Experimental Wireless

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Experimental Topics.

Wireless Television.

IN the course of an address given before the Royal Society of Arts last month M. Edouard Belin disclosed the fact that he had recently succeeded in transmitting real photographs in half-tones by wireless. M. Belin has been making extended researches in his laboratory at La Malmaison, and he is convinced that the solution of the problem of wireless television is near at hand. The Belin system of telephotography had been developed not only to permit of the transmission of ordinary handwriting and of shorthand, but also to provide absolute secrecy in telegraphic and radiotelegraphic transmissions. Autograph messages have been transmitted by wireless both in France and America. This is a fascinating field of research, and it does not require much imagination to visualise the enormous possibilities of wireless television when achieved on a commercial scale.

The Wireless Exhibition.

The All-British Wireless Exhibition at Shepherd's Bush which has formed the centre of radio interest during the middle fortnight of November came exactly at the right moment. The Postmaster-General, by his recent licensing decisions had cleared the way for a revival of business, and a large section of the public, fortified by the knowledge that they had made their peace with the law, or could do so quite easily at the nearest post-office, flocked to see the latest developments in British wireless practice. In one respect the crowd was very different from that which thronged last year's Exhibition at the Royal Horticultural Hall. It was a much better informed crowd. Last year the attendants at every stand in the show were bombarded with requests for explanations of how "it was done." This year the crowd came armed with knowledge: questions of an elementary nature were much less in evidence, and reasoned praise or criticism of construction and design much more general. This is all for the good of wireless, and the Exhibition itself has undoubtedly still further advanced the education of the radio public. The Exhibition, taken as a whole, was a very representative display, though broadcasting interests certainly predominated and some very fine examples of complete receiving installations moved one critic to describe it as being more of a cabinet-making than a scientific exhibition. This is not altogether an unfair comment for the time is within sight when every well-appointed home will have a receiving equipment *en suite* with the rest of the furniture, just as it now includes a book-case, or a sideboard, or a piano. From the experimenter's point of view the outstanding feature of interest was the display of dull-emitter valves by various makers, although there were many firms showing other components and accessories worthy of close attention. Elsewhere in this issue we deal in some detail with the more interesting items which came to our notice; it is outside our province to attempt a complete description of all the exhibits, and we have contented ourselves with commenting on those matters of especial interest to experimenters. We would add our congratulations to the National Association of Radio Manufacturers, and to Mr. Bertram Day, on the success of the Exhibition, and hope that it has given to the wireless trade in general an impetus which was very badly needed.

The Transatlantic Tests.

This year the Transatlantic Tests organised in conjunction with the American Radio Relay League are due to commence on December 22. Although many experimenters occupy their time with Transatlantic work throughout the greater part of the winter, the official tests always arouse considerable interest amongst amateurs as a whole, and it is anticipated that the number of listeners on this side will be greatly increased by many newcomers in the field of experimental work. To those we make a special appeal. The radiating properties of a receiving aerial on 200 metres are very good, and unless particular care is exercised in the use of oscillating circuits, it is highly probable that the work of an experienced experimenter may be completely spoiled by radiation from a neighbouring aerial. In the subsequent pages of this issue will be found several articles particularly relating to short-wave reception, and it is sincerely to be hoped that many will adopt the suggestions given, to the benefit of all concerned. So far as our own transmission is concerned, the granting of 100 and 1,000-watt licences to certain experimenters certainly increases our chances of "getting across the pond," but the ultimate success of the experiment is, unfortunately, wholly dependant upon the prevailing conditions during the period of the tests.

Very Variable Condensers.

We publish in our correspondence columns this month a letter from a reader who complains of the unsatisfactory state of affairs in the trade in regard to the capacity rating of variable condensers. While it is true that there are firms to whom our correspondent's criticisms do not apply, we think it is equally true that there are good grounds for complaint in other directions It is easy to see the harm which may be caused to the wireless industry by the sale of unreliable or of mis-represented goods; the disappointed constructor or experimenter may prove to be a very bad advertisement for wireless in general, and for unreliable firms in particular. Possibly the trouble complained about arises in some cases from want of thought, or from the lack of real technical knowledge, on the part of the vendor. A good many people have rushed into the wireless business with only a slight smattering of the science underlying the apparatus they sell, and they do not altogether appreciate the need for something more than approximate accuracy in their instruments or in their descriptive matter. Day by day wireless is becoming more and more of an exact science, and indeed one has only to move among the best firms in the trade to realise how much true scientific knowledge and research is being applied to the advancement of the industry. It is important that the lesser firms too should realise the need of putting their products on a sound basis of scientific accuracy, and the importance of making impossible such criticism as our correspondent expresses in the letter we have referred to.

Our Progress Abroad.

We are glad to be able to report that Experimental Wireless is making friends with wireless workers overseas just as readily as at home. Although the time for the receipt of return mails has in many cases barely elapsed, we have already received subscriptions and letters of congratulation from experimenters in the United States, Brazil, South Africa, Switzerland, France, Portugal, Austria, Belgium, Holland, Germany, and Egypt. Some of our correspondents have promised us notes on experimental equipment and methods in their own countries, and this friendly co-operation coupled with other arrangements for overseas information we have put in hand will ensure for our readers that international exchange of experience and knowledge which is essential for the advance of every branch of science. Our readers may be interested to know that one letter we received during the past few days from Germany carried twenty-one postage stamps, each of the value of two thousand million marks!

Directive Radio Telegraphy and Telephony.

By R. L. SMITH-ROSE, Ph.D., M.Sc., D.I.C., A.M.I.E.E.

During the last few years there has been considerable development in directional work, particularly with the use of extra short waves. There are obviously many applications of directional transmission, and we are giving below a general summary of modern methods and practice.

I.—THE EMPLOYMENT OF SHORT WAVES UP TO ABOUT 20 METRES IN LENGTH.

(a.) Early Experiments of Hertz and Marconi.

THE classical experiments of Hertz carried out from 1885 onwards are now known as verifying the predictions of Maxwell's electro-magnetic theory. These experiments of Hertz* demonstrated the essential properties of the waves which are created by the electrical discharge of a condenser, these properties being exactly similar to those of the much shorter waves commonly associated under the terms light and heat. The means for the production of the waves was found in the type of open oscillator developed by Hertz, a similar open oscillator or a nearly closed ring resonator being used for reception purposes. The waves generated were shown to penetrate through bodies which are generally classed as dielectrics, and to be subject to refraction in such transmission, the angle of refraction being found to agree with that calculated from the usual optical formula, using the appropriate values for the refractive indices of the media traversed. Other bodies classed as conductors were shown to be opaque to the radiation, this being completely reflected from metallic surfaces. The superposition of the reflected waves from a metallic surface on the incident waves was shown to give rise to a set of stationary waves, which proved the finite velocity of travel of the waves and also provided a means of determining the length of the waves in air. The wavelengths used by Hertz and other workers at that time were of the order of 1 or 2 metres down to a few centimetres.

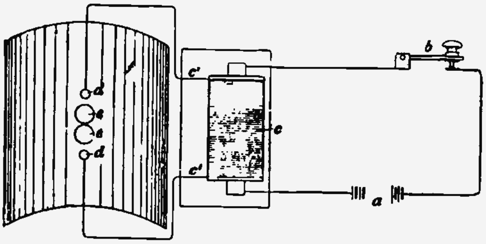

Fig. 1.—An early short wave directional transmitter.

By arranging the reflector in parabolic form, with its axis parallel to the oscillator employed, the radiation could be concentrated in a roughly parallel beam for projection in any desired direction, and a similar reflector at the receiving end served to concentrate the radiation on the detecting instrument placed at the focus. The radiation so produced was shown to be plane polarised with the electric force parallel to the oscillator, and experiments were carried out by Hertz with wire grid screens which are exactly analagous to the transmission and absorption of polarised light by Nicol prisms.

Many scientific workers were immediately attracted to Hertz's discoveries, but the majority of these were chiefly concerned with the researches opened up by the demonstration of the electro-magnetic nature of luminous radiation and the corresponding development of optical theories. Other workers concentrated their attention on the production of a more efficient generator of the waves, and a more sensitive and reliable detector of the oscillations produced at the receiving end. Confining our attention, however, to directive radiation, it appears that Marconi was the next to make any use of reflectors for the concentration of waves in the required direction in about

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* H. Hertz, "Electric Waves," translated by D. E. Jones, 1900, p. 172.

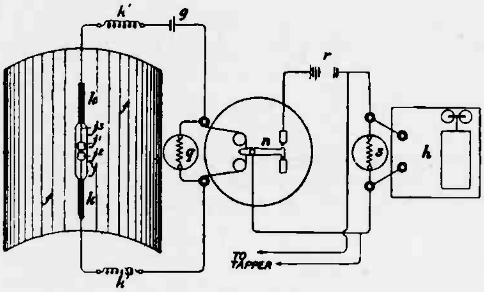

Fig. 2.—An arrangement comparable with Fig. 1, adapted for reception.

1895*. The general plan of the transmitting and receiving apparatus is shown by Figs. 1 and 2. An induction coil *c* (Fig. 1) was used to charge the spheres *d*, *e* of a Righi oscillator placed in the focal line of a suitable cylindrical parabolic reflector, *f*. On pressing the key *b* an oscillating discharge occurs across the system of spheres which thus become the source of radiated waves. At the receiving end, two short conducting strips *k* are placed in the focal line of a similar reflector *f*, connected to a filings coherer *j*, which acting as a detector on the arrival of waves caused the operation of the relay *n* and the recorder *h*. The length of the copper strips *k* was carefully determined to be in tune with the transmitted waves.

By means of apparatus of this description Marconi was able to transmit intelligible signals over distances up to 1¾ miles, and the concentration of the beam was such that, at this distance, its effective width in which the receiver could be operated was only 100 feet. Marconi immediately appreciated most of the advantages to be derived from the directional selectivity accompanying this arrangement and the possible application of a rotating wireless beacon as an aid to ship navigation in a similar manner to the use of lighthouses. Owing, however, to the greatly increased signalling range which was obtainable by earthing one side of the Hertzian oscillator and extending the other as a long vertical wire up to 100 feet in height, further experiments on the use of the reflecting system were discontinued. At that time the development of the subject was being concentrated upon its application to communication over the greatest distances possible, and with the generating apparatus then available this was found to be most easily accomplished by the use of elevated antennæ at both transmitting and receiving ends. Now the application of optical principles shows that in order that the parabolic metal sheet should act as a reflector its length must be equal to several times the length of waves employed and the focal distance should be not less than one-quarter of a wave-length. Hence, in order that the reflector system shall be practicable, particularly if the reflector is to be used to give a revolving beam, the length of waves employed must be limited to a few metres, whereas those emitted by the elevated antennæ ranged from 50 metres upwards. Research on the utilisation of the waves for the continued extension of the range for

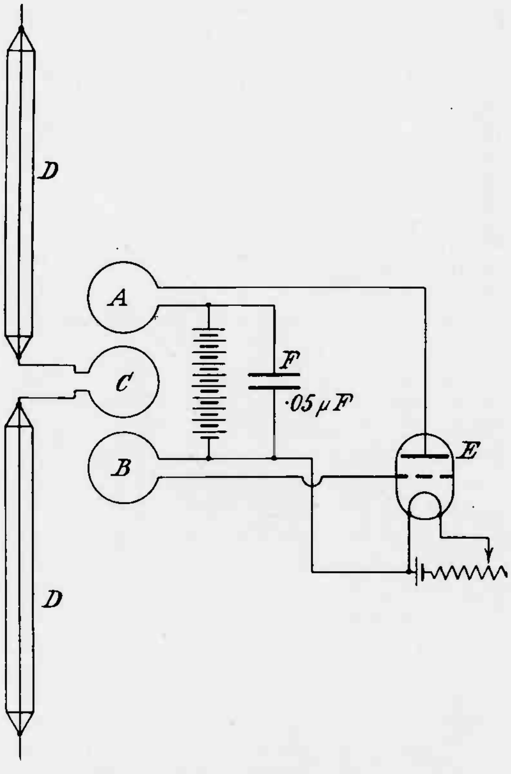

Fig. 3.—A short wave generator in which the inductances take the form of single turns, inductively coupled to the aerial system

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* G. Marconi, "Wireless Telegraphy," *Journal I.E.E.*, 1899, Vol. 28, p. 273; G. Marconi, "Radio Telegraphy," *Proc. Inst. Radio Eng.*, 1922, Vol. 10, p. 215.

transmitting purposes led to the use of increasingly longer waves, up to the present-day limits of about 20 kilometres, which, apart from being subject to less absorption by the atmosphere and surface of the earth, were much more easily generated in the higher powers necessarily involved. Also the first practical application of wireless, namely, for communication to and between ships, demanded "all round" transmission rather than a directional system. This aspect of the reflector system was apparently so discouraging that, except for the filing of one or two patents covering the use of separate vertical wires in place of sheet metal for the reflector, no research work of any description was carried out on short wave propagation between 1896 and 1916.

(b.) Recent Work of Marconi and Franklin.

In the latter year experimental work in this direction was resumed by Senatore Marconi, assisted by Mr. C. S. Franklin,* the waves employed being 2 or 3 metres in length. Preliminary experiments showed that on these short wave-lengths one of the great difficulties in modern wireless telegraphy, *viz.*, interference, is very greatly reduced. The only source of interference apparent was that due to the ignition systems of motor cars and motor boats in the vicinity, which emit waves of from 1 to 40 metres in length. Similar difficulties were experienced at the introduction of wireless reception on aeroplanes, and the remedy there adopted was to efficiently screen the whole of the ignition system.

The early experiments showed that the use of reflectors considerably increased the working range of the apparatus for communication purposes, and good directive properties were also obtained with reflectors properly proportioned to the wave-length. With the waves of 3 metres length used in some experiments at Carnarvon the attenuation was found to be very great even over sea, and the range of transmission was correspondingly limited to about 4 to 6 miles. The strength of the electric field, however, increases with the height above the ground at a rate dependent on the wave-length, and, although with the long waves commonly employed this is not perceptible, the increase is very rapid with short waves. Franklin found, for example, that by raising transmitter and receiver to a height of about 10 wave-lengths above the intervening ground the range could be increased to six or seven times its former value.

The usual arrangement of these directional transmitters is in the form of a single Hertzian rod placed vertically in the focal line of a cylindrical paraboloid reflector. The rod is coupled by a single turn loop at its centre to an oscillating valve circuit, which while of quite the usual form has very small electrical constants for the extremely high frequency required. Quite frequently the interelectrode capacity of the valve is sufficient for a circuit whose inductance comprises a single turn loop of a few inches. Such a generator is shown in Figs. 3 and 4, taken from a Bureau of Standards paper* in

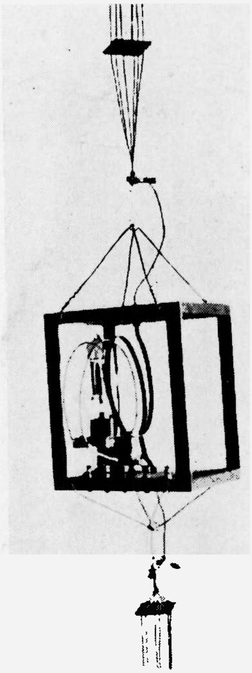

Fig. 4.—Illustrating the method of using the oscillator shown in Fig. 3.

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* C. S. Franklin, "Short-Wave Directional Wireless Telegraphy," *Journal I.E.E.*, 1922, Vol. 6, p. 930.

* F. W. Dunmore and F. H. Engel, "Directive Transmission on a Wave-length of 10 Metres," *Bureau of Standards Scientific Paper No.* 469, 1923.

which sufficient details are given to enable construction to be carried out. The reflector is formed of a framework supporting a number of straight vertical wires around its surface (Fig. 5). The length of the individual wires is adjusted to bring them in resonance with the wave-length in use, the length of the wires being usually somewhat less than half a wave-length owing to the mutual capacity between them. The effect of alteration in the length of wires on the polar radiation curves is shown in Figs. 6 and 7.

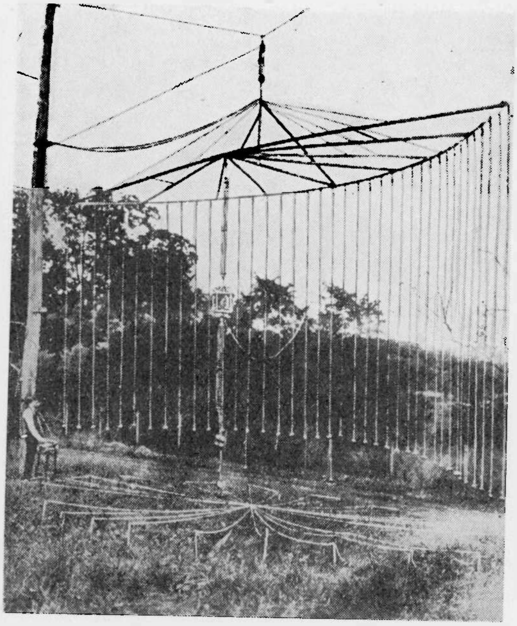


Fig. 5.—A parabolic reflector for a wavelength of 10 metres.

In the case of Fig. 6 all the wires have been carefully adjusted in length to be in tune with the waves. In Fig. 7 alternate wires have been removed from the screen, and owing to the resulting decrease in mutual capacity the remaining wires are now slightly out of tune and some radiation is now seen to be transmitted behind the screen.

For reception, either a loop or another rod oscillator may be employed suitably adjusted to the wave-length, and of course with the straight rod a parabolic reflector may again be used to concentrate the received energy on the rod.

(c.) Application of Reflector Systems to Communication.

One of the uses to which this directional transmission has been put experimentally by the engineers of the Marconi Company is that of radio telephony. Since in the employment of a rod oscillator with reflector a fairly concentrated beam of radiation is produced, it is evident that no wireless receiver placed outside the beam will receive any signals whatever. Within limits the "spread" of the beam can be reduced by increasing the aperture of the reflector as shown in Fig. 8. This, combined with the great difficulty of tuning a receiver to such a short wave-length when this is not accurately known, makes the system very much more secret for telephonic purposes than the ordinary broadcast mode of transmission. Tests carried out over both sea and land show this short-wave reflector system of radio telephony to be quite practicable at distances up to about 100 miles on a wave-length of 15 metres. In some of Franklin's experiments carried out between Hendon and Birmingham in 1921, local measurements of the polar curves taken round the station show that the electric field is increased about four times and that the same order of increase is obtained during reception. The increase of energy due to each reflector will, therefore, be sixteen times, giving a total increase of 256 with reflectors at each end. This calculated figure agrees well with actual measurements made with the reflectors both up and down. By using two medium-size power valves in parallel receiving about 700 watts input, about 300 watts radiated power could be obtained. To get the same signal strength without the use of reflectors would require a 140-kw. transmitter working at the same efficiency. Although the frequency of 20 million cycles per second gives rise to some problems in the structure and operation of the valves employed, there appears to be no reason why input powers of several kilowatts may not be used in such a system.

(d.) The Revolving Wireless Beacon.

Reverting now to the directional properties of the reflector systems, the general idea is to use a revolving beam transmitter as a kind of wireless lighthouse. The beam will be invisible, but if a suitable receiver be

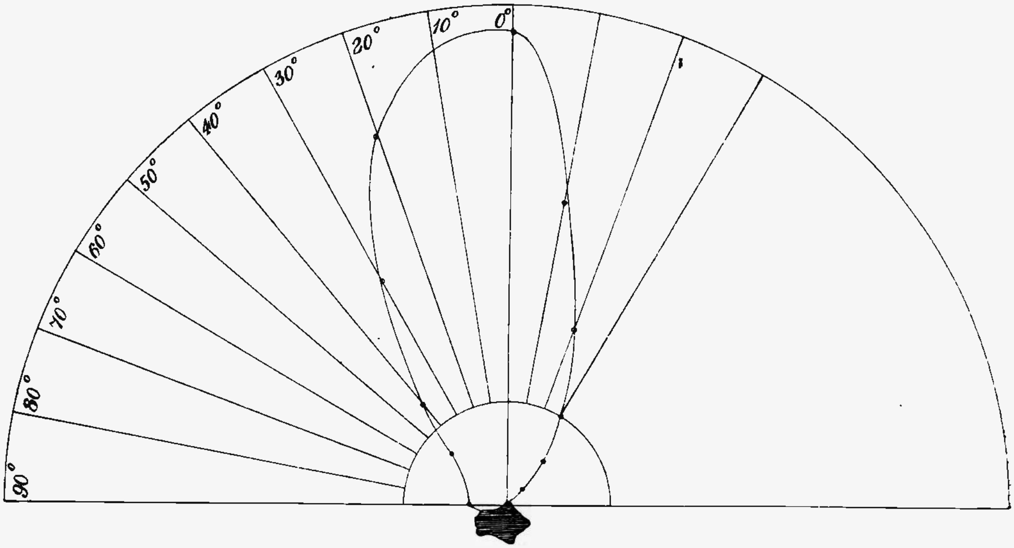


Fig. 6.—The Radiation Characteristic Curve of a parabolic reflector when the aperture is equal to one wave-length The deflecting wires are all in tone with the source.

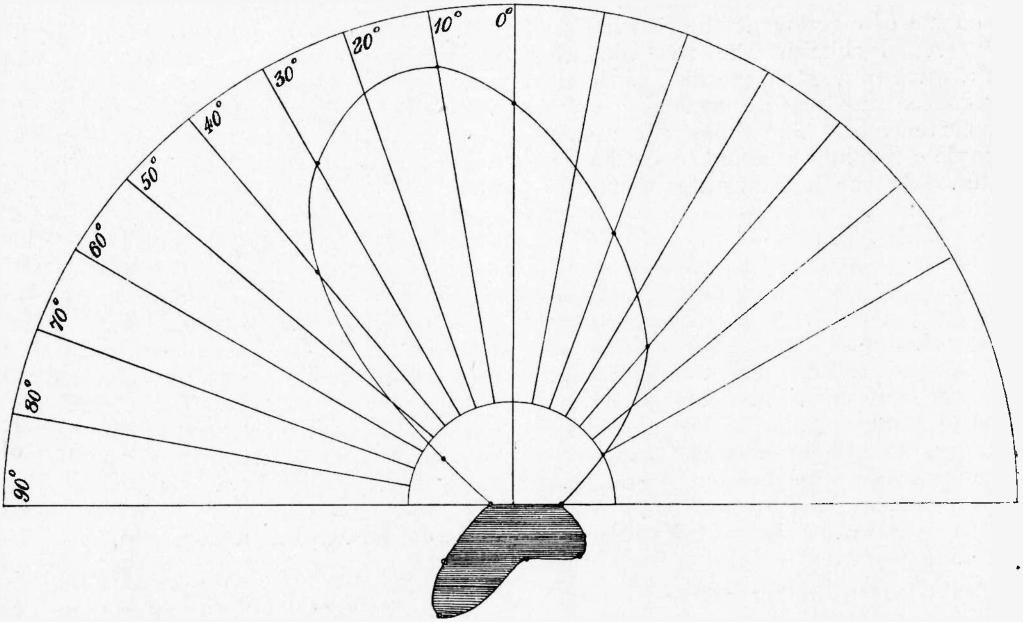
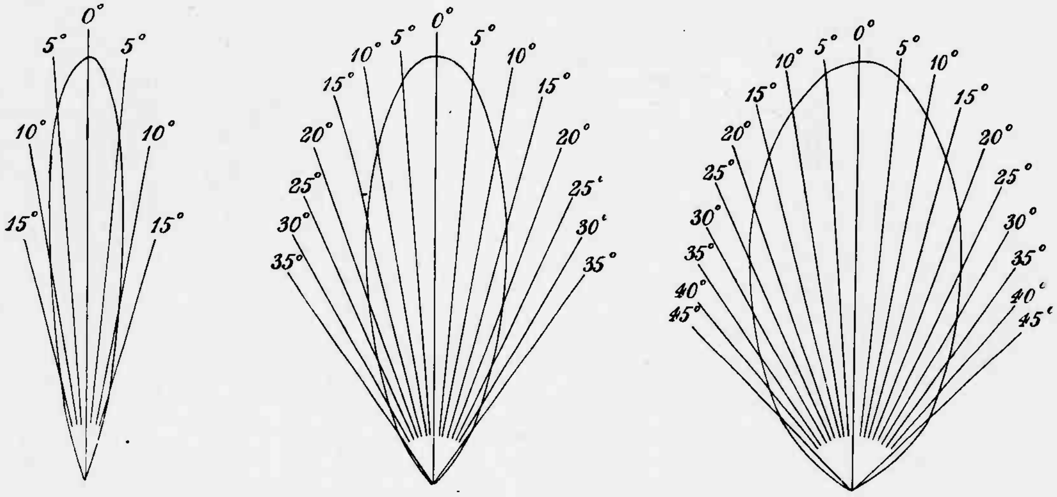


Fig. 7.—The Radiation Characteristic Curve of a parabolic reflector when the aperture is equal to one wave-length (10 metres), but with every other reflecting wire removed, the remaining twenty wires being detuned.



4·28 Metre Wave
Aperture 2·57 Waves:

5·54 Metre Wave
Aperture 1·99 Waves:

6·14 Metre Wave
Aperture 1·63 Waves:

Fig. 8.—Polar Curves of the Inchkeith reflector, measured at a distance of 4 miles from the transmitter.

used at a distance no signals will be heard until the beam flashes past the receiver in the course of its rotation. The first practical step in this direction has been the erection of such a beam transmitter at Inchkeith Island in the Firth of Forth, while a second is in course of erection at the South Foreland.* At Inchkeith the rod oscillator emits a wave of about 6 metres length, this being concentrated into a beam by a wire parabolic reflector. The whole system makes a complete revolution about once in two minutes. As the beam rotates distinctive Morse signals are sent out as shown in the compass diagram in Fig. 9. To each second point of the compass is allocated a special letter, and the intervening points and half-points are marked as T and I respectively. As the beam flashes past the receiver the signal strength rapidly increases to a maximum and then diminishes, and if the succession of Morse signals received during this time is read the direction of the transmitter can be obtained by reference to the diagram. The direction is that of maximum signal strength or midway between the commencement and cessation of the signal heard. For example, when listening at the receiver the succession of signals IKITI would indicate a direction of half a point east of N.E. Confirmation of the signal can be obtained on another rotation of the beam at an interval of two minutes. The receiver on the ship consists merely of a half-wave rod, erected at the end of the bridge and connected up with a detector and valve amplifier to telephones or a loud speaker. With the receiver is provided a disc, marked as in Fig. 9, into which pegs may be inserted at the points corresponding to the commencement and end of the signal, and the bearing of the transmitter is thus obtained as midway between the pegs to an accuracy of a quarter point or about 2·8 degrees. When two or more beam transmitters are put into use the same characteristic signals may be retained for the two-point positions, but the intervening points may be characterised by some letter other than T as at Inchkeith, so that the train of signals ITI or, say, ISI will identify the transmitters, the letter I indicating half-points as before.

It will be appreciated that this system is fairly straightforward in use, and with a slight knowledge of the Morse code any non-wireless officer can operate it from the receiver-end. The method is independent of the time of revolution of the beam and so accurate timing and the use of a stop-

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* J. A. Slee, "Recent Developments in the Application of Wireless Telegraphy to Shipping," *Engineering*, 1923, Vol. 116, p. 410.

watch are obviated. The working range of Inchkeith transmitter is about 10 miles, and as this is in daily use it will be interesting to watch for the results obtained from the point of view of its utility to navigation. Judging by experience in the propagation of wireless waves on wave-lengths of from 300 metres upwards, it is probable that the system will be entirely independent of prevailing weather conditions, and it should, therefore, be particularly useful in foggy weather when other lighthouses are invisible. In propagation over sea it is also to be expected that no other serious errors will be encountered, but when land intervenes the possibility of very serious errors due to reflection from cliffs and hills or refraction in crossing the boundary between land and sea is by no means remote. In fact, it has been suggested that the location of the reflected beam arising from a short-wave transmitter might provide a useful means of locating a near-by ship or even icebergs in the dark or thick fog.

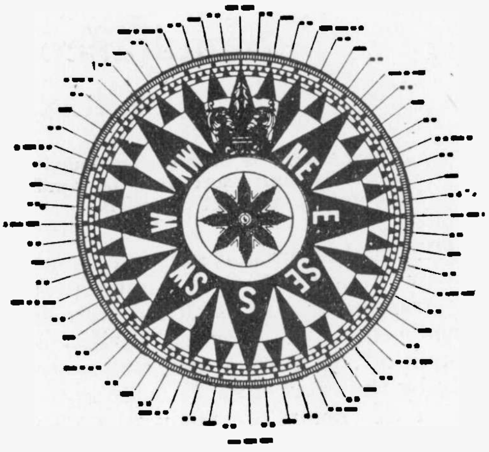

Fig. 9.—Compass bearings with letter designations for direction finding.

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The Sheffield Relay Station.

The Sheffield relay station was officially opened in the middle of November, and, no doubt, some details will be of interest to many readers. The circuits employed are exceedingly simple and straightforward. A perfectly normal choke control system of modulations is employed, the schematic diagram of which is shown in Fig. 1.

The present aerial consists of a four-wire cage about 120 feet high at the distant end; the earth screen consists of the iron framework of the building over which it is suspended. The set is rated at 100 watts.

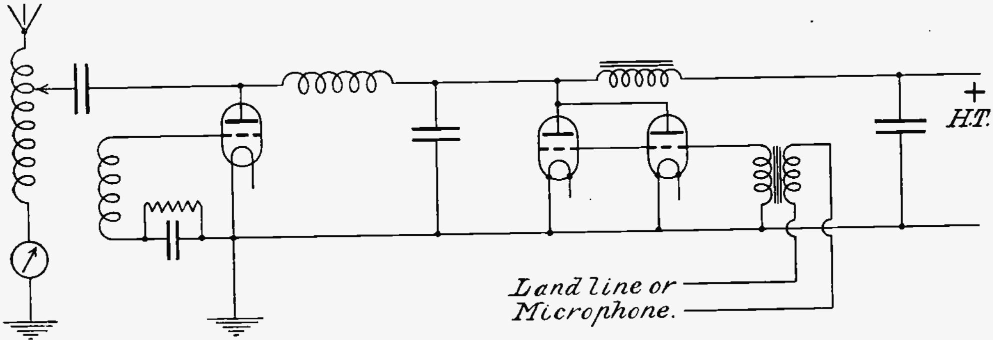


Fig. 1—Illustrating the fundamental circuit of the Sheffield Relay Station.

Simultaneous Broadcasting.

By ALEXANDER J. GAYES.

Much interest is now centred round the subject of simultaneous broadcasting, and in order that our readers may be familiar with the methods employed we outline below the general mode of operation.

THE wireless broadcasting of a speech or a musical item simultaneously from several transmitting stations in different cities, as now so satisfactorily accomplished, has been rendered possible largely by the great advance made in recent years in the study of attenuation characteristics as applied to land line telephonic communication. The problems which present themselves on any such undertaking are many and varied, and, further, the necessity, for commercial reasons, of employing existing lines and cables often make the solutions unduly complex. Without taking a specific case, however, it is interesting to review the subject in the light of the most modern developments in the telephone art, in which respect credit must be given to the Western Electric Co. for the development of both the principle and the apparatus described in this article.

