \log_{10} \frac{d}{r}$ ohms for the open-wire type.

$Z_o = 138 \log_{10} \frac{r_2}{r_1}$ ohms for the co-axial type.

Where

d = Distance between wires.
r = Radius of wires.
r_1 = Radius of inner conductor.
r_2 = Radius of outer conductor.

It will be found impracticable to construct an open-wire feeder with a surge impedance of less than 100 ohms, and it is here that the co-axial feeder may be substituted, since surge impedances ranging from 20 to 100 ohms may be obtained with comparative ease of design. An additional advantage of the co-axial feeder is that its outer cover may be earthed to prevent electrical shocks, or the whole feeder may be completely buried, a useful property in the case of long-distance lines.

Having discussed the half-wave dipole and the feeder as separate entities, it now remains to consider how the two may be associated so that a correct impedance matching results, and at the same time the properties of the dipole are not destroyed.

If a feeder whose surge impedance is 73 ohms is connected in the centre of a half-wave dipole (Fig. 4*a*), a perfect match results, since it was pointed out earlier that this is the radiation resistance of a half-wave dipole remote from conductive surroundings.

This type of aerial is known as a doublet, and is extremely effective in either the vertical or horizontal position at the wavelength for which it is designed. A piece of tightly twisted lamp flex may be used for the feeder, since its surge impedance is in the region of 73 ohms, although mostly on the high side, depending largely upon the dielectric constant of the insulating material being greater than unity (assumed for other calculations), and the inductance per unit length is a function of the twisting of the conductors as they overlap. The value must, therefore, be measured by the use of suitable inductance and capacity bridges.

High-Impedance Feeder

Fig. 4*b* shows the mode of connection for a feeder whose surge impedance is greater than 73 ohms (e.g., 400 ohms). In this case it must be connected between two points equidistant from the centre of the dipole at which the impedance is equal to that of the feeder. These points are best established experimentally by exciting the aerial by an oscillator and placing two flashlamp bulbs one-quarter wavelength apart in any one conductor of the feeder. The tapping on the dipole is then adjusted so that the lamps glow with equal brilliance, in which case the matching is correct and the feeder is thus correctly terminated.

Although it has been stated that the presence of a correctly matched feeder does not influence the proper functioning of a dipole, this is only strictly true if the feeder is taken away at right angles to the dipole for some distance not less than one-half wavelength. If the feeder is arranged so that it runs parallel with the dipole, and

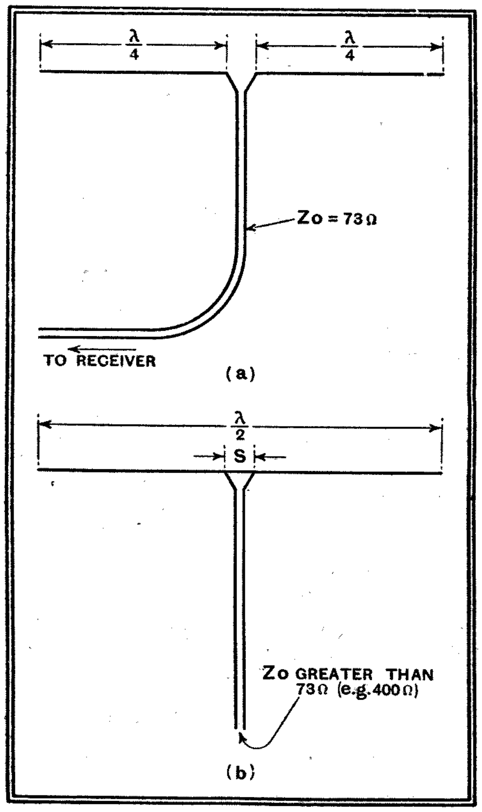

Fig. 4.—Alternative methods of connecting a feeder.

is closer than one-quarter wavelength to it, there is a possibility of endowing the dipole with marked directional effects and also possible difficulties in the way of obtaining a precise impedance match.

The foregoing has dealt with dipoles and

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feeders generally in which the impedance matching of the two has been carried out without the use of transformers, but by connecting the feeder at or near the centre of the dipole.

