THE WIRELESS WORLD

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CONTENTS

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THE WIRELESS WORLD

THE OFFICIAL ORGAN OF THE WIRELESS SOCIETY OF LONDON

VOL. VIII. No. 3. MAY 1ST, 1920 FORTNIGHTLY

THE DISCOVERY OF ELECTROMAGNETIC WAVES.

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

HERTZ'S researches, which eventually led to the discovery of these waves, were commenced in 1879, but with a somewhat different object in view. In that year a prize had been offered by the Berlin Academy of Science for the investigation of a problem involving the experimental establishment of a connection between electromagnetic forces and the polarisation of dielectrics. This research was not at first successful, but in the course of these and subsequent investigations, in 1886 and 1887, several rather puzzling effects were observed in the reaction between a primary circuit and a secondary circuit, both of which contained spark gaps. Contrary to expectation, it was found that the primary was able to influence the secondary and to cause sparks to occur in it at very much greater distances than were predicted from the then accepted views of electrical forces.

Prior to this time, Maxwell had developed a mathematical theory of electromagnetic action, but at the time of Hertz's experiments the validity of this theory was not fully recognised in Germany. Helmholtz had, by making certain assumptions, also deduced similar equations to those of Maxwell's theory, and it was largely to test the consequences of these assumptions that Hertz's experiments were undertaken. He was desirous of proving that electric displacements in a dielectric (or dielectric "polarisations," as they are also called) could produce the same electromagnetic forces as the currents which are equivalent to them. It was felt that if this relation could be found, the truth of Maxwell's equations would be more firmly established, and, with it, the accuracy of the theory—that light waves in the aether are an electromagnetic phenomenon. The full results of Hertz's researches, however, accomplished more than this, for they not only established the connection that he was desirous of proving, but at the same time showed the actual presence of true waves in the aether, produced, not by a source of light, but solely by electromagnetic means.

Hertz's apparatus took on many forms during the course of his researches; but it will be sufficient for our purpose to describe one of them.*

When an electric condenser, which may be typified by a Leyden jar, is charged up to a high potential and then suddenly discharged, we obtain, as is well known, a spark between the ends of the discharging rod as we approach them to the jar. It had previously been shown by Joseph Henry (1842) and others

* For those desiring further information an excellent account of the original experiments is given in Hertz's book "Electric Waves." (Translated into English by D. E. Jones. Published by Macmillan & Co.)

that such a discharge possessed an oscillatory nature, provided that the resistance of the discharge path was not too high. The oscillatory nature of the discharge implies that the electric charge stored up on the coatings of the jar surges backwards and forwards from one side to the other. It may, therefore, be seen that the glass dielectric between the coatings is alternately strained in one direction and then in the other—that is, that the dielectric strain is alternating in character. The essential feature of Hertz's early apparatus may be described as the opening out of the coatings of a Leyden jar or similar condenser and placing them as far apart as possible, leaving only air between them as the dielectric. The two coatings thus spread out then become two metal plates joined together by a connecting wire, in the middle of which is placed a small spark gap. In order to maintain a succession of oscillations in this condenser, the terminals of the spark gap were connected to an induction coil, which thus served to charge up the two plates to a high voltage, after which they could discharge through the small spark gap between them.

Dr. Heinrich Rudolph Hertz.

The effect of this spreading out of the plates of the condenser was to spread out the alternating dielectric strains taking place in the air between them. The result of Hertz's experiments was to show that these dielectric strains could set up electromagnetic waves in the aether which are propagated through space with the velocity of light, namely, 186,200 miles per second.

To detect the presence of these waves Hertz made use of a small circle or rectangle of wire of such a size that its natural electric oscillation period was identical with the natural oscillation frequency of his oscillator. The circle or rectangle of wire included a minute spark gap at one point, and the presence of the waves was indicated by the occurrence of small sparks across its spark gap when the receiving loop was placed in the appropriate positions.

In order to obtain the best effects, this "resonator," as it is frequently called, must have a certain size in relation to the oscillator, so that, as mentioned above, they may have the same oscillation period. In one of Hertz's experiments the oscillator consisted of two square brass plates of 40 centimetres side (=15¾"), connected together by a stout copper wire 60 centimetres (approximately 2ft.) long. This wire was broken by a small spark gap in the centre. The secondary circuit suitable for use with this oscillator was either a circle of 25 centimetres radius (13¾"), or a square of wire of 60 centimetres side (approximately 2ft.) In the case of both these resonators the spark gap was adjustable by means of a micrometer screw, and for convenience it could be observed through a lens in order to detect minute sparks.

When the oscillator was set going, and sparks were taking place regularly at its spark gap, it was found that sparks were observed in the resonator or secondary circuit when it was in some positions relative to the oscillator but not in others. Three chief positions were defined by Hertz, namely, first, with the secondary conductor with its centre on the horizontal base line passing through the spark gap of the oscillator and its plane in the vertical plane passing through the base line; second, with the centre of the secondary conductor still on the base line but with its plane turned to be perpendicular to the base line; and, third, with the plane of the secondary conductor turned down into the horizontal position while maintaining its centre still on the base line.

In the first position no sparks whatever were observed in the secondary circuit. In the second position sparks were observed in the secondary circuit whenever the spark gap was either above or below the horizontal plane through the base line ; but no sparks appeared when the spark gap was in the plane of the base line. As the distance from the oscillator was increased the length of the sparks diminished, but they were observed up to considerable distances. In the third position the strongest sparks were observed when the spark gap faced the oscillator, but they diminished in intensity as the spark gap was moved from this position, reaching a minimum value on the side farthest from the oscillator.

An interesting experiment may be performed with this apparatus, illustrating the formation of stationary waves on a wire. For this purpose a convenient arrangement is to stretch up a horizontal bare copper wire (which may be of any convenient size) connecting one end of it to a metal plate about 1 foot square, placed parallel and close to one of the oscillator plates, and leaving the far end of the wire free and well insulated from the earth. (Fig. 1.)

In order to obtain the best results, the length of this wire must be adjusted so that a whole number of wavelengths may be set up in the wire as, in that case the wave, when it reaches the end of the wire and is reflected back again, is able to reinforce the direct wave coming from the oscillator. For an oscillator of the size described above good results may usually be obtained with a wire 8 metres long (approximately 26′ 3″). To detect the presence of the waves in this wire the resonator should be held in a plane passing through the wire and preferably with its spark gap close to the wire. As the resonator is moved along the wire from one end to the other the intensity of the sparks will be found to vary and to regularly reach a maximum intensity and then die away again. By marking the positions on the wire where maximum sparking occurs, the wavelength of the oscillation may easily be found.

Similar results may also be obtained by reflecting the free waves in air by means of a large sheet of metal. By moving this metal reflector to various distances from the oscillator, positions may easily be found at which the reflected wave reinforces the direct wave, producing a stationary wave in the space between the oscillator and the reflector. By using the resonator in a similar manner to that described above, the wavelength of the oscillations may also be found by this method.

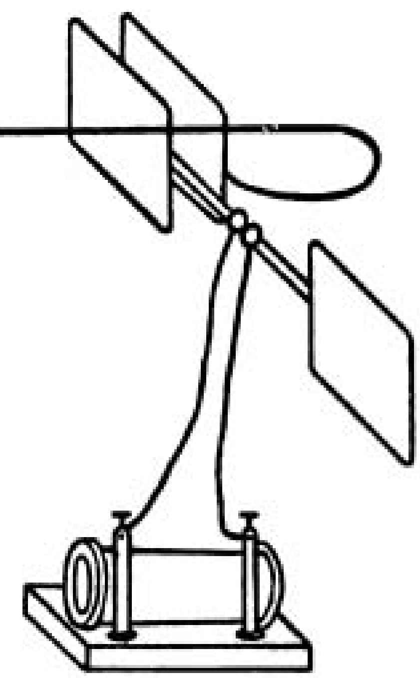

Fig. 1.

Besides simple reflection, a number of other optical effects, such as refraction, polarisation, etc., may fairly easily be demonstrated, using apparatus of this type ; but for purely experimental purposes, it is often more convenient to utilise a somewhat more sensitive receiver than the original micrometer spark gap and resonator used by Hertz. For this purpose a small coherer or thermo-electric detector may possibly be used with good results. Some particulars of a simple apparatus of this type will be given in a later article.

A HIGH POWER WIRELESS TELEPHONY INSTALLATION

By Frank P. Swann.

Wireless men far and wide were delighted with the opportunities for observing wireless speech and music which were furnished to them by the Marconi Company's station at Chelmsford from February 23rd to March 6th, and we feel sure that the following description of the apparatus used will be of great interest not only to those who actually heard some of the programmes but to all our readers.

IN 1913, experiments for the design of a small power valve wireless telephone set were commenced, and early in 1914 such sets were actually being manufactured. The range of these sets was 50 kilometres, but during the tests the longest range that could actually be attained was never determined. By means of a valve and a 500-volt anode battery, continuous oscillations were produced in a closed circuit, and this was coupled to the aerial in the ordinary way. The microphone was inserted directly in the aerial.

The development in wireless telephony during the war was with regard to low power sets only, and these were for aircraft work.

Since the armistice, however, rapid progress has been made in the development of high power valve telegraph and telephone sets. The Marconi 6 kilowatt telegraph and telephone transmitter is one of the most recent developments, and an illustration of this set is shown in Fig. 1. Wireless telephone tests with this set were carried out in January of this year to Madrid, and the results with regard to both telegraph signals and speech were very successful, for both were reported at Madrid as of exceptional strength and quality.

Work was then commenced on the erection, in the experimental building of the Marconi Works at Chelmsford, of a similar but larger set than the above, and this was the first 15 kilowatt set. In order that reports might be obtained from many places with the use of various types of receivers, it was decided to give some programmes with this set on a well-known wavelength, and that of Poldhu was the wavelength chosen. From February 23rd to March 6th speech was transmitted from Chelmsford daily between 11.00 and 11.30 and between 20.00 and 20.30 G.M.T. In addition to the daily news, vocal and instrumental selections were given.

Fig. 2 shows the diagram of connections of the circuits employed. The source of power is a 200 cycle, 500 volt, 15 kilowatt alternator, and this feeds the primary of a 20,000 volt transformer, the secondary or high-tension winding of which has its middle point brought out. By the use of two rectifying valves connected to this secondary, as shown in Fig. 2, it becomes possible to charge the condenser K_1 unidirectionally every half cycle ; but, of course, only to half the total secondary voltage. By this means K_1 is kept charged at about 10,000 volts, and acts as the source of high tension direct current supply feeding the transmitting valves and the low frequency magnifier valves as shown. The two high frequency circuits are the aerial, AL_1E, and the closed circuit L_2CK_2. A continuously oscillating current is maintained in L_2CK_2 by the transmitting valves and the reaction coil R. The energy in this circuit is transferred to the aerial by the coupling coil C.

For the wavelength used the frequency of the continuous oscillations in the aerial is approximately 100,000 per second. In order that speech may be obtained at the receiving end the high frequency transmitting aerial current must be modulated in accordance with the wave forms produced by speech. An approximate value of the frequency of the

A HIGH POWER WIRELESS TELEPHONY INSTALLATION

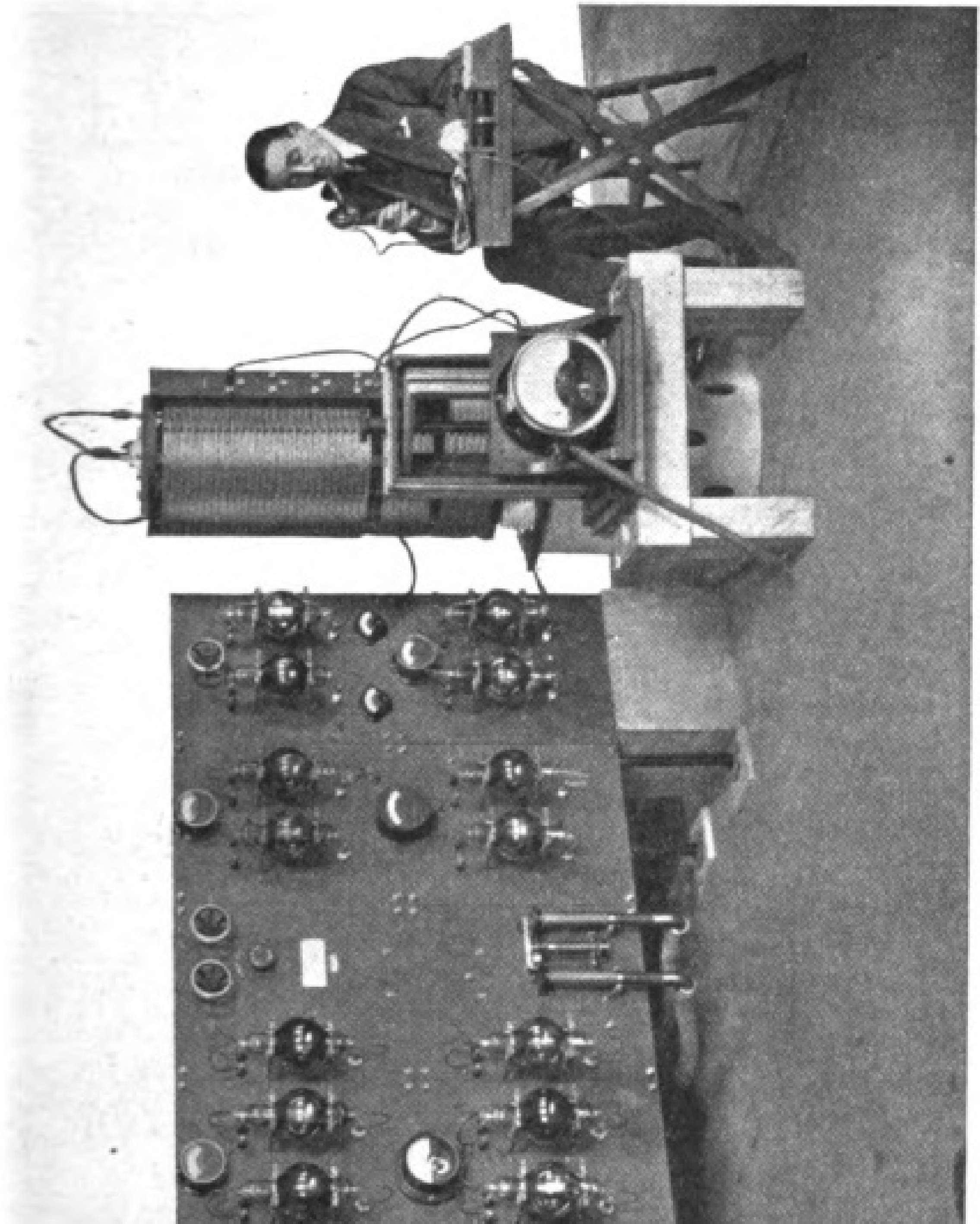

Fig. 1. A 6 K.W. Wireless Telegraphy and Telephony Transmitter.

Our illustration shows Mr. W. T. Ditcham, whose voice is now known to many of our readers through the medium of Wireless Telephony. Mr. Ditcham is a pioneer of that science, having evolved one of the earliest systems.

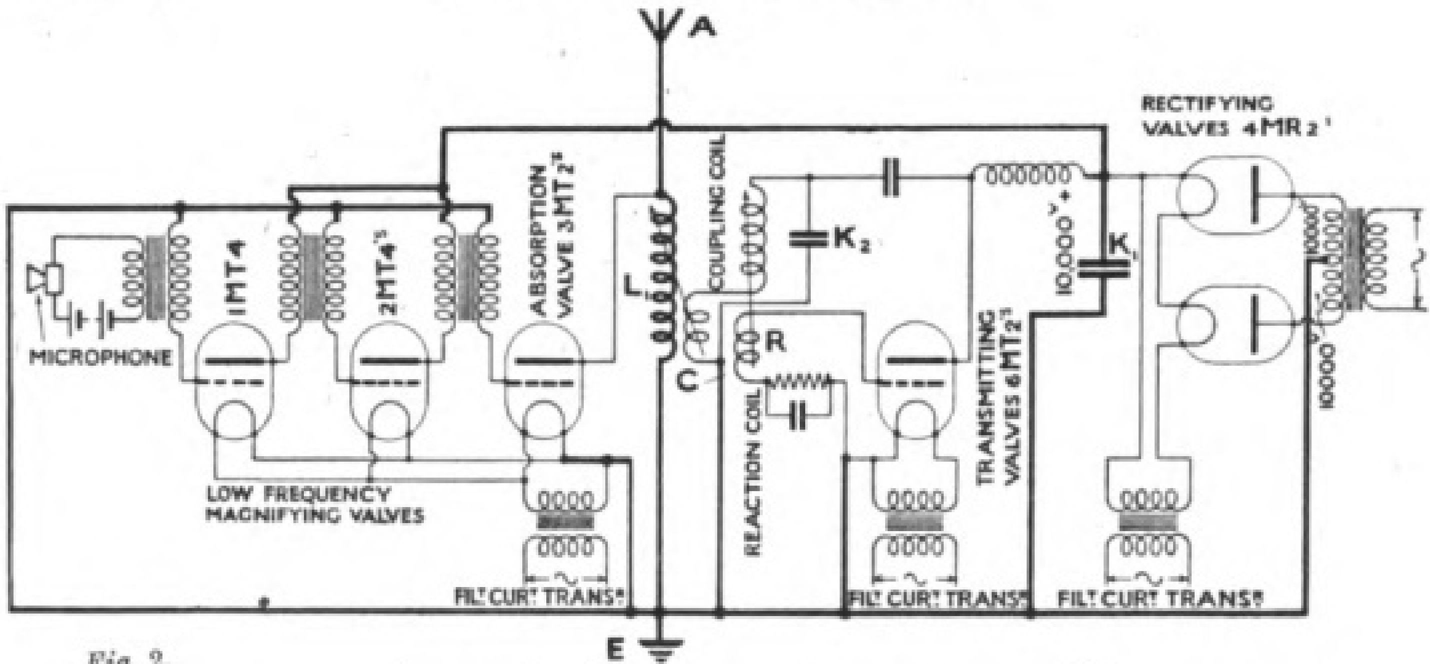

Fig. 2.

Diagram of connections of apparatus used during the two weeks' test.

speech wave may be taken as 800 cycles per second, but instead of being a sine curve, it is one which is rich in harmonics. It is the distortion of these harmonics which produces bad quality speech. There are several methods by means of which the aerial current may be modulated in accordance with the speech frequencies; the one used, however, and that which is found to give the best quality speech, is to absorb the energy in the aerial in accordance with the speech wave form. If Fig. 2 be referred to it will at once be clear how this is effected. The variations in the microphone current are transformed up to produce a curve of varying voltage, which is similar in shape to that for the varying current. By means of a two-stage low frequency amplifier, the amplitude of these voltage variations is magnified up, and they are then impressed on the grids of the absorption valves. The resistance of a three-electrode valve varies with the voltage impressed on the grid, and therefore the conducting power of the absorption valves will follow the varying voltage curve produced by the speech. As the absorption valves are connected across the aerial tuning inductance, these valves will

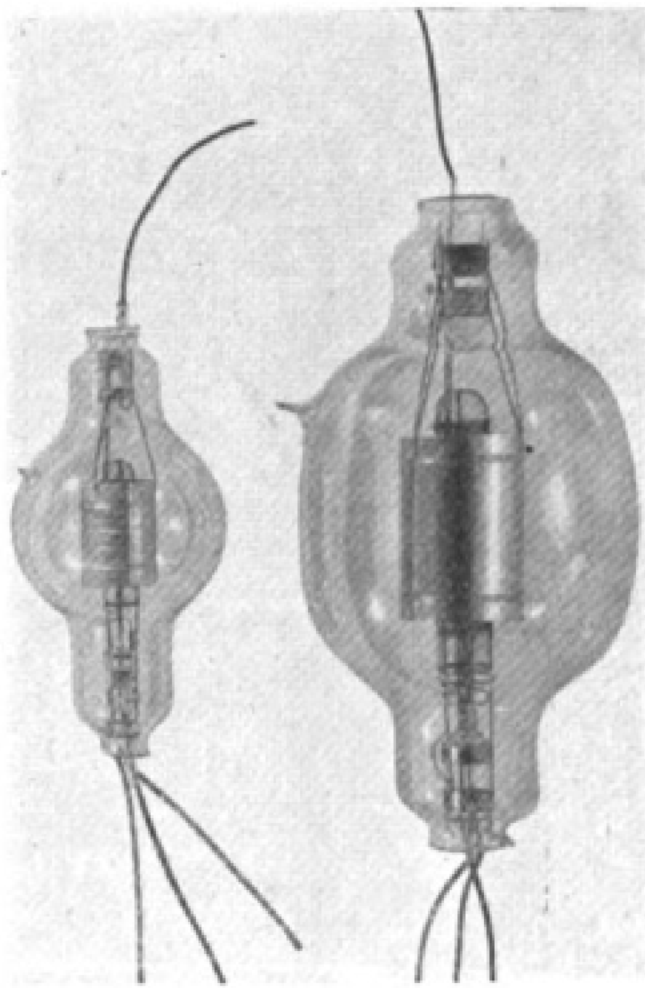

Fig. 3.

absorb energy from the aerial in the varying degree to which they are made conductive by the impressed speech volts. This energy is dissipated as heat in the valves themselves, and therefore they must be big enough to stand this energy loss without getting overheated.

The MT2 and MT4 valves are illustrated in Fig 3. An approximate idea of their dimensions may be obtained from the foot rule which is photographed with them. These valves are like a very much enlarged form of the ordinary three-electrode receiving valve; the filaments are made of tungsten, and the anode and grid are of nickel. The mechanical details of the construction are really the only novelties. The resistance of these valves is much higher than that of receiving valves in order that they may withstand the higher voltages, and the vacuum is made as high as it is possible to obtain with the most modern pumping appliances.

Referring to Fig. 1, the six valves (MT4's) on the left-hand end of the panel are the transmitting valves. The rectifying valves (MR4's) are the four valves in the middle of the panel. Of the four valves (MT4's) on the right-hand end of the panel, three are absorption valves, and one is a low frequency magnifying valve. In this case the low frequency amplifier consists of one stage only, as against two stages shown in Fig. 2. In the middle of the panel, at the bottom edge, will be seen the electromagnetically operated key which is used for keying when the set is being used for continuous wave telegraphy. During telephony, of course, it is not in operation.

In spite of the many precautions that are taken, the voltage across the condenser K_1 does not remain absolutely constant, but varies slightly for each half of the 200 cycle supply. The aerial current follows this slight variation of the supply volts, and this produces the hum which is heard at the receiving end when speech is not being transmitted.

The fortnight's test referred to, which marks the inauguration of the first wireless telephone news service in the world, was highly successful, good speech being received on ships over 1,000 miles distant and using only the ordinary wireless telegraphy receivers

WIRELESS TELEPHONY ON AIRCRAFT

The development of wireless telephony for aviation purposes is proceeding rapidly. The results of the latest tests are very gratifying. Wireless telephonic messages were picked up recently from a Handley-Page aeroplane at a distance of 120 to 125 miles, the signals being clear and distinct, and it is now possible for a passenger on an aeroplane in flight to call up a ground wireless station, and be connected up from that station to any ordinary telephone within a reasonable radius. The great advantages that will accrue to aviation from the use of wireless telephony are obvious. Hitherto, one of the difficulties encountered and not easily dealt with has been the successful landing of aircraft in foggy or hazy weather, etc. In the future, fog, in this respect, will offer little inconvenience, as the aeroplane pilot will be able to ring up a ground wireless station and have his exact position 'phoned back to him, the position being obtained by wireless direction finding.

From an aviation point of view, wireless telephony is an improvement on wireless telegraphy, as it saves a machine carrying the dead-weight of an operator to attend to the telegraphic apparatus. With wireless telephonic apparatus a knowledge of Morse is not necessary, and the pilot can himself carry on, by 'phone, the necessary communication.

In our next issue we shall publish an article describing the first commercial flight from London to Paris of a Handley-Page aeroplane fitted with wireless telephony apparatus. Written by a wireless man who made the flight, this article is of unique interest, especially as we are privileged to reproduce with it some very fine photographs.

NOTES AND NEWS

The Elektrotechnische Zeitschrift of February 5th contains an article describing the destruction of the great wireless station at Kamina, in Togoland, written as a sort of counterblast to the article we published on the same subject in our December, 1919, issue. The author of the counterblast, to whom the work of destruction was entrusted, evidently felt that some explanation is called for, and confides to his readers his reason for making such an awful hash of the station, when, as our article pointed out, a true engineer would have been content to destroy only vital parts. The reason is, that he had not sufficient time. We think it more likely that the destruction of the vital parts could have been accomplished in less time than the ruins which were actually brought about. From our photographs it would seem that an enormous crowd of natives were allowed to run *amok* over the station.

The critic of our article is so convinced that no good word for anything German could possibly be said by his late enemies that he even mistakes for adverse criticism an implied compliment about the duplication of the machinery. We can well believe, as he says, that the wireless staff at Kamina were pained at having to destroy the work of their hands, and we think the fact only serves to justify our wonder that they could have infused so much "hate" into the job.

Interplanetary Wireless Again. — Under this title a writer in the *Telegraph and Telephone Age* of March 16th, presents us with the following gems, whilst seeking to explain the probable origin of those "messages from Mars."

"Each body (of the solar system) is automatically and independently rotated upon its axis by the all-pervading ether of space, which is an adamantine expanse of static electricity or magnetic field . . ."

"The sun, an incandescent globe, is fired by friction against space."

"The aqueous ocean is another body of liquid gases also maintained as such by the earth's heat."

"The aurora borealis and australis are the charge and discharge of electromotive force from space."

"A veritable trinity—electricity, the primary; heat, the secondary; light, the teritiary (*sic*)—and resolves into its primal state, without loss—one hundred per cent. efficient, therefore never lost, infinite, omnipotent and omnipresent."

An automatic wireless transmitter for aeroplanes will be exhibited, it is announced, at the Aero Show, to be held at Olympia, London, in July next. In one form the instrument consists of an aluminium box, on the front of which is a series of messages engraved on plates in three rows, with a plug socket beside each message. The pilot simply has to insert a plug and depress a handle, which causes the selected message to be automatically transmitted.

The Steady March of Wireless.—A commercial wireless station at Jamaica, Long Island, has been established by the Radio Communication Company (America). Its call sign is WSK, and it will handle traffic to and from coastwise and transatlantic vessels.

A wireless telegraph service has been established between N'guimi, Upper Senegal and Niger, and Lamy, Abéché, Ati, Fada, Faya, Mao and Roro-poro.

Salina Cruz, Mexico, is to have a wireless telegraph station which will be erected by the Mexican Government Telegraphs. The apparatus is a Marconi low-power set, originally intended for ship-board, and which was purchased by the Mexican Government some four years ago. Since that date it has been stored in Vera Cruz. The aerial system will be of the umbrella type, mounted on a pole 8 metres high, on the top of a skeleton tower 72 metres high. The installation will include an electric motor run by current from the Salina Cruz power plant and a belt-driven generator of 5 K.W. capacity. A spare petrol engine will be in reserve to cover any failure of the power plant. It is expected that the station will link up Salina Cruz with Mexico City, 480 miles away.

The Royal Institution.—The following lectures, announced to be given at the Royal Institution, may interest some of our readers:—Friday, May 21st, at 9 p.m., "The Thermionic Valve in Wireless Telegraphy and Telephony," by Dr. J. A. Fleming, F.R.S. Saturdays, May 29th and June 5th, at 3 o'clock: "Recent Revolutions in Physical Science," by Mr. J. H. Jeans, LL.D. (Secretary, Royal Society).

The Institute of Radio Engineers (America) has chosen the following officers for 1920:—President, Mr. J. V. L. Hogan; Vice-President, Mr. E. F. W. Alexanderson; Treasurer, Mr. W. F. Hubley; and Secretary, Mr. A. N. Goldsmith. These officers, together with the following gentlemen, will constitute the Board of Direction of the Institute: Major-General George O. Squier, Mr. W. H. G. Bullard, Mr. E. H. Armstrong, Mr. R. H. Marriott, Mr. D. Sarnoff, Mr. D. McNicol, Mr. L. Espenschied and Mr. F. Cutting.

Société Independante Belge de Télégraphie Sans Fil.—Under this title a new Company has recently been formed at Brussels, with a capital of 1,000,000 francs in 2,000 shares of 500 francs each, 1,000 shares being reserved to the founders. Amongst the objects of the Company is the exploitation of wireless telegraphy and telephony.

In a recent issue of the *British and Foreign Journal of Engineering* appeared an article dealing with the Mcgruer Hollow Spar. Amateurs might like to know that the Hollow Spar is (amongst other things) suitable for amateur wireless masts.

DIGEST OF RADIO LITERATURE

CONSTRUCTION OF A SIMPLE RADIO TELEPHONE. E. S. Rogers. (*Radio Amateur News, New York; January*, 1920; *p.* 343.)

A short article, giving the constructional details and a few points on the operation of a wireless telephone set, built by the author (a Canadian wireless amateur). A photograph of the apparatus and a diagram of the circuit are included.

MAGNETIC STORMS. Lindley Pyle, Professor of Physics, Washington University. (*Electrical Experimenter, New York; January*, 1920; *p.* 876; *continued on pp.* 920, 922, 923, 924.)

The subject of magnetic storms and electrical disturbances generally is of peculiar interest to wireless enthusiasts, and this article, which is accompanied by splendid illustrations, deals with the sources of magnetic storms and their effects. It also describes apparatus employed to record and measure the disturbances, detailing results obtained.

TELEGRAPHING BOATS THROUGH CHANNELS AND ALONG COASTS. R. H. Marriott. (*Telegraph and Telephone Age, New York; January 1st*, 1920; *pp.* 4–7.)

In this article Mr. Marriott deals with an electrical signalling method for guiding craft into harbours, through narrow or dangerous channels, along coasts, etc. Up to the present fog has resulted in holding up many ships at harbour entrances: with the new method described, this difficulty can be overcome, and ships guided into and out of harbour regardless of fog. A signal-carrying conductor is installed along the sides of or under the channel which picks up signals from the vessel, and a receiving device is installed on the bottom of the ship. Three illustrations accompany the article.

WIRELESS TELEPHONY. Reprint of paper by N. H. Slaughter, D.S.M., presented at a Joint Meeting of the Electrical Section and the Philadelphia Section, American Institute of Electrical Engineers, held in October last. (*Journal of the Franklin Institute; January*, 1920. *Published by The Franklin Institute of the State of Pennsylvania, Philadelphia: Agents: B. F. Stevens & Brown,* 4, *Trafalgar Square, London, W.C.*2.)

This article, which is copiously illustrated, starts with a historical summary, and goes on to describe how the vacuum tube is utilised for wireless telephony. Its use on aeroplane sets is touched upon, and a diagram of an aeroplane wireless telephone set is given. Mr. Slaughter also deals with wireless telephony as related to and contrasted with wireless telegraphy.

WELL-DESIGNED CRYSTAL DETECTORS. (*Everyday Engineering Magazine, New York; January*, 1920; *p.* 187.)

A short article with four illustrations, giving ideas for making crystal detectors suggested by the types of detector built by the Wireless Speciality Apparatus Company, of America.

A RADIO TELEPHONE TRANSMITTER. M B.. Sleeper. (*Everyday Engineering Magazine, New York; January*, 1920; *pp.* 222–224.)

Article dealing in detail with the construction of a wireless telephone transmitter for short distances. The sectional panel system is employed. The article is splendidly illustrated.

NOTES ON RADIO ANTENNÆ. (*Everyday Engineering Magazine, New York; January*, 1920; *pp.* 229–230.)

Article giving a few suggestions for overcoming the disadvantages of large aerials. The article is designed for amateurs who, for lack of space or funds, and also at present through Governmental restrictions, are unable to use any but small-sized aerials. Various types of antennæ are dealt with.

THE WORK OF THE BUREAU OF STANDARDS. (*Everyday Engineering Magazine, New York, January*, 1920; *pp.* 232–233.)

Gives a list of the radio tests made by the Bureau. Tests are undertaken for amateurs at reduced fees.

THE PROCEEDINGS OF THE WIRELESS SOCIETY OF LONDON

HARMONICS IN C.W. TRANSMISSION.

By L. A. T. Broadwood, A.M.I.E.E.

An Ordinary General Meeting of the Society was held on March 26th, at 6 p.m., in the Lecture Hall of the Institution of Civil Engineers, the President, Mr. A. A. Campbell Swinton, occupying the chair.

After the minutes of the previous meeting had been read and confirmed, Mr. L. A. T. Broadwood delivered his Paper, which was followed by a discussion and a vote of thanks to the lecturer. A discussion then took place on the question of the admission of ladies to membership, and it was decided by a unanimous vote to admit ladies. Finally, a number of exhibits of wireless apparatus were described and explained by the exhibitors.

Mr. L. A. T. Broadwood, A.M.I.E.E.: The action of any circuit working in conjunction with a valve to produce alternating currents should not be taken for granted.

It is easy to take some inductances and condensers, valves and batteries and make up a circuit to a diagram given in a technical paper or textbook, and to produce oscillations of a sort, but no real increase of knowledge can be gained unless the experimenter asks himself the question : "How and why does this work ?" Beginners are apt to race along, to get readings in a hot-wire ammeter, without pausing to think. I will not, therefore, apologise for starting with elementary theory.

Fig. 1 represents an ideal curve, which shows how the plate current in a valve varies with different potential differences between the grid and the filament at constant plate battery potential and filament current. As the filament is heated electrically, there is a potential drop from the positive to the negative end of the filament, and in taking readings for characteristic curves it is usual to connect the grid in series with a suitable battery to the negative end of the filament. Hence, the grid voltage on the curve is that applied between the negative end of the filament and the grid. Notice that the perpendicular or ordinate through zero grid volts cuts the curve at half saturation current,

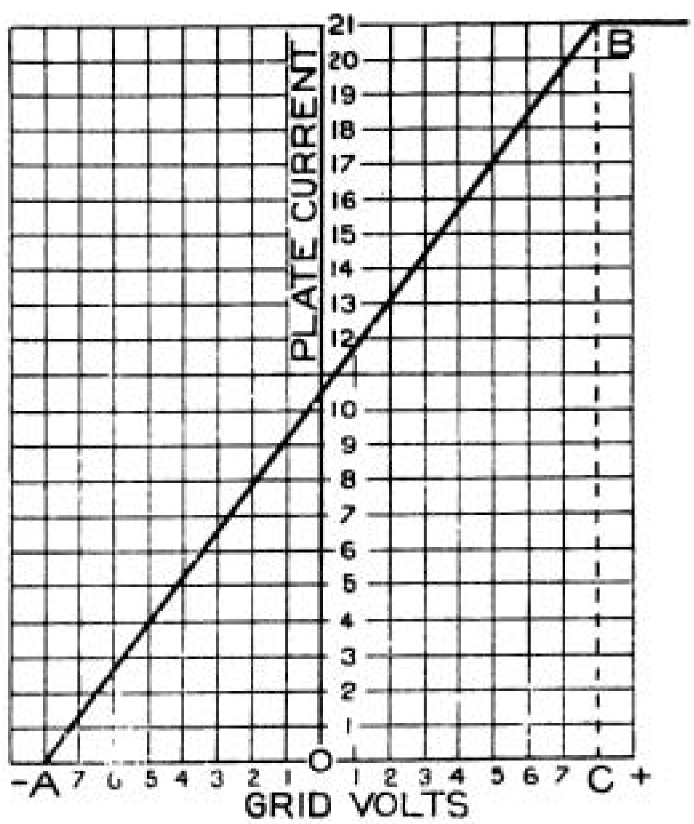

Fig. 1.

and that A B is a straight line. At all parts of the curve between A and B the slope or gradient is constant ; therefore, provided the grid volts do not vary beyond A and C, the plate current variation will be an exact copy of the grid volt variation, however complex this may be.

We can look upon grid volts as performing the same function as the slide valve in a steam engine. The slide valve is attached by means of a connecting rod to a crank, or eccentric, whose revolution will cause it to travel to and fro between A and C. There will be a cylinder at an angle to the valve travel, the piston being connected to a second crank on the same shaft as the volt crank. A B is the cylinder axis.

The volt valve then moves horizontally and the current piston at an angle.

The current piston is the driver and the volt valve is driven. The volt valve thus controls the admission of current to the current cylinder.

In the case of a three-electrode valve generating alternating currents, an inductive coil is connected in series with the plate, a battery and the filament, and a second inductive coil is connected in series with the grid and the filament. A condenser is connected in parallel with either or both of the coils. The coils are inductively coupled together, so that a change in plate current will produce a change in grid voltage.

Let the characteristic be the same as in Fig. 1 such that, when no oscillations are taking place, grid volts are zero with respect to the negative end of the filament and plate current is at half saturation value. Let the coils be so arranged that a decrease in plate current makes the grid volts increase in a positive sense, then no oscillations can take place, because immediately the plate current tends to decrease the grid volts tend to rise positively and bring the plate current back to its original value.

If the connections to one of the coils are reversed then the oscillations can take place, provided that, if condensers are connected to each coil, the respective circuits are in tune. Oscillations can always take place, provided that a condenser is connected to one coil only and the coils are connected up correctly.

Take the case of tuned plate coil and untuned grid coil, as in Fig 2, which shows the transmitting circuit of one of the earliest C.W. sets supplied to the Army overseas. Assume for the time being that the aerial and earth are disconnected and that oscillations are taking place.

At any instant of time the potential difference between the grid and the negative end of the filament is directly proportional to the time rate of change of the total current traversing the plate coil.

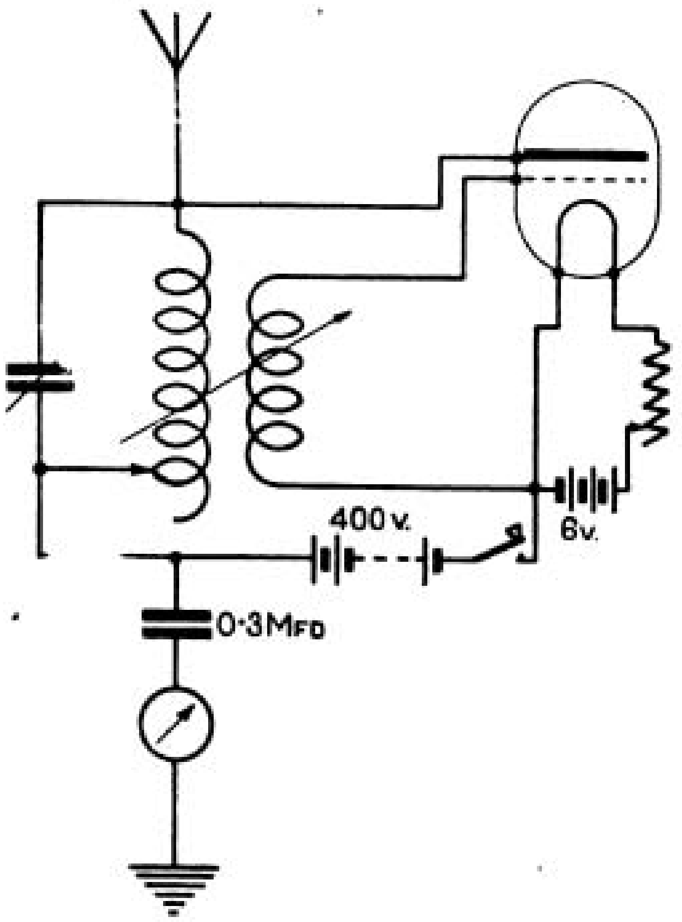

Fig. 2

Referring again to elementary theory, take the case of a simple air core transformer, in which current from a battery can be varied in the primary coil. We can have a steady current of large value traversing the primary coil, yet there will be no potential difference at the terminals of the secondary coil. As soon as the current in the primary is varied there will be a potential difference set up at the terminals of the secondary coil, whilst the change in current is taking place. For example, starting from 1,000 amperes in the primary coil, we can reduce the current at the uniform rate of 1 ampere per second, and provided the mutual and self inductances are of suitable value, the potential difference at the terminals of the secondary will have a constant value of 1 volt. If we reduce the current at the rate of 2 amperes per second, the potential difference will have a constant value of 2 volts.

If the current in the primary is an alternating current of pure sine form, then the potential difference at the terminals of the secondary will be an alternating E.M.F. of the same form, but differing in phase with the primary current.

Consider the case of a simple clock pendulum, swinging to and fro. The pendulum comes to rest at each end of its travel. When at rest, there is no change in its position. Let the left-hand limit be negative, and the right-hand limit be positive. Notice that at both limits the distance from the ground to the bob is a maximum, whilst the action of gravity is such that at the positive maximum the ensuing motion will be in a clockwise direction, and *vice versa.*

Similarly, the primary current changes from a positive maximum to a negative maximum, whilst its value is constant at these two points. The secondary E.M.F. corresponds to the velocity of the pendulum, and its value will therefore be zero when the current is at a positive or negative maximum, and at a positive or negative maximum when the current has fallen from a negative or positive maximum to zero respectively.

The natural position of rest of a clock pendulum coincides with the mid position of its travel when it is swinging or oscillating. The rest position, and hence the mid point of its travel, corresponds with zero current in the analogous electrical case.

If the pendulum swept through an angle of 180°, the mid point of its travel would be 90° from the positive and negative maxima, and the point of maximum velocity would therefore be 90° from the positive and negative maxima. Starting from either of these latter points, notice, that as regards time, maximum velocity is attained 90° later than zero velocity.

Similarly, the secondary E.M.F. will lag 90°, or one quarter of a period behind the primary current.

Referring back to the ideal characteristic, notice that whenever grid volts are zero, plate current is at half its maximum value, and that maximum and minimum values of plate current correspond to maximum positive

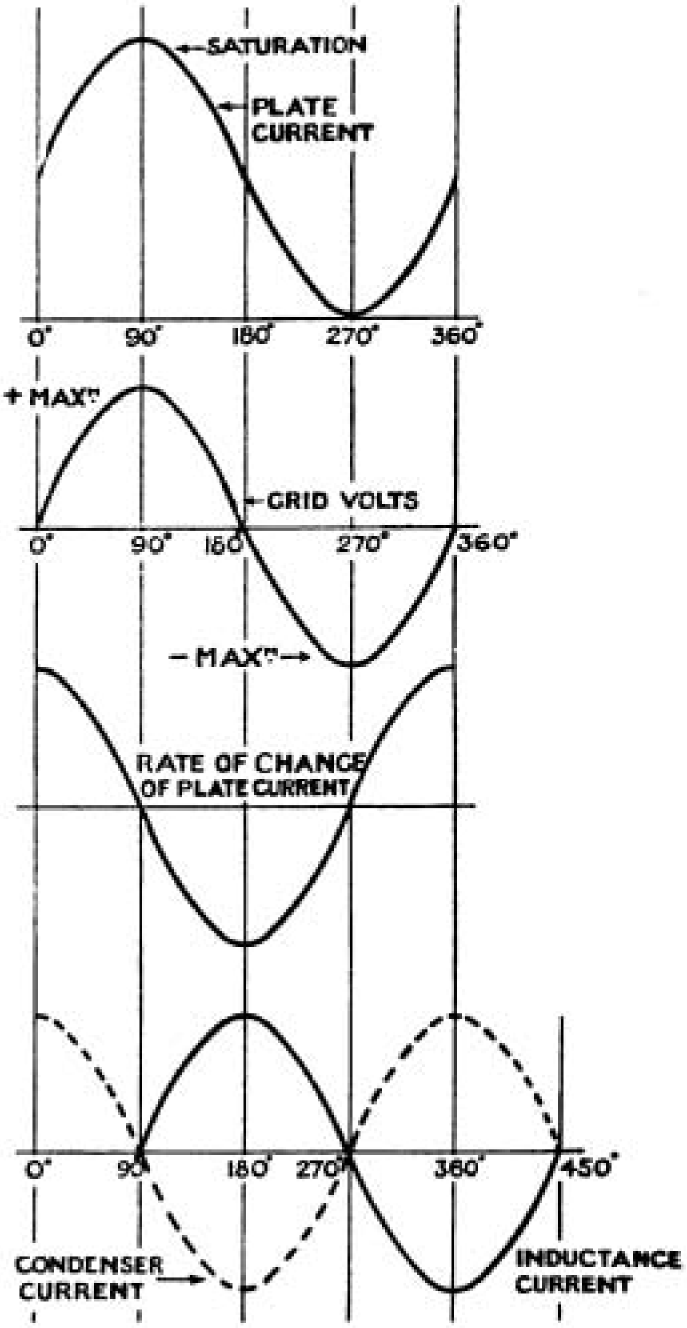

Fig. 3

and negative values respectively of grid volts.

We at once meet a difficult point. *See* Fig. 3.

According to the characteristic curve, grid volts are in phase with plate current, yet if plate current induces grid volts, by the explanation already given, the grid volts would lag 90° behind plate current.

The true explanation lies in the fact that we are dealing with two entirely separate currents traversing the plate coil.

In the first place, the current from the plate battery is a pulsating current, so that it will divide into two portions in the plate oscillating circuit. One portion will travel *via* the condenser and the other portion *via* the inductance. The condenser current will be a leading current approximately 90° in advance of the total battery current, and the inductance current will be a lagging current approximately 90° behind the battery current. It should be easy to see that as soon as a steady state has been reached, the condenser and inductance components of the battery current may nearly cancel each other. This is shown in Fig. 3. Hence the battery current will be small.

The behaviour of the whole circuit is, in fact, similar to that of a commercial transformer at no load, which merely takes sufficient current from the mains to balance the iron losses.

The second current is the oscillating current in the circuit formed of the plate coil and condenser. This will have a very much larger value than the total battery current, and will be practically a wattless current, because the resistance of the plate coil is small.

In the case of a wattless current the E.M.F. wave leads the current wave by 90°.

It is this wattless current, differing by 90° from the plate battery current, which induces the grid voltage which will lag 90° behind the wattless current, and will thus be in phase with plate current, which is the condition required for oscillations to take place.

