"THE COASTAL THREE"
By A. JOHNSON-RANDALL
A bigger range of Burndept Standard Precision Condensers
—obtainable with Super-Vernier Dials

THE introduction of Burndept Standard Precision Condensers last season met with instant success. Wireless enthusiasts will be pleased to learn that a new type—Corrected Square Law pattern—has been added to the range and, further, that these Condensers may be obtained with ordinary dials or with the new Super-Vernier Dial which has attracted so much interest.

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"How can I cut out interference?" is a question constantly asked. With the progress of broadcasting the problem of selectivity is becoming increasingly important, and the broadcast listener is beginning to realise that it is better to lose a little in signal strength provided a big gain in selectivity is obtained, rather than to receive strong signals together with perhaps even stronger interference.

Effective Signal Strength

In short, the effective strength of a received signal is simply the ratio of signal strength to interference. It is only necessary to compare the effects of a loud signal accompanied by interference from a multitude of spark stations with a weak signal together with a reasonably silent background, to realise the truth of this statement.

Some wish simply to be able to cut out the powerful local station in order to receive other more distant ones, while on the other hand, many are unable to obtain satisfactory results from the nearest station on account of local interference, such as spark jamming from ships. This applies particularly to those listeners living near the coast.

It was with the object of satisfying the requirements of those who desire selectivity combined with simplicity that the receiver described in this article was designed.

Simple Control

I have always been of the opinion that to appeal to the majority the number of controls must be a minimum, and some considerable thought was expended in the choice of a suitable circuit. Since long-distance reception is desirable, in fact, almost essential, it seemed necessary to employ a stage of high-frequency amplification, which, in addition to extending the range, would at the same time tend to increase selectivity. Again, many listeners require loud-speaker reception from at least one station, hence a stage of low-frequency amplification was indicated.

The Circuit

The circuit finally chosen was one described by Mr. John Scott-Taggart, F.Inst.P., A.M.I.E.E., in an article entitled "Trap Circuits," in the February issue of Modern Wireless (Vol. iv., No. 1), and is shown in Fig. 1.

I have called the receiver the "Coastal Three" because I consider it to be eminently suitable for those living at a distance from the coast where interference from ships is bad.

The aerial coil consists of an aperiodic coil of comparatively few turns and has coupled to it a coil L2, tuned by a 0.0003 μF variable condenser. The effect of coupling L2 to L1 may be regarded as equivalent to turning the aerial circuit into a single tuned circuit, but the net result is a great increase in selectivity, without the disadvantage of an increase in the number of controls. Tuning is therefore precisely the same as in the case of the ordinary conventional three-valve circuit employing one stage of high-frequency amplification but very much more critical. The decrease in signal strength is only slight, and the receiver is very suitable for those who are unfortunate enough to reside in a district where interference is bad. Reaction is employed on to the anode coil and this has the advantage of minimising radiation should the receiver be in an oscillating condition.
Adequate control of oscillation can be obtained by means of the potentiometer.

Constant Tuning
Since the method of tuning is independent of aerial characteristics, any variation in the aerial constants will not appreciably affect the condenser setting, hence the receiver can be calibrated with a practical degree of accuracy by receiving three or four stations, and in this way determining the approximate positions of others, whose wavelengths are known, by interpolation. Plug-in coils are employed so that the set may be used for the reception of 5XX in addition to those stations working on the ordinary broadcast band.

Components Required
One cabinet, mahogany, 16in. by 8in. by 7 in. (inside) with loose baseboard (Camco).
One ebonite panel 16in. by 8 in. by 4 in. (Paragon).
Two 0.003 µF variable condensers square law pattern (Erganic Electric Co.).
Three dual filament rheostats (L. McMichael, Ltd.).
One potentiometer (L. McMichael, Ltd.).
One two-coil holder, type R (Burne-Jones & Co.).
Three "anti-pong" valve holders (Bower-Lowe Co., Ltd.).
One 0.003 µF grid condenser and 2 µA grid leak (L. McMichael, Ltd.).
One coil plug, baseboard mounting type (Burne-Jones & Co.).
One trap coil, size A/T to clamp on to existing coil, and also one size D/T for 5XX if required (Gambrell Bros., Ltd.).
A quantity of square bus-bar wire (Sparks Radio).
Two angle brackets, a few 4BA screws and nuts, and a short length of flex.
A set of Radio Press panel transfers.

Mounting the Components
The mounting of the components upon the panel is particularly simple in this receiver, since the filament rheostats and the potentiometer are of the one-hole fixing type. In the case of the two variable condensers, which are secured by means of a three-point suspension, a drilling template is supplied, so that the position of the spindle hole having been marked off, it is only necessary to prick through the centre marks on the cardboard template to determine the points of
which the fixing holes are to be drilled. It is as well to mention that this should be carried out with great care, since a slight inaccuracy may render the mounting of the condensers somewhat difficult. The three filament rheostats and the potentiometer require a 1⁄8 in. drill, and the operation of drilling these large holes is simplified if small pilot holes are run through first. The two-coil holder is placed on the centre line of the panel and may with advantage be used to form its own template.

Baseboard Lay-out

Turning now to the disposition of the components upon the baseboard, these are not placed in position to any fixed dimensions, but the constructor should follow the lay out shown in the wiring diagram Fig. 3, since the general scheme was decided upon after much careful thought.

The terminal strip on the back of the baseboard can be obtained engraved and ready for use, or it can be made by drilling seven holes one inch apart and half an inch from each end of a 7 in. by 2 in. by 1⁄2 in. ebonite strip.

Wiring up the Set

Having now drilled the panel and mounted the components upon the baseboard, the next operation is to commence wiring up the set. Before securing the panel to the baseboard join up the filament rheostats with a length of square section wire as shown in Fig. 3, this particular lead being rather difficult to solder when once the panel is mounted. A good plan is to solder all the inside leads, working gradually towards the back of the baseboard, and starting with the filament connections to the valve-holders. Always take care to allow ample clearance in the immediate neighbourhood of the valve-holders, for the valves themselves to be inserted. This applies also to the leads near the aerial and trap coils. Lack of care in this respect may cause certain important leads to be damaged in removing the valves or coils while in use. In soldering cleanliness is an essential factor and provided a really hot iron is employed there should be no difficulty.
MODERN WIRELESS

If other than a resin flux is used it is good practice to clean up all joints, in order to prevent corrosion, with methylated spirit.

Operating the Set

First connect the aerial, earth and telephone leads to their respective terminals and join up the L.T. battery. Place the valves in the valve little practice is necessary at first. The best size of reaction coil should be found by experiment, the two sizes mentioned being tried to commence with. Any good general purpose valve can be used in the receiver and that in the H.F. socket might be one specially designed for H.F. amplification. For loudspeaker work a small power-valve worked with the H.T. voltage and grid bias which the makers specify will be found an advantage.

Test Report

The receiver was carefully tested upon an aerial, 100ft. in length and 33ft. high (average), at a distance of 15 miles from 2L0. London was full loud-speaker strength and during the ordinary programme Bournemouth, Newcastle, Birmingham, Belfast, Aberdeen and Glasgow, together with a number of Continental stations, were received at full telephone strength. The coils, used were a Gambrell a/T and "C" for the aerial and trap circuits with a "C" in the fixed socket of the two-coil holder and a "B" for reaction. During a test at midnight all of the B.B.C. stations with the exception of Cardiff were logged, Bournemouth on a wavelength of 367 metres (774.7 Kc.) was separable from 2L0 on a wavelength of 363.5 metres (724.8 Kc.), Manchester could be heard with 2L0 in the background, and the ratios of their respective strengths when tuned to Manchester I should put down as Manchester three and 2L0 one. The wavelengths were announced during the test.

Receiving 5XX

In addition to the thorough test on the broadcast band, the receiver was employed upon several occasions for receiving Daventry on the loud speaker. Using a D/T coupled to a G coil for the aerial and trap circuits respectively, with an F as anode coil and an E for reaction 5XX came in at full loudspeaker strength, suitable for a large room. Of the numbered coils a No. 250 would be correct in the anode socket and a No. 100 or 150 should suffice for reaction. It will be noticed that I have not included H.T. shunting condensers in the receiver itself, the reason for this being that I consider these to be essentially part of the H.T. unit.

Practice Necessary

Any tendency to oscillate can be controlled by means of the potentiometer, rotating it anti-clockwise increasing it and vice versa. Tuning will be found very sharp, and some

There is ample clearance for valves of all types.
MOST people who have used valve receivers and amplifiers in the last three or four years are familiar with a very objectionable feature of some types of valves. Certain disturbing noises are produced under various circumstances. When a valve is "flicked" with the finger a sound is started in the telephones or loud-speaker which may continue for a few seconds. When the amplifier is knocked, again the noise is obtained. Generally when the amplifier is subject to any form of vibration or movement, noises are produced in the loud-speaker or telephones, which tend to destroy the quality of speech or music which is coming through.

Another feature which is noticeable is that sometimes when one speaks loudly or sings in the neighbourhood of the amplifier, again this noise is produced. The banging of a door will also sometimes produce it. Sometimes this noise becomes very bad, and perhaps the worst feature from the broadcasting point of view is that the loudspeaker produces sound waves which are sufficiently powerful to act on the valves and cause vibration, which again produces these microphonic noises. When this happens, a continuous howl washes out any reception of telephony. This is microphonic noise in its worst form. These noises can be produced whenever there is mechanical vibration or direct mechanical shock, and thus for broadcast reception the problem is divided into two parts, either when the mechanical shock is produced direct, or when it is produced by sound waves, particularly from the loudspeaker.

**Dull Emitter Valves**

Troubles with microphonic noise have been more pronounced since the introduction of dull emitter valves. Of course, the noises can be obtained with bright emitter valves, but it is due to the introduction of the dull emitter type of valve that the noise has become serious. However, the trouble is not pronounced with all types of dull emitter valves (but depends on the thickness of the filament to a very large extent).

We must now ask ourselves the question why noises are produced when the valve is subject to shock or vibration.

**The Cause**

We must consider which parts of the valve are set in vibration. This question will be answered in the following paragraphs, but in the meantime supposing that any single part of a valve is subject to vibration, we must consider how this can produce microphonic noises, or, in other words, how this can cause a note to be produced in the telephones or loudspeaker? The reason appears to be as follows:

The characteristics of valves depend upon the shape and disposition of the various electrodes. It is the function of valve manufacturers to know precisely how the change of electrodes can alter the characteristics of valves, so that they can produce valves with any desired characteristics. We will refer to one example in this connection. This is the case of the influence of the grid mesh.

**Spiral Type Grids**

We can consider grids of the spiral type. The closeness of this spiral as regards winding controls the lateral position of the characteristics. Referring to Fig. 1, two characteristic curves are shown. The characteristics which are shown are the grid-volt, anode current characteristics. The curves are for a fixed anode voltage and for fixed filament current. The two curves AB and CD are almost identical, except for the fact that one is to the left of the other. The difference is accounted for by the fact that in the case of the curve AB, the mesh of the grid is comparatively open, and in the case of the curve CD, the mesh is comparatively close.

These examples tend to show that the shape of the electrodes controls the characteristics of the valve. Other examples could be given, such as, for instance, where one displaces the filament somewhat, inside the grid. Thus, whenever there is mechanical motion of any part of the electrode, the result is that we move immediately to another characteristic, keeping the anode voltage and the filament current constant. If we move from one...
characteristic to another, this usually results in giving different anode currents. Changing the anode current suddenly produces a noise in the telephones or loud-speaker. Thus we see that relative mechanical movement of the electrodes will produce noises in the telephones or loud-speaker, and thus we can account for the production of microphonic noises due to the shaking of a valve or to mechanical vibration produced by sound waves.

**A Serious Problem**

The annoyance produced by microphonic noises is very considerable in private houses, but there are conditions where these noises are very serious indeed. There are many conditions where the amplifier is necessarily subject to a considerable amount of vibration. In my recent capacity as technical head of the Wireless Laboratories of the Royal Air Force, the problem was very serious indeed, for reception in aircraft is by no means under ideal conditions. There is continual vibration of the aircraft, and this must be kept from the amplifier as much as possible.

In the Royal Air Force the problem assumed very serious dimensions, and it was necessary to attack the problem fundamentally. It was necessary to work in close touch with valve manufacturers in order to produce the best type of valve which would be least disturbed by microphonic noises. It was further necessary to perform all types of tests with valves which had been produced.

**Apparatus Designed**

The members of my staff who were principally engaged on this problem were Captain H. L. Crowther, M.Sc., who is now with Radio Press, Ltd., and Mr. B. Williams, B.Sc. The apparatus about to be described for investigating microphonic noises was suggested and made in the first place by Mr. Williams. This apparatus was designed in order to determine the actual frequencies which produced microphonic noises, and further to discover which portion of the valve was responsible for producing the worst type of noise.

We know that mechanical jars produce the noises. Sometimes the noise produced is of the nature of a "ping" which appears to be of a definite frequency. At other times, the sound appears to be a mere noise without any specific single frequency. It is necessary to determine whether there is any definite frequency of vibration which will give the noises, and thus it is essential to have an instrument whose frequency can be altered continuously so that we can obtain any frequency we desire. We can then make the valve vibrate at any particular frequency to see whether any resonance effect can be obtained.

Various musical instruments exist which will give a variable frequency.

**The Monochord**

The instrument suggested by Mr. Williams consists of a stretched string, which will give frequencies from a low value of about 50 vibrations per second to a high value of the order of 2,000 or 3,000 per second. This instrument is called the Monochord. Many musical instruments depend upon the use of stretched strings. The frequency or pitch of a note produced by a string depends upon three factors: first, the mass of the string per unit length; secondly, on the amount of tension; and, thirdly, on the length of the string.

These principles are well known, and can be readily appreciated by reference to the violin. There are four strings on the violin, the string giving the lowest pitch being the heaviest one, and that giving the highest pitch being the lightest string, and thus the first principle is illustrated where the pitch is controlled by the weight of the string.

**Adjusting the Pitch**

Again, in order to adjust the pitch of the string, pegs are provided on the violin which can stretch the string to any required tension within limits. In order to raise the pitch of a particular string, it is necessary to stretch it a little more tightly. The third principle is also readily appreciated by reference to the violin, because the fingers of the left hand are used in order to stop the string at any particular point and thus to make the string essentially shorter. By shortening the string in this way a higher note can be obtained. With the violin, of course, a bow is used to produce the sound. With a monochord, however, a bow is usually not used, but the string is usually flicked by the finger.

**Description of the Monochord**

The Monochord, then, is essentially a string which can be stretched to any required tension, and which can have its length altered to any required amount. Fig. 2 illustrates the essential features of the monochord. There is a baseboard XY, which is screwed down upon a table. The string is fastened rigidly at one end, V, and at the other end there is a tension apparatus, A, so that the string can be stretched as much as required. Bridge pieces C, D and E are shown, each of which is variable in position, so that any required length can be obtained.

**Investigating the Noises**

In order to investigate the microphonic noises of a valve, all that we require is to place the valve
with its valve holder on one of these bridges, and this is shown in the figure at the bridge, EF. Into this small board EF is screwed the valve holder, into which is put the valve G. We thus have a portion of the string DE, which can be altered in length by moving one or both of the bridges. Also the tension of the string can be altered by tension screw A. Thus we can obtain any frequency we require within limits, and by moving the bridge piece E or the bridge piece D, we can get any required length between these two bridge pieces. By suitable adjustments a wide range of frequencies, say, from 50 to 3,000 per second, can be obtained. In order to appreciate the microphonic noises the valve G is made one of the valves of an amplifier. For preference the valve should be in the detector position of the amplifier.

Method of Operating

The method of operation is now to flick the string between the portion DE by the finger and to move one of the bridge pieces D or E until some pronounced microphonic noise is obtained in the loudspeaker. The baseboard XY is calibrated so that the length between the two bridges can be measured, and the actual frequency can then be obtained by adjusting the length between the two bridge pieces to get a note of the same frequency as that of a standard tuning fork whose frequency is known.

Then the length for a standard frequency is known, and thus the frequency for any length between the bridges can be calculated by the use of the formula which determines the frequency \( n \) in terms of the length \( l \), the tension \( T \), and the mass per unit length, \( m \). This formula is:

\[
\frac{1}{2} \sqrt{\frac{T}{m}}
\]

(being measured in centimetres, \( m \) in grams, and \( T \) in dynes.)

A photograph of the apparatus as used at the Royal Air Force Establishment is shown in Fig. 3.

Instead of flicking the string with the finger it is possible to excite it in a much more convenient manner. This is done by using a string of magnetic material such as iron or steel, and placing the magnets of the telephone head receivers immediately under the string, as shown in the photograph. This telephone headpiece is now excited by the low frequency hummer, which is an oscillating valve circuit arranged to give low frequencies of the order required.

Results

Some most remarkable results have been obtained. It was found that for any particular valve at least four different frequencies combined to give the microphonic noise. For two valves of the same type these frequencies were never the same. The frequencies varied from about 1,000 to about 50 per second. It was found that these notes were also fairly selective, and as the string was altered in length by altering the distance apart of the bridge pieces, the microphonic noise was not
It was very soon discovered that the disturbance in the form of microphonic noise came principally from the filament and from the filament supports. This was due to three different causes: First, the pitch of the note produced; secondly, the amplitude of the note; and thirdly, the persistence of the note. In some valves the note persists for many seconds, whereas in others its duration is small. The duration depends on the damping of the vibrations. One of the ways of having considerable damping is to have as little elasticity in the filament and in the support as possible. As regards the filament this depends on the temperature, the higher the temperature the less the elasticity constant. When the note produced is of a frequency below about 100 per second, the influence on speech is not serious, and in fact when below about 30 per second it has no appreciable influence at all. The disturbance becomes serious when the pitch of the note is above 200, and thus the chief feature on which to concentrate are the filament and the filament supports.

Oscillograph records were also taken of the microphonic noise, but this did not add very much to our knowledge except as regards the frequency. The actual frequency of the note produced was identical with the frequency of the Monochord required to give resonance.

Conclusions Drawn
We shall now enquire how this information can be used to enable us to avoid as much microphonic noise as possible. The first conclusion to draw is that it is necessary to prevent as much as possible, the vibration of the parts of the valve as possible. The anode and its supports must be as rigid as possible, thus tending to prevent any mechanical vibration being conveyed to the anode. The same remarks apply to the grid. Valve manufacturers should pay very careful attention to this point of design.

Further Considerations
As regards the filament and its supports, the problem is not quite so simple. It is, of course, possible to pay some attention to the filament supports, and these should be as rigid as possible. This is a point about which manufacturers may have some doubt, because they think it is necessary to allow the filament supports to have some form of movement in order to allow for the sag and general change of length in the filament due to change of temperature. In fact, patents exist for supports in the form of springs to take up the change in length when the filament is heated. This applies however more particularly to transmitting valves. As regards the filament itself, we shall discuss this in the following. The next point which arises is that it is advisable to design the valves in such a way that any mechanical vibration which can be obtained is of as low frequency as possible. Our investigations show that if the frequency is below 100 the microphonic noises, as a rule, are not serious.
Thick and Thin Filaments

We have seen that the pitch of a note produced by a string depends upon the mass per unit length, and thus if we can have a thick filament the note would be lower provided that the tension were not too great. It is obvious why the microphonic troubles have only become serious within the last three or four years, because some dull emitter filaments are essentially thinner than those of bright emitters. The tendency has been to attempt to obtain filaments which will give the required emission with as low a filament current and filament voltage as possible, and thus to make it possible to use low capacity accumulators or even dry cells to heat the filament. This has led to valves being made with very thin filaments. Some dull emitter filaments are thoriated, and this does not account for the filament being much thicker. Another form of dull emitter filament is the coated type, and this is automatically heavier, as the active material is put on to the metallic filament. In general practice it is found that coated filaments do not produce the same amount of microphonic noise as the thoriated filaments.

Filament Tension

The filament must have some tension in order to guarantee that as it changes in length owing to heating it will not sag on to the grid. Thus the manufacturers have a very difficult problem to solve in order to guarantee that the filament will just have the correct tension to prevent it from sagging on to the grid and at the same time will have small enough tension in order that the pitch of the note shall not be too high. The problem is again made more difficult for the manufacturer because he does not know what the tension will be when the filament is heated.