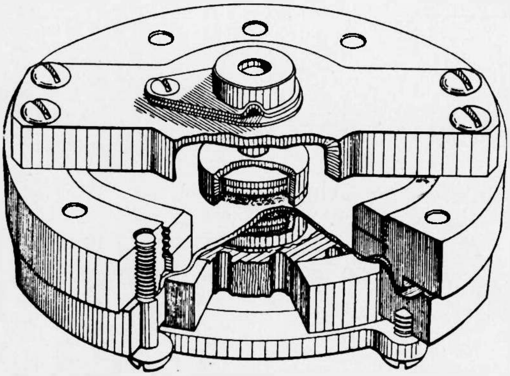


Fig. 1.—The push-pull microphone employs a stretched silk diaphragm, which is heavily air damped. The general form of construction should be apparent.

The two most important factors which enter into every problem of telephonic transmission are the attenuation and the distortion of the comparatively high-frequency waves which constitutes telephonic voice currents. By attenuation is meant the loss of energy of the waves of the telephonic currents, and distortion is the impairment of the many component waves of which the voice currents are composed. In a telephonic circuit the waves are slowly altered, both in form and in amplitude, as they progress along the lines, usually due to the wire-to-wire capacity, but by the addition of suitable inductance to the circuit this alteration can be very considerably reduced. The inductance is added at calculated intervals along the line in the form known as loading coils, and by means of these coils the original wave form and the initial wave amplitude can be preserved to such an extent as to bring the transmission efficiency of a cable under certain conditions up to six times that of an unloaded cable. More recently thermionic valves have been introduced in trunk line telephone circuits, and, owing to the amplification thus possible, the standard land-line speech transmission has now reached a very high level.

The requirement of the commercial telephone service, however, is intelligibility, whereas the transmission of high-grade music demands a naturalness which imposes far more severe electrical requirements, not only on the lines and cables, but on all associated apparatus. This is best expressed by saying that, whilst excellent speech transmission can be obtained with circuits and apparatus which function without material distortion between the frequency range of 400 to 2,000 periods per second, freedom from distortion over a frequency band of from 16 periods to 5,000 periods per second, or even higher, is necessary with music if each instrument in a first-class orchestra is to be discernible.

Obviously the first piece of apparatus to be considered in an extensive transmission scheme is the microphone. It is essential this be of a type which will faithfully convert every feature of the original sound waves into electrical energy ; that is, it must function uniformly between 16 and 5,000 periods.

An air-damped stretched diaphragm condenser microphone gives excellent results, and these are being constructed with a thin steel diaphragm about 2 ins. in diameter, stretched until its period of vibration approaches 8,000 periods per second. The diaphragm forms one plate of a condenser, the other being a rigid disc, the dielectric consisting of a film of air approximately 1-1,000th inch in thickness. The high natural frequency of the diaphragm, coupled with the damping effect of the film of air, results in a very high quality of reproduction uniform in intensity throughout the musical range. The condenser microphone, although highly responsive, is extremely insensitive, needing a voltage amplification of 50,000 times (corresponding to an energy amplification of $2{\cdot}5 \times 10^9$) to bring its output up to that of an ordinary microphone, and, further, considerable technical knowledge is necessary in adapting this microphone to the input circuit.

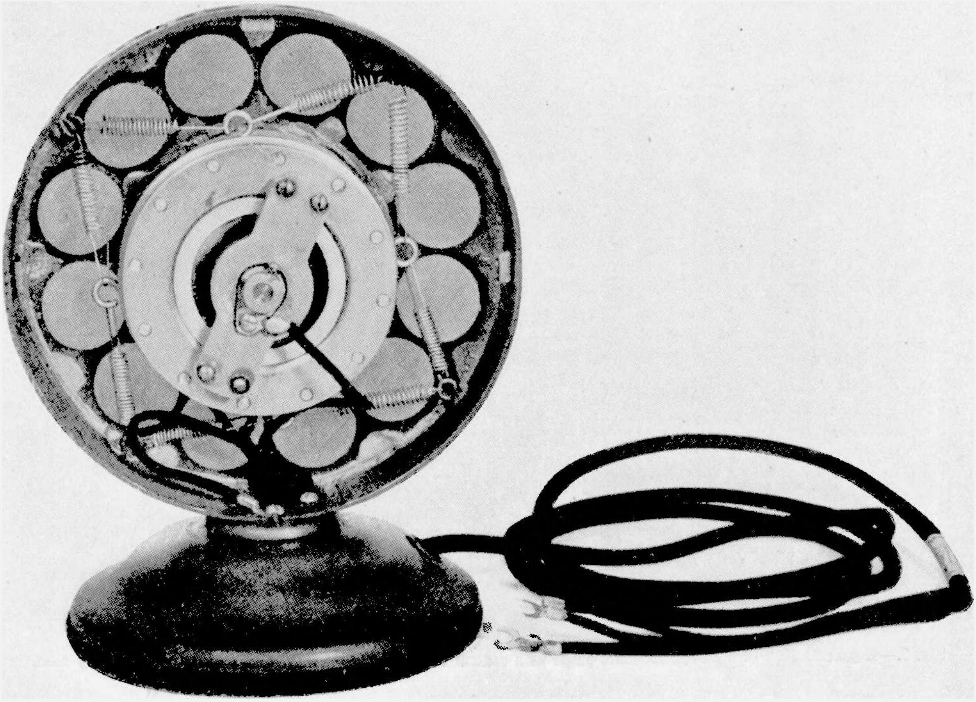


Fig. 2.—The push-pull microphone is normally suspended in a metal case by a system of springs so arranged as to reduce the effect of mechanical vibration.

A more manageable microphone, and one now in extensive use for high quality transmission, is the granular carbon type instrument with two buttons, one on each side of a diaphragm. This is commonly known as the push-and-pull microphone, and has nearly the same high quality characteristics as the condenser microphone owing to the use of a tightly-stretched diaphragm and the same principle of heavy air damping. The energy output of this microphone is, roughly, one-millionth part of that usual with ordinary microphones, and can be expressed as $1 \times 10^{+8}$ watt under average conditions. A part section view of the push-and-pull microphone is shown in Fig. 1, whilst Fig. 2 is a view of the microphone in its mounting with one side of the latter removed. It will be seen that the microphone proper is suspended on four hooks, which engage with spiral springs on the mounting in such a manner as to eliminate the effects of small mechanical jars and vibration. An outer drum, having perforations on all sides protected by fine brass gauze, serves to form a cover, and it will be noted that no horn or sound collecting mechanism whatever is used with this microphone. In passing, it might be mentioned that the double button construction referred to above almost completely eliminates the distortion caused by the non-linear nature of the pressure resistance characteristics of granular carbon.

After leaving the microphone, and before the speech energy is sent out on the line, it is amplified, and if, for example, it were desired to broadcast a theatrical performance, a very suitable apparatus would be the speech input amplifier, an illustration of which is shown in Fig. 3. The exact design of the amplifier would depend on conditions, but the aim is to produce an energy output approximating in value that of ordinary line telephones.

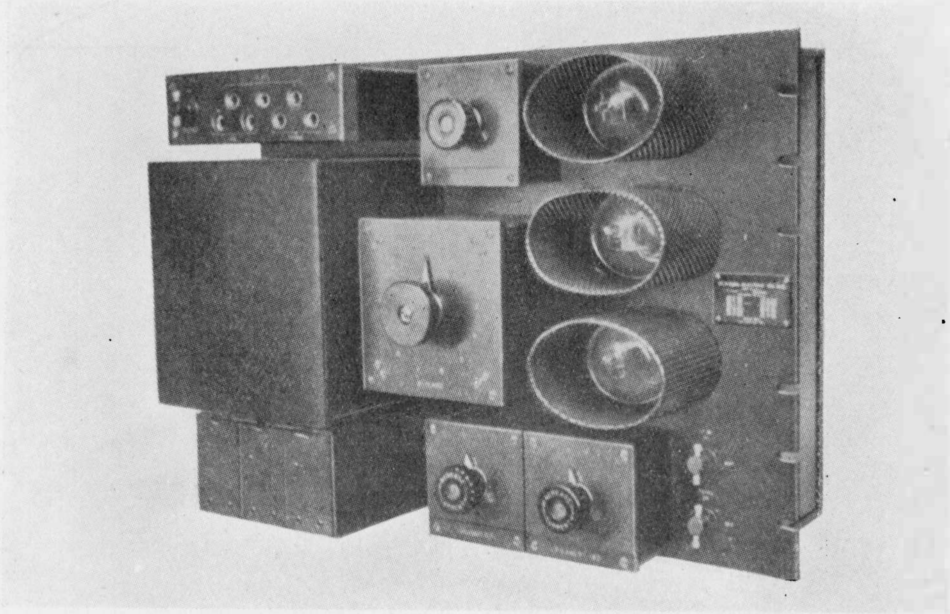


Fig. 3.—A general view of a speech amplifier panel with central devices. The screening of the valve is clearly seen.

The circuit diagram of a speech input amplifier, suitable for microphones when the latter are arranged to collect sounds within a radius of several feet, is given in Fig. 4. For close talking a less powerful amplifier would suffice, but it is interesting to follow for a moment the operation of the special three-valve amplifier illustrated. The microphone control apparatus consists of switches and other mechanism which enables the operator to switch quickly from one microphone to another, as with some public functions the speeches are made at different points during the ceremonies. Special precautions are taken to prevent clicks when switching from one microphone to another, and, if necessary, provision is made for two or more microphones being connected to the amplifier at one time. This latter feature is desirable when solo singers are accompanied by an orchestra in a theatre, for example, where by proper adjustment of the respective volumes very pleasing results can be obtained.

It will be seen that the feeble currents from the microphone enter the amplifier through a differential input transformer on to the first valve. This valve is similar to the one following it, and by a clever series connection the filaments of both are fed from a common 12-volt supply. Advantage of this method of connection is taken to secure the necessary negative bias on the grid of each valve with the exception of the third valve, where a special grid battery is provided for the purpose. The third valve

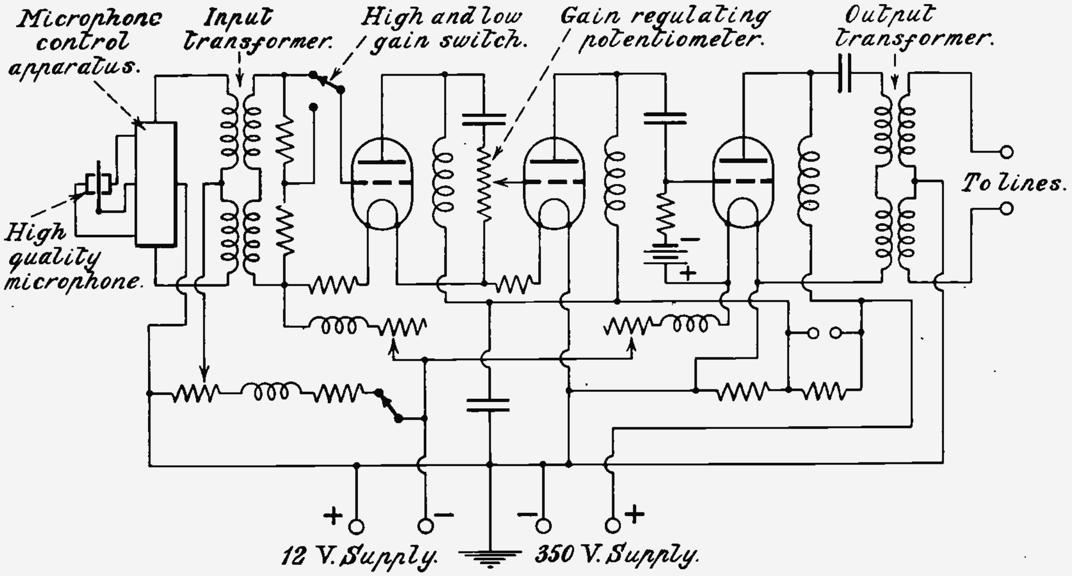


Fig. 4.—The microphone currents are applied through a differential input transformer to the first valve, the grid bias of which is determined by a series resistance. The subsequent valves are choke coupled, the grids being controlled by special potentiometric devices.

is of a different type to the other two, and current for filament heating is drawn direct from the 12-volt supply in this case. Needless to say the valves are of the latest oxide-coated dull emitter filament pattern, as with no other type would it be possible to secure so great a degree of amplification with entire absence of noise. From the last valve the output is taken to a special transformer, or repeating coil, as the telephone engineer would prefer to call it, out to the line through a winding, the centre point of which is earthed. This relieves the line of any static change, and generally makes it far less susceptible to interference effects by the employment of windings accurately balanced with regard to inductance, self capacity and speech-frequency resistance. From this point onward the transmission becomes a telephone problem of the highest class, and every effort must be made to maintain the value or power of the voice currents at a certain desirable level throughout the scheme. If the power be allowed to become too weak, the extraneous power induced from paralleling circuits would tend to obliterate the transmission. On the other hand, excessive amplification would overload any iron-cored inductances in the transmission line, and thus alter their characteristics, as well as giving rise to overhearing troubles on neighbouring circuits.

Referring now to the telephone transmission lines, as previously stated, these have been designed to function most efficiently between a frequency range of 400 to 2,000 periods per second. In other words, the attenuation at frequencies beyond this range is an uncertain factor, and thus we have the peculiar case of the modern telephone cable fitted with loading coils or repeater stations being inferior to an ordinary open wire for the transmission of the highest grade of music; that is, from a distortion point of view only, of course.

To understand the subject fully it is necessary to have a clear conception of attenuation and distortion as applied to telephone cables. These two effects are inter-linked, and the latter results from the former, but it is possible to eliminate distortion if only sufficient skill is exercised. This point can be made clearer if consideration be given for a moment to the study of the transmission characteristics of a telephone cable. Referring to Fig. 5, line A shows the transmission equivalent of a 10-mile length of ordinary dry-core paper-insulated cable. It will be seen that at about 800 p.p.s. the equivalent of the length is roughly 10 miles.

In other words, the cable under consideration approximates closely the accepted standard cable, on the basis of which all comparisons are made. At 2,500 p.p.s., however, the same length of cable exhibits properties similar to those of a 20-mile length of standard cable, assuming the latter to be functioning at 800 p.p.s. throughout, whilst at 5,000 p.p.s. the same 10-mile length of cable gives the effect of a 30-mile length at a uniform 800 p.p.s. From this it will be obvious that the attenuation taking place in a given length of cable varies according to the frequency of the impressed waves. In the case under consideration the loss at 2,500 p.p.s. is twice as great as it is at 800 p.p.s. In such a cable, with the energy loss varying with the frequency, the speech currents would suffer distortion, the degree of which would increase rapidly with widening frequency ranges.

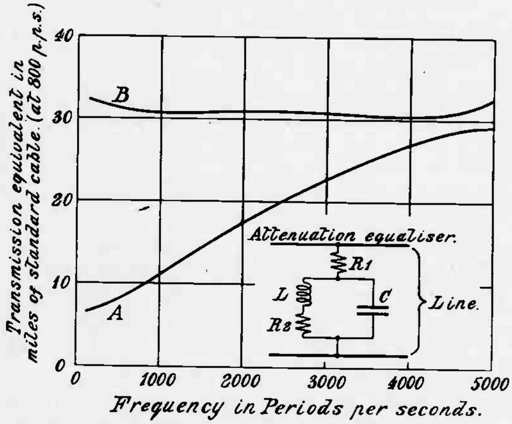


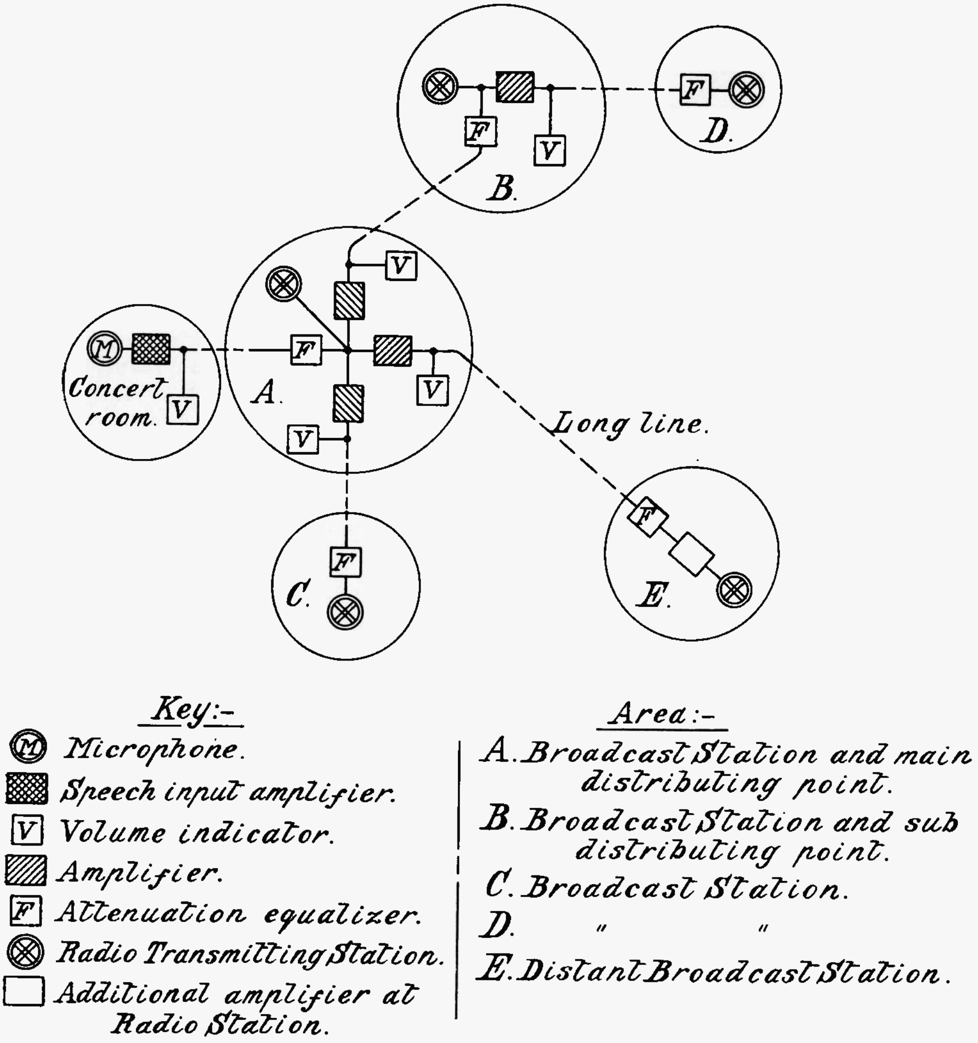
Fig. 5.—Illustrating the transmission equivalent without equalisers at A, and with equalisers at B.

By the addition of loading coils the attenuation, taken as a whole, can be reduced, and can be made more uniform throughout the speech range, but here the previously-mentioned wide range of from 16 to 5,000 p.p.s. must be considered. To secure uniformity throughout such a range is no mean feat, but it can be accomplished by the introduction of attenuation equalisers. Such an equaliser, as shown in the diagram (Fig. 5), consists of a calculated combination and arrangement of inductance, resistance and capacity. In a general way it could be said that such an equaliser increases the loss at the lower frequencies and results in a levelling up of the losses to such an extent as practically to eliminate distortion altogether. Curve B shows this clearly, and, although the nett result is a fall in the overall efficiency of transmission, this can easily be corrected by suitable amplification.

To maintain the desired level in the circuits by proper adjustment of the amplifiers it is found necessary to have some means for quickly indicating the volume of the transmission. This is accomplished by a " volume indicator " consisting of an amplifier detector operating a direct reading milliammeter. By adjusting the amplifier in such a manner as to keep the deflections of these instruments reasonably close to a point determined by previous calibration it is possible to maintain the volume or power of transmission between the required limits. In the case of an extensive distribution scheme small amplifiers can be fitted on all limbs of bridged or teed lines, and by means of volume indicators at these points the requisite amount of power or volume can be distributed to each station.

The volume indicators can be used in addition to compensate partially the large range in volume which occurs with music transmission ; this wide range being particularly noticeable if a theatrical performance is being broadcast. Consideration of this point will show that, were the amplifiers permanently set with sufficient volume to bring fully into prominence the words of a distant speaker, the volume of the loud music would be such as to overload the apparatus in the land lines, as well as the wireless transmitting and receiving apparatus, whereas by judicious use of the controls, based on the reading of the volume indicator, a more natural and pleasing effect can be secured.

The diagram will indicate the arrangement of apparatus involved in a typical simultaneous broadcast scheme. The speech input amplifier would be located in the concert room or in an adjacent room in the same building. A volume indicator would be provided, and, during a performance, an operator, who might also be provided with means of listening on a monitoring circuit, would regulate the amplifier to give approximately the predetermined output volume. This operator would also control the microphones if more than one were fitted.



At the main distributing centre (marked A) the incoming speech currents would be sent direct to the radio-transmitting apparatus, and also several amplifiers, as shown, would have their input circuits bridged on to the incoming lines. This is a fixed and steady load, which would remain unaltered by the demands of the several stations, these demands being met by amplifiers controlled by volume indicators as shown. The attenuation equaliser E in area A might prove unnecessary, as usually the concert room would be within a short distance of the main distributing point, but it is included to show the principle.

In actual practice many difficulties are encountered in attempting simultaneous transmission which cannot be detailed here ; for example, the linking of cables to open lines, or the coupling of cables having different attenuation characteristics. If perfection is desired throughout the very wide frequency range of from 16 to 5,000 p.p.'s all such matters become difficult problems, and the satisfactory accomplishment of an extensive scheme of simultaneous broadcasting undoubtedly reflects great credit on all concerned with so complex a venture.

Some Experiments on the Fading of Signals.

By J. ALLAN CASH (2GW).

In the October issue of "Experimental Wireless" some information was given relating to some of the probable causes of the fading of signals. Below will be found some data which has recently been collected, and the results should be of considerable interest.

VERY little is known about the fading of signals, and investigation of this phenomenon is likely to lead to the solution of many problems in radio. The writer does not propose to put forth any new theories in this article, but rather to indicate the lines on which other experimenters may pursue their investigations, and to give some idea of his own experiences.

It is surprising how wide a field of investigation is opened up when one attempts to find out something about this interesting subject. Many theories have been propounded to explain why signals on short wave-lengths should vary in strength, but none of them can be said to be really satisfactory. When the atomic theory of matter was first propounded it became evident, as time went on, that many problems in science could be solved by it. The more it was used, the more evident it became that it was more than a mere guess, until to-day it is universally adopted as the true conception of matter, and has been proved beyond doubt to be correct. What is wanted in fading is a similar theory, which, once propounded, would probably solve many more problems than fading alone.

Fading only occurs in any marked degree between 150 metres and 600 metres. Below 150 metres and above 600 metres signals remain steady during a transmission period, although they may vary in strength from day to day. There is really no way of overcoming fading at the moment. It is no fault of either the receiver or the transmitter, but there is something between the two which has a very big influence on the signals. As is generally the case in electricity, there is no visible indication of the cause, so one is compelled to start guessing and to see how the information already in one's possession fits in with the suppositions.

Last winter the writer burnt the midnight oil with Mr. W. R. Burne and others many times. After the first excitement of hearing American amateurs had died down, certain peculiar features about these and other signals began to impress themselves on the listeners' minds. Fading was hardly ever spoken of then, but it soon became evident that signals from any American station were very difficult to copy in their entirety owing to the fact that they varied in strength so persistently.

At first regarded as a nuisance, this phenomenon soon began to interest the writer and his friends, and, while one read the messages, another would time the fading. Then things began to hum. It soon became evident that there were two distinct kinds of fading—one irregular and the other regular. This seemed something new, and enthusiasm ran high. Many signals were carefully timed, and soon another point made itself known.

Signals coming mostly over land faded very erratically—sometimes slowly, sometimes quickly, and at times remaining steady for various periods of time. There seemed to be no system about this, so attention was turned to signals which faded regularly. These were found in all cases to have travelled over large stretches of water, *e.g.*, Malin Head, Valencia Island, and American amateurs. These stations hardly ever faded irregularly.

The first thing to be noticed about this regular fading was that the time for a complete swing (*i.e.*, from maximum to minimum and back to maximum) varied with different stations. Next it was discovered that the time for a complete swing was directly proportional to the distance between the transmitting and receiving stations. From observations made last winter, and partly corroborated this autumn, it seems that one swing takes two and a half seconds per hundred miles. This, of course, requires further proof, and is at the moment only a guess from comparatively few observations (see Fig. 1).

Malin Head was noticed to fade and return to normal strength in about six and a half seconds, being 250 miles away. Valencia took about 9 seconds, being 350 miles distant. A ship off Anglesey, 100 miles away, took 2½ seconds to fade. Other ships (C.W. harmonics on about 200 metres) all swung at the rate of 2½ seconds per hundred miles. It was, of course, necessary to find their exact positions, but once this had been done these signals formed excellent subjects for investigation. American amateur station 2ZL, belonging to Mr. J. O. Smith, of Long Island, New York, with which station special tests were carried out by Mr. Burne and the writer, took 80 seconds to fade and return. This station is 3,200 miles away, so the same thing applies in this case as in the others. Stations in the 5th and 9th Districts of America, *i.e.*, 4,000–5,000 miles away, took 100–125 seconds to swing. Further, whenever the fading of these signals was timed it was always the same.

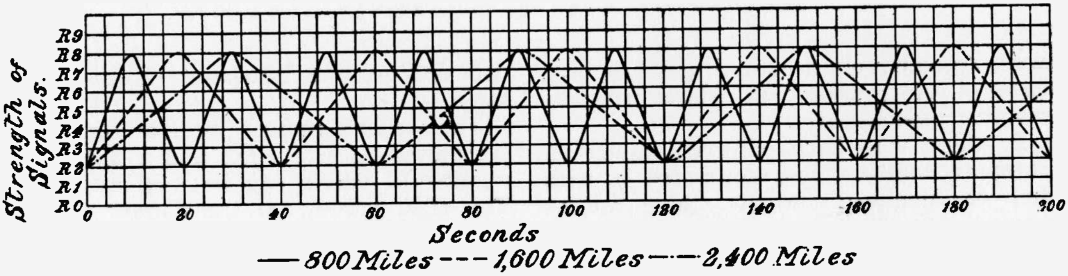


Fig. 1.—Fading curves of signals from 800, 1,600, and 2,400 miles.

A curious modification of this regular swinging was soon noticed (Fig. 2). After so many regular swings, a signal, beginning to fade as before, would be suddenly checked and begin to increase in strength again. This increase would be continued until the signal was far above its usual maximum strength. Then it would fade off again to its usual minimum value. After a few more regular swings, this process would be repeated only in the opposite direction, *i.e.*, fading away to far below minimum after increasing only about half way towards normal maximum strength.

An excellent demonstration of this modification was given on January 17, 1923, between 2 and 3 a.m., by station U.S. 2ZL. His strength at full maximum made it impossible to wear the 'phones. When at full minimum his signals were just readable. His normal swing varied between R.5 and R.9 or more.

It is very difficult to observe this modification of fading, as a station would have to transmit consistently for at least a quarter of an hour in order to demonstrate all the fading without doubt. This is very rarely done by American amateurs. Perhaps it would be easier to watch broadcasting. There are many things to be discovered yet about this strange double fading.

Perhaps it would be as well to mention here that fading varies from night to night. Last winter the fading of American amateurs seemed consistently to follow the above conditions, but since the summer their fading seems to have been influenced by some unknown cause. Very often quite irregular fading has taken place, and on many occasions the time for a complete swing has been wrong. However, bearing in mind last winter's results, it is quite easy to see that the fading tends to follow the same rules.

Now a word to those who have noticed regular swinging on English broadcasting stations. Several experimenters have written to various wireless periodicals saying that signals from London at a few hundred miles distant fade regularly every so many minutes. Quite right, but does London always fade in the same time? If so, by all means take as many observations as possible and try to find the cause of it. But if, when swinging regularly, the time for a complete swing varies from day to day, it seems to the writer that it would be far better to watch stations which always or nearly always fade regularly, find out something definite about regular fading, and then compare the results with the occasional regular swinging of London. In this way it should be much easier to detect the influences which cause irregularities in the fading of signals coming over land. By watching stations which only occasionally swing regularly one is apt to get lost in a maze of observations, in which irregular swinging predominates.

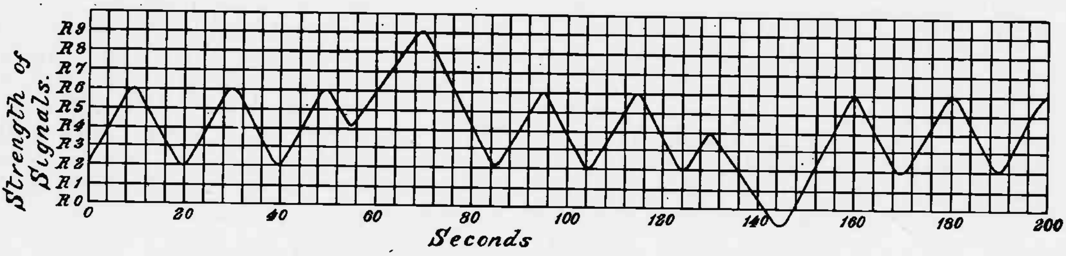


Fig. 2.—Fading curve of signals from 800 miles, showing double increase and double fade.

To those who have observed fading on European stations, and compared it with that of American stations, there are so many things which seem to influence signals coming over land that for convenience sake, for the time being anyway, it seems better to class all "local" stations as fading irregularly, and to concentrate on the best of all stations to observe on—American amateurs and broadcasting. As signals on 400 metres seem to fade in exactly the same way as those on 200 metres, American broadcasting is very useful to those who require a good "steady" signal to work on.

A most important point to remember when observing fading on a telephony transmission is—not to take the strength of the signal as being that of the music or speech, but to heterodyne the carrier wave and observe on that. Music is always varying in strength regardless of radio conditions. Speech, if consistent, is less likely to lead to mistakes, but better than either of these is the carrier wave. Great care must be taken if a self-heterodyne type of receiver is used to see that the set does not radiate, as this would probably spoil reception for others in the vicinity. It is far safer to use a separate heterodyne altogether, coupled, if necessary, as far from the aerial as possible. If a self-heterodyne receiver is used, it is easy to determine whether radiation is taking place or not by tuning in a C.W. signal and then moving the aerial tuning condenser, or, if a coupled circuit is used, the secondary tuning condenser. If the set is radiating the beat-note of the signal will change, but if no radiation is taking place only the strength of the signal will change, the beat-note remaining the same.