The actual efficiency of any wireless transmitter is the ratio $\dfrac{\text{power radiated}}{\text{power supplied.}}$

It is not easy to measure with any accuracy the power radiated, but it is easy to measure the power absorbed by the aerial.

Any aerial circuit can be replaced by an equivalent closed circuit, consisting of an inductance in series with a resistance and condenser.

Provided that the inductance and condenser are adjusted to the values appertaining to the aerial when connected straight to earth, readings of current can be taken when the aerial and earth are joined to the transmitter and when the equivalent circuit is joined to the transmitter. Assume, for example, that the aerial current measured 1 ampere. The transmitter is disconnected from aerial and earth by means of a double-pole change-over switch and connected to the equivalent circuit whose resistance is adjusted until the current measures 1 ampere. The resistance being known, the power absorbed by the aerial is simply the square of the current multiplied by the resistance.

In France, during the month of December, 1916, it occurred to us to measure the efficiency of the transmitter, and I have obtained permission to publish the results, which were astonishing, as we knew very little about C.W. work at the time. Fig. 4 shows the circuit employed.

Care was taken to make the constants of the dummy aerial as near as possible to that of the real aerial. The aerial capacity was not calculated or measured directly, owing to no standard being available. The insulation resistance was tested with an ordinary "Megger" testing set, and found to be "Infinity." A variable air condenser was procured also of "Infinity" insulation, and its capacity balanced against the aerial by a charge and discharge method at a low frequency of about 30.

A motor-driven commutator was constructed, the brushes and contacts being arranged to charge the aerial from a 200-volt dry battery and then discharge it through a moving coil mirror galvanometer of slow period.

A steady deflection was easily obtained from the aerial, and then the air condenser was substituted by means of a change-over switch and its capacity adjusted to give the same galvanometer deflection as for the aerial. The arrangement employed is shown in Fig. 5.

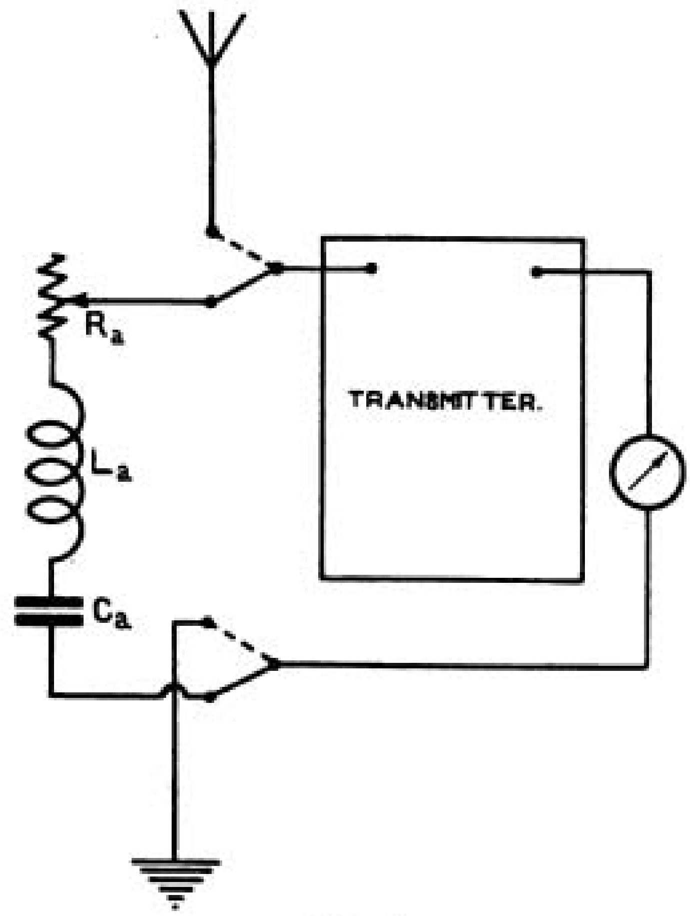

Fig. 4

The value of the inductance in the dummy circuit was adjusted to that of the aerial as follows :—

The aerial was connected through a single-turn inductance and a hot wire milliammeter to earth, and then excited by loosely coupling a small spark transmitter to it, the transmitter wavelength being adjusted to obtain maximum aerial current.

An open-wound inductance of negligible self-capacity, made of stranded wire supported on a framework of ebonite strip, was then connected to the previously adjusted air condenser and loosely coupled to the adjusted spark transmitter. Turns of the inductance were removed until the current in the dummy circuit was a maximum. This method sounds tedious, but ensured greater accuracy than that possible with a wavemeter. The balanced inductance and condenser are marked La and Ca in Fig. 4.

At each wavelength hot wire ammeter readings were taken, first with the aerial connected to the transmitter and then with the dummy circuit connected. The wavelength alteration was obtained by varying the plate inductance only, the plate condenser being kept at a minimum value throughout.

Heterodyne wavemeters were unobtainable in those days, so that wavelengths were obtained on an ordinary receiving wavemeter fitted with carborundum detector, a hiss being quite distinct at the correct wavelength.

No appreciable difference in wavelength could be detected between the aerial and dummy aerial positions. The aerial resistance curve is shown in Fig. 6.

This curve exhibits peaks at approximately 684, 912 and 1,140 metres. Now the natural wavelength of the unloaded aerial is 228 metres.

It is significant that :—

$$3 \times 228 = 684$$
$$4 \times 228 = 912$$
$$5 \times 228 = 1{,}140$$

It therefore follows that the curve shows the presence of a third, fourth and fifth harmonic, these harmonics being brought

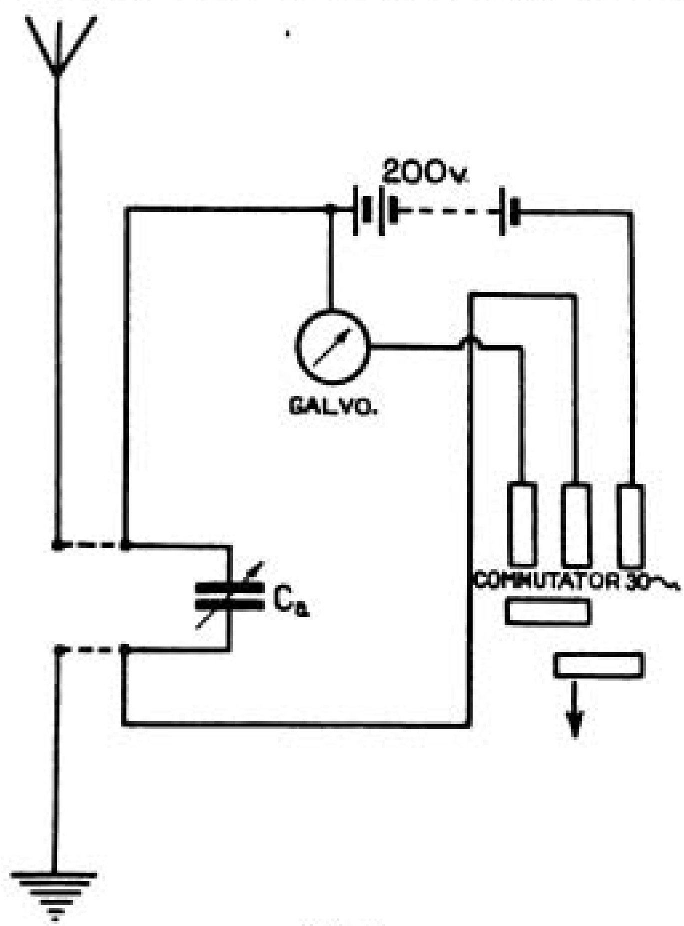

Fig. 5.

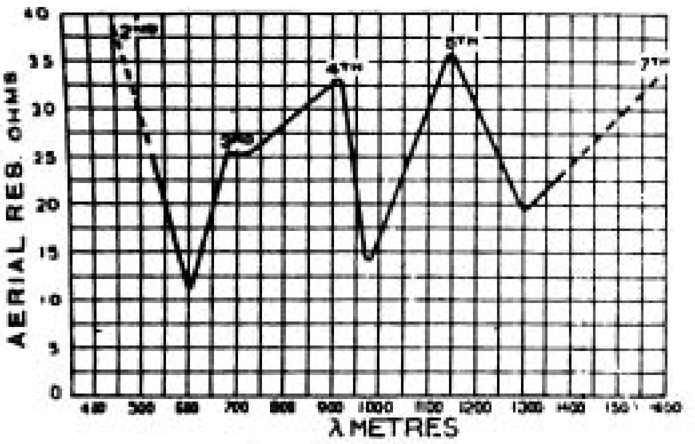

Fig. 6.

into resonance whenever the natural wavelength of the aerial is $\frac{1}{3}$, $\frac{1}{4}$ or $\frac{1}{5}$ of the actual wavelength to which the transmitter is adjusted.

Complex oscillations are essentially associated with uniform distribution of inductance and capacity in a circuit, and it is difficult to induce harmonic oscillations in circuits of concentrated inductance and capacity. Two analogous mechanical cases are :—

1. A stretched piano string, in which there is uniform distribution of mass and tension with tendency to harmonic oscillation ; and

2. The simple pendulum of concentrated mass oscillating at single frequency.

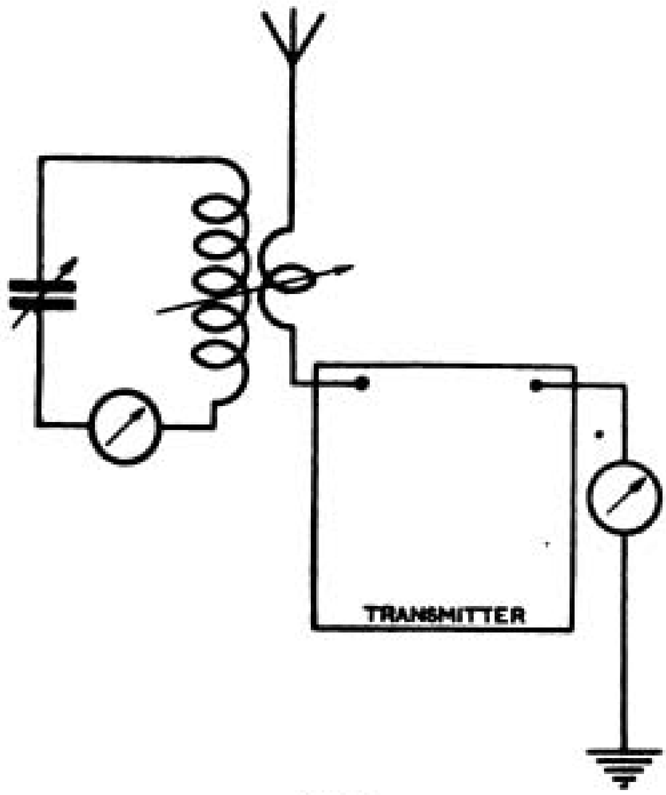

Fig. 7.

An analysing circuit was coupled to the aerial (*see* Fig. 7) and adjustments made to obtain readings in the ammeter.

When a reading was taken, the wavelength of the analyser was measured by buzzing into it with a wavemeter.

The wavelength of the transmitter being kept constant (1,380 metres), as many harmonics as possible were picked out. The second, third, fourth, fifth and seventh were detected in this way, the latter being rather feeble.

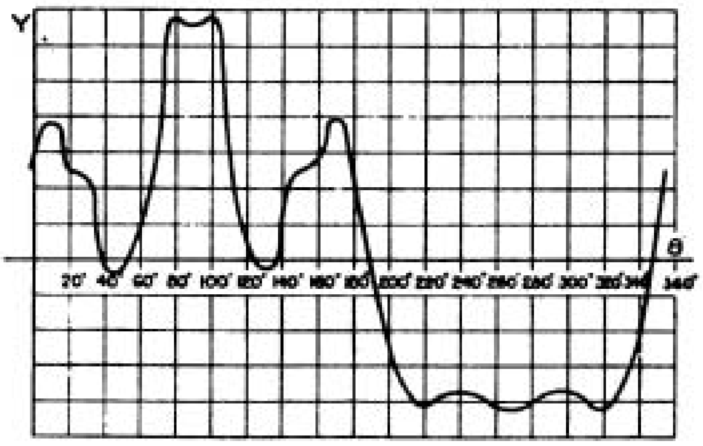

Fig. 8.

It was noticed that resonance of a harmonic in the analysing circuit lowered the aerial current, so that by taking the ratio of the currents in the two circuits a rough idea as to the amplitude of the harmonics could be obtained.

The fundamental second, third, fourth and fifth harmonics have been graphically compounded in Fig. 8, giving them these observed values.

A sixth harmonic could not be detected by the analyser, and it is absent in the aerial watts and aerial resistance curves. In the resistance method wavelengths of 456 and 1,596 metres could not be obtained, otherwise this method would, no doubt, have foretold the second and seventh harmonics which the analyser detected.

Fig. 9 shows the efficiency curve. Whenever a particular harmonic is brought into full resonance the efficiency is high. If the set is worked at 684 metres there will be three prominent waves radiated, viz., 228, 456 and 684 metres; at 912 there will be four, viz., 228, 456, 684 and 912, and at 1,140 there will be five, viz., 228, 456, 684, 912 and 1,140. Hence, as the wavelength is increased, the possibilities of jamming other stations increase. By working at points of low efficiency the harmonics are not prominent, and will not travel great distances, but there is always the possibility of jamming stations in the near neighbourhood. Judged from a pure wave standpoint, the efficiency is poor. At 565 metres the efficiency is lowest, and this point corresponds with maximum plate and aerial currents.

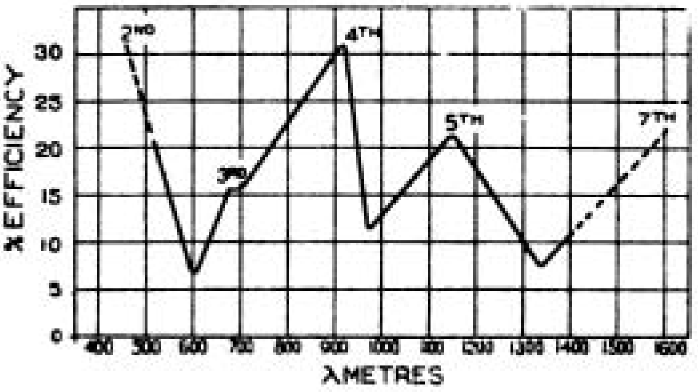

Fig. 9.

This emphasises an important fact—that maximum aerial current does not necessarily imply that radiation is also a maximum.

Fig. 10 is an interesting curve, as it is quite devoid of any evidence of harmonics.

It shows how the power supplied to the valve varies with wavelength. The power is simply plate battery current, multiplied by plate battery voltage. Notice that at one particular wavelength the power is a maximum and that, as the wavelength is increased, the power decreases.

The general shape of the curve agrees very well with the theoretical curve for an air core transformer with tuned primary and secondary, in which the secondary current is a maximum for a particular value of the square of the mutual reactance. This curve is shown below the valve power curve.

I give this example to emphasise that coupling plays a most important part in tuning all wireless circuits. Here we have a picture which shows why loudest signals do not necessarily correspond with tight coupling.

Referring to the practical curve, one gathers that there was not sufficient range provided in the coupling arrangement in the transmitter tested. As the wavelength was increased, the number of active turns in the plate coil increased; hence, the coupling increased automatically, whilst it was not possible to separate the coils sufficiently in order to obtain the optimum coupling. The valve power, other things being equal, depends upon the limits of travel of grid voltage. The shorter the travel, the smaller the power.

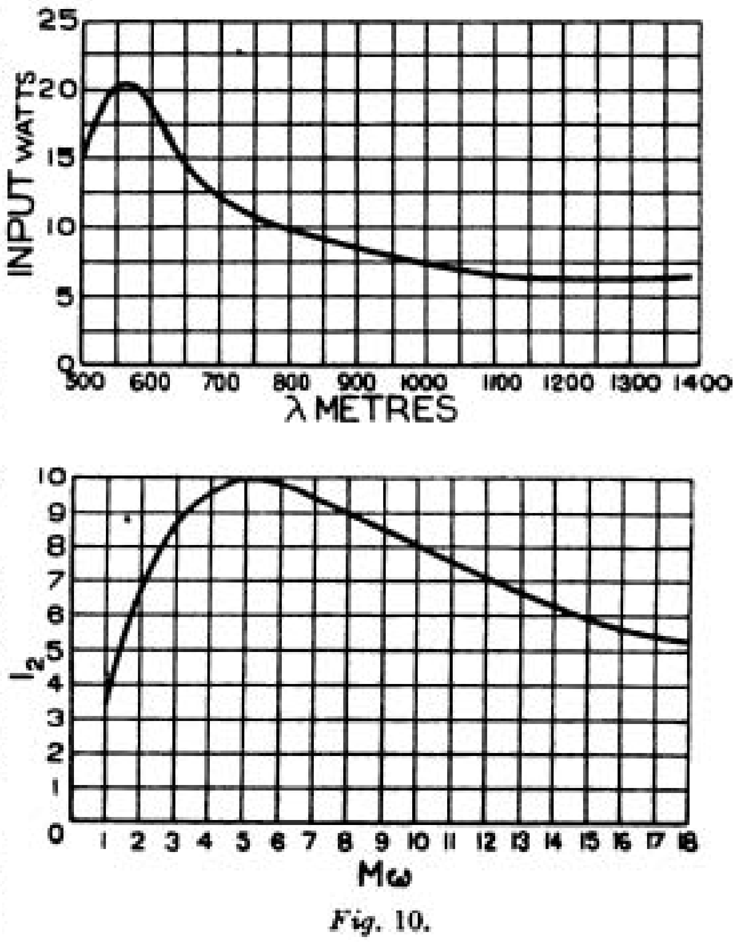

Fig. 10.

Fig. 11 shows the aerial current and the corresponding value of the plate or exciting current at each wavelength. Notice that both curves are similar to the curves just shown, and show no evidence of harmonics.

One concludes, therefore, that there is some peculiar behaviour connected with a particular voltage associated with the exciting current. The effective value of this voltage can be found and its action understood with the aid of Fig. 12, which is a more detailed repetition of the arrangement for measuring the power absorbed by the aerial.

It is necessary to introduce a little theory here which is comparatively simple.

The points A and E are important, because they are points common to several circuits.

The point A, and likewise the point E, is a point of zero potential to all the branches meeting at that point. Similarly, the points A and E are points of zero current for all the branches meeting at each point. So long as currents are flowing in any of the branches there will be a difference of potential between the points A and E. The separate currents are not necessarily in phase with the impressed voltage. This is known as Kirchoff's Law, and is true for both alternating and continuous currents.

Let this potential difference be V. If we know V and also the constants of any particular branch, we can determine the current in that branch and, conversely, if we know the constants of any branch and the current in it, we can determine V. At Resonance V is in phase with the exciting current from the plate battery, but not in phase with the aerial current. Hence, if I is the exciting current, the power supplied to the network is $I\,V$ watts.

Now the power supplied equals the power expended. Neglecting the resistance of the plate coil, the equivalent resistance R_a of the network has been found by substituting a dummy circuit for the real aerial in the way already described. The current traversing this resistance is also known. This is simply the aerial current I_a.

Hence, the power expended in the circuit is :—

$$I_a^2 R_a \text{ watts}$$

$$\text{Then, } \frac{I_a^2 R_a}{I} = V$$

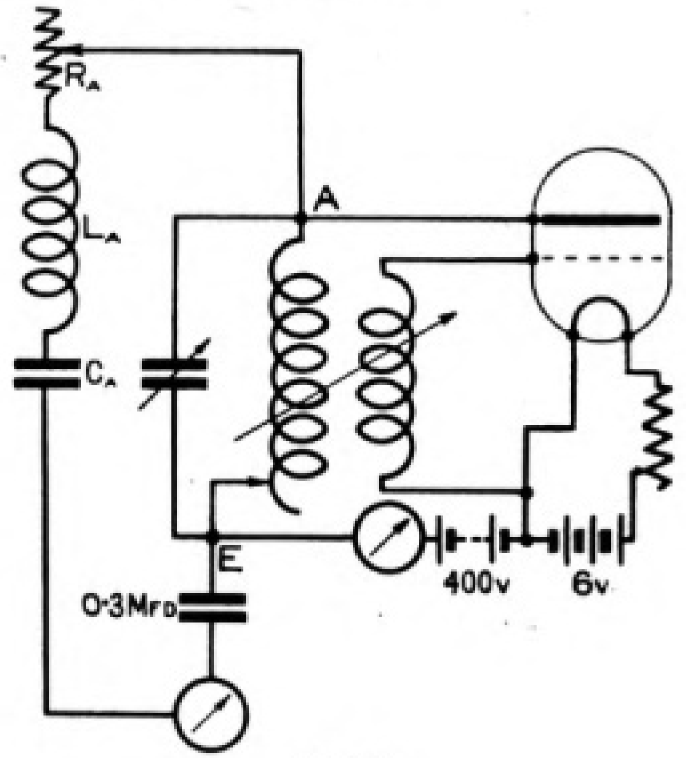

Fig. 12.

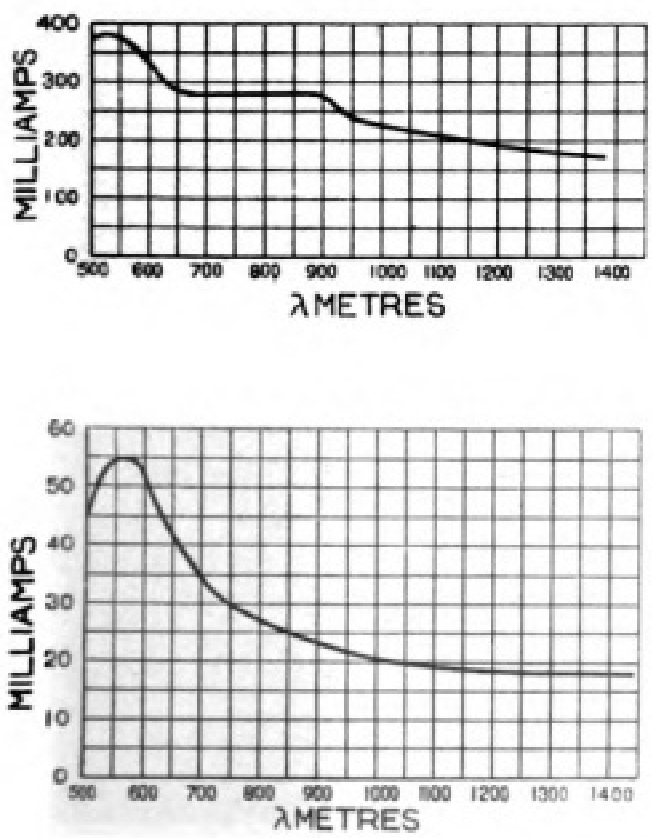

Fig. 11.

Values of V calculated from actual readings are plotted against wavelength in Fig. 13.

V is the resultant voltage of a number of voltages, and the shape of the curve indicates that harmonics are present.

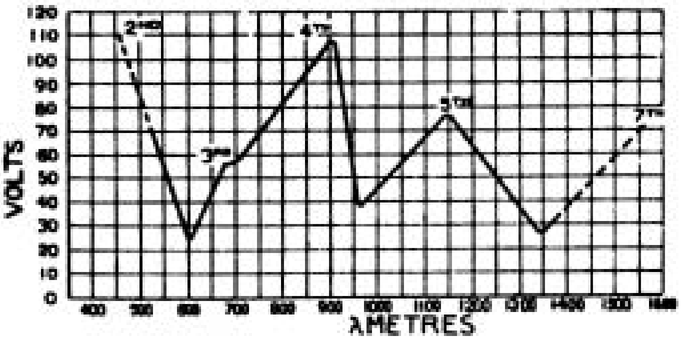

Fig. 13.

The wave form of V will be identical with the wave form of the plate current, which is in phase with it.

We know that the aerial current will differ in phase by approximately 90° from the exciting current. It follows that each component of the aerial current will, therefore, differ in phase by approximately 90° from the corresponding components in the exciting current. Hence, the grid voltage will contain a number of component voltages in phase with the exciting current.

It is, therefore, not easy to predetermine the resultant aerial wave form for any C.W circuit operated by valves.

However, it is worth while to obtain an approximate idea from the characteristic curve.

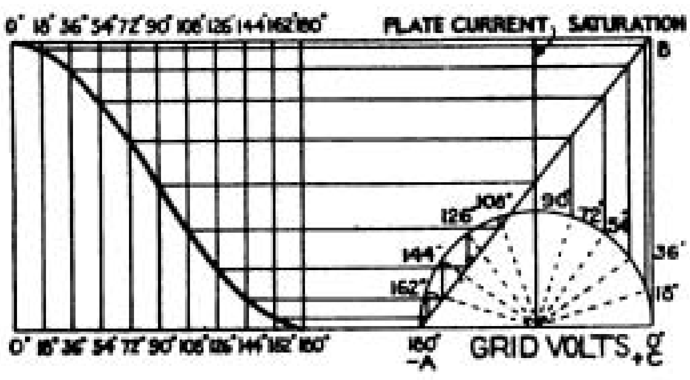

Fig. 14.

A graphical method, which should be sufficiently self-explanatory, is shown in Fig. 14, in which the ideal characteristic is taken as a basis. In this case a sine wave of grid voltage results in a sine wave of plate current. It should be easy to see that if the grid is over excited, the resultant plate wave will be flat-topped.

The full line curve in Fig. 15 shows the plate current wave form for an actual characteristic.

In this case the grid volts are assumed to obey a pure sine law. Notice that zero grid volts occur near the bottom of the characteristic. The result is that the plate wave is unsymmetrical, and will therefore be rich in harmonics.

To estimate the effect of the harmonics one must consider the process that takes place when the plate battery circuit is first closed.

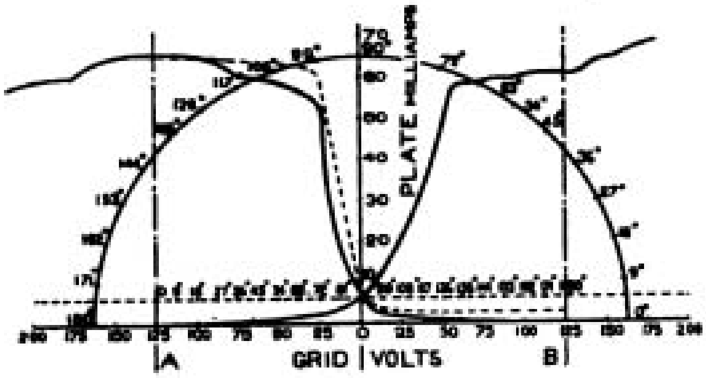

Fig. 15.

The initial oscillations are of minute amplitude and of pure sine shape as the minute portion of the characteristic operative is rectilinear. Remembering that the grid volts lag 180° behind the first wave of plate current—apart from the way the grid coil is connected up—it should be easy to see that the shape of any particular grid volt wave will be of approximately the same shape as the plate current wave preceding it.

Consequently, the first impure wave of plate current will be produced by a pure sine shaped grid volt wave. This will give us the full line curve in Fig. 15.

We then resort to a redrawing process by making the shape of the next grid wave of the same shape. This will produce further distortion of the plate current wave. The dotted curve shows the resultant wave after one redrawing.

Hence, by the process of action and reaction, the wave shape in the limit will be rectangular, and if it is asymmetrical, as is shown in the the dotted curve, it will be compounded of a large number of harmonics.

The original characteristic curve which was that of the particular valve used during the experiments, is on the right of the diagram.

Notice the similarity between the full line curve and the curve already shown of the approximate aerial wave form obtained by direct measurement containing a second, third, fourth and fifth harmonic.

To sum up, the main faults of this type of circuit are:—(1) The grid is over excited, which is responsible for a flat-topped plate wave. (2) There is no arrangement to correct the grid voltage to ensure that oscillations will take place about the mid point of the characteristic Hence the plate wave is likely to be asymmetrical, which means that a large number of harmonics will be present. (3) As the aerial is directly connected to the plate coil, any harmonics in the plate current wave will certainly resonate on the aerial which has distributed inductance and capacity.

(The Discussion will be printed in the next issue.)

WIRELESS CLUB REPORTS

The Wireless Society of London.

A meeting of this Society was held on April 30th at the Institution of Civil Engineers, when a Paper was read by Major Basil Binyon, O.B.E., on "An Automatic Wireless Call Device." The paper was illustrated by experiments, and wireless signals were received on an aerial specially erected. The lecture will be fully dealt with in a subsequent issue of this Journal.

The business of the meeting included the balloting for a further considerable number of new Members and Associate Members. It is gratifying to those managing the Society and to members generally to see the well-attended meetings and regular influx of new members, and it should be noted that at a recent meeting it was unanimously decided to admit ladies to membership and Associate membership Application forms should be filled in in the ordinary way, and may be obtained from the Hon. Secretary, Mr. L. McMichael, 32, Quex Road, West Hampstead, N.W.6.

The next General Meeting of the Society will take place towards the end of May, when a Paper, illustrated by experiments, will be read by Mr. Philip R. Coursey, B.Sc., A.M.I.E.E., entitled "Some Methods of Eliminating Atmospherics in Wireless Reception" This subject is one which will be of the greatest interest to experimenters, and Mr. Coursey's treatment of it is to be comprehensive and entertaining. The precise date of this meeting will appear in our next issue.

IMPORTANT ANNOUNCEMENT.

After some correspondence with the Postmaster-General the Committee has been informed that he agrees to the Committee's suggestion that the production of a Post Office permit to use wireless apparatus should be regarded as sufficient authority to dealers to supply such apparatus as comes within the terms of the permit, and that therefore no special purchasing permits will be required by amateurs.

Sheffield and District Wireless Society.

(Affiliated with the Wireless Society of London.)

Considerable interest was evinced during the period of the Wireless Telephony trials at Chelmsford, several members receiving the speech and music quite clearly by means of both crystal and valve as detectors. Measurements of the intensity of the sound were carried out by one member, and very interesting results obtained.

On March 5th a paper on "The Wavemeter: How Made and Used" was given by Mr. W. Burnet, who described in detail that most useful and essential adjunct to the wireless amateur or professional. In the discussion which followed one of the members kindly offered the use of a Fleming Cymometer for calibrating purposes.

A practical demonstration of C.W. and Spark Reception was given by Mr. L. Johnson on March

12th, using a 3-valve amplifier with great success, most of the signals being audible at the back of the lecture room.

On March 19th Mr. J. G. Jackson related his experiences as W/T operator in the Mercantile Marine during the War. Mr. Jackson's racy style and fund of anecdotes delighted the audience, and proved a pleasant relaxation from the more serious lectures which have been delivered during the session.

The meetings continue to be well attended, the average attendance being over forty.

Manchester Wireless Club.

(*Affiliated with the Wireless Society of London.*)

March 10th.—The Hon. Secretary in the chair. Mr. Evans again led the discussion (commenced February 25th) on "Detectors, Past and Present," touching upon the subjects of the Poulsen Tikker, Fessenden Heterodyne Receiver, Goldschmidt Tone Wheel and various crystal detectors. A member of the Wireless Society of London, in Manchester on business, attended the discussion, and gave a very interesting description of how he obtained C.W. signals with an ordinary crystal detector by using superimposed oscillations from an Ericson buzzer.

March 17th.—The Hon. Secretary in the chair. Mr. Evans concluded the discussion on "Detectors, Past and Present" by a brief historical sketch, explaining the various experiments which led up to the invention of the first Fleming oscillation valve.

March 24th.—Second General Meeting, held at the Club Room (335, Oxford Road, Manchester), Mr. Evans in the chair. The Hon. Secretary (Mr. Reid) read the minutes of the last General Meeting, which were passed in the usual manner. The chairman then announced that it was proposed to dissolve the Provisional Committee inaugurated on December 17th, 1919, and to elect a permanent Committee so as to establish the Club on a sound basis.

After the usual formalities, the following officials were unanimously elected: Vice-Presidents: Mr. W. G. Phillips, Mr. J. Griffin, M.B.S.C., and Mr. Chas. V. Morris. Hon. Secretary: Mr. Y. Evans; Hon. Treasurer: Mr. J. C. A. Reid; Committee: Mr. P. G. Thomasson, Mr. R. Hallam, and Mr. E. Samuels.

The election being successfully concluded, the resigning Secretary (Mr. J. C. A. Reid) announced that arrangements had been made for the members to have use of the Club Room at any time, also the workshop attached, should any member wish to construct his own apparatus.

A few letters concerning affairs of the Club were then read and discussed. Business being concluded, the chairman (Mr. Evans) called attention to the thoroughness which marked the work of Mr. Reid in organising the Club, and proposed a hearty vote of thanks to the late Hon. Secretary, which was passed with loud applause. He then expressed a wish that the members would pull together and devote as much time as possible to the advancement of Wireless Telegraphy and Telephony in general, pointing out that the steady increase of members was proof enough of the attractive side of the subject.

The Hon. Secretary invites correspondence from operators of His Majesty's Navy, Army and Air Force, and also the Mercantile Marine, with a view to increasing the present number of corresponding members, especially with regard to those residing in the Manchester area. Full particulars of membership will be forwarded to any part of the world.

Having been in close touch with the Navy and Air Force, the Hon. Secretary would be pleased to hear from old friends who served with him during the War.—Address: Mr. Y. W. P. Evans, 7, Clitheroe Road, Longsight, Manchester.

Leicestershire Radio Society.

(*Affiliated with the Wireless Society of London.*)

A meeting of the above Society was held on Friday, March 12th. There was a fairly good attendance. The President (Mr. E. Masters) occupied the chair, and a most interesting address was delivered by Mr. Dyson on "Elementary Wireless." The speaker presented his subject in a very lucid manner, and all present derived benefit from the discourse.

The Society again met on Friday, April 9th, for an evening of buzzer practice. Most of the members present were in good form, and it is hoped before long that some really good Morse manipulators will be found in our midst. Six new members have been admitted into the Society since the New Year, making a total of over 30, which is very encouraging to the officers and committee.

Plymouth Wireless Society.

(*Affiliated with the Wireless Society of London.*)

March 19th.—Mr. R. C. Laws in the chair, with a full attendance of members. A discussion on "The Theory of the 1·5 K.W. Marconi Standard Wireless Installation" took place. Selected members were questioned on many points of the theory by the rest of the members. The questions were numerous and varied, but for the most part effectively answered in clear, precise ways, diagrams being used to more fully illustrate the answers.

March 26th.—Mr. H. W. Harwood in the chair, supported by the Committee, Mr. S. G. Monk, B.Sc., gave a paper on "Searchlights"—an interesting and fully detailed account, showing that although searchlights had been replaced to some extent by the Very lights, they were indispensable for some things, such as coast defence work, naval operations, anti-aircraft work, etc. The actual working at the projector was instructive, excellent descriptions being given of the following: Carbons, mirrors, shapes of beams, lamps, switchboard work and devices for enclosing the carbon. The explanation of the different types of beams was also instructive and interesting. In describing the lamps used it was shown how the Schückert lamp gave an application of the Electromagnetic principle, and the Clark-Chapman lamp showed how the motor worked and the control of the field. The paper proved the most interesting and instructive one which has yet been given to the members of the Society.

WIRELESS CLUB REPORTS

Halifax Wireless Club.

(Affiliated with the Wireless Society of London.)

At a meeting held on Tuesday, March 30th, Mr. W. Emmott, M.I.E.E., M.I.C.E., was installed as President, with Messrs. A. Gledhill and J.G. Stirk as Vice-Presidents. We are looking forward to receiving some valuable papers from these gentlemen.

Mr. J. R. Clay read a very useful paper on "The Design and Construction of a Simple Receiving Set," which will put the recent recruits to the amateur wireless ranks on the right lines for constructing their own installations.

Burton-on-Trent Wireless Club.

(Affiliated with the Wireless Society of London.)

A meeting of the above Club was held on Wednesday, March 31st, at the *Burton Daily Mail* Offices, Mr. A. Chapman presiding. There was a large attendance. The chairman congratulated Mr. A. J. Wright on the honour of membership of the Order of the British Empire conferred upon him. He then stated that, owing to lack of room, it was not possible to demonstrate wireless wonders at the recent Fancy Fair, held at the Town Hall, but that it is hoped to exhibit wireless appliances on the Ox-Hay for the benefit of the public.

Mr. A. J. Selby initiated a discussion on the methods of connecting up instruments, wave production, valve applications, etc.

Newcastle and District Amateur Wireless Association.

The first post-war meeting of the above Association took place at the Y.M.C.A. Buildings on March 29th. This Association had dropped quietly out of existence upon the outbreak of war, through the withdrawal of the support of its members, who almost without exception, took service as W/T operators in the various branches of His Majesty's Services. The meeting was called together by several old members to ascertain the probable number of members who would join its ranks if the Association were successfully reformed. Without any publication (with the exception of one letter, published in a local paper) a good number of gentlemen turned up. Officials were elected and arrangements for obtaining a club-room or rooms are being pushed forward. At present it is not possible to decide the members' subscription through lack of reliable data to calculate it upon. Affiliation with the London Wireless Society has been decided upon. Local gentlemen who hitherto have not heard of the Association's proposed new existence are earnestly urged to send their names and addresses to me, that we may know how many are behind us and with us as new members.—Colin Bain, Hon. Secretary, 51, Grainger Street, Newcastle.

Liverpool Wireless Association.

A meeting of this Association was held at McGhies Café, 56, Whitechapel, Liverpool, on March 31st, when a number of new members were admitted. A very interesting lecture was given by one of the members, the subject being "An Introduction to the Study of Valves." The subsequent discussion proved very helpful and instructive. It is intended during the coming summer to arrange Saturday afternoon outings to places of interest, and it is anticipated that these visits will both be entertaining and instructive. The present programme is that the ordinary meetings of the Society shall be held on the second and fourth Wednesday in the month. The subscription is 5s. per annum. All communications should be addressed to the Hon. Secretary, Mr. S. Frith, 6, Cambridge Road, Crosby, Liverpool.

Edinburgh Wireless Club.

The above Club is now established on a more firm basis. New and more suitable premises have been obtained, after considerable delay, at the N.B. W/T College, Edinburgh, in which we held our meeting on Thursday, April 8th.

A receiving license has been applied for, pending which we have arranged for "buzzer" practice two days per week, to be supplemented by elementary lectures and general discussions.

Arrangements have also been made for current numbers of W/T and electrical periodicals, and other details such as furniture, etc., to be provided.

Subscriptions have been fixed at 5s. entry and 10s. annually. The Hon. Secretary will be very pleased to see anyone who is interested, either on Wednesday evenings at 8 p.m., or Sunday afternoons at 3 p.m. General Meetings are to be held early in each month.

When the Club's wireless set is installed it is hoped to have the club room open more frequently.—Hon. Secretary, Mr. W. Winkler, 9, Ettrick Road, Edinburgh.

Wanted.

To form Wireless Clubs at Birmingham, Spalding, Doncaster, Exeter, Grimsby, Gloucester, Bradford, Preston and Bournemouth. Those interested should communicate with Mr. A. H. Staples, Y.M.C.A., Dale End, Birmingham; Mr. W. G. A. Daniels, Pinchbeck Road, G.N.R. Crossing, Spalding; Mr. A. H. Wasley, Glenholme, Ravensworth Road, Doncaster; Mr. H. E. Allcock, 1, Prospect Villas, Heavitree, Exeter; Mr. C. Hewins, 42, St. Augustine Avenue, Grimsby; Mr. J. Mayall, Burfield Lodge, St. Paul's Road, Gloucester; Mr. J. Bever, 85, Emm Lane, Bradford; Mr. A. Wilkinson, 176, Tulketh Brow, Ashton, Preston, and Mr. T. H. Dyke, Hill Garage, Winton, Bournemouth.

SHOW YOURSELVES.

We shall be pleased to publish in this Section photographs of Club officers, committees, and members; of Club stations, workshops and exhibits, or of private installations.

PAGES FOR BEGINNERS

Under this heading we publish COMPLETE *instructional articles, forming a series specially designed and written for beginners in wireless work. Hardly any mathematics will be introduced, and we hope to present the fundamental facts of wireless in such a manner as will prove attractive to a much wider range of students than that for which this series is primarily intended.*

INDUCTANCE.

BEFORE the experiments of Arago, and, later, of Faraday in the early nineteenth century electricity and magnetism were usually considered as two separate forms of energy. Faraday showed that they were related, inasmuch as a current of electricity was produced by the action of a magnet on a wire, and, conversely, that a coil carrying a current exhibited properties resembling those of a magnet.

Most students of electricity are familiar with the lines of force produced by a magnet, which can be mapped out with the aid of iron filings sprinkled on a card placed above either of the poles (Fig. 1). These lines of force radiate from the poles in every direction.

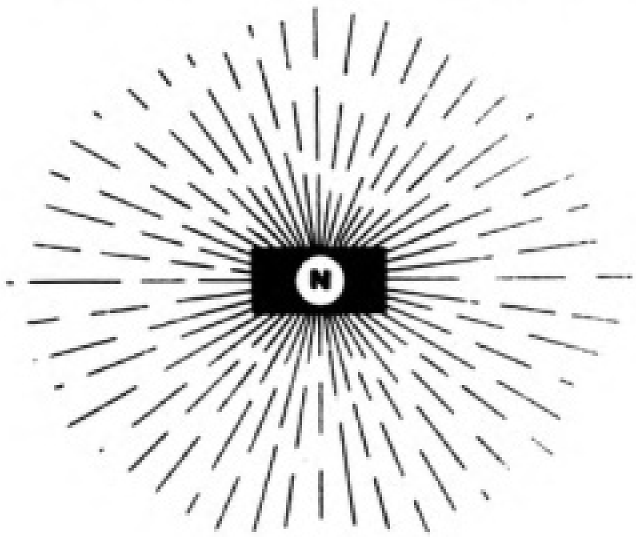

Fig. 1.

We see that if the magnet is moved past a coil of wire in a direction par.llel with its own axis, the lines of force will, so to speak, *cut* the wire, and thus will induce an electromotive force in it.

In the case of a conductor carrying a current, (Fig. 2), the lines of force take the form of circles having their centre at the centre of the wire. When the current is switched on these lines of force start to expand outwards from the wire. If another conductor is placed parallel to the first, the lines of force, in expanding, will *cut* the conductor, and thus induce an e.m.f. in it.

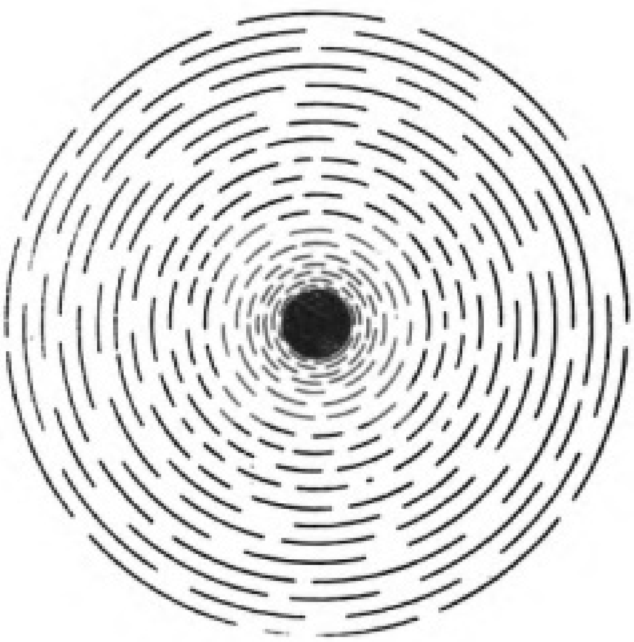

Fig. 2.

Consider the case of two conductors side by side, each carrying a current in the same direction. The lines of force round each individual conductor will be as before, but at certain points between the two the lines of force will "clash." The final effect will be as shown in Fig. 3. Similarly, the field due to a dozen conductors in a row will be as in Fig. 4. We may note the similarity between the lines of force, due to two rows of conductors and those of a bar magnet. (Fig. 5). Consider now a coil of several turns of wire, equally spaced, as in Fig. 5.

As soon as the current is switched on, the lines of force extend from each turn in the coil, and these lines of force, by Faraday's Law of Induction, will induce an e.m.f. in the adjacent turns of the coil. The important point in the whole matter is that the induced e m.f. is such as to *oppose* the e.m.f. which is sending the current through the coil.

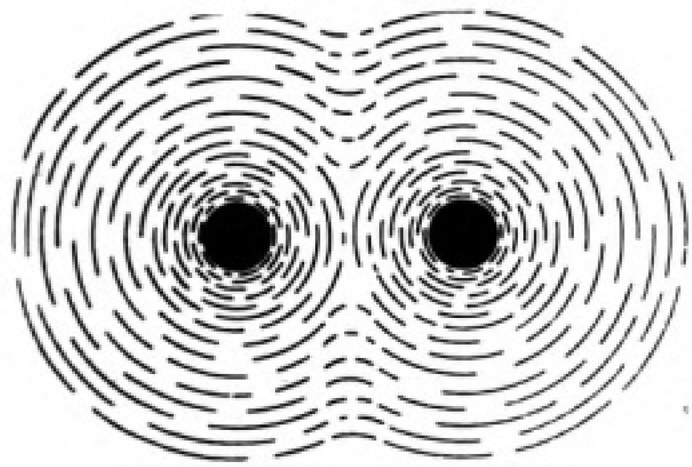

Fig. 3.

So, as the current is started in the coil, at the same time an opposing e.m.f. is set up which tends to prevent the growth of the current.

The curve of the growth of current is shown in Fig. 6. But, when the current has finally reached its steady value, the lines of force are no longer expanding, and in consequence do not cut the other turns. The back e.m.f. therefore dies away again.

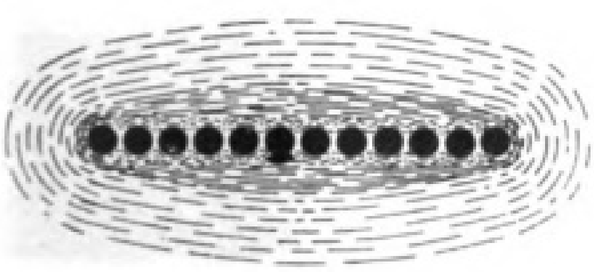

Fig. 4.