Elasticity and Temperature

Another point of interest is that the metallic filaments have a considerable amount of elasticity, which quality varies with temperature. At the very high temperatures which are used for bright emitters, the elasticity is considerably less than at ordinary temperature. At the temperatures used for low temperature emitters, or dull emitter filament, the elasticity is greater than for bright emitters. The temperature for the dull emission filaments of the thoriated type is of the order of 1,300 to 1,400 absolute, and of the bright emitter receiving valve of the order of 2,000 absolute. For transmitting valves the temperature might be of the order of 2,500 and 2,700 absolute.

As regard the question of making the electrodes as rigid as possible, various suggestions have been made from time to time. One suggestion was made by Captain S. G. Frost to keep the filament support and the grid rigidly attached together. In this case, of course, insulation has to be provided between the grid and filament support.

In some cases, again, the filament is supported at the middle in addition to the end supports. This, again, helps to keep the natural frequency of the filament low, as less tension should be necessary in such cases.

Minimising Existing Defects.

Up to this point we have discussed how microphonic noise can be minimised, by paying careful attention to the design of the valve, and we have seen that a certain amount can be done in this respect though practically impossible at the present moment to eliminate it completely without using very thick filaments, which is not always advisable, as these consume too much current. As so many listeners already have valves which have this microphonic noise, the problem is being attacked from another point of view by various manufacturers. In this case the existence of the microphonic noise is accepted, and attempts are made to prevent mechanical vibration from reaching the valve. In some cases rubber is placed between the valve and the valve cap, and in fact various forms of spring or padding are used in this way. In other cases the valve holder is mounted on a spring, so that the vibration of the amplifier is kept to a considerable extent away from the valve itself. In other cases the whole amplifier is often suspended on springs.

These devices only deal with the type of microphonic noise which is produced by mechanical shock or mechanical vibration. They do not deal with the question of the noise being produced by sound waves from the loud-speaker reaching the valves. Whenever this type of noise is produced, the only remedy at present appears to be to cover up the valve in order to prevent the sound waves from striking it.

We have discussed at some length the objectionable features of microphonic noises. It is possible, however, that these objectionable features from the reception point of view might become of great importance in other ways, and in fact suggestions have been made to use valves as microphones. It is possible to conceive conditions in which valves may be so designed that sound waves impinging on some parts of the valve may cause parts of the valve to vibrate with the sound waves, and thus cause the anode current to vary. This would then give a microphone, which is an instrument for converting sound energy into electrical energy.

The apparatus for testing microphonic noises which has been described here is quite easy to construct, and experiments with it are full of interest.
Those Figures

I wonder why these mathematicians must keep on butting in. Not so long ago wireless was an interesting and straightforward science such as a self-respecting man might study in his leisure moments. But now you are always finding yourself up against the most horrible things. You start an article the first page of which is splendidly interesting. Then you turn over and you find at the top of the next: ‘Hence it is obvious that

\[ \frac{Ex}{Ez} = \frac{nK^2}{t^{1-n}K^3} \quad \ldots \quad (1) \]

or something of that kind. That ‘obvious’ is insulting. The thing is not obvious. It is far from it, to me at any rate. I have a sort of idea that the fellows who indulge in these rows of figures do so simply in order to get out of some nasty fix in which they find themselves. Having no reasonable explanation on a certain point to offer they simply say ‘It follows obviously that …’ and then comes a mass of figures and of mathematical signs. They feel quite sure that they are safe since readers will lack either the ability or the energy to probe deeply into these things. Mathematics are certainly most useful in this way; I find them of the utmost assistance when I want to stave off those who put awkward questions. In case you do not know it, I give you the tip here and now free gratis and for nothing, you can prove conclusively that A would win by something over 11 yards whilst actually he would probably be beaten into seven different kinds of cocked hat, for A is obviously a long distance merchant whilst B is a sprinter of prowess. Even if you change A and B into racing motor-cars your mathematics are still as misleading as ever since in one race A’s carburetter is probably a little wonky, whilst in the next B’s suffers from semi-paralysis of the baffle-shaft or something of that kind.

Calculations

Mathematics would be all right if, everything always behaved exactly as it ought to. One of the great joys of wireless is that nothing ever does. You may calculate, with the aid of reams of paper, that in order to receive a certain station to the best advantage your frame aerial must point just so many degrees east of true north whilst for a second station it must be turned a good way from this bearing in one direction or the other. Actually you will find as likely as not that in both cases it has to be pointing towards the fire-place. This may offer an explanation of why it is that wireless reception is so much better in winter than in summer. In warm weather the waves go cavorting about simply anywhere thoroughly enjoying the genial temperature. But in winter they feel the pinch of cold, and seeing a chimney, they say to themselves ‘Ah, that means a fire and a nice warm room’ and
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so I can now, in time, really understand a slide rule.

Elementary Principles

It struck me some time ago, after having watched him make use of it, that the slide rule must be a splendid time-saver. I therefore purchased one at great expense and obtained also a little book of instructions in the art of using it. Having read the booklet through, I came to two conclusions: (a) that there was something in this slide rule and (b) that to master it I would entail a lifetime's work. However, I took the thing round to my mathematical friend one night and asked him to tell me all about it. He readily agreed, little realising what he had let himself in for. At the end of a week I had thoroughly grasped the elementary principles of the thing. I could multiply 17 by 42 or divide 195 by 5, not taking more than ten minutes to produce the answer in either case.

Practice Required

At the end of another week I was juggling with decams and decimals and things. My friend was delighted with my progress. He assured me that now I had got the hang of the thing speed was only a matter of practice. I practised so hard that I wore out the first slide rule and had to buy another one. If it had not been that I never could remember whether you read off the answer under the 1 or scale C or over the 1 on scale D, I think that I should have become in time really expert on slide rule.

Mathematics and Design

I need hardly say that my friend Professor Goop is an ardent and convinced mathematician. None of his great inventions ever assume concrete form until everything has been calculated and mathematically to unnumbered places of decimals. If, for example, it is a question of a new circuit, the Professor calculates with the utmost nicety the position that each component of the components must occupy in order that there shall be no interaction between them. He then calls in Poddleby and myself to help him to make up the receiving set. As he is rather short-sighted and things, my mathematical friend one night, and I shall lecture to a crowded hall at the end of the S.O.S. call, distracts the Professor's attention by reading on his toe or something of that kind, and in the meantime I find a convenient home for L2. And

Aids to concentration.

so the set gets built, and it works perfectly as all Professor Goop's sets do, thanks largely to Poddleby and myself. When we test it out he leaves the marking out of the components must occupy everything is just as it should be."

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New Words

Other fellows that I have no patience with besides mathematicians are those who will strive to invent new terms for the mental undoing of would-be students of wireless. Here I think we are up against sheer jealousy. The actual expert fellows are those who are really getting on to top things they invent a lot of new terms which they drag into their writings by the scruff of the neck in order to perplex and bewilder them. They are frightfully fond of things ending in -ance. Provided with a wet towel and other aids to mental concentration you master reluctance and reactance and impedance and capacitance and inducance. And then one day they hurl admittance at you, like the proverbial half-brick at the stranger's head. I suppose that they coined that term just to show that they do not want you and me to enter their sacred precincts; it was doubtless suggested by the well-known notice "No Admittance Except On Business."

The Hero of the Hour

Some day I shall offer to read before one of the learned societies a paper upon The Metagalabulous Promulgance of Exoneme Imbulations. They will accept, of course, for the title of the paper will be sufficient to show them that they are in for something special in the way of a mental feast. I shall lecture to a crowded house using nothing whatever that like those contained in my title, and they will sit nodding their heads and wafting their beards and applauding loudly whenever a pause in my discourse occurs. And the next day you will see in the papers glowing reports of my remarkable new discovery. No one will be quite sure whether it is a wireless direction finder, or a new constellation, or a safety signal devices for railways or a cure for bunions; but that will not matter. I shall become the hero of the hour; smudgy photographs will appear in all the daily papers and I shall receive the first class of the Order of the Bearded Goat from the Emperor Awakia. Meanwhile I would just like to place on record my own disgust with those who make still thornier the thorny path of wireless. In case you do not know it, the unit of disgust is the peha. The LISTENER-
This receiver is specially suitable for the long-distance enthusiast. By careful design losses have been kept to a minimum, and the selectivity is such that Bournemouth can be easily separated from 2LO at a distance of 10 miles from the latter station, when using a large and efficient outside aerial.

How many amateurs have been requiring a really powerful "DX" set for long-distance reception of stations on the broadcast band? Not a few, I expect; but I doubt whether many have realised their ideal in practice.

Essential Qualities

Let us examine the main essential qualities which such a receiver must possess. First and foremost we must have selectivity of a fairly high order, not merely a "general selectivity" sufficient to separate distant stations operating on fairly close wavelengths, but "special selectivity" which will enable the set to be worked to best advantage on a large outdoor aerial in close proximity to a main broadcasting station, and yet be capable of receiving stations working on wavelengths near to that of the main station.

Secondly, the set must be easy to control, tuning controls being limited to not more than two dials.

Thirdly, there must be fine control of reaction.

Lastly, we must limit the number of valves, say, to three or four, unless it is possible to use the more elaborate equipment of the superheterodyne.

Degree of Selectivity

If, then, we fix an approximate degree of "special selectivity," say, the complete elimination of London on full power without the use of a wavetrap, at 10 miles on a large outdoor aerial when receiving Bournemouth on the loud-speaker, we see that to combine all these qualities successfully in one
receiver we have set ourselves no small task.

**Simple to Operate**

This task is somewhat simplified if we concentrate solely on a receiver for one band of wavelengths only, in this case the 200 (1.507 Kc.) to 600 metre (4097 Kc.) band.

In this connection I have been carrying out a considerable amount of experiment with various sets and circuits for the purpose, and it is no exaggeration when I say that the receiver illustrated in the photographs is fully capable of doing this, and can honestly be said to comply with the conditions specified above.

The set is remarkably stable, simple to operate, and the reaction is delightfully smooth to night, direct on the loud-speaker without preliminary tuning with the headphones. In its present completed form the set possesses the same capabilities.

**The Circuit**

Consider the actual circuit diagram shown in Fig. 1. Here we have a "semi-aperiodic" aerial coil consisting of only 25 turns of wire on a small former loosely coupled to the grid inductance of the H.F. valve. Now the grid circuit of the H.F. valve is a circuit where there is little damping and this we can appreciably reduce; so it is an advantage to use here a low-loss single-layer coil with air spaced windings and remove any further damping as far as possible by the action of the grid battery.

The question now arises as to what form of inductance to use in the grid circuit of the detector valve. In *Wireless Weekly*, Vol. VI., No. 17, Mr. A. D. Cowper, M.Sc., has shown that the grid circuit damping of a detector valve operating on the leaky grid condenser method of rectification is of a fairly high order, equivalent in fact to an H.F. resistance of around 50 to 60 ohms.

**Coil Considerations**

Thus, apart from any other considerations, it does not seem worth while to go to the extent of using a low-loss coil here, and a plain single layer solenoid wound on a dry cardboard or ebonite tube is indicated. The great point is to avoid capacitative coupling handle. The receiver should therefore prove extremely popular with those enthusiasts who are keen on long-distance or DX reception of broadcasting stations, unhampered by the working of a powerful local station.

**Capabilities**

When the set was finally completed in its experimental form I was agreeably surprised at the results, and found no difficulty in tuning in such stations as Bournemouth, Newcastle, Glasgow, Belfast, Birmingham, Brussels, Hamburg, Munster, and other Continental and B.B.C. stations at full loud-speaker strength, on a good making the grid adequately negative by means of the grid battery connected as shown.

The H.F. valve must be coupled to the detector valve in such a manner that in these conditions the circuit is perfectly stable, and I have found that the method shown gives the best results. A good high-frequency choke is included in the anode circuit and what would have been an H.F. transformer is turned into another "semi-aperiodic" primary again loosely coupled to a tuned grid circuit of the detector valve. A stopping condenser $C_4$ is provided to prevent shorting the batteries between $L_4$ and $L_3$. I have tried several forms of inductance for $L_4$, and find that a small basket coil of few turns placed at the end of $L_4$ gives the best results.

**Reaction**

Where shall we provide reaction is the next question to be settled. We have seen that the damping in the grid circuit of the H.F. valve is fairly low, and full advantage is taken of this fact to obtain selective tuning. In the grid circuit of the detector valve the damping is fairly high, and this is a convenient place to apply reaction. This is done by a combination of magnetic...
Fig. 2.—This wiring diagram may be obtained as a full-sized blue print, price 1s. 6d. post free (Blue Print No. 1300).
and capacity coupling as shown in the diagram.

Arranging the Coils
We now encounter a further difficulty, for we have two inductances to mount in the same set.

Tuning Range
Now a word as to tuning ranges. In Wireless Weekly, Vol. VI., No. 23, and in previous articles in the same journal, I discussed the effects of stray capacities in relation to tuning ranges and gave practical details of experiments carried out with a view to showing the order of the maximum range possible, using only one fixed coil and a variable condenser. The values of inductances and condensers specified here are based on these experiments, and there will be no difficulty in covering the whole of the 200 (1499 Kc) to 600 metre (499.7 Kc) band with sufficient working overlap. I have also erred on the side of generosity in the number of reaction turns and the size of the reaction condenser, so that, while still giving the fine control necessary, there will be no difficulty in securing oscillation of the detector valve. It is interesting to note that the method of obtaining reaction and the design of the circuit largely preclude the possibility of much radiation from the aerial due to self-oscillation.

Further, if the sizes and numbers of turns in the coils $L_1$ and $L_2$ are carefully followed, the condenser readings on the tuning dials will be substantially the same on each for any given wavelength.

Stability a Feature
The whole circuit is so stable that I have put 100 volts on the first H.F. valve with more than 14 volts negative grid bias, and the control is still quite normal.

Fig. 3.—The filament rheostat $R_1$ controls the H.F. and detector valves. Ask for blue-print No. 130a price 1/6d. post free.

Fig. 4.—Details of the second grid Inductance and the reaction coil $L_4$. The small basket coil $L_5$ is shown separately on the right.

Panel Layout
As to the layout of the actual set I have followed the conventional American practice now very popular in this country, with the result that a symmetrical and pleasing panel layout is possible. The three dual type rheostats are along the bottom of the panel, and the first grid tuning condenser, reaction and second grid condenser dials along the top, reading from left to right. The aerial and the earth terminals are on the left, telephone terminals on the right; while the battery terminals are carried on a strip at the back of the base-board.

Below a complete list of components required is given, and if you have not had much experience in set building, and operation, I would strongly advise you to adhere strictly to these components. More experienced and discriminating constructors have ample selection in the choice of components.

Components Required
One ebonite panel, 21 by 7 by \(\frac{1}{4}\) in. ("Radion," American Hard Rubber Co.).
The terminal strip at the back of the baseboard eliminates unsightly battery leads from the front of the set.

One Collinson low-loss former, 5 by 3¾ in. diameter.
Two 0°005 µF variable square law condensers (Collinson Precision Screw Co., Ltd.).
One 0°005 µF variable (square law) condenser, geared (G.E.C.).
Two H.F. chokes (Lissen, Ltd.).
Four “Clearer tone” valve holders (Benjamin Electric, Ltd.).
Two H.F. chokes (Lissen, Ltd.).
One 0°005 µF variable (square law) condenser, geared (G.E.C.).
Two L.F. transformers, 1st and 2nd stage (Gambrell Bros., Ltd.).
Three dual-type filament rheostats (L. McMichael, Ltd.).
One grid condenser, and grid leak mounting (Dorwood Precision).
One grid leak 2M Ω (Dubilier Condenser Co., Ltd.).
Two clip-in condensers, 0°1 µF mounted, and 0°02-0°06 µF with clips (for L.S.) (L. McMichael, Ltd.).
1½ in. ebonite tube, 2 in. diam., and 5 in. ebonite tube, 2½ in. diam. (both as thin as possible, say, ½ in.).
Four large terminals and one No. 1 terminal strip.
Small strip of ebonite, 2½ in. by ½ in., wood screws, angle brackets; square wire for wiring; 2 oz. No. 22 d.c.c.; ½ oz. No. 24 enamal and ½ lb. No. 20 enamel.

One suitable cabinet (Carrington Mfg. Co.).
One 1½-volt dry cell (Ever-Ready, type UV 1).
Radio Press Panel Transfers.

Construction.

In the construction of the set no great difficulty should be experienced; the actual set took about a day or a couple of evenings to make after all the preliminary experimental work and the design had been completed.

The coils are, perhaps, best made first. When the Collinson former has been assembled, secure one end of the No. 20 enamel in the two small holes provided in one end ring and wind on 70 turns, having previously inserted the glass disc supplied with the former in the centre of same. The windings should be put on tightly, and the wire carefully straightened as the winding is proceeded with. Finally secure the other end of the wire in the second end ring.

Twenty-five turns of No. 22 D.C.C. are then put on the ½ inch length of 2-inch ebonite tube, the ends of the wire being simply secured through a pair of small holes at each end of the tube. This constitutes the coil L3, and is simply placed on the glass disc inside the low-loss coil L2, which has just been made.

The second grid inductance, L4, consists of 70 turns of No. 22 D.C.C. wire on the 2½-inch tube. When this has been put on, 45 turns of the No. 24 enamel are wound continuously with this first winding, and in the same direction. This constitutes the reaction coil, L5.

Mounting the Coils

The small basket coil L3 has ten turns of No. 22 D.C.C., and is wound on a former 2 inches in diameter.

The L3 winding is started about ½ inch from one end of the 2½-inch former, and the other end of same is bared and twisted round the bared end of the wire which forms the beginning of the reaction coil, for about ½ inch, and finally soldered. This constitutes the tapping point, which is connected to LT negative.

This whole coil is secured behind
The use of a geared condenser enables a delicate control of reaction to be obtained.

After a final clean up of all the wiring and components, the transfers may be affixed to the panel where desired.

**Preliminary Tests**

There is ample choice in the selection of valves, and I would recommend two of the dull-emitter '06 type for the H.F. and detector, such as the D.E. 3 or B.T.H. B 5 type, and two small power valves, such as the B.T.H. B6 type, if dull-emitters are used for V1 and V2 in the two L.F. stages.

As high an H.T. voltage as possible within the limits specified by the makers should be used on the first valves (H.T. + 1), such as 80 volts.

During the preliminary tests, first see that the set oscillates (you can tell this by the rushing sound and the faint "plonk" in the phones when the dial of the centre condenser is turned to the right). There should be no "backlash," i.e., when the set just starts oscillating it should stop when the condenser is moved back just a degree or so and not require the dial to be rotated back very much. Suitable adjustment of the H.T. + 1 voltage and the filament current of V1 will ensure that this is so.

Do not expect to tune in stations by swinging the dials; this is fatal, as tuning is remarkably sharp. A little practice will soon enable you to acquire this fine sense of tuning.

In conclusion, I should very much like you to write me if you try this set, as it will give a good indication of the popularity of sets of this description and be helpful in the design of future receivers.

**Test Report**

I shall not say much about the test report, since I have already given an indication of the capabilities of the set. I do not want to give any false impressions as to its possibilities, since conditions vary to such a large extent in various localities, but would rather that readers judge the receiver on its own merits.

**A SAFEGUARD.**

When ordering goods or corresponding with wireless firms be sure to use one of the special order forms inserted in this issue.

**NOTE THE GUARANTEE.**
A talk on the Design of an Important Component.

The high-frequency transformer, as a popular instrument in amateur design, dates from the introduction of the plug-in type by Mr. Burbury, of Criggleston, near Wakefield, an enthusiastic and experienced amateur. Mr. Burbury sent a number of his own make of plug-in transformers to Mr. A. A. Campbell Swinton, who, after confirming many of Mr. Burbury's experimental results, presented a paper before the Radio Society of Great Britain in 1921.

Early Forms

Prior to this time the high-frequency transformer had not proved very popular, and probably the most efficient design existing at that time was the type used in Army apparatus during the war—an ebonite barrel with a number of slots cut in it and with the slots filled alternately with primary and secondary windings. All the primary windings and all the secondary windings were respectively in series. By adopting this form of construction a good tight electro-magnetic coupling between primary and secondary was secured without too much trouble from capacity effects.

