The Wireless World

THE PRACTICAL RADIO JOURNAL

28th Year of Publication

No. 1018. THURSDAY, MARCH 2ND, 1939. VOL. XLIV. No. 9

Proprietors : ILIFFE & SONS LTD.

Editor :
HUGH S. POCOCK.

Editorial,
Advertising and Publishing Offices :
DORSET HOUSE, STAMFORD STREET,
LONDON, S.E.1.

Telephone : Waterloo 3333 (50 lines).
Telegrams : "Ethaworld, Sedist, London."

COVENTRY : 8-10, Corporation Street.
Telegrams : "Autocar, Coventry." Telephone : 5210 Coventry.

BIRMINGHAM :
Guildhall Buildings, Navigation Street, 2.
Telegrams : "Autopress, Birmingham." Telephone : 2971 Midland (4 lines).

MANCHESTER : 260, Deansgate, 3.
Telegrams : "Iliffe, Manchester." Telephone : Blackfriars 4412 (4 lines).

GLASGOW : 26B, Renfield Street, C.2.
Telegrams : "Iliffe, Glasgow." Telephone : Central 4857.

PUBLISHED WEEKLY. ENTERED AS SECOND CLASS MATTER AT NEW YORK, N.Y.

Subscription Rates :
Home and Canada, £1 10s. 4d. ; other countries, £1 12s. 6d. per annum.

CONTENTS

EDITORIAL COMMENT

"Better Reception"

A Word to New Readers

WITH this issue we present a booklet entitled "Better Reception," in which has been collected a large amount of information covering all the more important aspects of the subject. Although much of the material in this booklet will, it is hoped, be of value to those who have been readers of this journal for some time, the articles have been written primarily for the benefit of newcomers, and particularly for those who are beginning to take a serious interest in the technical side of wireless reception.

Introducing Ourselves

To describe this booklet as an introduction to *The Wireless World* would perhaps be an exaggeration. The subject of broadcast reception (which is but one of the aspects of radio to be covered in our pages) is too diverse and complex for even an introduction to it to be compressed into 32 pages. Thus, although we cannot with truth print on the last page of the booklet the classical formula, "New readers start from here," we can at least hope that the articles in "Better Reception" will help such readers towards an appreciation of the matter regularly appearing in the pages of the journal.

The time seems opportune for a word about the scope of *The Wireless World*. New readers sometimes find that some of our articles require a good deal of study. That is because we concern ourselves mainly with the technique of wireless, and our regular readers have shown most clearly that they regard that as our proper sphere. But every effort is made to treat the subject as simply and clearly as possible ; mathematical articles are comparatively few and even when recourse must be had to mathematics to illustrate a principle the author's conclusions are given for the benefit of those who cannot follow his arguments. Many of our subjects must be dealt with on a quantitative basis if the articles are to be of any value to the serious wireless worker, and it is our aim to cover every interest within our sphere.

Kilocycles Only

An Air Ministry Change

ACCORDING to a "Notice to Airmen" recently issued, the Air Ministry has decided that "As and from March 1st, 1939, the waves used in radio signalling will be designated by their frequency in kilocycles per second or megacycles per second, and not by their length in metres, in all communications exchanged between United Kingdom aircraft and United Kingdom aeronautical stations."

Custom Dies Hard

This change, though it will probably cause some minor initial difficulties among those who have for long been accustomed to think in terms of wavelength, is likely to be eventually beneficial and is certainly, as befits anything connected with air transport, in keeping with present international tendencies. The habit of thinking in frequencies is rapidly displacing the wavelength convention, which now has little justification except in connection with such things as resonant aerials and Lecher wires.

The Modern Receiver Stage

IN this series of articles the action of the modern receiver will be treated in detail stage by stage, especial attention being paid to the effects of any changes which can be made to a circuit. Not only will one or more particular circuits be discussed, therefore, but it will become clear why the arrangement adopted is the best for that receiver.

Part 1.— GENERAL BALANCE AND PERFORMANCE

ALL good design is very largely a matter of compromise between conflicting factors, and not all of these factors are technical; some are economic, others are æsthetic. When considering the design of a receiver certain standards of performance can be laid down, and provided that they are not mutually conflicting they can be realised in practice. The æsthetic standards, such as the shape and colour of the cabinet, and the arrangement of the controls, can also be met.

When cost is important, as it usually is, another factor is introduced and one which profoundly modifies the technical design of the receiver. It may often happen that it is impossible to obtain the required performance at the price which is laid down, and then something must be sacrificed.

If the question of a definite price limit is ignored, however, and price only enters in so far as it must be kept at a minimum for the performance demanded, no two receivers are likely to be the same. Ideally, different designers setting out to produce receivers of the same performance for manufacture in the same factory would produce identical designs.