Now, if we switch off the current, what happens ?

By Lenz's Law—" In all cases of magneto-electric induction the e.m.f. produced is such as to *oppose* the cause producing it." Now, the

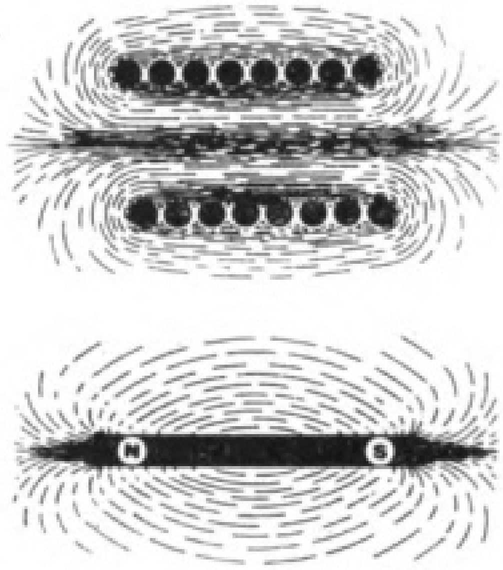

Fig. 5.

cause producing the e.m.f. in this case is the dying away of the current and the collapsing of the lines of force The e.m.f. therefore tends to keep the current flowing, and is now in the same direction as the applied voltage.

The effect of this e.m.f. is seen in the bright spark that occurs on breaking the circuit of a coil. If the wire is bare and is handled on breaking the circuit a severe shock is often felt.

A glance at Fig. 7 will show the relation between the lines of force and the induced e.m.f.

Now turn to the case of an alternating current. The current reverses its direction through the coil many times per second, so the lines of force are continually expanding and contracting. In doing so, they are continually cutting the adjacent turns of the

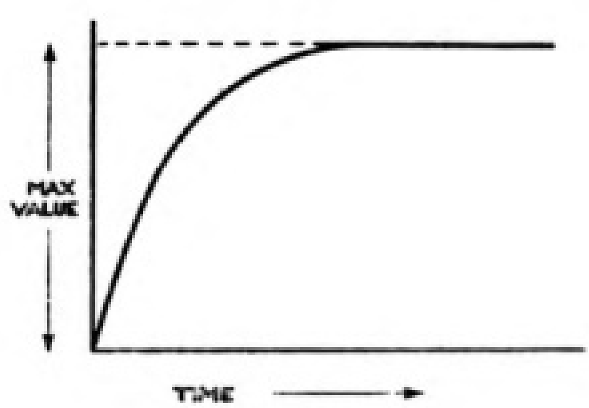

Fig 6

coil, and inducing a back electro-motive force. So the current is continually being prevented from growing, and when established, from dying away. Hence, in the case of an alternating current, the coil exerts a *choking* effect on the current, continually preventing its growth and diminution.

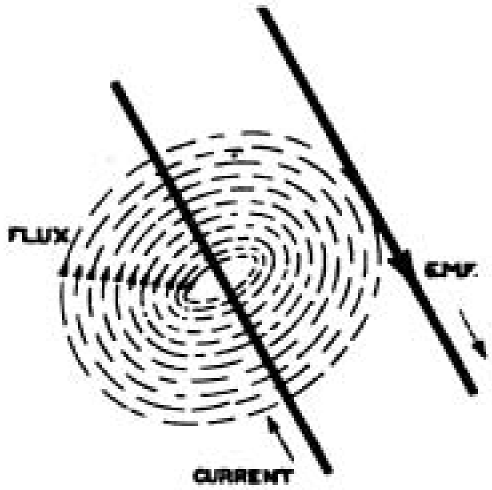

Fig. 7.

We now come to the meaning of the word "Inductance." The inductance of a circuit is that property which tends to oppose the flow of current in the circuit, and, the current once flowing, tends to prevent its stopping.

In the case explained above, what is it that tends to prevent the growth and subsequent changing of the current? The lines of force which cut the turns, obviously.

The inductance of the coil, therefore, is represented by the total amount of lines of force which cut the coil, when unit current is switched on.

If one ampere causes 10^9 lines of force to cut the circuit, the coil is said to have an inductance of *one henry*.

Finally, we have to see upon what factors the inductance of the coil depends. Clearly it depends first on the number of turns of which the coil is composed. Suppose one conductor has N lines of force produced by the passage of one ampere. Then a coil consisting of T turns will have $N\,T$ lines of force produced. Take the case of unit current flowing in a coil of T turns. A certain number of lines of force are produced. If the number of turns is doubled, twice as many lines of force will be produced. The field, therefore, varies as the number of turns.

As the inductance of a coil is proportional to N and T, and N varies as T, it follows that the inductance is proportional to T^2; or, the inductance varies as the *square* of the *number of turns* in the coil.

An expression for the inductance of a coil in terms of the number of turns and current will be given later.

Before leaving the question of inductance there are one or two things more to be noted in connection with it. We know that all wire offers a *resistance* to the current flowing through it.

If a wire has a resistance of ten ohms, and a hundred volts potential is applied to it, the current flowing will be ten amperes. This is true both in the case of alternating and direct currents. But if the wire is coiled, so as to exert an *inductive* effect, the current, in the case of alternating current, will be decreased owing to the inductance of the coil.

We see then that there are two properties tending to limit the current passing through the coil—the *resistance* of the coil, and the *inductance*. The combined effect of resistance and inductance is spoken of as the *impedance* of the coil.

Lastly, it is interesting to compare the definition of inductance with that of *inertia*, given in a preceding article. We see that the inductance of an electrical circuit corresponds in some respects to the mechanical effect of *inertia*.

STATION.	CALL.	λ (metres).	SYSTEM.	PRINCIPAL WORKING TIMES.
Annapolis	NSS	17,000 1,700	Arc Spark	Time signals at 0255 and 1655; 24 hours programmes with YN and Stavanger (LCM). Weather reports at 0130 and 1330. Works Constantinople 0500 to 0800 G.M.T.
Barcelona	EAB	2,000 600	Spark	Works ICI, HB and OHD irregularly; also ships.
Belgrade	BGD	6,000	Arc	Works SAR. (*Extracted from* "*T.S.F.*" *No.* 10).
Bucharest	BNS	4,000	Marconi Spark	0000 to 0215, to UA; 0330 to 0530, to UA; 0700 to 0800, to HB; 1630 to 1815, to UA; 1900 to 2315, to IQZ; 2315 to 0000, to UA. ("*T.S.F.*" *No.* 10).
Budapest	HB	3,700	Telefunken Spark	0200 to 0330, to FL; 0600 to 0700, to IQZ; 0700 to 0800, to BNS; 0800 to 0900, to Allied Mission at Bucharest; 1100 to 1200, to WAR; 1230 to 1500, to FL; 1500 to 1600, to FF (Sofia); 2030 to 2100, to PRG; 2100 to 2200, to FL. ("*T.S.F.*" *No.* 10).
Cairo	SQC	5,800	Arc	—
Carnarvon	MUU	14,000	C.W.	0000 to 0100 CQ press; 0230, RAF Weather report; 0070, USN traffic to Constantinople and Venice; 1430, weather report; 1630 to 2000, CQ press; 2000 to 2030, U.S.N. traffic as at 0070; 2030 to 2100, CQ press; all other times, commercial service to EAA and IDO.
Cleethorpes	BYB	3,000	Spark	Weather reports at 0500 and 1700.
Clifden	MFT	5,800	Spark	Continuous commercial service to GB (Glace Bay). Spark has musical note.
Eilvese (Hanover)	OUI	9,700 14,700	C.W. C.W.	To EAA, 0100 to 0500. Using Goldschmidt's H.F. machine. Works EAA and EGC throughout 24 hours.
Horsea	BYC	4,500	Spark	Works SQG (Cairo).
Koenigswusterhauser	LP	4,000 6,500 7,800	Telefunken Spark Telefunken Spark Poulsen Arc	0200, to MSK on 6500 m; 0500 to RVA (Reval) on 6500 m; 0530 to TOR (Thorn) 6500 m; 0700 to SEW (Nicolaieff) 6500 m; 0900 to TSR (Tsarko-Selo) 6500 m; 1130 to SAJ (Karlsborg) 6500 m; 1530 to OHD (Vienna) 4000 m; 1730 to TSR, 4000 m. (*Extracted from* "*T.S.F.*" *No.* 10).
Madrid	EAA	2,800	Marconi Spark	To OUI: 0000 to 0400; 0700 to 0900; 1615 to 2200.
Madrid	EGC	2,800 2,100	Telefunken Spark	1130, weather report, 2100 m; 1600, weather report, 2100 m.

STATION.	CALL.	λ (metres).	SYSTEM.	PRINCIPAL WORKING TIMES.
Nantes	UA	6,700 2,800 9,000 5,500 11,000	Arc Spark Arc Arc Arc	1031 to 1040, "FRI de UA." 11000 m; 1100 to 1145, "LLMV de UA" 2800 m; 1230 to 1240, to FRI, 11000 m; 1630 to 1815, to BNS, 6700 m; 2031 to 2053, to FRI, 9000 m and 5500 m: 2230 to 2300, to RQA (Archangel) 11000 m. (*Extracted from "T.S.F" No.* 10).
Nauen	POZ	3,900 12,600	Spark H.F. Alternator	2300, to U.S. Stations, 12600 m; 1200, time signal, 3900 m; 2200, weather report, 3900 m; 0000, time signal, 3900 m; 0740, weather report, 3900 m.
Norddeich	KAV	300 600 1,800	Telefunken Spark	General public traffic. Details of long-distance traffic reserved. (This information was furnished us by the KAV station.) Admiralty Notice to Mariners shows KAV sends two weather reports on 1650 m.
New Brunswick	NFF	13,600	Alexanderson H.F. Alternator.	Twenty-four hours programme with YN and POZ; 0430, to Pearl Harbour; 2100 and 0300, to San Diego.
Pola	IQZ	3,600 7,800	Telefunken Spark H.F. Alternator.	0600 to 0700, to H.B. (Budapest), 3600 m; 1400 to 1500, to PRG (Prague), 3600 m; 2030, weather report for mariners, 3600 m; 1900 to 2200, to BNS (Bucharest), 7800 m. (*From "T.S.F." No.* 10).
Poldhu	MPD	2,750	Spark	0100, press and long-distance ship messages; 0930, weather report; 2130, weather report.
Posen	PSO	1,750	Telefunken Spark	0300 to 0500, to VSL (Vasliun, Rumania); 0630 to 0800, to FL; 1800 to 1900, to FL; 2000 to 2200, to VSL; 2200 to 2330, to FL. ("*T.S.F." No.* 10).
Prague	PRG	3,000 10,000	Telefunken Spark H.F. Alternator	0945 to 1020, to OHD; 1100 to 1130 to WAR; 1200 to 1330, to OHD; 1330 to 1400, to MRHG; 1400 to 1500, to IQZ; 1545, weather report; 1630 to 1700, to FL; 2030 to 2100, to HB. ("*T.S.F." No.* 10).
Sao Paulo (near Rome).	IDO	11,000	Arc	To American stations; 1700 to 1800, to FL.
Saragevo	SAR	4,000	Arc	0015 to 0100, to FL; 0200 to 0300, to PRG; 0715 to 0745, to PRG; 1100 to 1200, to FL. ("*T.S.F." No.* 10).
Tsarkoe-Selo	TSR	5,000 6,000	Spark	0800 to ICI; 0900 to LP; 1300, press; 1700 to WAR; 2000, press; 2230, press.
Warsaw	WAR	2,000	Telefunken Spark	0330 to 0430, to FL; 0630 to SEW; 1100 to 1200, to HB; at 1700 to TSR; 1900 to 2000, to FL. ("*T.S.F. No.* 10).

The CONSTRUCTION *of* AMATEUR WIRELESS APPARATUS

A Crystal Receiver with Valve Magnifier (Part II).

The Jigger Unit.—Care should be taken that the tube formers, especially if made of cardboard, are thoroughly dry. If they are at all damp the signals will be weaker and the tuning of the circuit much flatter than would be the case with dry formers. Thoroughly dry the tubes and then impregnate them with paraffin wax or shellac varnish. Having prepared the formers in this way, proceed with the winding. About ¾ lb. of No. 24 Double Silk-covered Wire will be required.

The Coupling Coil.—Wind the sliding former with 100 turns approx. in the middle of the former. Make a tapping at 50 turns so that the coupling between the aerial and secondary circuits may be weakened if necessary.

The Secondary winding on the fixed former requires a little consideration. We have specified a 0·0005 mfd. condenser, and this, with an inductance, is required to tune from 300 to 3,000 metres. The condenser will have a maximum capacity of 0·0005 mfd. and a minimum capacity of 0·00005 mfd. (approx.)—a 10 to 1 change. This will give a 3 to 1 change in wavelength with a given inductance, as the wavelength increases in proportion to the square root of capacity. Therefore, in order to obtain the range of wavelengths desired, we must make tappings on the secondary and so arrange them that the range of wavelength with one tapping meets or overlaps the wavelengths given by the next tapping.

If we use three sections of winding we shall cover the required range and also obtain good overlap between the ranges.

Section 1 should have 40 turns ; section 2, 65 turns; and section 3, 215 turns.

The table below gives the approximate values of wavelength and inductance which will be obtained :—

Range	Section.	Wavelength (Metres.)	Mhys.
1	1 ...	250—700	265
2	1+2 ...	600-1,500	1,280
3	1+2+3	1,200-3,200	5,200

Commence winding the first section close to the open end of the fixed former, and leave a space of 1 centimetre between each section. Wind the three sections and the coupling coil in the same direction. Each winding may be finished off by fixing the ends by means of tape loops. Place the tape in position, loop outward, and wind a few turns over it. Slip the end of the wire through the loop and then pull one end of the tape taut. With one of these loops at each end of the winding the wire will remain tight.

When the windings are finished they should be given a good coat of shellac varnish and baked in an oven.

If possible, a switch for connecting the sections in series should be provided by means of which the idle sections may be cut off from the sections in use, thus avoiding the detrimental "idle turns" effect.

The Telephone Condenser should have a capacity of 0·003 mfd., approx.

It may be made up as described in the WIRELESS WORLD of April 3rd, in "A Wavemeter and Tuning Tester."

Cut the copper foil into strips 2½" × 1" and, with 0·002" mica, 15 plates should give the required capacity.

The High Tension Battery.—The French type of receiving valve will work quite well with approximately 60 volts potential on the anode. This potential can be supplied by using 15 4½-volt "Ever-ready" pocket flash lamp batteries, connected up in series. This arrangement will give about 68 volts. The current taken by the valve when in operation is of the order of a few milli-amperes; therefore these batteries should last, with normal use, for at least six months. A battery of accumulators can be used, but in practice a dry battery has been found most satisfactory and causes much less trouble.

The size of one "Ever-ready" battery is $3'' \times 2\frac{1}{2}'' \times \frac{7}{8}''$; therefore, if we arrange them as in Fig. 1, a light wooden box (8" long, 5" wide and $3\frac{1}{2}$" deep) will be large enough to complete the unit.

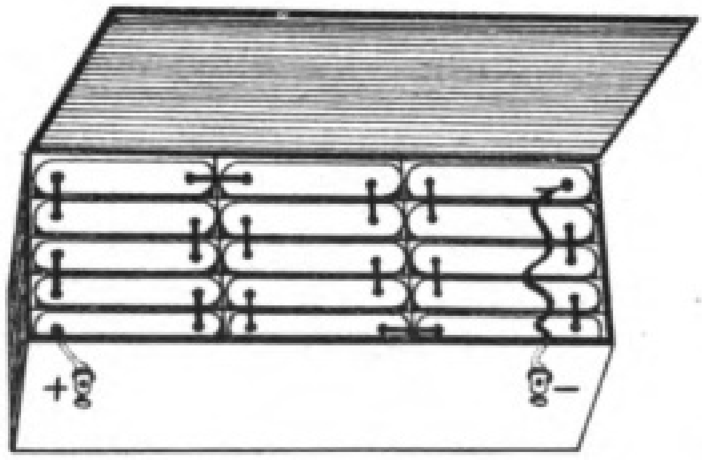

Fig. 1.

In assembling the batteries it is essential that precaution be taken to insulate the battery as a unit. The best method to adopt is to line the box with waxed paper and to place a double thickness of waxed paper between each battery. The terminals mounted on the box should be bushed with ebonite.

Connect up the batteries, positive to negative, with properly soldered joints, using thin copper wire for connectors. Usually the battery connections are of tinned metal, so the best procedure will be to tin the connecting wire first and then, with a hot, clean soldering iron, make a quick joint. The reason for care in doing this is to prevent the heat creeping along the battery connection and unsoldering the joints inside the battery.

The H.T. unit is of great importance to the set, and too much care cannot be taken in making it up. Experience will teach the amateur that when working with valves, slight leaks to earth due to bad insulation, and imperfect joints in the circuit, will cause great annoyance by giving queer noises in the receivers.

It is found that the anode voltage required for each valve varies slightly, so instead of joining both terminals to the battery direct, connect a flexible lead to one terminal with a tie-clip at the loose end, so that tapping may be made at any intermediate voltage.

Filament Resistance.—As we propose to use a 6-volt accumulator to supply the current for the valve filament, it will be necessary to make up a resistance of approximately 3 ohms, which must be variable in order to control the current taken by the filament.

For those readers who wish to make up a variable resistance, the following data will be sufficient to work from.

Size No. 22 B.W.G. Eureka, German Silver or Manganin wire, has a resistance of 1 ohm for a length of 24"; therefore, 72" will be required to make up a resistance of 3 ohms. It will be necessary to use bare wire.

The best way to make up the resistance in the most convenient form is to wind the wire closely round a lead pencil so that, when the wire is taken off the pencil the turns remain touching one another. If the wire is pulled out to a length of 6" it will form a helix with about $\frac{1}{16}$" between each turn. Fig. 2 shows clearly how the wire can be mounted on a base made of ebonite, hard wood or any other suitable material. This base should be about $2\frac{3}{4}$" in diameter, having

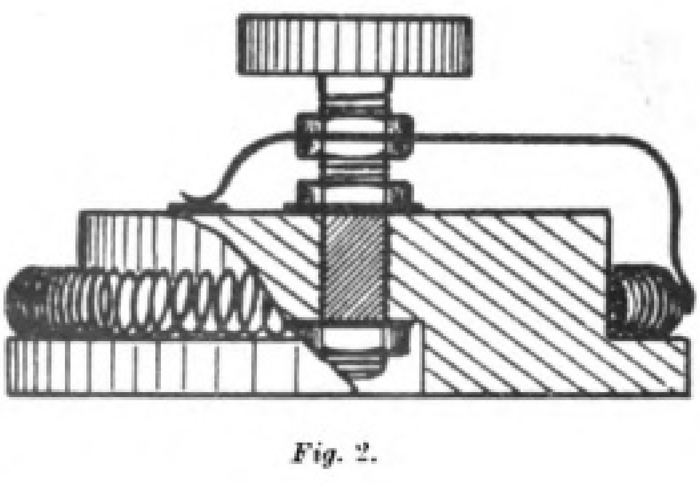

Fig. 2.

a ledge $\frac{3}{8}$" wide, upon which the wire rests. A convenient handle can be made, having a $\frac{1}{4}$" threaded spindle passing through the base, secured by nuts and washers.

This spindle also takes the contact arm. The contact arm must be sufficiently wide to span two turns of the wire, and must be adjusted to make light but good contact. The back portion of the arm should make contact on a brass strip upon which is a terminal mounted on the top of the base, another terminal being connected to one end of the wire.

This piece of apparatus does not call for much ingenuity to make up; at the same time it can be made a very neat job—neater and smaller than a slide wire type of resistance.

He is NOT receiving from Mars.

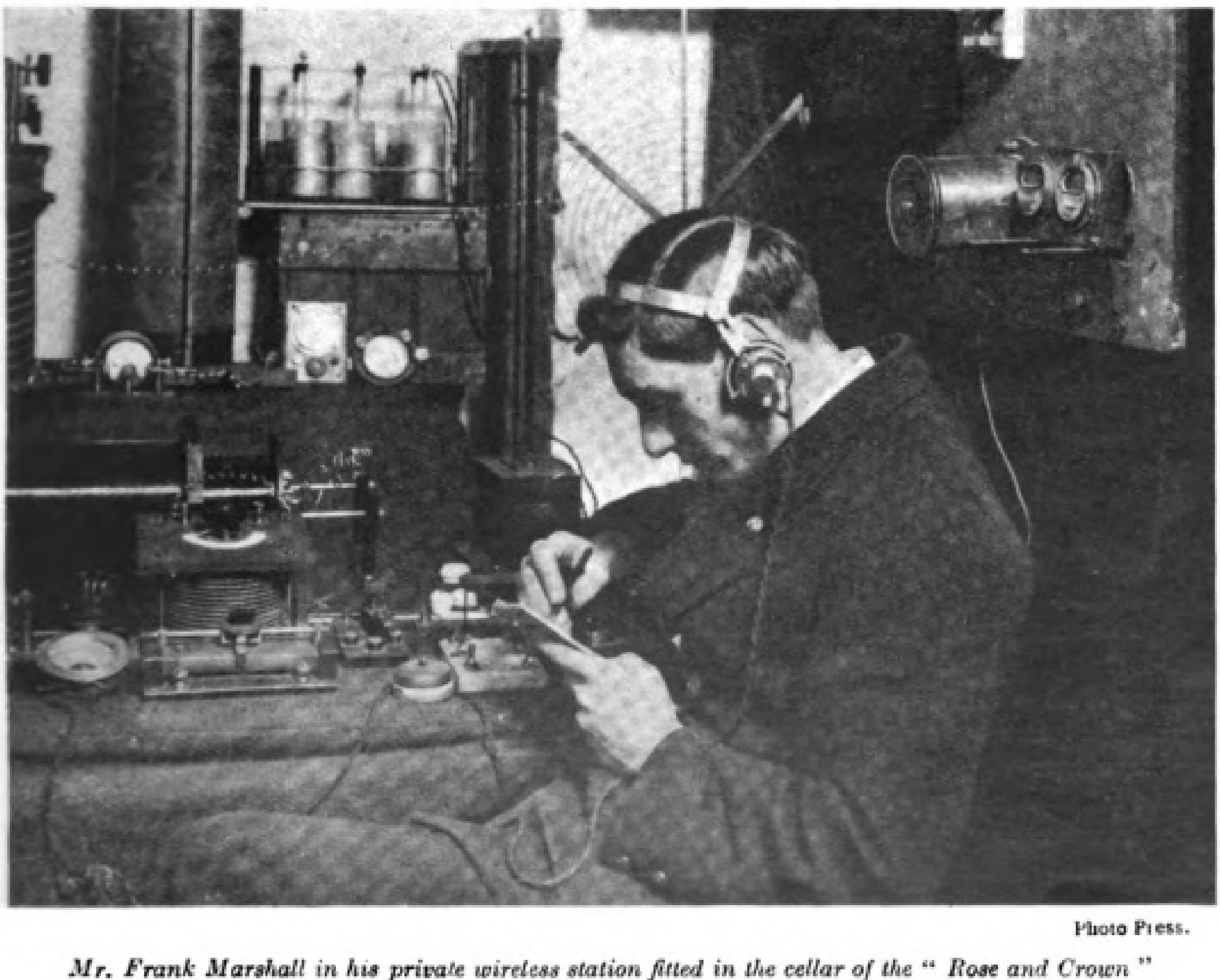

Photo Press.

Mr. Frank Marshall in his private wireless station fitted in the cellar of the "Rose and Crown" in Park Lane, receiving messages from Paris.

ALTERNATING CURRENT WORK WITH REFERENCE TO THE THREE - ELECTRODE VALVE

By R. C. Clinker.

Continued from page 68.

WE can now regard the combination of triode and oscillating circuit as two resistances in series placed across a constant A.C. voltage. One is fixed in value—that of the triode.

The other has the value $\frac{L}{CR}$ and is required to be such that the power consumed in it is a maximum. It can be shown that this obtains when the two resistances are equal, *i.e.*, when—

$$\frac{L}{CR} = \text{triode resistance.}$$

So far we have considered the simple oscillating circuit, shown in Fig. 7, and have assumed the adjustment of the value of $\frac{L}{CR}$ to be obtained by separate adjustment of L and C. A more convenient arrangement for adjustment, however, is that shown in Fig. 11. The aerial Æ (which acts as capacity C) is connected by moveable contact q, and the plate by moveable contact p, to the inductance L. By shifting q the wave-length is adjusted, and by shifting p the effective value of the resistance of the oscillating circuit in the plate circuit is adjusted. Moving p upwards evidently increases the A.C. plate voltage, and decreases the A.C. plate current (i) required for a given Æ current. This is equivalent to an increase in the value of $\frac{L}{CR}$. Moving p downwards, on the other hand, decreases the effective value of the latter quantity in the plate circuit.

In the foregoing treatment it has been assumed that the grid is excited from a separate A.C. source. When, however, a triode is generating, its grid is, of course, self-excited from the main circuit, either by mutual induction, as in Fig. 7, or by some other form of coupling. Also, the oscillation is not confined to the straight parts of the characteristics. The curvature sets a limit to the oscillations, which otherwise would increase indefinitely.

These differences modify somewhat the conclusions reached on the "straight line"

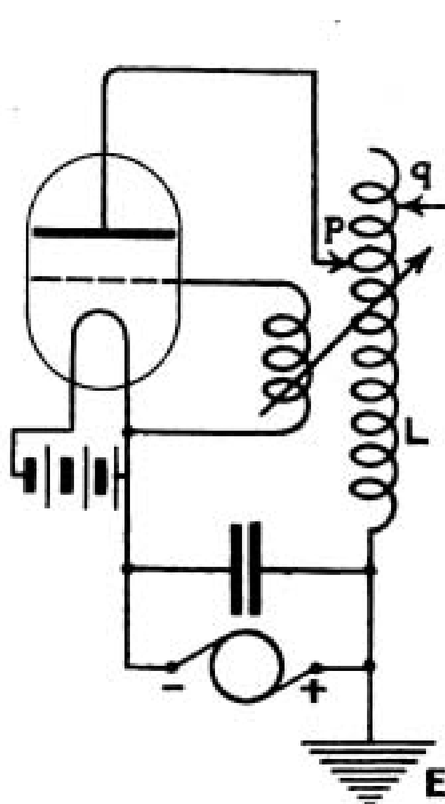

Fig. 11.

assumptions, and render the actions more complicated. The principle illustrated remains the same, however, viz., the treatment of the oscillating circuit as equivalent, at its natural frequency, to a non-inductive resistance, having a value of $\frac{L}{CR}$ ohms.

The term "triode resistance," as used above, must not be confused with the term "negative resistance" as sometimes applied to a triode circuit when used to generate oscillations. This latter term cannot be applied to the triode itself, but only to the combination of the triode and its circuits. As an analogy let us consider a series con-

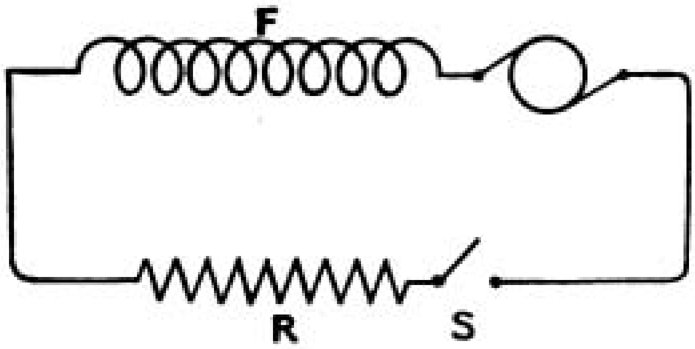

Fig. 12.

nected D.C. generator having negligible resistance connected to an external resistance as in Fig. 12. F is the field coil in series with the armature, and R the resistance.

Fig. 13 shows the shape of characteristic curve OA of such a generator, *i.e.*, the curve connecting current with generated voltage, or E.M.F. The first part is straight, but at

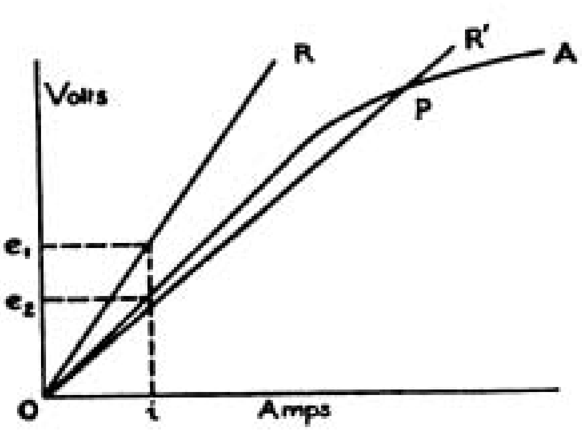

Fig. 13

higher current the line bends over, due to the saturation in the iron. Up to the bend, however, the ratio of E.M.F. to current is constant. But this relation is the same as that which holds with a resistance, *i.e.*, the E.M.F. is proportional to the current. Note this important difference, however: the counter E.M.F. of the resistance *opposes* the current, whereas the generator E.M.F. *assists* the current. We may, therefore, regard the generator as possessing "negative resistance." Now we can draw a line OR representing the value of R in Fig. 12. Will any current flow when S is closed? Clearly not, because the voltage e_1 required to drive any current i through R is greater than that, e_2, which the machine will give. If this current were started by an external E.M.F. it would sink at once to zero on removal of E.M.F. But if we reduce R to such a value as shown by line OR′ the case is different. The generator G can now supply more than enough voltage to drive the current, and the latter, as soon as S is closed, begins to rush upwards at a rate dependent on the circuit inductance. During this period the numerical value of the negative resistance R_G of G is greater than the positive resistance R of the circuit, so we have

$$R - R_G < 0 \text{ or negative.}$$

This condition evidently holds up to the point P, above which any further increase requires a voltage greater than the generator will give, and the conditions remain stable at this point, with steady current. Here, then, the value of the "negative resistance" of G is exactly equal to the positive resistance of R, or

$$R - R_G = 0.$$

The circuit now behaves like one having zero resistance and zero E.M.F.

The current is not oscillatory in this case, because no capacity is present. By connecting a suitable capacity in circuit, however, the machine could be caused to give A.C. current. The value of this capacity would have to be impracticably large, with a generator as usually wound. With a special machine, however, the writer has been able to generate low-frequency currents.

Applying the same reasoning to the triode, we see that, if oscillation is to take place, the numerical value of the "negative resistance" of the circuit must be at least equal to

$$\left(r + \frac{L}{CR}\right) \text{ ohms,}$$

which is the sum of the triode resistance, and that of the oscillating circuit. We can find the value of this in terms of the mutual inductance M between plate and grid coils, and so find the value of M required for the starting of oscillation.

Let I = "internal" current of oscillating circuit;
" i = "external" current of oscillating circuit or plate A.C. current;
" k = change of plate voltage per grid volt ("shift" in Fig. 8).

Then, considering the R.M.S. or effective values of the A.C. quantities, we have

Grid E.M.F. $= \omega MI$.

Corresponding plate circuit E.M.F. $= k\omega MI$

$$\text{Plate current} = i = \frac{\text{E.M.F.}}{\text{total resistance}} = \frac{k\omega MI}{r + \frac{L}{CR}}$$

$$\text{Or, } \frac{i}{I} = \frac{k\omega M}{r + \frac{L}{CR}} \quad \text{But } \frac{i}{I} = \frac{R}{\omega L}, \text{ or}$$

$R\omega C$, as found above.

$$\text{Hence, } CR = \frac{kM}{r + \frac{L}{CR}} \text{ or } r + \frac{L}{CR} = \frac{kM}{CR}$$

But as $\left(r + \frac{L}{CR}\right)$ represents the total positive resistance, the numerical value of the negative resistance of the circuit must be

$$\frac{kM}{CR} \text{ ohms.}$$

If the negative resistance has a smaller numerical value than this, oscillation cannot start because the total circuit resistance is positive. An infinitely small increase of $\frac{kM}{CR}$ over the value of $\left(r + \frac{L}{CR}\right)$ however, renders the circuit unstable, when the slightest disturbance initiates oscillations which continue to increase. For the starting of oscillation, therefore, we see that

$\frac{kM}{CR}$ must not be less than $\left(r + \frac{L}{CR}\right)$ or M must not be less than $\frac{I}{k}(L + CRr)$. Once started, the oscillation increases in amplitude, until, owing to the limits of the characteristic being reached, the effective values of k and r are so modified as to bring the two sides of the equation equal. This is equivalent to saying that energy is being dissipated in the resistances as fast as it is supplied by the action of the triode.

DIRECTION-FINDING STATIONS.

Information *re* Wireless Direction-Finding Stations is given in Admiralty Notice to Mariners, No. 363 of 1920. The information furnished comprises particulars of the general purpose and working arrangements of such stations, and also the regulations for Canadian and Newfoundland, United States, British, French, Italian and German D.F. Stations.

In a subsequent Notice, No. 524, the use of D.F. Stations by the Mercantile Marine and the advantages resulting therefrom are dwelt upon. The Admiralty point out that the existence of such stations in the United Kingdom, France, Canada, United States and Germany, and the regulations under which they are operated, are not as generally known throughout the Mercantile Marine as is desirable, and that where the system is known to Masters it is beginning to be more extensively used through its advantages becoming known and appreciated. It would seem advisable that all interested should obtain all the information possible regarding these stations, as Wireless Direction Finding for navigational purposes has proved to be of great value, and the Mercantile Marine cannot afford to forego the benefit and safeguards it gives

BOOK REVIEWS

THE ELEMENTS OF TELEPHONY.

By Arthur Crotch.

London: E. and F. N. Spon, Ltd., pp. 114, 57 illustrations, 2s. net (Second edition).

WHETHER this little volume really appeals to the reader for whom it is primarily intended, would seem to be largely a matter of conjecture. As the author states in the preface, "it is hoped that it may be of service to the larger class of telephone users," but the percentage of telephone users who either know or care how a telephone "works" is probably not very high.

An elementary introduction is given in Chapter I., setting out the first principles of sound transmission in air, of electric currents, of magnetism, and of the relations between electric currents, magnetic fields, etc.

In passing it is worth noting that the phraseology of this introduction is somewhat loose in parts, and although the student who is well grounded in electrical principles would have no difficulty, it is not wise to create incomplete or inaccurate ideas in the minds of new readers. The description of Fig. 1 is somewhat inaccurate, and the terms "left" and "right" appear to have been transposed. On page 14 it is somewhat difficult to reconcile the author's statements with the well-known values of the specific inductive capacities of glass and paraffin wax.

Chapter II sets out the elements of speech transmission by simple telephone apparatus, while Chapters III to X deal with the details and working of various forms of telephone apparatus in everyday use. The component parts and connections of table and wall instruments both for magneto and C.B. working are well described, as also are the arrangements of modern telephone exchanges, including the various indicators, pegs, jacks, keys, etc. The most useful part of the book begins at Chapter VII—C.B. Working—since this is the system most extensively adopted in practical work, while it is to be hoped that the few remaining magneto systems with their attendant disadvantages will also speedily disappear. It is, however, at this stage of the book that the wiring diagrams, which are very freely given, become (necessarily) more complicated, and we are somewhat afraid that the maze of lines representing the various circuits through a telephone exchange will deter the casual reader from a further perusal of the matter.

The aims of this book are certainly to be encouraged, and it is pleasing to find a P.O. Engineer endeavouring to help on the education of the great "B.P." to a better understanding of matters telephonic. After all, telephony is essentially such a simple process that it merits a much wider understanding of its essential principles than is usually found. The book concludes with a brief but simple and good description of the mode of operation of automatic telephone apparatus, and exchange equipment. May all who peruse this chapter and appreciate the simplicities of automatic working set up a prolonged wail for its speedy universal installation, for to come back to manual operated exchanges after the facilities of automatic is truly like going back from electric traction to the old stage coach.

* * *

SIMPLE WIRELESS TELEPHONES AND HOW TO MAKE THEM.

Published by *Popular Science Monthly*, New York, pp. 47, price 25 c.

This little booklet, apparently written some four years ago, is designed solely for the amateur and handyman who wishes to have practical details of the construction of wireless telephone apparatus. It does not, therefore, give detailed dimensional drawings but rather indications on the lines on which apparatus may be constructed. It opens with a brief *resumé* of photophony and telephony by conduction and induction, and then reviews briefly the Poulsen Arc, Mercury Vapour Arc, Goldschmidt Alternator and a Liquid Microphone. The third part describes very briefly and in places somewhat indefinitely a simple form of arc transmitter with microphone control in the aerial circuit. No mention whatever is made of valve work or of the many uses of valves for transmission and reception

QUESTIONS AND ANSWERS

NOTE.—This section of the magazine is placed at the disposal of all readers who wish to receive advice and information on matters pertaining to both the technical and non-technical sides of wireless work. Readers should comply with the following rules.—(1) Questions should be numbered and written on one side of the paper only, and should not exceed four in number. (2) Queries should be clear and concise. (3) Before sending in their questions readers are advised to search recent numbers to see whether the same queries have not been dealt with before. **(4) The Editor cannot undertake to reply to queries by post.** *(5) All queries must be accompanied by the full name and address of the sender, which is for reference, not for publication. Queries will be answered under the initials and town of the correspondent, or, if so desired, under a "nom de plume."* **(6) Readers desirous of knowing the conditions of service, etc., for wireless operators will save time by writing direct to the various firms employing operators.**

V.K.C.L. (Dovercourt) *sends a scheme for throwing an aerial from transmission to reception, by contacts on the manipulating key, which we have not enough space to describe at length. He asks for an opinion on it.*

The scheme is interesting, but we are afraid it is not practicable. You show the detector, apparently a crystal, in series with aerial, which is, of course, quite wrong. You could probably get over this, however. The great objection is that when transmitting, you have the charged aerial connected to earth through the receiver, and a small gap in series with it. The charge would certainly jump the gap, burning your key badly, and probably giving you violent shocks. Also your receiver is not protected from this discharge. Compare the arrangement of the Marconi earth gap, with the receiver connected across it.

AUDION (Fowey).—(1) *Sends two circuits for criticism and asks* (2) *If he may expect to receive Arlington using one valve.* (3) *If the condenser in the grid tuned circuit should be small.* (4) *If loading up an aerial with a natural wavelength of 100 metres to 5 500 metres gives good results.* (5) *Whether the arrangement shown with two tuned circuits makes tuning for signals difficult.* (6) *If the reaction coil tends to make the circuit oscillate.* (7) *What English stations send weather reports, and on what wavelengths they work.* (8) *Whether Poldhu transmits at 9.30 p.m., and* (9) *What time the weather report is transmitted from Rinella, Malta.*

Please note that the number of questions submitted to this column *should not exceed four*, and should preferably not be on points which are treated in nearly all text-books.

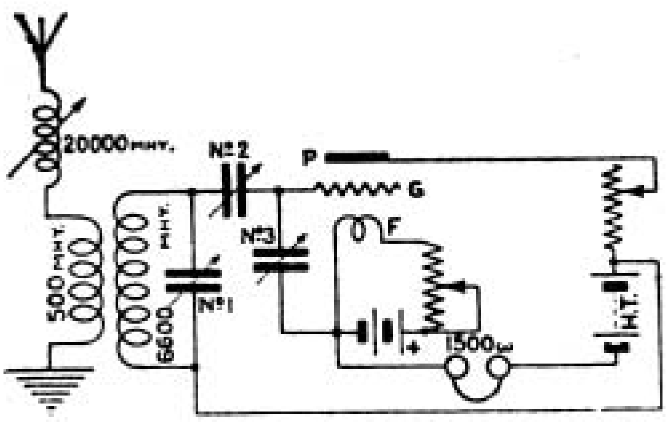

Fig. 1.

(1) With a hard valve we do not like your circuit *a* (Fig. 1). Circuit *b* (Fig. 2) should be all right if (1) you omit the connection marked C.W., which is quite unnecessary, (2) You make your reaction coupling much stronger. Use a coil of at least 100 mhys, and couple it directly to the 6,600 mhy coil, and (3) if you put your phones the other side of the H.T. battery to avoid risk of shocks.

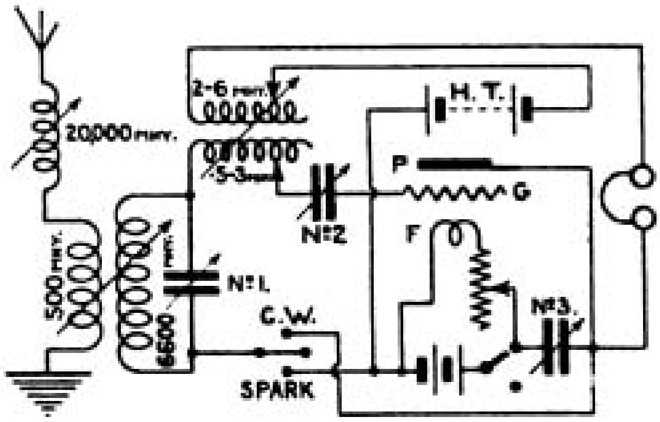

Fig. 2.

(2) If your circuits are very good, and very skilfully used, you may possibly do so.

(3) Yes.

(4) Not very.

(5) Somewhat, but not unduly.

(6) Yes.

(7) Poldhu, on 2,750 ms, and Cleethorpes, on 3,000 ms.

(8) Yes, a weather report.

(9) 9 p.m.

W.E.D. (Peckham).—(1) *Sends a circuit for criticism, and asks* (2) *If galvanised iron wire is any use for an aerial.* (3) *If circuit shown, which is a simple two-circuit receiver, could be conveniently improved by the use of a triode as a note magnifier.* (4) *If it could be improved with a triode used as a high-frequency amplifier.*

(1) Circuit (Fig. 3) would be improved with an A.T. condenser. The dimensions of the loose coupler are far too big, as the inductances work out at about 30,000 and 75,000 mhys. Use coarse wire, and less of it. Unless your plates of glass are very thin your variable condenser will not have enough capacity. Your telephone condenser should be much bigger.

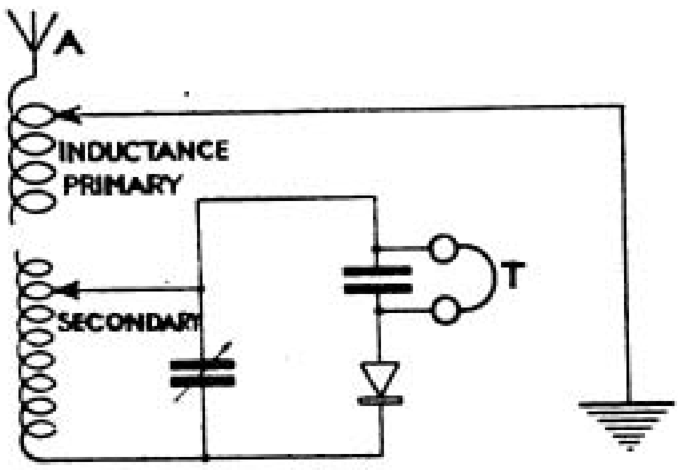

Fig. 3.

(2) Iron wire could be used for an aerial, but would be very inefficient, owing to its large resistance, particularly to high-frequency currents.

(3) Not much alteration would be needed. You would require an iron-core transformer in the place where the telephones are shown, and the usual resistances and batteries for working the valve.

(4) More alterations would be needed. For details with regard to the last two questions consult the constructional articles.

D.E.W. (Crouch End) *asks* (1) *If a Wollaston (? wire) fused in a glass tube filled with mercury and fitted with a terminal, can be used as one electrode, and a lead plate for the other, for an ordinary detector for a receiving station.* (2) *In what order does one wire up a receiving station;* and (3) *Whether a tuning coil, fixed condenser, and Wollaston wire detector is all the apparatus required for a receiving station.*

(1) There are two types of Wollaston wire detector, the electrolytic, and the thermal; we are in doubt as to which of these you are thinking of. However, neither is of any practical use, as they need exceedingly skilled work to set up, and are very fragile. We do not know where you could get the wire, and do not think it likely that there are a dozen men in the country with sufficient manipulative skill to make either type even given a supply of the wire. Do you realise that it is only about 1/20,000th of an inch in diameter in its final form?

(2) We do not quite grasp the point of this question. It does not matter in what order you connect up a set, provided you get everything in the right place. If you mean, how should the instruments be connected up, consult the earlier constructional articles in the last volume.

(3) The Wollaston detector is not worth trying. The apparatus you will need depends a good deal on what detector you decide to use. You will find information to help you in the articles quoted above, or in Bangay's "Elementary Principles."

A.C.C. (Birmingham) *asks* (1) *Why an arc generates oscillations.* (2) *Why it should burn in methylated spirit.*

(1) We have not space enough to discuss this adequately. You will find the reasons given in almost any modern text-book on wireless. Briefly, it is due to the fact that the greater the current flowing through the arc at any instant, the less are the volts across it. While the shunt condenser is charging up, the current across the arc is small, and therefore the voltage is big. When the condenser stops charging, the current through the arc gets bigger, and the volts across it drop, allowing the condenser partially to discharge across. Similarly, when the condenser is discharged, the arc volts rise again, allowing it to recharge. By this means the oscillations are built up and sustained.

(2) Chiefly to provide a conducting atmosphere for the discharge of some inert gas which will not cause burning up of the electrodes.

W.R.W. (Langdon Hills) *is in the fortunate position of being able to rig any form of aerial he pleases, subject to the P.M.G.'s restrictions, and asks for advice. He also asks for instructions for making a telephone transformer.*

(1) We should certainly use a single wire type. It will be quite satisfactory if nearly vertical, provided that it is not too much screened by stays, or any metal on the mast, in this position. If you are working near a house get it away from the walls before running upwards vertically. A straight wire inclined at an angle to the horizontal, say at 45°, will give you directive effects, if you feel inclined to try this. With short aerials, you should certainly not use a T, unless unavoidable: and we should not advise an L with a full right-angle bend, unless circumstances gave a strong reason for it.