The Plug-in Type

Mr. Burbury's high-frequency transformers were ingeniously adapted to plug-in to an ordinary valve socket, a method of fitting which has been very widely copied. In form, they were of the disc type, similar to that shown in Fig. 1, the primary of the secondary being tuned with a variable condenser. It must not be forgotten that at the time of the introduction of these transformers, short waves such as we know them to-day, were rarely used and broadcasting was but a vague possibility. Amateurs devoted most of their time to the study of longer waves, and it was very rarely that any wavelengths below 600 metres (499.7 Kc.) were considered of interest. For this reason it was possible to market a number of tapped transformers designed 'to work without any variable condenser across primary or secondary winding, and arranged to have tappings on wavelengths which were popular at that time. An excellent transformer which

I used with considerable satisfaction in those days, is that illustrated in Fig. 2, and made by Messrs. H. W. Sullivan. There were four tappings connected to a stud switch. The first stud covered on 600 metres (499.7 Kc.), and when so used the transformer gave excellent amplification for ship signals. On the second stud the Hague concert could be heard, the third tapping had a peak on the Eiffel Tower wavelength, and the fourth (very flatly tuned), gave quite good amplification on even the longest waves.

With the introduction of Mr. Burbury's plug-in transformers experimenters soon found that here was a way of getting excellent high-frequency amplification on the amateur band, which was then a thousand metres (299.8 Kc.). When Croydon started, however, on 900 metres (333.1 Kc.), it was found that the thousand metre (299.8 Kc.) amateur telephony often gave considerable interference, particularly on Sunday afternoons. A drop was then made to 440 metres (681.4 Kc.), and here also the plug-in transformer proved very serviceable.

The Barrel Type

The next step forward was probably the introduction of the plug-in transformer of the barrel type, suggesting in its appearance a combination of the Burbury type with the older Army design. This type of transformer was brought out by Mr. Hesketh, and had as a distinctive feature the "staggering" of the slots, the slots for the primary winding being much deeper than those for the secondary winding. In this way the capacity effects between windings were still further reduced. I think I can claim to be the first to popularise this type of transformer, for it was an essential part of the first of the "Transatlantic" designs, which I described in this magazine about two years ago. This type of transformer has been very extensively reproduced by other manufacturers, but it is only right that Messrs. McMichael should be given the credit of first introducing it.

An interesting modification of this design was described in Wireless Weekly some time ago by Mr. Donald Straker (see fig. 6). Dis-
tinctly improved results, both in sharpness of tuning and general efficiency, were obtained with this type of transformer, for as the illustration shows, there is a minimum of solid dielectric in the field, and the winding is not in any way bunched together. This transformer is, as Mr. Straker pointed out, a modification of my X coil design, which was first described in Wireless Weekly.

The Honeycomb Type

Before leaving this branch of the subject it would be a serious omission if I did not mention the plug-in transformer made by the Igranic Electric Co., and illustrated in Fig. 7. This was probably the first high-frequency transformer sold in this country to have a fairly thick wire for its winding. It is wound in the honeycomb fashion, similar to this Company's coils.

Available Components

In this brief survey of the history of the high-frequency transformer I have purposely omitted reference to anything other than the components generally available to the home constructor. Many commercial sets have, of course, special transformers wound to suit the particular instruments; and, of course, the tapped transformer, another means of covering a wide wavelength with variable condenser, is still available in a number of commercial forms.

American Lessons

My visit to America proved to me conclusively that if we are to equal with British apparatus the selectivity obtainable with the transformers sold in America which are comparable in quality of reproduction to the majority of those sold here, and as to valves, there is greater uniformity in the British product than in the American, quite apart from the fact that we here have a much greater variety to choose from.

A Useful Instrument

The plug-in high-frequency transformer, as it is available to-day, has proved a most excellent and helpful instrument in the development of the art. Without it I doubt whether the average experimenter would have had any appreciable success in high-frequency amplification. But with the rapid multiplying of stations, and the fact that many of us have to do our work near a station of much higher power than that of the average American broadcasting station, makes it necessary to have the highest selectivity if we are to enjoy long distance reception. Before proceeding further in this article, I would like to direct attention to one or two aspects of high-frequency amplification which we must bear in mind in considering transformer design.

The Main Problem

In an efficiently-designed receiver, if both grid and anode circuits are tuned to the same frequency, and no special form of damping is introduced into one or the other, then self-oscillation will occur. If, by connecting the aerial to the grid circuit (or the anode circuit, for that matter), we bring into action the damping of the aerial, then this will serve to check self-oscillation, and in many cases to stop self-oscillation entirely. A grid current set up by losses set up by grid current. The best known method of effecting this is to connect a potentiometer into the grid circuit so that a varying degree of positive bias may be placed on the grid. Another method is to introduce resistance in the plate circuit or the grid circuit (often unconsciously done by the home builder) in winding coils of very fine wire, or by placing them in such a position that eddy currents set up in adjacent metal work give the equivalent of resistance in circuit. All these methods are what may be termed "loss" methods, and every one of them has the effect of considerably reducing the selectivity of the set; while the selectivity of the set suffers far more than most home constructors, and even commercial builders, imagine. It is, of course, useless to utilise low-loss coils in those circuits when we are deliberately introducing losses in other directions.

Inefficiency

Some high-frequency transformers, wound with fine wire in multi-layer formation, are very inefficient. I carried out an interesting test the other day with a commercial type of plug-in transformer, using it as a "coupler" (aerial and grid coils). The circuit used is shown in Fig. 4. Compared with a good quality plug-in coil (commercial make), the signal strength obtainable was only about one-third, which shows how far we can go in improving our high-frequency transformers, both in sensitivity as well as selectivity.

I have come to the conclusion that efficient high-frequency transformers can be developed with the secondary wound as a single layer, the wire for this winding being of fairly
MODERN WIRELESS

heavy gauge compared with that now used. In short, we short make low-loss high-frequency transformers. A further important point is the coupling between the primary and secondary. The tighter the coupling within limits, the greater the tendency for feed-back between circuits. The coupling can, as a matter of fact, be

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A Suggestion

In my opinion the best method is one which enables the user to change valves if necessary without upsetting the whole design, and the neutralising portion should be made adjustable for this purpose. Another very important point in high-frequency transformer design is the question of capacity coupling between primary and secondary. Great improvements will be found by making the primary winding geometrically small compared with that of the secondary. The capacity coupling between primary and secondary windings in high-frequency transformers in this country is one of their chief disadvantages, and I am at present carrying out experiments with a new type of transformer which will be even simpler to manufacture than the present kind, and in which the chief difficulties are overcome. Meanwhile this article is intended to be suggestive to experimenters by pointing out the way in which developments are likely to take place.

Fig. 8.—A modification suggested by Mr. D. Straker.

loosened to such a degree that practically all tendency to feedback disappears. When this point has been reached, however, there is considerable loss in signal strength. By tightening the coupling and getting better signal strength, we increase the tendency to self-oscillation; but this again can be checked by one of the several neutralising methods now available. Many neutrodyne sets neutralise on the Hazeltine principle, which is so well-known in the United States; but most of them have the disadvantage that the neutralisation has to be carried out very accurately to suit the particular valve supplied.

In working out neutralising arrangements, do not forget that the less capacity shunted across the transformer windings, the greater the tendency to self-oscillation. For this reason a set with the ordinary form of Hazeltine neutrodyning is generally less sensitive on the upper part of the tuning scale than on the lower.

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Fig. 7.—The honeycomb type.
ONE hears a good deal of discussion at the present time of the "selectivity problem," but it does not seem to be generally realised that from the practical point of view it is convenient to regard this problem as being divided into two parts.

Two Classes

First, there is the question of what is sometimes described as "general selectivity." By this phrase is meant the power to separate distant stations from one another, and further, the power to receive any given distant station with a relatively small amount of spark and other miscellaneous interference. Secondly, there is "special selectivity," by which is meant the power to shut out a single powerful local interfering station, in order to receive more distant stations transmitting on near-by frequencies.

"Special Selectivity"

At first sight this would appear to be a "distinction without a difference," but as a matter of fact it is very convenient to regard the problem as being divided in this way. To achieve the degree of "general selectivity" needed to separate fairly distant stations whose frequency difference is more than the usually accepted minimum value of 10 kilocycles is not a very difficult matter, and it is fairly easy to design a set which will do this, but to achieve the amount of "special selectivity" which will suffice to shut out a powerful local transmitter such as a broadcasting station, to so effective an extent as will permit of the reception of quite distant stations on near-by frequencies, is a problem of a very different order of difficulty.

The Wave-Trap Method

It is, therefore, natural that there should be a considerable attractiveness about the wave-trap method of obtaining "special selectivity," although perhaps it is not quite correct to describe this as a method of obtaining selectivity at all, since it is really purely a matter of shutting out one particular station. Most experimenters no doubt have tried the various types of wave-traps, as they have been described in the past, and with varying success, since there can be no doubt that the behaviour of any one of the majority of such traps varies considerably on different aerials and earths. The particular type of tuner incorporated in the receiving set with which the trap is used also appears to have some influence.

An Effective Type

The type of trap which is to be described in this article appears to be one of a degree of effectiveness and reliability very much above that of most of the well-known ones, and I would strongly commend it to the notice of all those who desire to achieve what has been called "special selectivity." Now, one of the most effective of the simple circuits for obtaining a good degree of "general selectivity" is that in which what is known as the "aperiodic aerial" arrangement exists. The aerial circuit in this scheme consists merely of the aerial, a coil of some suitable number of turns, and the earth, no means of actually varying the tuning being provided. More or less closely coupled to this primary circuit is a sharply tuned secondary circuit, in which a fairly good degree of selectivity is usually obtainable.

Simplicity

A special type of wave-trap has been developed by Mr. A. D. Cowper for
Theoretical Considerations

When this acceptor circuit is tuned to resonance with the frequency of the incoming oscillations, these undesired oscillations will pass through the acceptor without producing any difference of potential across its ends, so that, in theory, no current can pass through the primary winding of the tuning arrangement, and nothing can be transferred to the secondary. I have emphasised the words "in theory," because to achieve such a desirable end the acceptor circuit must possess zero resistance, and this, of course, is not obtainable in practice. However, by using a good condenser and low-loss coil, the resistance can be kept low, and a good degree of interference elimination achieved. It is, of course, to be understood that this trap can be set to eliminate only one station at a time, and, therefore, it can only give selectivity of the "special" type.

Fig. 1.—The wave-trap may be cut in and out of circuit by means of the switch S.

use in conjunction with all such circuits, including under this heading the aperiodic aerial type, the auto-coupled circuit, and the Reimartz arrangement. This trap I have found extremely effective and dependable with a great variety of arrangements, in addition to which advantages it possesses the very great one of notable simplicity of construction and operation. The trap arrangement consists simply in placing in parallel with the primary winding to which reference has been made a coil and condenser in series with each other, constituting what is known as an "acceptor" circuit.

Fig. 3.—Showing theoretically how the instrument would be connected to a simple neutralyne circuit.

Components

To construct the instrument the reader will need the following components or their equivalents of similar good make:

1. Ebonite Panel, 5in. by 8in. by 3in.
2. Cabinet to take the above panel, arranged vertically, with a space of 8in. available inside from back to front. (Burne-Jones & Co., Ltd.)
3. Two-way Switch (Bowyer-Lowe Co., Ltd.)

Fig. 2.—With the switch arm to the right the trap is in circuit.

The Coil

The coil is wound with a total of ninety-five turns, and provision is made for varying the number of turns in circuit, by the following arrangement. At turns 70, 75, 80, 85, and 90, a point upon the wire is bared and to this is soldered a short piece of tinned copper wire with the end left projecting about half-an-inch. To any one of these ends the tapping clip mentioned in the list of components can be attached.
and this clip is carried on the end of a piece of flexible wire, whose other extremity is soldered to the moving plate terminal of the variable condenser. After the coil has been wound, it is mounted upon the 7 in. by 2 in. strip of ebonite, which is in turn attached to the upper part of the panel by means of the two brass brackets, in the manner illustrated in one of the diagrams.

Operation

The wiring-up of the trap will be found a very simple matter, and until you find the one at which the extinction point seems to be sharpest and most definite. This will probably give you the best results in practice, but it is as well to carry out the test very carefully again when some distant station has been tuned in, which is normally badly interfered with by the local station, noting upon which tapping point the best results seem to be obtained. It is, of course, understood that any alteration of the tapping point and consequently of adjustment of the trap condenser may slightly upset the calibration of the receiver itself. In general, the best results will be obtained by using as large a number of turns as possible in the trap coil, with a fairly small setting of the trap condenser.

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Results

As regards the actual results which can be obtained with a trap of this type, it is, of course, impossible to speak very definitely, since they will depend to some extent on the locality and the efficiency of the aerial with which the instrument is used, and, of course, upon the actual degree of selectivity possessed by the receiving set. With a set of quite indifferent general selectivity, at a distance of only seven miles from the new 2LO station, I find it quite an easy matter to obtain good signals from Bournemouth without any interference from London, and also, I think, without any loss of signal strength. With a set of fairly high general selectivity it is possible to obtain clear and undisturbed signals from Manchester, without very much difficulty in operation.
The Valve as a Rectifier

by JOHN SCOTT-TAGGART,
F.Inst.P., A.M.I.E.E.

There are innumerable valve users who have only the most remote ideas as to how a valve acts as a detector. It can act in two or three different ways, and each is explained in this article.

I

N almost every valve set a valve detector is used, and even when a crystal is used as a detector instead of a valve, one or other of the valves of a receiver is often acting unintentionally as a rectifier. This rectification is the cause of much distortion and unless it is eliminated it is not possible to get pure reception, hence the great importance of the whole problem of rectification in a wireless receiver.

Little Progress Made

I have previously expressed my views regarding the inefficiency of the valve as a detector. It has hardly progressed for the last 20 years since Fleming first used a two-electrode valve containing a filament and a plate as a means of obtaining rectification.

Not only has the problem of rectification never been seriously tackled by investigators, who have been far more concerned with amplifying methods, but there have been practically no published facts regarding any efforts in this direction.

The Grid Condenser Method

To-day we use the grid condenser method of rectification which, as a matter of fact, was invented by Dr. Lee de Forest in 1907. He used a grid condenser, and it is said that he obtained the leak effect by making the condenser leaky by moistening across its terminals with the aid of his finger.

Whether this story is true or not I cannot say. The chance of the "leak" drying up seems very great! Whether de Forest really understood what he was doing is very doubtful, but it is interesting to recall that the grid condenser made its appearance in the first three-electrode valve patent in this country. At any rate, the honours of the grid condenser and leak go to America in any case, because there is a patent dating back to October 29th, 1913, by Alexander of the Radio Corporation of America which not only specifies the grid condenser and leak but also gives an explanation of its operation.

A Neglected Subject

During the last year I have probably interviewed at least 500 applicants personally for staff appointments in the Radio Press, and of these only an extremely small fraction could explain how a valve acts as a detector; "I know how it does, but I cannot explain it;" is the usual reply. As a matter of fact, the question is the first one which is put to an applicant for a post in my organisation, so that those who have any ambitions in that direction may care to study this brief résumé of the subject.

The fact of the matter is, that detectors are taken for granted, always have been, but will not be in the future, if our new Elstree laboratories have anything to say in the matter. The rectifier valve is the weakest link in the reception chain. We can amplify high-frequency currents relatively easily and we can amplify low-frequency currents to any extent we desire, but we can use normally only one detector and a bad detector will spoil the whole reception.

The Fleming Valve

The incandescent filament valve using two electrodes is generally recognised as being the first commercial valve detector.

The Fleming valve was used by the Marconi Company and at the beginning of the war numerous sets used this method of rectification.

Although it might appear that a discussion of the ordinary two-electrode valve as a detector is dealing with an obsolete subject, yet on the contrary it is vital to enable us to understand the action of the common form of detection used to-day. The whole question of rectification may be dealt with assuming certain broad facts which are quite sufficient for the purpose of a simple, easy and fairly accurate explanation of the valve acting as a detector. I propose to adopt this plan in the present article and

Fig. 1. An explanatory diagram of a two-electrode valve.

Fig. 2. Increasing the value of B1 increases the current through the galvanometer I.

Fig. 3. When alternating potentials are applied across A and F the resultant current through I is in the direction of the arrows.
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to follow it at some future time by a more detailed examination of what I might call the special refinement. An extremely full explanation of valve rectification from several angles, both in two-electrode valves and three-electrode valves, is given in my book: "Thermionic Tubes in Radio Telegraphy and Telephony." Although this book gives a very detailed account, yet I propose to draw on a method of explaining which is given in my "Elementary Text-Book on Wireless Vacuum Tubes," a work of a much simpler character.

**A Two-Electrode Valve as a Detector**

Fig. 1 shows diagrammatically a filament F and anode A which constitute the simple two-electrode valve. Within the bulb are two-leading-in wires S1 and S2, between which is stretched the tungsten filament F. Near to F is a plate A, from which is taken a wire which passes through the bulb B. The filament is shown heated by an accumulator B1. If the plate A were left disconnected, the electrons E from the filament would simply float around near to the filament and then return to their source. If, however, we connect (as in Fig. 2) a battery B, and a galvanometer or other measuring instrument I across the plate A and filament F, electrons from the filament F will pass across the space to the plate A and so round the external circuit which is usually termed the plate or anode circuit. In the figure the resistance R1 is connected in series with the filament to enable the current through it to be varied; by this means we can vary the temperature of the filament and, therefore, the number of electrons emitted from it per second. The plate A is given a positive potential by means of the battery B2, and it is this positive potential which attracts the negative electrons given off by F. The plate A is called an electrode, and since it is given a positive potential it is called an anode; the term anode is preferable and is becoming more common than the word plate, which really means a disc, whereas anode is applicable to cylinders. The external circuit is usually called the detector circuit. The filament F is sometimes called the cathode, since it is negative with respect to the anode, and electron repel each other, whereas they attract each other if of opposite sign. Since there is no anode current whatever when the anode is made negative, we call the arrangement a valve. The valve only allows electricity to pass from the filament to the anode. No electron current can pass from the anode to the filament, since the anode is cold and does not emit electrons. The two-electrode valve is a device which is said to have unilateral conductivity since it conducts only in one direction.

**The Effect of Alternating Potentials**

Fig. 3 shows a circuit which demonstrates very clearly the valve action of a two-electrode vacuum tube. Across the plate A and filament F of the tube is connected a source L.F.A. of alternating current and a measuring instrument such as a galvanometer I. The source L.F.A. may be an alternator. Whatever the nature of the source may be, it will make the anode A alternately positive and negative with respect to the filament F. When the anode A becomes positive, electrons pass from F to A round through L.F.A. and I back to the filament. When the next half-alternation is supplied by L.F.A., the anode A is made negative and no current whatever flows through the valve. We thus see that positive half-cycles will produce a current through the valve but negative half-cycles will produce no current. The current through I will consequently take the form of a series of impulses of direct current always flowing in the direction of the arrow head; thus, whereas we started with alternating current we have now obtained a direct, although fluctuating, current by means of the valve.

**A Practical Case**

Looking at Fig. 3, we may imagine the source of alternating current L.F.A. to be the receiving circuit of a wireless station. The incoming currents will be of an alternating nature, but instead of being of low-frequency they will usually be of a frequency of the order of a million. Nevertheless, the action of the Fig. 3 circuit remains exactly the same whatever the frequency of the alternating currents applied across the anode and filament. The current passing through the galvanometer I will
always be a direct one. Since the galvanometer will not respond to each impulse, it registers the average current.

**Actual Reception**

Fig. 4 illustrates a wireless receiving circuit in which we use the circuit of Fig 3 with incoming signals acting in place of L.F.A., and a pair of telephone receivers taking the place of T. The usual form of coupled circuit is shown. The aerial contains an inductance L, shunted by a variable condenser C. To the coil L, is coupled the inductance L, which is shunted by a condenser C.

**The Circuit**

The closed receiving circuit L, C, is connected across the anode A and filament F of the two-electrode valve, the filament of which is heated by current from the accumulator B, which has in series with it a variable resistance. Between the negative side of the condenser B and the lower end of the inductance L, is connected a pair of telephones T of high resistance (usually about 4,000). Shunted across these telephones is a fixed condenser C.