The writer's present receiver consists of six valves—4 H.F., D., and 1 L.F. Any number of valves can be used at a time. The H.F. valves are transformer coupled. When the H.F. valve nearest the detector is used alone, the set radiates when oscillating, but when any more H.F. valves are brought into action they do not oscillate along with the first one. The heterodyning part of the set remains confined between the detector and the first H.F. valve, and with two, three or four H.F. valves in action the set does not radiate. This enviable state of affairs is only made possible by using reversible H.F. transformers—*i.e.*, with the four pins fixed in the form of a square and not in the usual valve-pin way. It often happens, when the writer brings another H.F. valve into play, that the whole set oscillates, and therefore radiates, but by pulling out the last transformer to be added, giving it a quarter turn, and again inserting it, the general oscillation ceases and there is no radiation. Signals are every bit as good as when the set radiates. The condenser tuning the transformer nearest to the detector is the only thing which will alter the beat-note of a signal when the set is adjusted correctly. By using reversible H.F. transformers, self-oscillation between H.F. coupled valves has been entirely eliminated at 2GW.

It will be seen that the writer pins great faith on H.F. valves. Perhaps some readers will question the necessity for so many valves. Let it be stated at once that signals from America can be heard quite easily on one, two and three valves, but in order to obtain accurate data on fading it is highly advisable to more than merely hear a signal. A signal should not fade to inaudibility at all, and, if possible, should be easily readable when at its weakest. It has been found that, when QRN is bad, the L.F. valve is more trouble than assistance in reception, but by bringing in one or two more H.F. valves, QRN is but little worse, while signals are considerably louder. It is very rarely necessary to use all the H.F. valves, but they are there for use when the occasion arises.

The writer has not troubled very much with record-breaking achievements, although American signals on short waves have been read on one valve, and various other "stunts" have been achieved "just to show there is no ill feeling!" Much more importance is attached to the scientific side of reception than to record breaking. After all, what one fool can do, another can!

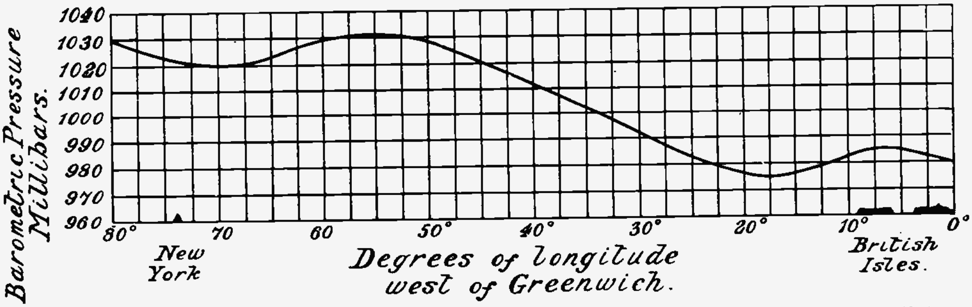


Fig. 3.—Chart showing barometric pressure over the Atlantic Ocean on December 20, 1922. It was found that very good conditions for reception existed at this time.

During last year's Transatlantic Tests signals came through very well until December 15, when they began to go off. On December 16 only two American amateurs were reported among all listeners in Great Britain. December 17 saw signals returning, and December 18 was a very good night. Here is a chance for investigation. Signals from America often go off like this, but generally return after a day or two. Local signals remain apparently the same as usual during these periods.

During September of this year great numbers of American amateur and broadcasting stations were received in England, but for the first four weeks of October no one, to the writer's knowledge, has heard more than a solitary one or two American signals. Why? Is it weather conditions, wind, temperature, clouds, humidity, or what? Further, is the cause of signals going off during last year's Transatlantic Tests the same thing that prevented signals coming across during October this year? These and many more questions remain to be answered. The only way to do it is to imagine everything that could possibly influence signals, obtain regular information about each thing, draw graphs if possible (Fig. 3), and compare them with the results obtained. Perhaps in this way some experimenter will come across a feature of Nature which influences signals, and which would account for fading of all kinds. Anyway, there is a vast field of research open to all who are interested, and no unusual or costly apparatus is necessary to begin with at least. Perhaps other experimenters will make known their views on this most fascinating subject.

British Amateur Call Signs.

It is understood that the supply of call signs commencing with the figure 6 is now exhausted. It seems that other figures are not to be introduced, and the call signs will be continued by another series of "twos," followed by various three-letter combinations. It needs little imagination to appreciate the confusion which is likely to arise when listening for American amateurs.

Some Original Notes on Selectivity.

By G. L. MORROW (6UV).

Since the introduction of broadcasting the experimenter has turned his attention to the question of selectivity with a view to separating the various broadcasting stations. Most time seems to have been devoted to the use of rejector or acceptor circuits, and the following notes which approach the subject from a different viewpoint are of great interest.

In the early part of the present year the writer was engaged upon the compilation of comparative data with respect to the fading of certain 600-metre marine traffic shore spark stations, and for the purpose of these investigations a receiver, comprising two aperiodic H.F. stages, rectifier and one note magnifier, was employed; the tuner being a standard, calibrated Mark III*.

To those who are conversant with 600-metre reception, it will be appreciated that anything in the nature of accurate signal strength measurement on any given station is practically impossible on this wave-length owing to interference.

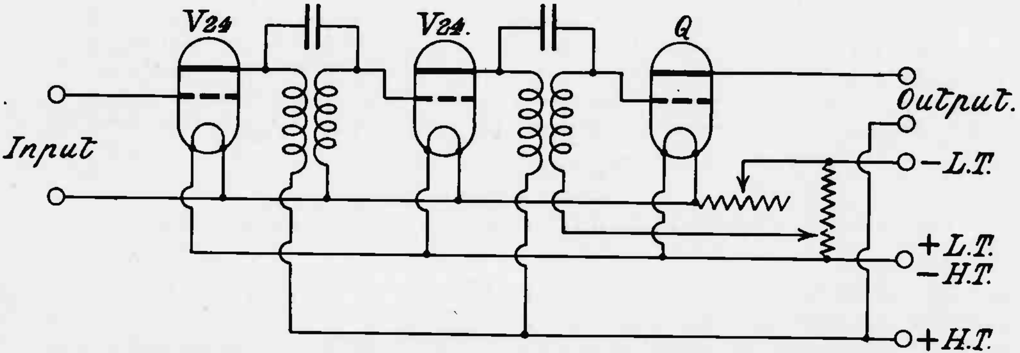


Fig. 1.—Small fixed condensers are placed between the primary and secondary of the transformers—that is, between the anode of one valve and the grid of the next valve.

It is hoped, therefore, that the methods to be described by which this interference was overcome may be of interest, opening out, as they do, an interesting field for research in amateur DX working in this country.

In considering the means by which this interference might be reduced, one of two methods only appeared to hold out reasonable chances of success, one being to strive for the utmost degree of selectivity obtainable by as small a coupling percentage in the tuner as compatible with signal strength; the other, by the use of rejector circuits or what are commonly known as "wave traps." As it is well known that by far the greater amount of 600-metre spark interference is caused by the "double-wave" radiation of such stations, it was decided to concentrate on obtaining as high a degree of selectivity throughout the receiver as was possible, and it was proposed to use the minimum coupling between the aerial coil and the secondary, together with a high degree of resonance in the H.F. stages, according to the particular station whose fading was to be observed.

For some months previous to the commencement of these investigations it had been noticed that the weather report transmitted nightly from GLD at 22.30 G.M.T. was subject to marked periodic fading, and it was, therefore, decided to start observations on this station. Owing to jamming by FFU and GNI such observations were of little value, and the writer therefore tried the effect of putting small variable condensers of 0·00025 mfd. maximum capacity in shunt to the secondary windings of the transformers. It was found that a capacity

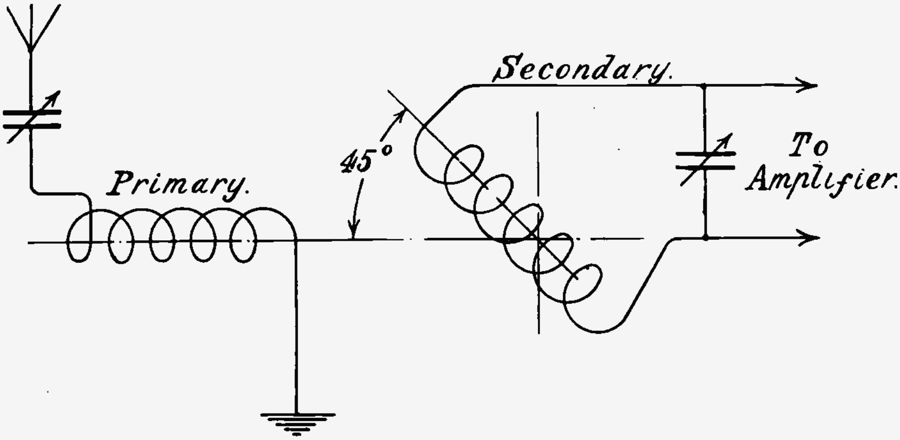


Fig. 2.—The longitudinal axes of the coils were first placed at 45°, as shown.

of 0·0003 mfd., together with the limiting action of the rectifying valve—anode rectification being employed—was sufficient to bring up GLD's strength from an average of R6 to R8 without increasing that of FFU or GNI. Two fixed condensers of this capacity were then made up with the intention of connecting them permanently across the transformer secondaries ; this was done, and a strange effect was immediately noticeable: whereas previously it had only required two divisions of the secondary (tuner) condenser to bring in FFU and GNI sufficient to jam GLD, it now required twelve divisions, and when tuned to GLD the two former stations were of very much reduced strength.

As no logical explanation of this effect was apparent, the wiring of the amplifier was examined, more by custom than in the hopes of finding an explanation, and it was then found that by mistake the small fixed condensers had been connected, *not* across the secondaries of the transformers, but *between* primary and secondary, as shown in Fig. 1. Thus the writer is bound to admit that what he might have striven for unsuccessfully for weeks was, through carelessness, discovered in a few hours.

At this stage it was decided to leave the amplifier as it was and employ the loosest coupling possible in the tuner, and it was discovered that, when the longitudinal axis of the secondary was at 45° with that of the primary, as shown in Fig. 2, GLD was quite inaudible, while FFU and GNI were reduced to strength R3 and R2 respectively. When, however, the coupling was still further reduced to approximately 85°, GLD became audible again at strength R4, FFU and GNI being both reduced to strength R2.

As these results were promising in the extreme, the primary and secondary coils were removed from a spare Mark III* tuner and mounted in such a manner that the secondary coil could be removed to a distance of 2 ft. from the primary, the longitudinal axis of both coils being the same, and, profiting from the experience of the H.F. transformers, a small variable condenser of 0·0005 maximum capacity connected as shown in Fig. 3.

At this point it may not be out of place to investigate the function of the condenser shown in Fig. 1. It should be remembered that the high-frequency transformers were of the aperiodic type wound with resistance wire, and thus, in their original condition, giving a comparatively speaking blunt, resonant peak on 600 metres. The effect of adding a small condenser in the position shown in the diagram is to increase the capacity between primary and secondary, thereby still further flattening out the resonance curve on the optimum wave-length. This, combined with the selectivity obtained by very loose-tuner coupling and the limiting properties of the rectifying valve, enabled the two interfering stations to be very much reduced in strength. In passing it may be of interest to mention that the true wave-length of GLD as measured by a standard wave-meter was 605 metres, with only a weak radiation on 585 metres, whilst the true wave-length of FFU and GNI were noted as 595 and 620 respectively.

Reverting now to the special tuner, it was found that, with the secondary coil removed to 1½ times its own length, and connected as shown in Fig. 4, when the coupling had been loosened sufficiently to obtain the dead point on GLD a slight movement only of the condenser was required to bring this station in again at quite good strength, at the same time eliminating the two interfering stations.

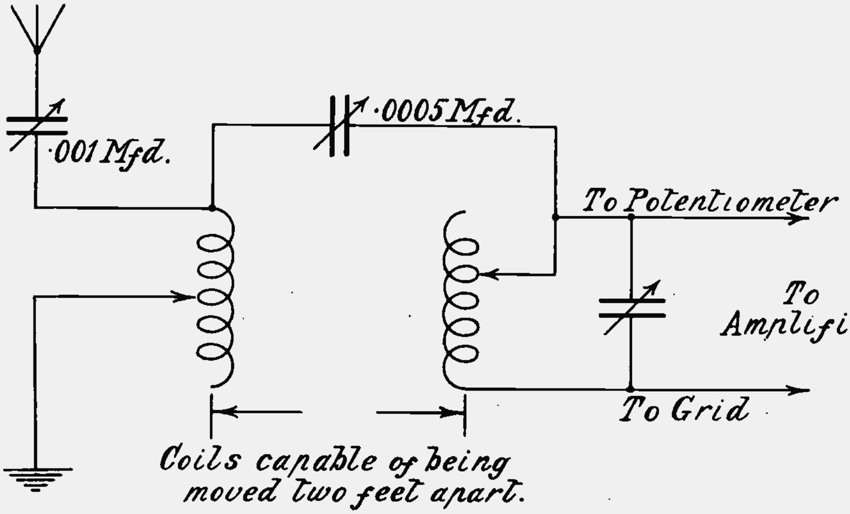


Fig. 3.—Subsequently the coils were separated by a distance of 2 feet, the axes being aligned, and the coils were electro-statically coupled.

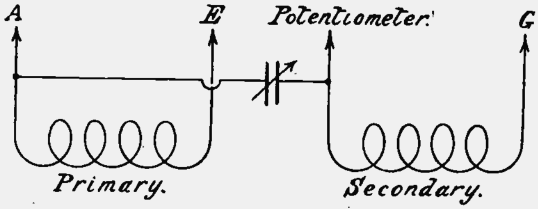


Fig. 4.—The secondary is removed from the primary to a distance of 1½ times its own length.

It would appear that, at the silent point, the coupling is so reduced that the magnetic and static components are equal, and that any further reduction in coupling results in the static component being the greater, thus giving in effect a capacity coupling which is actually accentuated by the small variable condenser. It would also appear that the shorter the wave-length with any given coupling, so the static component increases, and on wave-lengths below 300 metres the writer uses a vernier condenser of 0·0002 mfd. maximum capacity.

This method of what may, perhaps, be termed a combination of inductive and capacity coupling was sufficient to enable the necessary data on fading to be tabulated, and the results obtained were considered to be sufficiently interesting to warrant similar observations being taken on several British amateur stations operating round 200 metres. On this much shorter wave-length it was found, however, that this method was not wholly satisfactory on C.W. transmissions, as certain stations continually broke through and rendered observations almost impossible.

This was finally overcome by replacing the aperiodic secondaries of the H.F. transformers with tuned copper windings, and at the same time arranging variable coupling between the primaries and secondaries of these transformers. This gave all the selectivity necessary, and the final circuit is that shown in Fig. 5.

This, at first sight, would appear to necessitate several critical adjustments, but in practice the writer has found that once the " feel " of the circuit has been obtained stations can be tuned in and interfering stations eliminated with comparative ease.

In any case, the remarkable degree of

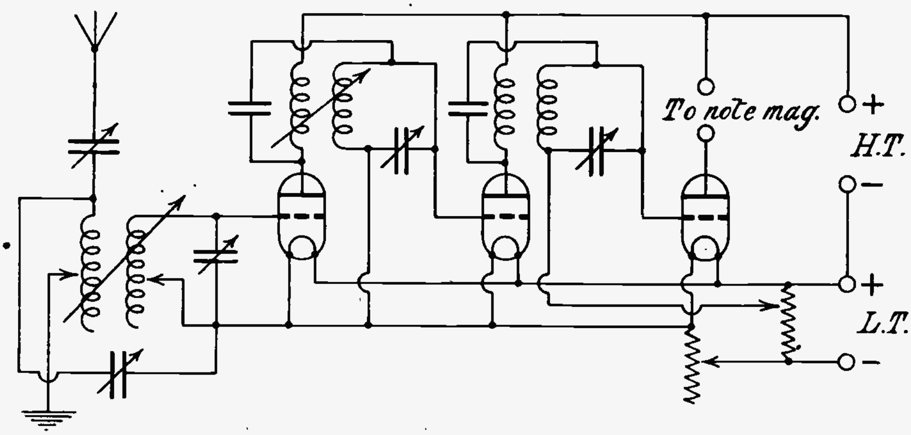


Fig. 5.—The final circuit employed, with the selective device applied both to the aerial circuits and the amplifier circuits.

selectivity which can be obtained by these means appears amply to justify the extra adjustments required. It will be noticed that throughout these notes no mention of reaction has been made. Reaction was tried, but, as would be expected, rendered the circuit unstable, and, since the signal strength was quite sufficient, and no tendency to instability apparent without its use, it was not adopted. Finally, as a matter of interest, using this arrangement, the 450-metre ship and shore D.F. traffic, which so frequently cuts through the broadcast transmissions from 5IT, can be completely eliminated, as also can the interference of any one broadcasting station with another at a position 30 miles N.W. of London.

In conclusion, the writer has made no attempt to deal with the theoretical explanation of the various phenomena observed, but has given these notes in the hope that they will prove of interest as showing in what manner a definite problem arose and how it proved capable of solution to such an extent that the observations on fading were able to be completed.

Copy of letter received from U.S.A. 8KG.

Niles, Ohio.
English 2KF. October 21, 1923.

Dear Sir,

We have completely verified your report of September 19 on our 'phone signals, and we wish to thank you for same.

The report has been officially recognised by *Q.S.T.*, the leading American amateur wireless magazine.

Perhaps you do not realise it, but you have helped us to establish a world's record. The 'phone set we were using at the time incorporated four 5-watt tubes in a Hartley circuit, using Heising method of modulation, two tubes acting as oscillators and two as modulators, the input being 500 volts D.C. at 180–200 milliamperes, or about 100 watts.

This set radiates from 2·3 to 2·5 amps. on 'phone, the voice being amplified by a special two-stage amplifier before it is impressed on to the modulator tubes.

As you will now realise, this is some record for low-power 'phone set such as this one is, and we should like to arrange tests with you at some time in the near future. . . . .

Again we wish to thank you for your very kind report.—Yours truly,

(Signed) J. Wm. Kidd,
Oppr. 8KG.

Note.—This station was received when working telephony to 2RS on the morning of September 19, 1923, at 4.50 a.m., using two valves (detector and 1 L.F.), and the speech was just audible, the calls being easily recognised. The transmission was steady, and no fading was observed. 2KF.

General Efficiency of Reception on Short Waves.

By HUGH N. RYAN (5BV).

A recent examination of a number of amateur receiving stations intended to operate on short wave lengths shows in a very large number of cases very poor examples of design. In view of the coming trans-Atlantic tests it is likely that many will be working on very short wave-lengths and those to whom the subject presents any difficulty will find the following notes helpful.

IN reading reports of the reception results obtained by various stations, one cannot but notice the great differences exhibited in the logs of different stations, which differences are too great to be accounted for entirely by the location of the stations. It is very interesting to look through the "Calls Heard" columns of several radio periodicals. One can "place" each station in its right class immediately. First look at the end of the list. Either there will be a string of O's and 8's, or there will be none at all. In the latter case, you can be pretty sure that every station in the list will be a 440-metre station. In some cases there may be some very good work indicated on the 440 wave-length, in the way of distant stations received, this showing that the station in question is not entirely "dud," in spite of his evident inability to receive on 200 metres. The chief object of this article, therefore, is to give a few hints to those who are experiencing difficulty with the short waves. I can hear many of you saying that a man who cannot receive as well on 200 as on 440 does not deserve hints. I would ask those to consider the time when their own 200-metre reception was, perhaps, not all that might be desired. It is even possible that, in a few cases, there is still room for improvement. Certainly, in the aforementioned lists, the results on short waves, when there are any recorded, are not always comparable with the receivers used. So, you who get everything there is to get on short waves, why not try getting the same results on one valve less? (In a few cases I know of, I should like to suggest four or five valves less!)

First of all, we will deal very briefly with those who cannot receive at all below about 300 metres. Their troubles can be reduced to three main headings. Too much dead-end. Too large a reaction coil. Too much stray capacity.

The remedies for the first and third are obvious, and have been emphasised too often to need any further remarks. The fault of having too large a reaction coil is probably responsible for 90 per cent. of short-wave troubles. Those whose receivers work only on the longer waves find that, as they tune downwards beyond a certain point, they need more and more reaction to make the circuit oscillate. A little further down the circuit will not oscillate at all. Strong spark and telephony can still be received fairly well, but it is noticed that, however much further the A.T.I. is reduced, the wave-length does not decrease. Now the point below which the reaction coupling has steadily to be increased is the natural wave-length of the reaction coil (or, more correctly, of the circuit comprising the reaction coil and the valve capacity). No circuit will oscillate freely at a frequency higher than its own natural frequency. Therefore, the oscillations which are obtained a little below the point are forced and unstable, and cease altogether a little lower down. The reason that reducing the A.T.I. fails further to reduce the wave-length is that the reaction coil has now taken charge of the tuning. It must be remembered that, although when we say that a set is "oscillating," we usually mean that it is generating oscillations of itself, yet the circuits of a receiver are oscillating whenever it is receiving signals, the oscillations being sustained by the distant transmitting station instead of the receiver. So, for the same reason that the circuit cannot generate oscillations below the natural wave-length of its largest coil, it cannot respond to signals of a lower wave-length than that. This explains why the reaction coil takes charge of the tuning as soon as the natural frequency of the grid circuit in the ordinary receiver is increased (*i.e.*, its natural wave-length reduced) above the natural frequency of the plate circuit.

Now, many experimenters do not realise this, and so, when they observe that, below a certain point, they require more reaction, and that a little lower still they cannot obtain oscillation at all, they assume that they have not sufficient reaction for short waves. They therefore put in a larger reaction coil, and so make matters worse.

Assuming that the coils are arranged so as to allow of a reasonable (but not necessarily tight) coupling, and that the damping of the grid circuit is not too great, a very small coil indeed will suffice for reaction. I have very often heard this excellent advice met with the reply that the set might be persuaded to oscillate a bit with a small reaction coil, but the oscillation would be pretty feeble. May I, therefore, interpolate at this point a few sentences dealing with popular ideas about oscillation. Oscillation is the fetish of the average non-technical experimenter. His first thought about any receiver is not " Will it receive ? " but " Will it oscillate ? "

The guiding rule of many receiving men is " if the set will oscillate it must be working, if it will oscillate hard it is working well, if it will howl violently it is working perfectly." Hence the often-heard objection to a small reaction coil, namely, that it will not make the set oscillate hard enough. Let us try to explode this fallacy once and for all. A good autodyne set of any ordinary type is working at its best for the reception of C.W. when it is just oscillating. Theoretically, the signals heard in the 'phones are loudest and purest when the local oscillations in the circuits of the detector valve are of exactly the same amplitude as those produced by the received signals. Now, with the slight degree of overlap present in the majority of receivers (even if it is too slight to be noticeable) the weakest stable oscillations which our receiver can generate are stronger than those which we are receiving. Therefore, always try to keep the receiver only just oscillating for C.W. reception, and on no account blame your receiver because it will not oscillate hard enough. Another very important point must be mentioned in this connection. Whatever the text-books may say about it, it is an indisputable fact that if a receiver is connected to an aerial, and any valve of that receiver is oscillating, some energy will be radiating from the aerial. The tuned anode H.F. amplifier, with reaction coupled to the anode coil, is no more free from this trouble than any other. If the set be tuned correctly, and the detector valve is generating oscillations, the H.F. valve will oscillate also and energise the aerial. So there is another important reason for keeping the local oscillations subdued. It has been said that the amplitude of the local oscillations should be equal to that of the received oscillations for the best results. In connection with this, it will be understood that the remarks about the local oscillations in an autodyne set always being in practice stronger than those received only apply when receiving weak signals, but, of course, the set does not need to be at its most sensitive adjustment for receiving a station in the next street.

If this ideal of equalising local and received oscillations is achieved, then the interference caused by the receiver is minimised. It means that, even if reaction direct on to the aerial coil were used, the interfering waves received by any other station, however near, could never be stronger than those of the distant station. Now, if all the usual precautions are adopted, and aerial reaction barred, the interference can be eliminated, and reception improved at the same time. In connection with the last two matters, one cannot too strongly urge the use of a separate heterodyne. It is the only method by which the strength of the local oscillations can be regulated to a nicety, and the most effective method of minimising the so-called re-radiation.

Now, having reduced the size of the reaction coil, it is possible that the set will still not oscillate on short waves. This may be because the reaction coil has not been sufficiently reduced. In this case the receiver will exhibit the same symptoms as before, but on a lower wave-length. But assuming that the reaction coil is now small enough, the trouble is probably due to an excessive dead-end, or too fine a gauge of wire on the A.T.I. or grid coil. For the best results on short waves, use a coil which just covers the required range and no more. From

150 to 220 metres is a reasonable range for one coil, with, say, three or four tappings. Use plug-in coils if you like them, but make them yourself, using thick wire for winding. The universal fault with all short-wave plug-in coils on the market is that the wire used is far too thin.

All coils for short-wave work should be wound at least 18 or 20 gauge wire. See that all the connections are made with heavy gauge wire, as short as possible, well spaced, and all joints soldered.

Use a well insulated counterpoise in preference to an earth connection wherever possible.

Now, having reduced all damping to a minimum, adjust the set to the highest wave-length on which it is required to work. It should just oscillate on this wave-length. If it oscillates readily with very little reaction coupling, take more turns off the reaction coil. After adjusting everything in the circuit to its best value, the reaction coil should be just large enough to produce oscillation over the whole range of wave-length.

I have already pointed out that it is essential for the natural wave-length of the reaction coil to be below that of the received signals, but so far it has been assumed that it does not matter how close to its natural wave-length we work so long as we keep above it. As a matter of fact, it is best to keep its natural wave-length as far as possible below that on which we wish to receive, for two reasons. The first is just a matter of mass, and has nothing to do with frequency. We do not want to introduce more matter, especially metal, into the field of the grid coil than is necessary, owing to eddy current losses, which may be quite high on these frequencies. The second reason has to do with smoothness in tuning the set. If the curve, obtained by plotting wave-length against the degree of reaction required to produce oscillation, is examined it will be found that it is fairly flat at a distance from the natural wave-length of the reaction coil, becoming steeper as it approaches that wave-length. In other words, if we want to keep the set just oscillating, while varying the wave-length, the necessary adjustment of the reaction coupling will be slight if we are working well above the natural wave-length of the reaction coil, but becomes greater as we approach that wave-length. This means that "searching" becomes very troublesome if we are working only just above this natural wave-length, since, if the set is just oscillating, raising the wave-length slightly brings the set "miles off oscillation" and lowering the wave slightly causes it to oscillate much too hard. Thus, for every reason, it is best to have the reaction coil as small as possible. The last reason applies with still more force when a separate heterodyne is used, as the receiver is then used "just off oscillation" instead of just oscillating, and, if these suggestions are followed, the set will be in this state over a small band of wave-lengths without adjustment of the reaction coupling, thus reducing the number of controls.

Finally, if this article helps anyone to improve his results on short waves, will he please remember that there are others trying to receive the same signals as he is, and that, by yielding to the temptation to let the set oscillate hard, he is spoiling other people's reception as well as his own. If people in the same neighbourhoods would co-operate in avoiding interference, things would go much better. I was listening in a few nights ago and heard about 40 American amateurs. The call signs and some of the traffic of 25 of these were completely blotted out by one local heterodyne.

If you must use autodyne receivers, use them carefully. Don't "swish" up and down anyhow, and remember that if one station in a neighbourhood is listening with a radiating aerial to a distant station, and he *keeps still*, all the others can keep just off oscillation point and receive fairly well, using the other man's radiation as a separate heterodyne, but one man "swishing" will ruin everything. So use a separate heterodyne if you possibly can, and whatever happens, if you hear anything, go for it carefully and steadily. Don't get wildly excited and "swish" up and down on the signal. A little friendly co-operation is worth a lot of fancy anti-radiation circuits.

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American Broadcasting Stations.

It is interesting to note that at the time of going to press, the American broadcasting stations are now being received some 50 per cent. louder than during the last month.

Some Notes on the Sources of Energy Loss in Condensers.

By PHILIP R. COURSEY, B.Sc., F.Inst.P., A.M.I.E.E.

The occurrence of losses in condensers, and their resultant effect upon a particular circuit, is a subject of which the experimenter has had little chance of investigating. Below will be found the first part of a simple discussion, and should prove of considerable value to those to whom the subject is new.

WHEN, as in the early days of electrical work, the use of condensers was confined to the storage of small high-voltage electrical charges, absence of leakage was a property of prime importance. Condensers were then of the Leyden jar form with a glass dielectric, and probably their chief application was to Wimshurst and similar electrical machines.

The phenomena of dielectric absorption and residual charge gave then an indication that the properties of the dielectric in such condensers were more complex than was to be suspected from the straightforward charge and discharge effects, while this complexity has only been further emphasised by recent developments in high-power continuous-wave radio.

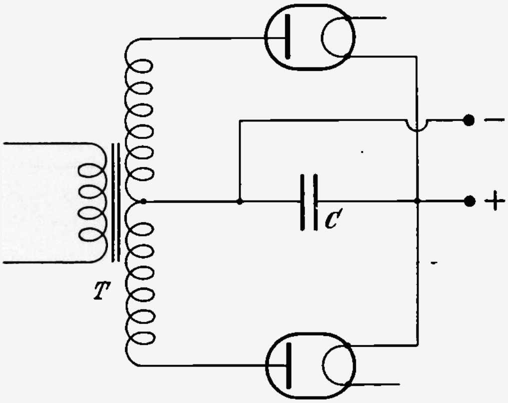

Fig. 1.—A typical arrangement of a smoothing condenser for double wave rectification.

Considering for a moment this question of insulation resistance, it is evident that when a condenser is maintained charged by a source of E.M.F.—such as in the case of the example quoted above of the Leyden jar charged by an electrical machine—there will be some loss of charge by leakage, this loss taking the form of a leakage current flow through the condenser insulation. If the condenser is charged to a potential of, say, 10,000 volts, and its insulation resistance is only as low as 10 megohms, the leakage current through the dielectric will evidently be—

$$I_l = \frac{V}{R_l} = \frac{10^4}{10^7} = 0 \cdot 001 \text{ ampere.}$$

Such a leak would be a very serious one, and if the condenser potential were maintained it would involve a not inconsiderable expenditure of energy.

This energy loss is—

$$W_l = \frac{V^2}{R_l} = \frac{10^8}{10^7} = 10 \text{ watts.}$$

The whole of this energy would be expended in heating up the dielectric in the condenser, and any other insulation—such as at the terminals, etc.—where the leakage was taking place. Although an energy loss of 10 watts is not much if it is in the open, if it occurs in a closed-up space, as in the dielectric of a condenser, it may lead in a small condenser to a considerable temperature rise. In actual practice the loss should be much less than this figure.