(2) See the March number of *The Wireless World.*

J.C. (Sunbury) *sends a diagram* (*Fig.* 4) *of a receiver which is essentially a self-heterodyne, with a second valve added as note magnifier. He shows two positions in which he has tried the phones, in different parts of the plate circuit of the second valve, and asks why one works and the other does not.*

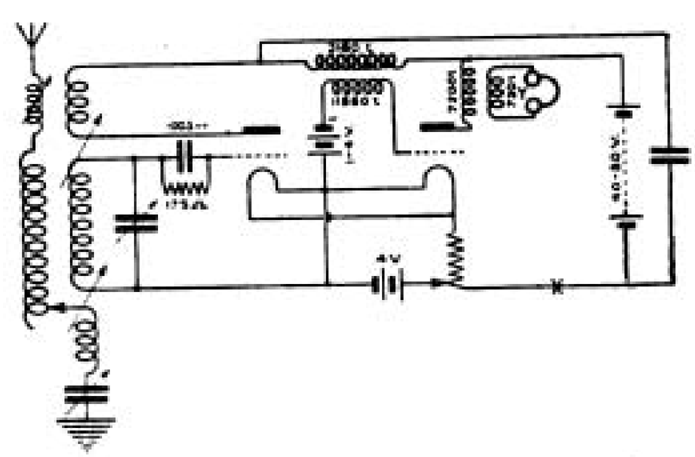

Fig. 4.

In position X you are getting the resultant of the plate currents due to both valves. These may be opposing. If your note magnifier is not working well, this opposition may give the weakening you mention. With the phones at Y you will not get this effect. It is probable that your note magnifier is not working well, as you appear to be putting too much negative potential on the grid.

R.L. (Falkirk) *asks* (1) *Whether certain circuits (shown in No. 4 reply to Capt. Delarue, W.W., May, 1919) can be used to receive C.W., by connecting the oscillating circuits of two buzzers in series with the aerial.* (2) *Whether an efficient condenser can be made with ebonite tube 12 inches long, between two sliding metal tubes* (3) *What amount of wire will be required for the plate inductance of the circuits indicated in* (1).

(1) The circuits discussed in question 4 of Capt. Delarue in the May number could be used as you suggest, as is there explained. The circuit No. 3 in the constructional article for November is much better, and being of heterodyne type, does not need local excitation. If you are going to use a valve why not let it produce the local oscillations needed, instead of bothering with buzzer excitation, which at best is only a makeshift and rather an unsatisfactory substitute. Though the circuit No. 3 mentioned above is quite all right, we recommend you to try a simpler arrangement on the same lines first. You will find such circuits given in the constructional articles.

(2) Yes, keep the thickness of the ebonite small, or your capacity will probably not be large enough.

(3) We are afraid we cannot say, without more information as to the wavelength, range required, and so on.

L.J.N.K. (Bedford) *asks* (1) *What is the construction of the Radioson detector.* (2) *If any other detector can be used with the Graillot relay.* (3) *If each addition to a set has to be notified to the P.M.G.*

(1) and (2) We do not know either of these articles. If you will give us some further particulars, we will try to obtain the information you desire. (3) It all depends what the addition is. If it radically alters the circuit previously passed by the P.M.G., it would be better to notify the latter.

J.W.D. (Constantinople) *asks* (1) *For a diagram for constructing a wavemeter.* (2) *For a simple method of calibrating the same.* (3) *How to tell the wavelength of any signals tuned in on a receiver.* (4) *If there are any other readers of the W.W. in Constantinople.*

(1) The diagram of connections is very simple. (*See Fig. 5*).

Where L = an inductance of a few turns of wire
C = a variable condenser
X = a crystal
T = a pair of telephones.

See article in our issue of April 3rd, which gives full details.

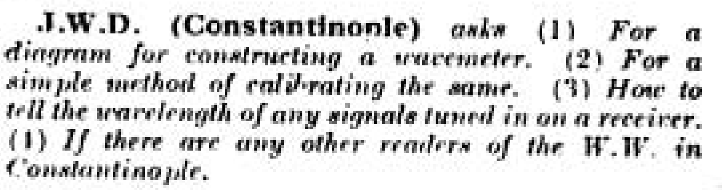

Fig. 5.

(2) The only satisfactory method is by comparing it against another wavemeter, or similar calibrated set. If you can fix a few wavelengths accurately, by means of stations whose wavelengths you know, find the condenser readings for these wavelengths. Plot a curve between wavelengths and condenser readings for all the values you can obtain in this way. You can then get the wavelengths corresponding to other values of your condenser from the curve.

(3) Tune the closed circuit to the signals. Then "buzz" it by connecting a buzzer and cell across the condenser. Bring the wavemeter near, and listen in the phones. Maximum sound will be heard when the wavemeter is set to the wavelength of the signals.

(4) We do not know of any.

L.A.W. (Bradford) *asks* (1) *If in a condenser having a dielectric partly of mica and partly of air, the S.I.C. will be the mean of the S.I.C.'s of the mica and the air.* (2) *If there will be excessive losses in a condenser of this nature and if the S.I.C. will still be the mean if the plates are not quite parallel.* (3) *Why on a type 31 crystal receiver (Marconi) a buzzer can sometimes be heard with all the switches open.*

(1) The S.I.C. will be intermediate between those of mica and air, but the exact value will depend on the exact thickness of each.

If D is the thickness of air
d „ „ mica
k „ S.I.C. of mica

it can be easily shown that the capacity per unit area of plates equals

$$\frac{k}{4\pi D\left(k+\frac{d}{D}\right)} = \frac{1}{4\pi(D+d)} \times \frac{k(D+d)}{kD+d}$$

Now $\frac{1}{4\pi(D+d)}$ would be the capacity per unit area if the dielectric were all air. Therefore the effective S.I.C. of the combination is $\frac{k(D+d)}{kD+d}$

(2) If the plates were not quite parallel a similar expression could be worked out, but would be more complex. The difference would not be very important if the angle between the plates were small. There would be no special dielectric losses in such condensers used for receiving purposes.

(3) When the switches are open, you may, if the buzzer coupling is too tight, force oscillations from it on to the open circuit, particularly if the buzzer circuit happens to be nearly in tune with the resonance frequency of the secondary circuit when open. Closing the switches of course alters the tune of the secondary circuit, and may weaken signals by throwing it out of tune with the buzzer circuit.

NOTE.

With reference to the very low frequency amplifier shown in Fig. 9, page 54 of the issue of April 17th, under the heading of "Some Wireless Wonders," the following values may be of use to readers :— R = 0.08 ohms ; R_1 and R_2 = 5 ohms ; C_1 = 0.0015 mfd. ; C_2 = 0.025 mfd. ; C_3 = 1 mfd.

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THE WIRELESS WORLD

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SELENIUM

AND SOME OF ITS USES

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

CHEMICALLY speaking, Selenium is a somewhat peculiar element. In many respects it is closely allied to the non-metallic elements, such as Carbon and Phosphorus, and especially to Sulphur, while on the other hand in some ways it is not unlike the metals.

All the known chemical elements have been classified and arranged in order of their atomic weights, and grouped together to form the well-known "Periodic Table," first described by Mendeléef in its present form. In this table Selenium occurs in the fifth series of the 6th group, and from its position in the table one would expect it to be somewhat similar in its nature and chemical properties to Sulphur and Tellurium. As a matter of fact it is in many respects intermediate between those two elements. Its atomic weight is 79·2 and it is usually represented by the symbol Se.

In its natural state it is found most frequently in combination with other metals—chiefly lead, silver, or copper—in the form of Selenides of these metals. Selenium, like sulphur is an element that can occur in more than one form, each different variety having somewhat different physical properties. It is rather peculiar to find that a given substance can be changed into several different forms, having different appearances and different physical properties, while all the time retaining the same chemical properties which are characteristic of that element. Various theories have been put forward with a view to explaining or in some way accounting for these differing properties of the various "allotropic modifications" as they are often called. In the case of a molecule of a complex compound the case is somewhat different to that of an element, as it is then easier to suppose that the atoms of which the molecule is composed have been arranged in slightly different ways in the different modifications. In the case of an element, however, there is as a rule no such complexity of the molecular structure, although in the case of sulphur, and possibly also in that of selenium on account of the resemblance of the two elements, it is known that different molecular structures can occur. These different structures may and probably do in some measure account for the changes of physical properties.

In most cases with elements, it is now assumed that the various physical forms arise largely from different arrangements of the electrons within the atom itself. The most modern theory of atomic structure postulates that all atoms consist of a nucleus of some form, about which at present very little is known, carrying a positive charge, and surrounded by a number of electrons. The number of these electrons in any given atom increases with the atomic weight, and is of the same order of magnitude as that weight.

The electrons in the atom are bound to the positively charged nucleus with various degrees of freedom, depending upon their geometrical arrangement round the nucleus. In a recent theory set out by I. Langmuir, he lays down certain postulates and from them deduces the electronic distribution in various atoms. He shows that they fall more or less naturally into the groups of eight of the periodic table, with the result that any given atom may either tend to take up additional electrons in order to complete the octet, or may tend to give them up. These electrons in the outer shell of the atom are the ones that very largely determine the physical properties of the atom. Thus to give one example, briefly the presence of one or more loosely attached electrons generally indicates that the element is coloured,

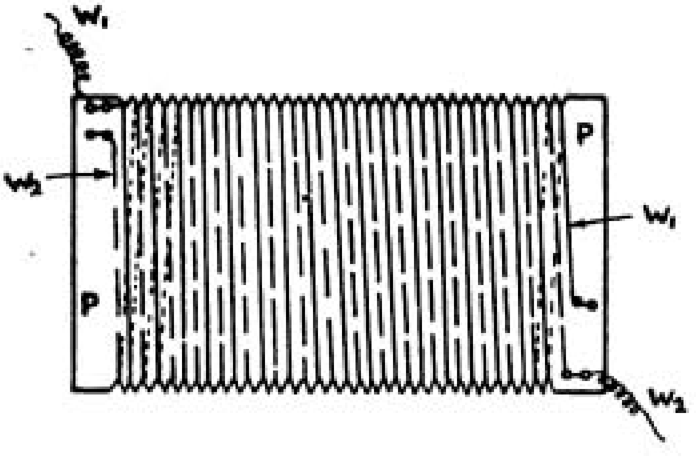


Fig. 1.
Simple flat type of Selenium Cell,

and produces coloured salts since the loose electrons are easily stimulated to set up light vibrations. Similarly when in a group of atoms, one or more electrons is easily displaced and removed from the original structure, a material is found that easily conducts an electric current, the presence of free electrons capable of moving from atom to atom being necessary for this purpose.

Two forms of selenium are usually recognised : (1) Amorphous, and (2) Vitreous. When the material is purchased commercially it is generally in the vitreous state, in the form of small cylindrical rods of a very dark greenish colour. By burning the vitreous selenium in oxygen, or by oxidising it with nitric acid, a white crystalline mass, selenium dioxide, SeO_2, is formed. This is soluble in water forming selenious acid, H_2SeO_3. If the solution of this acid is precipitated with a reducing agent, such as sulphur dioxide, SO_2, the amorphous variety of selenium is precipitated in the form of a reddish powder. By heating and sudden cooling this form may be reconverted to the vitreous variety.

A third form of selenium is sometimes recognised. It is obtained by heating and annealing the vitreous variety. It is sometimes termed the "metallic" modification, and is the one with which we are most concerned in connection with the electrical applications of the element.

For the preparation of this variety, the vitreous selenium should be melted and moulded into the shape required, and its temperature then allowed to fall to 210°C, or thereabouts, at which value it should be maintained for some hours, before slowly cooling to atmospheric temperature. The time during which the annealing process is carried out, as well as the exact value of the annealing temperature, affect to a certain extent the electrical properties of the final product. In its initial state the vitreous variety is practically an insulator, but after the annealing it becomes a conductor, of which the initial resistance is largely dependent upon the annealing process. In a good specimen prepared in this manner, it is found that the resistance of the material depends upon the light falling upon its surface. The selenium in its sensitive state possesses a greyish colour, but is nearly opaque to light except in very thin films. Hence when light falls upon its surface it will only be able to penetrate a very short distance into the mass of the material. As it is only natural to assume that the electrical properties of the material will only be affected in the actual part under the influence of the light, the necessity for arranging the selenium in an extremely thin film should be obvious. By this means the light is able to influence a much greater proportion of the total mass, thus bringing about a proportionately larger change in resistance.

Fig. 2.

An easily constructed Photophone Receiver using a Selenium Cell in the focus of a Parabolic Mirror to concentrate the light on the cell.

Given this effect of light upon the material, let us see briefly to what uses it may be put. One of the earliest suggested applications was for the purposes of photometry. Since the resistance of the material varies with the intensity of the incident light, it should be possible to arrange a selenium resistance to measure the strength of the light falling upon its surface, and thus to compare different light sources, as is customarily done by optical means in ordinary photometers. The apparent advantages of the arrangement lie chiefly in the elimination of the personal element in making the measurements. Such arrangements have been used to some extent, but the results obtained have not shown any marked advantages over the ordinary instruments. This is largely due to the fact that selenium is more sensitive to light of some colours than it is to others, with the result that when comparing lights of different colours inaccurate readings are obtained.

As far as signalling without wires is concerned, and this represents perhaps the most extended use of selenium cells, the cells have been used both for telegraphy and telephony, using light rays as the connecting link between the stations.

For this purpose it is desirable to make the selenium up in the form of a "cell," which shall present as large a surface as possible to the light rays, and at the same time is so constructed that the film of selenium traversed by the current is both thin and of large cross-sectional area. One of the simplest constructional arrangements for such a cell is indicated in Fig. 1. It consists of a small slab P of insulating material, such as porcelain, slate, or mica, around which two parallel wires are wound a number of times in notches cut in its edge. A convenient size for this insulating base is about 2" × 1". The (bare) wires may be of about No. 30 gauge copper wire, although platinum is somewhat preferable. The two wires should be wound as close together as possible without actually touching at any point, and for this purpose it is most convenient to cut a series of small notches close together along each edge of the base, as indicated in the diagram.

The base should then be heated, and a thin film of selenium melted on to it and smeared evenly over its surface. The two wires form the terminals of the cell so that

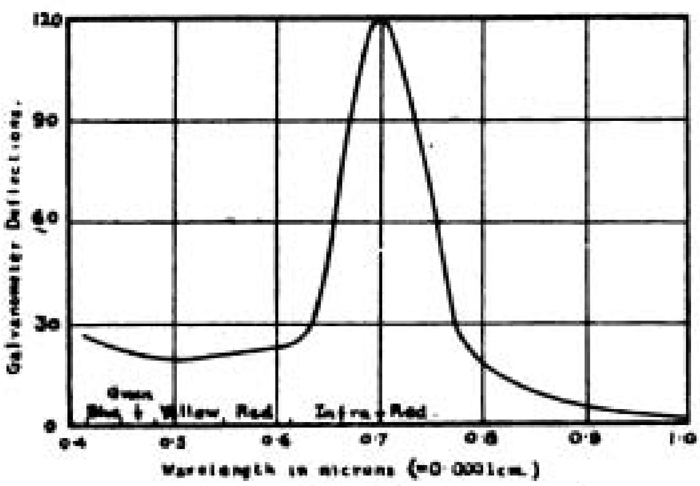


Fig. 3.

Sensitiveness Curve for a Selenium Cell to light of different colours.

the current passes from one to the other through the film of selenium spread between them. The complete cell must be annealed before use in order to transform the material into the light sensitive state.

Many other forms of cell have been used by various experimenters, but the principle of them all is the same.

To enable such a selenium cell to be used as a receiver for signalling purposes, it is

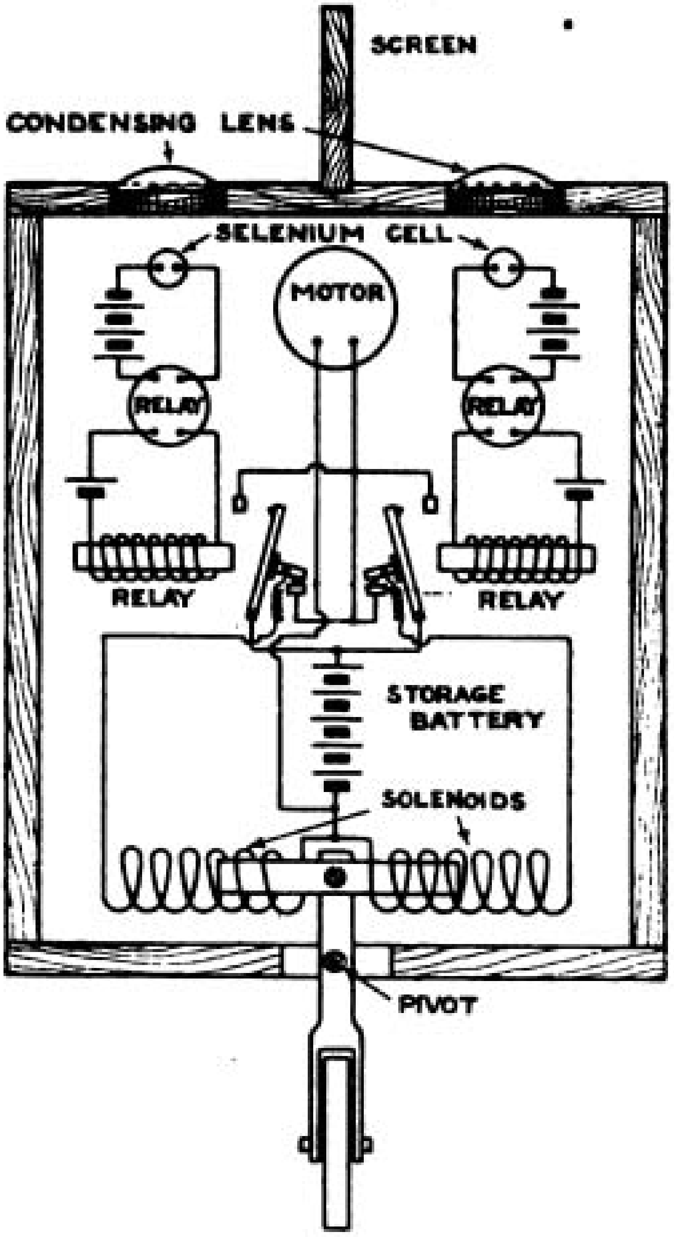


Fig. 4.

Arrangement of Mechanism in the interior of an "Electric Dog" for control by light waves.

merely necessary to connect it in series with a battery and a telephone receiver, and to expose it to the beam of light from the transmitter. The effects may be increased by using a lens or a parabolic mirror to concentrate the received rays upon the cell. (Fig. 2). By such apparatus, using an electric arc searchlight at the transmitter, and with the arc controlled by a transmitting microphone, as in the case of the well-known Duddell "Talking Arc," speech has been heard over a range of several miles.

By the use of appropriately coloured filters, light beams of any desired colour may be used for such signalling, thus rendering possible multiplex signalling between two points using beams of different colours. Proceeding still further along the spectrum, even "invisible light"—either ultra violet, or infra red—may likewise be employed, giving a much more secret means of communication since the beam between the two stations is invisible. Such beams of invisible light have in fact been used for signalling purposes during the recent War.

As far as sensitiveness goes, the curve of Fig. 3 indicates that for that particular cell, the sensitiveness was much greater for infra red rays than for ordinary visible light. This however, is dependent upon the conditions of preparation of the cell, and cannot be taken as a rigid generalisation.

Another important use to which selenium cells have been put, is in an instrument termed an Optiphone, an instrument designed with the object of enabling the blind to read printed type by means of sound. The principle of this apparatus is briefly to allow a beam of light reflected from the printed page to fall on a number of selenium cells which are joined in series with sources of interrupted current and a telephone receiver. Thus both the intensity and frequency of the sounds heard in the telephone receiver depend upon the illumination received by the cells, which again is dependent upon the shape of the printed letter from which the light has been reflected. By this means, after some practice, the characteristic sounds due to each letter can be learnt, and the type thus read by sound.

A similar instrument can also be used for locating and recognising different objects about the room.

In the latest type of optiphone a single selenium cell is employed to receive the light reflected from the printed sheet, which latter is illuminated through five rows of holes in a rotating wheel, each row having a different number of holes, so that different parts of each letter of the type are exposed to light with a different frequency of interruption. When the light passing through any given row of holes falls on the black part of a letter it is absorbed, so that practically no light of that frequency falls on the selenium cell, and therefore the note of that frequency is suppressed in the telephones. The apparatus therefore gives a sound for white spaces, and none for black spaces. In the most recent form of instrument developed by Messrs. Barr and Stroud, a compensating selenium cell is added so that when both cells are equally illuminated no sound is emitted, with the result that the sounds actually heard are dependent solely upon the shape of the letter opposite the cell. The original optiphone was the invention of Dr. E. E. Fournier d'Albe.

A very similar apparatus has been applied to the construction of an electric typewriter, that will automatically copy any printed matter put before it. The description of this instrument hails from America, and as far as the writer is aware it has not yet been put upon the market.

The light-sensitive properties of selenium have also been employed in connection with the electrical transmission of pictures and photographs, both wireless and by wire. The selenium cell is used to control the current transmitted along the line (or the intensity of the emitted waves, in the case of wireless transmission), in accordance with the light or shade from point to point of the picture.

A number of other but less important uses of the material have also been recorded at various times. Amongst these we may merely mention the control of a mechanism by light rays—perhaps the best known example of which is the "electric dog," a mechanical contrivance which by means of selenium cells mounted in its "eyes" can be arranged to follow a light in whatever direction the light may be moved. (Fig. 4.)

An interesting little experiment illustrating another property of selenium was described by Mr. A. A. Campbell Swinton a few years ago. The apparatus used consists of two plates, one of carbon or copper, and the other of copper coated on one surface with a film of selenium, and varnished on the other. They are immersed in ordinary tap water to form a simple form of primary cell, and are connected to a galvanometer. In the dark the deflection of the galvanometer indicates that the selenium is electropositive to the carbon, but when the cell is illuminated the galvanometer deflection reverses, indicating that the electropositive nature of the selenium has immediately changed to electronegative.

As regards the more scientific applications of selenium cells, they have been used by E. Ruhmer, and also by Dr. A. O. Rankine in connection with recording the wave forms of sound waves. By exposing a photographic film to a modulated beam of light from a source controlled by a transmitting microphone (as used for light telephones), a picture of the varying intensity of the sound wave may be obtained. (See Fig. 5.) By moving this

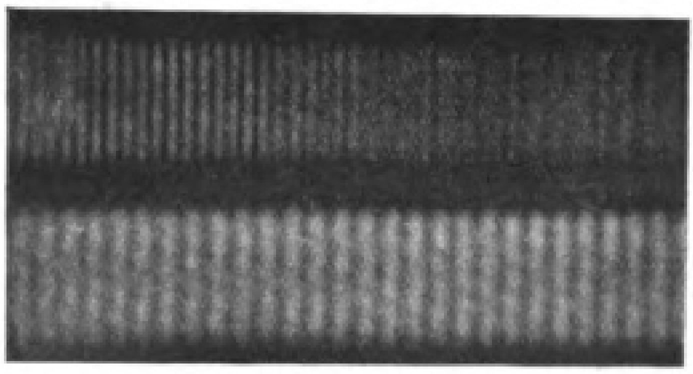


Fig. 5.
Reproduction of parts of two films of Sound Waves taken by Dr. A. O. Rankine. The lower one represents the sound of a tuning fork; and the upper one, reading from left to right, shows the waveform of the end of the word FIVE.

film at the proper speed through a steady beam of light, and allowing the resultant transmitted beam to fall on a selenium cell connected to a telephone receiver, the original sounds may be reproduced. A device of this nature has been suggested as a means of reproducing the actors' speech and sounds in the proper phase relation to the film on which their movements and actions are photographed, thus vastly increasing the realism of the scenes depicted in the ubiquitous cinema.

A. H. GINMAN, ESQ.

Personalities in the Wireless World

THE subject of our biography, Mr. A. H. Ginman, the popular Deputy Chairman, and Managing Director, of the Chinese National Wireless Telegraph Company, was born at Chertsey, Surrey, in December, 1874, and was educated at the Sir William Perkins School, Chertsey.

In 1895 Mr. Ginman, having become attracted to the Telegraph Service, joined the Cuba Submarine Telegraph Company and after a short period in the testing department of the Silvertown Indiarubber and Guttapercha Company's factory proceeded to Cuba by the cable ship *Silvertown*. His residence in Cuba coincided with very stirring times in that portion of the globe, the insurrection which culminated in the Spanish-American war breaking out. Mr. Ginman happened to be at Cienfuegos when it was bombarded.

In 1899 Mr. Ginman, having made good headway in Cuba, returned to England, and in 1901 took up an appointment with Marconi's Wireless Telegraph Company, Limited. After going through a course of instruction at that Company's Chelmsford Works he was assigned to the wireless coast station at Crookhaven, Ireland, where he gained much useful experience.

But Mr. Ginman was not one to rest on his laurels and the following year saw him once again leaving this country to conquer fresh fields, this time under the wing of the American Marconi Company to which he had obtained a transfer. During the voyage across to New York, on the s.s. *Campania*, he participated in the first game of chess played by wireless telegraphy, the passengers on the *Philadelphia* being the opponents.

Mr. Ginman's stay in America was a very successful one and before he returned to the mother country great strides had been made in the art of wireless which, when he arrived, was in its infancy. He was the first instructor in the school of wireless telegraphy at Babylon, N.Y. Then followed a period at the Cape Cod high-power wireless station as officer-in-charge. Leaving Cape Cod, Mr. Ginman rendered valuable service on the American Marconi Company's construction staff and whilst attached to that staff erected wireless stations at Virginia Beach (Virginia), Fernandina (Florida), etc. The next step was a transfer to the Head Office, New York, which furnished more valuable experience, after which came Mr. Ginman's big opportunity. At that time there were no Marconi stations on the west coast of the United States and none of the ships trading in those parts was fitted with wireless apparatus. Mr. Ginman was sent to San Francisco with the object of developing the wireless business on the Pacific coast. He set to work and in the short space of two years succeeded in bringing about the establishment of a chain of wireless coast stations from Alaska to San Diego, California, and the equipment of 190 ships with Marconi apparatus.

Unfortunately for the world of wireless, however, Mr. Ginman became financially interested in a shipping business at San Francisco and in 1916 he resigned from the Marconi Company, but he soon found that he could not divorce himself from his " first love " and in 1917 he rejoined Marconi's Wireless Telegraph Company.

In the same year he visited China on a business mission which was extremely satisfactory in all ways, Mr. Ginman being successful in concluding contracts there for 200 wireless telephone sets and several wireless telegraph stations.

In a subsequent visit to China he formed the Chinese National Wireless Telegraph Company (which Company is jointly owned by the Chinese Government and Marconi's Wireless Telegraph Company, Limited) and, as stated, he is now the Deputy Chairman and Managing Director of that Company.

Probably Mr. Ginman would count as one of the most important and joyful events in his inspiring career the arrival of his little daughter Alma. She was born in America and is now finishing her education in England.

FRAME AERIALS FOR RECEPTION

THEIR THEORY, DESIGN, CONSTRUCTION AND USE

Introduction and Theory.

THE directional properties of frame (or loop) antennæ have been known for some considerable time, yet it was not until during the war that they were developed and utilised to any appreciable extent. The war sent men and machinery below the level of the earth, and aerials perforce had to accompany them. In dugouts and other small chambers, where even fifty feet of straight wire could not be suspended, the loop aerial came into its own and was rapidly developed, so that to-day it occupies an outstanding position as an exceedingly useful and interesting adjunct of radio work.

To the amateur experimenter a frame aerial offers several distinctive attractions. It is cheaply, easily and quickly constructed ; it possesses a high degree of portability ; it may be set up and used inside the house, and in connection with the manner of its design and use there is still a large field for exploration. Beyond all this there is the added interest of its use as a direction-finder. This article deals only with the matter of reception. Being in reality a closed circuit of small dimensions, the frame aerial is a poor absorber of electro-magnetic energy and an indifferent radiator, but the former disadvantage may be compensated for by the use of valve-amplifiers.

In the following it is assumed that the loop is square. Let Fig. 1(*a*) represent a single loop of wire, with its plane perpendicular to the earth, capable of being rotated on the axis represented by the broken line. The peculiar characteristics of such a loop are that when the side c d is in the same direction as a transmitting station the strength of the received signals will be a maximum, and that when it is at right angles to the said direction the signal strength will be a minimum, it being understood that all other controlling factors remain constant. As the loop is free to swing through 360° (Fig. 1 *b*) there will clearly be two maxima and two minima : that is to say, there will be a maximum reading when the loop is in the direction of the transmitting station, no matter whether the loop is in the position as shown in Fig. 1, or whether it is swung through 180° and c and d thus reverse their positions ; a similar statement applies to the minima. Fig 2 may, perhaps, make this quite clear. As a general rule, with small loops the two values of the maxima and minima are not equal, an important point to which we shall return later.

Let us first of all consider why a loop aerial displays this power of indicating the direction of any given transmitting station. The time spent in such an enquiry will not be wasted, because unless the experimenter has some idea of fundamental principles his work will be only a series of plunges in the dark.

We will assume that the plane of the loop is in the first instance at right angles to the direction of the transmitter. In Fig. 3 are shown the sides c and d in section, as seen from above the loop ; T is the transmitter and W a representation of the advancing wavefront. In such a case we may assume

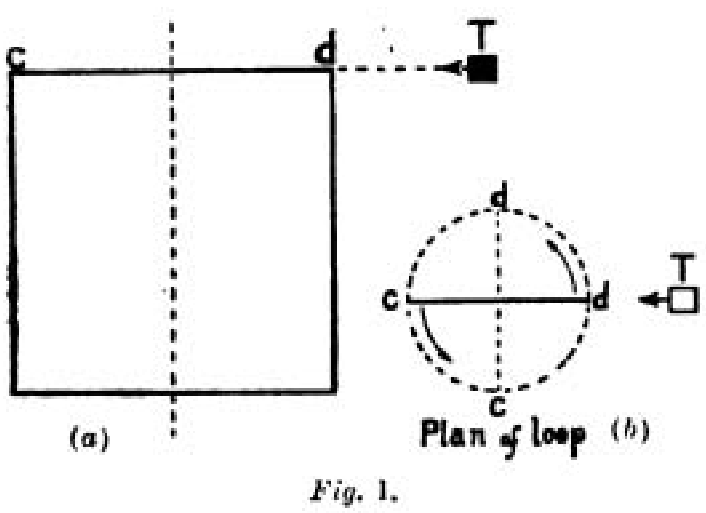


Fig. 1.

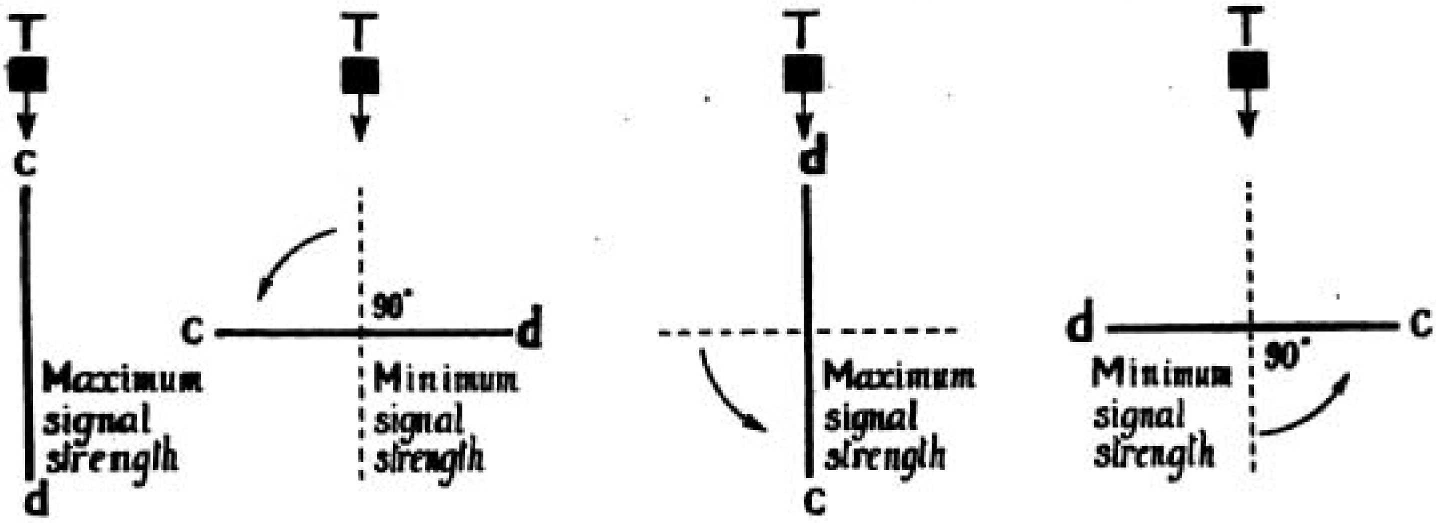


Fig. 2.

that c and d are cut *simultaneously* by the electromagnetic component of the wave and affected *simultaneously* by the electrostatic component. An e.m.f. is therefore induced in c and d simultaneously, and in each

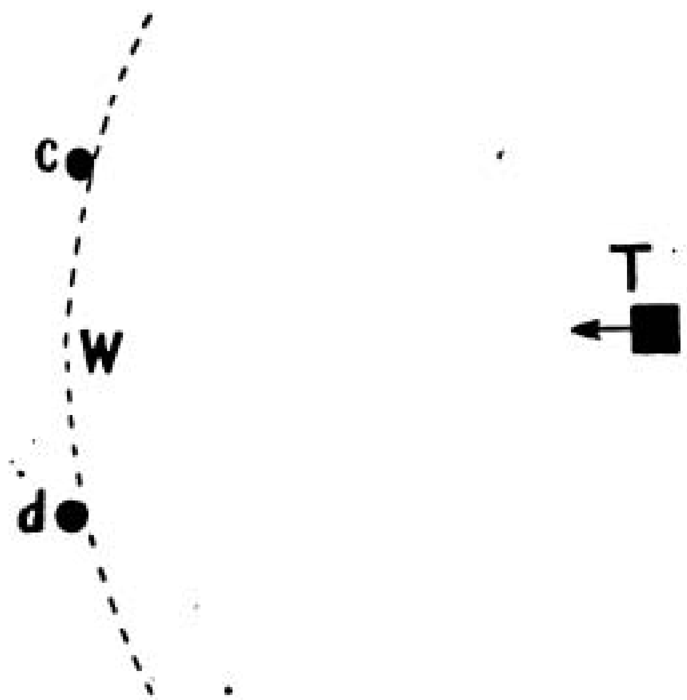


Fig. 3.

of these wires this e.m.f. will be in the same direction, either upwards or downwards, according to which half of the wave happens to be concerned at the instant we are considering. At this juncture let us again look at the loop as a whole (Fig. 4). This diagram shows plainly that if the e.m.f. is in an upward direction in both c and d the e.m.f.'s in each half of the whole loop are *actually opposed to each other*. Theoretically, therefore, being equal they cancel each other, and the action on the detector is nil. Fig. 5 demonstrates this in another manner. It should be understood that as the loop is being acted upon by high-frequency waves the components of which vary from zero to maximum approximately according to a sine law, the e.m.f.'s induced in the sides of our loop may be represented by sine curves. The base line represents time. Starting from t, we see that the e.m.f. in each half of the loop commences at zero and increases to a maximum of, say, 10. Being opposed e.m.f.'s and in phase with each other, one reaches the value +10, and the other the value −10, and they reach their respective maximum

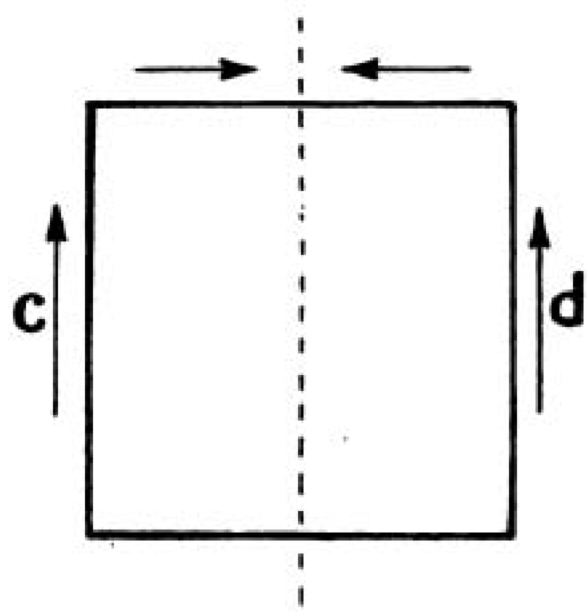


Fig. 4.

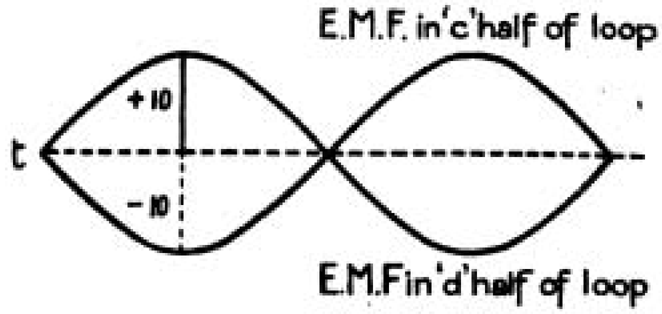


Fig. 5.

values at one and the same instant in time. The resultant value of the e.m.f. in the loop at any instant, therefore, is zero. In other words, the plane of the loop being at right angles to the direction of the transmitter the signal strength is a minimum ; theoretically, considering a simple loop, the e.m.f. will be zero, but in practice, with a detector and tuning circuit in operation, the e.m.f. although a minimum, has a value greater than zero.

Next, suppose that we swing the loop through 45° (Fig. 6). In this instance the wire d comes under the influence of the wave before the wire c, the length of time depending on the dimensions of the loop. Thus there will be a difference in phase, say, for example, 10° between the e.m.f.'s in c and d respectively, and the resultant of the two e.m.f.'s is available to actuate the detector. This state of affairs is shown in Fig. 7, in which the two e.m.f.'s are depicted with a phase difference of 10° and the resultant e.m.f. appears as a dotted line. The phase difference is, of course, actually exceedingly small.

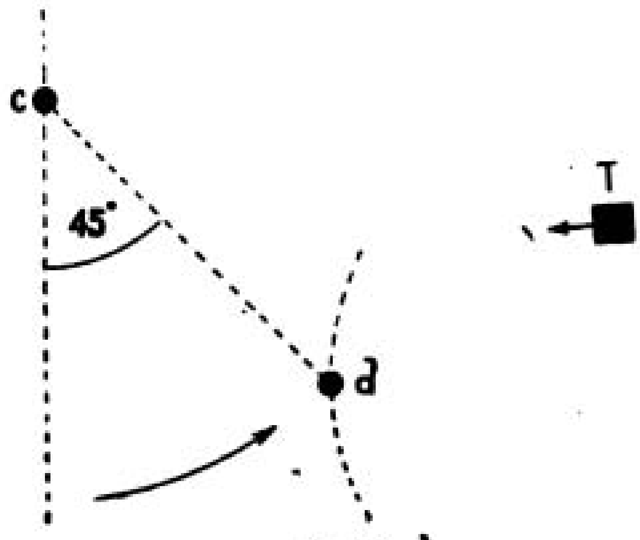


Fig. 6.

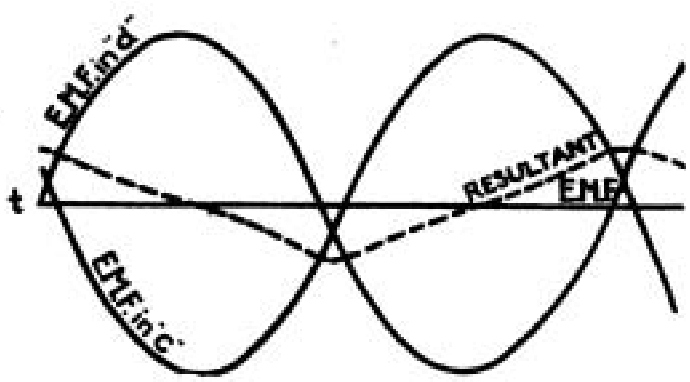


Fig. 7.

Finally, let us imagine the loop to be rotated a further 45°, thus bringing its plane into the direction of the transmitter (Fig. 8). The difference in phase between the e.m.f.'s in c and d is now a maximum, say, 20° for this particular loop, and the resultant, as shown in Fig. 9, is a maximum for this particular loop and a wave of given frequency and amplitude.

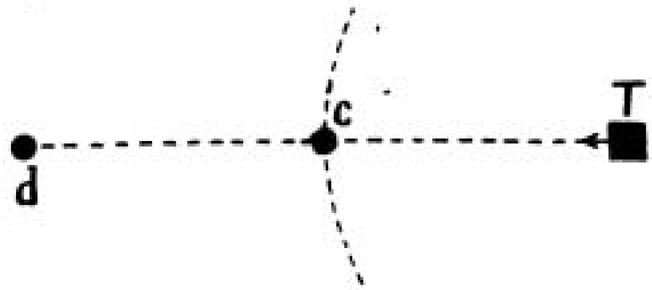


Fig. 8.

When such a condition exists we know that the loop is pointing to the transmitting station.

A word of caution is necessary with regard to Figs. 7 and 9, and the text referring to them. It must be clearly understood that the dimensions of the loop regulate the phase difference between the currents in c and d, and that as frame aerials are very small

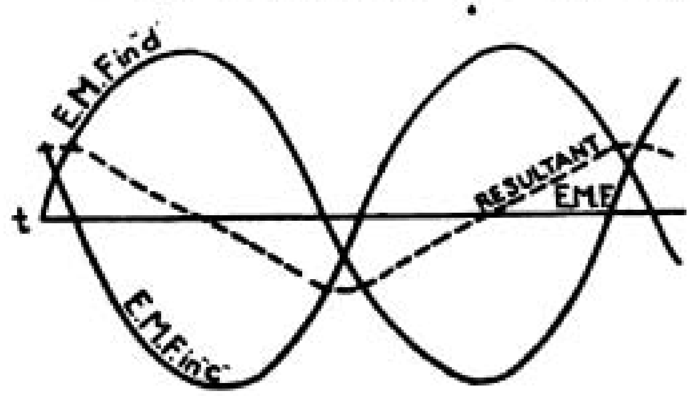


Fig. 9.

compared with the usual wavelength, the actual electrical phase difference is small. The Figs. 7 and 9 are purely diagrammatic and exaggerated on purpose to render the argument plainer. It is not suggested, for example, that the e.m.f. in c (Fig. 9) actually lags 20° behind that in d. The full effect

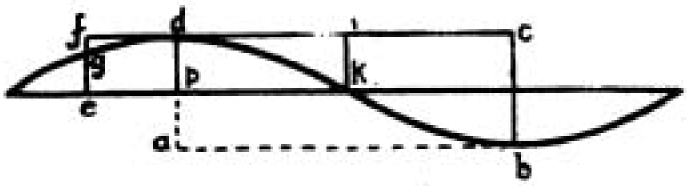


Fig. 10.

of the wave is only obtained when the loop is half a wavelength long. Thus, in Fig. 10, the loop a b c d has its sides half a wavelength apart and the value of the resultant e.m.f. in the loop when the plane of the latter is in the direction of the advancing wave, is b c, a maximum. If we reduce the loop area, so that the sides are a quarter of a wavelength apart, *i.e.*, the loop p k h d, the value of the e.m.f. drops to k h. A reduction to an eighth of a wavelength (the loop p e f d) reduces the e.m.f. to e f minus e g=f g. The value of the resultant e.m.f. in the loop thus decreases as the dimensions of the loop decrease. A large loop and a small wavelength seems to be the best general combination, because by such an arrangement we approach nearer to the ideal condition where the loop is half a wavelength long. Other factors supervene, however, and will be considered later.

The Asymmetrical Polar Curve.

With a loop possessing the directional properties described above we should be able to ascertain the direction but not the *sense* of the position of a transmitting station. That is to say, if the loop were to point due N. and S. when the signals were of maximum strength, the position of the transmitting station might

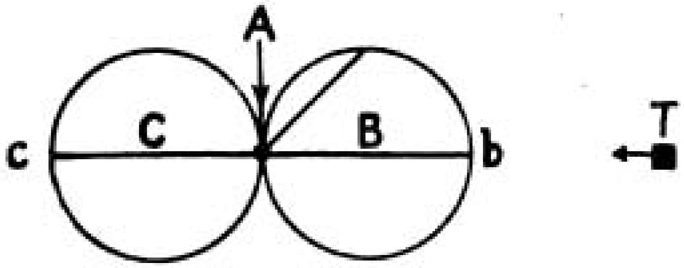


Fig. 11.

be said to be either due N. or due S. of the loop. There is, however, an asymmetry in the effect of the loop which enables us to decide definitely the direction and sense of the received signals. Considering Fig. 11, suppose that A is the axis on which the loop rotates and that the distance from A to any point on the circumference of the figures B or C represents the strength of the signals when the loop is turned in the direction of a line joining A and any such point. This diagram shows the theoretical case, for Ab and Ac, the maxima, are equal, and the signal strength is zero at A, that is, when the plane of the loop is at right angles to the direction of the transmitter T.

The practical case is shown diagrammatically in Fig. 12 where the two maxima are

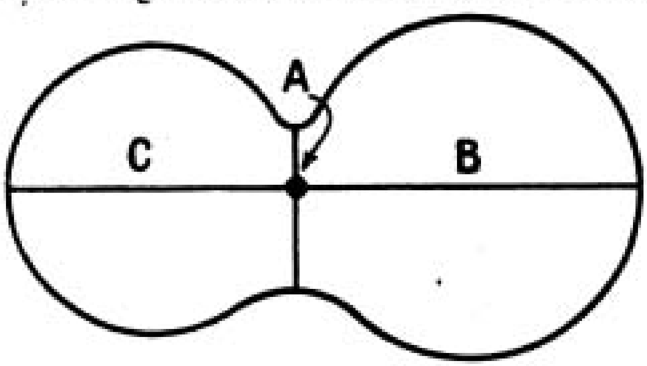


Fig. 12.

unequal and the minima are also unequal and never zero. We have therefore only to decide whether the smaller maximum points towards or away from the transmitter and then we shall have enough data to enable us to determine the direction and sense of the latter. This question depends upon the connections of the loop to the receiver, and may be resolved in any given case by trial with some transmitting station the direction of which is known.