**The Telephone Condenser**

The action of this circuit is briefly as follows: When spark signals are being received, the oscillations in the circuit L, C, take the form shown in the top line of Fig. 5. Each spark produces a group of waves which increase in amplitude up to a certain point and then die down again. The oscillations are called damped oscillations, and it will be seen that these currents apply alternating potentials to the anode A of the two-electrode vacuum tube or valve. The half-oscillations (or half-cycles) above the line, make the anode A positive with respect to the filament; consequently, a flow of current takes place round the anode circuit at each positive half-cycle. The negative half-cycles (those beneath the line) make the anode A negative with respect to the filament; as a result, the anode repels electrons and no current flows round the anode circuit. The action of the condenser C, must now be explained. If the telephones were disconnected entirely, the high-frequency potentials supplied by the oscillatory circuit L, C, would still be communicated to the anode and filament of the valve, since condensers, while acting as insulators to direct current, will allow alternating currents, particularly if they are of high-frequency, to pass through them. For each positive half-cycle on the anode there will be a flow of electrons to the anode round the anode circuit, through L, and on to the left-hand plate of the condenser C, but the second positive half-cycle may again make the anode positive and cause a further flow of electrons round the anode circuit and into the condenser C. We will thus see that during each wave-train or group of oscillations the condenser C will gradually get charged up to a high voltage owing to an accumulation of electrons on the left-hand plate. Since, however, the telephones T are connected across the condenser C, the store of electricity in C flows round through the telephones thus discharging the condenser C and giving a signal in the telephones.

**A Reservoir Action**

Since the telephones, connected across the condenser C, are of high resistance, it is not likely that much current passes through them except when the wave-train is finished. While the condenser C, is being charged up, it is, however, also being discharged to a certain extent by the telephones T. The action of the condenser C, is, therefore, somewhat similar to that of a reservoir which is being filled up by a stream and which has water taken from it through the main outlet pipes. Even if we eliminate the condenser C, the telephones will be shunted by the self-capacity of the windings and leads.

**Diagrammatical Representation of Rectification**

Fig. 5 illustrates very clearly how the circuit of Fig 4 operates. The top line shows two groups of incoming waves which produce similar oscillations in the aerial and the closed receiving circuits. The second line shows how the negative half-cycles are ineffective since only the positive half-cycles produce high-frequency impulses of direct current which charge the condenser C. The bottom line of Fig. 5 shows the impulses of fairly steady direct current which pass through the telephones T. The impulses of direct current shown here are really the average effect of the high-frequency direct impulses of the second line.

If we removed the telephones out of the Fig. 4 circuit the condenser C, would continue, being charged up so that the left-hand side became negative and the right-hand side relatively positive. When the voltage across C, equals the amplitude of the signals in the circuit L, C, the condenser C, will no longer charge up but will remain in its charged condition. Under these circumstances...
October, 1925

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the bulb B would no longer take part in any rectifying action. This, of course, assumes that the condenser C2 and the rest of the apparatus is so highly insulated that a leakage of the charge in C2 is impossible.

**Experimental Illustration**

An interesting experiment which has been proposed to show the charging-up action of a condenser in a two-electrode valve circuit is illustrated in Fig. 6. We have here the primary T1 of a transformer T1, T2 connected to a source of alternating current A C. The secondary T2 is connected on the one hand to the anode of the two-electrode valve V and on the other side to one plate of the condenser C. The right-hand plate of C is connected to the negative side of the filament accumulator B. Across the condenser C is connected a spark gap S, which may be adjusted to such a separation that a spark will take place when the voltage across the terminals reaches, say, 50 volts. The voltage across the secondary T2 may be, say, 100 volts, while the condenser C may have a capacity of 1 or 3 microfarads. If this arrangement is connected up, the following action takes place. The currents in T1 will be alternating, which means that the anode will alternately become positive and negative with respect to the filament F. When the anode A is positive electrons will be attracted from the negative side of the filament to the anode A, and when the anode becomes negative these electrons will be attracted back to the filament. Thus the anode acts as a condenser and leak method which may be used as a detector. These two voltages therefore oppose each other and, in fact, the voltage across the condenser C is all the time opposing T2, and gradually becomes equal to the voltage applied by T1.

**Sparking Point**

The second positive half-cycle draws up more electrons from the filament which go to charge the left-hand plate of C still more negatively. This process goes on until the potential difference across the condenser C is 50 volts when a spark immediately occurs at the spark gap.

**The Point at which Rectification Stops**

If there were no spark at all, the condenser C would charge up to the full voltage of T2, i.e., 100 volts. Afterwards the valve would no longer be carrying any useful function as a rectifier because the voltage across T2 which tends to make the anode A + 100 volts is counteracted by the voltage across C which is trying to make the anode A -100 volts. These two voltages therefore oppose each other and, in fact, the voltage across the condenser C is all the time opposing T2, and gradually becomes equal to the voltage applied by T1.

**MODERN WIRELESS**

**H.F. Currents most Important**

In actual practice, of course, we are not particularly anxious, in the ordinary wireless receiving circuit, to rectify low-frequency alternating currents, but we are interested in rectifying high-frequency currents because they cannot directly operate telephone receivers or similar instruments.

I now propose to discuss the question of the three-electrode valve as a detector and use the explanations I have already given in connection with the two-electrode valve.

**The Three-Electrode Valve as a Detector**

There are three essential methods whereby a three-electrode valve may be used as a detector. These are:

1. By working the valve at a bend in its characteristic curve.
2. By taking advantage of grid currents in the valve.
3. By the use of the grid condenser and leak method which is a development of the second method.

I will deal with these three methods in turn.

**Anode Current Rectification**

This is the name given to the method of rectification which depends upon a non-symmetrical change in the anode current for equal changes of grid voltage. When receiving wireless signals we can assume that negative and positive half-cycles of oscillating current are of equal amplitude. These, if applied to a valve which is acting simply as a perfect amplifier would result in a similar high-frequency output current which, however, would be of greater amplitude. It is not generally realised that the grid condenser method of rectification depends upon the valve acting as a perfect amplifier, i.e., a non-distorting amplifier in which positive and negative half-cycles of equal strength are equally amplified. When using anode current rectification, however, we may assume that the input positive and negative half-cycles are of similar values, and that rectification is obtained by an alteration in their effect on the anode current passing through the telephones. If, for example, we arrange that +1 volt...
produces a bigger anode current change than \(-4\) volt, then by applying our oscillating current to the grid of a three-electrode valve we can produce a low-frequency variation of current through our telephones. We talk about valves acting as rectifiers on the incoming oscillations. To be exact, however, a three-electrode valve as a whole never does actually act as a rectifier of the original currents, as is the case with a crystal detector. In the latter case the crystal itself actually rectifies the high-frequency alternating currents and the resulting direct currents are used to work the telephones, or other apparatus. In the case of a valve operating on the anode current rectification principle, the anode circuit is quite distinct from the grid circuit and the oscillations in the grid circuit may not be altered in any way whatsoever when using this method. The grid is really acting as a means of controlling the anode current, the grid circuit and the anode circuit being absolutely distinct. The best explanation is obtainable by looking at the characteristic curve of a three-electrode valve.

**Working on the Bottom Bend**

Fig. 7 shows a typical characteristic curve, and we know that there is a bend near the point C, and a bend near the point G. If we now work the valve at the point C by placing \(-4\) volts on the grid, incoming positive half-cycles will move the representative point up to D and produce a large increase of anode current, whereas negative half-cycles will produce small decreases of anode current. A positive half-cycle of \(1\) volt would cause the anode current to increase from C (0.04 milliam) to D (0.08 milliam), whereas a negative half-cycle of \(1\) volt will cause the anode current to decrease from C (0.04 milliam) to B (0.02 milliam). The increase for every positive half-cycle is, therefore, 0.04 milliam, while the decrease for each negative half-cycle is 0.02 milliam. The result is that, as the high-frequency alternating currents are super-imposed on the fixed potential of \(-4\) volt on the grid, the mean or average change in the anode current will be an increase. When signals cease, the anode current, of course, returns to its normal value of 0.04 milliam. During the reception of signals the average current rises to some value between the points C and D. These increases will be produced during each group of incoming waves and a click will be produced in the telephone receivers if they are connected in the anode circuit of the valve.

**A Simple Receiving Circuit**

Fig. 8 shows a simple receiving circuit in which the closed circuit is quite different. A fixed by-pass condenser \(C_2\) may be connected across the telephones or across the negative side of \(B_2\), and the anode side of \(T\). This condenser is not essential.

**Unwanted Rectification**

It is important to bear in mind that rectification with a three-electrode valve will take place under almost any conceivable circumstances, and the beginner will be puzzled by this fact. As long as you have telephones in the anode circuit of a valve, you are almost bound to get signals of greater or lesser strength.

**A Point to Note**

Any of the above-mentioned methods may be taking place, and sometimes all three are taking place at the same time! There is only one set of conditions when rectification would not take place. This place would be somewhere between the points E and F on the curve of Fig. 7. At this point it is possible to obtain practically no rectification at all, and this point is really the ideal one for low-frequency amplification, wherever distortion is to be avoided.

**The Condition for no Grid Current**

An advantage of anode current rectification is that when the operating point of a characteristic curve is produced by a negative potential on the grid, there is roughly speaking no grid current flowing, and in these circumstances the damping of the circuit \(L_1, C_1\) in Fig. 8 is very small. In the case of a crystal detector, the damping introduced into the circuit by the crystal detector is very considerable and affects both selectivity and signal strength. To a certain extent the same effect is obtained when using grid current methods.
Results are only as good as components permit

The results obtainable from any radio receiver are only as good as the merits of the component parts used. It has been demonstrated time and time again that good components are the cheapest in the end.

Sterling components are made to a standard of performance and not to a price. That does not mean that Sterling components are necessarily expensive, but that the price charged for any Sterling component is the lowest fair price at which a component capable of continuously performing its purpose perfectly can be sold.

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October, 1925

of rectification which come under the headings 2 and 3.

A Bend not Essential

Another point in connection with this method of rectification is that an actual bend in the curve, as modified, is not an essential. Any curve, even of a regular nature, will cause rectification. For example, if part of the characteristic curve were shaped like a portion of the circumference of a circle, rectification effects would be obtained; it is not necessary, as many people imagine, that there should be a change in the curvature, although a big change in curvature at a certain specified point is undoubtedly going to give excellent rectification effects, and various attempts have been made to produce such rapid changes in curvature, although without much success. I have, however, heard of a recent valve which possesses distinct advantages over the ordinary type in this respect.

Graphical Representation of Rectification

Fig. 9 shows very clearly what happens in the Fig. 8 circuit, the top line showing two or three groups of incoming waves such as would be produced by a spark at the transmitting station. The oscillations produced in the circuit L, C, will vary the grid potential above and below the normal negative value given to it by the potentiometer. The second line shows how the positive half-cycle produces an average decrease of anode current greater than the decreases due to the negative half-cycles. The anode current variations are therefore of a high-frequency character and resemble more or less the received oscillations. The average effect of each group of oscillations, however, will be to produce an increase in the steady anode current. This increase is shown by a dotted line in the second line of Fig. 9, and the effect on the telephones will be as though direct current pulses were passed through them. This is shown in the third line of the figure.

Using the Upper Bend

Instead of working the valve at a point C of Fig. 7, we can work at the point G or thereabouts. In this case positive half-cycles will produce small increases in the anode current, whereas negative half-cycles will produce large decreases. The effect of a whole cycle or alternation will be an average decrease in the anode current and this will affect the telephones in the same way as in our previous case.

Grid Current Rectification

We now come to another method of detecting wireless signals. In the first method we did not alter the incoming oscillations, but caused them to produce unequal changes of current in a separate anode circuit. To do this, we utilised the change in curvature of the anode current curve. In the method to be described, we work the valve on the straight portion of its curve, but achieve our object by causing the grid potential variations to differ. The positive half-cycles have their amplitude lessened while the negative half-cycles remain the same. This is done by taking advantage of the fact that when the grid is made positive with respect to the anode current curve of a simple two-electrode valve. Now if we connect a conducting circuit across an oscillatory circuit we will lessen the oscillating potential across the latter; for example, if we connected a resistance across a closed receiving circuit the resistance would take current from the receiving circuit and would have a "damping" effect; the potentials across the oscillatory circuit would be less than if the resistance were absent. Now, the effect of a grid current is to damp out to a certain extent the positive half-cycles of oscillating potential applied to the grid of the valve.

An Analogy

A somewhat similar effect is obtained when we connect a lamp, for example, across a series of dry cells; when a current flows through the lamp the voltage across the cells immediately drops. Since the grid current only flows when the grid is made positive, the positive half-cycles never reach their full amplitude; whereas the negative half-cycles are unaffected. We do what is equivalent to partially short-circuiting the positive half-cycle. The conductive path between filament and grid acts as a shunt resistance to the oscillatory circuit L, C, (Fig. 10), which only affects the positive half-cycles. The grid potential, when using this circuit, should be kept in the neighbourhood of zero volts, and the filament current and anode voltage should have such values that the valve is being operated at such a point on the characteristic curve that the anode current travels down a steep straight portion. Such a point is F in Fig. 7.

The Least Effective Method

Positive half-cycles now produce only a small increase in the anode current, whereas negative half-cycles produce a large decrease. The result is an average decrease in the anode current, and this affects the telephones T. A small fixed condenser is usually connected across the primary T of the telephone transformer T, T, and may be connected so as to shunt both the anode battery B, and the winding T'. This method of rectification is the least effective.

Grid Condenser Rectification

The commonest form of a detector circuit works on a rather more complicated principle than the arrangements already described.
The receiving circuit is similar to that of Fig. 10, but between the grid and the top of the inductance $L_1$ is a small fixed condenser $C_2$, usually having a capacity of about 0.0003 μF, or less. Across this grid condenser, as it is called, is connected a high resistance $R_2$ (see Fig. 17). The resistance $R_2$ has in practice a value of between 1 megohm and 5 megohms, a value of 2 megohms usually giving good results.

**Action of Condenser**

Let us first of all consider the action of this circuit without the high resistance or leak. The condenser $C_2$ acts as an insulator to steady currents which might otherwise flow in the grid circuit. The potential of the grid is usually in the neighbourhood of zero volts, or slightly negative. Electrons on their way to the anode pass through a certain extent to the grid which collects them. These electrons charge up the grid, but since they cannot flow through the condenser $C_2$, the grid acquires a slightly negative charge which prevents more electrons from going to it. The effect, then, of putting a condenser in the grid circuit is to give the grid a normal potential which is just sufficient to prevent the flow of any current round the grid circuit. We may say that the normal steady potential of the grid will be equal to that potential which, when connected to the grid circuit (C2 being shorted) would just prevent the flow of a grid current. This potential is usually between zero volts and minus one volt. It is that voltage which, if slightly raised in a positive direction, would start a flow of electrons to the grid. We will assume, for the sake of the following explanation, that the grid potential is normally zero volts, and that if its voltage is raised above the value it begins to attract electrons.

**The Grid**

When incoming signals produce oscillations in the closed circuit $L_1$, $C_2$, the grid will become positive and negative alternately with respect to the filament. This is because the condenser $C_2$, although acting as an insulator to direct currents, will act as a conductor to high-frequency or pulsating impulses. When the grid is given a positive potential with respect to the filament, it immediately begins to attract electrons from the filament, but these electrons remain on the grid and on the right-hand side of $C_2$. These electrons give the grid a small steady negative potential, which remains after the end of the positive half-cycle. The negative half-cycle of oscillating current makes the grid momentarily still more negative, but since no electrons are drawn to the grid, the change in grid potential only lasts during the short period of the negative half-cycle. The next positive half-cycle comes along, overcomes the small steady negative potential on the grid, and raises the grid potential once more above zero. The grid, becoming momentarily positive, attracts a further supply of electrons, which, since they cannot escape, increase still further the negative potential on the grid. At the end of the second positive half-cycle, the steady grid potential will have become still more negative. The process repeats itself a number of times, the grid potential gradually becoming more and more negative.

**Decrease of Anode Current**

At the end of the wave-train, however, there is a comparatively long interval (actually about 1.000th of a second) for the accumulation of electrons on the grid to leak away through the resistance $R_2$. When they have all leaked away, the grid is once more at about zero potential, and the process is repeated as each subsequent wave-train. During each spark at the transmitting station the grid potential gradually drops, and the anode current at the same time decreases. There is, therefore, a click in the telephones for each spark, a note being thus produced when signals are received. Most British valves detect best when the grid circuit is connected to the positive side of the accumulator.

**An Alternative Connection**

Instead of having the grid leak across the grid condenser, it may be connected directly across grid and filament without altering the action in any way. The bottom end of the resistance is connected either to the negative or positive side of the accumulator, whichever gives the best results with the valve used.

**A Graphical Representation**

Fig. 12 shows graphically the process of grid condenser or "cumulative" rectification. The first line shows three groups of damped waves (waves from a station, such as a spark station). The second line shows how at the end of each positive half-cycle the grid potential has gradually fallen. The lowest mean negative potential reached by the grid is always less and cannot be greater than the amplitude of the largest positive half-cycle; a point is therefore reached somewhere between the largest positive half-cycle and the end of the wave-train where the average grid potential ceases to fall. Since it takes a comparatively long time for the electrons on the grid to leak away through the grid resistance, the grid potential is usually between zero volts and minus one volt, which remains after the end of the positive half-cycle.

**The Effect of the Grid Leak**

At the end of a wave-train the grid would normally still be at a negative potential. The anode current which has meanwhile been decreasing, owing to the increasing negative potential on the grid, would also remain at a steady decreased value. Subsequent wave-trains would produce no effect, and consequently the circuit would be useless for receiving wireless signals. It is essential that at the end of each wave-train the valve should be restored to its former positive condition ready for the next group of waves. In order to restore the original conditions, we provide a high resistance which we connect so that the electrons stored up on the grid can leak away back to the filament in time before the next wave-train comes along; we usually connect a grid-peak across the grid condenser. The electrons thus flow through $R_2$ and $L_1$ back to the filament. During the very short period of the wave-train the leak $R_2$ has practically no effect, since its resistance is so high that it takes a very much longer time than the duration of a wave-train for the electrons on the grid to leak away through it.
Sir, you've been looking for me!

RIGHT along you've wished for a better fixed condenser, and now, at last, such an instrument is obtainable. The Efficient Watmel is my name—a better fixed condenser, superior in all the points that make for highest efficiency. Witness my Test Report, it speaks for itself.

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He speaks quite normally and without the least fuss. Very likely he goes on to say "In New York to-day—," or "In Tokyo this afternoon—." Even as he speaks we just give a touch to our "ATLAS" Condenser, alter the micrometric adjustment of our "ATLAS" Coil Stand, perhaps plug in another "ATLAS" Coil, and he gives place to an opera from Germany, or a song from Spain.

"ATLAS" LOW LOSS COILS are typical of the supremacy of the whole range. The patent twin-wire winding and special design carry the "low loss" principle to its extreme. The least possible resistance is offered to high frequency currents, and a real meaning is given to phrases like "maximum inductance," "signal strength," and "minimum self-capacity." Prices from 4/3 to 17/6.

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potentials remain at their negative potential for some considerable time. The value of the leak should be such that the electrons on the grid have a sufficient time to leak back to the filament before the next wave-train arrives. In line 2 of Fig. 12 will be seen how the grid potential rises slowly from its negative value to zero volts. All the time that the grid is kept at a negative value the anode current will be reduced, and since the anode current is kept reduced for an appreciable period and to an appreciable extent, the response in the telephones is greater than in the methods of rectification which have been previously described. The fourth line shows the average pulses of current which flow through the telephone receivers.

**The Best Working Point**

Since we desire to get the maximum decreases of anode current for the average decrease in the grid potential we must work our valve somewhere on the steep straight portion of its characteristic curve. The point F of Fig. 7 would be suitable. To obtain the best results with cumulative (or grid condenser) rectification circuits the filament current of the valves should be variable.