Supposing that it is inconvenient from a structural viewpoint to connect the feeder to the centre of a typical half-wave dipole erected vertically in a garden. The end of the dipole presents an impedance of approximately 5,000 ohms at either end at 7 metres, assuming that a substantial gauge of copper wire is used and the aerial is well insulated from supporting ropes, etc. It will be found a practical impossibility to construct a feeder with a surge impedance of 5,000 ohms, so that recourse to some transformer scheme must be made, whereby a low-impedance line may be accurately matched to the end of a half-wave dipole. Take, for example, a typical case of a 75-ohm co-axial feeder which is buried for the length of the garden, and which is to terminate on the lower end of a half-wave vertical dipole suspended above it. It is a case of matching 75 ohms to 5,000 ohms without introducing any factor to influence the performance of the dipole in an adverse manner.

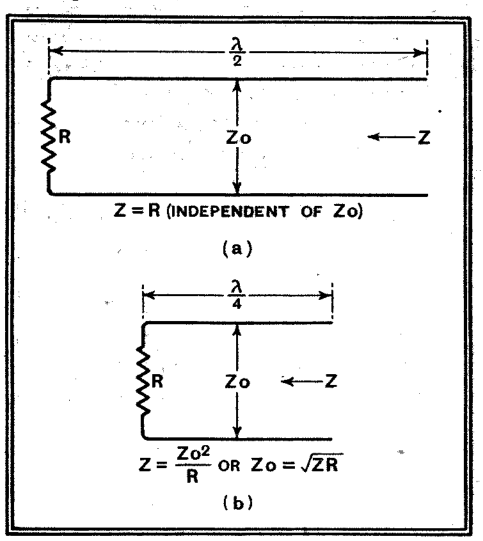


Fig. 5.—Half-wave and quarter-wave feeders.

An appropriate matching may be made by means of an additional feeder of certain length and characteristic impedance. This feeder is termed a quarter-wave transformer, and is highly efficient at the one wavelength for which it is designed.

Before dealing with this type of transformer, reference must be made to Figs. 5*a* and 5*b*, in which feeders are accurately cut to one-half and one-quarter wavelength respectively. R is the terminating load, which is 5,000 ohms in the case of the vertical dipole contemplated. Z_o is the characteristic impedance of the feeder, while Z is the impedance which must be placed at the other extremity of the feeder to ensure correct matching to the load R. In the case of the half-wave feeder, Fig. 5*a*, it can be proved that Z is entirely independent of R, so that in the case of a doublet aerial it does not matter what type of feeder is used providing its length is the same as that of the doublet itself,

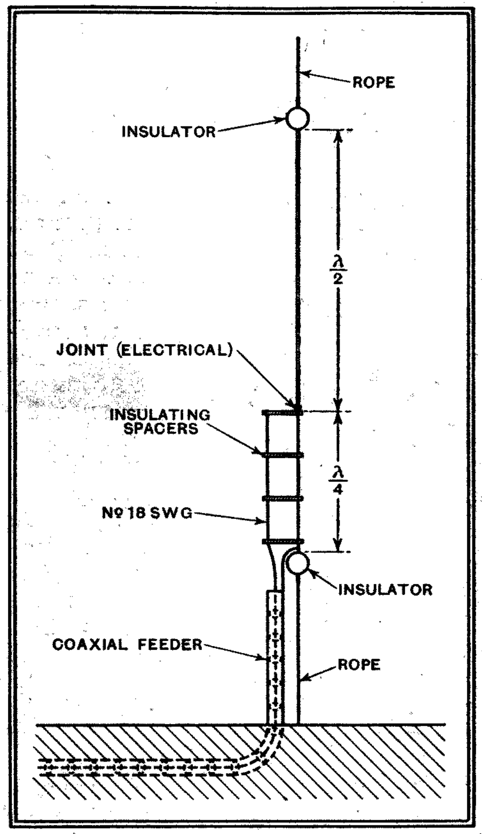


Fig. 6.—Practical arrangement of a system of linkage in which a quarter-wave parallel-wire feeder is used as a coupling.

namely, $\lambda/2$. Fig. 5*b* is far more interesting. The correct impedance Z is now in function of Z_o and R, so that if Z and R are fixed it is merely necessary to obtain Z_o from the formulæ shown in order to obtain the correct matching.