The theoretical explanation has been worked out by A. S. Blatterman in an excellent paper contributed to the *Journal of the Franklin Institute*, September, 1919, and according to him the distortion of the polar curve is regulated by the shape and size of the loop, the way in which the loop is wound, its proximity to earth or other conductors, the arrangement of the receiving apparatus and the nature of the terrain between the receiver and transmitter.

(To be continued.)

NOTES AND NEWS

The Morse Code and Wireless in Schools.—Educationalists are generally agreed upon the importance of the part played by "hand and eye training" in modern school curricula; indeed, there can be no doubt but that instruction designed for the express purpose of co-ordinating the brain and the hands and eyes is eminently desirable, especially for the young. Having this in mind, we desire to point out the benefits which would be derived from the introduction of Morse Code teaching in Elementary Schools. For rendering the mind agile, for training in concentration, for co-ordinating the work of the ear, brain and hand, and for the development of a swift, flowing handwriting, Morse practice with a buzzer or sounder would be hard to beat. In addition to these things, there is the value of the knowledge of an universally used code, which can be applied to the boys' work as Scouts or, later, as Territorials or commercial telegraphists.

The photograph on this page shows a Morse Reception Class at the Hitchin Road Elementary Schools, Luton, where, with the assistance of a master, the boys have fitted up an efficient wireless receiving station. We congratulate the school's headmaster, who initiated the Morse Class, upon a wise and far-reaching innovation.

Photo, A. P. Cook, Luton.

Morse practice in an elementary school.

From the foregoing arises the question of teaching wireless in schools. In the House of Commons, on March 11th, it was said by Mr. H. Fisher, in answering Mr. Chadwick (C.U., Barrow), that it would be quite impracticable to arrange for the introduction of instruction in wireless telegraphy in all Government Schools, but that the Board of Education was prepared to approve suitable courses of training in technical schools and schools of nautical training.

Since very little expense would be incurred, inasmuch as most of the instruments required are to be found in any physics laboratory, we fail to see much justification for Mr. Fisher's reply. To demonstrate the elementary principles of wireless telegraphy interestingly and instructively does not necessitate the erection of a high-powered plant; any small induction coil, a few Leyden jars and a battery, being sufficient to explain its principles. Books giving lucid instructions, and fully illustrated with diagrams, written in a manner such as the average boy can follow, are extensively used in wireless schools. There can be little doubt, therefore, of difficulty arising from lack of literature and elementary text-books.

Extension of Indian Empire Wireless System.—Determined not to neglect the development of wireless, the Government of India has recently formed an Indian Wireless Telegraph Board, with a view to extending and reorganising its existing wireless telegraph system, in order to meet the strategic, political and commercial requirements of the Empire. The following list of members constituting the Board is indicative of early development and of the assured progress of wireless in India:—*President*, The Director-General of Posts and Telegraphs; *Vice-President*, The Chief Engineer, Telegraphs; *Members*, The Director of Wireless Telegraphs, the Chief Signal Officer at Army Headquarters, an officer of the Military operations directorate, an officer of the Royal Air Force, an officer nominated by the C. in C. of the East Indian Station, an officer nominated by the Director of Royal Indian Marine, and representatives of the Commercial, Political and Home Departments.

Nauen Press Programmes.—On May 4th Nauen began a Press service, as follows:—On 9,400 metres (C.W.) at 2.30 p.m. and 9 p.m. These programmes are repeated on 4,700 metres (damped). Presumably the times given are G.M.T. and the repetitions on spark occur immediately after each C.W. programme.

British and Foreign Sailors' Society.—At the annual meeting of this Society, on May 3rd, it was proposed that a Hostel be erected and equipped "as a Memorial from the Empire to those splendid men of both Sea Services who have laid down their lives in the service of their country."

In order that this estimable proposal may become a reality, it is required to raise a further £75,000 and the City of London, together with other cities, is asked to co-operate in the Empire's efforts to complete the scheme.

The world of wireless men that reads these words is made up chiefly of those "who go down to the sea in ships," and to those men especially should this proposal of a Hostel for British and Foreign sailors make a special appeal.

The sea, at all times hand-in-hand with wireless, is the resting-place of many of our comrades, and if only out of esteem for those we have known, let us advocate this admirable cause and do our very best to contribute towards the capital required to carry out the erection of such a worthy Memorial.

NOTES AND NEWS

Institute of Physics.—This new Institute has been founded by the co-operation of the Faraday Society, the Optical Society and the Physical Society of London. Its first Board is formed from representatives appointed by the Councils of those societies. The need of a body similar to the Institute of Chemistry has long been felt by those to whom physics is a daily study, and to secure recognition of the position and value of the physicist is one of the aims of this new Institute. Its officers are as follows :—*President*, Sir Richard Glazebrook, F.R.S.; *Treasurer*, Sir Robert Hadfield, F.R.S.; *Hon. Secretary*, Professor A. W. Porter, F.R.S. These officers, together with the following gentlemen, will constitute the Board of the Institute :—Dr. H. S. Allen, Instructor-Commander T. Y. Baker, R.N., Professor F. J. Cheshire, Dr. R. S. Clay, Mr. W. R. Cooper, Professor W. H. Eccles, Major E. O. Henrici, Dr. C. H. Lees, F.R.S., Mr. C. C. Paterson, Major C. E. S. Phillips, Dr. E. H. Rayner, Mr. T. Smith and Mr. R. S. Whipple. *Secretary of the Institute*, Mr. F. S. Spiers, 10, Essex Street, Strand, W.C.2.

Notice to Airmen.—A wireless telegraphic aerial has been set up on the eastern side of Le Bourget, seven miles north-east of Paris. This obstacle is marked by fabric pennons during the day and a white light at night.

The Steady March of Wireless.—The United States Navy Department has opened a wireless station at Poitiers, which will be extensively used in maintaining communication between the new naval headquarters at Paris and Washington, by way of Arlington and Annapolis stations.

In connection with the erection of a high-power wireless station in Denmark, from which communication will be established with America, a commission of experts recently left Copenhagen for New York to make the necessary arrangements.

We understand that the Japanese Government is erecting a high-power wireless station similar to that of Fukushima, in order to relieve congested communication between the United States and Japan.

Private reception of news by wireless has been put into practice by the German newspaper, the *Danzig Gazette*, which has installed a wireless station of its own for this purpose. A plan to establish a chain of such stations for connecting the larger German papers has been under consideration for some time.

The Continental Radio Telephone and Telegraph Company has been organised at Dallas, Texas, with the object of supplying communication between Dallas, the oilfields, and the principal cities of Texas, Oklahoma, Arkansas, New Mexico and Louisiana. The company has a capital stock of $20,000. Mr. W. R. Field is President, Mr. W. J. Chilton is Vice-President and General Manager, and Mr. L. C. Field is Secretary-Treasurer of the Company. It is stated that the construction of the Dallas station has already been begun.—*Telegraph and Telephone Age.*

Wireless telephony is to be employed in Ireland by the Government Authorities for the purpose of establishing a reliable means of communication, free from the danger of interference. This development has resulted owing to the frequency with which telephone and telegraph wires are cut in Ireland. It is expected that the operators to work this wireless system will be drawn from the Navy.

Amateur Long-distance Reception.—A Dutch correspondent (Mr. J. Thissen, Parkstr. 19, Venlo, Holland) mentions that, with a receiver consisting of a Philips Audion and a one wire antenna 125 m. high, he hears regularly the Bandoeng Station, in Java, call sign PKX, distant over 11,000 kilometres. The times of the PKX programmes are as follows :—4 p.m. to 4.15 p.m. ; 5.30 p.m. to 5.45 p.m. ; 6.30 p.m. to 7.30 p.m. ; 8 p.m. to 9 p.m. ; 9.30 p.m. to 11 p.m. ; Amsterdam time. C.W system, wavelength 9,000 m. The station mentioned works with PAA (Blaricum, Holland) and PCC (Sambeek).

Naval Wireless Operators.—Relative to our notice which appeared under "Notes and News" of the *Wireless World*, Vol. viii., No. 2, of April 17th, 1920, we are informed by the General Post Office that the Certificate of Proficiency is only issued after a separate examination for the purpose, and not merely on the strength of the applicants having served as a telegraphist in the Navy.

The American Amateur.—Wireless amateurs in the United States total over 200,000, according to a reliable New York source. Wireless matters appear to arouse more enthusiasm in the States than in Great Britain, and at the present time there is a powerful agitation going on to induce the American Authorities to introduce more legislation of a favourable nature for United States experimenters. Behind this appeal for fresh legislation stands the powerful American Institute of Radio Engineers. According to our contemporary, *The Model Engineer and Electrician*, the news of the ceremony of the opening of the new workshop of the Chicago Society of Model and Experimental Engineers was transmitted from Chicago to New York by United States wireless amateurs over a chain of private wireless stations.

"The Wireless World," Vol. VII.—We have made arrangements whereby our readers may have Vol. VII. of the *Wireless World* bound and indexed and returned, post free, at a fee of 8s. Binding covers may be obtained, price 3s. 3d. post free, and index 7d., post free. The Wireless Press, Ltd.

Wireless Telephony.—Regarding the many enquiries from amateurs concerning the origin of wireless telephone signals audible on April 29th, and again on May 2nd, we would point out that these signals are in no way connected with the experimental work progressing at Chelmsford.

It has come to our knowledge that the station from whence these signals emanated is PCGG, of Dutch nationality, belonging to a manufacturer of amateur wireless apparatus. It is believed that the station is of about ¼ K.W. capacity, and situated near Scheveningen Harbour. The transmitter is equipped with the Dutch IDZ valve, made by Phillips, the Dutch firm which is amalgamated with the G.E.C.

THE PROCEEDINGS OF THE WIRELESS SOCIETY OF LONDON

AN AUTOMATIC CALL DEVICE

By B. Binyon, B.A., O.B.E.

An Ordinary General Meeting was held on Friday, April 30th, 1920, at 6 p.m., in the Lecture Hall of the Institution of Civil Engineers, the President, Mr. A. A. Campbell Swinton, occupying the chair.

After the minutes of the previous meeting had been read and confirmed, Major B. Binyon delivered his paper, which was followed by a discussion and a vote of thanks to the lecturer. The President then read a letter which had been received by him from Admiral Sir Henry B. Jackson, relating to the work of the Radio Research Board. The President next announced that the 23 persons whose names had been put up for ballot at the commencement of the meeting, had been elected members of the Society.

The President also announced that the next meeting would be held on May 21st, and that Mr. Philip R. Coursey, B.Sc., A.M.I.E.E., would then read a paper entitled "Some of the Problems of Atmospheric Elimination in Wireless Reception."

Mr. H. E. Wilkinson exhibited an interesting collection of German wireless apparatus, and the meeting adjourned at 7.30 p.m.

Major Basil Binyon, O.B.E. :—

Mr. President, ladies and gentlemen,—I have been informed by our President that in some Press notices concerning this meeting I was described as the inventor of the apparatus I am to show you to-night. I should like at once to dispel any misunderstanding in this respect ; the solution of the difficult problems of call apparatus must be entirely attributed to the genius of Captain L. B. Turner and Mr. W. H. Shephard, whose several inventions have been so admirably combined by Captain Lea into the complete "Call" device.

The short time at our disposal does not permit treating this subject historically, but as a matter of interest it is worth while noting that the early forms of radio apparatus, operated by a coherer with relay and bell, constituted an elementary form of call apparatus and doubtless the advantages of being able to ring up in the manner of line telegraphy and telephony was considered of great importance at the time. It is probable, however, that the introduction of aural reception presented so great an improvement in reliability and sensitivity over the old coherer methods as to completely swamp any benefit to be gained by the use of a "call-up" apparatus; moreover aural reception has come to be so universally applied to radio communication that it is now difficult to conceive of any mechanical substitute having the sensitivity and discriminating qualities possessed by the human ear.

It is doubtless in the provision of a practical means of communication between ships at sea that Radiotelegraphy has found its most valuable application, and the extent to which this has been recognised is well evidenced in the International Convention on Safety of Life at Sea, drawn up in London, 1914, and legislation concluding with the Merchant Shipping (Wireless Telegraphy) Act, 1919.

The main aim of this legislation is to make the best possible use of this method of communication for securing safety of life at sea. The most recent legislation has laid down what are to be the minimum requirements furnishing a fair measure of adequacy.

To obtain a fully efficient system for the purpose of saving life at sea requires nothing less than the equipment of all ships with Radio apparatus and the maintenance of a continuous watch at all ship and shore stations.

The small "tramp" may be the nearest ship to a large liner in distress and, therefore, it is most important that continuous watch be kept on every class of vessel.

The maintenance of a continuous watch on the smaller class of vessel presents serious difficulties by way of finance and accommodation, and the apparatus I am to show you to-night has been designed with the object of overcoming these difficulties.

The development of mechanical appliances to minimise skilled labour must now be regarded as the progressive aim of every branch of modern engineering. The difficulties encountered in the design of such appliances usually increase in proportion to the delicacy of the operations to be performed, more particularly so where mechanical devices have to attain a sensitivity and selectivity equivalent to that of the human senses.

It is well, therefore, to state briefly what have been the ideals aimed at in designing an automatic call.

(1) The apparatus must be designed to operate on the means of radio communication now in general use, *i.e.*, Morse signals by calls of 3 or 4 letter groups or numerals.

The employment of any special code must at once considerably limit the useful field of application.

(2) To be universally applicable the apparatus should be designed to respond to signals of any system adaptable to any receiver and independent of synchronism if it is to respond to calls sent in the ordinary way.

(3) The apparatus must respond only to an S O S signal and/or the call sign of the ship or station in which it is installed.

(4) It must possess a sensitivity equivalent to that of clearly readable aural signals (say R 4-5).

(5) Its action must be independent of the speed of transmission within the limits of ordinary operating.

(6) The apparatus should be reliable and simple to adjust ; it must *not* give false alarms, and in registering a "call" must distinguish between a distress signal and ordinary call.

(7) Should the apparatus for any reason become inoperative a distinctive alarm must be immediately registered.

(8) The apparatus should not be more

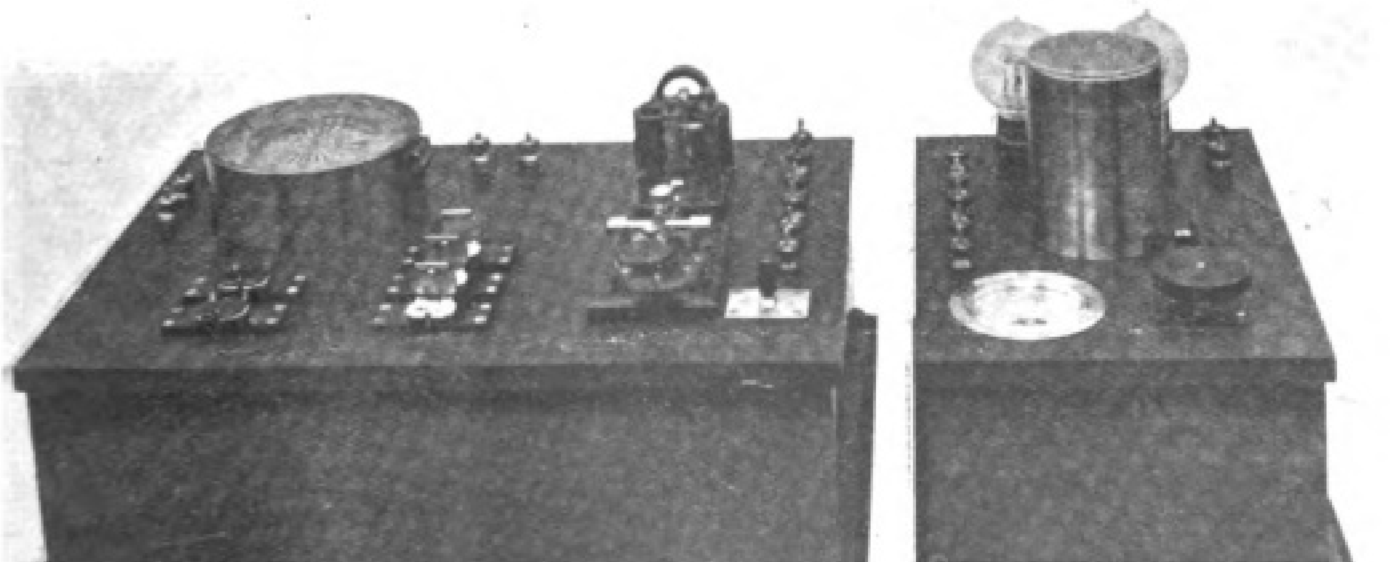


Fig. 1.

The complete Automatic "Call" Apparatus susceptible to jambing and atmospheric interference than other methods of wireless reception, and false calls from such causes must not be possible.

How nearly the apparatus I am to show you to-night approaches these ideal conditions you will be able to judge for yourselves.

Principle of the Apparatus.

The mechanical "call" or watchkeeping apparatus may be attached to any Radio receiver in lieu of, or in addition to, the head telephones usually worn by the operator.

The apparatus consists of two units :

(1) A sensitive relay operated by thermionic valves. (Fig. 1 on right.)

(2) The mechanical selector. (Fig. 1 on left.)

The Turner Valve Relay.

The valve relay comprises the sensitive unit of the call apparatus, and responds to all incoming signals to which the wireless receiver is tuned ; its function is that of an automatic switch whereby the arrival of a relatively feeble signal is made to open or close the circuit of a local battery which in turn supplies the power for operating the mechanical selector.

It is not possible in the time available to deal with the numerous applications of the thermionic valve to wireless telegraphy. Various methods of grouping such valves for the purpose of magnifying or amplifying signals have been devised, but the Turner valve relay differs in its mode of operation from all such arrangements in that it comprises a combination of both amplifier and relay.

In a relay the local current is started or stopped by the signal current, but is not otherwise measured by it. Moreover, there is a threshold strength of signal below which no local effect is produced, and above which an effect is produced whose magnitude may be of any desired value and is independent of the strength of the controlling signal. In the case of an amplifier there is a very clear distinction between its performance and that of a relay in that there is no threshold effect, the smallest incoming signal producing some change in the local circuit, the local effect being a magnified copy, more or less true to scale, of the incoming signal.

The valve relay comprises an ordinary standard Post Office relay operated through special circuits by two thermionic valves.

The first valve is employed as an ordinary low frequency amplifier ; the incoming signal is led to the "grid" of this valve, the local circuit being from the anode through the primary of a step-up transformer and battery to the filament of the valve. A magnified signal is thus obtained from the secondary of the transformer and this is conveyed to the grid of the relay or "trigger" valve.

The circuits of the trigger or relay valve are so arranged that local high frequency oscillations will be generated and sustained when the potential of the grid reaches a certain critical value. The potential of the grid is capable of adjustment by means of a potentiometer which is normally set so that the trigger valve is unstable and on the verge of producing sustained oscillations.

The effect, therefore, of the magnified incoming signal is so to change the potential of the trigger valve "grid" as to cause local oscillations to be generated, which results in a large increase in current in the anode circuit of that valve.

The anode circuit of the trigger valve includes the coils of a standard Post Office relay and the sudden rush of current to the anode, produced when oscillations occur, trips the relay and actuates the local circuit operating the selector mechanism.

The high frequency oscillations generated in the trigger valve circuits persist even if the grid be restored to its normal potential. It is obvious, therefore, that the relay circuit once tripped will remain permanently in this state and means must be provided for stopping the oscillations and restoring the apparatus to its original condition immediately on the cessation of the signal.

This operation is termed "quenching" and will be more clearly understood by reference to Fig. 2.

If the slider of the potentiometer P be moved to the left the potential of the grid of the valve with respect to the filament will

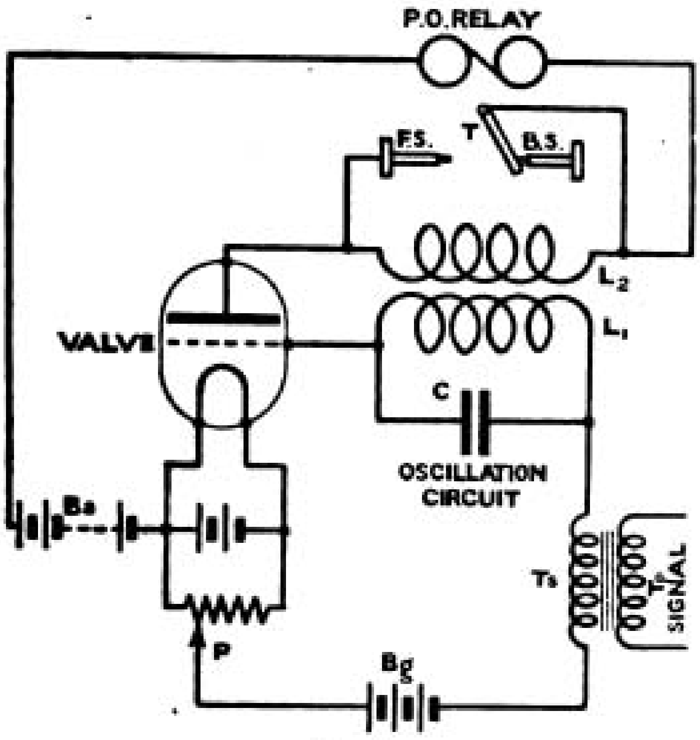


Fig. 2.

become more positive until a critical value is reached when oscillations will build up in the oscillation circuit comprising the condenser C and the inductance L_1. If now the grid potential be set a small amount (called the "margin") below the critical value (called the "threshold") any signal applied to the transformer T_p T_s producing in the secondary T_s a momentary electromotive force of the right sense, and exceeding the "margin" in amplitude, sets the system into oscillation. The accompanying rise of current in the coils of the Post Office relay pulls over the tongue T to the front stop FS, short-circuits the anode coil L_2, and thereby quenches the oscillation which is thereupon only restarted on the arrival of another signal in the transformer primary T_p.

The quenching of the oscillation as described causes a reduction of the current in the relay coils, and the tongue T, as a result of the "bias" of the relay, returns to the backstop BS.

If, however, the grid potential remains above the "threshold" due to a sustained signal, oscillation will be restarted immediately after quenching and the tongue T will chatter against the front stop FS, but will not travel far enough to touch the back stop BS; thus a clean steady *break* is assured between T and BS for the duration of the signal.

Since the front stop of the relay is employed for automatic quenching it is necessary to employ the back stop for operating the local selector circuit. The back stop circuit is normally closed and, as explained above, remains open only for the duration of the signal. Morse signals so obtained are of the "reversed" type and it is therefore necessary to introduce a simple form of insensitive relay between the valve relay and the selector mechanism for the conversion of "reversed" Morse to ordinary signals. This second relay may be of the "sounder" type and being of robust construction requires no attention or adjustment; it serves a further useful purpose in relieving the sensitive valve relay of handling the heavy currents required for operating the selector mechanism. If desired signals may be read by ear direct from the sounder relay, or it may be utilised for operating a Morse inker to obtain a permanent record of all signals received.

The valve relay though highly sensitive possesses great simplicity and reliability and has only one adjustment, that of the potentiometer for setting to the correct sensitivity.

The energy required to trip the valve relay is less than the millionth of a watt, while an ordinary Post Office relay requires about a five-thousandth of a watt, hence a step-up effect of about 500,000 is obtained between the signal current and the anode current flowing through the energising coils of the Post Office relay.

A magnification of the above order is approximately equivalent to that of a seven valve amplifier allowing a magnification of 6 times per valve. The employment of the valve relay, therefore, effects a considerable economy in valve consumption and filament current—a matter of considerable importance in practice when the call apparatus has to be in operation day and night for long periods.

As an illustration of the sensitivity of the instrument I have here a microphone connected in series with a single dry cell and the circuits of the valve relay. You will observe that quite a small noise such as a clap

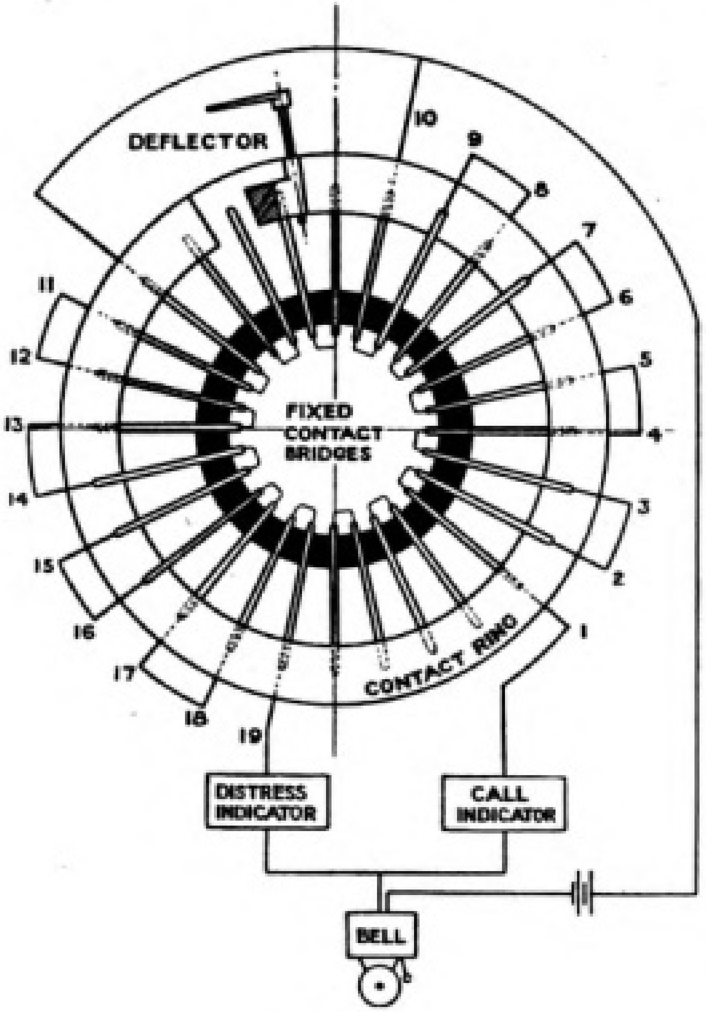


Fig. 3.

of the hands at the back of the room is sufficient to trip the relay and light a pilot lamp.

The Mechanical Selector.

This apparatus may be regarded as the "sorting office" of all incoming Radio signals, so that the alarm bell with which it is connected rings only when an SOS signal, and/or the call sign to which the apparatus is set is received.

The Selector has a central hub which carries a number of radial and separately insulated Brush Arms (see Figs. 3 and 4).

Each element of the Morse Code, whether it be a "dot" or a "dash" is made to turn the hub (by means of an electro-magnet and ratchet mechanism) through a step equal to the pitch of the brush arms.

The brush arms are made of springy metal and bear either on the upper or lower side of an outer Contact Ring.

This ring has a gap in its circumference and as the brush arms move round and across this gap it is possible to guide them so that during their next revolution they will pass either above or below the contact ring. This is accomplished by means of a Deflector—a small wedge-shaped piece of steel not unlike a "point" on a railway line—whose operation is automatically dependent on the length of each individual Morse element.

The operation of the Deflector depends on a "delay action" mechanism and will be explained later, but the result is that whenever "dots" are received the deflector remains unmoved in its upward position and consequently forces the brush arms to pass *below* the contact ring (see Fig. 5). If, however, "dashes" are received the arms are forced to pass *above* the contact ring owing to the downward motion of the deflector (see Fig. 6).

Each individual Morse element is "tested" separately by the deflector, and if, for example, we get alternate "dots" and "dashes" the brush arms will pass above and below, above and below, and so on, as in Fig. 7.

Returning to Figs. 3 and 4. The contact ring is made of insulating material, but has

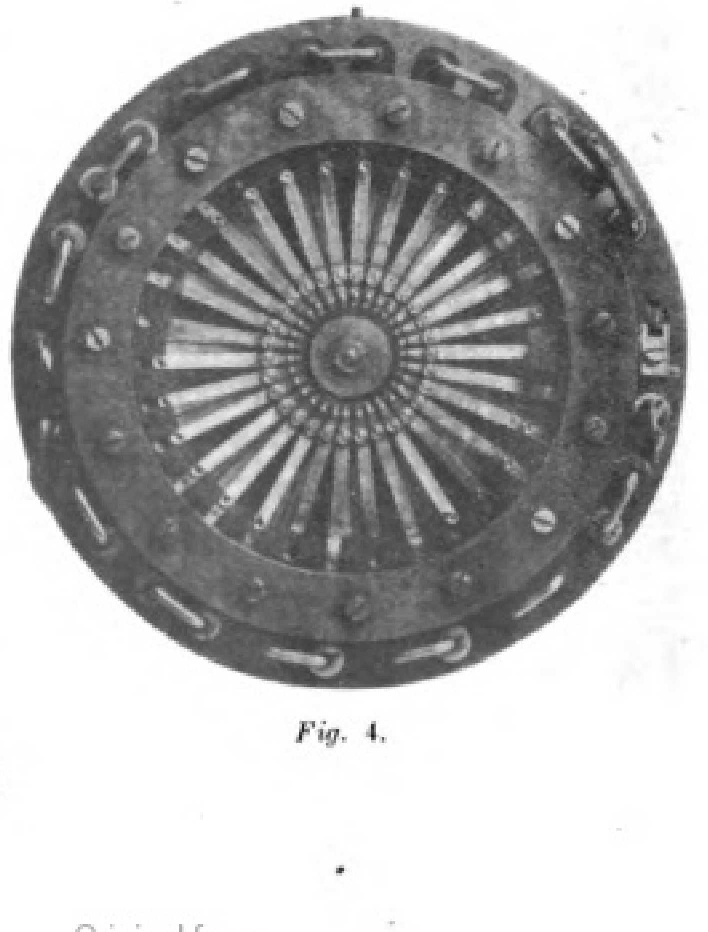


Fig. 4.

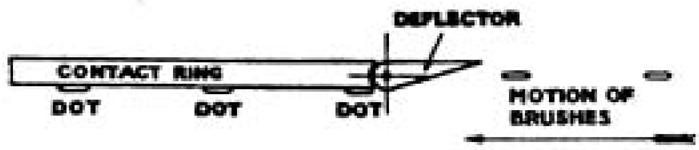


Fig. 5.

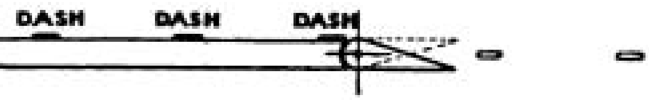


Fig. 6.

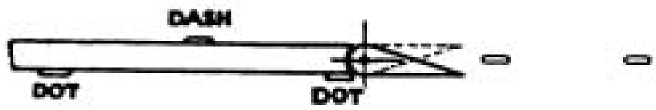


Fig. 7.

mounted on it fixed contacts which can engage with the outer ends of the brush arms

These fixed contacts are spaced round the ring at the same pitch as the brush arms.

Some of the contacts are on the upper surface of the ring and some are underneath ; the exact arrangement depends on the call sign to which the instrument is required to respond.

Consider, for example, contacts numbered 1 to 10 in Fig. 3.

It will be noted that :—

1	is below	and	represents	a	dot	together • ▬ *i.e.*, A.
2	„ above	„	„	„	dash	
3	„ „	„	„	„	„	„ ▬ • • • *i.e.*, B.
4	„ below	„	„	„	dot	
5	„ „	„	„	„	„	
6	„ „	„	„	„	„	
7	„ above	„	„	„	dash	„ ▬ • ▬ • *i.e.*, C.
8	„ below	„	„	„	dot	
9	„ above	„	„	„	dash	
10	„ below	„	„	„	dot	

Contacts 1 to 10 are therefore arranged to correspond to the call sign ABC, and if such a call is received the brush arms will be arranged automatically by the deflector so that they fit the "pattern" of contacts both on the upper and lower surface of the ring.

To illustrate this the brush arms have been drawn out in the position of alarm, and it will be noticed that the bell circuit is completed by the closing of all the brush contacts in *series*. If, therefore, one brush only is out of place owing to the incoming signal differing from the set call sign by only one Morse element, an alarm will not be given

Other contacts on the ring are reserved for the distress signal SOS (see contacts 11 to 19 Fig 3). These work in exactly the same way as the ones we have already considered, but they are arranged to bring into play another indicator so as to show the operator which type of signal has been received.

For clearness of illustrating Fig. 3 has been drawn with a somewhat small number of contact arms, but Fig. 4, a photograph of the real instrument shows there are enough brushes and contacts to enable both the call sign and the SOS signal to be repeated within the circumference of the ring. This provision is necessary to guard against false calls owing to the possibility of the same group of letters occurring in ordinary text. For instance, this system of repetition entirely prevents a distress call being registered on the receipt of the words SO Slowly.

It may be of interest to show how the deflector differentiates between long and short elements of the Morse Code. For an understanding of this point reference should be made to Figs. 8, 9, and 10.

In Fig 8 will be seen the electro-magnet and ratchet mechanism by means of which the brush arms are moved round a step at a time.

At the commencement of a Morse element the magnet arm is pulled quickly into the position shown "dotted" and the ratchet pawl passes into position on the next tooth of the ratchet wheel. At the end of the Morse element, the arm and pawl return under the action of the spring shown on the right and

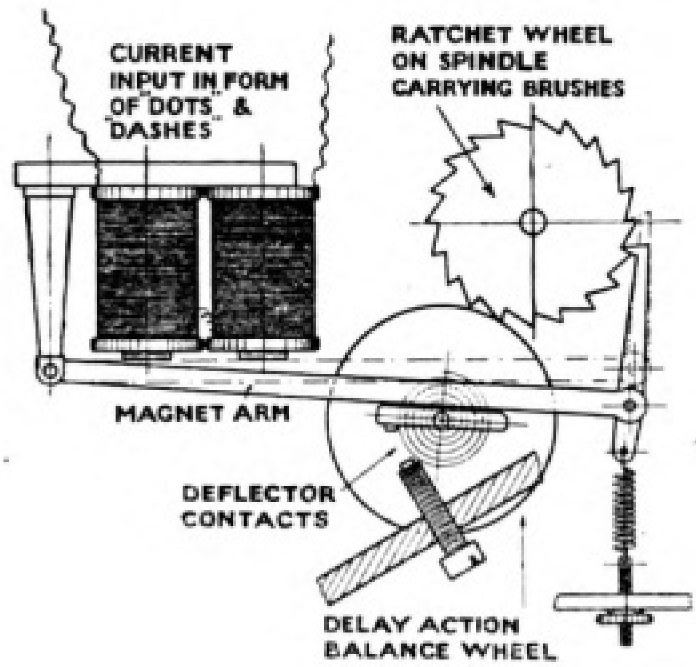


Fig. 8.

in so doing rotate the hub and contact arms through one step.

It will be noticed that the magnet arm in its position of rest butts up against the flat side of a cross-arm which is mounted on the spindle of a balance wheel.

A hair spring attached to the cross-arm is tending to turn the balance wheel and cross-arm in a counter-clockwise direction, but is normally prevented from doing so by the pressure of the magnet arm on the cross-arm.

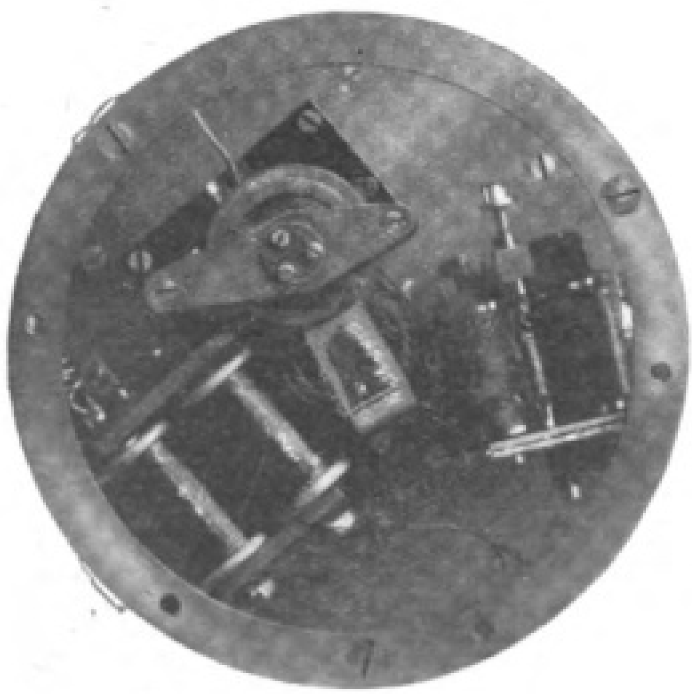


Fig. 9.

When, however, the magnet arm moves into the "dotted" position at the commencement of a Morse element, the wheel and cross-arm begin to rotate, and if the element is long enough (a "dash") the cross-arm will have time to move far enough to come into contact with a contact screw. The contact is shown closed in Fig. 10. If this happens, a second electro-magnet is energised and the deflector is pulled downwards and so passes on the next brush arm *above* the contact ring

Although the balance wheel is in the nature of a timing device its action is not at all critical as it merely has to distinguish between a "dot" and a "dash," hence the action of the apparatus is independent of the speed of transmission within the limits of ordinary operating.

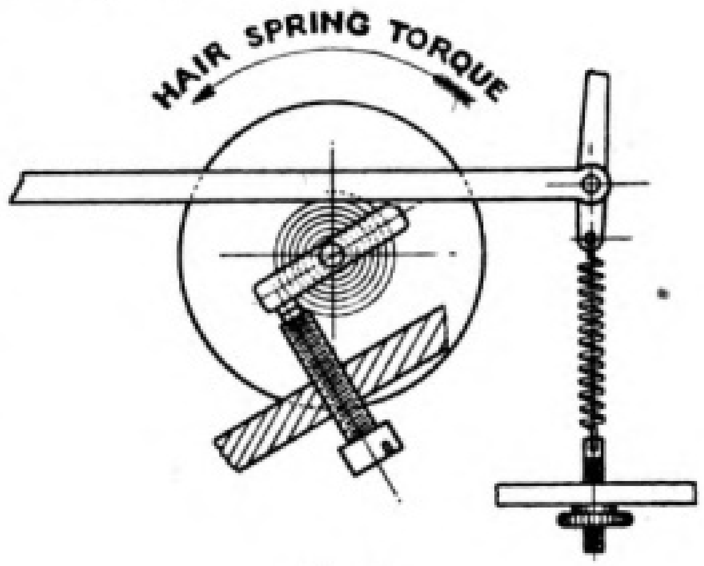


Fig. 10.

Various devices are included so that an alarm shall be given in the event of one of the valve filaments reaching the end of its life. (This latter contingency may occur perhaps once every 1,000 hours).

Demonstrations were then given by means of a buzzer in which the apparatus rang the bell in response to the distress signal SOS and the call letters 2AA and disregarded all other signals.

At the conclusion of the discussion signals were received from Slough, ringing the bell in response to the call letters 2AA. The apparatus was also shown actuating on signals from North Foreland Wireless Station and the Air Ministry.

DISCUSSION.

Mr. P. R. Coursey, B.Sc.: I did not expect to be called upon to speak in this discussion, and I do not think there is any particular point I can call attention to just now. Major Binyon has shown us some very interesting apparatus to-night, and I am sure we are all indebted to him for bringing it to our notice. Undoubtedly the Turner valve relay is an extremely sensitive instrument, which will probably have other uses before it than the one we have been shown to-night. The selector mechanism is also extremely ingenious, and appears to carry out its functions in a very excellent manner. I should like to congratulate Major Binyon on the clear description he has given us this evening.

The President: We are favoured with the presence of the inventor of the selector, Mr. Shephard. Would he like to say anything on the subject?

Mr. W. H. Shephard: Major Binyon has given us such an excellent and clear description of the instrument that I do not know that there is anything I can add to what he has said. It is not an electrical instrument at all. It is a mechanical instrument. There is no wireless in it, and, owing to its mechanical properties, there is not much of interest to electrical engineers. Most matters relating to wireless are usually full of mathematics, but I am afraid there are none in connection with this instrument. The only mathematics which enter into it are in connection with electromagnets, moments of inertia, rotation, etc. I am, however, very glad to have had the opportunity of seeing the excellent slides which the author has shown us, and also the apparatus working here.

Mr. F. Hope-Jones, M.I.E.E.: I, also, was not expecting to be called upon to speak in this discussion; but, since I have been asked to do so, I would like to add my appreciation, not only of the excellent demonstration of the apparatus given by Major Binyon, but also of the electro-mechanical device of Mr. Shephard. I am looking forward very much to seeing the signals come through from Slough, and I hope we shall see the instrument working at twenty words a minute in order to see what it will do with high-speed working. I think the problems which that step-by-step mechanism have to cope with are very difficult; but, obviously, from what we have already seen, they appear to have been successfully met.

Mr. R. C. Clinker: I should like to thank Major Binyon for his very clear explanation of the instrument. There is one thing I should like to ask—although I do not know that it is a very intelligent question—how bad can the Morse be before the apparatus will not respond to a given signal? I can imagine that a man sending out an SOS will not always be in a perfectly calm frame of mind, and the difference between the dots and the dashes might not be so very clear. In fact, in some ordinary signals it is rather difficult to say which are dots and which are dashes, and it would be interesting to know what the difference would have to be in order that the apparatus should respond. The instrument is certainly most beautiful, and I thank Major Binyon for his interesting paper.

Mr. M. Child: There are one or two questions I should like to ask Major Binyon about the mechanism. The first is, I think, rather an important one. In considering the working of such an instrument, when we are dealing with relays which have to close circuits in which there is a considerable amount of energy passing, especially when the energy is passing through an electromagnet, there is always a great danger of contacts sticking, and I imagine that in the case of the selector itself under practical conditions at sea, there will be some possibility of the contacts becoming oxidised. These difficulties are particularly noticeable when one comes to practical working at sea. The instrument on the table is certainly a very beautiful one, but I suggest there may possibly be difficulties in keeping the contacts in good order at sea, owing to the salt atmosphere. I should also like to ask if any provision has been made to overcome the sparking. Further, I should like to see the apparatus working at from 20 to 25 words per minute, although, of course, it is not to be supposed that an operator would necessarily send at such a rate when he is sending out a distress signal. In fact, the usual thing is to send rather slowly, because if there is jambing going on in the surrounding space, the SOS is usually got through rather better if the signalling speed is kept down. I imagine that slow speed signalling would be favourable to the apparatus. I thank Major Binyon for his description, and I have been very much interested in it.

Mr. W. M. Holubowicz: I should like to ask about working at various speeds. I should imagine that when working slowly the dot would very often be as long as the dash when working fast, and as it is a mechanical device, it may actuate the dash for the dot on the selective apparatus.

The President: I should like to say that I do not know which to admire most—the beautiful mechanism that has been shown us this evening, or the extremely clear manner in which it has been described to us. It is not at all easy to describe these mechanical arrangements, but, with the slides and the cardboard model and the projection on the screen, I think it must have been made quite clear to everybody how the mechanism works. Major Binyon is really to be much congratulated upon the way in which he has put the subject forward. I do not know that I can add anything further. I am not sure what is going to happen next in the way of signals coming in, and I will meanwhile ask Major Binyon to reply to the discussion.

Major Basil Binyon: With regard to the point raised by Mr. Clinker, as to how bad the Morse can be before failing to operate the apparatus, it is a little difficult to deal with that question, because the Morse may be bad in one sense but it must be good, or fairly good, in another, *i.e.*, the operator may space exceedingly badly, and the result is quite immaterial; but he must not, of course, clip the duration of his dashes too short, otherwise the danger then arises of the dashes becoming dots. As a matter of fact, it is quite an interesting experiment, with a buzzer adjacent to the call apparatus, to begin to clip the duration of dashes unnecessarily short, when it will be found that a critical point is reached where a dash lasting less than about 1/10th second will be recorded as a dot.

Mr. Holubowicz said that probably dots might become dashes at slow speeds. There is admittedly a risk of a dash becoming a dot at high speeds, but the converse—a dot becoming a dash at slow speeds—rarely if ever occurs, for the reason that an operator sending slowly unconsciously endeavours to give clearness by prolonging his dashes and spaces and making his dots as short and crisp as possible—a process which, as Mr. Child pointed out, favours the certainty of operation of the apparatus. Therefore, it rarely occurs in practice that a dot is recorded as a dash.

Mr. Child raised a number of important points with regard to the life of the instrument and the durability of the contacts. It may interest you to know that the selector instrument I am showing you to-night is an old model, built in 1913, and although it has not been to sea, it has been through severe tests, working for very long periods, and, so far, practically no trouble whatsoever has arisen from the contacts in the mechanism itself. It should be remembered that all the contacts between the ring and the brushes are of the rubbing type, the movement of the instrument itself keeping them clean and bright.

A powerful inductive kick will invariably occur at the contacts of the operating magnets of the selector which may amount to a potential difference of 200 volts, and when it is recollected that this occurs in close proximity to the valve relay, which is sensible to an impulse of 1/100th of a volt, it is evident that elaborate precautions have to be taken to eliminate sparking at the contact points by means of non-inductive shunts, condensers and resistances. This has been successfully accomplished with the result that no trouble has been experienced from this source.

Some slight trouble has arisen from backlash in the revolving spider of brushes, with the result that the brushes occasionally fail to tally with the contacts: but in new models this difficulty has been entirely overcome by considerably increasing the width of the fixed contacts on the ring.

As regards the effect of sea air on the apparatus, no trouble is anticipated from this cause, the apparatus being hermetically sealed.

Although no queries have been raised regarding the susceptibility of the apparatus to jambing and atmospheric interference, the point is of importance and one which, had time permitted, I had intended to deal with in the paper. From what has already been said, you will appreciate that, should a brush be incorrectly placed in the pattern produced by the signal, the alarm circuit will not be completed; such displacement of one or more brushes may be caused by interference. As a matter of fact, the apparatus is capable of working through quite an appreciable amount of jambing, partly due to the "threshold" effect of the Turner valve relay, which disregards all signals below a certain strength, and partly due to the fact that only disturbances occurring in spaces will affect the instrument. The apparatus is unable to distinguish between different signal notes, and it is undesirable that it should do so, since calls or distress signals may be sent out on different spark frequencies, to all of which it must respond. It is inconceivable that any mechanical device could, at will, concentrate on the reading of one particular note and disregard another in the manner adopted by the skilled operator when endeavouring to read through interference.