**High and Low Frequency Variations**

The grid potential of the valve in Fig. 11 varies in two ways, when signals are received. In the first place, the grid potential is varied at a high-frequency; the frequency of the impulses on the grid is equal to that of the incoming signals. At the same time, however, the average potential of the grid gradually becomes more and more negative during a wave-train. These average decreases in potential occur at each wave-train and, therefore, take place at audio-frequency. Since the anode current variations are cumulative, (or grid condenser) rectification circuits, we get radio-frequency current variations in the anode circuit; but while these are taking place we are getting audio-frequency decreases in the anode current which take place every time the grid falls to a steady negative potential. The high-frequency variations are called the "radio-frequency component" of the anode current, while the low-frequency variations are usually called the "audio-frequency component" of the anode condenser.

**An Example**

It may at first be a little difficult to understand how the two current variations take place at the same time. We may, however, take the analogy of a swinging pendulum. The pendulum may be swinging to and fro very rapidly, but at the same time it may be gradually lowered towards the ground. The rapid sideways movement of the pendulum represents the radio-frequency component, while the slow movement of the pendulum towards the ground is analogous to the audio-frequency component of the anode current. We may also be helped to understand the problem by considering a variable resistance in series with a delicate ammeter which, instead of being supplied with current from a battery, is supplied from direct-current mains. The current supplied by the mains, while being fairly steady, usually varies very slightly at a frequency of, say, 50 times per second. The slight periodic variation is due to the commutator of the dynamo. The ammeter needle, while remaining comparatively steady, will tremble perceptibly. By gradually increasing the resistance the current through the ammeter will gradually decrease, but whatever the current through the ammeter may be, there will always be slight commutator variations which will make the needle tremble.

The commutator "ripple" represents the radio-frequency component, while the slow steady drop in the current through the ammeter represents the audio-frequency component.

**Use of the High-Frequency Component**

In the simple detector circuits which we have so far considered, only the audio-frequency component is used to operate the telephone, which are unaffected by the radio-frequency current variations. In Fig. 11 these latter pass through the condenser C4 and are not utilised in any way. But there are many more circuits in which use is made of these radio-frequency currents.

**An Explanatory Circuit**

A circuit which may help to explain the fundamental action of the "leaky grid condenser" circuit of Fig. 11 is shown in Fig. 13. A two-electrode valve V1 is connected across the oscillatory circuit L2 C2, a condenser C2, shunted by resistance R2, being connected in position shown. A three-electrode valve V2 may be connected across the anode and filament of V1, as shown; but for the moment we will leave out of consideration the valve V2. Incoming signals make the anode of V1 positive and negative alternately. Negative impulses have no effect, but positive half-cycles cause the anode A to draw up electrons from F1, and these electrons accumulate on the anode and on the right-hand side of C2. At the end of each group of oscillations the negative side of C2 and the anode A will have acquired a negative potential with respect to the filament F. In order that this negative potential may leak away before the next train of waves arrives, the high resistance R3 is connected across C2. We can now connect up a second valve V3, to amplify the negative potential on the anode A. This may be done as shown in Fig. 13. At each wave-train the anode A becomes negative, and therefore causes the grid G2 to become negative. The anode current of V3 consequently decreases, and produces a click in the telephones. This circuit is really the same as Fig. 11, except that instead of having a separate anode Al, and a separate filament Fr, the grid G2 acts not only as a means of controlling the current through V1, but as a valve which draws up electrons from the filament.

The valve of Fig. 11 acts as a combination of a two-electrode rectifier and a three-electrode amplifier.

**MODERN WIRELESS**

**The Self-contained Three-Valve Receiver**

Sir,—It may interest you to know that I have just completed the "Self-contained Three-Valve Receiver," described by Mr. John Underdown in the August issue of Modern Wireless.

I have altered the layout slightly in order to put it in a portable form, the size on the panel being 11½ in. by 10½ in. I also altered the wiring of the H.F. transformer to take an Igranic Honeycomb Duolateral transformer.

Using three 1½ v., 3 amp. valves, the last being a power valve with 70 volts on the first two valves and 100 volts on the F,, SXX comes in at loud-speaker strength and Radio Paris at good 'phone strength in daylight. I have not yet obtained a transformer for the lower broadcast wavelengths, so I do not know what the results will be on the lower wavelengths. My aerial is 30 ft. high and 50 ft. long, badly screened, the earth 100 ft. of copper wire buried beneath the aerial. Wishing your papers every success,

—Yours truly,

S. Nino.
Cornwall.
SHARP-TUNING is not generally one of the outstanding features of crystal receivers; in fact, it is well known that one of the disadvantages of this type of receiver is its lack of selectivity. In a great number of cases no attempt is made when designing crystal sets to obtain sharp tuning, ordinary headphone signals only being desired from the local station—a demand very easily satisfied.

Morse Interference

There are, however, several thousands of listeners who are so unfortunate as to reside in areas near the sea or a river, where the reception of local broadcast is very often spoiled by interference from ships.

These people need a selective receiver even to listen to their local station, and it is for them more especially that the set to be described was designed.

Daventry transmissions, I know, offer one solution, but the local programme is often preferred.

The Circuit

The circuit used in this set may be seen in Fig. 1. It will be observed that the aerial circuit is aperiodic, and variably coupled to the secondary coil, which is of the low-loss type, tuned by a 0.003µF. condenser.

The crystal and telephones may be connected across the whole or part of the secondary coil, which is tapped at seven points along its 72 turns. Provision for adding a loading coil for the reception of 5XX has been made in the secondary circuit, and a further position to which the crystal lead may be connected is seen indicated at X. The loading coil plug is placed in this position, and not on the earth side of the coil, in order that when receiving 5XX the effect of tapping the crystal across the low-loss coil alone may be tried.

Three terminals appear on the left-hand side, these being Aerial, A1, and Earth respectively.

The centre terminal, A1, is used when it is desired to receive Daventry, the aerial now being parallel tuned.

Components

The general arrangement of the panel is simple, and lends itself to easy operation of the three adjustments on it.

In order to construct this receiver you will require the following components, and whilst actual names are given, it is not to be understood that the special makes used are essential for successful results; any good quality components will do equally as well, but the quality must be good. Their size, however, will have to be considered if the same size panel is used with them.

1. Ebonite panel, 9 in. by 6 in. (Paragon).
2. Mahogany cabinet to take panel.
4. Shorting plug. (Burne-Jones & Co., Ltd.)
5. 0.003µF. variable square-law condenser (low-loss type). (Jackson Bros.)
THE RIGHT THING in THE RIGHT PLACE

ALTHOUGH the experience of the average man with wireless matters has been comparatively short, it has certainly been intensive. In the summer of 1922 an aerial outside a house was a rarity. In 1925, on the other hand, it is the house without one that is the exception. Literally millions of people nowadays know quite a lot about the theoretical and practical sides of wireless. Above all they now realise that a successful set must be fitted with good condensers, and in every case the name Dubilier is generally recognised as the hallmark of condensers both fixed and variable, Anode Resistances, and Grid Leaks, and other similar products.

In the illustration above, we show some examples of the right thing in the right place:

- at C1 a Dubilier Type 610 Mica Condenser (from 3/-) with Grid Leak (2/6)
- at C2 & C3 Dubilier Type 620 Mica Condensers (from 3/-)
- at C4 a Dubilier Type 600a Mica Condenser (from 2/6)
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Dubilier Condensers are made in a very wide range of capacities, and the Grid Leaks in several values. Every wireless Dealer stocks Dubilier products, and they are used in every good wireless set.

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A New
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If your loud speaker does not give uniformly good reproduction of all notes, tones, instruments and voices, the trouble can probably be eliminated by the use of the new B.T.H. Transformer. Its chief characteristics are:

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Insist on B.T.H.—the Best of all.

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A general
back of
panel view.

Note the
tappings on
the low-loss
coil and on
the fixed
plates
condenser
terminal.

Drilling the Panel

Mark out and drill the panel according to the drilling diagram shown in Fig. 2. Since all necessary dimensions are given, this will not be found a difficult matter. Now take the baseboard and temporarily affix the panel to it.

Winding the Coils

The coil former, with the two brass angle-pieces fixed, should now be placed in position on the baseboard, care being taken that it does not foul the telephone terminals. When its position is decided, mark the positions for its fixing screws.

The panel may now be removed from the baseboard and the condenser, crystal detector, terminals and 2 B.A. brass bush mounted.

The winding of the coils must next receive attention. As stated in the list of components, the low-loss former should be 4½ in. long, but if a longer one is obtained, then it will not be found a difficult matter to cut it down to the desired length. As there are 16 threads to one inch, a 4½ in. former will be of sufficient length for 72 turns of wire to be wound on it.

A Point to Note

The circular disc of ebonite supplied with the former should be fixed inside the latter before wiring is commenced. One end of the No. 22 enamelled wire must be secured by passing it through the two small holes provided in the end ring, leaving about 6 in. free for connecting later. Now the winding may be proceeded with, and when completed this end of the wire must be secured in a similar manner to the last, 6 in. being left free.

The Aerial Coil

For the aerial aperiodic coil former I have used an ordinary piece of stiff, dry cardboard. Its exact size is immaterial, and about 35 turns are wound on it in the usual basket-coil manner. The photo makes this clear. Two or three inches must be left free at either end of the winding.

Fig. 1.—The long wave tap is indicated at X.

Fig. 2.—The knob in the centre of the panel is for the purpose of adjusting the aerial coupling.
A sufficiently large hole to take the 2 B.A. rod must be drilled through the former in the position shown.

Soldering the Crystal Taps

Having progressed thus far, take the low-loss coil and fix it temporarily on to the baseboard in its correct position. The small lengths of square tinned-copper wire must now be soldered to the various turns as shown in the diagram.

The first is to be soldered to the end turn furthest away from the panel, 10 turns separating each tap, with 2 being left between the seventh and the coil end.

If the following instructions are carried out this soldering will be greatly facilitated.

Force up the turn to be soldered and push a small piece of a matchstick underneath it, but above the adjacent windings. It is now an easy matter to scrape the enamel off, and, after tinning the wire, solder the small piece of square section wire to it.

The two connections, one from the upper telephone terminal to the detector, the other, a flexible lead (with clip attached) from the other side of the detector, should be soldered in their correct positions before fixing the panel and baseboard together. When this is completed, screw the panel to the baseboard and fix the loading coil plug in position, so that any coil to be used will not foul the condenser or low-loss coil when plugged in.

Wiring Up

In Fig. 3 the wiring diagram will be seen. It is perfectly simple, and with its aid the actual wiring up should present no difficulty. It will be noticed that a projecting length of wire is secured under the fixed plates terminal on the condenser. Being in this position, when the clip connects to it, it places the crystal across the whole of the loading coil, plus the low-loss coil, when receiving 5XX. At the same time, if it is desired, the crystal can be tapped across the near as possible, without fouling, to the low-loss coil end, and flexible leads are connected from the aerial and earth terminals to it.

Testing Out

When the wiring up is complete, the set may be tested out.

First, short the loading-coil socket then connect the aerial to the top left-hand terminal and earth to the bottom terminal, the telephones, of course, also being connected to the correct terminals. The detector lead must be clipped on to the tap furthest from the panel. Swing the coupling to its maximum position, and after adjusting the crystal to what is thought to be a good spot, adjust the condenser slowly from minimum to maximum. If local broadcasting is going on, it is almost certain that something will be heard.

However weak the signals heard may be, the condenser can be adjusted to its correct position by their aid, and a really good crystal setting found.

The effect of varying the coupling and the crystal tap should be tried, and in some cases it may be found that signal strength increases to a certain extent if the crystal is tapped across only part of the coil.

Receiving 5XX

To receive the long-wave station a No. 100 coil must be plugged into the socket provided, and the flexible lead clipped on to the wire projecting from the variable condenser terminal. When signals have been heard and the condenser and crystal correctly adjusted, try the effect of tapping the crystal across the low-loss coil. (Continued on page 67.)
In radio working the letters "Q.R.B." followed by the interrogation mark mean "What is your distance?"

Station replying sends "Q.R.B. . . . . . miles." (no interrogation mark) meaning "My distance is . . . . . miles."

**What is your distance?**

Night flying! Illimitable and impenetrable space, the objective unseen and, to the uninitiated, unattainable, but by keen judgment and the aid of scientifically designed apparatus, the pilot, without fuss or worry, quickly attains to it. "Q.R.B. 100 miles" soon becomes "Q.R.B. 50 miles," and finally "Arrived O.K."

Use your judgment, obtain scientifically designed apparatus, and you will reach to distant stations hitherto considered unattainable.

**H.F. TRANSFORMERS**

"M.H." H.F. Transformers are of original and scientific design.

Supplied in six ranges of wavelengths, covering from 80 to 7,000 metres.

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<td>No. 0</td>
<td>80 to 150 metres</td>
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Working Your Set from the D.C. Mains

By Captain H. J. ROUND, M.I.E.E.

In this interesting article the well-known Chief Research Engineer of the Marconi Company describes how the H.T. and L.T. supply may be obtained from the house-lighting mains.

A very large number of people are supplied with direct current for lighting purposes and it is now quite easy to use this for working a two or three-valve set, thus avoiding the expense of accumulators and of high-tension batteries, and, incidentally, giving more reliable power for loud-speaker work.

The mains are usually 220 or 240 volts, and one side or the other of these mains is much nearer earth potential than the other. It does not really matter whether the positive or negative is near earth potential except for the following point. If the positive is near earth potential, then a fuse requires one to stand .25 amperes, and with a resistance of \(\frac{240}{15}\) ohms, \(= 900\) ohms.

Where \(240\) = voltage of mains;
\(15\) = voltage of 3 valves in series;
\(.25\) = current.

A Lamp Resistance Preferable

Another way and much cheaper is to choose a lamp which takes .25 amperes at the particular voltage, which will be the mains voltage minus three times the valve voltage.

Or, still a third way is to choose a lamp which takes a little more than .25 amperes and put a resistance across the 3 valves as a regulator.

If you have an ammeter or voltmeter you will be able to judge exactly either by current or voltage.

The lamp or rheostat must be put in on the positive side of the mains, and I would recommend a fine thin fuse to be put in on the negative side in case during the test an accidental earth is put on the set.

It is nearly always necessary to choke the mains with high-frequency chokes. For the ordinary broadcast range two 50 coils are enough, but for Daventry two 150 coils will be necessary. There seems to be quite a lot of H.F. mush coming from D.C. mains. It is preferable to put chokes in right at the mains switch-board if possible, but in this case special chokes must be used, plug-in coils being unsuitable, and an electrician should be employed for the job.

Suppose we incorporate the chokes in the set, the filament lighting system will be like Fig. 1. I will show a little later how you can tell which is positive and which is negative. The high-tension supply has to be well smoothed out, but it was not difficult to do this in all cases I have tried.
The terminals $T_1$ and $T_2$ have the full mains voltage on them, say, 240 volts. We shall seldom need quite as much as this. The connections to be made are as in Fig. 2; $r_1$, $r_2$, $r_3$ are three 16 c.p. 240-volt carbon lamps.

**Comparison Purposes**

With the same set running completely off the mains, the comparison purposes with Fig. 5, the same set running completely off the mains.

**A Safety Measure**

If the whole set is connected up as shown, but without regard to which is positive and which is negative on the mains—and then the mains plug is inserted—no signals or clicks on making and breaking the loud-speaker will be obtained if the plug is in the wrong way round.

It will be noted that I have put a $2 \mu F$, 400-v. Mansbridge type condenser in series with earth lead. This should be put in the earth lead near where it enters the house, so as to avoid possibilities of earthing the mains and blowing fuses.

**A Further Precaution**

I have indicated a leak across it to relieve static discharges. Those who are anxious to prevent any chance of this main earthing happening under any circumstances, can insert in the system a large 240-volt carbon lamp on the negative side at $M$. This, of course, will alter current and voltage values. The larger, it is the less the alteration, but now if the negative side of the system is accidentally earthed, instead of a fuse blowing the lamp $M$ will light up to full brilliancy.

**Grid Bias**

If a greater splitting of voltage is required 3 or 4 lamps can be put in instead of $r_3$ and $r_4$, all of course in series, noting that a condenser of large value must go across from the tapping to the negative end. The only voltage which it is better to supply from a battery is the grid bias, and I will represent this in the set as dry cells, but of course it can quite easily also be supplied by providing a variable resistance of small value in the negative side of the mains. If dry cells are used it saves a lot of trouble and they last a very long time.

In Fig. 4 I show an ordinary 3-valve set working off accumulators and dry cell H.T. for

---

**Fig. 4.** A conventional three-valve circuit, using accumulator L.T. and dry cell H.T.

Z is a choke which can be made by winding in three longitudinal sections, 6,000 turns of No. 28 D.C.C. wire on a straight iron wire core of about $\frac{1}{2}$ in. diameter and 8 in. long (Fig. 3). The two condensers should be 400 volt condensers to prevent chances of breakdown. We now have available 80 volts from $T_1$ to $X$ and 160 volts from $T$ to $Y$, and of course 240 volts across the set.

**Fig. 5.** A similar circuit to Fig. 4, in which both H.T. and L.T. are obtained from the mains. A common H.T. tapping at 160 volts is shown for simplicity.
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Are Neutrodyne Circuits Worth While?

By J. H. REYNER, B.Sc.(Hons.), A.C.G.I., D.I.C., Staff Editor.

 Quite a number of home-built high-frequency amplifiers made nowadays are fitted with a neutrodyne control, or some other method of neutralising the effect of the inter-electrode capacity of the valves employed. The question as to whether this extra trouble and expense is justified by the results which are obtained is one which must have occurred by now to every serious enthusiast.

Effect of Inter-Electrode Capacity

Let us consider for a moment what happens in a high-frequency amplifier associated with any one valve: we have firstly an input circuit, and secondly an output circuit. These circuits may be represented as in Fig. 1. The input circuit may be the secondary of an inter-valve (H.F.) transformer, or it may be a tuned circuit, either applied directly to the grid, or tapped from the previous valve through a condenser. In any case we may represent it, for the time being, as an impedance of some sort which we will call \( Z_1 \). The output circuit, similarly, may be either an inductance, a resistance, or a tuned circuit, and we will represent this by an impedance \( Z_2 \).

Now the incoming signal will apply a certain voltage between the grid and filament of this valve, which will cause amplified currents to flow in the anode circuit. These currents in turn will develop voltages across the external impedance of the anode circuit, and due to the amplification of the valve, these voltages will be considerably greater than those originally applied across the grid and filament.

Feed-Back

Now, theoretically, one would expect to obtain an amplification of something like 5 or 6 for each stage of high-frequency amplification, and in practice one finds that it requires very considerable skill in construction to obtain an overall amplification of as much as 2. If the amplification is increased any more than this the whole amplifier bursts into oscillation.

The reason for this lies in the inter-electrode capacity. The voltages which are developed across the external impedance \( Z_2 \) in the anode circuit produce currents which flow through the capacity between the anode and grid of the valve, which is shown as \( C_m \) in Fig. 1, and complete a circuit back to the filament through the grid impedance \( Z_1 \).

From this figure it will be seen that the voltage really splits up into two portions, one of which is dropped on the internal capacity \( C_m \), and the other is developed across the external impedance \( Z_1 \). This latter voltage is, of course, applied across the grid and filament of the valve, and will be amplified as if it were an incoming signal.

Fig. 3 shows this part of the circuit re-drawn in somewhat simpler fashion.
plifier, these voltages which are developed by this shunting effect through the capacity of the valve are in such a direction as to cause reaction or

feed-back. That is to say they will tend to produce oscillation, and if they are sufficient in quantity they will actually do so. It is this feed-back which, causing oscillation as it does, limits the amplification which is obtainable in a high-frequency amplifier.

The 'Neutrodyne'

Professor Hazeltine, in America, proposed an ingenious method of overcoming this difficulty, which in one form or another has since come into very general use. He suggested that, in addition to the existing shunt path through the internal capacity of the valve, we should supply, external to the valve, another shunt path arranged in such a way that it would produce voltages across the grid and filament exactly equal and opposite to the voltages produced through the valve itself.

If this were done, it is obvious that the two effects would neutralise each other and the feedback which causes the oscillation would be neutralised. One would then expect that the amplification of the valve could be increased to a figure somewhat more in keeping with the theoretical estimate, and in practice this anticipation was justified.