In the case considered, R is 5,000 ohms and Z is 75 ohms. For this formula $Z_o =$ 610 ohms. From the original formula for Z_o, the surge impedance of open wires, it is found that a value of 610 ohms may be obtained by the use of two wires of 18 SWG spaced four inches apart.

Fig. 6 is the structural arrangement for carrying the proposals into effect, and by which a 75-ohm co-axial feeder is correctly matched to a half-wave dipole at the 5,000-ohm impedance point for maximum efficiency on 7 metres.

The method of matching by means of quarter-wave feeders is well known and used by certain communication companies in their transmitting aerial arrangements for short-wave work from 10 metres upwards, but a wide field of experimental aspect at the television frequencies is open to those who possess an average garden, since the dimensions are such that simple structures may be easily erected.

Notes on Contrast Expansion

IN the above article, published in *The Wireless World* of September 18th, the paragraph at the foot of col. 2 should begin "We can now call *minimum* desired attentuation A1 and *maximum* A2 . . ."

Similar transpositions took place in col. 3, where line 11 should read "Taking A1 (*maximum* volume) . . ." and line 24, "Taking A2 (*minimum* volume), *maximum* attenuation. . . ."

For the Short-wave Enthusiast

Short Wave Wireless Communication (Third Edition). By A. W. Ladner, A.M.I.C.E., and C. R. Stoner, B.Sc., A.M.I.E.E. Pp. 453 + xiv, 11 plates and 248 other illustrations. Chapman and Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 21s.

TO those who have not seen either of the two earlier editions this volume may justifiably be introduced as the standard British textbook on the subject. And when it is described as a textbook this must not be allowed to call up visions of academic theory set down by out-of-the-world professors. Though the authors are teachers, they are practical engineers, and their work tackles the subject from this standpoint, only the necessary theory being included.

The previous editions have been revised and enlarged to the extent of 70 pages, including an entirely new chapter on commercial wireless telephone circuits. There is a brief history of short-wave work, a concise treatment of wave theory, and chapters on modulation, push-pull, constant-frequency oscillators, high-frequency feeders, aerials, and other aspects of transmission and reception. Ultra-short waves receive special attention in a final chapter, and there are several appendices containing useful data.

Although the book is presumably intended primarily for engineers and students, it should be possessed by every amateur seriously interested in the subject. Incidentally, the authors pay a tribute to the pioneer work of amateurs in demonstrating the possibilities of short waves.

There is a great amount of eminently clear and practical guidance for those concerned with transmission, to which the major part of the book is devoted. Detailed information about receivers, which is abundantly available elsewhere, should not be sought here, but the chapters on feeders and aerials are particularly valuable for reception as well as transmission, and the chapter on propagation should be carefully studied for enlightenment on the peculiar behaviour of waves of various lengths. A short description of the "Single Span" type of receiver is included.

In such a rapidly developing field as this it is inevitable that some of the latest results are missing from even a newly published book, but there seems little excuse for the war-time V24 to be represented as the last word in low-capacity valve construction, when the vastly superior "acorn" has been "out" for a year or two. On the whole, however, the work is up to date, and the further editions that will unquestionably be demanded will no doubt keep it so.