This type of condenser loss is one that is, or may be, encountered in the case of smoothing condensers used in connection with rectifying valves, as at C in Fig. 1, which is the conventional arrangement for "two-wave" rectification. If the rectifying equipment is doing nothing beyond charging the condenser C to a potential of approximately 0·7 V, where V is the R.M.S. voltage across the outer ends of the secondary winding of the transformer T (assuming that the connections are arranged as shown in Fig. 1, with one terminal of the condenser connected to the mid-point tapping of the transformer secondary), the above source of loss will be the only one when once the condenser has been charged up to the above-mentioned voltage. The energy loss will be as before—

$$W_c = \frac{V_c^2}{R_l} \text{ watts} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where W_c = the energy loss due to D.C. leakage, and V_c= the actual voltage across the condenser C.

The extent of this loss can obviously be determined if the insulation resistance of the condenser is known. The value of this quantity R_l which should be used in equation (1) should be determined by measurement with a direct-current voltage of the value V_c under which the condenser will be operating. The reason for this statement is that, with most dielectrics used in commercial condensers the *apparent* value of R_l is by no means constant, but varies with the method of measurement. If the leak is a very serious one across terminal insulators, etc., there will not, as a rule, be such large changes as when the whole of the leakage takes place through the dielectric of the condenser. Some idea as to the extent of this variation may be seen from Fig. 2, which shows the apparent D.C. resistance of a condenser plotted against time as measured from the instant of first application of a charging voltage. Curves are also given in the diagram for different values of the applied charging voltage, as this effect of changing apparent resistance is not independent of the voltage.

The changes in resistance with time are due to the absorption of the charge by the dielectric—an absorption which not only shows itself in this way, but also by the residual charges which are given out by the dielectric after the condenser has been discharged. While the charge is soaking into the dielectric in this manner the current flowing into the condenser is really mainly made up of the charging current which is supplying these absorbed charges, and this current does not, therefore, accurately give

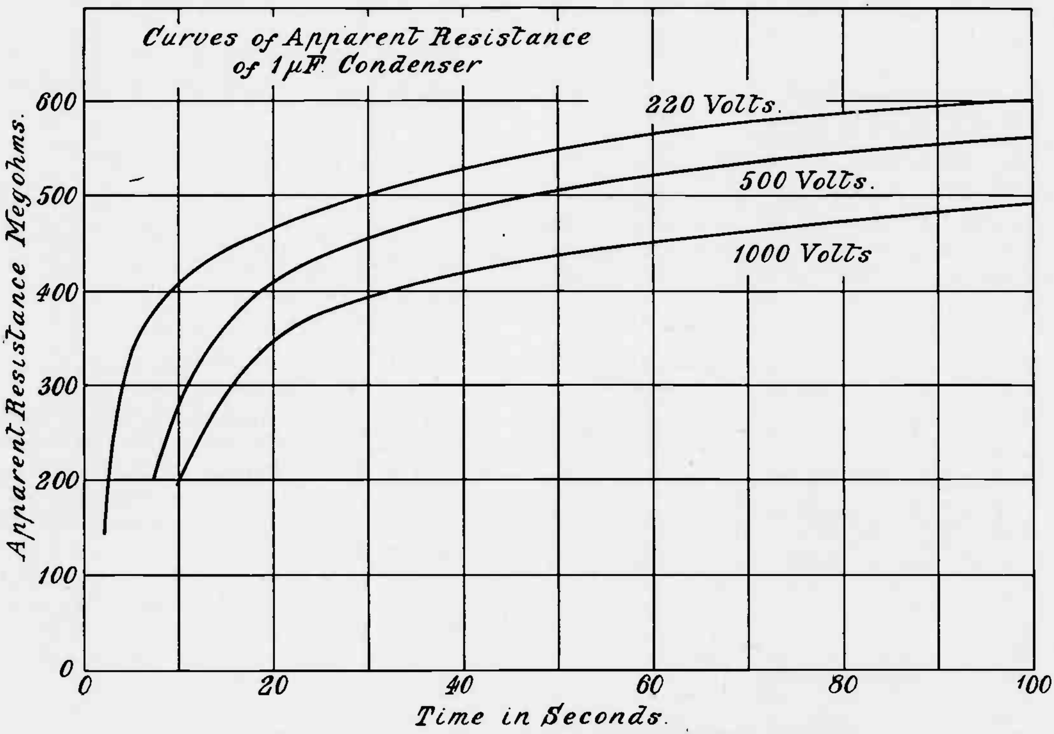

Fig. 2.—Illustrating the apparent resistance of a condenser plotted against time.

any indication of the true insulation resistance of the condenser.

This latter is the value that the apparent resistance takes up after an infinitely long charging period. Expressed otherwise, it is the asymptotic value of the apparent resistance curves of Fig. 2. It is frequently desirable to be able to specify some value of the apparent insulation resistance of a condenser which can be readily determined without the necessity of a very prolonged charging period, and consequently in many cases the apparent value of the insulation resistance after a charging period of one minute at a certain voltage is specified. Such a definition, while not, of course, giving the true insulation resistance, gives a figure which can be used for comparison purposes between a number of similar condensers.

In connection with determinations of insulation resistance by measuring the flow of current through the condenser under an impressed D.C. voltage on the lines indicated above, it is desirable to bear in mind the necessity for a truly steady voltage. Any fluctuation of voltage, such as may be due to commutator ripples in a generator supplying the circuit, may cause violent fluctuations in the reading of the microammeter or galvanometer which is used to measure the leakage current, due to the comparatively large currents flowing into or out of the condenser charging or discharging it in accordance with the voltage fluctuations. Such effects may entirely mask the readings which it is desired to obtain. For a similar reason readings taken with an ordinary "megger" are usually quite unreliable on account of fluctuations of voltage from the generator.

In actual practice, when a condenser is used for smoothing out the ripples from a rectifying valve circuit for feeding a valve transmitter, the load put upon the smoothing condenser by the oscillator valves prevents the condenser from being charged up to the full no-load voltage, and consequently there is a pulsation of voltage at the condenser terminals. This state of affairs entails additional losses, as compared with what has already been considered. In the first place, the charging time during each pulsation of the charging voltage is small, so that the effective D.C. leakage loss is increased due to the apparent decrease of insulation resistance caused thereby. This D.C. leakage loss may thus be regarded as made up of two parts, the first being the steady D.C. leakage loss due to the portion of the rectified voltage which does not pulsate, and the second due to the similar loss arising through the short charging period during each pulsation of the total voltage. Reference to Fig. 3 may make this clearer. In this diagram the sine curve AA is intended to represent the applied voltage, while the curve B, C, D, E, F is the curve of voltage across the condenser terminals assuming single-wave rectification. This latter curve rises during the periods B, C and D, E, during which the condenser is being recharged by the supply at a greater rate than it is being discharged by the load circuit of the oscillator valves.

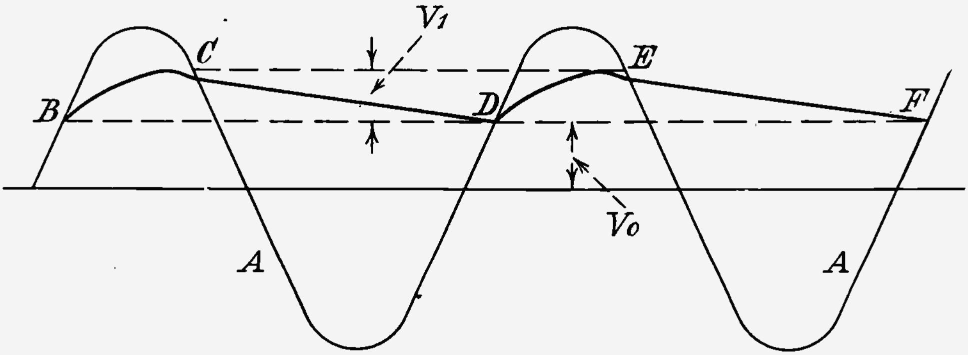

Fig. 3.—Illustrating the condition of a condenser when a sine wave voltage is applied across it.

During the periods C, D and E, F the condenser is not being charged by the supply circuit, but its potential is falling under the steady discharge of the load circuit. Thus the condenser voltage curve can be regarded as made up of two parts, a steady part of value V_0 and a pulsating part V_1. Hence we may also look upon the D.C. energy loss in the condenser as made up of two parts: the first V_0/R_{l_0}, where R_{l_0} is the true D.C. insulation resistance of the condenser under steady applied voltage V_0, in the sense that has been defined in this article; and the second $V_1^2/4R_{l_1}$, where R_{l_1} is the apparent insulation resistance of the condenser under applied voltage $V_1/2$ for a short time of application of the voltage represented by the period of the A.C. supply, and $V_1/2$ is the mean voltage during this period. This second quantity is one which it is, perhaps, easier to measure than to define, as the determination of R_{l_1} is likely to prove a difficult experimental feat. The effective energy loss could more readily be determined by difference between the total loss and that due to V_0^2/R_{l_t}.

Unfortunately, however, this is not the end of the story, as the determination of this portion of the energy loss by difference, as just indicated, would be likely to give a false value to this quantity, for the reason that other sources of energy loss might be included. Thus, for instance, it is possible to look upon this extra loss in other ways, and to consider it as partly due to the energy loss consequent upon the soaking in and out of the absorbed charges. The cause of the absorption effects which have here been discussed may be looked upon as the charging up of particles of the dielectric material (particles possibly of molecular dimensions) in the interior of the mass of the dielectric, the charges having to filter their way through the molecules of the dielectric in this process. This conduction of the charges into the interior entails an energy loss due to the flow of the charging current through the resistance of the body of the dielectric. As we have seen from the curves in Fig. 2, the magnitude of these charging currents may be much greater than that of the final steady currents through the dielectric, and in consequence the actual energy loss due to them may be correspondingly greater. This may be clearer from Fig. 4, which expresses similar measurements to those plotted in Fig. 2, but in this case given in terms of the current flow through the condenser dielectric.

The magnitude of this source of energy loss will evidently depend upon the frequency of the pulsations of voltage applied to the condenser, for each time the condenser is charged and discharged these absorption charge currents must flow into and out of the dielectric. Hence, on this basis, this loss will increase approximately in proportion to the frequency. As the frequency is raised, however, another effect begins to come into play. We have seen that this absorption of the charges is a process requiring time, and therefore it follows that if the actual charging period is very short (as must necessarily be the case if the frequency of the charges and discharges becomes large) less charge will be absorbed than would be the case for longer charging times.

At ordinary commercial supply circuit frequencies this reduction of the absorption effect does not seem to be very pronounced, but there is evidence indicating that for the higher frequencies there is a marked reduction in the absorption, so much so that the reduction of absorption may overtake the increase of loss due to the higher frequency, with the result that there is a nett *reduction of loss* at very high frequencies. The experimental difficulties surrounding measurements of this nature render an exact determination of these changes by no means easy, but at least in the case of some materials which show considerable absorption losses at comparatively low frequencies (in the neighbourhood of 1,000 ∽) there is certainly much less loss due to this cause when they are subjected to radio-frequency voltage pulsations.

This effect may perhaps more simply be expressed by saying that at radio frequencies there is *no time* for the charges to soak into the material, with the result that, under these conditions, the materials behave as much more perfect dielectrics. Whether these results are truly general for all dielectrics, or are confined to a few only, can only be settled by exhaustive experimental investigations.

Still another effect needs consideration if the voltage pulsation (V_1 in Fig. 3) is of any considerable amplitude on a condenser used for smoothing purposes with a valve rectifier. This is the A.C. energy loss in the condenser dielectric due to the voltage pulsations. The

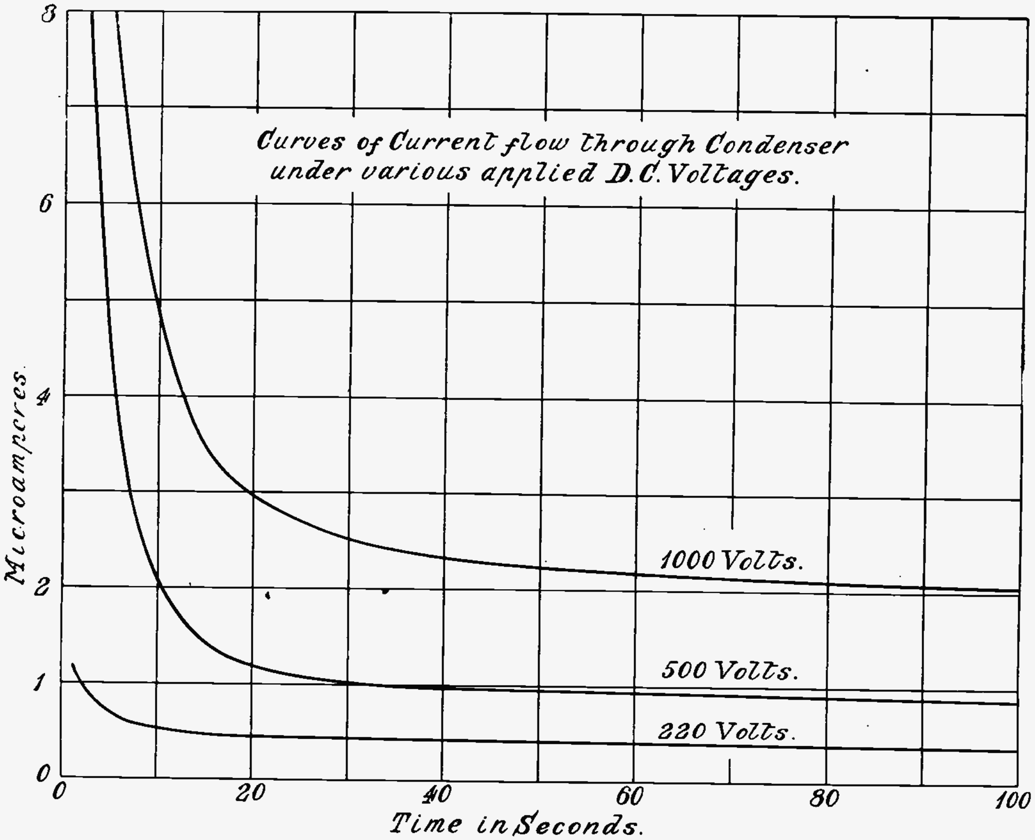

Fig. 4.—Showing how the current through a condenser at various voltages varies with the time.

application of an E.M.F. between the plates of a condenser implies that the condenser dielectric is subjected to a mechanical strain as well as to an electrical one. This strain will be of an alternating or pulsating nature, depending upon the type of potential variations to which the condenser is subjected. In a condenser built up of a stack of alternate sheets of tinfoil and paper fastened together with a suitable binding, such as of tape, it is quite possible to obtain audible evidence of these mechanical strains. By applying an alternating E.M.F. to such a condenser the varying attractions and repulsions between the condenser plates set up an actual mechanical vibration of the electrode plates, which will give rise to a sound if the A.C. frequency is a suitable one. Such mechanical stressing of the dielectric and mechanical vibration of the electrode plates entails the expenditure of energy, which, since it is drawn from the electrical circuit in which the condenser is connected, represents another source of energy loss in the condenser.

In a properly designed condenser this loss should be a very small one, but its magnitude will depend very greatly upon the nature of the material used for the dielectric, and upon the method employed for the construction of the condenser.

To summarise, then, the main energy loss in a condenser used for D.C. smoothing purposes may be regarded as made up of three parts :—

(1) The leakage loss W_l, which may itself be resolved into two components—

$$W_l = V_0^2/R_{l_0} + V_1^2/4R_{l_1} \quad \text{.....................} \quad (1a)$$

(2) The absorption loss W_a, which may be written—

$$W_a = V f(n) \quad \text{.......................................} \quad (2)$$

(3) The vibration loss due to voltage pulsation—

$$W' = f_v\ (V_1^2 n) \quad \text{..} \quad (3)$$

So that we may therefore write—

$$W_{d.c.} = W_l + W_a + W_v \quad \text{.....................} \quad (4)$$

The exact type of the functions expressed by f and f' will vary with different dielectrics, and probably also with the numerical magnitude of the frequency, as has already been indicated. The vibration loss W_v has been put down as a function of V_1^2 (where V_1 is the applied pulsating voltage), since the mechanical attraction between the oppositely charged plates will thus vary with the voltage between them.

In a badly constructed condenser there may also be some small additional loss due to the flow of the charging currents through the conducting plates themselves, but this loss should be negligible in a condenser used solely for smoothing purposes. It may become serious in some cases when the condenser is carrying considerable high-frequency currents, but this case will be considered in a later section.

(To be continued.)

Artificial Aerials.

MANY applicants for transmitting licences have received from the P.M.G. authority to transmit on a non-radiating artificial aerial circuit, and consequently a few notes on artificial aerial working will no doubt be of interest. The artificial aerial is defined as a closed non-earthed oscillatory circuit containing inductance, capacity and resistance. Now many amateurs say on receiving such a licence that this is not any use to them. However, if any experimental work is really intended, a great deal can be done. I consider that my own most useful work has been accomplished with an artificial aerial, and many others will agree that they find it of equal use.

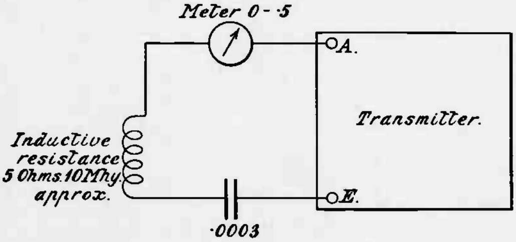

Fig. 1—Showing the connections of the artificial aerials to the transmitter.

The artificial aerial is so called because it is a closed circuit which is intended to shunt the aerial earth terminals of the transmitter, thereby replacing the aerial earth system. It is meant to have just the same characteristics as an outside aerial, so that on replacing one by the other the operation of the transmitter is not interfered with in any way. The usual amateur aerial constants are approximately as follows:—Capacity ·0003 mfd., resistance, say 10 ohms, inductance 10 mhys. These figures of course really only apply to one particular wave length, but serve as a guide for a suitable circuit. If a ·5 amp. max. aerial current meter (hot-wire) is used we have in this a resistance of say, 5 ohms. The other 5 or so ohms can be made of about No. 30 S.W.G. Eureka on a 2-in. former, which will provide a small inductance to suit the conditions. The condenser should be as good a one as possible. Two or three large copper or brass plates carefully air-spaced and made nearly self-supporting, so that little insulation is needed, will be found very satisfactory. These three components are connected in series all across the transmitter output terminals. The transmitter is then adjusted in the normal way as if the usual aerial and earth system were connected to the transmitter. The efficiency of the set can be found as the resistance of the artificial circuit is known and also the current in it (see EXPERIMENTAL WIRELESS No. 1, Efficient Transmission).

By using such a circuit as this a great deal of useful information may be obtained, and I hope that many will now conduct some of their testing on artificial circuits so as to leave a clearer ether for others who have experiments which of necessity have to be carried out on a radiating aerial.

"2 SH."

The Design and Construction of Filters.

By FREDERIC L. HOGG (2SH).

The design of a smoothing circuit seems to be a subject which presents considerable difficulty when the frequency is rather low. Many amateur experimenters spoil their telephony by generator hum, and it is hoped that the following article will help in the solution of the problem.

IN radiophone transmitters it is essential that the anode voltage supply should be perfectly pure D.C. Now, when this supply is obtained from a D.C. generator or from rectified A.C. there is a considerable ripple on the steady D.C. voltage which completely spoils any telephony. The usual procedure in amateur stations is to grab hold of half a dozen old spark coils and Mansbridge condensers and hope for the best. Needless to say, the best is usually the worst. It would not be far out to say that there are probably not more than half a dozen amateurs using A.C. for their 'phone sets whose smoothing is absolutely perfect in this country. In this article it is proposed to deal with the design and construction of wave filters from the amateurs' standpoint.

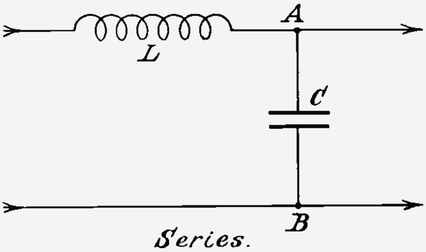

Fig. 1(a)—A series resonant circuit.

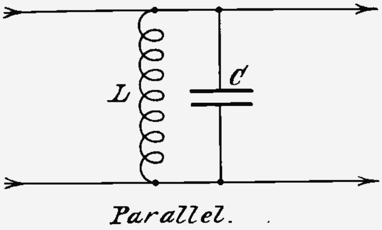

Fig. 1(b)—A parallel resonant circuit.

An electric filter is an apparatus which enables us to separate into its various parts an electric current made up of a combination of different frequencies. For instance, a small condenser of, say, ·001 mfd. will discriminate between a radio-frequency current of 1,500,000 ∽ and a speech frequency of 800 ∽. The action of an inductance is the reverse. The simplest practical filter is a resonant circuit across the supply, either series or parallel (see Fig. 1). If we apply an A.C. voltage to one of these circuits, and vary the frequency, we find that in the series circuit the current will increase as we increase the frequency up to a certain point, and then will fall off again on further increase (see Fig. 2). The impedance or effective resistance is shown also in Fig. 2. It will be seen that the impedance and current are respectively at minimum and maximum at a certain point. This is called the resonance point. For a parallel circuit we get just the reverse of

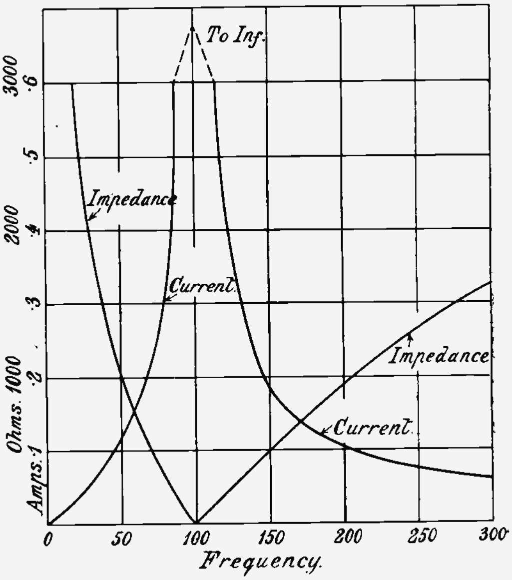

Fig. 2—Illustrating the relation between current and frequency applied to a series circuit.

what a series circuit gives us. In these cases we have assumed that the filter is of infinitely low resistance. We will now investigate the case when the filter contains a resistance, or, in other words, has a load taken from it. Let us consider, again, the series circuit. We take our load across A, B. The effects of various loads are shown in the diagram (Fig. 3). From elementary A.C. theory the voltage across the condenser will be :—

$$e = \frac{E}{\sqrt{\left[1-(2\pi f)^2 LC\right] + \left[\frac{2\pi f L}{R}\right]^2}}.$$

Where E is the supply voltage, f its frequency, and L, C and R the constants of the circuit.

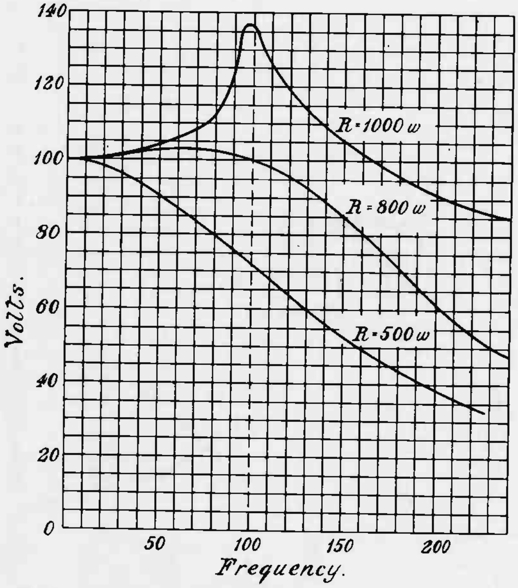

Fig. 3—Illustrating the effect of various loads applied to a series filter.

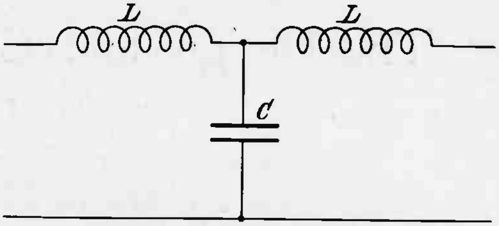

Fig. 4—An inductance is connected in series with the load.

In the diagram the curves have been worked out for E=100 volts, L=1 henry, C=1 mfd., and R 1,000, 800 and 500 ohms. It will be seen that any filter works best for a particular load. This difficulty, however, does not arise very much in practice, except when a small filter is overloaded. However, it must not be overlooked in building a filter. Now, it will be seen that this series circuit will transmit current below a certain frequency, and above this frequency the current rapidly diminishes, or, rather, the circuit increases in resistance and so cuts down the current. This type of circuit is known as a "low-pass" filter. It will be obvious that if we put the load across the inductance we should get the reverse effect, and this is really, in effect, a parallel circuit. This type is known as a "high-pass" filter.

The simple series circuit mentioned above does not give a very sharp separation of frequencies. This can be improved considerably by inserting an inductance in series with the load. This is called a T section (Fig. 4). If we were to re-draw Fig. 3 for this section we should find that the cut-off would be very much sharper, and that it would be moved to 141 ∽ ($100 \times \sqrt{2}$). Also for heavy loads it would be found that the voltage first falls and then rises again to normal at the cut-off frequency, falling once more as the frequency rises. Note that the two inductances have the same values. In all types of filters the inductances or condensers should all be of the same size except the end sections, which should

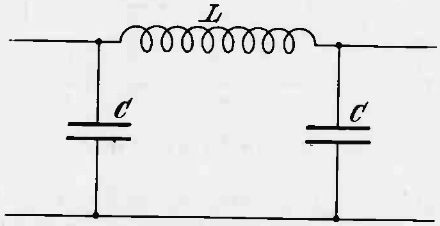

Fig. 5—The "π" type of filter.

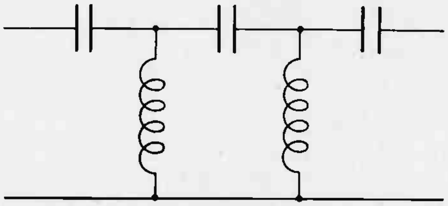

Fig. 6—A "high pass" filter circuit.

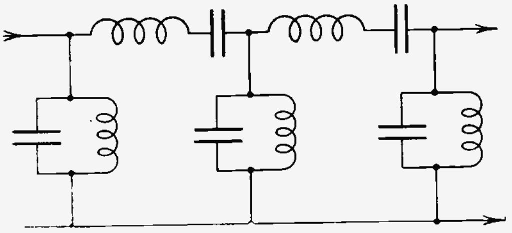

Fig. 7—A "band-pass" filter circuit.

be of half the capacity or inductance as the case may be. The reason for this is fairly obvious. The addition of further sections to the filter will have the effect of sharpening the cut-off and increasing the number of maxima and minima in the portion of the curve before the cut-off frequency.

Another type of section is the π. This is shown in Fig. 5. The same remarks apply here. Now, we can build either a filter which will pass all below a certain frequency, and, under the same conditions, one which will have the reverse effect. Now, if we insert a low-pass filter in our line, cutting off at, say, 200 ∽, and follow this up by a high-pass filter with a cut off of 100 ∽, we should get what is known as a band-pass filter, passing all frequencies between 100 and 200 ∽, and by reversing the cut-off frequencies we get a filter of the band elimination type between 100 and 200 ∽. However, as we are only interested in the low-pass type, no further mention of the others will be made. Figs. 6, 7 and 8 show complete high-pass band-pass and band-elimination filters respectively.

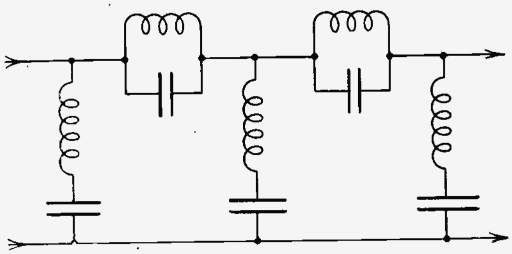

Fig. 8—A "band-elimination" filter circuit.

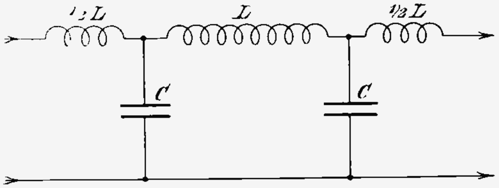

Fig. 9—A two-section T type filter.

To get to the more particular design of low-pass filters, the simple T and π types dealt with above will give us a fairly gradual cut-off, but the attenuation increases with the frequency, *i.e.*, they become better and better as filters. Now, by inserting resonant circuits in series with or across the line we can make our filter give us a very sharp cut-off, but the attenuation will decrease as the frequency rises. Thus we could make a filter of this type to cut off at 100 ∽ and give maximum attenuation at 120 ∽ for some special purpose. The calculations in the design are rather complicated, and would be of little use, so will not be given here. Figs. 9 and 10 show two-section T and π filters giving distribution of inductance L and capacity C.

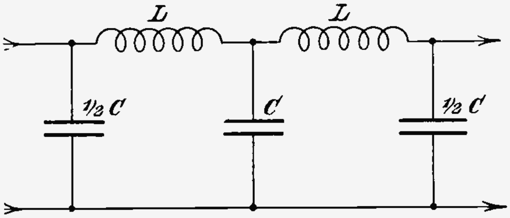

Fig. 10—A two section π type filter.

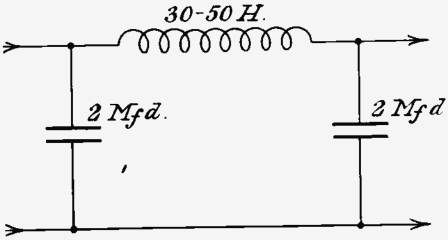

Fig. 11—A practical filter for 50 cycles.

To find L and C for any particular set of conditions, if Z is the resistance of the load in ohms, and w is 2π times the cut-off frequency—

$$L = \frac{2Z}{w} \quad \text{and} \quad C = \frac{2}{wZ}$$

Z would be the effective internal resistance of the valve in the cases we are considering, or the total resistance of one or more in parallel. This would be given by $\frac{\text{anode volts}}{\text{anode current}}$ when actually working, and not the steady internal resistance value, as the valve is oscillating and is transferring energy to the aerial circuit. In designing a filter for an experimental set the filter should be of generous dimensions, as a large filter on low power is better than a small filter on high power.

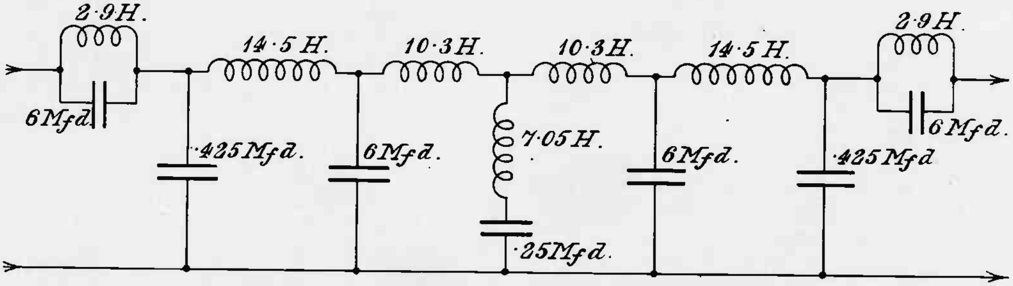

Fig. 12—Illustrating the arrangement of a correctly designed filter circuit for 50 cycles.