In practice, different designs result very largely because factory conditions are different. One firm, for instance, may have exceptional facilities for the cheap production of mains transformers and can afford to fit a larger transformer than another. As a result, its designer is likely to choose a triode, or even a push-pull, output stage, and will not economise in current consumption. Another firm to whom mains transformers are more expensive will reduce their cost by cutting the current to a minimum; a pentode output valve will be used. In hundreds of different ways small variations between the products of different designers will creep in.

In the case of the amateur the considerations are rather different, and his choice of design depends more on what components he has on hand rather than on the total cost of the parts. If he has a good mains unit with an output of, say, 500 volts at 100 mA, he will naturally prefer to use it with a single 25-watt triode output valve instead of buying a new transformer of, perhaps, 400 volts at 125 mA and using two push-pull 12-watt triodes. Technically, the latter course is the more perfect and it is little, if any, more costly if all parts are bought new. It would be much more expensive, however, if it entailed the loss of material on hand.

In addition to questions of cost, the same standard of performance does not please everyone. In commercially produced receivers a rough balance is preserved between the main attributes of sensitivity, selectivity and quality. The higher the price of a receiver the better

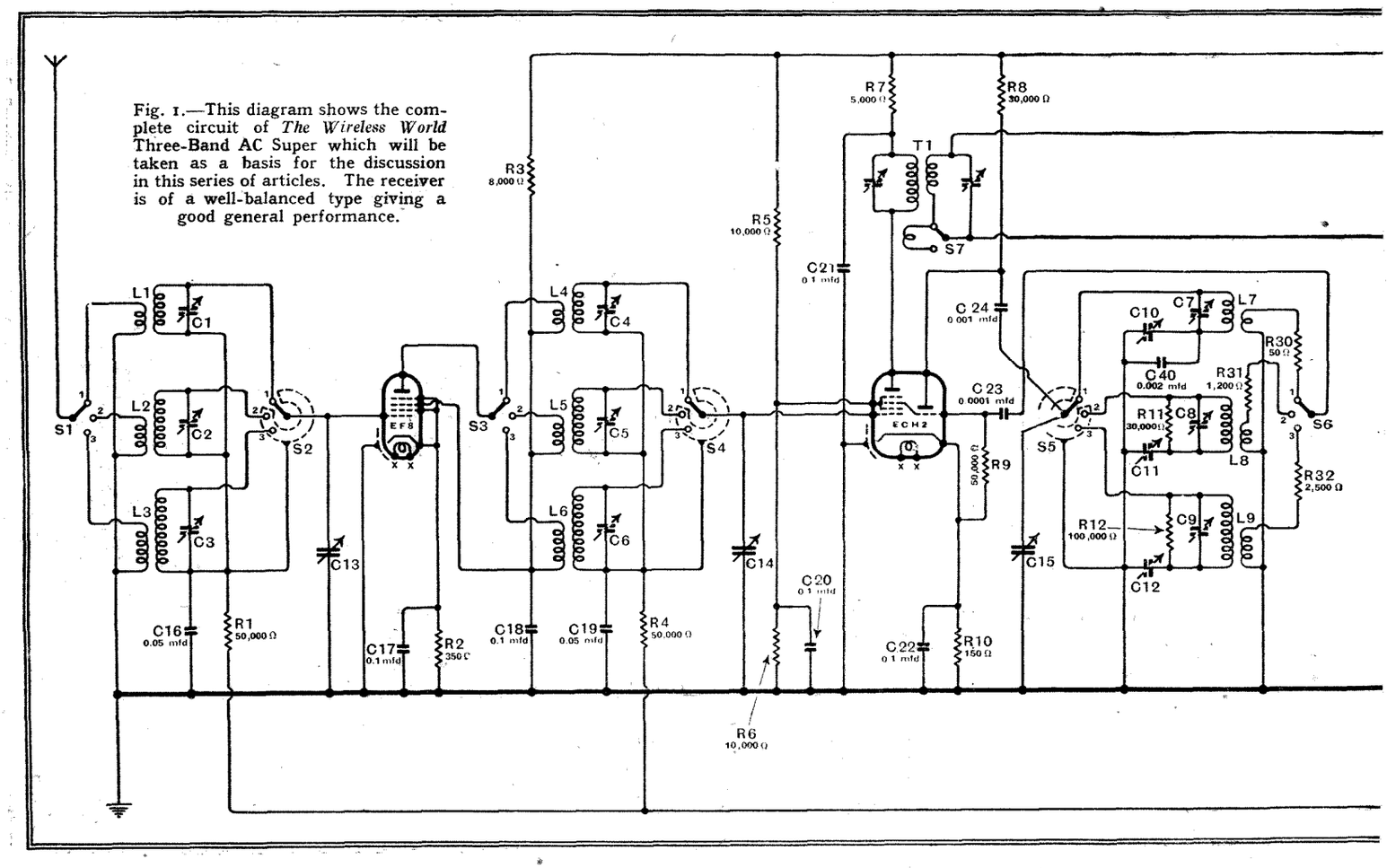
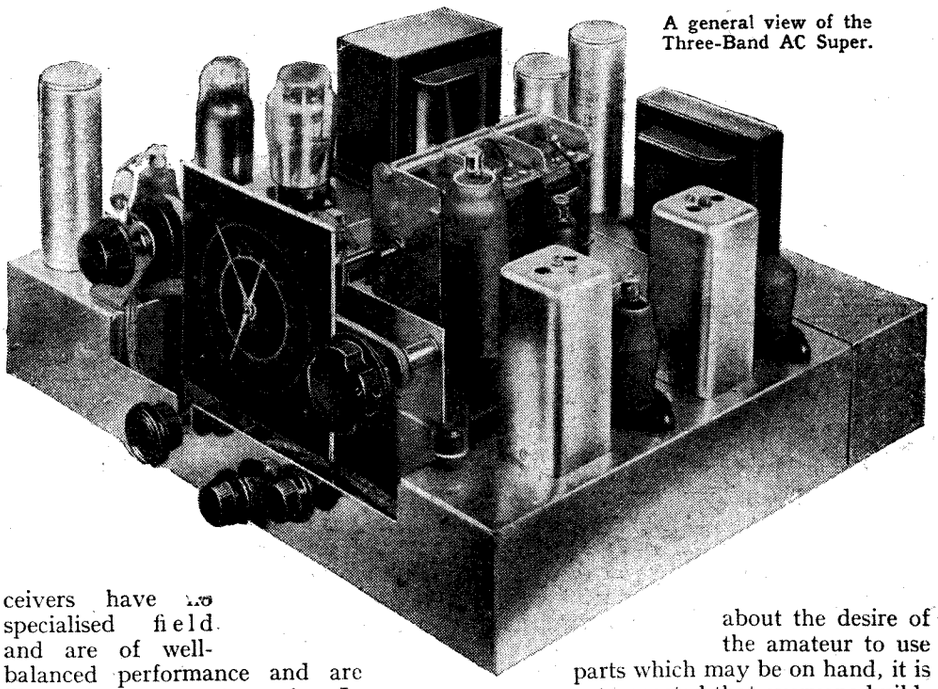