It should be remembered that interference is a defect common to all wireless signalling, and any of the known remedies such as interference stoppers, filters, and limiting devices can be equally well applied to this apparatus if it is desired to do so. Moreover, when a ship is approaching port or steaming in congested areas where jambing is likely to occur, the operator will usually be at his post to handle traffic or pass "Master's service messages."

Weak signals and atmospherics will not interfere with the working of the call apparatus when a medium or strong signal is received.

The effect of "calls," to which the apparatus is set to respond, is cumulative, and should one call out of three be rendered inoperative, due to interference, the other two may prove effective; and, under the most adverse conditions, calls will rarely fail if persisted in.

From the point of view of safety of life at sea, the Regulations provide that all wireless traffic must cease on the sending of a distress signal; the mechanical watch-keeper could then not fail to ring the alarm bell, unless the signals were exceedingly weak. Further, the very fact of jambing occurring in the vicinity of a ship in distress is an indication that other ships with operators on duty are available to render assistance. Any failure of an automatic call apparatus from this cause is therefore not so serious.

In conclusion, my thanks are due to Captain N. Lea and Mr. W. H. Shephard for the assistance they have given me; to Mr. Horace Beck, for the loan of the projection lantern, and the Radio Communication Company, for the use of the automatic "call" apparatus.

I should like to thank you for the kind manner in which you have expressed your appreciation of the apparatus demonstrated to you to-night.

The President: I think, by your applause, you have shown that you wish to accord a very hearty vote of thanks to Major Binyon for his most interesting and instructive paper.

I have here a letter which is addressed to me as President of the Society by Admiral Sir Henry Jackson, in his capacity as Chairman of the Radio Research Board, which has recently been inaugurated by the Department of Scientific and Industrial Research. The letter is as follows:—

"Department of Scientific and Industrial Research.
"Westminster, S.W.
"*11th March*, 1920.

"R.B. 11/1.

"Dear Sir, As you may be aware, a Radio Research Board has been established under the Department of Scientific and Industrial Research, with the main purpose of co-ordinating and developing research work in wireless telegraphy and telephony undertaken by Government Departments.

"The personnel of the Board is as follows:—Admiral of the Fleet Sir Henry Jackson, G.C.B., K.C.V.O., F.R.S. (Chairman); Commander J. S. Salmond, R.N.; Wing Commander A. D. Warrington Morris, C.M.G., O.B.E.; Lieut.-Colonel A. G. Cusins, C.M.G.; Mr. E. H. Shaughnessy, O.B.E.; Professor J. E. Petavel, F.R.S.; Professor Sir Ernest Rutherford, D.Sc., F.R.S.

"The Board are anxious to enlist the sympathetic co-operation of universities and colleges and other institutions, and to keep in touch with the valuable results that are being achieved in this department of scientific investigation. For this purpose they would be very much obliged if you could find time to furnish me with any important suggestions, especially as to possible fresh lines of departure in research work in this matter, and also any resources with which your members may be willing to assist the Board, provided that the authorities concerned see no objection. This information will be regarded as strictly confidential.

"If you can send such a statement, please address it to the Secretary, Radio Research Board, at the above address.

"Yours faithfully,
"(Signed) H. B. JACKSON,
Chairman, Radio Research Board."

This letter was put before the Committee of the Society, and it was thought that the best thing to do was to read it to the meeting, so that it may be published in the Proceedings of the Society. If any member thinks he can do anything to assist in the way suggested by Sir Henry Jackson, if he will communicate either with the Secretary or myself in the first instance, we will do what we can in the way of communicating with the Radio Research Board.

I have to announce that Mr. Duncan Sinclair has been made a full member of the Society. He was previously an Associate member. I have also to announce that the twenty-three ladies and gentlemen who have been ballotted for this evening have been unanimously elected. I think we can congratulate ourselves that the additions to the Society show no signs of falling off. Of course, we have to make up a certain amount of leeway. There are a number of people who were members before the war who are either dead or have gone away and left no address; but I think I am right in saying that we have now more than made up the loss that we sustained in that manner since 1914, and, as I say, the number of people who still continue to apply for membership shows no signs of falling off.

In addition to the beautiful apparatus which we have been shown by Major Binyon, Mr. Wilkinson has kindly brought a collection of German wireless apparatus used in the war. You will remember that at the last meeting this apparatus arrived so late that Mr. Wilkinson had not time to put it on view. I understand that Mr. Wilkinson does not wish to describe it, because it more or less describes itself, but it is there for any member to look at.

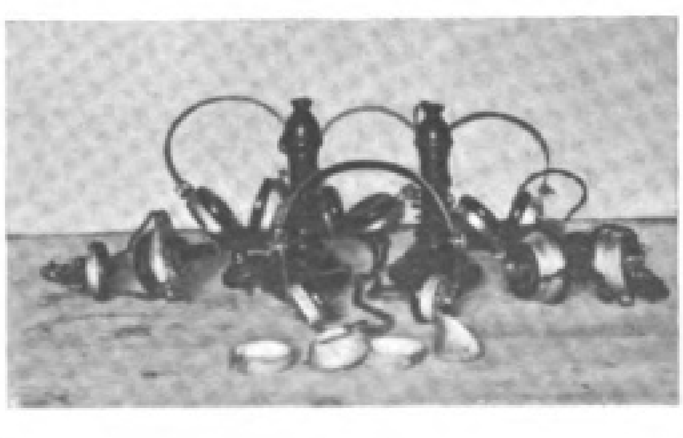
I have also to announce that Mr. M. Child, one of our Committee, is giving a lecture on Tuesday next before the Association of Supervising Electricians, and the Honorary Secretary has about thirty tickets for distribution, if any members of this Society would like to attend this lecture, which, I may say, will be given at St. Bride's Institute, Bride Lane, Ludgate Circus, on Tuesday, May 4th, at 7 p.m.

The only other matter that I have to deal with is to announce that Mr. Coursey will give the next lecture on May 21st, and that it will be entitled "Some of the Problems of Atmospheric Elimination in Wireless Reception." That will be held in this room at 6 o'clock. The meeting is now adjourned.

OLD AND MODERN TELEPHONES

By W. J. Fry.

THE photo shows a pair of old single pole Bell Receivers made of polished mahogany. These were made at the Silvertown Telegraph Works some 40 years ago, before the advent of the carbon microphone and were used both for transmission and reception. The particular reason for showing these is to give an idea of the great difference between their size and that of a pair of modern receivers, a pair of which (Sullivan's) can be seen with them. The latter though much smaller are of much greater strength. All the other receivers which are shown I have constructed from old aluminium valve and motor car parts, some examples of which are shown in the bottom of the photo.



WIRELESS CLUB REPORTS

Glasgow and District Radio Club.

(Affiliated with the Wireless Society of London.)

A general meeting of this Club was held at 206, Bath Street, on Wednesday, April 21st, at which it was intimated that, on account of increasing pressure of other business, the Hon. Secretary (Mr. R. A. Law) has been reluctantly compelled to resign. Mr. Robert Carlisle was appointed in succession to Mr. Law. The following Committee was appointed at this meeting:—Messrs. W. K. Dewar, A. Gray, S. Hay, R. A. Law, W. Mitchell, H. McGregor, E. Snodgrass and J. S. Stewart.

Application has been made to the Postmaster-General for authority to instal a valve receiving set in the Clubroom at the N.B. Wireless School, 206, Bath Street, and Mr. Dewar has kindly promised to allow us the use of the school's aerial.

On Wednesday, April 28th, Mr. T. Senior delivered a lecture on the "Poulsen Arc System of Continuous Wave Transmission." This very interesting lecture was illustrated by diagrams.

The following members have consented to give lectures on the dates named:—May 12th, Mr. M'Lennan; May 19th, Mr. Dewar.—Hon. Secretary, R. Carlisle, 40, Walton Street, Shawlands, Glasgow.

The North Middlesex Wireless Club.

(Affiliated with the Wireless Society of London.)

At the 38th meeting of the above Club, held at Shaftesbury Hall, Bowes Park Station, on Wednesday, May 5th, there was an unusually good attendance. The Chairman (Mr. A. G. Arthur), in his opening remarks, explained the unfortunate absence of the Secretary (Mr. E. M. Savage) through illness, and expressed hopes of his early recovery. The minutes of the previous meeting were taken as read, but the Chairman informed the Club of the nomination and election of Mr. Wm. Le Queux as Vice-President of the Club.

Lieutenant Holton then gave his very interesting lecture on the "Peculiarities of the Valve in Various Circuits," describing and illustrating each point by means of diagrams, and such is his masterly grasp of the subject, that he was able to make interesting as well as instructive this highly technical subject.

The Chairman, in proposing a vote of thanks to the lecturer, asked for the opinion of the members as to whether Lieutenant Holton should not be given another evening on which to finish his subject and to make the demonstrations he was forced to cut out for lack of time. As this suggestion was readily agreed to, the lecturer generously agreed to "carry on" at the next meeting, on May 12th.

Full particulars of the Club can be obtained from the Hon. Secretary, E. M. Savage, Esq., "Nithsdale," Eversley Park Road, Winchmore Hill, N.21.

Burton Wireless Club.

(Affiliated with the Wireless Society of London.)

The last of the season's meetings of this Club was held at the offices of the *Burton Daily Mail*, on April 30th, when Mr. E. Huson, of Derby, gave a lecture on "Wireless Telephony." The lecturer was accompanied by Captain W. Bemrose and Mr. A. T. Lee. Mr. A. Chapman presided, and advocated wireless telephony in view of a brighter and better news service. Mr. Huson expounded, illustrating his lecture by means of diagrams, upon continuous waves and the advent of the modern-day valve. Mr. Huson and Captain Bemrose were heartily thanked, and, in replying, extended an invitation to Burton members to visit Derby.—Hon. Secretary, Mr. R. Rose, 214, Belvedere Road, Burton-on-Trent.

The Cardiff and South Wales Wireless Society.

(Late Glamorganshire Scientific Wireless Research Society.)

The inaugural meeting of the above Society was held in the Wireless Department of the Technical College, Cardiff, on Thursday, April 29th, 1920. The organiser's efforts were successful in obtaining a good representative attendance from Glamorganshire, Monmouthshire and Carmarthenshire. As a first duty, it was proposed by Mr. A. E. Hay and seconded by Mr. T. K. Jenkins, Nantyglo (Mon.) that we accord a hearty vote of thanks to Mr. W. A. Andrews (Head of the Wireless Department of the College) for his kindness in placing his department at the disposal of the Society for headquarters. (Carried unanimously.)

The meeting elected Mr. W. A. Andrews, B.Sc., President, and Mr. W. J. Stephens (Cardiff), Vice-President, who thereupon relieved Mr. A. E. Hay of the chair. It was decided to elect the following gentlemen Vice-Presidents of the Society, the gentleman to be appointed Secretary of the Society to write inviting them to accept the office of Vice-President:—General Ferrie, Eiffel Tower, Paris; the Right Hon. the Marquis of Bute; Captain Bailey, Crickhowell, Mon.; Mr. Coles, Head of the Cardiff Technical College; Professor Bacon, of Cardiff University, and Senatore Marconi.

The meeting elected Mr. A. E. Hay to continue in the capacity as Honorary Secretary, and Mr. A. T. Dudley was appointed Hon. Treasurer. The subscription rate was fixed as a minimum of 5s. per annum, a few gentlemen present heading the subscription list with donations of 1 and 2 guineas, and it was decided to hold meetings monthly. Local meetings, such as those of the Mountain Ash members, will be held more frequently, as required.

Notice of motion was made by Mr. A. E. Hay *re* Affiliation with the Wireless Society of London, and, after discussion, the meeting decided to affiliate with the said Society immediately.

It was decided to amend the title to the Cardiff and South Wales Wireless Society, to include certain gentlemen who were present from other counties.

The next meeting was fixed for Thursday, May 13th, at 7 p.m., in the Wireless Department of the Technical College, Cardiff. Agenda:—1. Minutes of the inaugural meeting; 2, formulation of rules; 3, demonstration of lantern slides and wireless apparatus by Mr. W. A. Andrews; 4, reading of correspondence received by Secretary; 5, any other business.

Membership is open to all wireless workers (amateur or scientific) throughout the counties of Glamorgan, Carmarthen, Pembroke, Brecon, Radnor, Cardigan and Monmouth, and particulars will gladly be sent on application to the Hon. Secretary, A. E. Hay, 6, Oxford Street, Mountain Ash, Glam.

Sheffield and District Wireless Society.
(Affiliated with the Wireless Society of London.)

The last lecture of the present session was given on April 30th, when Messrs. L. Johnson and W. A. Ward gave an interesting account of the manufacture and working of "Amateur-made Wireless Gear." Many useful and valuable tips regarding the correct proportions of the various inductances for use with short and long wave tuners were given, the result of careful experiment, and the authors recommended the use of three sizes of reaction coils, one for 200–1,200, one for 1,000–4,000, and one for 4,000–18,000 metres wavelength. The lecture was illustrated by lantern slides, and some of the gear described was connected to the Society's aerial and demonstrated to all present that "the proof of the pudding is in the eating."

On Saturday, May 1st, by the kindness of the President, a party of some thirty members visited the Neepsend power station of the Sheffield Corporation Electricity Department, and spent a most enjoyable and instructive afternoon. The tour was personally conducted by the President (Mr. H. E. Yerbury, M.I.E.E., M.I.C.E.), who afterwards provided tea for the party, this latter function being graciously presided over by Mrs. Yerbury, who is a member of the Society.—Hon. Secretary, Mr. L. H. Crowther, 156, Meadow Head, Norton Woodseats, Sheffield.

Three Towns Wireless Club.
(Affiliated with the Wireless Society of London.)

A meeting at the house of the Chairman (Mr. J. Jerritt) took place on March 17th, when Mr. L. T. J. Greenwood gave a discourse on Valve Receiving and Transmitting Circuits. A large collection of diagrams accompanied the lecture. A vote of thanks was granted Mr. Greenwood for his entertaining and instructive deliberation.—Hon. Secretary, Mr. L. J. Voss, 16, Bedford Park, Plymouth.

Leicester Radio Society.
(Affiliated with the Wireless Society of London.)

A meeting of the above Society was held on Friday, May 14th, at the Turkey Café. The Vice-President (Mr. C. T. Atkinson) in the chair. After various items of business had been attended to the chairman called on Mr. S. May to address the meeting. The subject was "Some Constructional Ideas." The speaker dealt with three pieces of apparatus he had made, viz.: (1) a switch, for use on variable inductance to cut out idle coil; (2) a double variable condenser; (3) a Grissen Transformer, for induction coils. The speaker explained each piece in detail and, with the aid of diagrams, made his matter clear to all. A most enjoyable evening was spent. The next meeting was fixed for Friday, June 11th.—Hon. Secretary, W. J. Rowlatt.

Stoke-on-Trent Wireless Club.

A meeting of the above took place on Thursday evening, May 6th, at 7.30 p.m., at the Grand Hotel, Hanley. Mr. Wilson occupied the chair. The election of officers for the ensuing twelve months took place.

On a discussion *re* Affiliation with the Wireless Society of London, a decision was arrived at, that affiliation was advantageous and would be completed when the finances were in a more settled condition, probably in a month's time. It was also decided to apply for a licence forthwith. Meetings take place weekly, in future, on Friday evenings, at the Club's permanent address. Five new members were admitted.—F. Shaw, Secretary, 55, Alexandra Road, Longport, Staffs.

Birmingham Wireless Association.

A meeting was held on Thursday, May 13th, at 7.30 p.m., in the Midland Institute, when the following officers were elected: *Chairman*, Mr. J. B. Tucker; *Secretary*, Mr. A. H. Handford; *Committee*, Messrs. Chatwin, Old, Westwood and Whitfield; *Technical Committee*, Messrs. Anderson, Bishop, Chatwin, Littley, Westwood and Whitfield. It was also resolved to hold meetings every Tuesday and Thursday at 7.30 p.m. for lectures on practical work and discussion of apparatus.

Any further details may be obtained from A. H. Handford, 188, Hamstead Road, Handsworth, Hon. Secretary of the Wireless Section, or J. C. Watkins, 215, Alexander Road, Acocks Green, Hon. Secretary of the Scientific Society.

Edinburgh Wireless Club.

A general meeting of this Club took place on May 2nd, to discuss Club business and questions of general interest. Suggestions for the extension of the Club's library were also considered. A committee was elected, consisting of five members and the Hon. Secretary, Mr. W. Winkler, 9, Ettrick Road, Edinburgh.

Wireless Society of East Anglia.

We have much pleasure in acquainting our readers of this new Club, particulars of which we give herewith. Present membership, 18; meetings held fortnightly, as from April 23rd, at 8 p.m., at Radio House, St. Giles, Norwich. Those interested please communicate with the Hon. Secretary, Mr. J. H. W. Willink, The Deanery, Norwich.

Amateur Clubs.—It may interest our readers to know that there are in the United Kingdom twenty-six Clubs, formed for the purpose of studying and practising Wireless Telegraphy and Telephony. Of these Clubs, seventeen are affiliated with the Wireless Society of London. As far as we are able to gather from our records, the total number of Amateur Club members in the United Kingdom is, approximately, 800: but since the honorary secretaries of many Clubs have not apprised us of further membership, our figures must necessarily be short of the actual total. There are still wanted to form Wireless Clubs at Bournemouth, Spalding, Doncaster, Exeter, Grimsby, Gloucester, Bradford, Aberdeen and Rugby. Those interested should communicate with Mr. T. H. Dyke, Hill Garage, Bournemouth; Mr. W. G. A. Daniels, Pinchbeck Road, G.N.R. Crossing, Spalding; Mr. A. H. Wasley, Glenholme, Ravensworth Road, Doncaster; Mr. H. E. Alcock, 1, Prospect Villas, Heavitree, Exeter; Mr. C. Hewins, 42, St. Augustine Avenue, Grimsby; Mr. W. W. Inder, Crown Mansions, 41, Unions Street, Aberdeen; Mr. A. T. Cave, 3, Charlotte Street, Rugby.

PAGES FOR BEGINNERS

Under this heading we publish COMPLETE *instructional articles, forming a series specially designed and written for beginners in wireless work. Hardly any mathematics will be introduced, and we hope to present the fundamental facts of wireless in such a manner as will prove attractive to a much wider range of students than that for which this series is primarily intended.*

THE INDUCTION COIL.

THE Induction Coil, or Ruhmkorff coil, as it was formerly called, after its inventor, is essentially an apparatus for producing high tension high frequency current from a low voltage source.

We have seen that a wire carrying a current will induce an electromotive force in an adjacent wire when the circuit is made or broken. If the adjacent wire is wound into a coil of many turns, the induced electromotive force will be correspondingly increased. Suppose a certain magnetic force will induce an electromotive force of 1/10th volt in a wire of certain length. If the wire were so wound as to form, say, ten turns, the electromotive force in *each* turn would be 1/10th volt, and the potential difference between the ends of the coil would then be $10 \times 1/10$th, or 1 volt.

The induced electromotive force does not only depend on the number of turns in the coil, but also upon the rate at which the magnetic lines cut the coil. The quicker the magnetic lines move past the coil, the more powerful is the induced effect.

The Induction Coil, therefore, must contain three principal parts: (1) the coil through which the magnetising current is passed, known as the Primary Winding; (2) the coil in which the alternating electromotive force is induced, called the Secondary Winding; (3) an apparatus for making and breaking the circuit of the Primary Winding, usually termed the Interrupter. This may be mounted on the base of the Induction Coil itself, or may, in some cases, form a separate fitting.

We know that iron is a better conductor of magnetic lines of force than air. It is customary, therefore, to wind the primary coil over a rod of soft iron, or, better still, a bundle of soft iron wires. The number of lines of force produced by the current will, by this means, be increased, and the secondary voltage correspondingly higher.

A bar of soft iron has very little resistance, and thus heavy currents would be induced in it by the action of the primary coil itself. A bundle of iron wires, however, offers con-

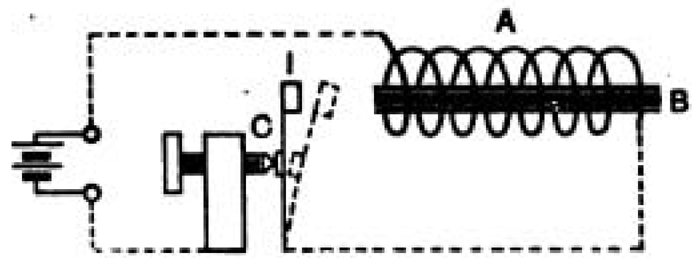


Fig. 1.

siderably more resistance to the induced current, as the thin film of oxide round each individual wire serves to insulate it from its neighbours. It is usual, therefore, to form the core of a bundle of iron wire, in order to minimise the energy lost in the iron.

A convenient and simple method of interrupting the primary current is made by employing the magnetism of the iron core to break the primary circuit. Such an arrangement is shown in Fig. 1.

A is the primary winding, through which is fitted the iron core B. Opposite one end of the core is mounted a springy arm carrying an iron disc I, and a contact plate C. Another contact is adjusted so that it just touches C when no current is flowing. The interrupter is connected as shown in the figure.

On closing the switch of the primary circuit the iron core is magnetised, and attracts the disc I, thus pulling the contacts apart and breaking the circuit as shown by the dotted lines in Fig. 1. The circuit broken, I is no longer attracted, and so flies

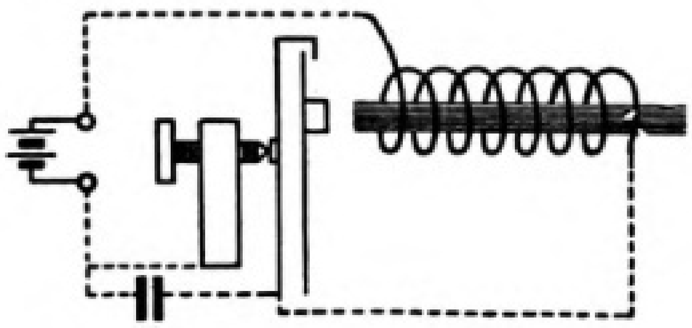


Fig. 2.

back into position under the influence of the spring; the current is re-established. and the cycle of operations is repeated.

It has been emphasised that the interruption of the current must be as sharp and abrupt as possible. otherwise the lines of force will not cut the secondary coil sufficiently quickly to induce a high e.m.f.

Referring again to Fig. 1, it will be noted that the iron disc I moves with a gradually increasing speed towards the iron core, but that the circuit is actually broken when the disc has just started to move, and its velocity is small The effect of this will be to cause an arc to form between the contact points, and the current will die away gradually instead of abruptly.

This effect is also helped by the self-induction of the primary coil. It was mentioned before that when the current in a coil is cut off, an e.m.f is set up by the collapse of the lines of force past the turns of the coil itself. This e.m.f. tends to prolong the flow of the current.

We have, then, two causes tending to make the cessation of the current gradual, rather than abrupt—the construction of the interrupter itself and the "back e.m.f." of the primary coil. The first defect has been overcome by improvement in design of the interrupter. Fig. 2 shows a typical example. It will be seen that the iron disc has to move through a certain space before it causes the contacts to open. The speed of breaking the circuit is therefore increased.

The e.m.f. of the primary winding is successfully overcome by connecting a condenser across the contact points (also shown in Fig. 2 at K.) On breaking the circuit the back e.m.f. is expending in charging up the condenser, which is discharged when the contacts come together again.

Of the separately mounted interrupters, nearly all are driven by a small motor connected to the storage battery supplying the primary current.

In one type a rotating jet of mercury impinges on a number of contact plates in succession, placed round the circumference of the containing vessel.

For small coils, however, one of the types of magnetic interrupter works quite satisfactorily.

The primary winding usually consists of one or more layers of thick wire wound on an insulating bobbin. The resistance should not be high, in order that a strong magnetising current may flow; the turns should not be too numerous, in order to avoid the troublesome sparking due to the back e.m.f. referred to above.

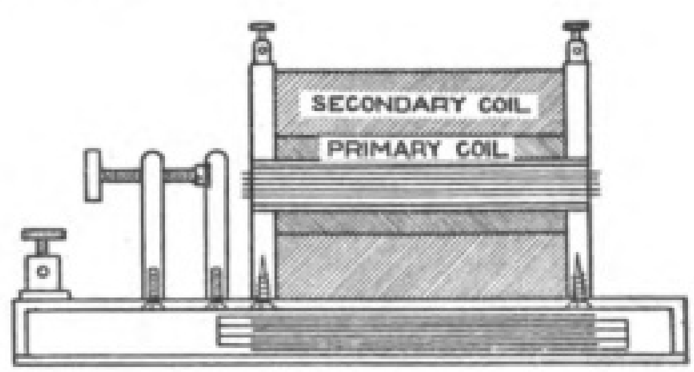


Fig. 3.

The turns composing the secondary winding are usually of fine wire, well insulated, having the ends brought out to terminals mounted at the top of the coil support. Fig. 3 shows a complete section of a small induction coil. The condenser is mounted in the base of the coil.

The potential induced in the secondary winding will not take the form of a regular wave, such as that given by an alternating current generator. On making the circuit of the primary the current will grow comparatively slowly, owing to the self-induction of the winding, but the breaking of the current will be more rapid owing to the effect of the condenser. Figs. 4 and 5 show the growth of the current and voltage in the primary and secondary coils respectively.

It can easily be understood that in the case of large induction coils where the spark obtained is eight inches or more, the potential difference between successive layers of secondary winding is very high. This eventually leads to the breakdown of the insulation between layers, and the destruction of the whole secondary winding.

Various special methods of winding have been resorted to in order to overcome this danger.

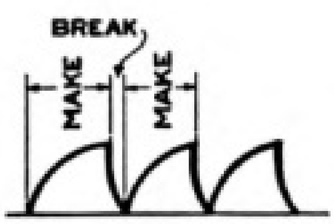


Fig. 4.

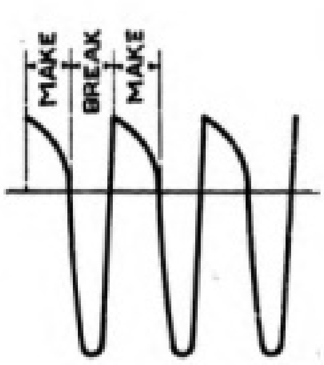


Fig. 5.

The usual method employed consists in winding the secondary coil in a number of sections or "slabs" of wire, each section being carefully insulated from the ones adjacent. The object of this type of winding is this: suppose the potential difference between the inner and outer layers of an ordinary secondary coil is 100,000 volts. Now if we were to wind the same number of turns in two separate coils, the potential difference between the inner and outer layers of *each* coil would only be 50,000, but, if suitably connected, the potential between the ends is still 100,000. The number of sections may be increased to as many as convenient, the potential between extreme layers of each section being correspondingly decreased. Fig. 6 shows such an arrangement.

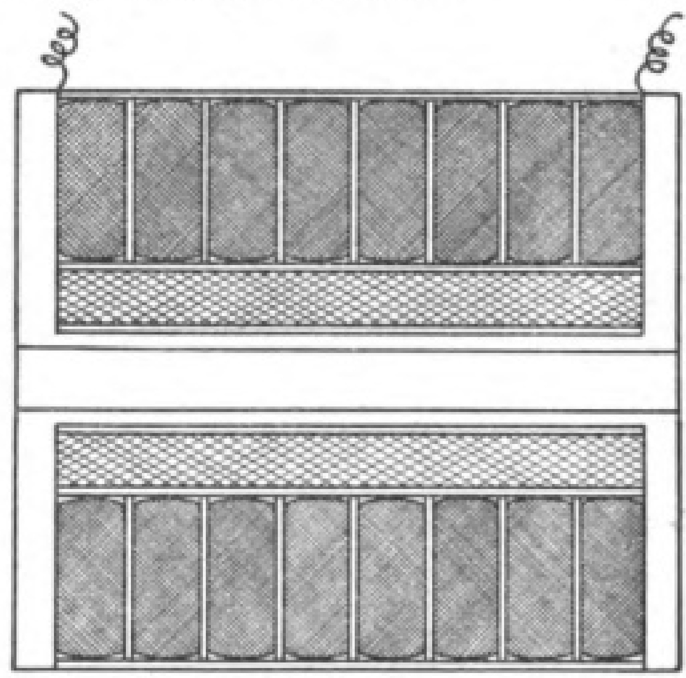


Fig. 6.

It is customary to wind the sections alternately in opposite directions, which avoids the necessity of connecting the inside layer of the first to the outside layer of the second

An expression for the potential of the secondary winding is given approximately by the equation

$$V_s = V_p \times \frac{T_s}{T_p}$$

where V_s is the secondary voltage

V_p is the primary voltage applied,

and T_s and T_p are the number of turns in secondary and primary respectively.

The CONSTRUCTION *of* AMATEUR WIRELESS APPARATUS

A Separate Oscillator for C.W. Reception (Part I).

THE utility of an amateur installation can be greatly increased by the provision of a "Local Oscillation Generator," which permits of C.W. signals being heard on either a crystal or valve receiver designed only for spark reception. The oscillator coupled to the aerial or jigger secondary generates H.F. oscillations which interfere with the received continuous oscillations and gives an audible frequency "beat" which can be detected by either a crystal or valve, giving a pure musical note in the telephones. The musical note of a spark station will be changed into a hiss by the oscillator.

A very effective "oscillator" can be made by using a Marconi V24 valve. The normal anode voltage of this valve is,—as its name implies,—24 volts, but oscillations of sufficient strength may be generated with no additional anode voltage, beyond that given by the 6 volts necessary to light the filament. The oscillations thus generated would not be of any use in a transmitting circuit but are quite strong enough for interference reception.

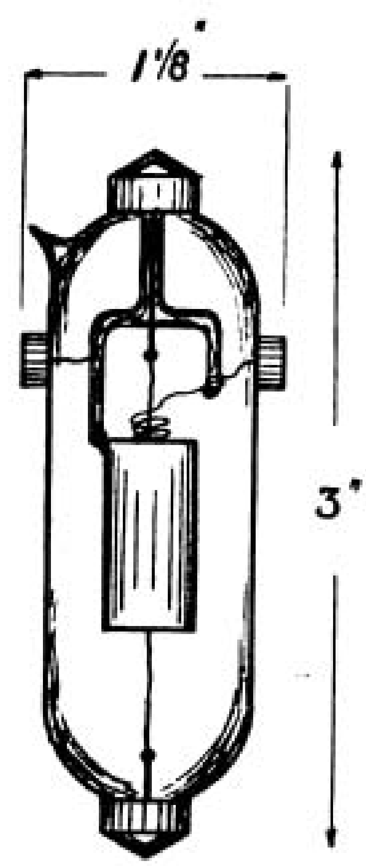


Fig. 1.

A description of an oscillator working under this condition will now be given. The wavelength range will depend upon the condenser and coils which each individual may decide to use. A comprehensive table of windings and condensers will be given later.

The sketch (Fig. 1) gives the size and dimensions of the V24 valve from which a holder can be made of brass or copper strip approximately $\frac{1}{64}$ inch thick and $\frac{3}{8}$ inch to $\frac{1}{2}$ inch wide, mounted on an ebonite or hard wood base. Four terminals should be provided or connection made to the screws which fix the valve clips to the base.

Fig. 2 gives an approximate static characteristic curve of the valve—taken with

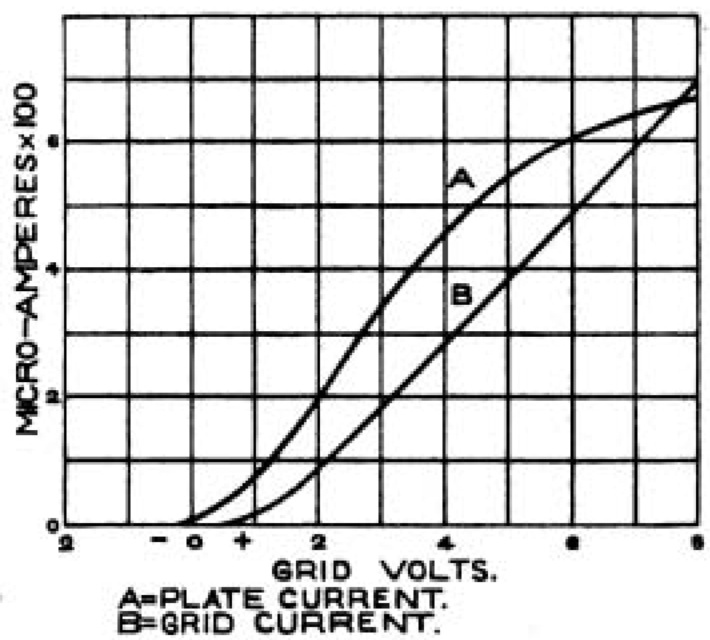


Fig. 2.

6 volts on the anode. The filament current for normal working is 0.75 amp. and the voltage drop across the filament is approximately 5 volts. This is best obtained by using a 6-volt accumulator having either a fixed or variable resistance in series with the filament, to adjust the current to the correct valve. If the resistance is fixed, its value should be 0·8 ohm, which will allow for the voltage of the battery to drop below 6 volts. A variable resistance may be up to 1·5 ohm.

Fig. 3 shows the connections of the oscillator complete. It will be seen that the grid circuit is untuned whereas the plate circuit is tuned by means of a variable condenser. One end of the grid winding is connected to the negative of the filament and one end of the plate winding to the positive of the filament battery;—this connection makes the potential of the plate, 6 volts above the negative end of the filament.

The filament resistance is connected in the positive side of the filament, for, with a

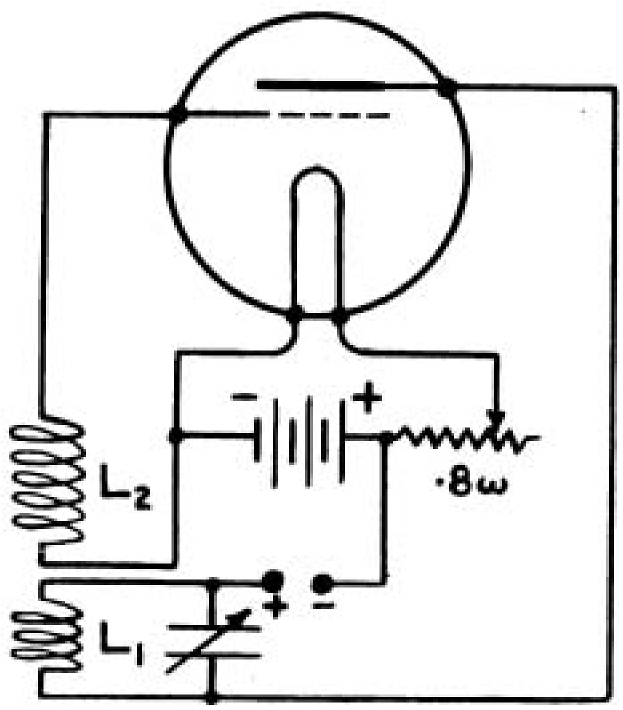


Fig. 3.

given anode voltage the set will oscillate more freely with the resistance in the positive, than if it were in the negative side.

The terminals "H.T." are provided so that if desired, additional voltage can be put on to the anode to increase the strength of the oscillations. If the H.T. voltage is increased too much the circuit will tend to become "floppy," owing to the tightness of the coupling between the grid and anode circuits. One or two pocket-lamp batteries are quite sufficient to use as additional "High Tension."

It should be pointed out that owing to the tight coupling necessary to generate oscillations under the conditions described,—necessitating the use of two flat coils placed face to face, one in each circuit,—it is not possible to use a variometer to alter the wavelengths. It will be necessary to use a variable condenser to give the wavelength range required. The capacity value of the condenser to be used is left to the individual concerned, who may be governed by the wire available or the possession of a suitable condenser. For this reason we cannot describe any special method of mounting the various parts. It should be possible to mount the filament resistance and a pillar to take the coils, on the back of the valve holder, using the valve holder base to form the top of a small wooden box. The inductance coils will be in the form of flat pancakes about $\frac{3}{16}$ inch thick with diameters varying from 2 inches to 4 inches in external diameter and about $\frac{3}{4}$ inch inside diameter.

In the next article of this series will be given a method of coil winding, illustrated by photographs of finished coils. A table showing the number of turns and gauges of wire for various ranges of wavelengths, with several different condenser values, will also be given.

DO NOT FORGET

that we have started an Exchange and Mart for the benefit of readers who have apparatus to dispose of or who desire to exchange articles of any kind for "wireless" things.

EIFFEL TOWER WEATHER REPORTS

The Eiffel Tower transmits meteorological reports three times daily, based on data received from a number of French stations and from Brussels and Mayence (Mainz), as follows :—at 09.45, Readings made at 7.0 a.m. ; 16.00, Readings taken at 13.00 ; 22.30, Readings taken at 18.00 (all times G.M.T.). Wavelength = 2500 metres. Power=150 K.W. (damped waves).

The 9.45 *programme*. Four groups of five figures for each station.

BBBDD FWTTC βbbRR MMmms

BBB Barometric pressure in millimetres and $\frac{1}{10}$ths of a millimetre, the first figure, 7, being omitted.

DD Direction of wind from 0 to 32 as per table *DD*

F Force of wind on Beaufort scale from 0 to 9 as per table *F*.

W Weather as per table *W*.

TT Temperature.

C Direction of upper clouds (*cirrus* and *cirrostratus*) 0–9 (International Code).

β Indication of Barometric tendency

bb Barometric movement in $\frac{1}{10}$ths of millimetres If movement is negative 50 is added to the number *DD*

RR Rain, in millimetres, for previous 24 hours.

MM Maximum temperature 7 a.m. to 7 a.m.

mm Minimum temperature.

s State of sea, 0–9. (Omitted when station is inland—only 4 figures being sent.)

Upper Winds.

Two groups of 6 letters for each station :—

$D_1 V_1 D_2 V_2 D_3 V_3 \quad D_4 V_4 D_5 V_5 D_6 V_6$

$D_1\ D_2\ D_3\ D_4\ D_5\ D_6$ Indicates direction of wind at the different altitudes.

$V_1\ V_2\ V_3\ V_4\ V_5\ V_6$ Indicates force of wind at different altitudes.

D_1 and V_1 at 500 metres.
D_2 and V_2 „ 1000 „
D_3 and V_3 „ 1500 „
D_4 and V_4 „ 2000 „
D_5 and V_5 „ 3000 „
D_6 and V_6 „ 4000 „

The 16.00 *and* 22.30 *programmes*. One group of 5 figures, one group of 4 figures, and one group of 3 figures for each station.

BBBDD FWTT βbb

Upper Winds.

Two groups of 6 letters for each station.

$D_1 V_1 D_2 V_2 D_3 V_3 \quad D_4 V_4 D_5 V_5 D_6 V_6$

Method of transmitting. The telegrams begin with the words :—Meteo, France.

The groups of figures and the groups of letters for each station are preceded by a group of two figures indicating the station.

Missing stations are shown by five X's, *i.e.*, xxxxx preceded by the number of the station. Groups of figures are given for the following stations :—

01 Ile d'Aix	11 St. Matthieu
02 Biarritz	12 Marseilles
04 Brussels	13 Mayence (Mainz)
05 Cherbourg	15 Paris
06 Clermont	16 Perpignan
07 Dijon	18 Rennes
08 Gris Nez	19 Strasbourg
09 Limoges	

Groups of letters are sent for the following stations :—

03 Bordeaux	15 Paris
04 Brussels	17 St. Pierre Quiberon
14 Montpelier	19 Strasbourg

For upper winds the following code is used :—

DIRECTION OF WIND.

NNE	*a*	*SSW*	*i*
NE	*b*	*SW*	*j*
ENE	*c*	*WSW*	*k*
E	*d*	*W*	*l*
ESE	*e*	*WNW*	*m*
SE	*f*	*NW*	*n*
SSE	*g*	*NNW*	*o*
S	*h*	*N*	*p*

F

(*Force of wind on Beaufort Scale.*)

W

(Weather by following code.)

0 = fine, cloudless.
1 = less than half sky covered with cloud
2 = about half sky covered with cloud
3 = about ¾ sky covered with cloud
4 = overcast.
5 = rain.
6 = snow.
7 = mist (not wet fog but fog less thick than for 8)
8 = fog.
9 = thunderstorm.

bb—Barometric tendency.

These figures give the barometric movement in millimetres and tenths.

C

(Direction of upper clouds.)

0 = Clouds observed having no appreciable movement.
1 = Clouds coming from the *NE*
2 = " " " " *E*
3 = " " " " *SE*
4 = " " " " *S*
5 = " " " " *SW*
6 = " " " " *W*
7 = " " " " *NW*
8 = " " " " *N*
9 = No observations.

S

(State of the surface of the sea.)

0 = calm—glassy.
1 = very smooth—slightly rippled.
2 = smooth—rippled.
3 = slight—rocks buoy.
4 = moderate—furrowed—choppy.
5 = rather rough—much furrowed.
6 = rough—deeply furrowed.
7 = high—rollers with steep fronts.
8 = very high—rollers with steep fronts.
9 = phenomenal—precipitous.

TT

(Temperature.)

Fifty is added to this number when temperature is negative (Deg. Cent.). For temperatures near zero the following is used.

From 0·1° to 0·4°	00
From 0·5° to 1·4°	01
From—1·4° to —0·5°	51
From—0·4° to —0.0°	50

β

(This figure indicates slope of barometric curve for the three hours preceding the time of observations.)

0 = Stationary barometer.
1 = Irregular movements.
2 = Rising steadily.
3 = Falling steadily.
4 = Preliminary fall, then rising.
5 = Stationary, then rising.
6 = Stationary, then falling.
7 = Falling, then stationary.
8 = Rising, then stationary or falling.
9 = Storm indications (oscillations).

Speed of Wind.

Metres per second.			
0	*a*	26	*n*
2	*b*	28	*o*
4	*c*	30	*p*
6	*d*	32	*q*
8	*e*	34	*r*
10	*f*	36	*s*
12	*g*	38	*t*
14	*h*	40	*u*
16	*i*	42	*v*
18	*j*	44	*w*
20	*k*	46	*y*
22	*l*	48	*z*
24	*m*		

DD

(Direction of wind according to following code, unless otherwise specified.)

02 = *NNE*	18 = *SSW*
04 = *NE*	20 = *SW*
06 = *ENE*	22 = *WSW*
08 = *E*	24 = *W*
10 = *ESE*	26 = *WNW*
12 = *SE*	28 = *NW*
14 = *SSE*	30 = *NNW*
16 = *S*	32 = *N*

For calm the figures 00 are used.

BOOK REVIEWS

THE YEAR BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY (1920).

London : The Wireless Press, Ltd., pp. 1,148 +cxxiii ; 106 maps, 33 photographs. 10s. 6d. net.

THIS is the eighth edition of an unique and indispensable work of reference, and the present volume (although prepared during a period of world-upheaval) has fulfilled the tradition of its forerunners by being an improvement upon the issue immediately preceding it.

The Calendar section has been rendered more useful by the inclusion of the hours of sunrise and sunset in the meridian of Greenwich, and the phases of the moon, and the section has been amplified and revised generally.

The Record of Development has received careful revision at the hands of Dr. N. W. McLachlan, and the past year's progress has been ably described by Mr. Philip R. Coursey, B.Sc.

The Laws and Regulations section displays a new and welcome feature in the shape of a number of maps, which are incorporated with the particulars of the Countries or Districts they represent, and show the positions of Wireless Stations. These maps supersede the large map of the world hitherto published in the Year Book.

One of the most important sections, that of Land and Ship Stations and their call letters, has been brought up to date, and now occupies about 380 pages.

In the Special Articles section are included a series of national *résumés* of the past year's progress in "wireless," which forms an attractive and authoritative history of endeavour and achievement in the various countries represented. In the same section Mr. W. T. Ditcham, A.M.I.E.E., M.Inst. R.E., writes on "The Progress of Wireless Telephony," and Major C. E Prince, O.B.E., on "Wireless Telephony and its Application to Aircraft." Mr. G. M. Wright contributes a valuable article on "Direction Finding," and Mr. F. P. Swann deals with the subject of "Valve Amplifiers for Shipboard Use." "Valve Patents for 1919," by Mr. I. Shoenberg, is a carefully compiled article of extreme interest and utility, and the important subject of Meteorology and Radio-communication is dealt with by Lieut.-Col. E. Gold, D.S.O., F.R.S., his article being closely followed by an excellent collection of data in connection with International Time and Weather Signals.

Major Robert Orme, B.A., writes on "Radiotelegraphy and Aviation," and Mr. A. R. Hinks, M.A., F.R.S., the Secretary of the Royal Geographical Society, describes the inter-relationship of time and wireless telegraphy.

The Useful Data section has received skilled attention from Mr. E. V. Appleton, M.A., B.Sc., who has revised and augmented it, and the record of the literature of wireless telegraphy and telephony, published during 1919, has been collected into what is one of the most useful sections of the book. The last-mentioned section comprises:—(*a*) New books dealing with wireless published during 1919, and new radio periodicals started during 1919 ; (*b*) *résumé* of articles published during 1919. This sub-section is divided into parts, such as Radio-frequency Measurements and Theory, Transmitting Apparatus, Radiotelephony, etc., a method which greatly facilitates search. (*c*) Standard publications on wireless. This sub-section is divided into parts which separate the literature of various countries. Both books and periodicals are classified in the Literature section.

In spite of the fact that a very large amount of extra matter has been incorporated a skilful selection of type has averted the production of an unwieldy volume ; the printing is excellent, and the photographic illustrations possess a high order of interest for all who desire to keep in touch with modern wireless apparatus.