In our case, when we are dealing principally with rectified A.C., we can take our wave form as consisting of a large number of harmonics, or we can consider it as wave in which there are gaps to be filled in! In the first case a certain amount of brain is used, whereas in the second we get D.C. because the A.C. cannot help itself when we put huge capacities and inductances in. A filter for 50 ∽ A.C. should be designed to cut-off at about 20 ∽. It will be found, unfortunately or fortunately, whichever way you look at it, that dealing with the irregular wave forms which we get the "brutal" method is best, though a judicious combination of both helps. For an average set Fig. 11 gives an excellent filter. Fig. 12 gives a most excellent design, but works not quite so well as Fig. 11! An improvement can be made by inserting a few tuned traps, and a filter such as Fig. 13 will really filter and give almost perfect D.C. under the most stringent tests. Values are shown against the various components.

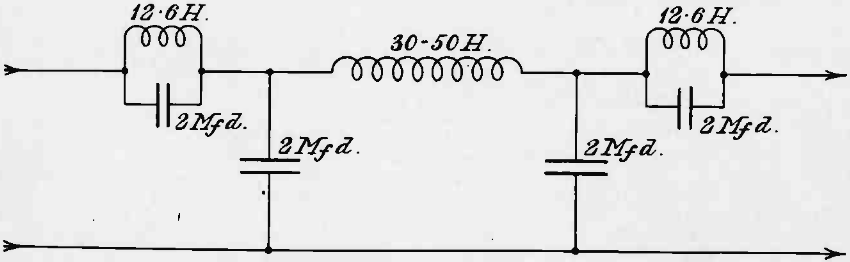

Fig. 13—A resultant filter which is a modification of Figs. 11 and 12, two tuned traps being inserted.

The average amateur will say, perhaps, that he has already 50 to 100 henries for his filter. But, unfortunately, iron core chokes must be designed just as much as anything else. First of all, a closed core choke must not be used. A closed core fosters the harmonics and often does more harm than good. Also if care is not taken the steady D.C. current present will saturate the core. The choke should be made with a small air gap and sufficient iron to ensure that it is never near saturation. A good transformer iron, preferably stalloy, about ·015 in. thick, should be used. Fig. 14 shows type of core and windings. All the wire should be placed on one limb, and the two ends should be butt-jointed instead of lapped. The other limb must be adjustable and rigidly fixable in any position. The table gives sizes of core (square) and other details for various currents and inductances:

"X" and "Y" are the actual dimensions of space occupied by wire. ¼ in. or more space must be left for cheeks, according to

Current amp.	Henries.	Air Gap. in.	Turns.	S.W.G.	X. in.	Y. in.	Core. in.	Volt Drop.
·05	1	1/64	2,300	36	·5	·33	½×½	7
·05	5	1/40	3,500		·62	·42	¾×¾	14
·05	10	1/32	3,800		·64	·43	1×1	18
·05	20	3/64	5,700		·78	·52	1×1	29
·05	50	7/64	11,000		1·10	·75	1×1	64
·05	100	¼	8,900		·97	·65	2×2	76
·1	1	1/50	1,500	33	·53	·37	¾×¾	6
·1	5	1/40	2,600		·71	·49	1×1	14
·1	10	1/32	1,900		·60	·42	2×2	16
·1	20	3/64	2,900		·75	·51	2×2	26
·1	50	7/64	5,300		1·00	·70	2×2	50
·1	100	⅙	8,900		1·33	·90	2×2	90
·25	1	1/50	1,100	27	·75	·5	1×1	6
·25	5	¼	1,300		·82	·53	2×2	10
·25	10	5/16	1,300		·82	·53	3×3	16
·25	20	3/64	1,900		1·00	·65	3×3	24
·25	50	1/3	5,000		1·60	1·1	3×3	70
·25	100	19/32	8,400		2·1	1·4	3×3	120

size, so that the length of longer laminations will be X+(depth of core)+¼ to ½ in. space for cheeks. Enamelled wire is quite suitable, but the winding must be well insulated from the core. On the larger sizes a layer of waxed paper should be placed over every few layers. The inductance can be varied by adjusting the air gap or by changing the number of turns. It must be borne in mind that the inductance will vary approximately as the square of the number of turns. The air-gap figures are meant merely to indicate the order of magnitude of the gap. It should be varied for best results. A good method of testing is to put a loud speaker in series with a good ·001 condenser across the output on load and to vary chokes, etc., till hum is least. Don't use a pair of 'phones and wear them. If you use 1,500 volts or so a shock on the head is unpleasant, to say the least of it; and if you use 2,500 volts or so your filter will be no use to you, however good it is, because you would probably be dead! Care must be taken to clamp the iron core choke very tightly so that the air gap cannot alter. Considerable force exists in such a choke. When choke control is used for telephony it is best to use another choke in the positive lead apart from the usual filter chokes. The size of choke necessary is given by—

$$L = \frac{E}{2\pi f I},$$

where E=anode volts,
I=anode current,
f=mean speech frequency,
=800 ∽,

though usually about 10–20 henries is found sufficient for all-round purposes. This can be designed from the tables given above.

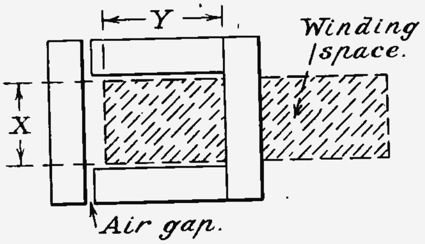

Fig. 14—Constructional details of a smoothing choke.

In this short article it has only been possible to touch on a few points of the subject, but I hope sufficient information will be found herein to enable anyone to get rid of any ripple in his plate supply. If but one of the stations who appear to do telephony on raw A.C. is cured of trouble I am satisfied!

The Construction and Manipulation of Wavemeters.

Readers may have noticed that in Fig. 7, Page 74, showing the wiring lay-out of a heterodyne wavemeter, the positive and negative poles of the high tension battery were shown reversed. This point should be remembered when making the instrument.

Notes on High Tension Electrolytic Rectifiers.

B. E. H. ROBINSON (2VW).

As the chemical rectifier is now used for obtaining the high anode voltage for transmission purposes by many experimenters, it is thought that the following notes by one who was the first to develop it in these directions will be of considerable value.

IN an issue of the *Wireless World and Radio Review* last December the writer described an aluminium electrolytic rectifier suitable for rectifying high-voltage currents to produce D.C. suitable for valve transmitters. Since then a number of inquiries for further details have been received concerning the construction and working of such rectifiers and in view of the fact that many experimenters are now adopting this method of obtaining their H.T. supply the following notes may be found useful.

Suitable A.C. Frequency.

In the first place it should be noted that the electrolytic rectifier is only suitable to work on an alternating current supply whose periodicity does not exceed about 120 cycles per second. A certain amount of rectification may be obtained on periodicities up to 200, but not much higher, as the rectification becomes extremely poor. Electrolytic rectifiers cannot be used with 500 cycle supplies such as are obtained from some Disposals Board alternators. Similarly there is no hope of using electrolytic rectifiers with a T.V.T. unit, as such units give an unsuitable wave form at too high a frequency.

Electrolytic rectifiers work best on sinusoidal A.C. at the usual commercial frequencies between 50 and 90 cycles per second. On these low frequencies very good results may be obtained at quite a favourable overall efficiency.

Electrodes.

For the cathodes of the rectifier cells aluminium is almost invariably used, and as it is at the surface of the aluminium that all the rectification takes place, too much attention cannot be given to the proper design and maintenance of these aluminium electrodes. In the original Nodon valve the aluminium was alloyed with a certain amount of zinc or other metal, but ordinary commercial sheet aluminium is quite suitable provided that it is properly cleaned. It is a good plan thoroughly to clean the surface of the aluminium electrodes the last thing before mounting them *in situ* in the rectifier cells. This may be done by immersing them in a solution of caustic soda for about ten minutes or until the surfaces are slightly but uniformly corroded; they are rinsed free from caustic soda, drained and immersed in strong nitric acid for a few minutes. Nitric acid attacks practically all impurities, but not the aluminium, so that after a second thorough rinsing in clean water the aluminium should have a matt silvery-white appearance.

The actual metal used as anode in the cells is not very important as its only function is to make contact with the electrolyte and takes no part in the rectifying action. The only important thing is that the anode should not be attacked by the electrolyte. The most common substances used are iron, carbon, tin and lead, the latter being the best from practical considerations. Iron shows a tendency to slow corrosion when ammonium salts are used for the solution, whereas lead is absolutely permanent. In use a brown deposit of lead peroxide forms on the surface of the lead, but this does not appear to be in any way detrimental.

The Electrolyte.

The choice of electrolyte is one of the most important factors. A number of neutral salts give solutions in which an aluminium electrode shows a rectifying action to a greater or less extent, but only a few salts combine efficient rectification with clean working. Of these, pure ammonium phosphate is one of the most readily procurable and, in the writer's experience, the most efficient. Sodium phosphate is considerably cheaper and gives fair results, but is distinctly inferior to the ammonium salt. When the ammonium phosphate is used care should be taken that the solution does not give acid reaction ; it should be neutral, or, if anything, very slightly alkaline. The cheaper commercial grades of ammonium phosphate are apt sometimes to be rather strongly acid. It is therefore advisable to buy the pure phosphate if the extra expense is not objected to. Even the latter is sometimes strongly enough acid to turn a piece of blue litmus paper red, and when this is found to be the case the solution should be rendered neutral before using. This may be done by adding either some strong ammonia solution (sp. gr. ·880), or a half-saturated solution of sodium phosphate, and stirring until the phosphate solution will just turn a piece of red litmus paper blue. If the neutralising is done with sodium phosphate the solution obtained will, of course, contain a mixture of the two phosphates, but this is found to work quite well.

With regard to the strength of solution the writer recommends that whichever salt is used as electrolyte the solution should be half or three-quarters saturated. The frequent practice of using a fully saturated solution is not to be recommended because as soon as a little of the water in the solution evaporates some of the dissolved salt crystallises out, the crystals not infrequently forming on the aluminium surfaces, thereby causing leakage and spoiling the rectifying properties of the surface. Also a saturated solution seems to favour the formation of sludge and colloidal aluminium hydroxide more than a weaker solution does.

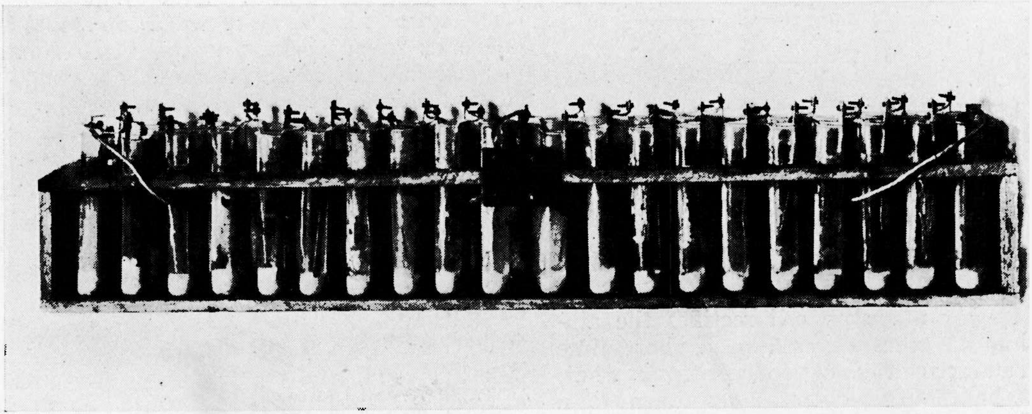

Fig. 1.—An electrolytic rectifier, employing the connections shown in Fig. 3, capable of delivering 50 milliamps. at 1,000 volts of ful. cycle rectified D.C. The small quantity of sediment which forms at the bottom of the cells does not matter as long as it does not reach the aluminium strips.

The following data about sodium and ammonium phosphates are useful when solutions are being made up.

AMMONIUM PHOSPHATE.

Chemical formula of the salt manufactured commercially $(NH_4)_2HPO_4$.

Solubility :—One part in four parts of water (by weight).

Weight of ammonium phosphate required for half-saturated solution is

125 gms. per litre of water, or

2½ ounces per pint (very nearly).

SODIUM PHOSPHATE.

Formula of commercially manufactured salt $Na_3PO_4.12H_2O$.

Solubility one part in five parts of water (by weight).

Weight of sodium phosphate crystals to make a half-saturated solution—

100 gms. per litre of water, or

2 ounces per pint.

In comparing the performance of sodium and ammonium phosphates it is interesting to note that sodium phosphate becomes strongly alkaline after continued use whereas ammonium phosphate tends to lose ammonia and become acid. Partially used sodium phosphate is found often to contain free caustic soda, which accounts for the fact that the rectification degenerates and the aluminium becomes corroded when this salt is used. This does not seem to happen with ammonium phosphate.

Other electrolytes than the two mentioned above may be used, but none seem to surpass ammonium phosphate. Sodium bicarbonate and borax are two commonly recommended substitutes. Borax, in particular, is frequently recommended in American periodicals for high-tension rectifiers, but the writer has tried it several times and found it hopeless. In the first place, boron is only sparingly soluble in water and forms a comparatively poorly conducting solution. Secondly, the rectification is not particularly good and the borax tends to crystallise out on to the aluminium electrodes. Even if the freshly made up cell rectifies the aluminium becomes covered in a short time with an incrustation of goodness knows what, and the rectified output goes down to a negligible quantity. Similar remarks apply of sodium bicarbonate.

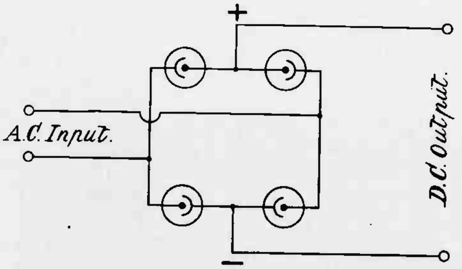

Fig. 2.—Showing the Gratz connections for full-cycle rectification.

Voltages and Currents Allowable.

If a rectifier cell is connected in series with an ammeter across a source of direct current quite a large current will be registered when the supply is connected so as to make the current pass from lead to aluminium. On reversing cell, however, so as to make the current pass from aluminium to lead only a very small current flows. This reverse current may be only a few milliamperes when the voltage of the D.C. source does not exceed about 150 volts. If the applied voltage is raised much above 200 the insulating film which is formed on the submerged surface of the aluminium begins to break down, the cell heats up and passes a large current. A very good cell may hold up against 240 volts of reverse e.m.f. for quite a considerable period. For rectifying 50 or 60 cycles A.C. such high voltage should not be allowed per cell. A good working basis is to allow 100 volts per cell of A.C. That is, if we wish to rectify 1,000 volts (R.M.S.) A.C. input with the four-group (Gratz) connections we should have ten cells in each group to sub-divide the potential strain. As a matter of fact it has been found that when in good condition rectifier cells will often work quite happily at 120 to 140 volts apiece without unduly large back currents occurring. The higher the voltage that can be allowed per cell the less will be the total number of cells required and the higher will be the overall efficiency of the rectifier, provided always that heating and excessive reverse currents are not set up. Owing to the fact that aluminium electrolytic rectifiers show a maximum efficiency when working at about 100 volts per cell they are more satisfactory for high-tension low current work than for large currents at only a few volts as in accumulator charging. Thus the fact that the rectifier has rather fallen into discredit for battery charging should not unduly bias our opinion when judging it for H.T. purposes.

The size of the aluminium electrodes should be properly proportioned to the current which is to be rectified. If the surface area is too big the current density will be small and the electrodes will not polarise rapidly enough to keep out reverse currents. An analogy may be drawn with a pump whose valves are too sluggish to act if the plunger is moved too gently. If, on the other hand, the surface area is too small the resistance of the cell in the right direction will be too high and sufficient output will not be obtained. The correct current density is about 5 milliamps. per square centimetre of submerged aluminium surface; this includes both back and front surfaces in the case of flat strips or plates. For rectifiers to deal with very small currents such as are wanted for receiving H.T. supply or for transmission on powers below 5 watts aluminium wire of about No. 14 gauge may be used with satisfactory results. For powers of 10 watts or over it is more satisfactory to use strip electrodes cut from aluminium and lead sheets. The aluminium should be as thick as can be conveniently cut with a pair of metal shears. Aluminium and lead strips may be connected together in pairs by drilling or punching holes at their upper ends and clamping with small bolts and nuts. Fig. 1 clearly illustrates the method of assembly. As at two points (output) there are lead-to-lead and aluminium-to-aluminium connections extra long strips of lead and aluminium are bent over to may the two adjacent electrodes without the necessity of clamping two separate pieces together.

The rectifier shown in the diagram will readily deliver 50 milliamps. of D.C. (full cycle rectification) at a voltage of 900 to 1,000, this being much more than is required by the 10-watt transmitter.

When heating occurs the hot electrolyte rises to the surface and it is just where the aluminium enters the solution that the most rapid corrosion occurs ; bad electrical leakage frequently occurs here also. This trouble is often met by sheathing the aluminium with a piece of tightly-fitting rubber tubing over the parts which extend above and about half-an-inch immediately below the surface of the solution. It is simpler, however, to float about an inch of paraffin oil on the surface of the solution. The writer has always found this effective, and it serves materially to prevent " creeping " and evaporation.

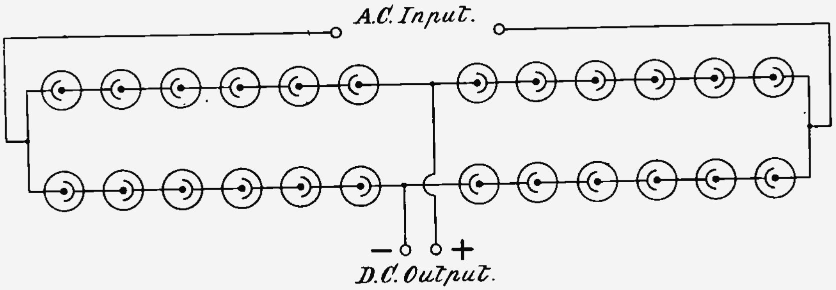

Fig. 3.—Showing how the old Gratz connections are modified to handle voltages above 100. Allow one cell for every 100 volts in each of the four groups.

One of the chief limitations of the load which may be put on to such a rectifier is the heating up of the electrolyte. The only simple practical remedy is to make the cells of ample size so that the bulk of liquid is too great to allow any serious rise in temperature at the normal working current. On no account should the temperature be allowed to exceed 40° C. as the rectification is very poor above this temperature and there is a marked tendency for the aluminium to be corroded, with the consequent formation of a precipitate of aluminium hydroxide. The rectifier shown in the photograph employs large test tubes (" boiling tubes "), 6 inches long by 1 inch diameter, which are filled within an inch of the top with half-saturated ammonium phosphate solution. The cells get just slightly warm when run on a load of 40 milliamps. for about half an hour. On smaller loads the rectifier may be run indefinitely. Very small rectifiers to handle a few milliamps. for reception purposes may be quite satisfactorily made up in the ordinary ⅝" × 5½" test-tubes.

" Forming " the Electrodes.

A freshly made up electrolytic rectifier seldom rectifies immediately the A.C. input is first applied, but the cells may for a time pass a heavy current in both directions. It seems as if some " forming " process with the aluminium electrodes is necessary before the proper rectifying action sets in. For this reason it is not advisable to put a new rectifier straight across the full high-tension voltage, but the voltage should be cut down to begin with or a safety resistance inserted in series with the supply. Usually a rectifier forms nearly completely after the current has been passing for about a quarter of an hour, after which period full voltage may be applied. Sometimes, however, the rectifier proves more refractory and a more drastic method of gingering up the cells must be resorted to. The following plan is very effective where 200-volt D.C. mains are available. Each cell in turn is connected in series with a high-consumption lamp (about 1 amp. normal rating) across the 200-volt D.C. mains with the aluminium electrode connected to the positive main lead. If, on switching on, the aluminium is not formed the lamp will light up and a relatively large current will pass through the cell. As the aluminium surface forms the current drops rapidly and the lamp goes out and if the cell is a good one the current will fall to a negligible value. If the cell is a dud the lamp will remain alight and the solution will get hot and if on several successive tests the cell still refuses to form it may be taken that either the solution is at fault or the aluminium requires chemically cleaning as described above. If only A.C. is available put two aluminiums in opposition in one cell and apply about 120 volts in series with a lamp; this tests two aluminiums at once. In the event of there being only a 220 A.C. supply available two test cells will have to be treated in series at a time.

If each cell has responded properly to this method of gingering up the rectifier as a whole should at once work satisfactorily off the normal high-tension A.C. supply.

Once a rectifier is properly formed it should work for weeks without further attention, provided that it is not unduly overloaded.

Sometimes it is found that a cell refuses to rectify owing to a grey or black deposit which forms on the surface of the aluminium. Strong nitric acid will usually clean this off without the previous use of caustic soda. Aluminium electrodes that are doing their work properly always have a very clean white appearance.

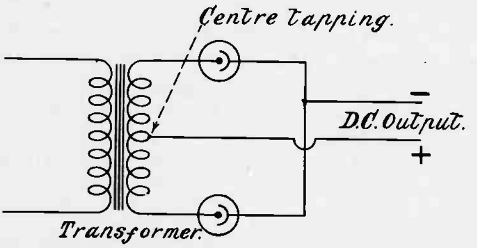

Fig. 4.—Connections for obtaining full-cycle rectification, using a centre-tapped transformer.

Indications of Correct Working.

If an electrolytic rectifier is viewed in the dark when connected across the H.T. transformer but with no load across the D.C. output a luminosity is seen on the submerged surfaces of the aluminiums. Under ideal circumstances this takes the form of a uniform glow, but more frequently it has a sparkling appearance not unlike a starry sky on a very clear night. This scintillation is no cause for great anxiety—it only shows that the cell is functioning well and is, perhaps, working near its voltage limit. It is the cells that show no luminosity in the dark that are the black sheep in the fold; in these either the solution is impure or the aluminium needs forming or cleaning. It not infrequently occurs that all the cells in a set are made up at the same time and under apparently identical conditions, yet after a short period of working some of the cells refuse to rectify while others work well. This is due, no doubt, to contamination on parts of the original sheet of aluminium from which the electrodes were cut, and the remedy has already been indicated.

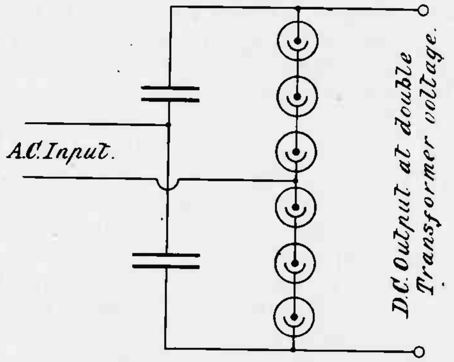

Fig. 5—Double condenser connections for full-cycle rectification. A doubling of voltage is obtained.

It is important that the bolts which hold adjacent strips together should be well away from the surface of the electrolyte.

Various Rectifier Connections.

It is always worth while to use full-cycle rectification in preference to half-cycle as a higher output is obtainable for a given transformer voltage and it is very much easier to smooth the D.C. output from a full-cycle rectifier. Half-cycle rectified 50-period A.C. gives a ripple frequency of 50, whereas full-cycle rectification gives a ripple frequency of 100. Other things being equal, the higher the ripple frequency the more easily is it smoothed out with chokes and condensers.

Fig. 2 shows the original four-cell or Gratz connections for full-cycle rectification as used for accumulator charging with large-capacity rectifier cells. Fig. 3 shows how these connections are modified for high-tension purposes by replacing each of the cells in Fig. 2 by a bank of cells in series. This system of connections is used in the rectifier shown in Fig. 1 and is very satisfactory for general purposes.

Fig. 4 shows the centre-tapped transformer arrangement which is well known and does not call for much comment. It is well to note, however, that although only half the number of cells is required to give the same voltage as the arrangement in Fig. 3, it has the practical disadvantage that a special transformer is needed with twice the number of turns required in the ordinary way. Thus if one is working on 1,000 volts each half of the transformer secondary in Fig. 4 must each give 1,000 volts, the total voltage between the outer ends being 2,000 volts. Thus not only is it necessary to use twice the amount of wire in the secondary, but it is necessary to insulate for 2,000 volts instead of 1,000. Readers who have attempted to make efficient H.T. transformers will agree that the task of getting well-insulated secondary into the small space available is one which does not admit of unnecessary magnification.

Fig. 5 is one of the most ingenious and convenient rectifier connections. The writer can thoroughly recommend it where it is possible to obtain a couple of condensers of at least 4 mfds. apiece which will stand the voltage. The arrangement not only gives full-cycle rectification, but doubles the transformer voltage. Also for a given D.C. output only one-quarter of the number of cells used in the Fig. 3 arrangement is required, thus reducing the labour involved in constructing the rectifier as well as reducing the space taken up by the apparatus. Actually the D.C. output voltage on no load will be nearly twice the peak voltage of the transformer or nearly 2·8 times the R.M.S. voltage. On load this will fall to a little over twice the R.M.S. transformer voltage, depending upon the capacity of the condensers and the efficiency of the rectifier cells. If one requires, say, D.C. at 1,000 volts with this arrangement only about 10 cells are required and the transformer secondary need only give 500 volts. The arrangement in Fig. 5 should be particularly useful to men who have 220-volt A.C. mains as it will give them nearly 500 volts D.C. without the use of any transformer at all. The bigger the two condensers are the better. 6 mfds. each is quite a good value, but if larger condensers are available so much the better.

In the event of any reader being fortunate enough to have a 3-phase supply the connections for a 3-phase rectifier is shown in Fig. 6. For simplicity each group is represented by one cell. The great advantage in a three-phase rectifier is that the D.C. output never falls to zero owing to the overlapping of the phases, so that without any smoothing arrangements at all there is always a steady continuous current component with only about 20 per cent. ripple. What ripple there is has a frequency of six times the supply frequency and is consequently very easily smoothed.

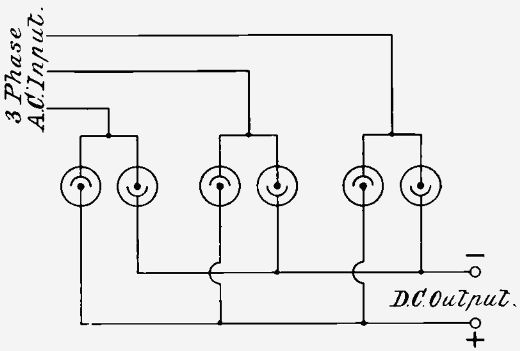

Fig. 6.—Scheme of connections for rectifying a 3-phase supply.

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St. Dunstan's Broadcast.

In connection with the St. Dunstan's Carol League, a selection of Christmas Carols will be simultaneously broadcast from 2LO between 8.30 and 9 p.m. on December 23 by four gentlemen from St. Paul's Cathedral Choir. St. Dunstan's wish to ask every reader of EXPERIMENTAL WIRELESS to arrange listening-in parties amongst their friends, at which they will make a collection on behalf of the funds which they so badly need. We have little doubt that readers will be only too willing to comply with the request, and special collecting envelopes may be obtained from St. Dunstan's Headquarters, Regent's Park, London, N.W.1.

The Heterodyne Reception of Short Continuous Waves.

BY CAPTAIN ST. CLAIR-FINLAY, B.Sc.E. (Laus.),
Late Chief Experimental Officer, Inter-Allied Research Commission, etc.

It appears that certain difficulty is experienced in the reception of weak short-wave signals. The following notes deal adequately with the subject, indicating how best to obtain efficient amplification without complicated circuits, and at the same time securing the minimum of interference.

IN view of the forthcoming Transatlantic Tests, for which it now behoves us seriously to consider the preparation of our stations, a few notes upon the subject of suitable receiving arrangements may serve as a "refresher," and may not be inopportune.

The essentials of a receiver suitable for such a purpose may be summed up briefly as follows :—

(1) High sensitivity ;
(2) Ease of searching and tuning ;
(3) Self-silence ; and
(4) Non-interference.

Selectivity being a matter of course, as will be shown, whilst the fourth will speedily become obvious when two or more stations in a given area commence searching for given signals with energised aerials.

In order to design and effectively operate such a receiver the principles and considerations underlying the beat reception of C.W. signals must be appreciated, and it is here proposed, firstly, to discuss these relative to the special object in view, and, secondly, to describe certain forms of circuit which fulfil in considerable degree the necessary requirements.

It is known, firstly, that this system of reception is based upon the fact that when waves of different frequencies are allowed to interact, a third or "beat" frequency results which will be equal to the difference between the originating frequencies and must be lower than either, thus :—

$$f_\beta = f' - f'' \text{ or } f'' - f'$$

where f' = frequency of incoming or received oscillations,
f'' = frequency of local or heterodyning oscillations,
f_β = frequency of resultant or beat oscillations,

so that, although the originating frequencies may themselves be far above the limits of audibility, a resultant beat of any desired audible frequency may be produced according to the difference given to the former.

It is also known that such resultant beats must be greater in amplitude than the lesser of the originating oscillations, and will, in fact, be equal to the sum of the latter, since—

$$I_\beta = (I'' + I') - (I'' - I') = 2I',$$

where I' = amplitude of incoming oscillations,
I'' = amplitude of local oscillations,
I_β = amplitude of resultant beats,

so that an amplification of the original signals amounting to $\frac{2}{1}$ results from the heterodyne effect quite independently of the amplifying action of the valve or other magnifier, and this ratio will hold good so long as the local oscillations are not inferior in amplitude to the incoming oscillations.

If, however, the latter are allowed to exceed the former a somewhat different state of affairs results, with very far-reaching effects. The production of beats, of course, remains unaltered, and the resultant amplification also remains unaltered, except in the important respect that, whereas in the former case it was the incoming oscillations that were amplified, it will now be the *local* oscillations that will be amplified, thus :—

$$I_\beta = (I' + I'') - (I' - I'') = 2I'',$$

with the result that the incoming signals may not now be amplified at all, but may, on the contrary, actually be limited by the heterodyne action, as would occur were they of more than twice the amplitude.

The consequence of this being manifestly a loss in amplification of the desired signals, the importance of making the local oscillations strong enough will be evident.

Neither is this by any means all. Let us reconsider the first case, where

$$I\beta=(I''+I')-(I''-I')=2I'.$$

Now, under these conditions the *selectivity* of the arrangement will be at a maximum, since $I\beta$ will depend entirely upon I' and not upon I'', so that the heterodyne amplification will be greatest under conditions of resonance (because I' will then be at its greatest), as will naturally apply to *desired* signals, and will fall off greatly as signals become detuned, as will apply to undesired signals unless these be of exactly the same frequency.