Increased Amplification Obtained

In an ordinary high-frequency amplifier, without any neutrodyne control, one finds that, as the potentiometer or other control is moved more and more towards the sensitive position, so the amplification rapidly increases, but that this increase is very soon cut short by the set bursting into oscillation. With a neutrodyne amplifier, however, the amplification continues to increase for a considerable distance past this point, and one is able to obtain a really effective amplification from the valve. There is no doubt, therefore, that neutrodyning is very distinctly worth the trouble, for it enables one to obtain more amplification from each valve, and therefore in the long run saves an additional valve, and possibly more.

The Original Circuit

The original circuit employed by Hazeltine for his neutrodyne arrangement is shown in Fig. 3. Here a small condenser is connected between the grid of the second valve, at the point G₂, back
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to the grid of the first valve $G_1$. The functioning of this can readily be seen. If the voltage developed at the point $A$ in the anode circuit of the first valve is such as to apply voltages through the capacity $C_m$ of the first valve, across the grid and filament in such a direction as to cause oscillation, then the neutralising arrangement must be such as to apply voltages in the opposite direction.

Fig. 8.—Hand-capacity effects may be obviated by placing the lower end of the condenser $C$ at earth potential.

Now the voltage developed across the coil in the grid circuit of the second valve (which in this case is the secondary of an ordinary anode-tuned transformer), is in the opposite direction to the voltage existing in the anode circuit. Therefore at any instant the voltage existing at the point $G_2$ is in the opposite direction to the voltage existing at the point $A$. Consequently, if this voltage is allowed to produce current through the neutralising capacity $C$, it will produce voltages across the grid and filament of the first valve in the opposite direction to those voltages which are produced by the current flowing through the capacity of the valve itself, and thus by a suitable adjustment of the value of the condenser $C$, this anti-reaction can be so adjusted as to neutralise completely any tendency to oscillation, so making the amplifier absolutely stable.

**Over Neutralisation**

It will be obvious that, in order to accomplish this, the size of the neutrodyne condenser $C$ must be of the same order as the anode to grid capacity of the valve. Now this capacity is very small indeed, ranging from 5 to 10 µµF for ordinary receiving valves, which requires rather special construction if it is to be duplicated mechanically.

However, it is not necessary to employ quite so small a capacity, as will be seen from the following considerations. The larger the condenser the more easily can the energy by-pass through it. Consequently, if the condenser is made too large, over-neutralisation will occur, and the circuit will begin to lose efficiency, and ultimately, due to certain secondary effects, it may even commence to oscillate once again, in this case on a different wavelength from that which is being received.

**Neutrodyne Condensers**

We can avoid over-neutralisation, however, and still use a reasonably large condenser, by reducing the size of the coil which supplies the energy in the first case, i.e., $L_1$, in Fig. 3. With the original circuit, Hazeltine used very small condensers, made up from two lengths of wire partly covered with insulating sleeving, as shown in Fig. 4. These condensers had a capacity of the same order as that of the anode-grid capacity of the valve itself.

By taking a tapping from the secondary winding, however, the condenser $C$ may be increased in value, and this enables us to utilise a practicable form of small condenser for neutrodyning purposes.

There are now various makes of condensers suitable for neutrodyne circuits, having a capacity of the order of 50 µµF.

**Tuned Anode Circuits**

If such a condenser were used with the circuit of Fig. 3, it would have to be connected, not to the point $G_1$, but to a tapping across a comparatively small portion of $L_1$.

It is more usual however, as will be seen, to employ a tuned anode arrangement. One of Mr. A. D. Cowper's arrangements suitable for use with a tuned anode system is indicated in Fig. 5. Here it is necessary to have a coil coupled to the tuned anode coil itself in order to produce the voltage in the opposite direction, as has just been described.

The voltage induced into this coil is then allowed to pass current back to grid of the first valve through a neutrodyne condenser, as has just been described.

Standard neutrodyne units are made up for this type of circuit, the primary winding being tuned and inserted in the anode circuit of the valve, and the secondary winding being used as the neutrodyne winding and connected back to
the grid of the valve through the neutrodyne condenser.

**Operation of Circuit**

After the neutrodyne condenser has been correctly inserted, the value of the capacity is then adjusted until the circuit can be brought to its most sensitive condition without causing any self-oscillation or howling. With complete neutralisation there would be no tendency to oscillate whatever, assuming that there was no appreciable magnetic coupling between the coil in the grid and anode circuit of the same valve, but in practice the neutralising is not carried to this pitch, as a certain tendency to oscillation gives a reaction effect, which is useful.

It is found that the setting of the neutrodyne condenser remains fairly constant over a wide range of frequencies, so that the broadcast band can usually be covered with one setting.

**Other Forms of Neutrodyne Circuits.**

A modification of this circuit, which is employed by Mr. Percy W. Harris in the Harmony Four, if, of course, it was desired in this case also to place one of the plates of the neutrodyne condenser at earth potential, that is to say, if any hand effects were obtained with this arrangement, the neutrodyne condenser could be inserted in the position shown in Fig. 8, which would not cause any radical alteration to the circuit itself. A circuit which may be convenient in certain circumstances is that shown in Fig. 9. Here the neutrodyne coil is made part of the tuning circuit, the condenser C being connected across the whole coil L1.

**Loud-Speaker Circuits**

A stage of low-frequency amplification has been added to the circuit in Fig. 9 to enable the signal strength to be increased, to operate a small loud-speaker on near-by stations. This circuit, however, may not prove as suitable as some of the previous ones, as there is a tendency for the adjustment of the neutralising condenser to vary the anode tune. This defect is not present in the circuits described earlier in this article, which can be stabilised without any effect on the tuning. A good circuit for loud-speaker working is that shown in Fig. 10, in which two stages of low-frequency amplification are incorporated. This circuit would give good reception of distant stations and loud-speaker strength on a large number of closer stations.

**Conclusions**

The foregoing considerations will indicate quite clearly that there is a distinct advantage to be gained from neutralising the valve capacity. Any of the methods described may be used, although the neutrodyne itself, with the simple modifications proposed by Mr. Cowper has advantages in that various plug-in neutrodyne units may be obtained which are specially designed to work with the various types of neutrodyne condenser now on the market. Provided reasonable care is taken, the results obtained amply repay the additional trouble.
THE secret of long-distance reception when using a single-valve receiver largely depends upon a fine control of reaction. Probably the most popular method by which a reaction effect is obtained in receivers of the type under consideration is that of variably coupling a coil in the plate circuit of the valve to the aerial or grid coil, and though this method has much to commend it, it has nevertheless certain disadvantages.

When using a receiver of this type for long-distance reception it is often found that the required fineness of reaction coupling cannot be obtained on account of the receiver falling into oscillation before the maximum signal strength is obtained. Further, when the reaction coil is moved away to stop the receiver oscillating, it is sometimes necessary to separate the two coils by several further degrees before the non-oscillating condition is obtained.

Other Methods
Apart from the swinging coil method, there are several other ways by which a reaction effect may be obtained, chief among which is the well-known Reinartz method, where the reaction coil is immovable and adjustment given by a variable condenser.

Reaction Control
When using a receiver of this type, the chief being that variation of the reaction coil coupling upsets the aerial tuning adjustments.

In the receiver to be described will be found still another method by which a fine adjustment may be obtained, while the reaction setting does not affect the aerial tuning. The reaction coil is coupled to the grid coil in the usual way, but in this case the coupling is not variable, control being given by a variable condenser.

The Aerial Circuit
In order that long-distance stations may be received, it will be appreciated that some attention must be given to the question of selectivity, and in the present receiver auto-coupling is employed with the earth connection arranged in such a way that the aerial turns may be varied in their number. This same earth tapping also serves the purpose of allowing grid damping to be reduced, bearing in mind, however, that when reducing the grid coil turns, the aerial turns are increased in number, thus reducing selectivity. A complicated arrangement possibly, but a compromise is easily found, when the receiver becomes both highly selective and sensitive, in addition to being delightfully easy to operate.

The Circuit
In Fig. 2 is given the theoretical circuit of the receiver, and it will be seen that there are in all three coils L1, the grid coil, with its earth connection shown variable; L2, the fixed reaction coil; and L3. This last coil is a radio frequency choke, and is shunted by a variable condenser, which is used to give control of reaction; the value of this condenser is 0.003 μF, and though in the present receiver this was found to be large enough, it may be experienced with some aerials that a larger value is required. In order to meet such a case, the receiver is fitted with two clips for adding a fixed condenser in parallel should occasion demand its inclusion.

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The reaction coil L2 may be seen in the bottom slot of the coil former.
one set Press panel transufs. Quantity of connecting wire.

The Coil
As stated previously, this is wound upon a "three-step" former, which will be found to allow of 69 turns being wound from start to finish. In the present receiver the last turn is removed from the former altogether, the 58th turn being secured by threading the No. 22 enamelled wire through a hole provided in the former. The vacant slot is used for winding the reaction coil, the turns of which are close wound in the same slot, there being nine complete turns of No. 32 d.c.c. wire. The actual number of turns wound for this reaction coil should preferably be found by experiment, and though in most cases nine will be found sufficient, there may be other cases where the receiver will not oscillate at the lower end of the grid condenser scale, indicating that there are too few turns.

The Reaction Turns
When building the receiver it would be best to wind, say, a dozen turns for the reaction coil, when one turn at a time may be removed during the period of tuning the receiver in actual operation. This removing of turns does not in any way necessitate dismantling the coil or receiver, as they are easily removed by merely unsecuring the last turn and unwinding as required.

Construction
The winding of the coil, should it not be procured already wound, is perfectly straightforward, in that the No. 22 enamelled wire is first secured in one of the holes provided in the rings of the former and then one complete turn is wound in the first slots; the wire is then crossed over to the next slot, when the operation is repeated, the wire in this case being crossed over to the third slot. When this third turn is wound the wire is crossed over to the fourth row of slots, which will be of the same level as those of the first turn; the fifth turn will be of the same level as the second turn, while the sixth turn will be the same as the third, and so on. When sixty-eight complete turns have been wound the wire should be secured through one of the holes provided in the ring at the opposite end to that where the coil winding was commenced.

We now have one row of slots perfectly free, and into these are wound the reaction coil turns, using No. 32 d.c.c. wire; the number of turns, as previously advised, being determined by actual experiment. The beginning of this winding is secured by twisting the wire round the actual ebonite base where the first turn is to start, whilst the end of the coil is preferably not secured at all until the correct number of turns is found; the wire being of such a small gauge is soft enough to stay in position without unravelling. When the number of turns is decided upon, the end of the coil may be secured through one of the holes in the ring nearest to it.

Connecting Up
The panel, after being drilled in accordance with the instructions given in Fig. 1, should be secured to the baseboard by means of the two right-angle brackets, whereupon the components and terminals may be mounted in their respective positions, care being taken to give sufficient...
The N.A.R.M.A.T. Exhibition settled the question — made Ediswan superiority clear, undeniable.

The Exhibition Dispersed any doubts!

Thousands of Wireless Enthusiasts, not quite convinced of Ediswan perfection, learned at the Exhibition of the thoroughness that goes to the making of each Ediswan Valve, realised that such painstaking care in manufacture, backed by the Ediswan Patents, must inevitably result in Ediswan Users "Hearing more—Hearing better."

EDISWAN VALVES.

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<tr>
<th>Type</th>
<th>Fil. Volts</th>
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<tr>
<td>P.V. 5 D.E.</td>
<td>22/6 5.0</td>
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<tr>
<td>P.V. 6 D.E.</td>
<td>18/6 1.8-2.0</td>
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<tr>
<td>P.V. 8 D.E.</td>
<td>22/6 3</td>
</tr>
<tr>
<td>A.R. (L.F. or H.F.)</td>
<td>8/- 4</td>
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<tr>
<td>R.</td>
<td>8/- 4</td>
</tr>
<tr>
<td>A.R.D.E. (L.F. or H.F.)</td>
<td>14/- 1.8-2.0</td>
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<tr>
<td>A.R.O., 6</td>
<td>16/6 2.5-3</td>
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At all Wireless Dealers.

EDISWAN VALVES

THE EDISON SWAN ELECTRIC CO., LTD.,

In replying to advertisers, use Order Form enclosed.
MODERN WIRELESS

October, 1925

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Low Loss Condensers
(SQUARE LAW)

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2. One-hole fixing—one in. diam. hole is needed to fix this condenser to panel.
3. Rigid construction—cannot warp; end plates of stout aluminium, perfectly flat.
4. Fixed vanes supported by in. ebonite strips.
5. Smooth action, spindle tension is maintained by a specially designed friction washer.
6. Moving vanes and end plates are at earth potential.
7. One-piece knob and dial—supplied loose. Secured by 4BA Set Screw.

This condenser is fitted with optional soldering Tags, or Terminals, and can be supplied with or without Vernier as desired.

<table>
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<tr>
<th>Size</th>
<th>Price with Vernier</th>
<th>Price without Vernier</th>
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<tr>
<td>.00025</td>
<td>5/6</td>
<td>6/6</td>
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<tr>
<td>.0003</td>
<td>7/6</td>
<td>8/6</td>
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<tr>
<td>.0005</td>
<td>9/6</td>
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MODERN WIRELESS

The choke coil socket L3 is secured to the baseboard by means of one screw only.

The reaction condenser should give a smooth and easy control of oscillation without "floopiness"; it will be found preferable to adjust the reaction turns so that the receiver will oscillate over the whole range without the ability to "howl"; the ideal being when the set will just oscillate over the whole range. A big reaction coil will mar to a great extent the smooth control which the reaction condenser will normally allow.

Valves

The receiver under description has been tried with both bright and dull emitter general purpose valves, and also with special valves, such as the B.4, D.E.4, D.E.5b, and has given equally good results with these types. Though with some valves the receiver is found to oscillate more freely than with others, there is nevertheless a good smooth control of reaction in all cases.

Testing for SXX

When the tests upon the shorter wavelengths have proved satisfactory, the aerial connection should be changed to A2, the shorting plug substituted for a No. 150 coil, and if the choke coil was formerly a large one, this should be changed to one of the order of a No. 100. The connecting clip should be connected to the last turn. The No. 100 coil should be set at right-angles to the loading coil (No. 150) and tuning made upon the grid tuning condenser with the reaction condenser set at, say, 90°. Increasing the reading of the reaction condenser and varying the angle between the choke and loading coils will now give a sufficient amount of reaction, control being obtained by varying the reading of the reaction condenser.

Operating the Receiver

Tuning is obtained by means of the grid tuning condenser.

(Continued on page 67.)

clearance between the valve and the moving vanes of the reaction condenser. The positions of the choke and loading coil sockets should also be determined upon with care.

When mounting the coil, that end which supports the reaction coil should be mounted on the base-board, and that section of grid coil turns which is nearest the loading coil socket should be rubbed with fine emery or sand paper in order to raise the enamel, thus enabling the connecting clip to make proper contact with whichever turn is being used.

Testing the Receiver

When the wiring is completed, the receiver should be tested for oscillation before the actual reception tests are attempted. The batteries, aerial and earth and telephones, should be connected to their respective terminals, and a suitable valve inserted in the valve socket. The aerial connection should be first made at A1, and the shorting plug inserted in the loading coil socket; a No. 250 coil or larger should be inserted in the choke coil socket, and the Burndept connecting clip attached to, say, the twelfth turn from the bottom of the coil. At this stage adjust the H.T. voltage to about 45 volts. Set the grid condenser at its 180° setting, with the reaction condenser adjusted to its zero reading. Light the valve to its normal degree of brilliance and turn the reaction condenser slowly towards its higher reading; if it is found that the receiver does not oscillate until, say, the 160° reading is reached, move the connecting clip up one or two turns, when the receiver will be found to oscillate more freely. If, however, it is found that the receiver will not oscillate at all, either by adjusting the connecting clip at various turns or by increasing the value of the reaction condenser by means of adding a fixed condenser in parallel, then the connections to the reaction coil should be reversed. If it is still found that the set will not oscillate, then the reaction turns should be increased in number, though if the former instruction indicating that twelve turns be wound to start with this difficulty will not arise. The position of the connecting clip will vary with different aerials, but as an indication of its approximate position the best results are obtained on my own aerial when it is connected to a turn about the fifteenth from the bottom; the actual turn number

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Operating the Receiver

Tuning is obtained by means of the grid tuning condenser.

(Continued on page 67.)
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**EVERSOLE BROS.**
17 WALLER STREET, HULL.
Improv'in3 Reaction Control
By STANLEY G. MARRIOTT, M.I.E.
(Continued from Page 65)

Reaction is obtained with the re-
aviation condenser, and the connect-
ing clip is changed from one turn to
another until the maximum signal
strength and desired degree of
selectivity is obtained. It must
be remembered, however, that
any alteration in the position
of this clip necessitates resetting
both the variable condensers.
Probably the best station upon which
to practise for the first time is the
nearest, and those readers who live
fairly near to a main broadcasting
station, say, within 50 miles, will
be able to pick up this station by
first setting the reaction condenser
to its zero reading and then slowly
turning the grid tuning condenser
until the set stops oscillating, and
quickly
point the dial should be turned
towards the zero reading or just
a number of these appear to be too modest to
announce their identity, their
nationality, however, would appear
to be German.
Among the identified stations are
Oslo, Hamburg, Frankfurt and
Ecole Supérieure.
The receiver is both selective and
easy to operate, the control of
reaction being delightfully smooth.

Test Report
The receiver was tested on a
moderate aerial about 6 miles west
of 2LO. That station was received
at excellent strength, and it was
found that best all-round results,
considering signal strength together
with selectivity, were obtained
with the aerial coil in nearly the
maximum coupling position, and
the crystal tapped across only 52
turns of the secondary coil.
It was noticed that the smaller
the number of turns across which
the crystal was connected, the
greater was the selectivity ob-
tained. Quite good signals were
also received with the crystal across
only 12 turns.

Daventry
With regard to 5NX, this station
was heard at satisfactory strength,
the aerial now being joined to A1
with a 150-turn coil plugged in the
loading socket and the crystal
connected across both the low-loss
and the loading coil. Signals could
also be heard with crystal tapped
across only 30 turns of the low-loss
coil, but in this position they were
declaredly weak.

A Sharp-Tuning Crystal Set
by E. J. Marriott.
(Continued from Page 65)

Stations Received
Using this receiver in S.E.
London (in the lee of the Crystal
Path), with a poor outdoor aerial,
London is received at too
great a strength for telephone
use, though a few degrees on either
side of this adjustment upon the
grid tuning condenser eliminates
the signals completely. In the
reception of the more distant
stations, signals are relatively as
good, the reaction control being
delightfully smooth, while the selec-
tivity possible is equally attractive.
Using a D.E. 4 valve with 40 volts
on the plate, the loudest stations
appear to be Birmingham, New-
castle, Radio-Toulouse, and Radio-
Belge, whilst other stations come
in at good strength though not
quite so loud; a number of these
appear to be too modest to
announce their identity, their
nationality, however, would appear
to be German.
Among the identified stations are
Oslo, Hamburg, Frankfurt and
Ecole Supérieure.
The receiver is both selective and
easy to operate, the control of
reaction being delightfully smooth.

A Sharp-Tuning Crystal Set
by E. J. Marriott.
(Continued from Page 65)
THE attention of serious experimenters has for some time been concentrated upon very short waves, ranging downwards from 100 metres (100 Kc.), until at present waves of 20 metres (14991 Kc.) are in constant use, and this fact has necessitated the design of special transmitting and receiving circuits, or rather the modification of ordinary well-known circuits to suit the new conditions, and many interesting developments have been brought forward from time to time.

A Modification

The particular modification of the Hartley transmitting circuit which is in general use upon short waves, in which the main inductance is split into two portions, these latter being joined up through a variable condenser, provides much scope for experiment when the coils are increased in size so as to cover the broadcast band, and many interesting hours have been spent in getting the assembly to function satisfactorily on the broadcast waveband.

The aerial is joined through a twenty-turn coil, to earth, the coil being wound upon the same former as the anode and grid coils, the latter being of the same size and spaced equally on each side of the aerial coil. The inner ends of the anode and grid coils are connected together through the condenser C1, which serves to give a very smooth reaction control. In the original circuit which Mr. Cowper described, a variable condenser of 0.001 μF capacity was used, in order to enable broadcasting to be received with minimum interference from undesired sources, such as ships at close quarters, as well as providing a means whereby weaker signals may be searched for without the annoying background from the local station persisting.