Fig. 1.—This diagram shows the complete circuit of *The Wireless World* Three-Band AC Super which will be taken as a basis for the discussion in this series of articles. The receiver is of a well-balanced type giving a good general performance.

by Stage



A general view of the Three-Band AC Super.

it is likely to be in all three. A balanced performance such as this best meets the average requirements, and most people consequently rightly choose such sets.

This general balance does not suit all, however. The listener at extreme distances requires higher sensitivity and selectivity than the average and can tolerate a lower standard of quality. At his distance he probably cannot get first-class quality in any case.

Another listener lives only a few miles from a broadcasting station and listens to no other. It is a waste of money for him to pay for sensitivity and selectivity when he wants quality of reproduction above all.

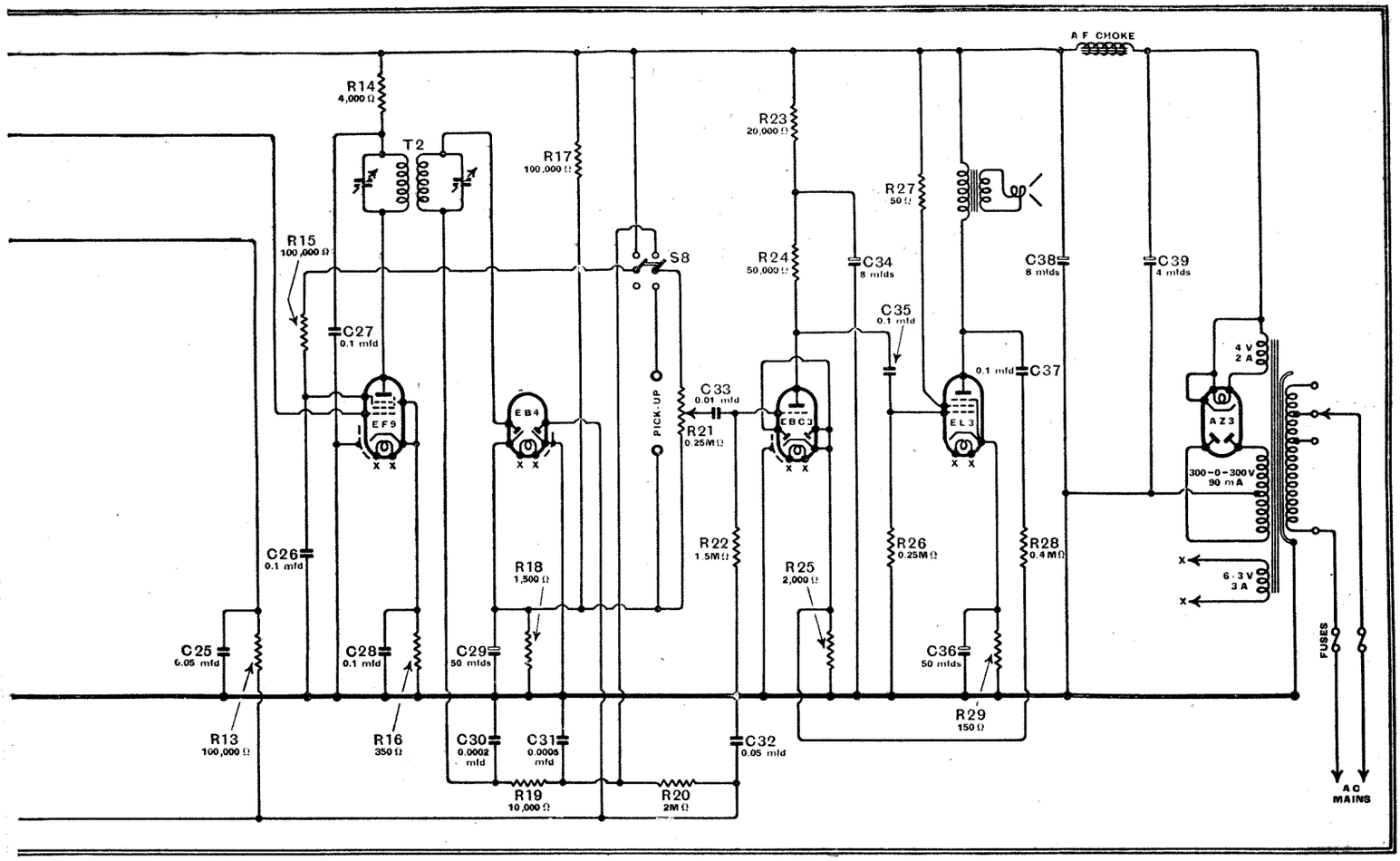
Between these extremes there are all grades of requirements, and it is here that the amateur comes into his own, for he can build a receiver of just the kind he needs. Moreover, if his requirements change in time, he can alter his set suitably.

Modifying Designs

From time to time details of receivers designed in *The Wireless World* Laboratory are published, and these sets represent all classes. In addition to meeting many somewhat specialised requirements, they also illustrate in practical form new developments in technique. Other receivers have no specialised field and are of well-balanced performance and are illustrative of current practice. In all *Wireless World* receivers, however, the question of quality of reproduction is kept well to the fore in design. When a compromise between quality and some other factor is inevitable the choice lies in favour of quality unless this would be *seriously* detrimental to the other attributes.

Bearing in mind the earlier remarks about the desire of the amateur to use parts which may be on hand, it is not expected that everyone building a receiver will adhere exactly to the specification. Quite a lot of latitude is often permissible and more than minor changes can be made if they are carried out properly.

It is just here that the difficulty arises. It requires a good deal of knowledge to know just what alterations it is possible to make safely; sometimes, in fact, it is not



The Modern Receiver Stage by Stage—

possible to predict whether a change will be satisfactory. It must be settled by trial.

The beginner cannot be advised to make any changes either in components, layout, or wiring, for he lacks the knowledge and experience necessary to predict the effect of changes. The expert can do as he likes, for if his changes are unsatisfactory, as they are bound to be sometimes, he can trace and remedy the trouble for himself.

Between these extremes are many who can carry out modifications of varying degrees of complexity with success. Now, the introduction of any alteration to the design of a receiver necessitates some familiarity with circuit theory, and the bigger the alteration the greater must be knowledge.

To change any part of a design, the amateur must be in some degree a prophet. He wishes, let us say, to improve the automatic volume control. There are perhaps half a dozen different ways of doing so, and he must consider each carefully and judge how each will affect the performance in other respects.

One system may introduce distortion on strong signals, another on signals of a particular strength, while still another may mute the receiver on very weak signals. One may be simple and straightforward, while another may be complex and critical in adjustment.

Since perfection is rarely to be found, whichever method he chooses will have some drawback, and it is up to him to choose the one with the least disadvantages from his point of view. Having done this, he has to consider it in relation to the whole receiver with a view to minimising its drawbacks.