But now, if I'' be inferior to I', as in the second case, then the reverse condition

$$I\beta=(I'+I'')-(I'-I'')=2I''$$

obtains, which means that $I\beta$ is now entirely dependant upon I'' and not at all upon I', so that variations in I'—whether of desired or undesired signals—produce no effect upon resultant signal strength, and undesired signals, although mistuned and therefore relatively weak, will consequently be heard as strongly as the desired signals so long as their amplitude be not less than that of I'', selectivity which is normally so valuable a characteristic of heterodyne reception being thus to a great extent lost. (Actually, this selectivity will be at a maximum when $I''=I'$, since under these conditions the resultant amplitude of undesired signals—however great their initial amplitude—will be limited by I'' and cannot exceed $2I''$, which will only be the same as that of the desired signals, so that these will usually remain readably selectable to within a small fraction of a metre—on short waves—by separation of the respective beat-notes—this being of considerable importance when interference is experienced, for example, from high-power or local stations operating or producing harmonics at or near the same wave-length—whereas if I'' exceed I' these may greatly exceed and completely jam the desired signals, it being thus sometimes of advantage to limit I'' to I'.)

But this is not the only consideration. It will have been noted from the foregoing that the amplification directly due to heterodyne action reaches a maximum when I' and I'' are equal and cannot be increased by increase of I'' beyond this point. Actually, however, a secondary but important effect of the local oscillations is to increase the efficiency of the detector by polarisation, so that an additional amplification effect independent of the actual heterodyne amplification and due mainly to improved rectification, is obtained, which increases (within limits) with the amplitude of I'', so that, in practice, ***best result will usually be obtained when I'' is materially in excess of I', and is variable, which should, therefore, be provided for in the design of our receiver***, whether this be of the separate or auto-heterodyne type.

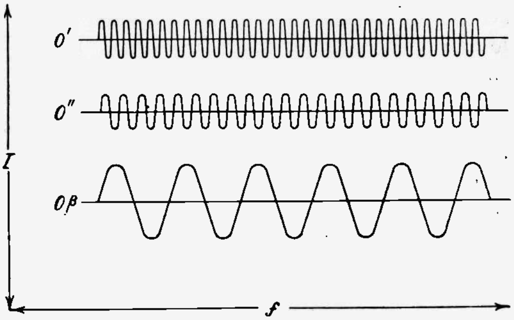

Fig. 1.—Illustrating the interaction of two oscillations of equal amplitude and different frequency.

The relative merits of these will be discussed later, the next point to be touched upon being that of the actual sensitivity of the receiver itself to weak signals.

This—given that the aerial system, etc., has been made as efficient as possible—will depend mainly upon :—

(*a*) The circuital resistance ;
(*b*) The inter-electrode and circuital capacities ;
(*c*) The static inertia of the circuits ; and
(*d*) The sensitivity of the detector as such to feeble impulses.

(*a*) and (*b*) have already been discussed and their vital importance emphasised by the writer elsewhere in these pages (Vol. I, No. 1), and may, therefore, now be dismissed with the bare statement that *the resistance and inter-electrode capacity of valve circuits, particularly H.F. valve circuits, should be as small as possible.*

What may be termed the " static inertia " of circuits is a rather different—though closely allied—matter, which, considering its extreme importance where actua lsensitivity is concerned, is usually insufficiently considered. It should be appreciated that, whilst the current required by the grid to operate a valve is very small, and is commonly dismissed as "negligible," it is, in reality, by no means negligible when considered in relation to that available for its operation, *e.g.*, the currents due to the incoming signals, which are also minute. Thus, since P.D. is always proportional to charge for a given capacitance and inversely proportional to capacitance for a given charge, it follows that the smaller the capacitance of a circuit the greater the potentials set up therein by given currents, so that, valves being potential-operated devices, the inference is obvious that *all valve circuits, and in particular grid circuits, should have as small a capacity as possible if sensitivity to weak signals is desired.* Since the valve electrodes themselves, as well as external parts of the circuit—such as wiring, terminals, condensers, etc.—will manifestly enter into this matter of capacity, it follows that not only should the latter be kept as small as possible consistent with efficiency in their respective functions, but that the electrodes of valves intended to deal with weak signals—such, for instance, as H.F. valves—should also be small; and this, of course, applies especially to the first stage in a receiver, where a special high-frequency valve should always be used.

Now comes the all-important question of detector efficiency, upon which the successful reception of weak signals above all depends.

It being essential in this case that the system adopted be specifically suitable to the purpose intended, and not merely for general use, crystal detectors, owing to their comparative unreliability, can be ruled out and some form of valve detector regarded as essential; and amongst these it will be observed that no form of anode rectification will be suitable, since the characteristics of such are sensitivity to strong and relative insensitivity to weak signals, which is the reverse of what we here require; so that some form of grid rectification is indicated. This may be either of the grid current or cumulative variety, the latter, being somewhat the more sensitive to very feeble impulses, being the more suitable; and either of these, moreover, permit of the detector being utilised as the local oscillator in an autodyne circuit without loss of efficiency.

Our receiver should, therefore, employ leaky-grid-condenser rectification, and a valve specially designed for this purpose should preferably be used.

The next item of importance is amplification, *i.e.*, valve amplification as distinct from heterodyne amplification, which we have already discussed; and the first effect of this—assuming it to be on the radio-frequency side—will naturally be to increase the amplitude of the incoming oscillations so that stronger beats may be produced by the heterodyne action.

Now, since signals received from distances of 3,000 miles may be expected to be attenuated cut of all comparison with the local oscillations produced by even the smallest valve, and since it is known that the rectified or telephone current output of a detector is proportional to the *square* of the impulses applied to it, it will be evident that *pre-heterodyne amplification of the signals will be of very great advantage in enabling reasonably strong beats to be produced for rectification, and may, in this case, be regarded as essential.*

A further advantage accompanying the use of H.F. stages is the fact that it enables a non-radiating receiver—even of the autodyne type—to be readily designed.

Since, however, radio-frequency valve circuits are somewhat tricky and liable to cause trouble if over multiplied, H.F. amplification has certain limits imposed by the need for practicability in a receiver and should not be overdone, and the condition to be aimed at is maximum amplification efficiency per valve, so that the number of stages necessary to produce a given result may be as few as possible—which, of course, also holds good from the standpoint of economy.

Since, moreover, this condition may be fulfilled by efficiency of circuital arrangements only up to a certain point (*vide* "practicability" below), it must be fulfilled as far as possible by the valves themselves—*i.e., the amplification factor of valves used for radio-frequency amplification should be high, and their characteristics made as steep as possible* by suitable values of plate voltage and filament temperature.

This will, in the present case, apply also to audio-frequency stages, since many such will be undesirable owing to their tendency to noisiness; in fact, in the interests of self-silence of the receiver, which is here so important a matter, it is recommended that *not more than one L.F. stage, and preferably none at all, be used.*

Now comes the essential factor of *practicability, i.e.,* ease of searching tuning, etc., and we are faced with the necessity of reconciling this with efficiency as far as possible, since we cannot afford to lose either to any great extent.

Fortunately, both efficiency and selectivity are inherently greater in heterodyne than in telephonic reception, so that less difficulty exists in arranging a practical receiver which shall at the same time be satisfactory in these respects.

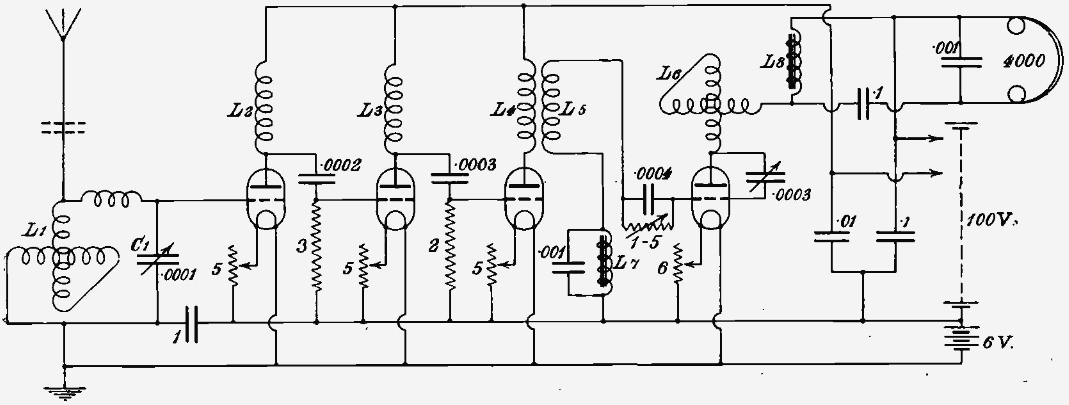

Fig. 2.—An "Interdyne" reaction circuit or four-stage autodyne receiver.

This is due to the absence of "spreading" of the carrier due to modulation, to the high degree of regeneration present in the circuits under working conditions, to the polarisation of the detector by the local oscillations, to the heterodyne amplification effect, and to the natural increase in selectivity due to the heterodyne action, which latter is so great as to make almost any heterodyne receiver inherently selective in such degree that, for short-wave work at all events, no special consideration need be given the matter so far as interference due to undesired signals is concerned. That due to atmospherics and to arc "hash" is a different matter, and will be discussed in due course.

We thus see that it is not in the matter of selectivity, but in the reconciliation of efficiency with practicability that the difficulty chiefly lies.

The former admittedly demands fully-tuned circuits throughout the radio-frequency side of a receiver, for example, but since the latter puts this out of the question where more than one—or at most two—H.F. stages are concerned, we must endeavour to find the best possible compromise.

Since the tendency to instability increases with each stage and becomes disproportionately greater with each *tuned* stage, and inasmuch as the complexity of tuning increases as the square of the number of tuned circuits employed, it will be evident that the latter must have a very strict limit, so that *a receiver intended for reception of intermittent signals of indeterminate frequency should have as few tuned circuits as may be consistent with reasonable efficiency, and experience shows the maximum number generally permissible in practice to be three.*

Now, since two—*viz.*, the aerial and the heterodyning circuits — will in any case be a *sine qua non*, this will leave only one more available irrespective of the number of H.F. stages adopted, so that, if more than one stage be used, these will have to be untuned, *i.e.*, semi-aperiodic.

In practice, however, it is found that even three tuned circuits in a receiver make anything like rapid and reliable searching and tuning difficult, and cause the chances of missing signals to be considerable—in fact, no less than 9 to 1, which odds are rather long, and may have a serious effect upon the percentage and total number of stations logged in a given period.

This rather cramps us, as it leaves only two tuned circuits with which to produce
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"efficiency"; but, since it is in practice possible to dispense with one such circuit out of three without serious loss of efficiency, and as the advantage in practicability gained by doing so will usually outweigh any such loss, it is suggested that *a limit of two tuned circuits may be adopted with advantage in receivers to be used in the Transatlantic Tests*—"tuned" circuits, of course, here meaning such as actually require variation in searching and readjustment for any change of wavelength.

The desirability of avoiding interference with other stations that may be working being manifest, it is also suggested that *a non-radiating arrangement be in all cases adopted—e.g.*, that reaction be not applied directly to the aerial circuit, either open or closed; that at least one H.F. valve stage be interposed between the aerial circuit and that to which the heterodyne is applied; and that signals be in no circumstances heterodyned in the aerial circuit itself or in any circuit directly coupled thereto.

Three types of receiver designed in accordance with the various considerations enumerated are now shown.

Fig. 2 shows a four-stage autodyne circuit in which the amplified signals are heterodyned by a detector-oscillator V4, preceded by three H.F. stages. Here the audio beats are produced in the grid circuit of V4, three valves thus separating the aerial and oscillation circuits and energisation of the aerial being completely avoided. It will be observed that two tuned circuits only—L1-C1 and L6—are used, *inclusive* of the oscillator, C1 being merely a vernier for fine tuning, and C2 a static coupler. (The iron-core choke L7 is merely an audio-frequency rejector of the beat-oscillations, so that these may be effectively built up in the grid circuit of V4 and passed on for rectification in their entirety—a point usually neglected, but which will be found repeated in each of the receivers here illustrated. It is shown shunted by a small fixed condenser so as to constitute an acceptor of the higher frequencies and not interfere with the action of L5 as a high-frequency circuit. It has no effect when the receiver is used for telephony, spark, etc., other than slightly to increase the efficiency of the detector as an audio-frequency amplifier. Both it and the impedance choke L8 should have a resistance of at least 4,000 *w*.)

It has already been stated by the writer elsewhere in these pages (Vol. I, No. 1) that an autodyne receiver may be used for *short* wave work as efficiently as a separate heterodyne, and, as this may not be the generally accepted view, the reasons for it are here given.

The first is that, whilst it is manifest that a certain amount of de-tuning of one or other of the circuits concerned will be necessary for the production of an audio beat-note, this de-tuning in the case of short waves will only be very small, and, moreover, if the receiver be scientifically designed for the purpose, need not occur in the actual receiving circuit at all, so that the incoming signals need by no means be inefficiently tuned. Thus in Fig. 2 the de-tuning, or heterodyne frequency, may be and should be in L6 only, and not in L1, so that, L6 being post-rectificational, and its tuning without very material effect upon preceding circuits, the loss of signal strength will be negligible.

The second is that, since the received signals will pass through *all* the valves, and each will, therefore, be directly operative as an amplifier (which is not the case in a separate heterodyne), any small loss in strength due to de-tuning of L6 will be more than compensated for by the extra amplification due to V4 itself.

The third reason is that searching and tuning are generally easier in an autodyne than in a separate heterodyne, as the receiving and heterodyne frequencies are varied to a certain extent simultaneously, so that adjustment of the beat-note is less critical and signals are less likely to be missed. This is an actual advantage of the autodyne, and it is suggested that, for wave-lengths below, say, 200 metres, the latter is actually the superior arrangement, although on medium-short waves there is probably little to choose between them.

Fig. 3 shows a five-stage receiver with separate heterodyne, the amplified signals being here heterodyned in the anode circuit of V3, preceded by three H.F. stages, and followed by the detector, two tuned circuits only being still used. The local oscillator may here be simply a heterodyne wavemeter.

The advantage of this type of receiver is that the required beat-note is produced by variation of the local oscillations at L5-V5 only and not in the actual receiver, the signals thus not losing strength through de-tuning of the receiver itself. Moreover, the majority of headphone instruments are designed to have a natural period in the neighbourhood of 1,000, which corresponds to that of most acute audibility, and such a frequency may here readily be given to the beat-note without other considerations becoming involved, whereas in the case of an autodyne receiver the amount of de-tuning of the circuits necessary to produce such a note may appreciably affect signal strength, so that, in practice, a lower note of the order of 500-600 usually has to be adopted.

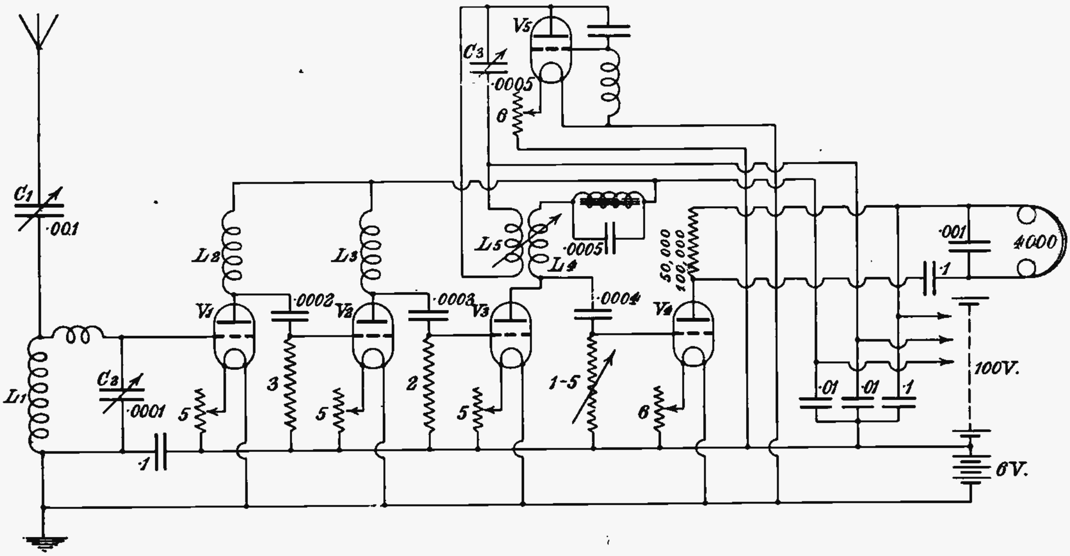


Fig. 3.—An "Exterdyne" reaction circuit or receiver with seperate heterodyne.

In the case of a separate heterodyne receiver the note will, of course, be adjustable by variation of the heterodyne frequency (at L5) *only*, as variation of the receiver tuning cannot alter the frequency of the incoming signals themselves, or, therefore, the beat-note.

The disadvantages of this type of circuit are, on the other hand, the criticalness of adjustment of the heterodyne frequency on short waves, and the fact that the oscillating valve is not itself directly useful as an amplifier, and is, therefore, partly wasted.

Fig. 4 shows an entirely different and considerably superior arrangement, which has been specially designed for the purpose in view, and operates on the Supersonic principle.

Space will not permit of any enlargement upon the subject of super-heterodyne receivers here, but the circuit itself is given owing to its special value in this case. Suffice it to say that it operates in the main upon exactly the same principles and is subject to the same considerations as have already been discussed, with the difference that the beat-note produced, instead of being given an audible frequency, is given a *supersonic* frequency, *i.e.*, one above the limits of audibility and corresponding to a fairly low *radio* frequency, and is subsequently treated as such.

Thus, in Fig. 4, the incoming signals are amplified at their original frequency by V1 and V2 in the usual way, and are then heterodyned by the local oscillator V3 to produce a beat-frequency, also as usual, except that the frequency chosen in this case will be of the order of, say, 100,000 instead of 1,000, corresponding to a wavelength of about 3,000 metres instead of

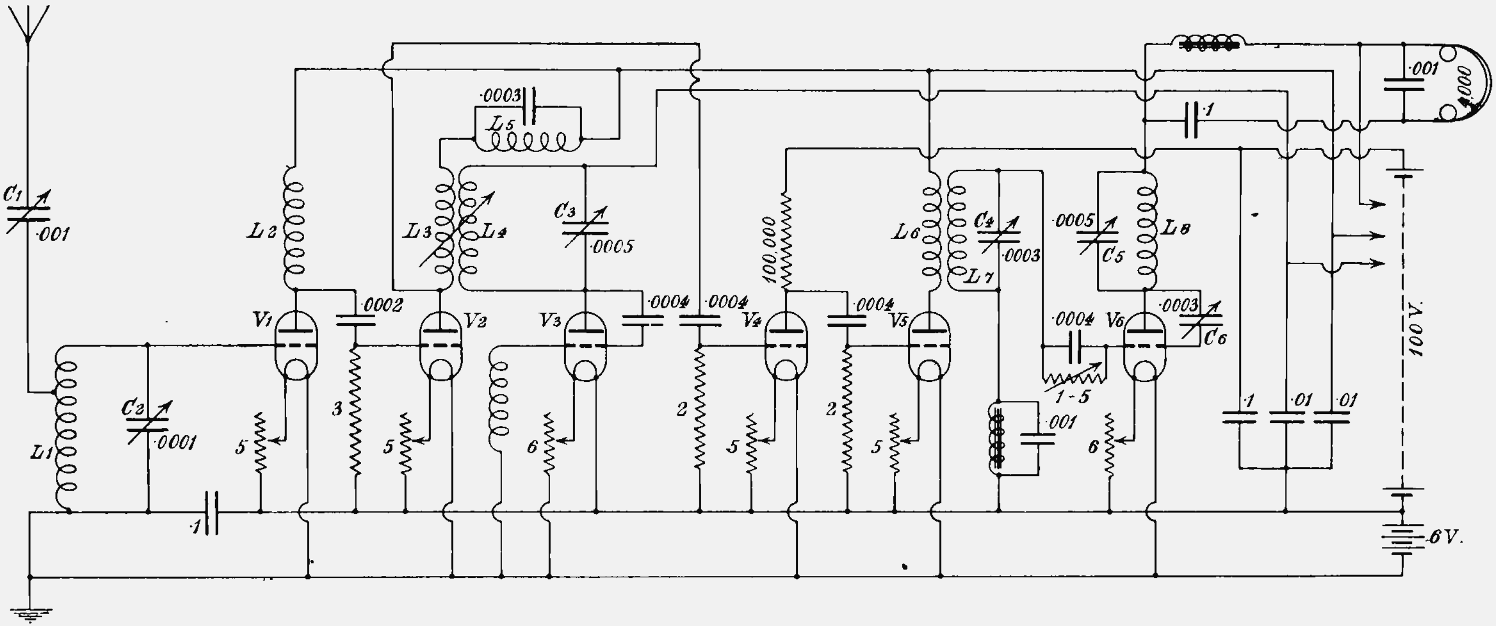


Fig. 4.—A "Superdyne" receiver which operates on the supersonic principle. The incoming signals are amplified by the valves V1 and V2, and are heterodyned by the local oscillator V3 to form a beat note of about 100,000, corresponding to a wavelength of 3,000 metres. The beat note frequency is amplified by the valves V4 and V5 being subsequently rectified by V6. The valve V6 also acts as a second heterodyne, which is adjusted to produce an audible beat note.

an audible note. This is conveyed to V4 and V5, where, being still a radio-frequency, it is amplified as such before rectification by V6, which also acts as a second oscillator to re-heterodyne it for the production of a final *audible* note in quite the usual way.

V3 is an ordinary separate heterodyne, which is, in this case, desirable as the detuning necessary to produce a beat-frequency of anything like 100,000 would cause considerable inefficiency in an autodyne arrangement. It may in this case, as it will form an essential and permanent part of the receiver, be "built in" as shown in the diagram. Similarly, though only an audio-frequency is required at the final stage V6, considerable de-tuning will be necessary to produce it when the originating frequencies are as low as 100,000, so that, although a self-heterodyne arrangement will here answer quite well, and is actually adopted in Fig. 3 with a view to suiting the receiver to permanent general use, a separate oscillator is really to be preferred.

L6 in the anode circuit of V5 is semi-aperiodic at the first beat-frequency—say, 3,000 or 4,000 metres—and constitutes an acceptor of the no longer required original frequencies and of any interfering currents—such as arc-hash, spark, and, to some extent, static—which may accompany them, and which usually force us to work at four ack-emma, these being thus filtered out to a great extent. It may be tuned if desired, but this is by no means necessary.

They are further suppressed by the use of resistance coupling between V4 and V5, which, whilst quite efficient for amplification of relatively low frequencies such as that of our beat, is very inefficient at the high frequencies in which the "mush" demon lives, so that any of these that may escape the filters L6 and L7 remain unamplified and comparatively pure signals at the new frequency to which they have now been converted are passed on to the last valve V6, which is the oscillator-detector, the grid circuit L7 of which is tuned to the new frequency and the anode L8-C5 to a slightly different one, such as to produce an audible rectified note in the telephones (except, of course, in the reception of telephony, when V6 will be used as a detector only and not as an oscillator).

It would appear from the diagram that a considerable number of tuned circuits are involved, and that the arrangement would be rather awkward to operate, but this is by no means the case. It must be appreciated that, whatever the original wavelengths received, the beat-frequency to which they are converted will always be what we choose to make it, so that a suitable beat-frequency may be adopted once for all and used for all receptions, the long-wave part of our receiver being set thereto in the first instance and *permanently left so*. Likewise, when a suitable audio note has once been found there will be no need to alter it again, and this may be permanently set, too. In fact, the variable capacity C4, which is merely for the purpose of setting the long-wave circuit in the first instance, may be dispensed with altogether if the inductances L6-L7 are carefully calibrated. Thus in practice the number of tuned circuits actually used in searching and tuning-in is still *two only*—L1-C1 and L4-C3—inclusive of the oscillators, notwithstanding that adequate amplification of the fundamental—an important matter too commonly neglected—is duly provided. The rejector L5 in the anode circuit of V2 is unusual, and its purpose is to improve the circuit in its function of *long* wave oscillator, whilst it is shown shunted by a small condenser to improve it as an acceptor of the higher frequencies so as not to impair the circuit as a *short* wave oscillator. It should be resonant at the lower frequency—say 3,000–4,000 metres—and L6-L7 made the same.

The coupling between L3 and L4, by means of which the local oscillations are introduced into the receiver, is shown variable in the figure, but in practice once a suitable setting has been found any adjustment in the strength of the oscillations that may subsequently be necessary can be obtained within sufficient limits by variation of the anode voltage to V3 or by adjustment of its filament temperature, or both, without any disturbance of the tuning of any of the circuits, the same applying to V6 and its static coupler C6 (which is made variable to allow of the oscillation here being stopped when the receiver is used for telephony, spark, etc.), and, indeed, to the heterodyne couplings in each of the figures; and it should here be pointed out that, whilst one form of oscillation circuit is shown in these diagrams, any other appropriate form may, of course, be used according to choice.

The outstanding advantages of a superheteordyne receiver are :—

(1) Great sensitivity and amplification, particularly of C.W. signals, due, in the latter case, to the *double* heterodyning.

(2) Extreme selectivity from the same cause, without increased criticalness of tuning.

(3) Ability to eliminate arc-hash, etc.—which is amongst the most serious difficulties in the way of short-wave long-distance reception—to a considerable extent.

(4) Ability to use a long-wave amplifier, relatively insusceptible to stray capacities, for the greater part of the receiver, with consequent reduction of body-capacity and other disturbing effects, resulting in far less instability and criticalness of adjustment and a more easily operated receiver for short waves.

The use of such a receiver, whilst perhaps a little more troublesome to set up and become accustomed to in the first instance, is likely to make a material difference to the success of receptions and is strongly to be recommended.

With regard to details, all inductances shown in the diagrams, particularly those forming the anode coils of valves, which are intended to be semi-aperiodic, should be wound to have the least possible self-capacity. Whilst any efficient form of tuner, such as shown in the preceding figures for example, may of course be used for the aerial circuit, variometer tuning will be found very practical and efficient and may safely be used with either of the receivers shown.

The aerial itself should preferably be an inverted L or T of the single or twin wire type, as high and long as possible, and may be used with either direct earth or counterpoise as lower capacity. Too many wires in the antenna tend to increase the interference due to mush, static, etc., and are inadvisable.

" R " valves may be used quite well throughout either of the receivers at the frequencies concerned, but those recommended are V.24 or ORA B. for the H.F. stages, and R.4B. for rectification. A " Q " valve will give particularly good amplification at V4 in Fig. 3 if a high-tension voltage of about 150 is used with it.

The H.T. battery should be of large capacity, whilst the filament accumulator should have a capacity of at least 60 amp.-hours (actual), unless of course dull-emitter valves are used, as is sound practice owing not only to current economy, but to the very desirable silence in operation of valves of this type. In this case suitable valves will be D.E.V. for the H.F. stages, and B.5 for rectification, the filament voltages of these coinciding very closely.

It will be noticed in each of the circuits shown that the last valve—*e.g.*, the detector—is made to function as an L.F. amplifier also, partly by the action of the iron-core choke in its grid circuit, and partly by the use of a static transformer, operating on the impedance or resistance-capacity principle, in its plate circuit, with high-resistance telephones, and this arrangement will be found very efficient. Low-resistance 'phones with ordinary transformer may, of course, be used if desired, and instruments of the adjustable-reed type may in either case be used with advantage.

Suitable constants are given in the figures, and, it being appreciated that few will want to build special receivers for the short period of the tests which may subsequently be of little use to them, an effort has been made to suggest circuits which shall also be of all-round use and permanent value to the experimenter afterwards.

The Institution of Electrical Engineers.

Mr. E. H. Shaughnessy, O.B.E., Chairman of the Wireless Section of the Institution of Electrical Engineers, delivered his Inaugural Address at the Institution Building, London, on November 7. He commenced by pointing out that the meetings of the Wireless Section are open to all members of the Institution ; they are not, as seems to have been the impression, limited to members of the Section only. The address was of an interesting character ; it reviewed the inception and development of broadcasting, mentioned the difficulties which had occurred in the United States, and predicted the eventual establishment of a sound national order of broadcasting in this country. Mr. Shaughnessy referred to the broadcasting of music as a wireless triumph.

Radio 2UV A.R.R.A.

By W. E. F. CORSHAM.

Amateur transmission stations usually show a marked dissimilarity in circuits, systems, and apparatus employed. This is due no doubt to the fact that many experimenters build their sets as a result of their own investigations. In order that experimenters may become acquainted with the work of others, details of stations embodying novel methods and circuits would be welcomed in these pages.

EXPERIMENTAL station 2UV, better known as "Two Uncle Vic," the station's 'phone call, is located in the valley at the bottom of Harlesden Gardens, London, N.W.10, and came into action at the beginning of 1920, the twin aerial being hoisted almost immediately after my demobilisation from the R.E.S.S. The first difficulty consisted of getting gear together, and, due to this trouble, a crystal set was the first set in use. I wonder if the broadcasting people know what a wonderful amount of interest can be got out of a crystal set? Most of the Mediterranean stations were copied off this set, and it was in use for quite a long period, giving entire satisfaction, and on some nights some remarkable performances.

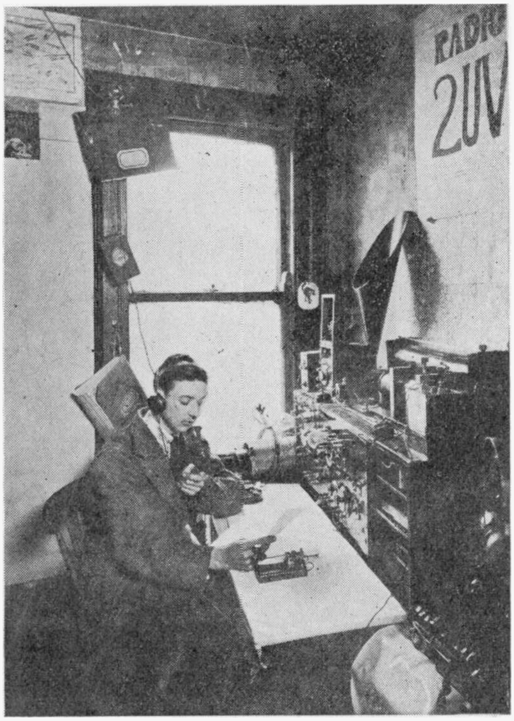


Fig. 1.—Showing the general appearance of 2UV.