The second inductance consists of 64 turns in two portions of 32 turns each, wound in low-loss fashion upon a threaded squirrel-cage type of former, the threads being cut sixteen to the inch. Five threads are left on each side of the aerial coil, which is wound in the middle of the former, the outer positions being occupied by the two halves of the main inductance. No. 20 d.c.c. wire is used for the aerial coil, twenty turns being wound on, and a...
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Variable Condensers

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One hole fixing. Ebonite Ends.

With Vernier. Without Vernier. 

D.E. 2111.10.

2/11. 5/11. 8/11.

Standard... 2/11. 5/11.

5/11. 8/11.

D.E. 2111.10.

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The simplicity of the panel layout is evident. Full-size Blue Print No. 132a may be obtained, price 1s. 6d., post free.

Experience Necessary
At the outset it must be emphasised that the circuit is decidedly of the "stunt" variety, and is therefore not to be recommended to the novice, only those with a thorough knowledge of ordinary reaction receivers being advised to tackle the present instrument. As previously stated, the circuit is one which, with suitable coils, is in common use upon short waves for transmitting purposes, and therefore is capable of causing considerable interference if incautiously or inconsiderately handled.

Components
The more experienced experimenter may wish to make up a set along the lines of the present instrument, and for this reason I am giving a list of the components actually used in my receiver in order that the experimenter may be able, should he desire, to make an exact copy of the original.

Tapping made at the fifteenth turn for an optional aerial tap, which is necessary in order that the aerial may be kept out of tune with the secondary circuit. The outer coils are wound with No. 18 or 20 enamelled wire, there being 32 turns in each.

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One insulating panel, 14 in. by 7 in. by 3/16ths or 1/4 in. I have used Radion Mahogany, but any good brand of ebonite will do.

Suitable cabinet (Camco).
Two variable condensers, square-law type, with a geared motion.

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Suitable cabinet (Camco).
Two variable condensers, square-law type, with a geared motion.
October, 1925

MODERN WIRELESS

design, when housed in a cabinet the lid of which is made to lift up, is very handy, as all parts are easily accessible without disturbing battery and other leads, while at the same time the valves are well protected from damage. Again, in such designs as the present, in mounting purposes, and in this case the coil is easily removed by loosening two screws and lifting it off the supports.

Valve-Holders

In view of the fact that dull emitter valves will in all probability be used by any who make this set, and certainly in my own case, I have incorporated anti-capacity anti-microphonic holders, in order to reduce undesired noises as well as to reduce stray capacity effects.

A jack of the single filament type has been used, so that it is not difficult to use the valves burning when the telephones have been disconnected.

Panel Drilling

As will be seen from the drawing, Fig. 2, there are very few holes to be drilled in the panel, so that no possible to leave the valves burning when the telephones have been disconnected.

Panel Drilling

As will be seen from the drawing, Fig. 2, there are very few holes to be drilled in the panel, so that no

Fig. 3.—Showing how the set is wired up. The thin wires are ends of the coils taken to the correct points. Blue Print No. 132b, price 1s. 6d., post free.

which coils of the "low-loss" variety are used, it is almost essential to secure the coil to a baseboard as in the present set, in order that alterations may, if necessary, be easily carried out. The type of coil former employed is supplied with angle clips for
The combined forces of the Philips and Mullard Technical Research Organisations have achieved the first of many wonderful developments in the perfection of radio valves.

The first objective of this gigantic research collaboration was to produce a master loudspeaker valve with vastly increased life and reduced current consumption. The P.M.4 Valve is the result of their labours. No finer valve has ever been offered to the British radio public.

The Laboratories from which this master valve has emanated employ the services of over a hundred skilled technical radio experts. From end to end the P.M.4 Valve will be entirely of British manufacture.

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The Finest Loudspeaker Valve ever produced

The P.M.4 Master Loudspeaker Valve stands triumphantly alone above the accepted standard in valves for loudspeaker reception. It is the NEW "N" FILAMENT VALVE! Behind its design and performance lies the most advanced knowledge in Europe. The most striking departure in the production of the P.M.4 is the filament. This filament is prepared by an entirely new process, whereby the special coating is obtained in an extremely adherent condition, making it capable of giving considerable electron emission at very low temperatures. There are four supports to this unique "N" filament. It is absolutely non-microphonic. The low current consumption of only 100 milli-amperes means vastly increased valve life and longer battery service without re-charging.

The whole construction is one of extreme rigidity and power, there being eight electrode supports. Only a 4-volt accumulator or three dry cells are required for the P.M.4 Master Valve. Try one in your set to-night and note the wonderful purity of tone and volume you will obtain from your loudspeaker. PRICE 22/6 each

Note the wonderful construction of the P.M.4 Master Valve.

Mullard

THE MASTER VALVE


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Distortionless Amplification

All Purpose Transformer

This model, although enclosed in the same case as our De Luxe type, differs from it in all other respects except as regards quality of manufacture and performance. It works equally well as a first or second stage amplifier, and is strongly recommended for use with power valves.

You will need this Transformer when you build the new S.T. 100. It is the first-stage transformer for this popular circuit.

List No. 5152, in brown metal case ... 15/-

De Luxe Transformer

This model has achieved its pre-eminence by reason of the high degree of amplification obtainable, which remains constant over a wide band of frequencies, resulting in the reproduction of speech and music with all its natural characteristics preserved. The sectional illustration shows that the primary and secondary windings are side by side, which gives a high degree of insulation and low self-capacity between windings.

List No. 5150, High ratio (first stage)  
List No. 5151, Low ratio (second stage)  
In black metal case ... 27/6

Dimensions (both models):—Height, 2 in.; Base, 2½ in. by 3 in. Fixing centres, 3½ in.

Write for our complete radio catalogue.

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The valves are switched off upon removal of the telephone plug from the jack.

operation is carried out before any components are mounted, in order that the panel may be more easily handled.

The disposition of the parts on the baseboard has been carefully worked out, to provide good spacing of essential wires, together with ability to insert large valves into the sockets. If any departure from the design is effected, care must be taken to see that the valves will not be fouled by the moving vanes of the variable condensers. As designed, it is possible to use a D.E.3B valve in the detector socket, and a similar large valve in the note magnifying position without any trouble.

Good Spacing Essential
It is advisable to wire up the low tension side first, in order that the grid and plate leads may receive the fullest consideration. The connections to the coil and condensers should be spaced as well as possible. The remainder of the wiring is quite straightforward, and will be easily effected.

Valves to Use
The panel transfers may next be affixed, and in this connection it may be pointed out that the title of the receiver, as seen in the photograph of the front of the set, is made up from the transfers, the word “Hartley” being built up of single letters. This will be found easy to accomplish if a pencil line is lightly drawn along the position of the letters, and each letter in turn is then fixed in place, sufficient time being allowed between the fixing of each letter for the previous one to dry off.

With regard to valves, it is necessary that two valves of the same class should be used in this receiver, owing to the fact that only one resistance is provided.

Testing
The set is now complete, and ready for an initial test of the wiring. Join up the accumulator and insert the valves. Plug in the telephone plug and turn the rheostat towards the “on” position. If each valve lights correctly, turn the resistance off and move the L.T. leads to the H.T. terminals. Turn the resistance on and note that neither valve lights up. If this is so, return the L.T. leads to the correct terminals, join up the H.T. battery, aerial, and earth. Plug in a value of high-tension voltage to suit the particular valves you use, and be sure not to run the filaments of your valves too bright.

Operating the Set
The operation of the receiver is fairly simple after a little practice has been obtained, but some difficulty may be experienced at first. Tuning is so sharp that it is quite possible to revolve the dials and hear nothing, in which case it is not safe to assume that the wiring is incorrect. The reaction condenser should be kept at a setting which is just below the point at which the set commences to oscillate, and the tuning condenser is then rotated as slowly as possible, the reaction condenser being readjusted meanwhile. Tuning is a matter for two hands, and considerable practice will be necessary before the best results are obtained.

(Continued on page 94.)
The science of radio communication has developed so rapidly of recent years that the information on this branch of engineering is in a particularly scattered state.

Although many radio engineers and amateurs have a very good idea of the trend of development in the art of radio, quantitative information, such as actual figures and data, are available only through the publications of the various learned societies, or through the medium of expensive textbooks. Moreover, it is often found that a textbook which contains information on one point will not give the particular details required on some other point. To remedy this defect, Messrs. Radio Press, Ltd., have published a complete handbook on wireless entitled *Radio Engineering*.

This work, which has been compiled by Mr. J. H. Reyner, B.Sc. (Hons.), A.C.G.I., D.I.C., of the Radio Press research staff, is a unique collection of data on almost every phase of radio science. The work is in three sections. The first section deals with wireless data pure and simple; the second section is a brief review of the systems of telegraphy and telephony in use in this country; while the third section is a collection of general physical and electrical data.

**Circuit Design**

Chapter I. contains information on the calculation of inductance, capacity, resistance, etc., and the measurement of these quantities at high frequencies.

The next chapter deals with the properties of oscillating circuits, and shows various methods whereby the tuning properties of any given circuit may readily be obtained. This section will prove extremely valuable in the design of wave traps, rejectors, etc.

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The next chapter is concerned with valves, giving details of their design and construction. An important feature is that tabular details and representative characteristics are given for over 60 of the principal valves in use at the present day.

**Radio Transmission and Reception**

The next chapter deals with radio transmitters, and much useful information is given on the subject of obtaining high efficiency in valve transmitters which should prove useful to the amateur. A very complete review of the modern methods of radio reception follows, and practical data are given on many points of circuit and amplifier design.

Two more chapters follow, dealing with the design of masts and aerials, and with miscellaneous points such as high-speed working, atmospherics, screening, etc.

A Book which Every Experimenter Should Have

In the other two sections, as has been stated, there are data on the principal telegraphic and telephonic systems in use in this country, and 196 pages of mathematical and physical tables. The whole book, which comprises 484 pages, with 314 illustrations, and 111 tables, is a new departure in wireless literature, and the volume is, unquestionably, one which should be in the home of every serious experimenter as well as the practising radio engineer. The price is 15s., or 15s. 9d. post free.

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Reception Conditions in Derbyshire

An interesting letter giving details of some results obtained with the All-in Portable Receiver, described by Mr. A. S. Clark in the June issue of "Modern Wireless."

Working the set in the open air.

Dear Sir,—I recently had an opportunity of spending a short holiday in Derbyshire, and as this seemed an excellent opportunity to study reception conditions in a country district well removed from all the main B.H.C. stations, it was decided to make use of the two-valve portable receiver, described by Mr. A. S. Clark in Modern Wireless, Vol. 4, No. 5. It will be remembered that this set employs a straightforward detector and low-frequency amplifier circuit, with transformer coupling and reaction on to the aerial coil. The usual series condenser is used for C.A.T., and a loading coil for the high-power station is incorporated.

At Spinckhill

The reception to be described was carried out at Spinckhill, a delightful little village situated on the top of a hill, about eight miles south of Sheffield, and surrounded on every side by open country.

The first step was to arrange a suitable aerial and earth connection. The aerial, thanks to a convenient tree, was not difficult, and consisted of 50 feet of rubber-covered flex. One end was attached to an insulator fastened on the tree at a height of about 20 feet, the other end passing through an open window, across a room, and straight on to the set, this end being but 7 ft. from the ground. The earth presented more difficulties than the aerial, because no water main was laid on to the house and it was impossible, for several reasons, to erect a counterpoise under the aerial. Some preliminary experiments were made with a few yards of flex laid across the floor of the room. This sufficed to bring in the Sheffield relay station at a good 'phone strength, but other stations were weak and the set was inclined to be unstable. This short counterpoise was therefore replaced by about 20 ft. of 26 gauge d.c.c. wire, which wandered across the room and out of the door, where it was securely fastened to a garden fork, the latter then being thrust into stony ground.

Screening Effect by Hills

Both the Sheffield and Leeds-Bradford stations now came in at tremendous strength on the 'phones, and subsequent test with a borrowed loud-speaker (a Junior model) showed that fair loud-speaker reception was possible, even during the afternoon, from 2LS at 35 miles. On a slightly higher wavelength was Nottingham. This relay station was 30 miles away, and although incapable of operating the loud-speaker, really good 'phone strength was obtained. At approximately the same strength was Manchester on 378 metres (793.2 Kc.). One might have expected really powerful signals from this station, since it was less than 40 miles distant, but a glance at the map will show that the Pennine Derbyshire Peak lies exactly between the two places, and this undoubtedly accounts for the loss of signal strength. Clear reception was possible at all times from Birmingham (65 miles), Newcastle (115 miles), and 2LO (140 miles), and their strength improved somewhat after sunset. The Bournemouth station (185 miles) was heard on several occasions, but only by careful adjustment of reaction. Stoke-on-Trent is only 8 metres above Sheffield in wavelength, and consequently could only be heard when the latter was not working; even then reception was rather difficult, and was not probably to the intervening hills.

Reception of Daventry

The only other British stations heard were Aberdeen, Glasgow and Hull, and these were very weak indeed. Petit Parisien came in on one occasion at about the same strength as 2LO, but this reception was after sunset. The high-power station at Daventry was received at about the same strength as it is heard in London with the same receiver.

Freedom from Interference

Whilst giving all due credit to the receiver, which invariably seems to give good results, the ease with which a number of distant stations could be tuned in at any time of the day shows how fortunate are those amateurs who are in a position to set up their aerials in the open country far removed from the screening effects of surrounding buildings and the howls of "local oscillators." To one living less than 10 miles from 2LO and on the west side of London, the most noticeable features were the freedom from interference with all the stations received, and particularly the absence of mush from powerful arc stations. On one or two occasions very slight interference was experienced from ship stations, but this seldom lasted long.

On Another Aerial

It may be of interest to record that the "portable" was also tested on the aerial of a friend living barely a hundred yards away. To our great surprise Sheffield was not nearly so loud, but 2ZY was practically at loud-speaker strength.

The valves used in the set were two D.E.3's, operated from a 4½-volt dry battery tapped at 3 volts. Best results were obtained with 13½ volts H.T. on the detector and 7½ on the amplifier.—Yours faithfully, K. T. ARTER.
WE have pleasure in announcing that the genuine Mansbridge Condenser, originated and designed by G. F. Mansbridge, Esq., over 20 years ago, will now be manufactured by the Mansbridge Condenser Co., Ltd., under the aegis of G. F. Mansbridge, Esq., himself, and marketed with the full backing of the Dubilier Condenser Co. (1925), Ltd.

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In your own interests you should see that when you require condensers of this type you specify Mansbridge.

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The Life of a Valve

By Capt. H. L. CROWTHER, M.Sc.

An interesting description by our Deputy Director of Research of some of the chief factors which govern this important subject.

The life of the thermionic valve is of extreme importance to everyone interested in wireless transmission or reception. The chief factors on which the life of a valve depend are not generally realised, and it is therefore proposed to outline briefly the essential points to keep in mind, so that one is able to obtain the longest possible life for any given valve.

In considering the question of life, valves should be divided into at least two definite classes, namely, ordinary bright emitters, and dull emitters, since in each of these cases the life is dependent on essentially different properties of the filament. The dull emitter that will be considered is the type with the highly thoriated filament. The coated filament dull emitter, and the low vacuum or soft valve will not be dealt with at present, as these are not in such general use.

Life of Bright Emitter Valves

By bright emitter valve is meant one which has an ordinary tungsten filament, which is normally run at a temperature of from about 2,000°K to 2,700°K. The life of the bright emitter essentially depends on the life of the tungsten filament. It is generally assumed that the condition in which the valve is used does not influence its life. That is, the life of the valve is approximately the same whether it is used in a transmitter or a receiver, or whether it is simply run as a lamp, without high tension on the anode. This of course would not hold good in the case of valves with faulty vacuums, since under these conditions the application of H.T. to the anode causes abnormal disintegration of the filament.

Evaporation of the Tungsten Filament

Whilst the valve is in use the tungsten filament slowly evaporates and in consequence gets gradually thinner. For a time this process is probably more or less uniform over the entire length of the filament. The filament then becomes slightly thinner at one spot, possibly owing to a slight flaw in the filament. This spot becomes hotter than the remainder of the filament. In consequence the evaporation at this particular point becomes more and more rapid, with the result that the filament ultimately fuses or burns out. The time required for a ten per cent. reduction in the diameter of the filament due to evaporation is generally considered the maximum figure that can be allowed for the life of the filament.

Effect on Life of Increase of Filament Current

Since the evaporation of a tungsten filament increases very rapidly as the temperature is raised it is very important that the filament current should not be more than is necessary to give the electron emission required.

Experiments have shown that the life of a tungsten filament is inversely proportional to at least the 15th power of the filament current. That is, a ten per cent. increase in the filament current above normal reduces the life of the filament to less than one-quarter of its original value. Thus if a 0.5 amp. filament valve gave a normal life of 400 hours, it would only last for 100 hours with a filament current of 0.55 amps.

The Longest Possible Life under Working Conditions

For a valve to function properly, a certain minimum electron emission is required. The emission from an ordinary tungsten filament is directly proportional to its area and to its temperature. Owing to evaporation, the resistance...
of the filament gradually increases throughout its life. It is thus impossible to keep both filament current and voltage constant. If the current is to be kept constant then the voltage will have to be gradually raised. In this condition, the temperature and also the emission gradually increase. Thus after a short time the valve is being run at a temperature considerably higher than is necessary to give the required emission. The life of the valve under these conditions is thus much shorter than it need be in order to give a

Emission may Decrease

The life of a valve as a dull emitter is not necessarily the life of the filament itself. In the case of the bright emitter valve, the emission is maintained until the filament actually burns out. In the case of the dull emitter, however, the emission may fall off, either temporarily or permanently, long before the filament actually fails.

In this type of valve, the emission at the working temperature depends almost entirely on the presence of thorium on the surface of the filament. Temporary loss of emission may occur through the evaporation of most of the surface thorium. By suitable treatment the surface of the filament can be reconditioned and the valve is then as good as before.

If, however, the distillation of the thorium from the filament has been more or less complete, then the valve is useless as a dull emitter. This loss of thorium may take place before the filament has completed 75 per cent of its actual life. This failure in emission before the filament actually burns out is not serious, as the life of the filament at the working temperature of the dull emitter is extremely long. When the valve fails as a dull emitter it can still complete its life as a bright emitter valve.

A Noteworthy Point

Temporary loss of emission may be caused by either running the filament at a temperature higher than that normally used or else using too much high tension. For example, if a valve which normally operates at 3 volts is run at, say, 4 volts for a few minutes, it may lose a large percentage of its emission and be quite useless when again run at its normal three volts. Similarly, if the anode voltage is raised much above its normal value the emission may be reduced to a fraction of its original value.

For dull emitter valves, therefore, it is very important not to exceed the values of filament voltage and high tension as recommended by the manufacturers for the particular type of valve in use.

Fig. 2.—The effect of different values of filament current upon the life and rate of decay.
October, 1925

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A Low-Loss Loud-Speaker Reflex Circuit

By A. D. COWPER, M.Sc., Staff Editor.

The very loudest signals ever heard by the writer on a single valve were obtained with the low-loss crystal-valve dual amplification circuit shown here, in which a number of separate factors that make for high efficiency in reception have been incorporated in the one circuit, and where, by making use of crystal rectification, combined with a heavily negatively biased valve of the small-power type, the heavy damping influence of a rectifying valve is to a large extent eliminated.

Low-Loss

The writer has had occasion recently to call attention to the surprising magnitude of this damping effect, which appears to baffle most of our efforts to attain a really "low-loss" circuit; but the effect of negative grid-bias in diminishing this damping of the valve is quite remarkable, when measured directly in the manner suggested by him in Wireless Weekly, July 29 issue. By using a crystal for rectification in a lightly-coupled tuned-anode circuit it is possible to operate with a negative grid; and by utilising one of the modern small power or L.S. valves with ample H.T. it is practicable to obtain a full degree of L.F. amplification in the same valve, without experiencing the distortion due to overloading the valve.

Fig. 1.—The L.F. transformer should be of good quality and preferably of the high-ratio type.

C. B. +

-0.002 μF

120 V

2 μF

Reactor

Control

Radio Choke

0.001 μF

2000 ohms

0.002 μF

Galena or

Zincitro.