Now, this cannot be done without a good working knowledge of what goes on in a receiver, and in this series of articles it is proposed to discuss in detail every part of a typical modern set. It is best to start with a well-balanced receiver rather than with a specialised type, and we shall accordingly consider *The Wireless World* Three-Band AC Super.[1]

It will be remembered that this receiver is a superheterodyne with one short waveband, in addition to the medium and long wavebands. It has one RF stage, frequency-changer, one IF stage, diode detector and AVC system, triode AF amplifier and pentode output valve. Negative feed-back is used, and there is variable selectivity.

The receiver is sensitive and selective, and gives good-quality reproduction. It is not superlative in any one of its qualities, for if it were it would probably be deficient in others, but it has a very well-balanced performance. It is, then, a particularly good set to take for our purposes, since it will be relatively easy to show how an alteration which effects an improvement in one attribute is likely to spoil the performance in other ways.

The complete circuit diagram of this receiver is repeated in Fig. 1 for ease in reference. At first it may seem complex, but this is more apparent than real, and is caused largely by the switching. In succeeding articles we shall analyse it step by step, and the complexity will disappear.

[1] *The Wireless World*, December 22nd and 29th, 1938.

The Three-Band AC Super

Before doing so, however, a few words about the general arrangement may be advisable. The receiver is a superheterodyne because it is easier to secure high selectivity with it than with a straight set. Because it is a superheterodyne, a frequency-changer is necessary.

Now, there is a very broad optimum signal level at which a frequency-changer should operate. If the signal is too strong, distortion and whistles are likely, while if it is too small, background noise becomes serious. The amount of amplification needed before the frequency-changer, therefore, depends upon the strength of the signal to be received.

With strong signals no amplification is necessary, but with weak ones quite high gain is desirable. Experience shows that one RF stage is sufficient.

The amount of IF amplification needed depends on the frequency-changer output and upon the detector input required. If the detector is to be operated at a high level then two stages may be necessary, but with the usual moderate input a single high-gain stage suffices.

The type of detector, its normal input level, and to some degree the IF circuits, depend upon the AVC arrangements. The inter-relations are actually quite complex, and will be dealt with later in this series.

Turning now to the AF circuits, the output valve is chosen to give the necessary output with the required freedom from distortion. The choice between triode and pentode is dictated largely by their relative efficiency, the standard of quality required, and the sensitivity obtainable.

The gain and type of intermediate AF stage is not, however, chosen to bring the normal detector output up to the level required by the output stage. It is chosen to suit the output of an average gramophone pick-up, because this is less than the detector output.

This at once raises a point which well illustrates the necessity for care in making alterations. If one has a receiver in which no provision is made for the use of a pick-up, one is tempted to connect it to the first AF valve, and the changes for this are usually very simple indeed. It may easily happen, however, that the receiver has its detector designed to operate at an unusually high-signal level, and the audio-frequency gain will be correspondingly low. It will then be impossible to obtain adequate volume from the pick-up. Another AF stage may have to be introduced, and this is obviously much more complicated.

It is not usually difficult, however, to judge whether a modification such as this will be satisfactory or not. It is easy to form a rough estimate of the AF stage gain; but trouble is likely if an alteration is made without thinking about it beforehand.

PROBLEM CORNER—9

Test Your Powers of Deduction

HENRY FARRAD, though an invalid and therefore unable to investigate wireless problems on the spot, has so developed his powers of deduction that he can generally diagnose receiver faults successfully from the most unpromising data. Here is a comparatively easy problem from his postbag.

2, Tanner Road,
Shillingsworth.

My dear Farrad,

We still have the all-wave set I got over two years ago, and the reason you haven't heard much about it is that it has been behaving itself very well. What little spots of bother there have been I have been able to tackle myself, having had plenty of practice on its predecessor! After the first enthusiasm wore off I didn't do much with the short waves, but it has been used pretty regularly for the usual handful of good medium- and long-wave stations. Then just lately, having heard that there is so much news in English from different foreign stations, I though I would hear some of it. But I couldn't get a single thing below 27 metres, not even morse. Yet on 31 metres I heard several foreign stations quite well. Of course, I thought at first the batteries were down, but even when a new HT was put in and the LT freshly charged it wasn't much better, except that I got an American and one or two others on about 25 metres. But not a whisper of anything below that. As reception was quite good on other wavebands, my previous experience warned me to look at the waveband switch for dirty contacts, but after the twisting to and fro I gave the knob when turning to the short waves after such a long lapse it had proved to be truly self-cleaning. So now I am stuck, and hope you will help once again; for, although I can tackle most things in an old straight set, I am still not quite clear about superhets.