QUESTIONS AND ANSWERS

NOTE.—This section of the magazine is placed at the disposal of all readers who wish to receive advice and information on matters pertaining to both the technical and non-technical sides of wireless work. Readers should comply with the following rules.—(1) Questions should be numbered and written on one side of the paper only, and should not exceed four in number. (2) Queries should be clear and concise. (3) Before sending in their questions readers are advised to search recent numbers to see whether the same queries have not been dealt with before. **(4) The Editor cannot undertake to reply to queries by post.** *(5) All queries must be accompanied by the full name and address of the sender, which is for reference, not for publication. Queries will be answered under the initials and town of the correspondent, or, if so desired, under a "nom de plume."* **(6) Readers desirous of knowing the conditions of service, etc., for wireless operators will save time by writing direct to the various firms employing operators.**

STUDENT (Cahirciveen).—A Senior Operator is entitled to wear two rows of gold braid with a diamond between them; a Second Operator is entitled to wear the two rows of braid, without the diamond; and a Third Operator, one row of braid.

D.C.M. (Cardiff).—Kindly apply to the firm you mentioned, as they can give you much better than ourselves the information you require.

AMATEUR (Weybridge) *asks* (1) *Is it necessary to have a permit or a licence for a receiving station and aerial only.* (2) *Where to apply for forms of application for such licence.* (3) *Can firms supplying wireless outfits demand to see a licence before selling such wireless apparatus.*

(1) Yes, a permit. (2) The Secretary, G.P.O., London. (3) Yes.

R.T.T. (Birmingham).—Yes. A Post Office permit must be obtained before erecting an aerial for receiving messages. The fee for such a permit is 10s. This covers the erection of the aerial and apparatus.

J.T. (Venlo, Holland).—(1) The wireless telephony you heard originated from the Marconi Station at Chelmsford. It was a long-distance test, extending over two weeks, and is now finished. (2) Poldhu sends press at about 1 a.m.

RADIO (Burton-on-Trent) *has annoying induction from A.C. supply, there being both lights and motors on the premises. He asks for advice.*

We are afraid his prospects are not very good. Some improvement might be effected by screening the receiving gear in a metal case. It might be possible to balance out some of the induction by suitably placing a coil in the aerial circuit, but this is by no means certain. The earth lead is too long; shortening this might help, as might a small condenser in the earth lead.

C.E.S. (Dublin) *sends a sketch of an oscillator (Fig. 1) consisting of two metal plates, 6 feet apart, connected by a few turns of wire. He asks what would*

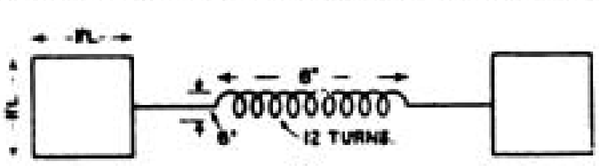


Fig. 1.

be the approximate wavelength, and if it could be used in a simple valve circuit (Fig. 2) for demonstrating wireless telephony over a few yards, using a crystal receiver. If not, what lines would be better to go on.

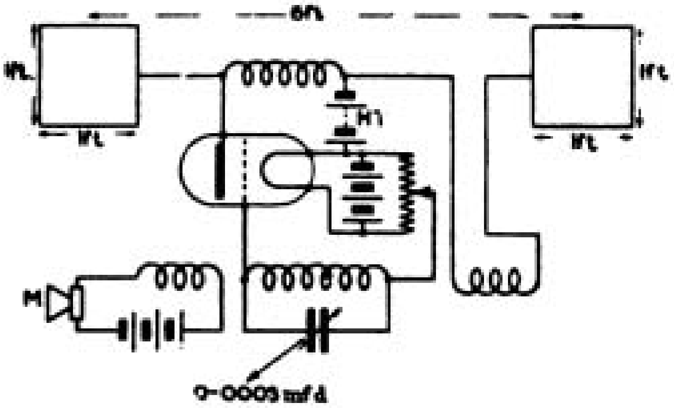


Fig. 2.

The wavelength might be from 15 to 30 feet. We are afraid you would find it very difficult to induce the set to oscillate on such a short wavelength. You show grid control. For such a set a microphone direct in the oscillating circuit would be simpler and much better. You would find it difficult to receive such short waves, even if you could produce them, which is very doubtful. Increasing the anode potential would probably not help you much. A much better line would be to abandon the idea of using extremely short wavelengths in favour of a workable wavelength in a closed circuit. By suitably adjusting the area of your loop of wire you should be able to get a range of a few yards only on a wavelength of, say, 300 ms quite easily.

D.C.F. (Tunbridge Wells) *has a pair of 'phones wound to 750 ohms, which he wishes to use for crystal reception. He asks* (1) *Whether they can be used with a telephone transformer.* (2) *If so, what windings should be used.* (3) *If it would be better to dispose of them and get new 'phones of either high or low resistance.*

(1 and 3) The 'phones, if well made, should be quite satisfactory with a suitable transformer. There is no need for you to get others of more usual resistance.

(2) The transformer should be similar in construction to that described in the March *Wireless World*, but should have more turns of rather finer wire on the low resistance side. In place of the 6 oz. of No. 30, suggested in the article referred to, use about the same weight of No. 36. The other details of construction should be as given in the article.

W.H.D. (Windsor) *asks* (1) *What resistance to wind 'phones to, with No. 50 copper wire, for use with a platinum silicon detector.* (2) *What length* *and gauge wire would be required for an inductance to tune to 3,000 ms. with about 40 ft. of double-wire aerial.* (3) *If the 'phones should be single or double.* (4) *If a licence is necessary for a receiving set if valves are not used.*

(1) Wind on as much wire as you can get on the bobbins—some thousands of ohms, at least.

(2) The dimensions of the aerial given are rather vague, and we can therefore only give you approximate figures. Try a former 15 cms. in diameter and 30 cms. long, wound full in one layer with No. 30 wire.

(3) Double headpiece 'phones are generally preferable. You could use single, however, if you wished.

(4) Yes; apply to the Secretary, G.P.O., London.

F.J. (Kentish Town) *asks for a complete diagram of a receiver, stipulating that only the following items should be used—single slide tuning coil, loose coupled inductance, one condenser (variable), valve, filament battery, H.T. ditto, filament resistance, and grid leak.*

We think this is a rather unsatisfactory point of view from which to design a good receiver: we should prefer to settle the type of receiver first, and then fix what apparatus would be necessary for use in it. Moreover, it is difficult to advise the best disposition of the apparatus without more knowledge of the dimensions of the components.

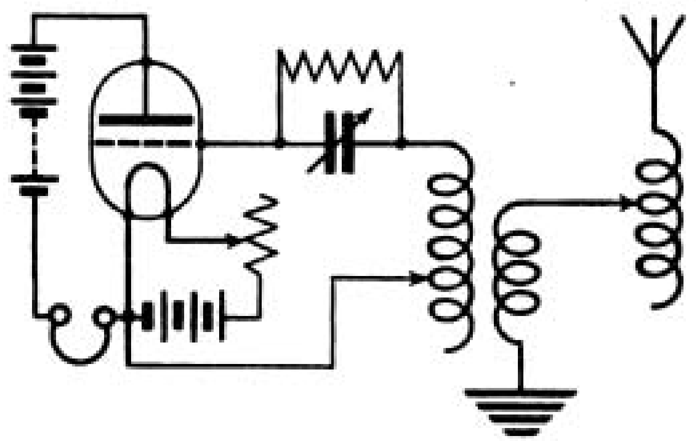


Fig. 3.

However, if the various parts are of suitable sizes, the above diagram might give fairly satisfactory results. (Fig. 3.)

G.P.K. (Leeds) (1) *has a French valve which gives good signals for about 10 seconds after switching on the batteries, the signals then fading away and recovering again after a few minutes' rest. The circuit behaves normally with a different valve. He asks the reason for this.* (2) *He wishes to make a continuously variable inductance up to 2,500 mhys. and asks if it will be possible to do so by making a coil with about 20 tappings, and adding a spherical coil at one end as a variometer to give fine adjustment between the tapping points.* (3) *He also asks whether A.C. at 50 ~ can be used for lighting the filament of a H.F. amplifying valve.*

(1) The effect might be due to a partial short between the plate and the filament, making the H.T. current excessive, causing polarisation of the H.T. battery; or it might be due to a change in the hardness of the valve. We are afraid we cannot say without an examination of the valve.

(2) This method should be quite satisfactory.

(3) This would not be satisfactory. Even if you rectified the A.C. you would need elaborate and very expensive condenser arrangements to smooth out the resulting uni-directional pulses sufficiently for use as you wish. The method is not practicable.

S.J.R.B. (Southsea) *asks for the dielectric constants of the substances mentioned below.*

The values vary a good deal with the exact composition and physical properties of the substances—except, of course, in the case of air. The following ranges cover the usual values obtained :—

Air	1.00
Ebonite	2.0 to 2.75
Mica	8.0
Glass	6.0 to 7.5; but certain special sorts may be as low as 3.0 to 3.25
Paraffin wax	2.0 to 2.35

R.B. (Peterborough) *refers to Bangay's "First Principles," Fig. 283, and asks* (1) *Whether a single slide inductance wound with, say, No. 28 wire, would be suitable for the sheath inductance.* (2) *Whether about 10 turns would do for the reaction coil, and* (3) *Sends a diagram of a receiver, and asks whether the transformer shown should be air or iron cored.*

(1) The coil should certainly be single-layered, and No. 28 would be all right for the wire. It would be better wound without any slider, and the circuit tuned by the variable condenser across it.

(2) Unless your wavelength is to be very small you will probably want more than 10 turns. Try about 50 to begin with.

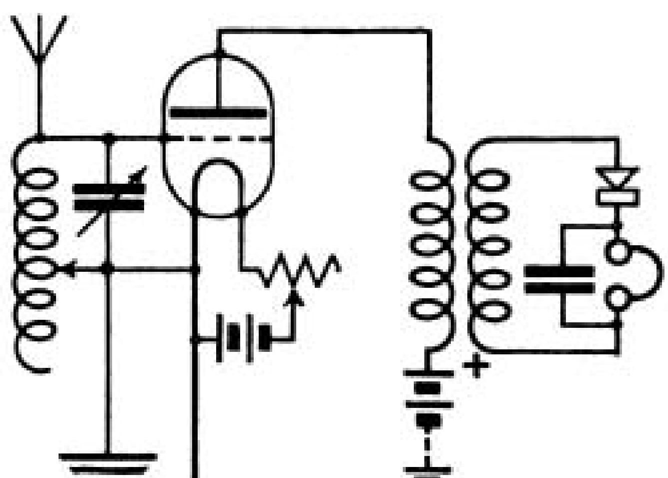


Fig. 4.

(3) Neither type of transformer would give results with the circuit you show. (Fig. 4.) You can either omit the crystal and use an iron-cored L.F. transformer, or retain the crystal, put a variable tuning condenser across the side of the transformer connected to the crystal and the 'phones, and make the transformer air-cored H.F.

A.N.T. (Cardiff) *sends two diagrams of a proposed receiver of somewhat unusual type, which he wishes to have a range of 400–15,000 ms. He asks (1) What values certain inductances and condensers should have. (2) What should be the capacity of a grid condenser, (3) If a leak across a grid condenser is necessary. (4) What value another special inductance should have.*

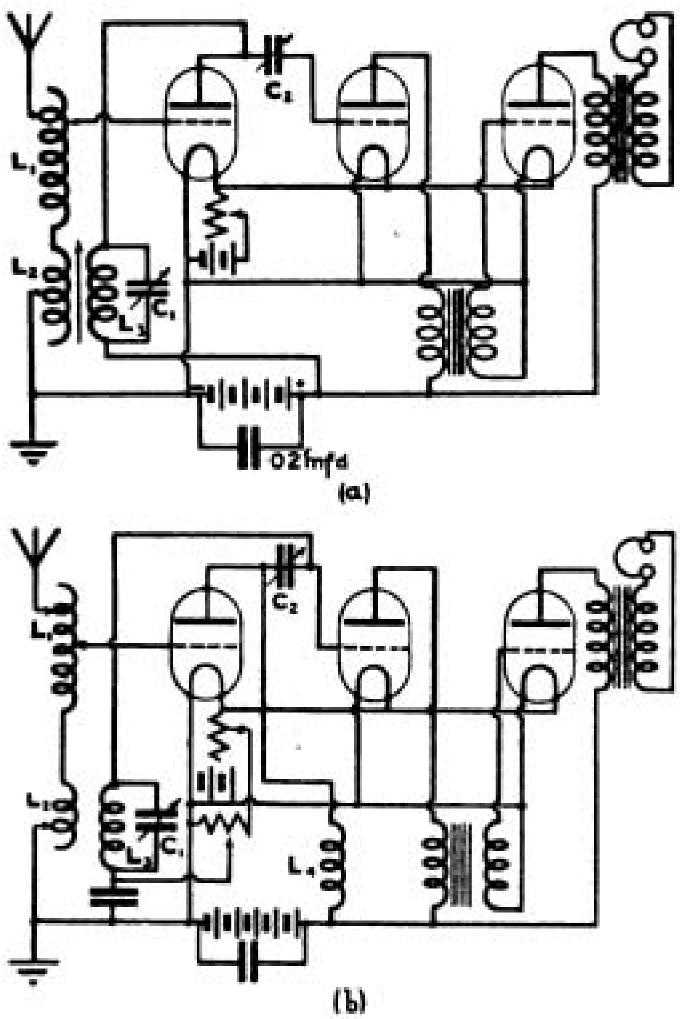


Fig. 5.

You will probably find it difficult to make a receiver satisfactory over such a large range.

(1) C_1 should be about 0.0005 mfds.
L_2 might be about 500 mhys. You will have to find the best value by experiment.
L_3 should be about 120,000 mhys.

(2) The grid condenser should be about 0.0002 mfds.

(3) Yes: 2 or 3 megohms should be a suitable value for it.

(4) We should prefer to omit inductance L_4 (Fig. *b*) altogether, making the connection from the L_3 C_1 on the side of the grid condenser nearer to the plate of the first valve, as in your Fig. (*a*), which should be satisfactory for spark working.

C.E.W. (New Cross) *asks (1) What effect, with formula, a condenser has when placed in series or in parallel with an inductance. (2) Whether in determining what inductance is required for a certain wavelength it is necessary to include the maximum capacity of the condenser to be used with it. (3) Whether it would be possible to make a variable inductance to tune a circuit from 1,000 to 15,000 ms. on the variometer principle without the use of tappings. (4) What is the best way of getting over the difficulty of an excessive length of earth lead when using an upper room for reception.*

(1) A detailed description would take more space than we can spare. Consult a book on alternating current principles. The formulæ for the resultant impedance of a condenser and inductance are as follows: (*a*) in series, $L\omega - 1/C\omega$, the resistance being assumed negligible, and $\omega = 2\pi \times$ the frequency.

(*b*) in parallel, $\frac{L}{C(L\omega - 1/C\omega)}$, the resistance being negligible, as before.

(2) It is certainly necessary to calculate the amount of inductance required by means of this value of the capacity and the formula connecting inductance, capacity and wavelength.

(3) No: it would be impossible to get such a large range of inductance as you would require from the variometer principle alone.

(4) If you have a water-pipe near, earth to it. If not, you might try the effect of a balancing capacity of large area near your set. It would, however, probably not give you very good results. We do not know of any simple way out of the difficulty.

C.C.N. (Leicester) *wishes to use a chimney 80 ft. high for one mast of his aerial, and asks (1) If the lightning conductor would seriously affect reception, and whether it would improve matters if a switch were inserted in the lightning conductor. (2) What is the meaning of the statement that the lightning conductor has a radius of attraction of 20 feet. (3) If C.W. can be received with a crystal and a tikker, and if so, where it should be inserted.*

(1) The lightning conductor should not very greatly affect the signals, unless the down lead is close to it. From a wireless point of view it would be better to break the wire with a switch, if there are no other reasons which make this undesirable.

(2) This probably refers to the range within which the conductor is considered to give complete protection from lightning discharge.

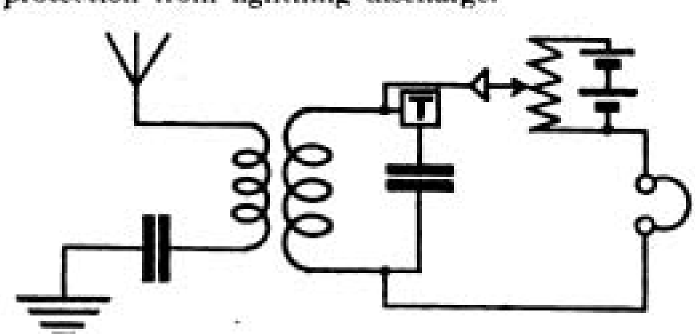


Fig. 6.

(3) The tikker is most simply used in the place of a crystal, and not with it. If you wish to use both, a suitable place for the tikker would probably be as shown at T in Fig. 6.

THE WIRELESS WORLD

VOLUME VIII Nº 4 NEW SERIES

CONTENTS

15TH MAY 1920

6D

NET

FORTNIGHTLY.

Weston

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Model 375 Galvanometer is a moving coil instrument with a uniformly divided scale 2·35 inches long.

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THE WIRELESS WORLD

THE OFFICIAL ORGAN OF THE WIRELESS SOCIETY OF LONDON

VOL. VIII. No. 4. MAY 15TH, 1920 FORTNIGHTLY

AERIALS,

THEIR FORMS AND USES.

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

IN an earlier article the simple form of wireless transmitter that was used by Hertz in his early researches, which led to the discovery of electromagnetic waves, has been described, together with the receiver that he used for their detection. The simple Hertz oscillator is eminently suited for demonstrations of small scale experiments on these aether waves in the laboratory, but is not very well adapted to practical wireless signalling over any considerable distances.

One of the most important features of Marconi's work in the early days of wireless was the substitution of the elevated aerial wire for this simple oscillator, and the use of a ground connection for the other terminal. The immediate effect of this change, even with the relatively insensitive receiving apparatus that was then available. was a comparatively large increase in the effective signalling range of the apparatus. In its earliest form the plain Marconi aerial consisted simply of a single strand of wire hung from the top of a mast, and joined to the transmitting or receiving apparatus at its base (Fig. 1). The electrical effect of the earth connection to the other terminal of the apparatus is to produce an electrical image of the elevated wire in the earth. The earth's surface may thus be regarded as acting very much like a mirror, so that an image of the wire is formed, as indicated by the dotted line in Fig. 1.

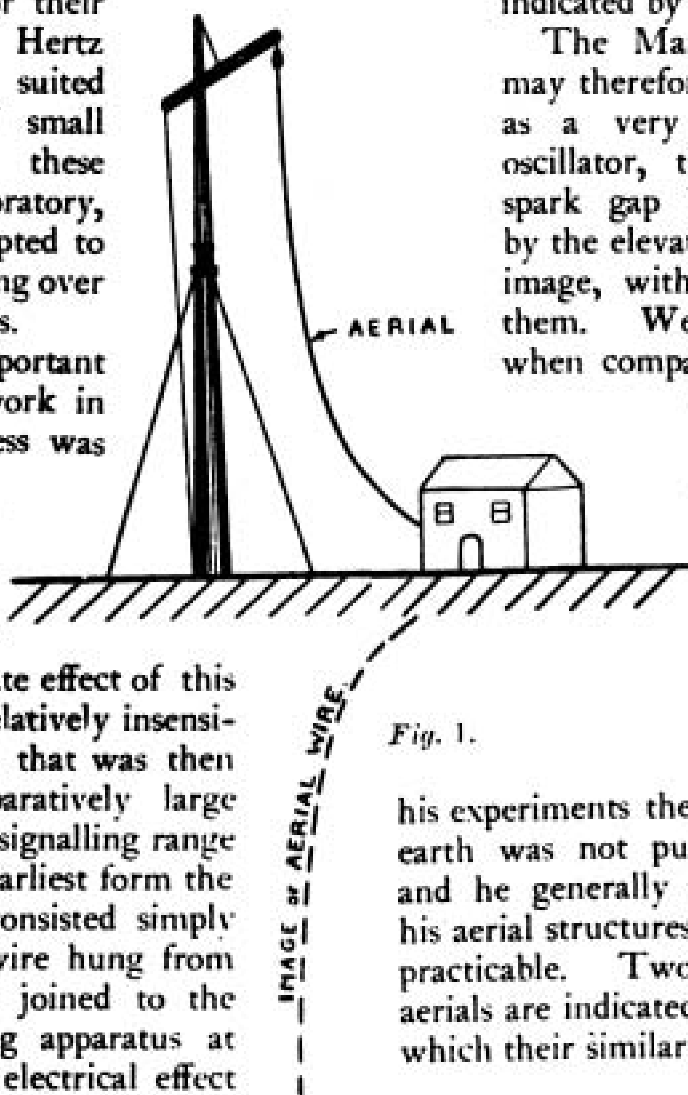


Fig. 1.

The Marconi single wire aerial may therefore be looked upon simply as a very much enlarged Hertz oscillator, the two plates with the spark gap between being replaced by the elevated wire and its electrical image, with the spark gap between them. We may therefore say that when comparing the two cases, the effective length of the Marconi aerial, regarded as a Hertz oscillator, is *twice* the height of the aerial wire.

Much about this time,* too, Lodge was experimenting with enlarged aerial structures; but in the majority of cases in his experiments the electrical image in the earth was not put to any practical use, and he generally endeavoured to remove his aerial structures as far from the earth as practicable. Two forms of early Lodge aerials are indicated in Figs. 2 and 3, from which their similarity to the Hertz oscillator

* About 1896–1897.

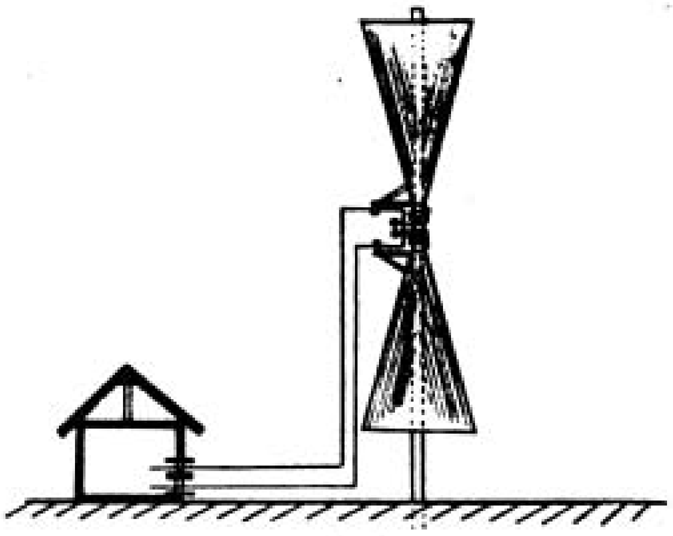


Fig. 2.
Early form of Lodge Aerial with no Earth connection.

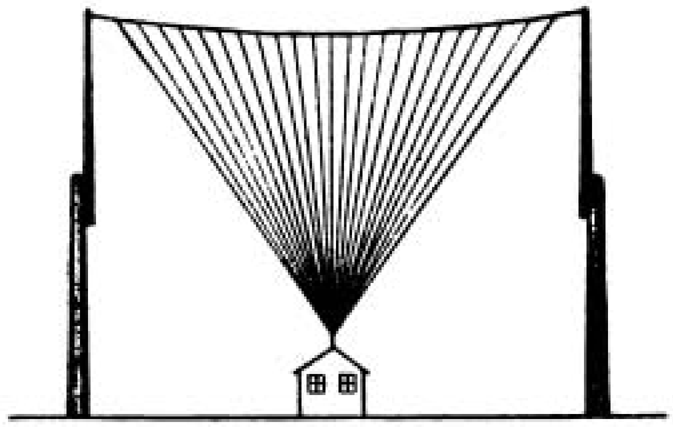


Fig. 4.
Fan-shaped Aerial of the type used at Poldhu in 1901.

may easily be recognised, more particularly in the case of Fig. 2

With the later 'introduction of coupled circuits into the transmitter to replace the direct connection of the aerials to the spark gap, a considerable change gradually came over the constructional form given to the aerials, since the alteration in the transmitting circuits enabled more power to be handled, and greater ranges to be covered, using the larger and higher aerials.

In order to increase the energy that the aerial can effectively handle, it is desirable to increase as much as practicable its electrical capacity to earth. This involves an increase in its size, and generally also, to secure large signalling ranges, an increase of height as

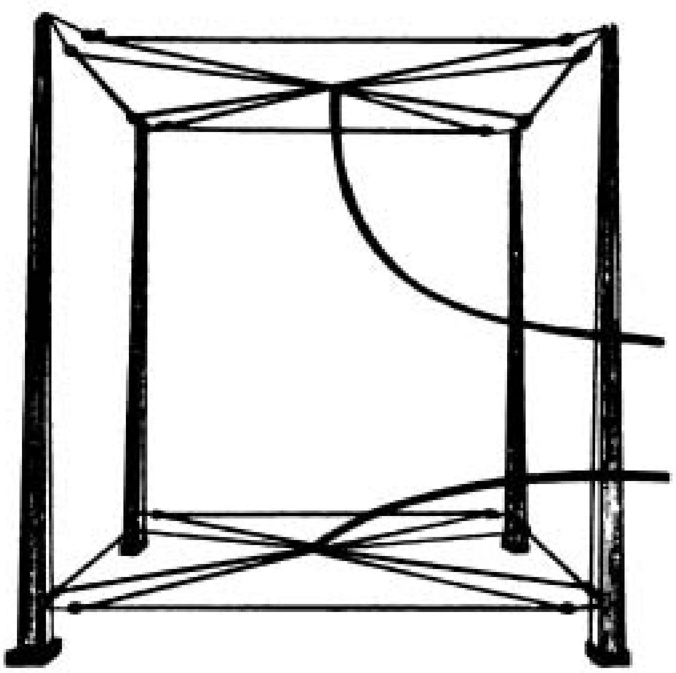


Fig. 3.
Later type of Lodge Aerial —" Maltese-Cross" Pattern.

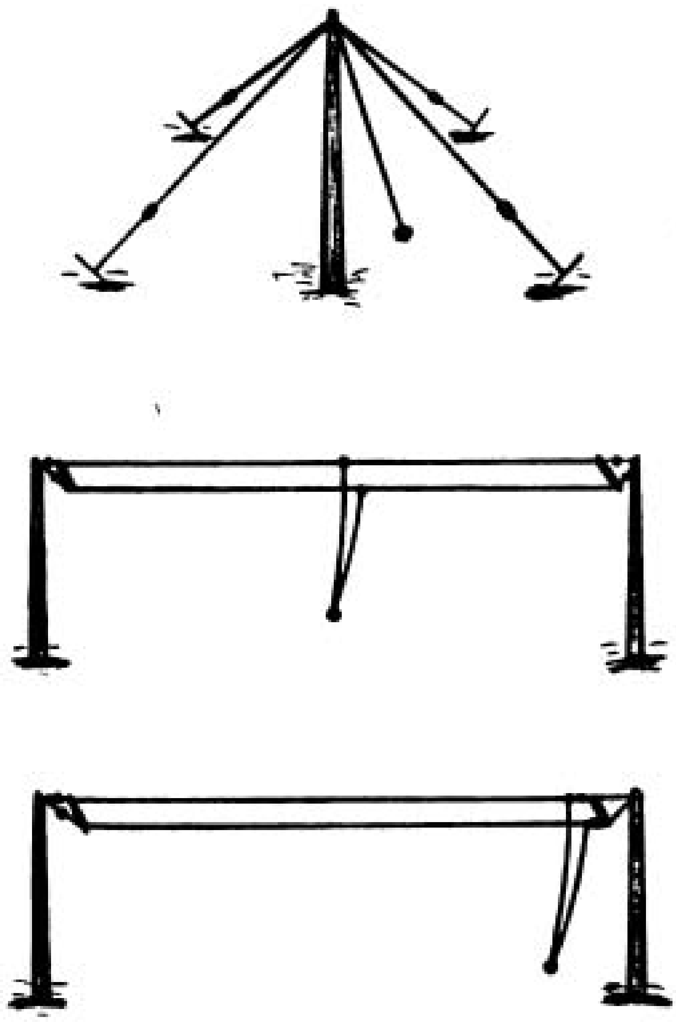


Fig. 5.
Typical forms of Modern Aerials. 1. Umbrella Aerial. 2. T Aerial. 3. Inverted L, or ˥ Aerial.

well. Thus the aerial at Poldhu, used on the historic occasion on which signals were first transmitted across the Atlantic in 1901, was fan-shaped, and consisted of 50 wires supported by a triatic between two masts, 160 ft. in height and 200 ft. apart (Fig. 4).

The signalling range of an aerial, other conditions being given, depends upon its "mean effective height." This height is the height of the electrical centre of its capacity, measured from the reflecting conducting layer, at or near the earth's surface—the layer in which the aerial is reflected to form its electrical image below the earth's surface. In the case of a ship aerial, this reflecting layer is evidently the surface of the sea, since sea water is a reasonably good electrical conductor; but with a land station aerial, erected over somewhat dry soil, the reflecting layer may often be some distance below the surface. In general this reflecting layer is coincident with the surface of any underground water that may be present.

On account of the above facts, it is found desirable to increase the capacity of the *top* of the aerial as much as possible, as this raises the effective height and renders the current distribution more uniform in the vertical portions. Hence the prevalent designs in which the bulk of the wires are concentrated in the upper parts. Figs. 5 and 6 illustrate several typical forms of aerial showing this feature.

Since the function of the aerial, as in the case of the Hertz oscillator, is to provide a capacity into and out of which the current can surge as high frequency oscillations, it is immaterial what shape is actually given to the aerial, provided the natural reactions which take place between the aether and the moving electrons of the oscillatory current can give rise to useful wave radiation.

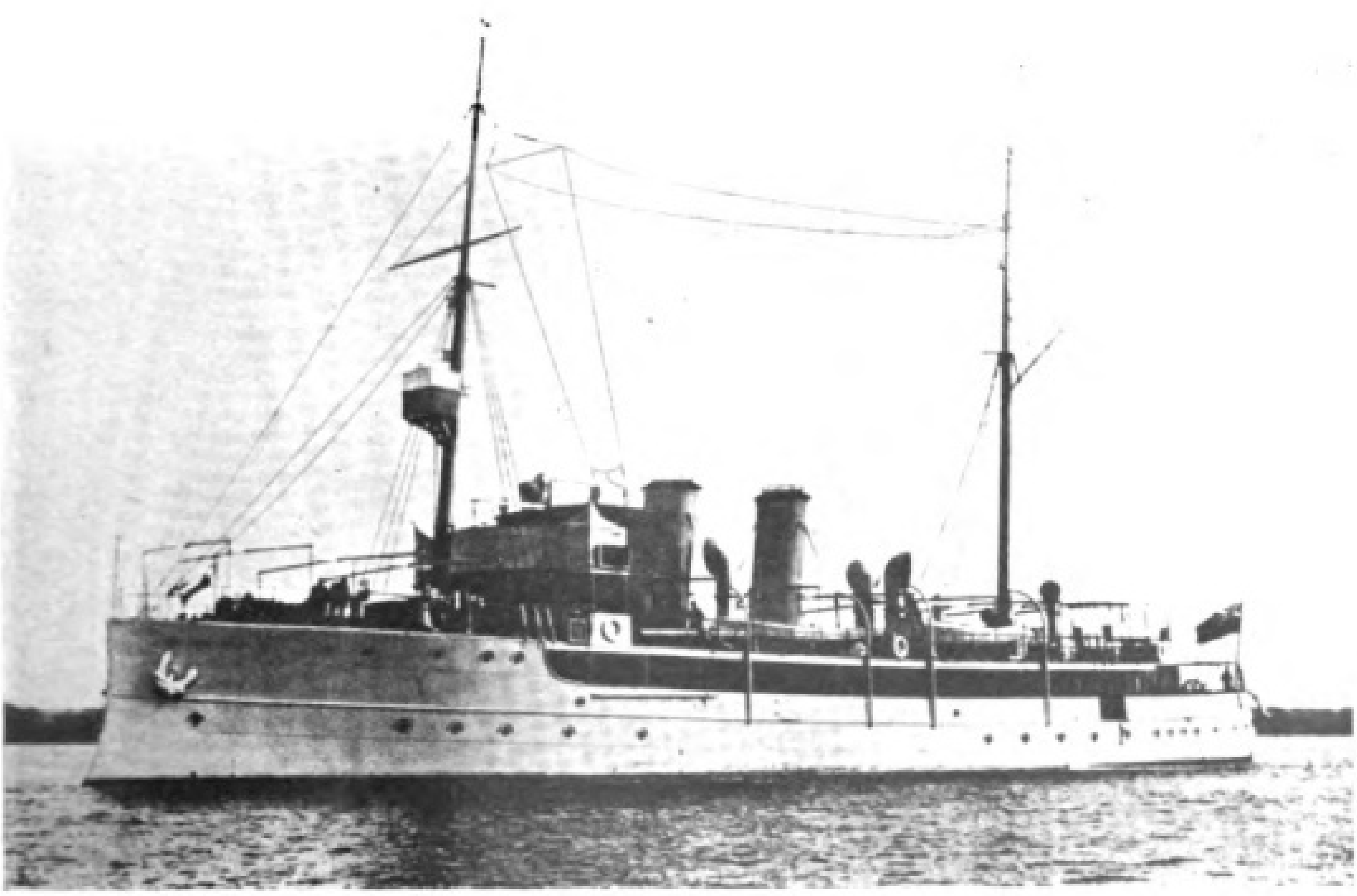


Fig. 6. Typical Ship's 2-wire Inverted L Type Aerial.

Given, then, an oscillatory current in the vertical wire, it is not essential that the upper end of the wire should be free or "open," but it may be connected to a return wire leading back to the apparatus again, provided that the return is at a sufficient distance from the first vertical wire for its effect not to neutralise the radiation from the main wire. The closed loop type of aerial (Fig. 7) is thus obtained. These aerials are also often referred to as "frame" aerials.

Evidently, if the two vertical sides of the loop are too close to each other, their effects will largely cancel out at a distant point, since the currents are evidently flowing in opposite directions in the two sides of the loop at any given instant in time. There will, however, always be some radiation from such a loop circuit, and its magnitude will increase rapidly as the size of the loop is increased to be comparable with half the wavelength of the oscillations impressed upon it.

These loop aerials have, in addition, valuable directive properties; that is to say, they are capable of transmitting, or receiving, best from one or two directions, as compared with the more uniform distribution of radiation from the ordinary open aerials. The various other forms of directive aerial used with different sets of apparatus, and for various purposes, are mostly modifications of the simple loop.

In the case of aircraft, it is evidently impracticable to maintain an earth connection to the wireless apparatus, so that the frame of the machine is often used to replace it as a counterpoise capacity, while a single wire aerial is trailed from the machine in flight. Loop aerials have also been employed on aircraft, particularly for direction and position finding work, while, in addition, their application to submarines during the later stages of the war considerably augmented the effectiveness of these craft, and relieved some of the dangers of their hazardous work.

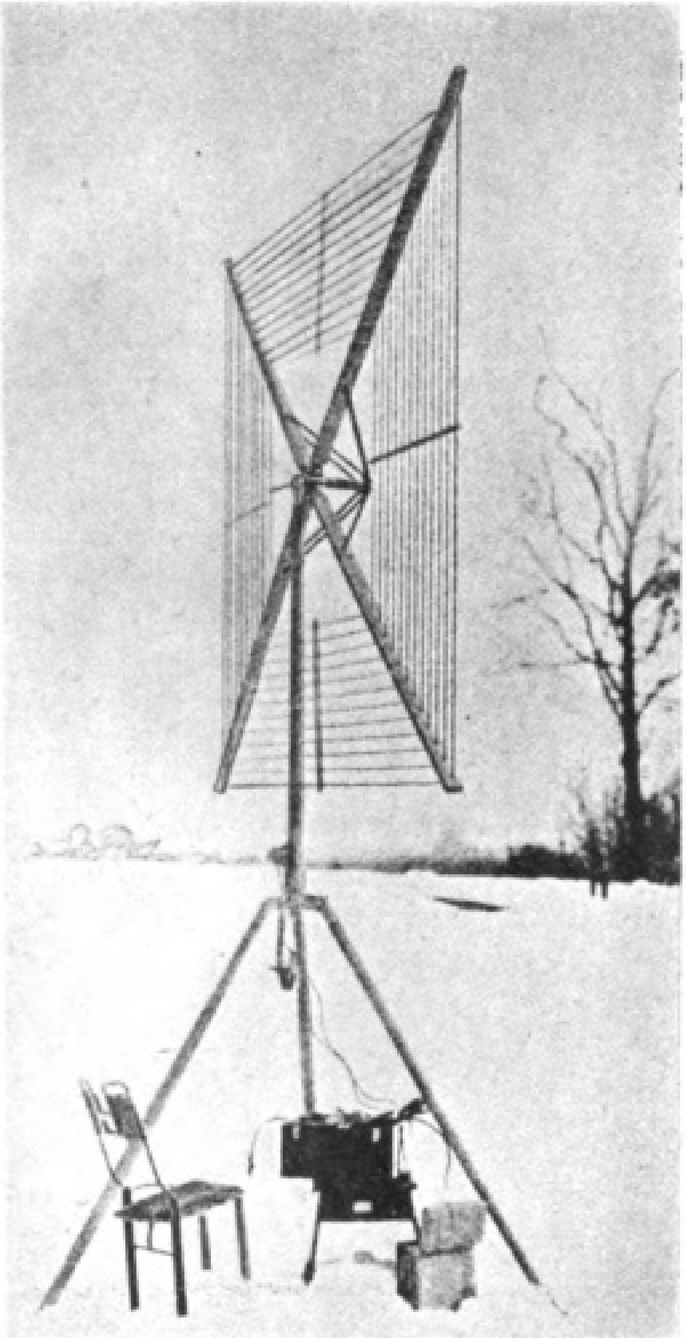


Fig. 7.
Loop or Frame Aerial.

RESEARCH FOR THE WIRELESS AMATEUR

By W. T. Ditcham, A.M.I.E.E., M.Inst.R.E.

THE present article has been written with the object of bringing to the notice of amateur wireless telegraphists a few lines of research which are well within their reach, and in the hope that some at least may be stimulated to take up experimenting with a definite idea in view

The average amateur too often remains content with merely possessing a receiver with which he can listen to the working of the various commercial wireless stations, or at most his ambition extends only as far as transmitting messages of doubtful utility to fellow enthusiasts. Many, certainly, construct their own apparatus, often very ingeniously and effectively ; but, in general, such apparatus only carries out well-known methods and in no way advances the development of the art. Even followed on these restricted lines the hobby possesses much fascination, but after the first novelty has worn off one would imagine that the interest is liable to die down, whereas, once imbued with the spirit of research, that is the desire to discover and invent, the excitement and interest remains unflagging and the hobby becomes a lifelong insurance against boredom and a never-failing source of genuine pleasure

There are probably few fields which lie so well within the attainments of the private experimenter and which offer such scope for improvement as does wireless communication. Of course, many lines of wireless research, particularly on the transmitting side, for financial and legal reasons can only be carried out by the large commercial organisations, but there remain numerous experiments requiring only very limited apparatus and power which are remarkably suitable for private enterprise

The following hints, it is hoped, may act as a preliminary guide to the amateur in the way of pointing out some few of the wireless problems requiring solution.

At the present time the thermionic valve secures more attention than any other instrument known in wireless. In its capacities as rectifier, amplifier, current limiter and oscillator it has made many things possible which, before its inception, were little more than mental concepts. Great as have been the advances rendered feasible by the development of the valve, and notwithstanding the glamour surrounding the instrument, it is already being recognised by some that the valve in its present form is not immune from criticism and is far from being the last word in electronic relays.

The weak point in the present form of receiving valve is obviously the incandescent filament. The useful existence of the valve depends on the life of this filament, and, moreover, the current required to heat the filament to incandescence is such that accumulators or large primary batteries are necessary for its operation, and this, besides increasing the cost of valve receivers, is frequently very inconvenient in the cases of portable or remote receiving stations. The amateur might well devote his time to searching for a substitute for the vacuum valve, with its electrically-heated cathode. A promising and interesting field of research exists in the use of flames for heating the cathode and for providing a fairly free path to the anode for the electrons. I have myself made a few experiments on these lines, using a Bunsen flame to heat a lime-coated platinum wire and placing a grid and positive plate in the colder part of the flame. With the ordinary reaction circuits distinct evidence of signal amplification was obtained, and it seems quite feasible that such a method might be developed into a very cheap and simple amplifier, and even into a generator of continuous oscillations. The difficulty of securing a steady flame should not be insuperable, and for some purposes might not even be essential. Even if the apparatus is not sufficiently stable for commercial use, it might be near enough to perfection for experimental purposes, and would certainly save the amateur's pocket as compared with the present-day standard valves. The hot cathode should be made of some refractory metal, such as platinum, tungsten, or tantalum, and the normal emission may be increased by coating the wire or strip with lime or one of the hydroxides of cæsium, potassium or sodium.

Another defect in the usual valve apparatus from the financial point of view, and one which must sometimes make the modern wireless amateur look back regretfully to the days of his crystal and dry cell, is the enforced use of primary or secondary batteries for obtaining the needful anode voltage. An enquiry into the possibilities of voltaic piles or thermal batteries, particularly the former, might prove well worth the time and effort spent. A novel combination, giving a contact potential and capable of delivering one or two milliamperes for a useful period, would undoubtedly be one of the world's "best sellers" in the present stage of valve development.

Another point that gives food for thought is the position as regards the reception of continuous waves. Spark signals can be effectively received on any one of a number of simple and compact detectors, but to secure the benefits of continuous waves we are practically forced to introduce the oscillating valve, with its accompanying paraphernalia of accumulators and high voltage anode batteries. I purposely ignore "tikker" methods of reception, owing to their ineffectiveness against interference and atmospherics. A simpler type of heterodyne is most certainly needed, and the need will be still more accentuated as continuous wave transmission becomes more and more general A flame oscillator, as previously mentioned, would go some way towards filling this need, but a still more promising suggestion lies in the query as to whether a simple rectifying contact can be made to generate oscillations of suitable characteristics, and there are good grounds for thinking that such is probably the case. Dr. W. H. Eccles some years ago demonstrated the production of oscillations by a galena contact, though at what frequency and amplitude, or with what constancy, I am not aware, and quite recently G. W. Pickard, the American experimenter, has stated that he has received signals in the United States from European continuous wave stations on an oscillating crystal heterodyne. There seem to be difficulties in the way of a practical application, probably due to lack of continuity of the oscillations, but such results having been obtained, we are encouraged to hope that a practical solution is within the bounds of possibility. If a crystal or crystal combination can be caused to oscillate, it can probably also be made to amplify, and one gets a futuristic glimpse of cascade crystal amplifiers, which, if they ever materialise, will quickly relegate valve receivers to the background for all ordinary purposes. I can think of no line of research more suitable for the average amateur than this one, as the apparatus requisite for the experiments need be of the simplest, and the phenomena met with would probably fall within the comprehension of the scientific novice. The investigator who first achieves success in this particular field may feel assured of an enduring niche in the wireless Hall of Fame, and the acquirement of a fair quantity of less enduring, but nevertheless perfectly good, lucre.

One unsolved problem which is ever with us is that of atmospheric prevention, endearingly termed "X-stopping." From the earliest days of wireless history atmospherics have been the skeleton in the cupboard, and almost numberless have been the devices tried in attempts to overcome the difficulty. In the last year or two very great advances indeed have been made in this respect, but we still await a simple solution capable of general application. The whole future of long-range wireless communication and especially wireless telephony is intimately bound up with this subject, and it behoves every enthusiast to at least give the matter serious thought and bring to bear any ideas he can muster The British experimenter is not very well situated for making tests in this direction, as atmospherics here are usually very feeble compared with those present in certain parts of the world ; but if the amateur strikes upon an idea that appears novel and promising he should undoubtedly try it out. Even if failure attends his efforts, he will at least have learnt a good deal during the experiments.

Another fascinating problem to which a final answer has probably still to be found, is that of duplexing with a single aerial or two nearby aerials. Any amateur with a transmitting licence can carry out extremely interesting experiments on this subject, and should secure successful results without much difficulty, although it must not be assumed that methods suitable where small powers are concerned will necessarily be applicable to higher powers. As the most obvious use for duplexing with nearby aerials is in connection with wireless telephony, a valve transmitter will be the most suitable form of generator for such experiments.

Referring to telephony, the present commonly used methods of speech-control still leave much to be desired. The principle of radiating a continuous stream of waves and modulating this stream is far from ideal, and there are opportunities for fruitful research in this connection. The standard to be aimed at is to secure radiation only during the time that speech is impinging upon the microphone or the equivalent instrument, and although several methods of doing this have been devised, they all lack something in simplicity or practicability All the usual systems of conducting wireless telephony are extremely inefficient, as compared with continuous wave telegraphy. If the experimenter will set up a frame aerial and excite it with a small oscillating valve, arranging matters so that when desired the output can be modulated by speech in the most effective manner he can devise, and then, on a receiver some distance away, make a comparison between the strength of telegraph and telephone signals sent from the transmitter, or alternatively compare the extreme distances at which the two different kinds of signals are audible, he will appreciate the ineffectiveness of the telephonic method. An attempt to invent means for reducing this disparity between telephony and continuous wave telegraphy constitutes a very worthy field of endeavour, and the experiments, carried out with small-power apparatus, should be quite possible for many private investigators.

Those wireless amateurs who are mechanically skilled, as many are, might do useful and interesting work in improving existing types of auxiliary instruments used in wireless installations, or in devising new apparatus of this sort. A lot might be done, for example, in increasing the accuracy and ruggedness of high frequency ammeters. Again, the magnetic telephone receiver, even in its best forms, is a notoriously inefficient instrument, and any marked improvement here would find an immediate and extensive use. News as it may be to some, it is a fact that a really satisfactory and simple high-note buzzer, capable of breaking half an ampere or so, is still to be sought An instrument that would be extremely valuable if brought to a reasonable degree of perfection, is a high frequency watt-meter Some efforts to evolve such an instrument have met with a certain amount of success, and although the task may seem an ambitious one, I suppose the difficulties will be overcome some time and there is no reason why an amateur should not tackle the problem with as much chance of success as a professional worker, provided he has a sufficient grasp of the factors involved.