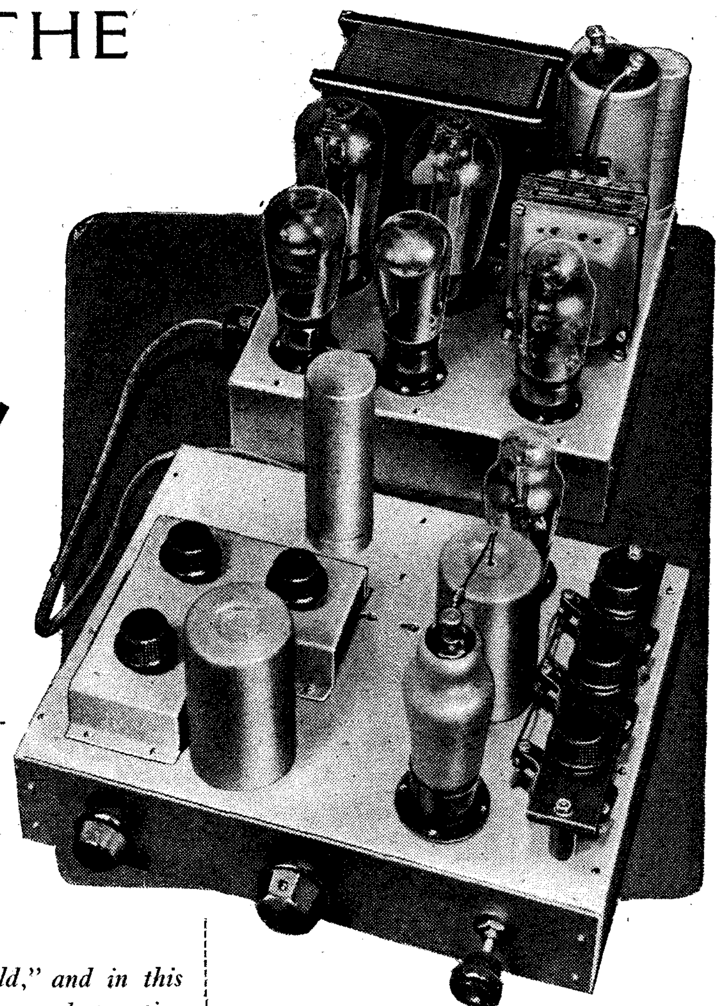
M. G. S.

Motor Cycles and How to Manage Them. Twenty-sixth Edition, 272 pp. Price 2s. 6d. net, by post 2s. 10d. Iliffe & Sons, Ltd., Dorset House, Stamford Street, S.E.1.

The twenty-sixth edition of this book has now made its appearance and deals with all aspects of motor cycling in an extremely lucid style. "Motor Cycles and How to Manage Them" should be invaluable to all enthusiasts.

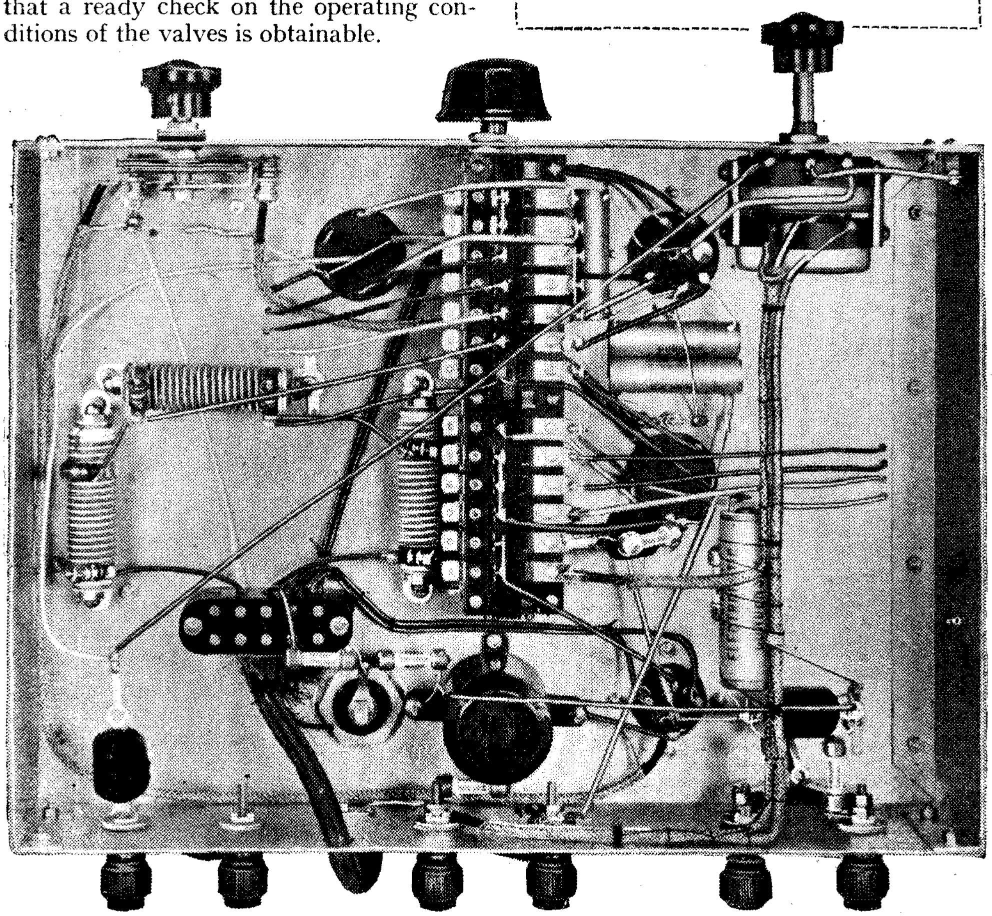
CONSTRUCTING THE *Wireless World* Pre-tuned Quality Receiver