Yours ever,
Bob.

For Henry Farrad's solution turn to page 206.

Radio Trouble-Shooters Handbook. By Alfred A. Ghirardi. Pp. 518. Published by Radio and Technical Publishing Co., 45, Astor Place, New York City, U.S.A. Price $3.

THIS book should be of great value to those engaged in servicing American receivers, since it contains an enormous amount of information. Some 270 pages are given to a list of the common troubles encountered in 3,313 models of various makes.

There are lists of the different intermediate frequencies used and data on car radio sets. The wiring diagrams of 90 American cars are given and there are details for the elimination of ignition interference with different models.

Designing an Individual Receiver

EVOLVING A SET TO SATISFY SPECIAL REQUIREMENTS

NOT the least of the advantages of being a wireless amateur is that one can design and build a receiving installation that is likely to be more suitable for one's personal tastes and local conditions than any mass-produced set. The evolution of a receiver embodying several unusual features is discussed step by step in this article and its sequel.

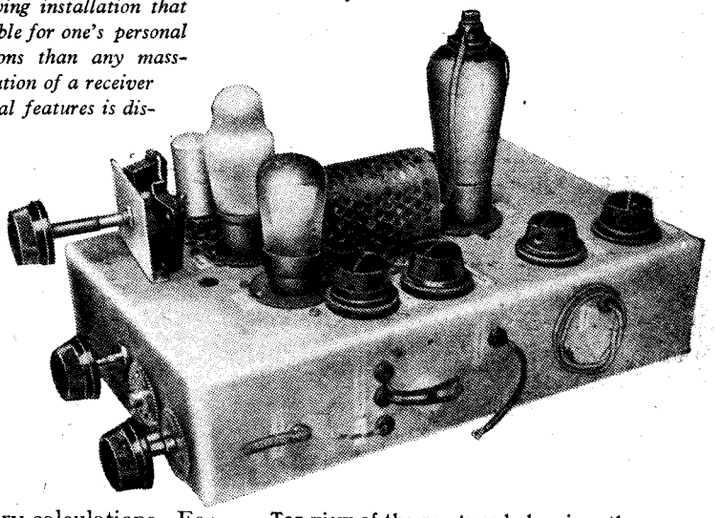
By R. H. WALLACE

THE chief differences between the design of a production receiver and that of an individual one arise from the respective quantities to be made. This naturally leads to a variation in technique, and to quite different solutions of the same problems. The commercial designer has the advantages of mass production, and can, therefore, call for components to his own specification, for resistances of non-standard values, or a variable condenser of special type, and so on. He can naturally rely on paying much less than the home constructor for those parts which he cannot himself manufacture, and if a standard article does not exactly suit his purpose, can arrange with the maker to supply it in a more convenient form. On the debit side, he is constantly working against cost figures, and must introduce many features which he would not otherwise choose in order to compete with his rivals.

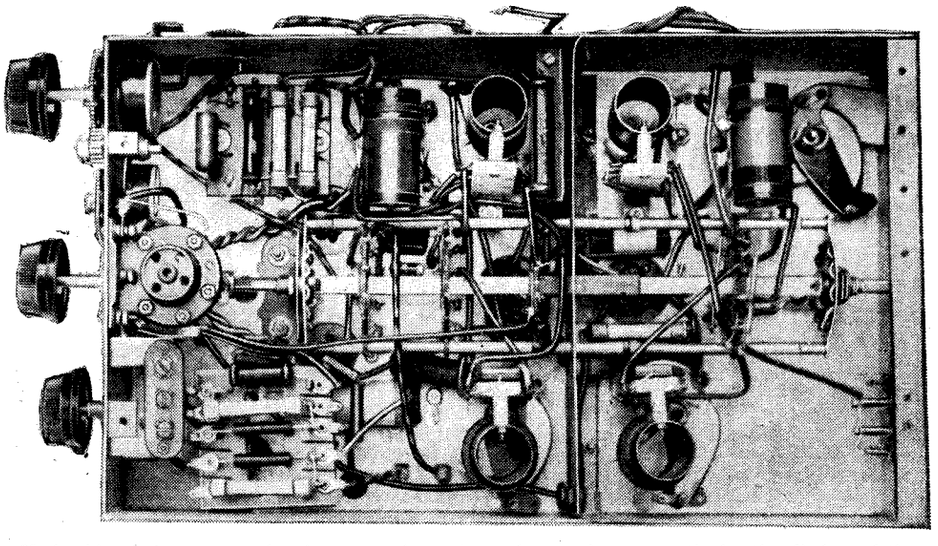
The home constructor has the advantage on his side of being able to incorporate the very latest developments even if these become known while the design is in preparation; he knows just what he requires, and if he personally does not think some feature desirable can omit it with consequent saving in cost. He is also able to alter the response of the set to suit the conditions of the listening room, thus simplifying the tone-control section. In addition to these points, he is able to choose the cabinet and the power sections so that he can rebuild from time to time and keep up to date.