Small Power Valve

Fig. 2.—An alternative method of aerial coupling employing a simple tapped coil.

The author of this article claims that although this circuit is not to be recommended for long-distance work, quite the loudest signals he has ever heard when using a single valve, were received from 2LO at a distance of twelve miles.

Full use can then be made of really low-loss tuning arrangements; the aerial has the semi-aperiodic, extremely loose coupling which the writer has shown by actual measurement to be most favourable for signal strength, with a secondary inductance of the low-loss type made up with spaced windings of a generous gauge on a skeleton former, and tuned by a parallel tuning condenser of low maximum capacity. The inevitable damping effect of the crystal detector across the tuned anode is diminished by placing it across only one-half of the inductance (as in the manner suggested for obtaining the maximum signal strength in plain crystal reception, where a low-resistance aerial and earth connection are available). Both signal strength and selectivity are favourably affected by this device. The low-frequency reflex feed is by the "parallel" method favoured by the writer, via a radio choke connected behind a small grid-condenser; this eliminates casual H.F. feed-back via the distributed capacities in the L.F. transformer, etc. An ample H.F. by-pass condenser is also inserted across the primary of this transformer.

Buzzing

A common fault of dual amplification circuits is that of buzzing or whistling, particularly when the crystal detector is disturbed. One reason for this is that the heavy damping of the crystal is necessarily relied upon largely to restrain the valve from oscillating, and in many dual circuits there is no fine control available to regulate the degree of this damping.

In a powerful, but admittedly trickly, neutrodyne dual circuit the writer described in Modern Wireless, Vol. 2, No. 7, which apparently aroused considerable interest at the time both here and in the States, the fine control necessary for obtaining the last ounce of signal strength was obtained as suggested by the title, by a small neutrodyne condenser operating in the manner now familiar in the neutrodyne-tuned-anode H.F. coupling. Here the control is effected by the expedient
described by the writer in *Wireless Weekly*, Vol. 4, No. 10, and subsequently utilised a good deal as a method of measuring H.F. resistances. The tuned-anode is isolated "up in the air" by a good radio choke, which latter is bridged by a "reaction-control" condenser, which gives the needed fine control over the degree of inherent capacitative feed-back, and, therefore, enables the circuit to be adjusted nicely for the degree of damping offered at the moment by the crystal; or can even control self-oscillation when the crystal is put out of action. The result is that buzzing and whistling are unknown, with any reasonably intelligent operation of the circuit; and, at the same time, the ultimate degree of power is obtained from the crystal-rectifying device for whatever setting has been obtained.

**An Important Point**

An obvious disadvantage of this method is that the tuning of the anode circuit varies appreciably with alteration of the reaction-control condenser; if for no other reason, the circuit should not be brought forward for distant reception (invariably involving searching). It is almost invariably found that the margin between quiet oscillation and howling is small in a dual circuit, so that such circuits are not, in general, recommended for critical work. The writer cannot too strongly emphasise that this particular dual circuit is not recommended for real long-distance work, but solely for loud-speaker reception of the local station, in which service he has found it to give more volume, and better reproduction, than any in his experience. Then the triple tuning-control (two of these controls are fairly flat) is not prohibitively difficult.

**Details**

The maximum effects will not be obtained unless each single one of the details implying efficiency be attended to; the valve must be of the small-power type, such as the D.E.5, or P.V.3D.E., to mention only two of the several types now available; at least 100 volts of H.T. should be employed, more, if possible, and really ample negative grid-bias must be used. The plate current is fairly heavy in operation (some 5 or 6 milliamperes in normal operation with proper grid-bias), so that a large type of H.T. battery—or better still, an H.T. accumulator battery—should be used, with the usual 2 µF blocking condenser across it. A modern large L.F. transformer of high ratio (61 or even higher) should be used for the reflexing; too large a grid-condenser should be avoided, as the effect of this is to lower the tone or "pitch" of the reproduction considerably.

**Construction of Inductances**

The primary coil is a 50-turn tapped solenoid of No. 22 d.c.c. wound on a 3 in. diameter plain dry cardboard former. The aerial is permanently connected to the upper end; the earth connection is made to a tapping point at No. 15, 20, 25, 30, 40, or 50 turns, as practical trial shown to be best, and according to aerial dimensions and wavelength. This will cover efficiently the ordinary B.B.C. short-wave range, with aerials varying from a short single wire to a large triple arrangement. A very small indoor aerial might possibly require a larger number of primary turns, which is readily adjusted. A simple alternative device is that of the auto-transformer semi-aperiodic coupling which the writer has advocated frequently; here alternative tappings should be tried at, e.g., No. 10, 15, 20, or even higher for a small indoor aerial on the secondary low-loss inductance. There appears to be no advantage in a low-loss primary.
The Grid Coil

The secondary must be of the low-loss design, of stout-gauged air-spaced wire on a skeleton former; the latter to avoid possible subsequent effects of moisture if, e.g., dry cardboard were adopted here, rather than to give any measurable improvement in immediate efficiency. The writer actually used a standard Collinson Precision Screw Co.'s low-loss former, 3¾ in. diameter and 6 in. long, wound with about 65 turns of No. 20 enamel-insulated wire, with about the usual spacing of 10 to the inch. The primary is mounted fully 2 in. below the commencement of the secondary winding, and at the "earth" end of the latter. There is no advantage at all in putting it closer, provided that it is roughly tuned by the tappings so that the natural frequency of the aerial, etc., is just above that of reception. The tuned-anode inductance is wound in a fairly low-loss manner (for we have the crystal-damping here, so that the ultra-low-loss is irrelevant) with 50 turns of No. 22 d.c.c. on a 3 in. former, 5½ in. long, of dry cardboard with a centre-tap for the crystal connection. This must have a minimum of direct magnetic coupling with the other inductances, so should be placed well away from the low-loss secondary, and so as to form the crossing of a T when the former represents the vertical stroke, i.e., exactly at right angles and symmetrically placed. Wiring should be kept as short as possible and well isolated for the same reason. The circuit would be uncontrollable if such direct magnetic back-coupling were permitted.

Radio Chokes

The radio chokes can be of the commercial type, or simply narrow coils, as shown above. The grid coil is just above that of the vertical stroke, i.e., exactly at right angles and symmetrically placed. Wiring should be kept as short as possible and well isolated for the same reason. The circuit would be uncontrollable if such direct magnetic back-coupling were permitted.

Radio Chokes

The addition of a clip-in type fixed condenser across the loud-speaker is useful for tone control. The writer recommends the use of the Colvern low-loss coil, 0.0006 mfd.

The Grid Coil

The writer made use of the matching coil, 0.0006 mfd., and so forth, in the tuned circuit. The setting of the two condensers is just above that of the vertical stroke, i.e., exactly at right angles and symmetrically placed. Wiring should be kept as short as possible and well isolated. The circuit would be uncontrollable if such direct magnetic back-coupling were permitted.

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The general lay-out used by the author in his experiments. Note the method of arranging the tuning coils.

condensers. There should be no difficulty in picking up the local station on the 'phones'; it is quite futile to attempt to tune in distant stations at first. As stated explicitly, this is not a long-distance receiver, and the control has not the fine simplicity of a straight reaction circuit.

After finding the station, the optimum tapping of the semi-aperiodic primary is quickly found; then the secondary is tuned critically. Finally, that anode tuning which appears to show the most powerful reaction effect is sought, i.e., the setting in connection with which the 0.0001 μF control condenser has to be set to the lowest reading to avoid self-oscillation. The crystal is then set to give optimum signals, and the reaction control is adjusted so as to bring to bear all the power the crystal will stand without distortion appearing. Any large adjustment of the reaction control must be accompanied by a corresponding small adjustment of the anode tuning.

Results

When adjusted thus, real "loud-speaking" was readily attained, at about 12 miles from the local station and on a good aerial, at a strength comparable with a cabinet gramophone and readily relayed over the land-line telephone. With the window partly open on the first-floor, the Savoy band was readily audible in the street, the large loud-speaker used being pointed away from the window.

Similar results were obtained with a small single-wire aerial as well. On capacity aerial" alone, that is, without either proper aerial or earth connection, but merely casual pick-up on wires, etc., the band was audible along a passage and in another room in a quiet house at night, using the single valve. With the good aerial Bournemouth was tuned in directly on the loud-speaker some feet away, after other

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stations had finished, and one of the Paris stations was excellent on the head-phones; but as emphasised, such work is not the proper sphere for this type of loud-speaking dual circuit.

In the immediate locality of the local station, the smallest indoor aerial should suffice for good loud-speaking; for remoter suburbs evidently a good attic aerial and low resistance earth connection are all that will be needed. No A.C. hum was noticed at all, although close to the 50-cycle A.C. lighting mains.

**Components**

Components actually used in the experimental receiver were: Collinson Precision Low-loss Former; J.B. standard pattern tuning condensers; Lissen radio chokes; Grafton Electric 6V L.F. transformer, fixed condensers, and 120 volt accumulator H.T. battery; "Maxitone" Auto detector; Ediswan Dulcivox loud-speaker base; Scientific Supply Stores’ large fibre loud-speaker horn, H.T. and filament resistance; Ediswan P.V. D.E. valve; Ever-Ready grid-bias battery. Primary and anode formers were the ordinary 3 in. cardboard tube, carefully dried.

A.D.C.

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"Ariane" Portable Aerial

A **SAMPLE of the "Ariane" portable aerial has been submitted by Messrs. B.E.N. Patents. This consists of a strip of enamelled wire-gauze about 3/4 in. wide and some 11 yards long, wound on a reel, with swivel, and with insulator and connecting terminal at the outer end. It is suggested that this can be suspended in any convenient position indoors, and does not require supplementary insulators. Tested practically first as a short indoor aerial in conjunction with a sensitive single-valve receiver, and in the same room, satisfactory reception resulted on the local station, and the valve oscillated with ease.

**A Second Test**

In a second test, under favourable conditions, using the whole length along a first-floor corridor and as lead-in down the staircase as well, in direct comparison with a similarly-wound aerial of standard 7/32" stranded copper wire of like dimensions, at a dozen miles from the local short-wave station the Ariane aerial gave 2.5 microamps rectified current with a good galena crystal used in a low-loss, "proportional-crystal-tap" crystal-receiver of the most favourable design; as compared with precisely the same figure for the stranded wire. The capacity of the Ariane strip was slightly greater, but which at the same time has a shank reduced to 1/4-in. diameter, and hence small enough to hold in the chuck of an ordinary geared hand-drill or breast-drill. This drill, a sample of which has reached us and has received practical test, is 4 in. long and has a parallel 1/4-in. diameter shank 11 in. long. On trial it proved to be fast-cutting and keen; and eminently suited for this special service.

The B.T.H. L.F. Transformer.

**B.T.H. L.F. Transformers**

**INTERVALVE low-frequency transformers of 4:1 and 2:1 ratio have been submitted by Messrs. The British Thomson-Houston Co., Ltd. These are of medium size, standing about 3 in. high by 2 in. square. Both are enclosed in an insulated case of the familiar B.T.H. chocolate-brown colour, and have an unusually generous iron core of thin laminations. The four terminals are arranged conveniently on the sides of the case, and are plainly marked. The case also provides holding-down lugs. As might be expected in a product of a firm of Messrs. B.T.H.'s reputation, insulation-resistance, workmanship and finish were beyond reproach.

On practical test against standard large types, under the most favourable conditions as to grid-bias and plate-potential and controlling a small power-valve, in telephony reception the 4:1 ratio instrument gave excellent results, both as to the degree of amplification and freedom from distortion. After a low-impedance detector-valve the results were almost comparable with the standard, if a little "low-pitched"; after a high-impedance "R" detector-valve the performance fell off a little. But for a medium-sized instrument, the result was really good; the instrument can accordingly be recommended for the first or second stage.

**The 2:1 Ratio Type**

The 2:1 instrument showed a disappointing performance in the matter of degree of amplification, whether in a first stage or in a second or third stage of transformer-coupled L.F. amplification, using the proper equipment of power-valves and stabilising devices, and in comparison with the 4:1 and 6:1 ratio instruments which both modern practice and theoretical considerations as to matching valve and transformer primary impedances dictate. The tone was good, and, of course, stability may be obtained a little more easily in a third stage transformer-coupled L.F. valve if a low-ratio instrument be used (as in current American practice), and amplification thereby sacrificed; but it is not easy to see the point of a 2:1 ratio instrument in ordinary practice.

"National Super-Crystal Detector"

**A WELL-THOUGHT-OUT crystal detector of the horizontal glass-enclosed type for the galena cat-whisker combination has been submitted for our criticism**

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Issue No. 1 published Sept. 12th. 12 months Subscription rate 7/6 (U.K.), 10/- (Abroad).

PROGRESS AT OUR ELSTREE LABORATORIES

The first two huts at Elstree are now completed. This photograph shows the site itself with the research hut in the foreground. Note the entire absence of trees, wires, iron pipes, etc., which could cause trouble with short-wave experiments.

Work has already commenced in the test hut, which is shown in the left-hand photograph, while the view above depicts the ideal conditions under which testing and research will be carried out.

Appreciation of "Modern Wireless" Sets

Sir,—A further note of appreciation on the sets described in MODERN WIRELESS. I have constructed at least a dozen of these, from "S.T. 100" onwards. My latest are Mr. Cowper's "Simple Selective Set" (MODERN WIRELESS for April, 1925), and the Simplified Three-Valve Dual (MODERN WIRELESS March, 1925, by John Scott-Taggart). To the former I added one stage of power amplification, and the results were extraordinary, and the set being constructed in the American style it made a most useful portable instrument. I wrote to Mr. Cowper thanking him, and he took a very kind interest in some further modifications for the reception of short waves, which I have carried out with much success.

The "Three-Valve Dual" was completed recently and was really originally the W1 3-valve receiver, which had been superseded by the Cowper set for loud-speaker work 17 miles from 5SC. So having a spare panel and handsome cabinet doing nothing, I converted the W1 to the Three-Valve Dual, taking great care in spacing wires. I expected little, but received much; and at the moment Arneagles' band is full loud-speaker strength on a short indoor aerial. I have logged Belfast, Dundee, Edinburgh, Bournemouth, Manchester, and several Continental stations on the loud-speaker up to date. I consider this is excellent for summer conditions.

The receiver is really delightfully easy to handle, and I am looking forward to the winter months and to enjoying many pleasant hours with the "Simplified Three-Valve Dual."—Yours truly,

WILLIAM SCOTT, M.B., Ch.B.
Alexandria,
Dumbartonshire.

The General Purpose Three

Sir,—I think it may interest you to know the results I have obtained from my "General Purpose" three-valve receiver, described by Mr. Johnson-Randall in MODERN WIRELESS, April, 1925. I am able to receive all B.B.C. stations except Edinburgh and Plymouth at good 'phone strength, and several of the nearer ones on loud speaker. Birmingham, 35 miles, being too loud for comfort. This set seems to have an appetite for Continental stations, some of my best being Petit Parisian, Radio-Toulouse, Hamburg, Frankfurt, Rome, and a Dutch on about 360 metres.

Some evenings Toulouse comes in at quite good loud-speaker strength. One evening last week I heard an American station, WGY, at about 12.35 a.m., but atmospherics were so bad that at times nothing was distinguishable. Considering that I have been at wireless for just under a year, and that I am only just 16, I do not think results at all bad. If you can make any use of this letter I shall be very pleased indeed. Meanwhile I remain a faithful reader of your excellent papers.—Yours truly,

S. E. KENWORTHY.
Priors Lee, Salop.
Envelope No. 4

Sir,—I enclose photograph of the "All- Concert de Luxe" receiver which I have constructed from instructions given in Envelope No. 4 by Percy W. Harris. I have incorporated a switch to cut out the third valve.

Have also built, as you will see by the photograph, an extra L.F. unit from instructions given in "Twelve Tested Wireless Sets," also by Mr. Harris, but made to match the design of the set.

The results I have obtained with this set are really marvellous; my aerial is 30 ft. high, total length 65 ft. about, and with coils 35, 75, and 75. I tuned in one evening twenty-seven stations in under fifteen minutes.

I get most of the British main stations on the loud-speaker with three valves, Glasgow, one of the most distant, coming in quite well.

Mr. Wall's "All Concert de Luxe" Receiver, with Note Magnifier added

With the four valves the loud-speaker brings in several Continental stations, also Edinburgh relay station and KDKA.

I have made my own coils for KDKA (one of which is seen in the receiver as photographed).—Yours truly,

Felixstowe. S. D. WALL.

"Full Volume from Three Valves"

Sir,—With reference to the article "Full volume from Three Valves" by Mr. A. Johnson-Randall, in the July issue of Modern Wireless, I should like to state that it fully justifies the author's remarks as to tone and volume, and it is well worth the time taken in constructing it.

On plugging in all three valves the Junior Amplion Loud-speaker has all its work cut out to carry the volume, and taking into consideration the above remarks the tone obtained is exceptionally pure.

I have a single aerial 25 ft. high each end, and the valves are Edison A.R.D.E. for the 1st and 2nd stages and a Cossor W.3 for the last stage.

The above remarks, I think, show that I for one am fully satisfied with the working of the set, and can only thank you for the opportunity of constructing same.—Yours truly,

Catford, S.E.

R. C. SHARWOOD.

A Simple Selective Set

Sir,—May I heartily endorse the tribute paid to Mr. A. D. Cowper, M.Sc., on page 926 of the last number of Modern Wireless. There is no Radio Press writer who gives me greater interest.

I have made up several circuits of his, including "A Simple Selective Set," given in the Modern Wireless some months ago (April, 1925). This I consider to be the ideal one-valve design for reception of short-wave broadcasting.

Finally, I hope to see more of Mr. Cowper's articles on the lines of "Low Resistance Frame Aerials and Distant Reception" in the March issue of Modern Wireless.

Yours truly,

Glasgow. THOMAS SCOTT.

A Two-Valve Hartley-Reinartz Receiver

By JOHN W. BARBER. (Continued from Page 75.)

The setting of the reaction condenser will be found to affect that of the tuning condenser, in a similar manner to that in which an ordinary reaction coil affects the tuning of a simple reaction receiver, hence it will be necessary to follow up adjustments of the tuning condenser with adjustments of the reaction condenser, in order to find the best setting for a particular station. The local station can be tuned out with remarkable ease, and it has been possible to receive Bournemouth, at five miles from London, with no interference from the local station, while during an initial test on a bench hook-up it was necessary to join up a crystal set to find out whether 2L0 was working, since that station was not discovered in two or three rotations of the tuning dials! When the operation of the circuit was understood more clearly, it was possible to receive several distant stations in a few minutes using the detector valve only, but as the reception was only in the nature of a preliminary test to find out the best number of turns in the coils, the call signs of the various stations were not waited for, but music was clear and distinct in all cases.

Results

After building the receiver up into its present form, the first station to be received was Radio-Toulouse on 275 metres (1090 Kc.), which came in at characteristically good strength. London is, of course, too loud at five miles for comfortable telephone reception, although it is hardly loud enough to operate a loud-speaker at sufficient volume for a medium-sized room.

Other stations received included 3IT, 5EC, Hamburg, Brussels, several British relay stations, Petit Parisien, and L'École Supérieure. In view of its selectivity, this set will provide the means whereby many distant stations may be heard without local interference.
Another "Cosmos" Development

The latest product of the "Cosmos" organisation, this compact New Model Three Valve Radio Set possesses a number of distinctive features, giving perfect reproduction with the minimum of controls.

A reflex circuit with resistance-capacity coupling is employed and Interchangeable Coil Units cover Wavelengths (i) 250 to 550 metres and (ii) 1300 to 3000 metres.

Anti vibration valve holders are fitted and a dual rheostat with battery switch allows for the use of either Bright or Dull Emitter Valves.

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Note this extract from "Wireless Weekly" Editorial, June 17th, 1925:

"... It is not unprofitable to wonder what would be said by one of those who preach efficiency in tuning inductances if it was suggested to him that he should use tuning coils consisting of a winding of quite fine wire without any other separation of turns than that produced by slot winding, the whole inductance to be embedded in a lump of ebonite. His scorn would, no doubt, be vitriolic, yet is not the description which we have just given an approximately correct one of the average high-frequency plug-in transformer?"

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