When the first amateur transmitters began to get into operation on 1,000 metres did anyone ever hear such a large amount of Q.R.M. that immediately began to spring up on that wave-length; BYK and other Navy sparks using about 2 to 5 kw. seemed to work most of the day and nearly all night, and the "Sorry, O.M., Q.R.M.!" got so frequent that it was obvious that a new wave-length would have to be found, especially as Croydon was occasionally being Q.R.M. by a slight miscalculation of wave-length, and PCGG had commenced music tests. The non-transmitting amateurs began to voice their disapproval of the heterodyning effect of carrier waves on this station, so that the poor transmitting amateur, already well bound up by restrictions, began to look for some other wave to release his experiments on, and the first stragglers began to appear on 360 metres, where, in course of time, new emigrants from 1,000 appeared every evening, until in time 360 began to get as bad as 1,000 metres for congestion. Then the Cross Channel commercial sets began to get busy, and shipping

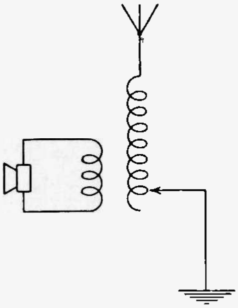


Fig. 2.—The simple modulation system consists of an absorption coil coupled to the aerial circuit.

to increase their use of the 300-metre wave. D.F. stations on 400 to 440 also got busy, and down we went again to 200. Finally the Post Office authorities sanctioned the use of 200 and 440 metres and the 1,000-metre wave-length was closed for amateur work.

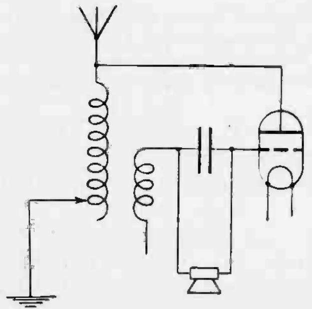


Fig. 3.—Here the microphone replaces the normal grid leak.

The first transmitter at 2UV consisted of a tonic train set, radiating ·06 on 1,000 metres, 0·1 on 360 metres, and 0·13 on 200 metres. This was, I believe, the first tonic train set of its kind to be used in London after the war, the feed consisting of 4 volts on a ½″ spark coil, taking about 2 amps. in primary coil, and supplying heavens knows how many volts on the plate, but very few milliamps., hence the low radiation. Very successful results were obtained with this set, quite good distances being worked, an example being the tests worked with 2JZ of Huntly, Aberdeenshire, in February, 1922, when he received my signals and replied to me on a set whose input was less than 50 watts. I got his speech very well on a three-valve L.F. set. That's 500 miles on a set radiating 0·1 amps., whose actual wattage must have been in the region of 2 to 3 watts output, and good clear speech on 50 watts.

The set used can be seen in Fig. 1. A small power 'phone set, also radiating 0·1, came into being at this time, with about 120 volts on plate; good speech at 20 to 30 miles was obtained on this input, and on some very special tests arranged with 2OD and 2SX, they received my speech Q.R.Z., but clearly when my input consisted of the six-volt

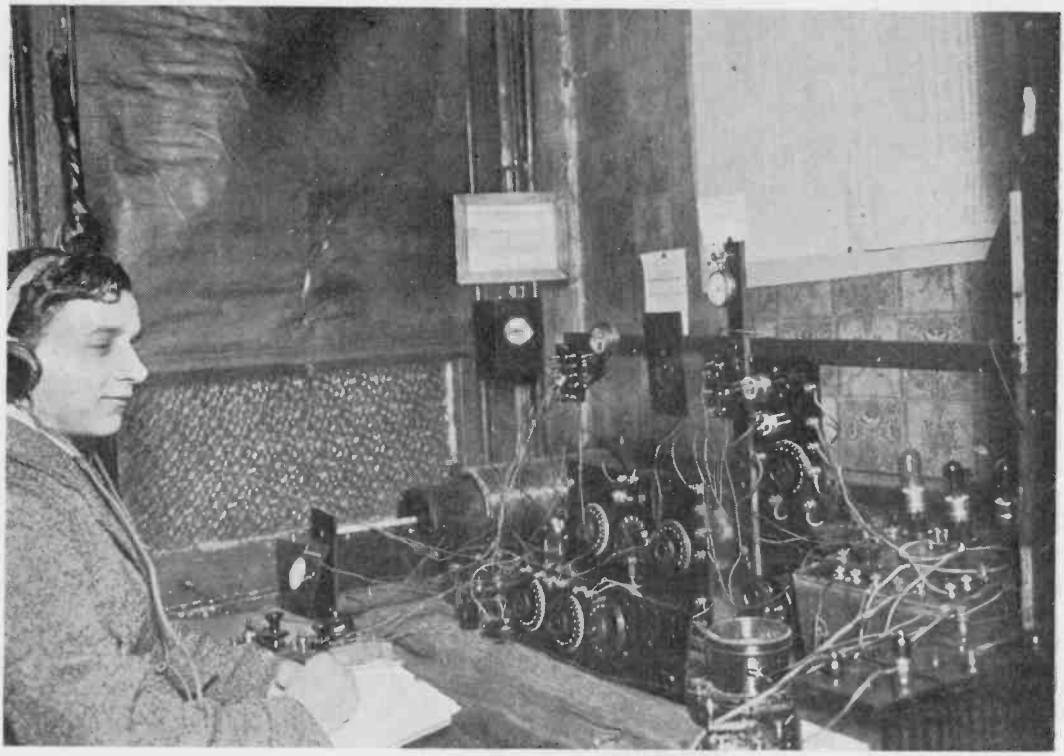


Fig. 4.—The apparatus employed by 2UV during the last Transatlantic Tests.

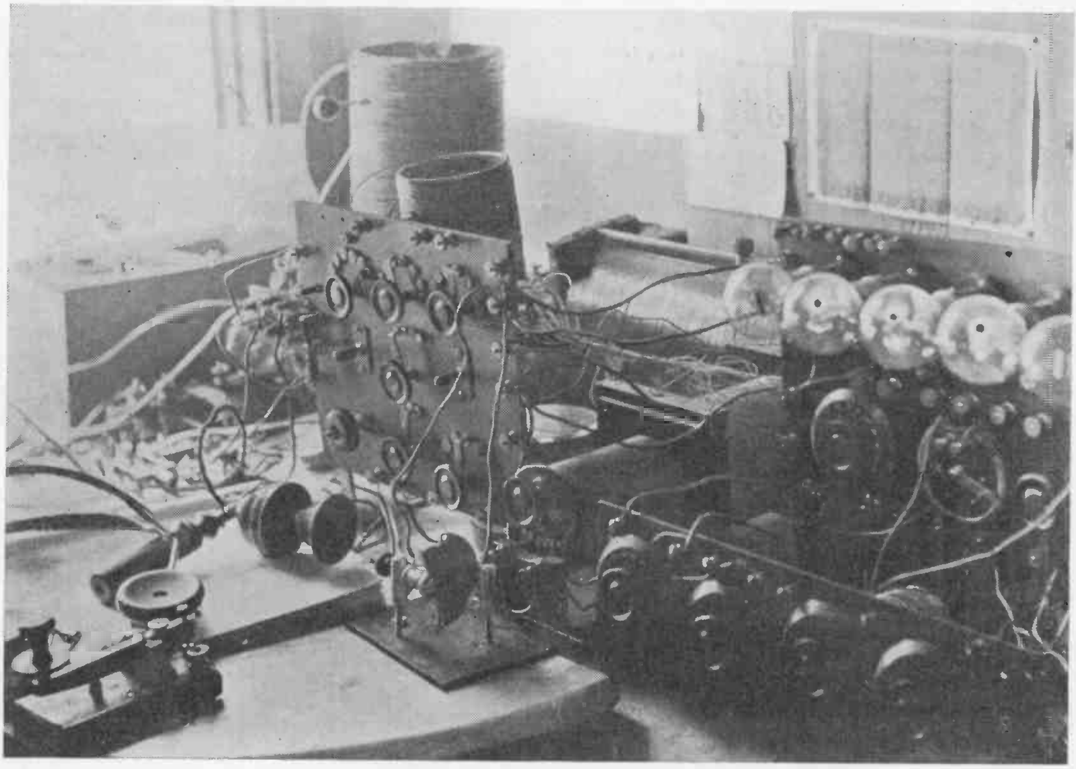


Fig. 5.—A near view of the apparatus now in use at 2UV.

accumulator supplying the valve filaments, and a four-volt dry cell from the H.T., very much the worse for wear ; in other words, a doubtful ten volts. How did I modulate it ? Perfectly simple—a coil coupled to the aerial circuit on the earth side will do this very well, but a better and much easier system is as in Fig. 3, where the microphone, shunted by a condenser, takes the place of the grid leak. This system works excellently on radiations up to 0·2, but heavy saturation begins to set in here, and ordinary grid control is far more reliable then, but wonderfully clear results are obtainable on these systems at low inputs, and a good deal of unnecessary trouble and fuss can be saved. So much for the transmitter.

The receiver at 2UV is possibly one of the most efficient of its kind in London. The first record put up was the first reception of the American amateurs in Great Britain, when 2UV successfully logged 1AFV of Salem, Mass., on a three-valve set (L.F.), a most astounding piece of work, considering that it was the first time the receiver had got down to 200 metres, and that the first three hours it was at work saw the code word

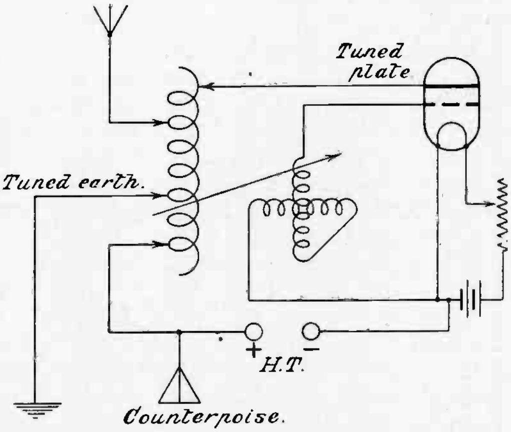


Fig. 6.—Illustrating the circuit employed for transmission.

YLPMF safely in the log book. Since then numerous experiments have taken place, too long to elaborate upon in this article, but the first French tests were arranged on October 31 with 8LBC, and very good Q.S.A. results obtained. Before the 1922 transatlantics were commenced a rather interesting incident, worthy of mention here, occurred, and possibly the first of its kind in this country. On November 26, 1922, at 11.59 p.m., when testing out the set I was going to use for the coming tests, and working with 2OD, of Gerrard's Cross, to my annoyance a C.W. station came dead on top of him, making reception exceedingly hard. I couldn't get one tuned out without getting the other, and accordingly I took steps to listen to the Q.R.M. man with a view to asking him to change his wave-length, when, to my surprise, he turned out to be American amateur 2AWF, working 1XM. Needless to say, I did not call him, but that reception certainly augured well for the success of the coming Transatlantic, and, despite the awful Q.R.M. from Northolt GKB, I logged nearly 200 stations from periods 3 a.m. to 6 a.m., GKB making reception hopeless up to 3 a.m., I am so near him. I first heard WJZ's howl in February, 1922, and 0NX I logged on December 10, 1922, together with 0NY. I took part in the transmission period tests from this side, and had some good reports from various places on the Continent, tonic train being used. No doubt 2KF, 2OM, and 2SH remember those early morning chats that passed away the hours of waiting for the period, the station at 2UV in use then being pictured in Fig. 4.

The present station will be seen in Fig. 5, and consists of a tonic train set capable of radiating 1 to 2 amps.; a C.W. and 'phone set capable of radiating 0·7, and a five-valve receiver one to five valves at will. The usual number in use being two. Most of the U.S.A. broadcasters have been logged on this, together with a good number of American amateurs.

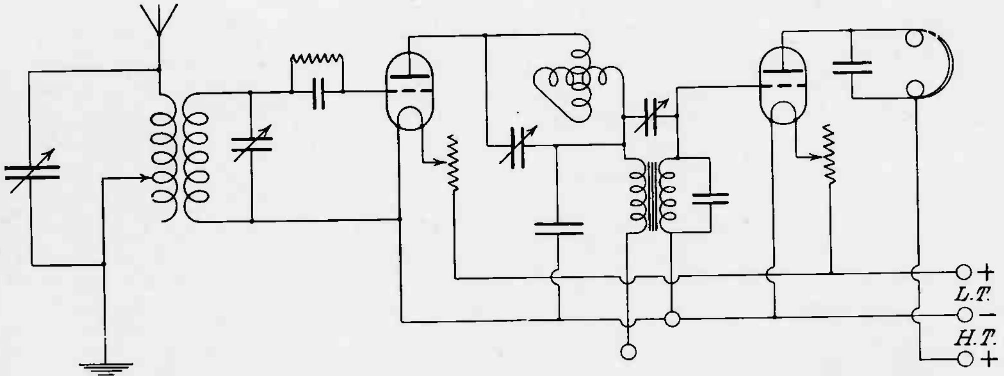


Fig. 7.—The receiver employs a single valve regenerative circuit with tuned plate coil, followed by a special note magnifier.

The circuit of the transmitter is shown in Fig. 6, and that of the receiver in Fig. 7. I always use L.F. because it is my practical experience that much better results are obtainable on distance work if great care is exercised to clear distortion for speech, and it is quite possible to get rid of that bugbear to the low-frequency worker. The only good word I have for H.F., and I have at times used it fairly extensively, is for its better selectivity, and I use it occasionally when GKB is Q.R.M., but a good tuned circuit is just as good.

This concludes a rough outline of 2UV, and the work accomplished since its inauguration. A 1-kw. license has been granted to the station by the P.M.G., and if all goes well, I hope for good DX work with the U.S. amateurs in the near future, together with my brother amateurs of the A.R.R.A. "Best 73's C.Q.!"

The Month's "DX."

Recorded by HUGH N. RYAN (5BV).

The increasing efficiency of amateur transmitters and receivers is resulting in the creation of many new long-distance records which are undoubtedly worthy of mention. It is proposed to record month by month work in this direction, and the Editor will be pleased to receive details for inclusion in these pages.

THE outstanding feature of the past month has, of course, been the extraordinary spell of bad conditions, lasting about five weeks, and including the whole of October, during which reception of American amateurs was practically impossible. The conditions on the early morning of September 23 were perfect, and Americans were coming in nearly as fast as they could be logged. It was a few days after this that last month's notes were written. Apparently I was crowing about the splendid conditions a little too soon, as I heard not a single American between that date and November 10, neither have I heard a report of any other listener doing so. 2JF, 2ZS, 2KF and other well-known men all report to the same effect.

The Transatlantic aspect of these notes was in imminent danger of disappearing this month when quite suddenly normal conditions returned. They may or may not last, but at the time of writing all is well. Now for the actual results obtained. Reports from the North are not yet to hand, but certainly London has been getting some excellent logs.

On the morning of October 11 5NN logged twelve Americans on one valve. 2WY received the very fine total of twenty-three on the same morning, using three valves. About twelve Americans were received on one valve by 2AAH (British, not American !), who has one of our latest series of call-signs, but is nevertheless an "old-timer" in DX work. I only kept a short watch that night and received ten Americans on one valve.

I heard 2JF and 5KO calling 1CMP several times, so it may be assumed that they were also on the war-path.

The two strongest Americans were 1CMP and 2BY, both of whom produced very loud signals indeed. An interesting item was an A.R.R.L. broadcast message from 1FD. This was rather badly jammed in London, but parts were quite readable, including a report of a cable just received from England in connection with Transatlantic work. The message was signed "Schnell," the A.R.R.L. traffic manager. That practically concludes the American news, since the bad weather spell only broke a few days before writing.

Canadian 1AR has written asking for the co-operation of British amateurs in Transatlantic work to show our American "Radio-Cousins" how DX really can be conducted. He is using transmitting apparatus of British manufacture, and works with an aerial current of 7½ amps. He would appreciate reports of reception in this country, having been received here a record number of times in August and September.

A curious feature of the spell of bad conditions was that it only seemed seriously to affect Transatlantic work. European DX has not been seriously hindered by it. The Dutch stations have been coming in very well, but nothing of great interest has occurred in connection with any of them except PCII of Leiden, who reports having effected two-way working with 7ACM on the morning of Sunday, October 4, between 3 and 4 a.m., Amsterdam time. The whole of the working was overheard and confirmed by 0MX of Amsterdam.

The Dutch "Radio-Expres" states that PCII was using 100 watts, and radiating 3 ampères, using a Mullard valve with 1,500–2,000 volts on the plate. The working remains to be confirmed, but if it turns out to be authentic it is a very fine piece of work, as the seventh district is the one most remote from Europe, and 7ACM is at Cambridge, in Washington State, right over on the Northern Pacific coast of America ! We will leave our congratulations until it is confirmed.

The only other notable feature of Dutch work this month is the sudden and considerable increase in the strength of 0DV.

The French stations are now awaking from their summer sleep, and have been very much in evidence during the last month. I suggested in last month's notes that 8AQ's silence was due to the non-arrival of his new alternator. It appears that the reverse is the case. The alternator turned up, full of beans, and 8AQ is now having his valves repaired! 8BF, of Orleans, has just installed a new transmitter, using 25 cycles A.C. The signals from this set are extremely strong, and the note is exactly like the once-familiar note of 8AB. 8BF tells me that the power of this set is one kilowatt, and that during the Transatlantic tests he is going to use it alternately with his old 100-watt pure C.W. set. In spite of the power of the 25-cycle set, I think I would put my money on the pure C.W.

There are now several more British stations "on the air" with their potential Transatlantic transmitters. 5NN has been suffering from valve trouble, but is now working again. 2SH is again using big power, under a special licence for 100 watts. He is putting about 4 amps. into the aerial. Several other stations have been granted these temporary licences for increased power during the Transatlantic season, and may soon be expected to establish some interesting records. An important point in connection with these licences is that, under their terms a British station calling an American should prefix the American call sign with the letter "n" and his own call sign with the letter "g," *e.g.*, "n 1CMP de g 2JF." This will help to avoid confusion between British call signs and their American duplicates. It is to be hoped that all British transmitters using sufficient power to render distant reception possible will, in future, use this prefix. It is much less clumsy than the present "British" or "Brit." prefixes.

In connection with the issuing of special licences for Transatlantic work, it is interesting to note that the Dutch authorities have sanctioned the erection of a station for this purpose, the licence allowing the station to operate until May, 1924.

The station is to use C.W., power 500 watts, and wave-length 200 metres. It is to be situated at Delft, and its call sign is PA9.

It will be remembered that last month I suggested that the fault of the non-reception of our signals in America did not, perhaps, lie entirely with the receivers on the other side, as is rather commonly supposed by our men. I think that my view is confirmed by the results obtained by several American amateurs in *working* with the Macmillan Expedition Station WNP. The Macmillan ship is at present frozen in the Arctic at a nearer point to England than to an average point in the States, but yet he has carried out two-way working with several American amateurs, while he has never yet been received in England, neither has he received any British signals. That, I think, should dispel the idea that American amateurs cannot receive. This should give us more hope of getting over so long as we send out good stuff, and it should also encourage us to try to receive WNP. I know that many of our stations are trying to do so, and it is difficult to explain their lack of success.

With regard to the well-known Americans of last year upon whose absence this year I commented in the last notes, the list still holds good with the exception of 1BDI, who has now been logged this year by 5NN (November 11).

Apart from the chronicling of DX, I should like this month to put forward a suggestion for the better reporting of signal strength in DX and other work. The present "R" code of signal strengths has become useless, firstly because it has far too many different degrees of audibility, and secondly because everybody applies a different meaning to it. Nobody can really say what is the difference, for instance, between R5 and R6, nor is that difference of sufficient importance to be worth worrying about.

I suggest a new code, which should be called by a different letter to distinguish it from the old "R" code, which should have only four degrees of audibility, and which should take into account the receiver used. Let us call it the "A" code, then "A21" would mean strength 2 on one valve.

The figures for strength would be—

1—just readable (with difficulty).
2—comfortably readable, but not very strong.
3—good strong signals (the best strength for good consistent work).
4—very strong.

The second figure should indicate the

number of valves used for reception. Even this code is far from perfect, but it is an improvement on the practically meaningless "R" code. If you like the code you can use it without much fear of the other man not understanding, as I think that this paper is read by nearly all transmitting men.

Just before going to press the log from the North has come to hand. 2JF has received eighteen Americans so far this month. His transmitter has also been heard in Christiania (indoor aerial and two valves) and Toulouse (two valves). 8CWR has reported receiving 2JF, but the time is not yet confirmed, though it appears to check O.K.

2PC, 2GW and 2KW are all rebuilding their stations for the tests, and may soon be expected "on the air."

◆

The Trend of Invention.

We summarise below the more important wireless inventions which have been disclosed during the month, special reference being made to those of immediate interest to the experimenter.

Elimination of Interference.

A great deal of experimental work has been done, and a great many patents have been taken out, on the subject of the elimination of interference. Still, however, much remains to be done in this direction. British Patent No. 205,117 (of German origin) shows a method of attacking this problem in a somewhat novel way. In order to increase the selectivity of resonant circuits the inductance thereof is made very large and the capacity very small. In order to produce coils of very large inductance and very low self-capacity these are wound with fine wire and may have iron cores and be of multi-layer form. The losses so occasioned are neutralised by using a retroactively-coupled triode. A wireless receiving circuit is shown in Fig. 1, in which a separate triode (R_1) is used to neutralise the aerial losses and the closed circuit (S_3, C_2) of the receiving set is inductively coupled to the aerial tuning coil (S_1). S_5 is the coupling coil of a separate heterodyne. The telephone may be inserted in the anode circuits of either R_1 or R_2, thus making possible the use of either a direct-coupled or loose-coupled receiver. It does not appear that the arrangement described would overcome the difficulty of heavy atmospherics setting the aerial into oscillation at its own natural frequency. However, the arrangement produces a very feebly-damped aerial circuit for a loose-coupled tuner and thereby enhances the benefit of loose coupling. A possible improvement might be found in tuning the reaction coil S, for example.

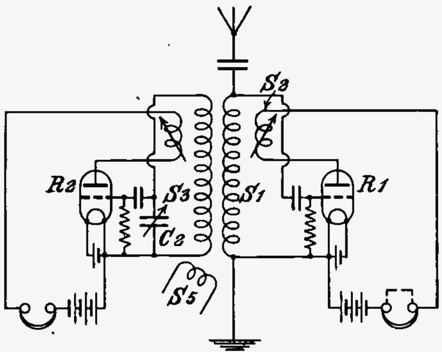


Fig. 1.

Relay Arrangements.

A certain amount of experimental work has been done on the lines of causing an incoming signal to set a local valve in oscillation at a frequency independent of the incoming signal. This, as will be remembered, is the principal of the Turner valve relay. British Patent No. 183,130 (of German origin) deals with arrangements of this type. Fig. 2 shows the simplest arrangement. Owing to the rectifying action of the two diodes 3 the negative charge on the grid of the triode 6 is reduced in proportion to the strength of the oscillations in the closed circuit 2. This effects the raising of the conductivity of the filament-anode space of the triode 6. The anode circuit of this triode is in series with the anode circuit of a second triode 7, which is retroactively coupled. Thus the triode 7 will oscillate, when the potential on the grid of 6 becomes sufficiently positive, at the frequency to which it is tuned, which would generally be an audible frequency. Other arrangements are shown in the patent specification using triodes only, and circuits may be arranged for the relaying of received signals at a different frequency.

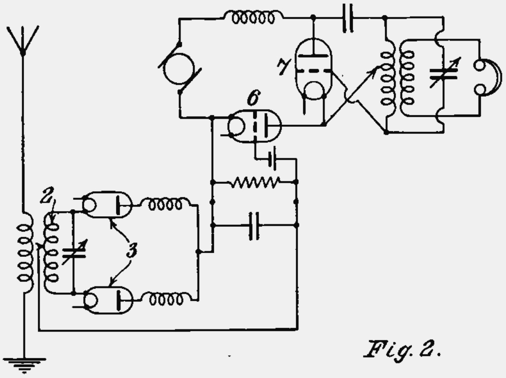


Fig. 2.

Another relay device is described in British Patent No. 186,305 (of French origin). This arrangement depends upon the effect of ultra-violet light upon metals in a low-pressure atmosphere. In the arrangement particularly described the beam from an arc lamp is focussed upon one electrode in a two-electrode tube, and the beam is controlled by perforated slip. The current in the tube circuit is said to be proportional to the intensity of light falling upon the electrode. The beam may be controlled by a mirror or mirrors, or, for example, by a pair of grids, of which one is connected to a sound-collecting diaphragm. It is possible that in this way a very sensitive microphone arrangement might be made, since a grid of fine wires, to cover slits in a screen, may be made very light indeed.

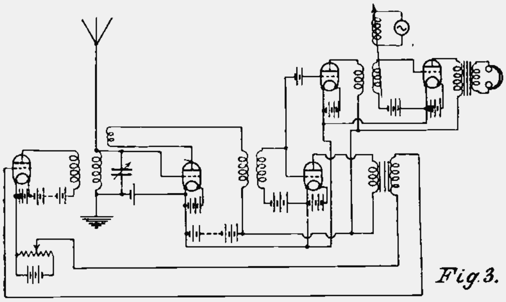


Fig. 3.

Controlling Decrement of Circuits.

A most interesting principle and means for carrying this into effect is shown in British Patent No. 204,482 (E. Y. Robinson, British). According to this patent the decrement of receiving circuits is caused to decrease with a weak and to increase with a strong signal, and remain constant when the signal is constant or zero. Preferably, the incoming signal itself effects these changes, and in such a manner that the change of decrement is proportional to the rate of change of signal strength. This can be effected in several ways, all dependent upon changing the normal grid potential of a triode in proportion to the rate of change of the signal strength. An extra transformer is included in the anode circuit of the detector triode, and its secondary winding is connected in series with the grid and filament of another triode. An inductance in the anode circuit of this latter triode is coupled to the aerial inductance so that some energy is absorbed therefrom, the amount of which will depend upon the anode circuit conductivity, and hence grid potential of this triode. Reaction into the aerial circuit is used in this case. A circuit arrangement employing this principle is shown in Fig. 3. A similar effect may be produced by changing the amount of regeneration due to a retroactively-coupled tube by varying the grid potential of this tube. A suitable arrangement for this purpose is illustrated in Fig. 4. It is said that by this method the modulation of telephony can be improved and circuits of lower decrement than usual can be used. It appears that some precautions are necessary

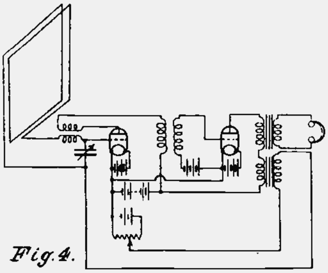


Fig. 4.

to make the arrangement work well; for example, it would seem necessary to design the H.F. transformer in Fig. 4 so that substantially no audio-frequency energy transference could take place between its windings. Incidentally, there is a similarity between this arrangement and some fairly common reflex arrangements. Are some of the wonderful results claimed for certain reflex circuits due to the unbeknownst employment of the principle disclosed in this patent?

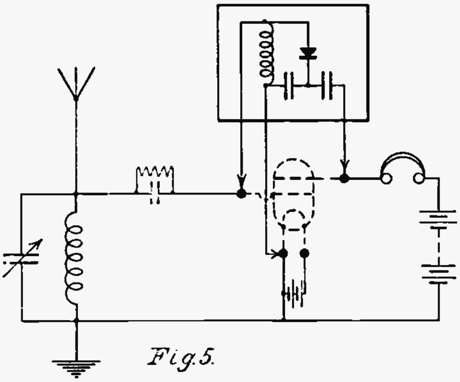


Fig. 5.

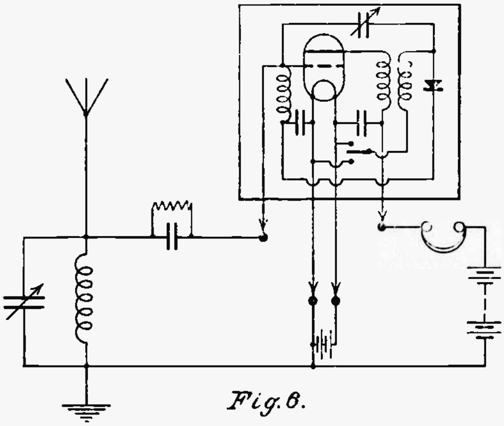


Fig. 6.

Crystal Detectors.

It is sometimes useful to be able rapidly to change from a single-valve circuit to a circuit employing a crystal or similar detector. British Patent No. 205,148 (P. G. A. Helmuth, British) describes two arrangements for plugging in to the socket of a detector valve, the first being for crystal detector only, and the second being for a crystal and triode reflex arrangement. Diagrams of these arrangements are shown in Figs. 5 and 6. The circuits used are somewhat unusual, but appear simple, but the construction of the high-frequency transformer in Fig. 6 might require some care.

Reflex Circuits.

Much attention has recently been devoted to reflex circuits, particularly those employing a crystal detector. In reflex circuits it has been usual to impress the rectified signal upon the grid of the first H.F. triode, and thereafter carry out audio-frequency amplification throughout the series of triodes in the same order as they are used for radio-frequency amplification. This method has the disadvantage that one triode carries both weak radio-frequency currents and weak audio-frequency currents, while another carries strong currents at both frequencies, and is therefore liable the more easily to become saturated. British Patent Application No. 204,301 (of American origin) sets forth a method of overcoming this trouble by carrying out audio-frequency amplification throughout a series of triodes in an order different from that in which radio-frequency amplification is performed, preferably in the reverse order. The diagram of connections is shown in Fig. 7. Particular care must be taken in designing and making the radio-frequency transformers for this arrangement, as it is essential that practically no energy at audio-frequency should pass between their windings. Amplifiers working on this system have found some popularity in America, and are said to be much more stable than the ordinary reflex amplifier. In that country these circuits are called "Inverse duplex circuits."

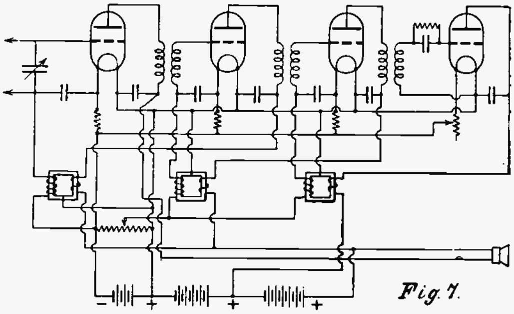


Fig. 7.

Duplex Telephony.

Many experimenters have during the last year been working hard at duplex telephony, and in this branch of work there is great scope for experiment. British Patent Application No. 190,699 (of German origin) describes a method of effecting duplex telephony which appears very simple. The arrangement is shown in Fig. 8. The oscillating valve has four electrodes, a kathode, anode and two grids. The grid nearer the anode is used in conjunction with the anode and kathode to function as a triode and form the oscillator. The oscillatory circuit is of a fairly usual form, except that in the anode and grid leads respectively a telephone and microphone are connected. The extra grid adjacent to the filament is connected to the junction of a resistance and the anode of another triode. The grid of this latter triode has potentials of the requisite frequency impressed upon it by suitable means, shown as a transformer with the primary shunted by a condenser. The anode current in the oscillator is controlled by the potential of the extra grid. When the anode current is large the set functions as a transmitter, and when the anode current is small the set functions as a receiver on the same wavelength. The specification states that ordinary triodes may be used, but does not detail how this may be done. It is possible that the magnetic control, described by Mr. Andrewes in the November issue of Experimental Wireless, could be used to replace the extra grid shown by this specification.