Some readers may argue that the complete design of a set is a very long and troublesome business, and that they have not the ability or the time to perform the necessary calculations. For these there are the designs published from time to time in *The Wireless World*, and amongst these are to be found circuits for most cases. There is, however, another use for these published sets, and that is as a short cut for the individual designer in the matter of calculations; the knowledge that a certain circuit and arrangement has worked satisfactorily is a good indication that a choice of somewhat similar components will give a comparable performance.

A design for a diode load circuit might be wanted, for instance. Well, a search of back numbers will probably reveal a similar set, and the values may be taken from this in much less time than it would take to calculate them. It should not be thought that the indiscriminate use of details of circuits will always be successful; care is needed, of course, especially to see that the receiver does not become unstable, but a great deal of time may be saved by judicious borrowing.



Top view of the pre-tuned chassis; the connections at the side for the superhet unit are shown; note the use of rubber grommets where these connections emerge. The felt discs visible under the tuning knobs of the variable condensers are to prevent any movement of these through vibration. Photo was taken before the fitting of the low-pass filter and a temporary condenser filter is shown.



Underside of the pre-tuned unit; note the two panels carrying, respectively, the diode and the phase-changer components; also the small panel mounting for the 200-ohm resistor in the cathode of the RF pentode, and that for the voltage dropping resistance fitted near the dividing screen. The 8-mfd. condenser for detector decoupling is under the AF output terminal strip at the front of the chassis.

Clarifying One's Ideas

The first step in any design should be to set out on paper the specification; by this is meant the orderly setting forth of those features which are considered essential or merely desirable so that it may be clear just what will be needed to give effect to them. This is a step which should on no account be omitted as much valuable time may be wasted at later stages of the design if the end is not clearly in sight. It may be needful to relinquish some of the desirable points if they cause undue difficulty, but any temptation to jettison those set down as essential would obviously have to be resisted.

The question of future alterations ought to be borne in mind, and if opportunity occurs where the use of a slightly dearer component will leave a substantial margin of performance, then it would be better to choose it; the time may come when this may save much more than the difference. Similar remarks apply to the provision of extra positions on switches and the choice of a cabinet of ample size so that

Designing an Individual Receiver—

there is room for any needed extensions.

Consideration of further steps in the design and the manner in which use may be made of published circuits to save time and better guarantee the eventual performance can best be described by dealing with an actual example. The design worked out in the following example was for the writer's own set, which started out as a local-station quality receiver with a moderate output, and which it was desired to rebuild as a more ambitious model with less restriction on the stations obtainable. It proved possible to do this and provide all the desired features at no greater cost than would have been involved in buying a good table model, and with the incorporation of many extra points, plus a vastly better quality of reproduction, than the alternative course would have provided.

Basis of the Design

The specification had first to be decided upon. After some thought and a scrutiny of the various features included in the better class of set the following was sketched out and used as the basis of the design:—

SPECIFICATION.

Essential Features:—High-quality local reception. Reliable daylight reception of Regional stations. Provision for gramophone reproduction. Simplicity of operation. Provision of switching for extension lines.

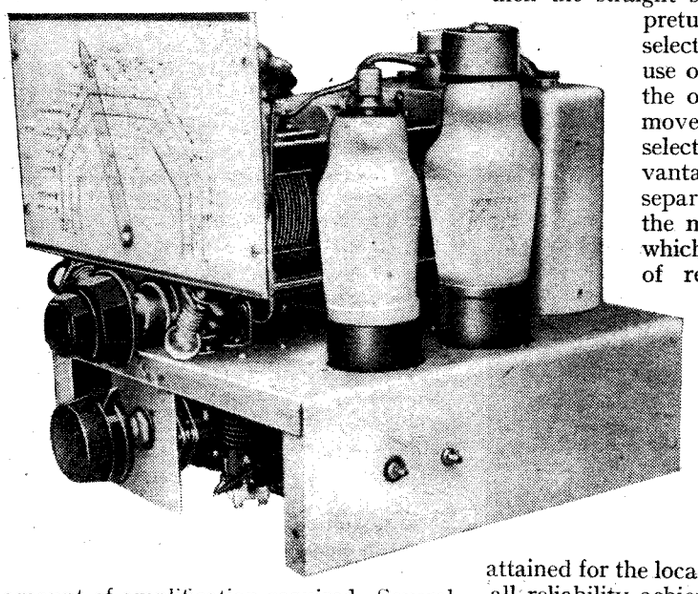
Desirable Features:—Permanent tuning of local stations. Foreign and short-wave reception. Low noise level. Use of existing cabinet, speaker and power packs. Suitable tone control for gramophone and radio.