By W. T. COCKING



THERE is little which need be said about the actual construction of the equipment, for there is nothing difficult about it, and full details appear in the various drawings. It should be noted, however, that it is necessary to insulate the spindle of C11 from the chassis. There is, too, nothing difficult about the operation, and a table of the voltages and currents prevailing in the various circuits is given so that a ready check on the operating conditions of the valves is obtainable.

THE theoretical considerations underlying the design of this receiver were discussed in last week's issue of "The Wireless World," and in this article the construction and operation are dealt with.



An underview of the receiver chassis. The multi-way switch can clearly be seen in the centre, with the dual volume control on the right.

When setting up the receiver, set the switch to position 1 (fully anti-clockwise) and tune in one medium-wave station by C2 and C8, using reaction if necessary. Then set the switch to position 2 and tune in another medium-wave station, this time using C3 and C9; lastly, set the switch to position 3 and tune in a long-wave station with C4 and C10.

Adjusting the Receiver

It should always be possible to receive the local stations without mutual interference, although in a few cases where one is received more weakly than the other it may be necessary to employ a little reaction in order to sharpen the tuning while listening to the weaker station. In the case of the third station, the one selected must necessarily be one which is within the capabilities of the set, and it will usually be necessary to use reaction to provide the requisite sensitivity and selectivity. It may sometimes happen that while the sensitivity is adequate without reaction, the selectivity is not; the correct procedure is then to turn down the volume control while increasing reaction so that the volume remains the same and reaction, in effect, increases only the selectivity. For this procedure to be effective it is necessary to perform the initial tuning of the circuits while making use of reaction. It is therefore wise to tune the circuits with the volume control set so that signals are quite weak, and reaction advanced so that the detector is near the oscillation point.