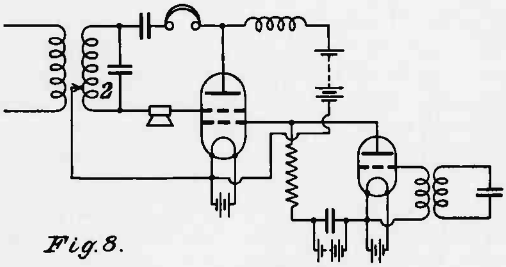


Fig. 8.

* * *

Recent Wireless Publications.

Figures after the title of each publication indicate Volume and Number of Publication containing the article. Where only one number is given, this indicates the serial number of the publication. The abbreviations used in this bibliography will be found in the previous issues of "Experimental Wireless."

I.—TRANSMISSION.

An Improved Method of Modulation in Radio Telephony.—Charles A. Culver (*Proc. I.R.E.*, 2, 5).

Uber Parallelschaltung von Röhrensendern.—A. Semm (*Jahrb. d. drahtl. Telegr.*, 22, 3).

An Interesting Control Device for Radiotelephony.—Alan L. M. Douglas (*W. World*, 221).

Side-Band Telephony.—E. H. Robinson (*Exp. W.*, 1, 2).

The Principles of Choke Control.—L. E. Owen, (*Exp. W.*, 1, 2).

Radio Antenna Design.—Frank Conrad (*W. Age*, 11, 1).

Sur les conditions de rendement des lampes-valves génératrices ayant une caractéristique d'arc chantant et sur la définition de leur puissance.—André Blondel (*R. Elec.*, 4, 14).

A Real Short Wave Transmitter.—Brown, Darne and Basim (*Q.S.T.*, 7, 3).

I.C.W. Without Mechanical Motion.—Howard M. Williams (*Q.S.T.*, 7, 3).

II.—RECEPTION.

Der Empfang von Hochfrequenzschwingungen mit Niederfrequenzmodulation. — G. Joos and J. Zenneck (*Jahrb. d. drahtl. Telegr.*, 22, 3).

Messungen der Empfangsintersität der atmosphärischen Ionisation und anderer meteorologischer Elemente während Sonnenfinsternis an 8 April, 1921.—B. Iliin (*Jahrb. d. drahtl. Telegr.*, 22, 3).

Zur Frage nach den Ursachen der Schwankungen in de Empfangsintensität.—B. Iliin (*Jahrb. d. drahtl. Telegr.*, 22, 3).

The Automatic Reception of Wireless Signals.—E. R. Batten (*W. World*, 219).

"Blind Spots" and "Fading of Signals."—S. R. Chapman, B.Sc. (*W. World*, 221).

A New Dual Circuit.—James Strachan, F.Inst.P. (*W. World*, 221).

The Supersonic Heterodyne Receiver.—W. S. Barrell (*W. World*, 222).

New Types of Valves.—(*W. World*, 222).

Valve Receivers on D.C. Mains.—Alexander Gayes, M.J.Inst.E. (*Exp. W.*, 1, 2).

Dull Emitter Valves.—(*Exp. W.*, 1, 2).

Les accrochages dans les amplificateurs.—André Delvigne (*R. Elec.*, 4, 15).

Resonance Wave Coils.—(*Q.S.T.*, 7, 1).

III.—MEASUREMENT AND CALIBRATION.

The Construction and Manipulation of Wavemeters.—Leonard J. Sayce, B.Sc. (*Exp. W.*, 1, 2).

Factors of Wavemeter Design and Operation. —L. R. Felder (*W. Age*, 11, 1).

A Method of Measuring Very Short Radio Wave-Lengths and Their Use in Frequency Standardization.—Francis W. Dunmore and Francis H. Engel; (*Proc. I.R.E.*, 2, 5).

IV.—THEORY AND CALCULATIONS.

Vacuum Tubes as Power Oscillators.—D. C. Prince (*Proc. I.R.E.*, 2, 5).

The Efficiency of Three-Electrode Tubes Used for the Production of Continuous Waves in Radio Telegraphy; that is, the Conversion of Direct into Alternating Current.—Marius Latour and H. Chireix (*Proc. I.R.E.*, 2, 5).

Longeur d'onde optimum.—Léon Bouthillon (*R. Elec.*, 4, 14).

V.—GENERAL.

Observations on Lafayette and Nauen Stations in Washington, March 1, 1922, to February 28, 1923.—L. W. Austin (*Proc. I.R.E.*, 2, 5).

Radio Frequency Tests on Antenna Insulators.—W. W. Brown (*Proc. I.R.E.*, 2, 5).

Digests of United States Patents Relating to Radio Telegraphy and Telephony; Issued June 26, 1923—August 21, 1923.—John B. Brady (*Proc. I.R.E.*, 2, 5).

Untersuchung eines Elektronrelais auf Grund elektrostatischer Ablenkung des Elektronenbundels durch ein Querfeld.—A. Gebbert (*Jahrb. d. drahtl. Telegr.*, 22, 3).

L'influence de traces de gaz dans les lampes à trois Electrodes.—(*L'Onde Electrique* No. 14, 1923.)

A Novel Method of Rectification.—F. L. Hogg (*W. World*, 219).

Distortion in Radio-Telephony.—H. A. Thomas, M.Sc. (*W. World*, 222).

Magnetically-Controlled Valves.—H. Andrewes B.Sc., A.C.G.I., D.I.C. (*Exp. W.*, 1, 2).

Amateur Radio Work in Holland.—J. Westerhoud (*Exp. W.*, 1, 2).

A Primary Cell H.T. Battery.—N. K. Jackson (*Exp. W.*, 1, 2).

Ionization in Vacuum Tubes.—W. A. Dickson (*W. Age*, 11, 1).

Notes on Insulation Phenomena.—A. Reisner (*W. Age*, 11, 1).

Single-Layer Inductance Coils Suitable for Radio Frequency Standards.—(*Mod. W.*, 2, 2.)

Some Causes of Poor Reception.—R. W. Hallows, M.A. (*Mod. W.*, 2, 2).

The Construction of a Novel Folding Frame Aerial. (*Mod. W.*, 2, 2).

Anticipations sur la transmission de l'energie à distance.—Léon Bouthillon (*R. Elec.*, 4, 14).

Sur les origines de la T.S.F.—Prof. A. Turpain (*R. Elec.*, 4, 15).

La T.S.F. en Yougoslavie.—R. Belmère (*R. Elec.*, 4, 15).

Le service d'écoute pendant la guerre.—Gen. Cartier (*R. Elec.*, 4, 16).

A propos des Origines de la T.S.F.—(*R. Elec.*, 4, 16.)

La Radiotélégraphie en Tchécoslovaquie.—R. Belmère (*R. Elec.*, 4, 16).

Le phonographe de l'avenir.—E. Pepinster (*R. Elec.*, 4, 16).

Transatlantic Radio Telephony.—H. D. Arnold and Lloyd Espenschied (*Electn.*, 2,372).

The Paris Radio Centre.—(*Electn.*, 2,373.)

Electric Filters. Part II.—F. S. Dettenbaugh (*Q.S.T.*, 7, 1).

Final Report on the Fading Tests.—(*Q.S.T.*, 7, 1).

Hard Rubber in Radio Instruments.—(*Q.S.T.*, 7, 1).

A New Radio System.—Howard J. Tyzzer (*Q.S.T.*, 7, 3).

Electrostatic Voltmeters.—R. R. Ramsey (*Q.S.T.*, 7, 3).

Correspondence.

Variable Condensers.

To the Editor of Experimental Wireless

Sir,—As an experimenter in wireless telegraphy of long and pre-war standing, I am wishful to assist the present experimenter, and incidentally the broad-catcher, who intends constructing his own set, by pointing out to him a possible cause for disappointment in the results obtained when endeavouring to follow too literally the valuable instructions for constructing a set as given by the various undeniably expert writers who contribute articles to the several wireless journals.

I write with regard to the capacities of the condensers therein stated to be necessary, and the risk when purchasing many of the condensers now on the market, of being supplied with one of much less capacity than the value at which it is rated.

I have recently come up against a most glaring instance of the gross inaccuracy of one of the types, for although I possess a number of Mark III condensers, and others made up to various capacities, I was led to purchase a condenser purely because it possessed an extra Vernier plate built therein.

It was sold to me as a condenser of .0005 microfarad capacity, and I had no reason to doubt its approximate accuracy, as, so far as my memory serves me, it had about 31 closely-spaced plates.

Being found to be *mechanically* defective, it was returned to the dealer, and by him to the makers, and another make of condenser supplied in substitution, with an apology from the makers for the same being of less capacity, namely, .0003 micro-farads, as they were out of stock of .0005 condensers for the moment.

Upon their stock being replenished, the makers forwarded to the dealer several condensers, and then stated that the condenser sent as a substitute was of .0005 and not of .0003 capacity.

Upon it being measured, and its capacity calculated, it was found to be round about .0003 micro-farads, and therefore representations were made to the makers, who now reply that "*there* *is a standard number of plates usual in the trade for the various capacities*" (apparently without regard to the diameter and thickness of the moving plates, and thickness of the spacing washers, that is, to the actual active air space between the plates).

Now, this cannot be a correct statement, as one cannot believe that trade firms would knowingly misrepresent the capacities of the condensers they sell. Moreover, a reference to the list of one of the most prominent makers of condensers shows that his .0005 micro-farads condenser has 29 plates, and a .0003 19 plates, whereas the so-called .0005 I purchased had 11 moving plates, equal to 23 plates all told, and the .0003's they sell have seven moving plates, equal to 15 plates in all, so that presumably, if there is a *standard number* of plates, the latter types do not comply with the standard.

Had the condenser been sold to me as having a certain number of plates, I could not have objected, excepting that the one sent in substitution had a much smaller number of plates.

I have also compared the said .0005 condenser, having 11 moving plates, with a cheap American condenser, containing 28 moving plates, with a much closer air space, and stated to be of .001 capacity, and this confirms my view that there can be no standard custom in the trade, as to the number of plates.

The point which affects the amateur is that he is advised that with a certain coil and a certain capacity of condenser he can cover, say, the broadcasting range of wave-lengths, and finds upon assembling his set that it falls short of this range, and wonders why.

Summing up for the guidance of the investigator, there can only be one correct method of calculating condenser capacities. One square inch of active surface, with an air space of $\frac{1}{1000}$ of an inch, gives a capacity of .0002246 micro-farads, and each moving plate of 2¼ in. diameter if faced on *each* side with a *fixed* plate (having a centre piece of ⅜ in. radius cut out for clearance, and having an air space of $\frac{1}{1000}$ of an inch) will give a capacity of approximately .0008 micro-farads, and in the case of a 2½ in. moving plate, .001 micro-farads.

If the spacing is $\frac{25}{1000}$ of an inch, then the capacity per *moving* plate will be one twenty-fifth of the above respectively, and if the plates are 23 S.W.G., and the spacing washers ⅛ in. thick, the capacity will be about one-fiftieth of the above.

Finally, it would be interesting to know the legal position of a dealer who knowingly sells an alleged .0005 micro-farad condenser (actually of about .0003 capacity) as a condenser having a capacity of .0005 micro-farads.

Geo. H. Strong.

To the Editor of Experimental Wireless.

Dear Sir,—With reference to the article entitled "Efficient Transmission," by Mr. F. L. Hogg, in the October issue, there appear to be certain points which, so far as my limited technical knowledge goes, do not fit in with each other, and as to which I would much appreciate an explanation—even if it only shows up my ignorance.

From particulars given, it appears that Mr. Hogg's aerial is 70 ft. above the counterpoise level at the lead-in end. The height of the other end is not stated, but I think it safe to assume that the average height is 50 ft., or say, 16 metres. Mr. Hogg further states that he has reduced the total resistance of his aerial system to 5 ohms, and on this basis shows how 1.26 amps can be obtained with an input of 10 watts to the valve at 80 per cent. efficiency.

What puzzles me is this: How does Mr. Hogg make his aerial system have a total resistance of 5 ohms when the radiator resistance alone works out at over 10 ohms (calculation attached).

If Mr. Hogg actually gets 1.26 amps. in his aerial on 10 watts at 80 per cent. efficiency, it is obvious that the total resistance of his aerial cannot be more than about 5 ohms, else he would have more than 10 watts in his aerial, which is ridiculous.

Awaiting your reply.—I remain, yours faithfully,

A. B. Richardson (6FQ)

Calculation of Radiation Resistance of Mr. F. L. Hogg's Aerial on 200 Metres.

$$\text{Formula } 1580\left(\frac{H}{\lambda}\right)^2$$

Where H = effective height of aerial.
λ = Wave-length.

See *Wireless World*, page 652, issue of 17-2-1923.

$$1580\left(\frac{16}{200}\right)^2$$
$$= 10.112 \text{ ohms.}$$

To the Editor of Experimental Wireless.

Dear Sir,—With reference to Mr. Richardson's remarks *re* my aerial, I can only say that I wish my aerial was 70 ft. above the counterpoise! I purposely split up this length into parts to emphasise the actual length of wire. The lead-in comes through the roof and across the room. The counterpoise lead goes back across the room a greater distance and across a short roof before dropping vertically on to counterpoise. Actually the aerial is 45 ft. above ground at lead-in, and 35 ft. at free end. Its effective height is only 28 ft., as the counterpoise is 12 ft. high. This figure gives a radiation resistance on 200 metres of 3.2 ohms true radiation resistance. Actually owing to R_g and R_d the total resistance is 5.8 ohms, and the aerial current is 1.20 amps. at 85 per cent. efficiency. I hope this clears up Mr. Richardson's difficulty.—Yours faithfully,

Frederic L. Hogg.

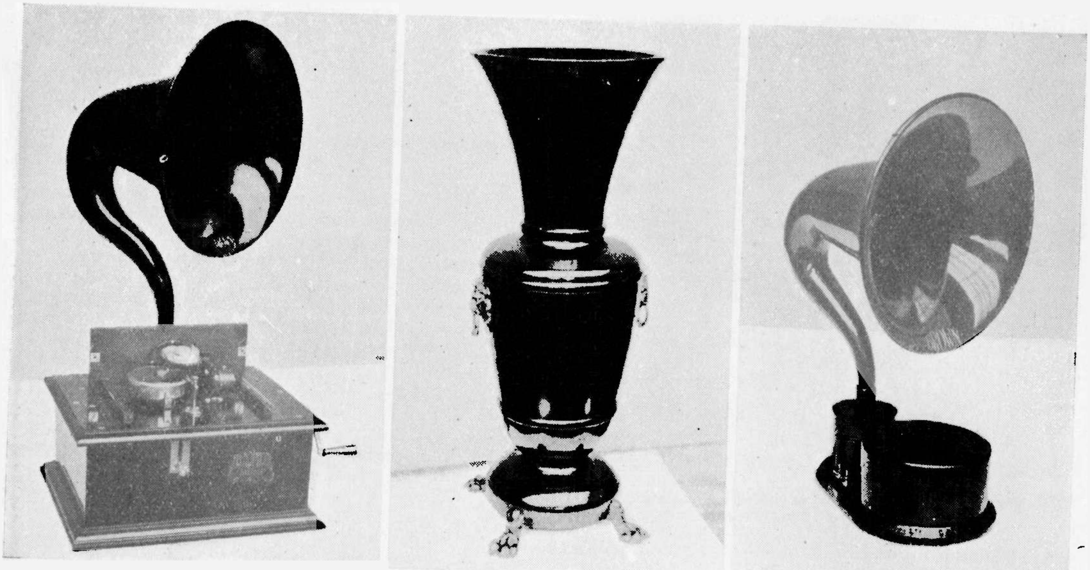
To the Editor of Experimental Wireless.

Dear Sir,—There seems to be a prevailing impression that when D.C. mains have their positive lead earthed they can only be used for high tension by putting a condenser in series with the earth lead (which still leaves the aerial at high potential), or using loosely-coupled circuits. This, however, is not the case; all that is necessary is to connect the bottom end of the inductance to the H.T. positive instead of the L.T. negative. All the tuning instruments, as well as the 'phones, are now at earth potential. Of course, if the first valve is a high-frequency amplifier, the grid condenser and leak have to be specially introduced.—Yours faithfully, W. Lawrence.

Some Impressions of the Wireless Exhibition.

That the second All-British Wireless Exhibition and Convention has been a gigantic success is no secret. Some idea of its popularity may be gathered when it is realised that at one time the queue of interested sightseers waiting to gain admission reached a length of some three-quarters of a mile. We offer our heartiest congratulations to the organisers who paid attention even to the most minute details with such gratifying results.

It is only natural to imagine that an annual exhibition of this nature should reflect the advance and progress which the industry has made during the preceding year. If we adopt this attitude, then we must certainly express some disappointment. Taking the exhibits as a whole, we cannot honestly say that we found signs of any startling improvements or innovations. True, the manufacturer has had to devote the whole of his time to meeting the demand for broadcast receiving apparatus, and perhaps thereby he has been unable to give as much time to research as he would have liked. Nevertheless we were able to notice some really excellently designed receivers. The exhibition was essentially a "broadcast show," and it would be unnatural to imagine that the experimental side of amateur wireless work should predominate



The Frenophone, a frictional loud speaker ; the Burndept "Vase" and the "Crystavox," incorporating a microphone relay.

Perhaps the most striking feature amongst modern developments was to be found in valve construction and loud-speaker design.

One could not glance even casually around the show without noticing the predominance of dull emitter valves, several new types making their first appearance. Amongst these were the Cossor "Wuncell," constructed on the lines of the familiar Cossor valve, and the small thoriated filament valve, such as the D.E.3, A.R.O.6, and B.4, which resemble the U.V.199 described in the November number of EXPERIMENTAL WIRELESS. Two other newcomers were the B.T.H. B.5, somewhat similar to the U.V. 202A and the Cossor dull emitter power amplifier. The construction of the latter is of interest, as it will be observed that the grid is very rigidly connected to the anode by means of a supporting glass lug. So far as power valves are concerned there is little to report, except, perhaps, the new Cossor low-impedance high-tension rectifier, in which the drop is only of the order of some 30 volts. This should be of special interest to amateur transmitters. We were interested to note that the Mullard 50-watt valve is now capable of being re-filamented.

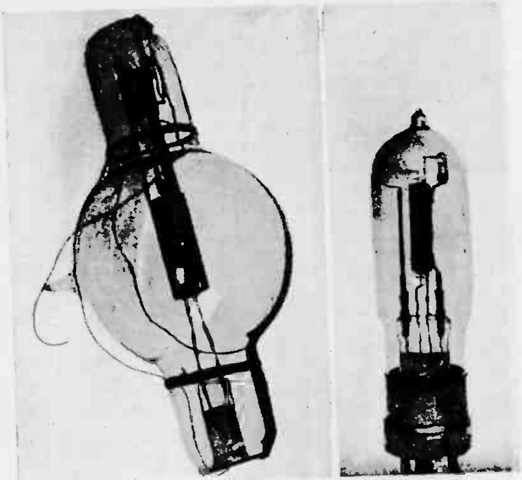
Progress in loud speakers has been in three directions. Better quality, better appearance and new principles have been the chief considerations. The well-known Amplion is now fitted with a wooden horn, a welded and pressed "throat," and an improved movement with a view to reducing resonance effects, resulting in an even more pleasing tone. In appearance the Burndept vase loud speaker is certainly the most novel. The Frenophone frictional loud speaker made its first appearance before the general public. A small Brown loud speaker, fitted with a microphone relay to operate from a crystal set, proved an attractive exhibit. Other attempts to eliminate resonance were to be found in the T.M.C. "copper-lead-copper" horn and the Hart Collins' instrument designed on the lines of the human throat.

While dealing with the subject of distortion, one may mention several loud-speaker filters such as the Beldam, Peronet and Fuller tone compensator. These components, of course, are connected to the output circuit, and are adjusted to give the desired speech quality.

So far as batteries are concerned, the most interesting exhibit was the Darimont primary cell, which is too complicated to deal with here. It may be said, however, that it has a remarkable performance, and we hope to discuss it at some later date. The Alkeum cell, shown by Radio Acoustics, Ltd., is a form of Edison battery having a voltage suitable for many of the dull emitter valves.

In the new Amplion the metal is welded and pressed and a wooden horn is used to prevent resonance.

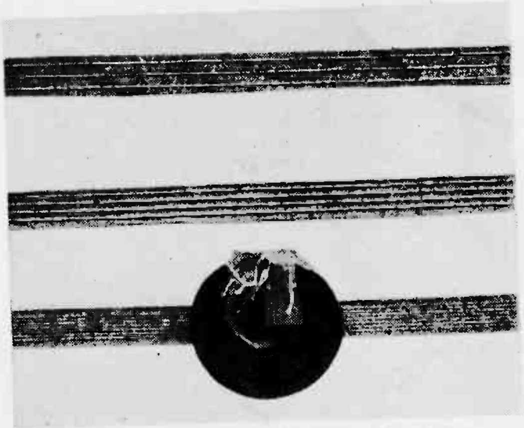
Coils of all types were very prolific, and one was apt to wonder what material advantages some of the specimens possessed. Perhaps the most interesting coil development was the "Cosmos Strip," consisting of several spaced wires fixed to a long roll of insulating paper. A multi-layer coil is wound with a strip and the two ends are subsequently cross-connected. Of course there are many possible permutations and combinations of connections, and many applications suggested themselves. It would seem that the strip could be of great use in the manufacture of high-frequency transformers. We were interested to note a new skeleton gimbal-mounted Igranic duolateral coil and coil-holder incorporating several novel features. Rough coupling is obtained in the ordinary way, final adjustment being secured by means of a long frictionally-geared anti-capacity handle. Another Igranic innovation is a type of high-frequency transformer composed of two concentrically-mounted duolateral rolls. While mentioning the subject of tuning, we noticed one or two rejector circuits or wave traps, such as the Radio Instruments and Peto Scott eliminators.



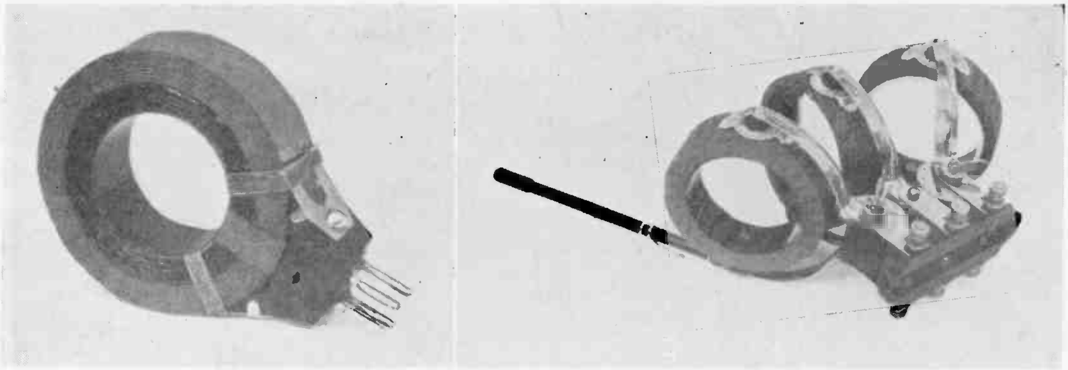
A new Cossor low-impedance rectifier and a dull-emitter power amplifier.

It was encouraging to see a greater selection of mechanically and electrically sound variable condensers, two examples being the Burndept low loss condenser and a square low brass plate condenser by the Sterling Telephone Co., Ltd. Double condensers for tuning two identical circuits simultaneously were also shown by the Dubilier Condenser Co., Ltd., Fallons, and A. W. Gamage, Ltd.

Rheostats and potentiometers were present in abundance, some very excellent American types being shown by the Ashley Wireless Telephone



"Cosmos Strip," used for winding multi-layer coils.



An Igranic duolateral H.F. transformer and their new coils and coil holder.

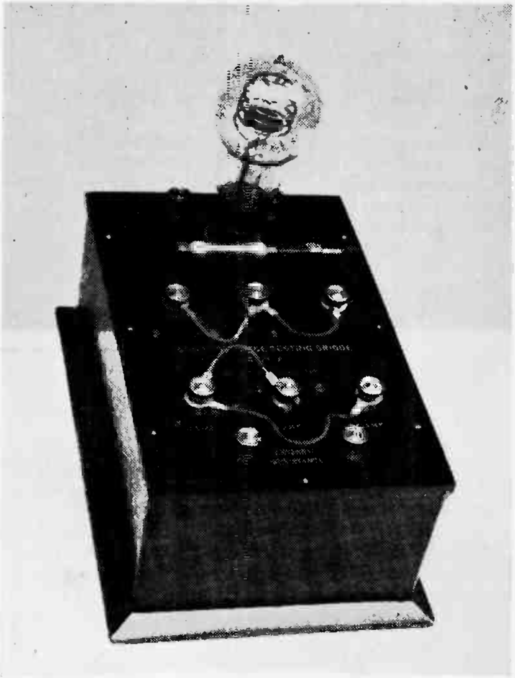
Co., Ltd., and Igranic Electric Co., Ltd. A glass-enclosed filament rheostat by Houghton was new to us. Practically every stand must have been a gold mine to the " gadget " hunter, as gadgets were very fully represented, so fully, in fact, that it is impossible to deal with them in such a limited space. However, we must certainly mention " Clix," a universal connector, and also " Polar Blox," the latest constructional outfit. Crystals of the " -ite " variety were to be found on many stands, and we were interested to see " YA1," a real synthetic specimen which functioned excellently.

A useful apparatus for comparing signal strength.

So far as complete receivers are concerned, there was a marked tendency to mount them in cabinets designed to tone in with existing furniture schemes. Here we may mention the Jacobean " Efescaphone," the beautiful lacquer finish of the Sterling Telephone sets, the Roger Foster & Howell set in an imitation piano, the beautiful cabinet model of the General Radio Co., Ltd., and the combined gramophone and wireless set by Abbey Industries, Ltd. The actual circuit which seems to have found most favour in the majority of sets is the tuned anode, but several transformer-coupled models were to be found, and also one or two reflex circuits such as the smaller Marconiphone, the Radiax set, and the Climax monovalve.

In addition to actual wireless apparatus itself, we noticed an audibility meter and a neon resistance bridge. Both these instruments are made by the Bowyer Lowe Co., Ltd.

Last, but not least, amongst the varied attractions, we must mention the demonstration of broadcasting by the B.B.C. Although we were informed on very good authority that some most excellent reproduction was obtained, our own experience was that on more than one occasion the speech was of somewhat poor quality, due, no doubt, to the somewhat trying conditions.



A neon resistance bridge in which measurements are taken by the flash interval.

One of our visitors described it as resembling an "elephant making a trunk call"!!

Business Brevities.

In our note last month describing the new instructional model of a two-valve set introduced by Messrs. George Philip & Son, Ltd., a printer's error made us refer to this as a 10-valve set. This was an obvious misprint; but we hope our readers will observe that this excellent model really describes a two-valve set.

* * *

A new book which will interest many experimenters has just been issued under the title of *The Radio Time Table*. This gives a full list of the transmissions from all the principal stations of the world during the 24 hours, so that an experimenter can see at a glance what to listen-in for at any hour of the day or night. The price is 6d., or post free 7½d. Any agent for EXPERIMENTAL WIRELESS, or from Percival Marshall & Co., 66, Farringdon Street, London, E.C.4.

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A new list issued by Messrs. Burndept, Ltd., Aldine House, Bedford Street, Strand, London, W.C.2, covers 88 pages. It is divided into five sections and deals with "Ethophones" and other receiving equipment bearing the B.B.C. seal, home constructional receiving sets, auxiliary apparatus and components, and transmitting apparatus. It is fully illustrated, and is priced at 1s.

* * *

Mr. H. Saville, Delamere Works, Stretford, Lancs., sends us his 6 H.S. Booklet. It gives illustrations of a number of wireless and engineering specialities supplied by Mr. Saville, and also a directory of Amateur Transmitting Stations in the Lancashire district and their call letters.

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Some samples of excellently-made basket coils have been received from Mr. F. Adcock, 39, Fore Street, Ipswich. These are known as the "Magna" coils, and are supplied in sizes suitable for wavelengths ranging from 100 to 10,800 metres. The special features of the coils are silk insulation, no wax, and rigid and regular windings. A list of sizes and prices may be obtained on application to Mr. Adcock.

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Messrs. Lionel Robinson & Co., 3, Staple Inn, London, W.C.1, send us a leaflet describing the "Ella" battery charge for A.C. circuits. It is a simple form of vibrating rectifier of the full-wave pattern, and works from any lamp holder.

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Two new lists have been issued by Messrs. Fuller's United Electric Works, Ltd., Chadwell Heath, Essex. No. 315 deals with wireless accessories, such as transformers, tone selectors, filament resistances, lead-in insulators, valve holders, potentiometers, fixed condensers, and coil holders. No. 250 B. covers the well-known "Fuller" accumulators for motor-car ignition and lighting, wireless and general purposes. Both standard plate type and block type cells are described.

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A wide range of good-class components are described and illustrated in a new 42-page list issued by The Sterling Telephone and Electric Co., Ltd., 210-212, Tottenham Court Road, London, W.1. These include 'phones of various patterns, variometers, condensers, valves, transformers, switches, keys, aerial equipment, and other useful accessories. The list is No. 368.

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Portable "Exide" Batteries are dealt with in the fourth edition of Catalogue P issued by The Chloride Electrical Storage Co., Ltd., Clifton Junction, near Manchester. A variety of types of cells are illustrated and described, including special high-tension batteries for wireless sets.

Experimental Notes and News.

The Postmaster-General, speaking at the Wireless Exhibition, said that 492,000 licences had been issued as the result of the recent campaign, or just four times as many as there were in March last. He also said that he was about to appoint a Broadcasting Committee, composed of representatives of the industry, the public and the Press, so that future Postmasters-General would not have to carry the whole burden on their shoulders.

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Election results are to be broadcast between 10 p.m. and midnight on December 6 and December 7. The results will be issued simultaneously from all B.B.C. stations.

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Dr. A. M. Low, writing in the *South Wales News*, says :—"I have already used a television machine of a crude sort. Placed 'looking' at a field, and with the twin apparatus one mile distant, the machine, piercing all obstacles, revealed the figures of men walking in that field. The vision, however, was so dim and vague that one could not distinguish such details as features or whether a cap or hat was worn by the individual."

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It is reported that Mr. H. Knight, a Hull amateur, has recently received a complete church service broadcast from New York between 12.30 and 1.45 a.m. The congregational hymns, an anthem, the sermon and prayers, and the sound of the people leaving the church, were perfectly audible.

* * *

Hearing a football match being played 150 miles away is a stepping-stone towards seeing it. Students of Princetown University, New Jersey, recently listened-in to their team playing a U.S. Navy team at Baltimore, some 150 miles distant. The students gathered round on the lawn, where four big projectors were in place on the roof of a motor car, and the various happenings in the game were described by an observer on the spot.