The next step was to decide on the circuit arrangement and the nature and amount of amplification required. Several possibilities were considered, as the desired performance could be obtained in different ways. The high-quality local reception could be provided by a simple RF tuner and grid detector, suitably designed, or by the use of really wide-band variable selectivity. It is clear that point two in the specification could only readily be met by the inclusion of a superhet with AVC, and if this were used then the provision of short-wave reception would not be costly.

The reliable daylight reception of the Regional stations would necessitate so much amplification that the worth-while foreign ones would be receivable at good strength, since few of these are any weaker than some of the home transmitters at the minimum of a "fade." If short-wave stations were to be satisfactory, then it was clear that there would have to be two bands at least in order to provide easy operation and not-too-critical tuning. There was the alternative of band spreading, but this was considered by the writer to be rather complicated for uninstructed users, and was therefore ruled out; even the use of two bands involved the choice of a good slow-motion drive to make tuning simple and the duplication of a given setting easy.

If short waves were to be allowed for, then the IF was at once settled at about 465 kc/s. There was then the question of whether one or two stages would be needed; with two stages the sideband cutting would have been drastic enough to make the provision of a good deal of tone control, or the use of variable selectivity, needful even for the average distant station, while with one stage at this frequency the cutting would not be serious on any but the locals. The problem therefore resolved itself into a choice between two alternatives; a superhet with variable selectivity, giving a band width of at least 20 kc/s, and with the detector designed accordingly, or a more ordinary superhet, plus some form of "straight" tuner for the local stations.

If the dual construction were chosen, then the straight section could easily be pretuned and operated by a selector switch, while the use of only one IF stage in the other section would remove the need for variable selectivity there. Other advantages of the adoption of separate tuners would be the much greater ease with which the required standard of reproduction could be attained for the locals and the greater overall reliability achieved by the use of two units.



Top of superhet unit; the aerial terminal is the one showing on the right; the lower knob is for wavechange and the upper for tuning; one of the bulbs illuminating the switch indicator is visible between the two knobs.

The commercial designer, faced with the same problem, would quite likely choose the variable selectivity superhet. As in the first place it lends itself more easily to manufacturing methods of to-day, and is therefore cheaper, since the factory can readily make allowances in the overall response to correct for sideband cutting in the tuned circuits, whereas the amateur has often not the necessary facilities for accurate measurement of the amount of compensation required. Also, the use of the more complicated IF transformers is not much more costly for the manufacturer, and a great deal less so than the provision of extra valves with the bigger cabinet needed to house them. The writer found that the advantages attaching to the use of two units did, in his case, far outweigh the disadvantages, and decided on that course. He also considered that it would be as cheap to buy ready made the necessary tuner unit, as this would save time and avoid the need for much ganging.

Choosing the Superhet Unit

The type of tuner had now to be settled; the required performance, in regard to sensitivity, could actually be obtained without the use of any RF pre-amplifier. But as one of the desirable features was a low noise level, it was clear that this would be more readily attained by the use of one stage tuned to signal frequency. This was accordingly decided upon. Since short-wave reception was to be included, the best valve for the frequency-changer was thought to be a triode-hexode and the IF was fixed at 465 kc/s. There would then be no need for tone correction to compensate for the moderate sideband cutting in this section.

As regards the AF amplifier, the specification of good-quality reception with the speaker available (an efficient type of baffle-mounted moving-coil) called for about 5 watts undistorted output, since the set was to be used in a room of moderate size. A push-pull amplifier is easier to design for really good reproduction, and no better design for the output required could be wanted than the *Wireless World* Push-Pull Quality Amplifier. When modified for the higher rating of the PX4 valves now permissible, this gives an undistorted output of 7 to 8 watts. Since the existing power pack could deliver 400 volts at 120 mA, this could comfortably feed the amplifier provided that the tuned stages were fed from some other source. Happily, a pack with an output of 250 volts at 60 mA was available, and the use of two separate sources of supply made the securing of stability easier, besides permitting the use of condensers of lower voltage rating in the tuner units. In order to save some expense the modified version of the amplifier given in connection with the Pretuned Receiver was used, the two valves in each stage being biased by common resistors without decoupling condensers.

Since the chosen amplifier required a split-phase input, the necessary feeder unit had to be allowed for and it had to function on both the straight and superhet sections. The question here was how to reconcile the differing outputs of the two units. An examination of the Pretuned Receiver above mentioned showed that the work of phase-splitting and detection could be combined in a single triode as long as the tuning coils and condensers