Pre-tuned Quality Receiver—

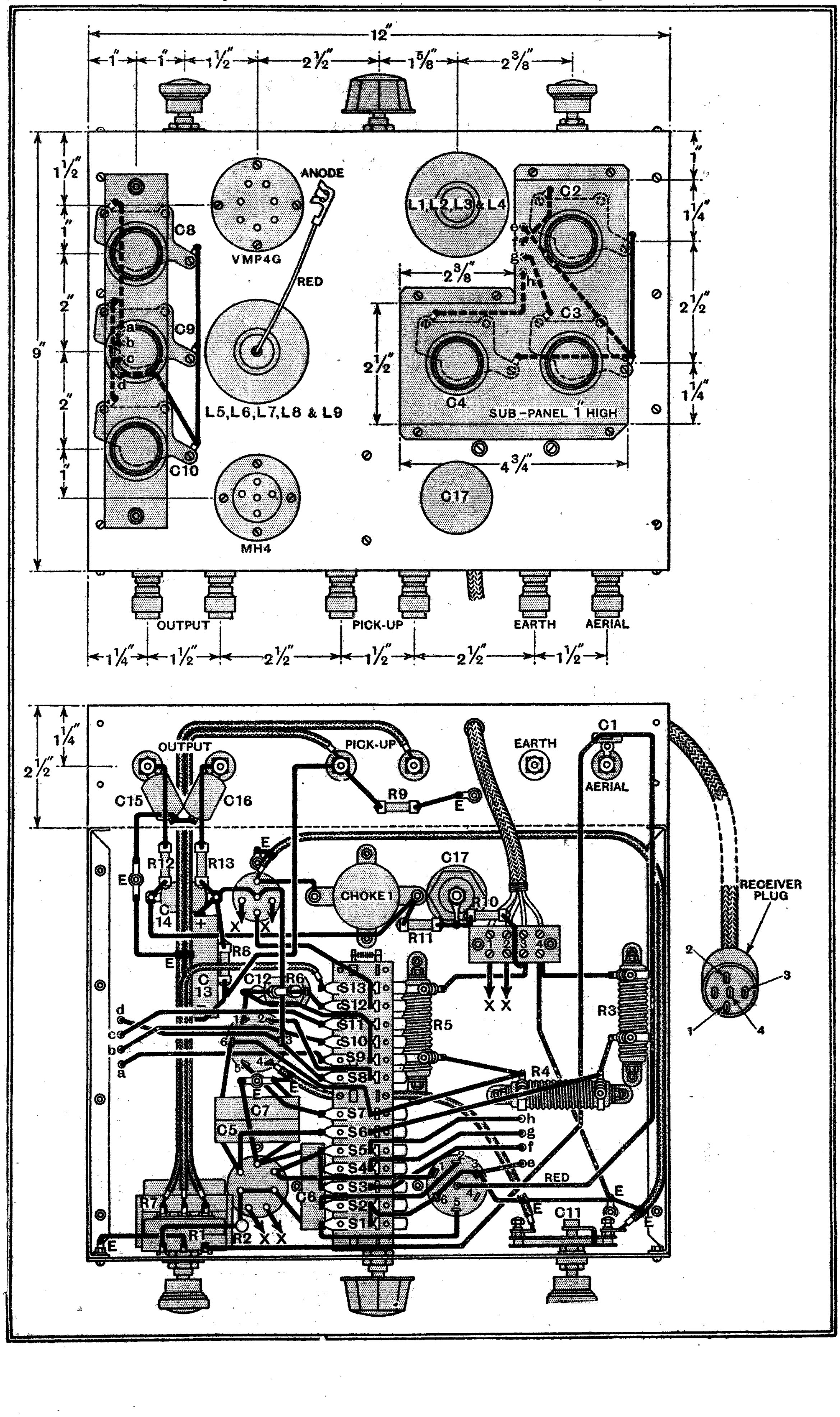
When this is done, only the panel controls need be operated when changing from one station to another. In general, reaction should be at a minimum, the desired station selected by means of the switch, and the volume adjusted to the required level by the volume control. If the sensitivity is inadequate, reaction can be brought into play. If the selectivity is inadequate, however, the volume can be reduced and then brought back again to normal by means of reaction.

A full-size blue print of the wiring diagrams is available from the Publishers, Dorset House, Stamford Street, London, S.E.1. Price 1s. 6d., post free.

It is a wise plan to set reaction at a minimum before changing stations, for it is likely that a setting of this control which is a long way from the oscillation point for one wavelength may be beyond that point for another. Similarly, the volume control should be turned down when turning from a weak station to a strong one, to avoid overloading. In this connection it is worth noting that on a strong signal the volume steadily increases as the volume control is turned up, until a point is reached at which no further increase can be obtained; if, however, the control is turned still further there may actually be a decrease; this being the overload point of the detector, and distortion takes place when it is exceeded.

When tested in London, the two medium-wave circuits were tuned to the London National and Regional transmitters, and the long-wave circuit to Luxembourg, Radio-Paris, or Huizen. At the point of reception the National is considerably weaker than the Regional, and at times it proved necessary to use a trace of reaction to avoid a faint background of the programme of the latter station. Huizen on the long waveband was easily received free from interference, but careful tuning was necessary to obtain Luxembourg or Radio-Paris without a small background from Droitwich; it could be done, however.

An alternative arrangement of the tuning circuits, of course, would be to tune the long-wave circuit to Droitwich and one of the medium-wave to London



Full details of the construction and wiring of the receiver unit are given in these drawings.