The foregoing suggestions have in view the improvement of the art as a whole ; but there are certain investigations the amateur might make which have particular interest for his own class. Doubtless many amateurs have recognised the financial gain that would accrue if they could construct their own receiving valves. As an alternative to relying solely upon the expensive standard type valve there are at least two schemes which are worth thorough investigation by the amateur, and are more likely to give useful results than would his attempts to construct and exhaust valves himself.

The first of these improvisations consists in taking an electric lamp of the type manufactured for motor car use, having two separate filaments (the one to give a bright light for main road driving, and the other a dimmer illumination for town work), lighting one of the filaments to act as the cathode, connecting the second filament, which is left cold, as the anode, and fastening on the outside of the lamp a cylinder of metal foil or gauze to serve as the grid.

The second suggestion is to employ an ordinary single filament lamp, and place outside and touching the glass both anode and grid. In the latter case, of course, the action takes place through the glass itself, which becomes sufficiently conductive, due to heating by the incandescent filament. Of these two methods the first seems the more likely to result in a workable amplifying valve. In carrying out any such investigations as these the experimenter would be well advised to have in his test circuits valves of the ordinary pattern, so that the operation and characteristics of the improvised types can be compared with a standard. The satisfaction of operating amplifying valves of one's own design and construction ought easily to repay the labour of the initial experiments in evolving a suitable instrument.

At some future date I hope to have the opportunity in these pages of outlining some other possible fields of research which might be attempted by amateur experimenters.

NEW STATIONS

COMMERCIAL LAND STATIONS, ALPHABETICALLY BY NAMES OF STATIONS

(Additions to the List of Radio Stations of the United States, edition of June 15, 1919, and to the International List of Radiotelegraph Stations published by the Berne bureau.)

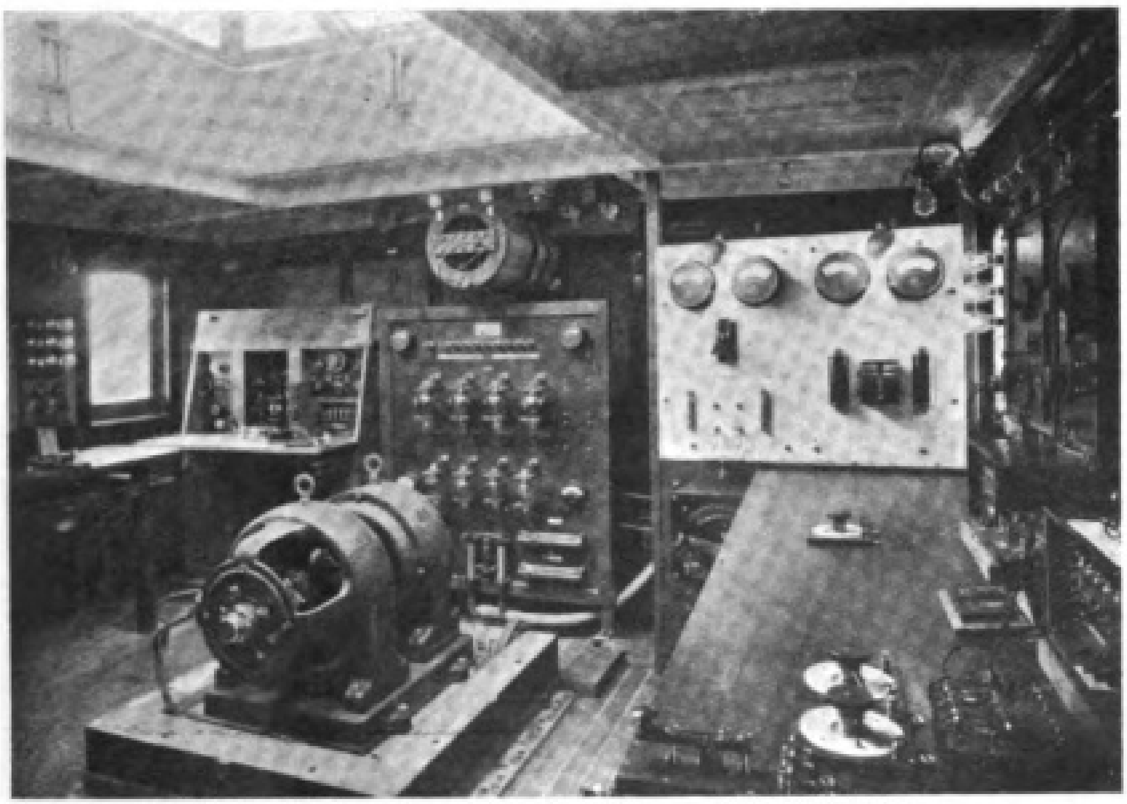
X = No regular hours. N = Continuous Service. PG = General Public Service. PR = Limited Public Service.

Station.	Call signal.	Wave lengths.	Service.	Hours.	Station controlled by—
Becharof, Alaska	KUDV	—	PR	X	Alaska Packers' Association.
Belmar, N.J. (see New Brunswick, N.J.).					
Bolinas, Calif.	KET	6,700	PR	N	Radio Corporation of America.
Brooklyn, N.Y.	WCG	300,600	PG	X	International Radio Telegraph Co
Burwood, La.	WBW	300,600	PG-PR	X	Tropical Radio Telegraph Co.
Chatham, Mass. (see Marion, Mass.)					
Chisik Island, Alaska	KUCP	—	PR	X	Surf Packing Co.
Cleveland, Ohio	WCX	—	PR	—	Inter-City Radio Co.
Detroit, Mich	WDR	—	PR	—	Do.
Jamaica, N.Y.	WSK	—	PG	N	E. J. Simon
Koggiung*	KUBX	—	—	—	
Kahuku, Hawaii	KIE	9,000	PR	N	Radio Corporation of America.
Koko Head (see Kahuku)	—	—	—	—	
Marion, Mass.	WSO	12,000	PR	N	Do.
Marshall, Calif. (see Bolinas, Calif.).					
New Brunswick, N.J.	WII	13,600	PR	N	Do.
New London, Conn.	WLC	300,600	PG	X	International Radio Telegraph Co.
New Orleans, La.	WNU	300,600	PG-PR	X	Tropical Radio Telegraph Co.
Newport, R.I.	WCI	300,600	PG	X	International Radio Telegraph Co.
New York, N.Y.	WHB	—	PR	—	Inter-City Radio Co.
Pilot Point, Alaska	KUDT	—	—	—	Alaska Packers' Association.

*Permanently moored scow in the Koggiung River, also known as Kvichak River.

NOTES AND NEWS

Senatore Marconi's Cruise.—Much interest has been aroused in both lay and professional wireless circles by the departure of Senatore Marconi for warmer latitudes in his yacht *Elettra*. Superadded to this natural interest in the movements of a famous scientist is the "hush-hush" atmosphere which has been so skilfully conjured up by the amateur Merlins of the "street of adventure." We were beginning to hope that the "messages from Mars" hoax had been successfully exploded, but the news of the famous yacht has slightly revived it. It seems a pity that an error apparently perpetrated by a reporter somewhat hard of hearing but possessing a fine sense of what looks well on a contents bill, should enjoy such popularity; therefore let a plain statement be considered. The illustrious Senatore has fitted his yacht with a complete wireless laboratory, a photograph of which appears on this page. During his cruise he will study a number of wireless problems, notably those connected with the art of direction-finding, although wireless telephony will also receive attention. Is it really necessary to embellish this statement with festoons of planets?



Wireless Laboratory on Senatore Marconi's Yacht Elettra.

Interplanetary Wireless.—Our New York contemporary, the *Wireless Age*, in its issue of March last, devotes five pages to this subject, embodying the views of prominent men in American scientific circles, and also the views of one or two English, French, Italian and German experts. As would be expected, the majority of such views inclines to throw cold water on the idea that the signals about which so much has been written come from Mars or that interplanetary communication is within the realms of possibility.

Amongst the appended comments of American amateurs we notice the following solution—"They (the signals) probably proceed from the inner consciousness of small nationalities still clamouring for the right of self-determination."

The *Scientific American* for March 20th tackles the subject from another point of view; that is, if communication with Mars were possible, in what manner could an intelligent exchange of ideas, etc., be brought about, and the article gives a few suggestions which are at any rate interesting to those to whom the subject is sufficiently attractive to warrant it being carried to such lengths.

Wireless Telephony.—A question has been raised in the House of Commons by Mr. Clough (C.U. Keighley) as to the policy of the Postmaster-General's Department with respect to wireless telephony.

Mr. A. H. Illingworth replied as follows—"Although wireless telephony has of late made great progress, it must still be regarded as in the experimental stage, even for those purposes (such as communication between ships and the shore or between aircraft and the ground) for which it may appear to be particularly well adapted. I am giving every possible facility for its further development, but its progress must be co-ordinated with that of wireless telegraphy. The questions of mutual interference between stations, and of electrical interchange between wireless and wire telephone circuits, are of great importance in relation to this means of communication, and to both these points my technical advisers are paying special attention."

Air Commodore E. M. Maitland, C.M.G., D.S.O., A.F.C., in an address to the Royal Society of Arts on April 21st last on "The Commercial Future of Airships," commenting on the extreme costliness of running an organisation solely for weather forecasts for aviation, said that "if, however, arrangements were made for all sea-going ships fitted with wireless, also the various shore wireless and cable stations throughout the world, to take and transmit meteorological readings, it would probably be possible, in time, to organise an adequate meteorological service for little cost, special meteorological stations only being required in a few isolated positions."

Amateur Wireless in South Africa.—The conditions under which wireless telegraph licences will be issued to amateurs in the Cape Colony are identical with those laid down for amateurs in this country. Transmission in certain cases is allowed, the name of the person or persons with whose wireless installation it is proposed to communicate having to be furnished to the Authorities. Communication beyond a radius of ten miles is forbidden.

The First Lady Wireless Operator in Great Britain.—According to a correspondent, the first lady wireless operator in Great Britain was Miss Parker, of London, and not Miss Rainie, as stated in our issue of 3rd April, and the first lady wireless operator in Scotland Miss Turnbull, of Innellan, Argyllshire, both ladies qualifying about seven years ago. Our correspondent, Miss A. Hardie, states that she herself is a qualified wireless operator having gained her certificate in July, 1915.]

The Steady March of Wireless.—Weather reports by wireless telephone for Wisconsin farmers is suggested, and a plan in this connection is now being worked out by the U.S. Weather Bureau Station at the University of Wisconsin. The plan at present is for the Weather Bureau to send the weather report to the Physics Department of the University and for the wireless telephone station at the University to broadcast it.

A Wireless Station in Hamilton, Bermuda, for commercial business with Canada, the West Indies and the United States is announced to be opened by the British Government.

The Wireless Stations at Eten and Trujillo, Peru, which have been under construction for some time past, have been completed and the wireless service is now in operation. These stations, with those at Paita, Lima, Callao, Pisco, Chala, Arequipa and Ilo give Peru a service which covers the whole country.

The Brooklyn Wireless Station of the International Radio Telegraph Company, call sign WCG, has resumed public service. This station, which is a powerful one, is installed at the Bush Terminal Building, Brooklyn. It will carry on a continuous service, handling traffic with constwise and transatlantic vessels.

Wireless and the Sahara.—Wireless stations are to be installed by the French Government throughout the Western Sahara, to enable aeroplanes on the proposed route from Algeria, *via* the Oran Peninsula to Timbuktu, the famous trading post in the south-western part of the Sahara, to keep in constant communication with the ground.

Wireless direction finding is the subject of a circular letter dated 30th March from the Admiralty Naval Staff to Shipowners and Masters of the British Mercantile Marine. This letter states that it would appear that the fact is not fully appreciated that the bearing received by Wireless D.F. is a Great Circle bearing, and not a Mercatorial one.

Three wireless direction finding stations are being erected at the mouth of the Mississippi River for the purpose of directing ships to New Orleans. These stations will better ensure the safety of ships in hurricanes, fogs, etc.

Eight stations of this nature are also in course of construction along the Pacific Coast from San Diego to Alaska. One station, that on the Farralone Islands, is nearly completed. The sites of the other seven are at Pt. Reyes, Bird Island, Pt. Montara, Pt. Hueneme, Avalon, Pt. Firmin and Imperial Beach.

The advantage of wireless direction finding for navigation was prominently illustrated recently by the case of the Spanish Royal Mail Liner "Leon XIII." This ship, when off the danger zone in the vicinity of Cape Hatteras, was unable to get its location owing to a storm obscuring the sun, and was in constant danger of being wrecked on the rocks of the treacherous coast, until the Captain took advantage of the facilities offered for obtaining the ship's position from the shore wireless stations. When this was done no further difficulty was experienced in navigating the ship.

The value and utility of wireless direction finding was brought into prominence during the exceedingly severe storm which recently swept the North Atlantic coast. The gale sweeping in from the sea reached a velocity of 72 miles, and many ships became uncertain of their bearings at sea, but thanks to the New York direction finding stations they were enabled by this means to obtain their correct position.

Warning to Mariners.—The German Naval Wireless Station at Borkum, according to an Admiralty Mine Warning to Mariners (No. 338), transmits every four hours—at 8 o'clock, 12 o'clock, etc. (Central European time)—information regarding mines and alterations in the marking of the mine-free channels in the North Sea. The wavelength employed is 600 metres.

A wireless telephone message of salutation to the King of Spain was transmitted on the occasion of His Majesty's visit to Senatore Marconi's yacht *Elettra* at Seville on April 27th by Senor J. E. Roara, President of the Spanish Chamber of Commerce, from the Marconi Wireless Telephone Station at Chelmsford.

MAN, AIR AND AETHER

THE FIRST LONDON-PARIS FLIGHT ON A HANDLEY-PAGE COMMERCIAL MACHINE FITTED WITH WIRELESS TELEPHONY.

By Harold C. Van de Velde.

On March 4th, 1920, the later editions of the London evening newspapers announced that the first commercial machine fitted with a Wireless Telephone installation (a Handley-Page) had successfully accomplished the journey to Paris.

Few people reading these articles during their journey from town to their homes in the suburbs realised the epoch-making nature of this statement, or what it actually meant to the future of commercial aviation.

When, however, a moment's thought is paid to what the bare announcement means, and when the subject is visualised in its entirety, the true splendour and marvel of the achievement can be grasped

Wireless Telephony, as applied to aircraft, was non-existent and unthought of a mere matter of five years ago, and it was only the exigencies of warfare and the ever-increasing demand for some quick and reliable method of communication between aircraft in the air and the ground that enabled the present advanced state of development to be brought about.

Sufficient for the purposes of this article to say that for four years unceasing research, experimental and, above all, spade-work, went on almost day and night in quest of the perfection of Telephony for Aircraft in the R.A.F. These unremitting efforts were eventually crowned with success, so much so, that at the time of the Armistice several squadrons were equipped, and all was ready to fit up the remainder of the squadrons in the R.A.F. with the beautifully simple Aircraft Telephone Sets which were the outcome of so much whole-hearted labour on the part of the devoted little band of enthusiasts, who had determined to see the problem conquered.

Totally different problems arose in regard to the employment of wireless telephones on commercial machines than were the case on purely war aeroplanes, and the problems were successfully tackled by the same personnel.

Whereas only small power sets were

The Handley-Page Machine which made the flight described in this article.

A group of passengers about to embark for Paris.

necessary in war machines, larger powered sets were necessary on commercial aircraft if any measure of success was to be obtained, and these new sets were designed in a record short space of time and available for use by the middle of 1919.

It was not until long after this time, however, that the fitting of the Handley-Page, which was destined to be the first commercial machine successfully to employ this new apparatus, was commenced, and in due course the preliminary trials of the apparatus took place.

The early morning at Cricklewood, on March 4th, was not at all promising, there being a thick fog on the ground which delayed the commencement of the flight until 12.30. The time was not wasted by the Marconi men, however, and finishing touches were put on here, another test carried out there, until finally the passengers, including a South American Vaudeville star, were embarked, the goods safely packed and necessary bills of lading, etc., signed and sealed.

The engines were given their final test, a cheery wave of the hand from the pilot and passengers to friends who had come to witness the departure, and then we were "taxying" smoothly out over the aerodrome to take up our position for the "take-off." A final look round, and then the huge engines were opened up with an ear-splitting roar, and we rapidly gathered way, until we were careering across the ground with the speed of an express train.

It seemed impossible that such a huge machine could ever rise, but at last one perceived that the ground was dropping away from us. We apparently were not "going up," but the ground was leaving us. Soon the hangars were far below us, and the people to whom we were so lately waving our hands appeared like little midgets seen from some remote hill, still cheerily waving their *adieux*.

No-one who has never experienced the noise of two powerful aircraft engines roaring out their song at such close quarters can ever hope to imagine the deafening volume of sound that assails one in the inside of a big machine. The first most obvious question is: How can one possibly talk and hear in such a din?

But this troubles not the wireless telephone operator. The aerial is run out, 250 feet of wire trailing below the aeroplane, the set is switched on, and the microphone held to the mouth, with the little key on the side of the handle pressed.

The ammeter in the aerial circuit denotes that we are getting over 2 amperes in our aerial, and then—

"Hallo, Hounslow! Hallo, Hounslow! Handley-Page machine GEALX calling. Will you please let me know whether you are receiving my signals O.K."?

A moment's anxious wait, employed in searching for Hounslow on the tuning condenser, and then comes back, loud and clear—

"Hallo, Handley-Page GEALX! Hallo, Handley-Page GEALX! Hounslow answering. Yes, your speech is perfect, and very loud. Is my speech to you quite good?"

And you answer: "Yes, thanks, old man! Splendid! I will call you up again later. Cheerioh!" and switch off, knowing that everything is as expected.

The imaginative reader can well appreciate the intense feeling of satisfaction that is experienced when, in an apparently isolated 'plane, thousands of feet in the air, a voice is heard from "Mother Earth" saying "Cheerioh!" etc There is, in the opinion of the author, nothing so soul-stirring, nothing so absolutely comforting, as this demonstration of how the forces of Nature have been conquered by the brains of British scientists and research workers. When one considers that, just a short space of, say, twenty years ago, the internal combustion engine was only in its infancy, wireless telephony just beginning to be thought of, and flying in a heavier-than-air machine, the phantom thoughts of a few so-called dreamers, one cannot but realise the wonderful and amazing rapidity with which these three world-shaking inventions have developed.

But we digress from our story!

Having established communication successfully with Hounslow, we next call up

The interior of the Handley-Page fitted with Marconi's Wireless Telephony.
(The set can be seen below the clock.)

Lympne, an R.A.F. wireless telephone station at the aerodrome which was the "pushing-off" place for all the machines delivered by our "Ferry Pilots" to our Air Forces in France during the Great War

Lympne is about 75 miles from Hounslow, and, of course, since we are only now just over Norwood Junction, it is rather more of an accomplishment to speak to the former than the latter station. Still we go through our same procedure again: "Hallo, Lympne! Hallo, Lympne!" etc. And, sure enough, back comes the welcome voice of the operator at Lympne, a little weaker, but still quite audible above the appalling din which is going on around one: "Hallo, Handley-Page GEALX!" etc.

By the time these tests have been carried out we are over Croydon, and as it is a perfect day and there is little chance of any trouble occurring, the operator determines to make the most of the trip, and accordingly goes up on the "Conning Tower," leaving his receiver switched on, ready to receive any messages that may be of interest to the pilot-navigator of the machine.

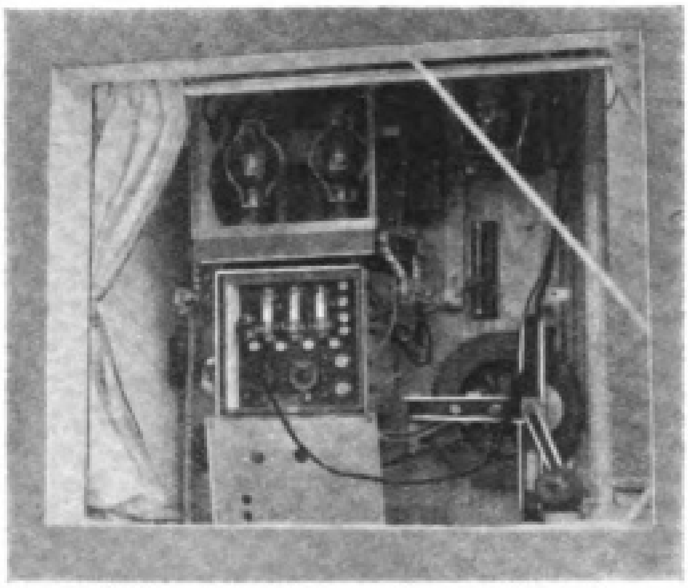
Below, a most perfect panorama is unfolded. The sun shines brilliantly; a few fleecy clouds far in the azure sky, and the wonderful Kentish hills and valleys, looking as verdant and peaceful as only the English countryside can.

Just a few hundred yards on our left can be seen Biggin Hill Aerodrome, with its orderly array of hangars and buildings nestling alongside the Bromley-Westerham Road, which winds like a thin white stripe into the maze of houses and hazy atmosphere that indicates London. Behind us, and projecting above the haze, are the towers and central transept of the Crystal Palace, the sun scintillating and corruscating from its myriads of windows. In front gleams the chalk quarries that are dotted alongside the Downs, and the quaint, picturesque town of Sevenoaks is passed, a jewel in a setting of variegated greenery, so beloved by our English painters and so characteristic of our beautiful country.

Slowly the picture unfolds. The range of vision is very great, owing to our height, and at one time we can see the South Coast line with the white-capped breakers tumbling merrily in on the yellow sands, and, on the other may be faintly distinguished the North Foreland and the ships majestically progressing to their berths at the London Docks.

The journey by air from London to the coast on a fine day is a sheer joy to all the æsthetic senses, and for pure beauty of colour must be very hard to excel in any part of the world.

It is very difficult to tear oneself away



A closer view of the wireless equipment. Operating key in top right-hand corner.

from the joy of the rushing intoxicating air and the scenery, but a message comes through from Hounslow: "Hallo, GEALX! Will you please report when you pass GEAMA". And regretfully one goes back to the instrument to answer: "Righto, Hounslow! I will let you know as soon as we pass her."

Lympne is then again called up, although on this occasion it was unnecessary, and asked what the weather is like over the Channel and in France.

Lympne gives the reassuring answer, and soon we are leaving the white cliffs of old England behind and entering an uncharted land with a perfectly circular horizon and white banks of clouds obscuring the water below.

Occasionally the sea becomes visible through holes in these billows of clouds, and is quickly lost again. A perfect shadow of a Handley-Page machine, moving rapidly along on our left, can be seen on the clouds below us, and it is difficult to realise that this is the image of our own machine which we can see as we are between the sun and the filmy "ground."

Presently, in the far distance, another machine can be seen, making its way swiftly towards us. It grows larger and larger, and as it passes quite close to us, silhouetted against the sun, it resolves itself into a Handley-Page, and on the side, in white glaring letters, can be read GEAMA—the Paris air liner on its way home. We wave our hands and get a greeting by the same means. A message is immediately despatched by the wireless telephone to Cricklewood, to say that we have passed her and that she should arrive about 3 o'clock.

Within a few minutes she has faded from sight, and we are again alone.

If all the beauty of the trip across the Channel and along the French coast to Abbeville, up the Somme and across the flat fertile plains of Picardy to Paris were described this would be a many-paged novel, and not a magazine article, so the reader must excuse the hurrying on to the essential points of interest. The Paris terminus was reached safely at 4.10, in a long, slow glide down over the hangars of Le Bourget Aerodrome, and we come to rest, a little tired, but exceedingly pleased with the successes attained.

On this outward trip no attempt was made to establish long ranges, but intelligible speech in the machine was not lost until after Abbeville had dropped far behind, while perfect speech was heard from Hounslow while over Boulogne, these giving us a range to the machine of practically 100 miles! Speech was also heard from the Marconi station at Chelmsford quite distinctly throughout the trip to the coast, and one other station which was, however, too faint to be really intelligible and where unmistakeable Dutch was being talked, was heard. On enquiry afterwards it was ascertained that this speech came from Hilversum, in Holland.

The transmitted ranges exceeded this, and clear, undistorted speech was heard at Marconi House, Chelmsford and Hounslow at distances up to 140 miles.

After undergoing Customs examination (there is a complete Custom House at each air terminus) a walk of about a mile took us to the tram terminus of Bourget, where we embarked for Porte Villayette.

The Return Journey.

On the following morning the aerodrome was almost obscured by a ground mist, and necessitated a wait after the usual hour of starting in order to find out from the local wireless station the weather conditions on the route. These were not at all promising, but, in spite of this, the pilot determined to take a chance and get off. This we accordingly did at 1.10, and were soon out of sight of the aerodrome

After a look round, a general call was sent out, and immediately a reply was received from Lympne

Owing to the great range this was hardly readable, but as we continued on our course the signals got gradually stronger and stronger. until, over Abbeville, good communication was obtained, both transmitting and receiving. The weather over the Channel looked very bad. Low, threatening clouds were lying only about 150 feet above the sea-level, and a message was sent to Lympne to ask what the weather was like on the English side. This station sent the information that, while the conditions over the Channel were very bad for flying, on the English side it was much better and was clearing rapidly. Under these conditions the pilot determined to push on, and accordingly we turned north-west from Boulogne, and within a couple of minutes were totally unable to discern land. We were now flying at about 150 feet above the surface of the water, which could be dimly seen just below us.

The sensation of flying in a fog is not at all pleasant, and here it was that the wireless telephone again demonstrated its great worth as a comforter.

Speech was carried on continuously with Lympne and Hounslow, and to hear these signals growing and gaining in strength was one of the most satisfactory feelings that one could imagine. It was like voices coming from the midst of a dense fog and cheering one on the way.

It was a never-to-be-forgotten experience, and when finally, with speech coming over the wireless as loud as if someone was shouting in one's ear, the jetty at Folkestone loomed up through the mist, which was rapidly clearing, one felt good to be alive.

The rest of the journey need not be

described. Everything worked satisfactorily, and the Marconi man called up his friend at Marconi House while over Ashford to tell him that he would be at Marconi House at 5.30. He actually arrived there at 5.35 !

Cricklewood was reached at 4.45, after a somewhat exciting trip, and GEALX was the only machine that day to make England from France.

The great value of wireless telephony was thereby demonstrated. It is absolutely necessary, in order to make civil aviation a success, to run a regular service day in and day out that can be relied upon under all circumstances.

Here was a case where the wireless enabled a machine to win through in spite of weather conditions that turned other machines back, and it does not need much imagination to foresee the multitude of ways in which wireless telephony can be of service to the pilot of an aerial liner. Lympne, after the flight, reported that satisfactory speech was obtained from the Handley-Page while over Beauvais—a range of 135 miles.

Perhaps the most fitting comment on this, the first commercial flight with wireless telephony, is provided by the following extract from the Handley-Page Weekly Bulletin. "The pilot (Captain W. L. Hope) admits that had he not received these extremely valuable wireless messages, he would have hesitated to attempt the Channel crossing in such inclement weather."

This epoch-making flight undoubtedly paves the way for the business man, travelling hurriedly to some far-distant city by aeroplane, while comfortably ensconced in a luxurious armchair on the air liner, to keep in touch with his affairs many hundreds of miles away through the medium of the wireless telephone linked on to the ordinary telephone lines.

Indeed, the time may not be far distant when it will be as common an occurrence to call : "Handley-Page GABCD flying to India, please !" as to call : "City, 8710." Who knows ?

SPECIAL SIGNALS FROM FL AND YN FOR THE CHECKING OF WAVEMETERS

(*Extracted from* "*T. S. F.*", *No.* 9, *p. cxviii.*)

ON the first and fifteenth of each month Eiffel Tower sends out special C.W. signals for the checking of wavemeters, as follows :—

On 5,000 *metres.*—At 18.00 o'clock and for one minute, a series of *A* (● ▬), followed by a dash lasting for three minutes.

On 7,000 *metres.*—At 18.10 and for one minute, a series of *B* (▬ ● ● ●) followed by a dash lasting for three minutes.

The programme is then continued by Lyons, as follows :—

On 10,000 *metres.*—At 18.20 and for one minute, a series of *C* (▬ ● ▬ ●), followed by a dash lasting for three minutes.

On 15,000 *metres.*—At 18.30 and for one minute, a series of *D* (▬ ● ●), followed by a dash lasting for three minutes.

At 18.45, or 19.00, according to the time required for the measurements, the actual measurements of the emitted waves are sent out by Y N, on 15,000 metres, and repeated thrice.

Example :	*A* —	5,170	metres.
	B —	7,080	,,
	C —	10,025	,,
	D —	14,990	,,

THE PROCEEDINGS OF THE WIRELESS SOCIETY OF LONDON

HARMONICS IN C.W. TRANSMISSION.

By L. A. T. Broadwood, A.M.I.E.E.

Continued from page 91.

DISCUSSION.

Mr. John Scott-Taggart: Mr. President and gentlemen, I think the point which amateurs will generally meet with in connection with continuous wave harmonics will occur when dealing with the measurement of the waves. The heterodyne wavemeter is now in general use, and when used to measure the length of waves emitted from a transmitting station it is exceedingly important to avoid measuring these harmonics by mistake. This is very likely to be done, especially in the case of small power continuous wave stations. The best way, probably, of overcoming this difficulty is always to see that the continuous wave heterodyne wavemeter is as far away from the transmitting station as possible. In this case the weaker harmonics will not be received by the wavemeter, and, consequently, the "chirp" will not be heard. If, on the other hand, the wavemeter is placed too close to the transmitter, it is quite possible that some of the weaker harmonics will produce a louder signal in the heterodyne wavemeter than will the fundamental wave; and the same applies, of course, when measuring the wavelength at which a receiving C.W. circuit is oscillating. In this case also it is exceedingly important to see that the heterodyne wavemeter is placed as far away as possible from the receiving circuit, in order that the weaker harmonics shall not affect the wavemeter. Another point in connection with harmonics in C.W. circuits is the possibility of the wavemeter itself generating harmonics which are liable to cause beats with the waves generated by the transmitting circuit. This is also to be avoided, and I think the best way is to use a wavemeter in which harmonics are eliminated to the greatest possible extent. One way of doing this is to reduce the coupling between the inductances in the plate circuit and the grid circuit of the wavemeter as much as possible.

While I am speaking, I may as well draw attention to one or two valves which I have recently designed for the Edison-Swan Electric Company, and which I have brought along to-night in the hope that they will be of interest to members. The two most important are the smaller valves. One of them, which has been called the E.S.2 (Fig. 1) has a very small diameter plate, and is especially useful for working on small plate voltages. In fact, this E.S.2 valve will work with a plate voltage of 20 volts for amplification, although 45 volts is a little better, and will oscillate with about two or three volts on the plate. It is consequently especially useful for receiving continuous waves. A special feature, apart from electrical characteristics, is its compactness and rugged strength. The E.S.2 valve with the small anode has properties which resemble very closely the Marconi V.24 valve, and the C valve which was later developed by the Air Force, and which, I believe, was based very largely on the Marconi V.24. The other valve (Fig. 2) has a considerably larger plate, and resembles, as far as the dimensions of the anode, grid and filament are concerned, the original French valve or "R" valve, which has been used so much during the war. The general design and construction, however, has been considerably altered and strengthened. I have brought along two other valves—one is a 100-watt transmitting valve, very suitable for continuous wave transmission up to that power—and also a small 100-watt rectifier, which works in conjunction with the other valve. This rectifier would normally operate with a voltage of about 2,000 volts, which can be obtained from the secondary of an ordinary induction coil. I have also brought two 250-watt valves which may also be of interest to members.

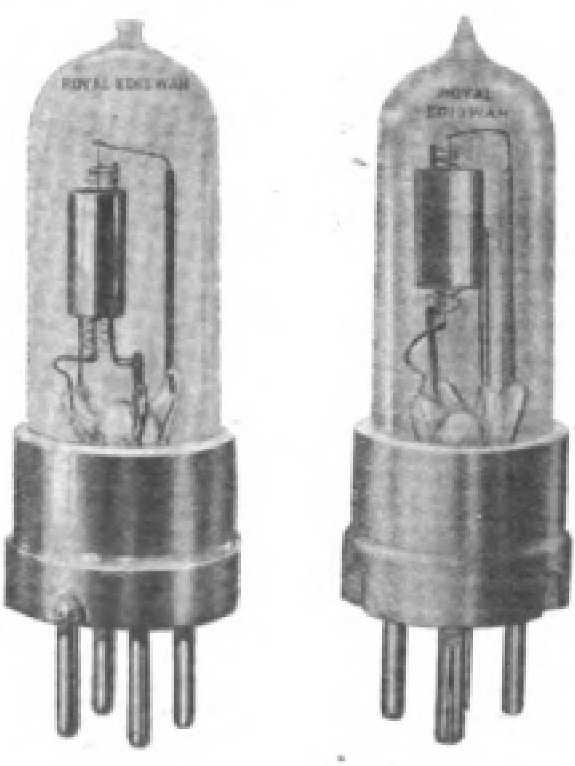


Fig. 1. *Fig.* 2.

Fig. 1. *A standard type E.S.2 valve designed by Mr. Scott-Taggart for general reception.*
Fig. 2. *A type E.S.4 valve designed by Mr. Scott-Taggart for receiving and low-power transmission.*

I would like to take this opportunity of advising the experimentalist about to instal a station to provide himself with a 6-volt rather than a 4-volt accumulator. Some valves, including the E.S.2, Marconi V.24 and Air Force "C" valves, operate most efficiently with about 5 volts across the filament. By employing a filament accumulator of 6 volts all these types may be experimented with by using a variable resistance. In this connection, however, I am carrying out experiments with E.S.2 valves fitted with 4-volt filaments, and if the results justify the modification it is proposed to alter the present design, which usually requires from 4 volts to 5 volts to give the best results.

In connection with the blackening of the glass bulbs, it is to be noted that this is in no sense a disadvantage. The blackening occurs during the manufacture and is largely unavoidable. It is rather an advantage, since it indicates that a very perfect vacuum has been obtained. Members will have noted that all transmitting valves of large power have blackened bulbs, due to the attainment of the very high vacuum necessary.

Mr. H. Rees: I should like to ask Captain Broadwood a question, if I may. I have been recently trying to calibrate a wavemeter. I have obtained the fourth harmonic of MUU, whose normal wavelength is 14,000 metres. Am I right in taking the fourth harmonic of MUU as being four times the wavelength?

Mr. P. R. Coursey: I should like to draw attention to one or two little points mentioned this evening in connection particularly with the measurement of the effective capacity of the aerials. The method described by Captain Broadwood apparently used a commutator frequency of about 35. It seemed important that gave practically the static capacity of the aerial as a whole, not its real effective capacity when oscillating—that is to say, if worked anywhere near its fundamental wavelength. If worked with a very large loading inductance, then the effective capacity is not very different from the static capacity, but I think it comes somewhere near $2/\pi$ times the static capacity when worked near the fundamental wavelength. Probably that would not much affect the value of the resonance current in the dummy aerial. I should also like to ask what kind of aerial he was using in the measurements shown in the slides on the screen, as there is always a possibility of harmonics being apparently caused by induction in neighbouring metallic objects, particularly any stay wires near the aerial if it should be supported by a mast. This will often give false effects by apparently causing harmonics in the radiation and thus affecting the radiation resistance.

It may perhaps be interesting to mention that it is sometimes found desirable to foster harmonics in C.W. circuits rather than to do everything possible to eliminate them. A method of calibrating wavemeters has been developed in France which depends upon the use of these harmonics, and, by a special arrangement of valves, it has been claimed that harmonics up to about the 150th have been obtained.

A Member: I should like to ask Mr. Broadwood if it is not possible that, on some occasions where it may be assumed that there are harmonics in the transmitted wave from the station from which you are receiving, the main wave might possibly excite harmonics in the receiving apparatus itself, which might be thought to emanate from the transmitting station, whereas they might actually be excited in the receiving apparatus itself.

Mr. W. M. Holubowicz: May I ask the best way of eliminating harmonics when receiving on long wavelengths, say 16,000 metres or thereabouts? I should be much obliged if you would suggest some method of dealing with this difficulty.

Mr. L. A. T. Broadwood: I thoroughly realise that this is a very thorny subject. It is possibly only of academic interest; but I think it might be worth while for some physicist to tackle it, because very often such abstruse things as this are very useful in practice afterwards. Mr. Scott-Taggart has touched on measurement. With regard to this wavemeter here, I took precautions that there were no harmonics that I could detect in the wavemeter itself. I have only just got sufficient high-tension voltage and filament current on this particular valve to make it oscillate. Of course, there is a way to eliminate harmonics for laboratory measurements. For instance, supposing you put an ammeter in your plate circuit and you get a certain reading which represents the saturation current. You then set your grid voltage so that half saturation current is obtained. It is possible in such a circuit to have very large oscillations taking place, and the needle of the plate circuit ammeter will not move. I have actually tried this on capacity bridge measurements; we were out for absolutely hair'sbreadth adjustments, which are hardly possible commercially. To get that hair'sbreadth adjustment I did not actually take an ammeter, but I knew roughly what voltage I required, and I put enough cells in series with the grid to make it more positive, so that I got this point and we obtained our absolute balance at once on our capacity bridge. That method is very useful for laboratory work.

I might mention another interesting fact. In laboratory work various forms of valve generator are used, and, if it is desired to tell whether the wave form contains a large number of harmonics, there is a very simple way which we discovered by accident. The arrangement is shown in Fig. 3. A galvanometer, G, is joined in series with some form of crystal detector, D, and connected across the wavemeter circuit, C L_2, as shown. The wavemeter circuit is coupled to the coil, L_1 which is joined to the transmitter through the reversing switch, S. A certain reading of rectified current is obtained on the galvanometer, G. When the switch, S, is reversed, without altering the coupling between L_1 and L_2, you very often find you get either a very much bigger or a very much smaller reading on G. This is due to an asymmetric wave. Suppose you have an exaggerated case, as shown at (*a*), Fig. 3, with a very large positive loop and a very small negative one, you get more rectified current when the coils are coupled up in one direction than in the other. You are dealing here also with a form of detector which is also a valve, and that will show up the effect at once. But if you adjust the grid voltage of the transmitting valve so that the same deflection of the galvanometer is obtained whichever way the exciting circuit is coupled, you then have as pure a wave as possible.

With regard to the question about harmonics and fundamental, I have possibly mixed the thing up; there is always considerable confusion. When I talked about the first harmonic I should really have said the fundamental. For instance, if 1,000 metres is our fundamental wavelength, the fifth harmonic will be one-fifth of that, since the frequencies are inversely proportional to the wavelengths. Hence, the fifth harmonic will be 200 metres, the third 333 metres, and so on. As to

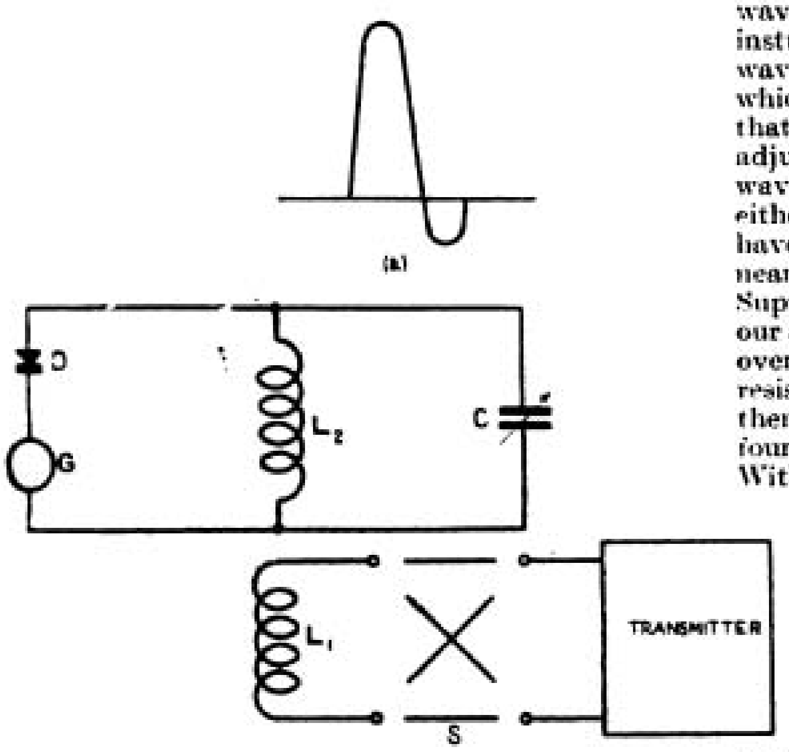


Fig. 3.

the case of 11,000 metres, of course, if that is the fundamental, the harmonics are of higher frequency. It is usually taken that a harmonic has a higher frequency than the fundamental; but I believe it is possible—I certainly think it is in acoustics—that with a particular note you can have both upper and lower partials. It can have notes above it higher in pitch, and it can have notes below it in pitch as well; and I expect that is the case electrically. I do not know whether that answers the question

Mr. H. Rees: The harmonics I speak of are of higher wavelength than the fundamental. Take Hanover, OUI, the fundamental is 10.000 metres. I am sure of the next two: one is 20,000 and the next one is 30.000; but I have got no means of measuring higher wavelengths. I am trying to use MUU to measure higher on my instrument in order to use it as a standard.

Mr. L. A. T. Broadwood: That is interesting, because those are really lower harmonics, 20,000 metres has a lower frequency than a 10,000-metre wave, or it is a lower harmonic.

Mr. H. Rees: I only hear what you speak of as lower harmonics. I hear harmonics of longer wavelengths.

Mr. L. A. T. Broadwood: You do not get, for instance, 5,000 metres?

Mr. H. Rees: I have not observed it.

Mr. L. A. T. Broadwood: With regard to Mr. Coursey's point, measuring aerial capacity, I quite realise that it was not an accurate method; but we were working up, as you saw, to 1,000 metres and it was possibly sufficiently accurate there. We set our condenser, which was equivalent to the static capacity of the aerial. Then we coupled the inductance to it, and adjusted that inductance until that circuit itself gave the same natural wavelength, as near as we could get, with the instrument we had. We did not have a very good wavemeter, only an ordinary "Station Tester," which had probably been knocked about. We set that as near the aerial wavelength as possible and adjusted the dummy circuit to get the same wavelength. The inductance may have been either larger or smaller than it really ought to have been, but I think the circuit was sufficiently near, because we checked it in the following way. Supposing we were working on 900 metres with our aerial, we listened in on our wavemeter, changed over on to the dummy circuit, and adjusted the resistance until we got the same ammeter reading; then listened in on the wavemeter again, and found there was no alteration in the wavelength. With regard to the point about stay wires, as far as I remember there were none; we simply had some bits of rope. I think, as a matter of fact, that it was a single wire aerial, and that at one end it went to a tree and at the other end it went to a short mast to which those ropes were attached We were working, it is true, in a corrugated-iron building, but I do not know that a large, flat surface like that would have any particular wave-length. Possibly there may have been some odd reflection effects from the corrugated iron.

With regard to the possibility of a pure sine wave generating the harmonics, one can think of a mechanical analogy. If we take a pendulum that swings once in a second, it can be given a push every time it comes towards us, or once in three times, or once in four times. But I am afraid I cannot say whether, if you took a pure sine wave, you could make that generate harmonics in another circuit Possibly if you had a pure sine wave of 1,000 metres wavelength, and had a circuit tuned to 500 metres and coupled to the inducing circuit there would be a transient effect in which the oscillation would have the natural frequency of the second circuit; but, after a period of time, you would simply get the forced oscillation in that circuit. But if the main wave has impurities in it naturally you will get harmonics at your receiving station. Of course, you get very curious effects very often in very long tuning coils. I remember before the war—I did not know much about wireless then, and I think as time goes on I know rather less—but at that time we had a long tuning coil (Fig. 4). It was the usual sort of thing that amateurs start with. We might only be using a small part, A B, of the inductance and trying to receive some other amateur. We found that when we earthed the end, C, we always got louder signals. Possibly it was owing to the fact that we were tapped off at that particular place. We might have been tapping across a node of potential. There might have been a stationary wave set up on the coil, somewhat as indicated by the dotted line in the Figure. That is the only case I know of harmonics in receiving instruments. I dare say some of you remember reading about some experiments on stationary waves, with what I think are

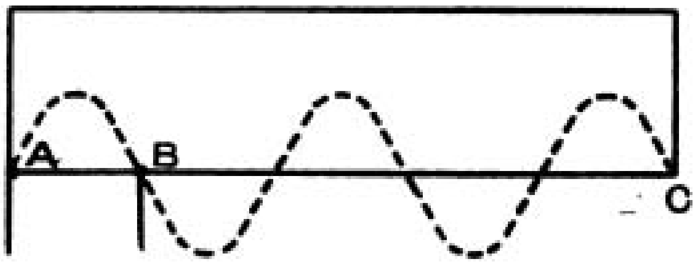


Fig. 4.

called Seibt coils, by means of which the nodes and loops of potential may be demonstrated by moving a vacuum tube up and down the coil.

With regard to Mr. Holubowicz's point about harmonics at the receiving end, the only thing I can suggest is that, if it is anything to do with the receiving valve, to adjust the potential of the grid with the potentiometer That will weaken the signals considerably, because it will make the damping very great.

I wish to say before I finish that I have to thank Mr. Drury of the Marconi Scientific Instrument Company very much indeed. None of the instruments are my work; he had to make them all. He has helped me very much indeed: I do not know what I should have done without him. (Applause.)

The President: I am sure you will all agree that Captain Broadwood has wonderful powers of exposition of a very complicated and difficult subject, and that we owe him a very hearty vote of thanks for the large amount of trouble that he has been to in preparing this very interesting paper. I will ask you to pass a vote of thanks to Captain Broadwood for his Paper.

A vote of thanks was given by applause.

The President: In the notice convening the meeting there was mention made of the question as to whether ladies should be admitted members of this Society. This question has been raised before the Committee, who thought it was a matter upon which the general body of the members should be consulted and therefore we have put it on the agenda for this evening. To-day you are to be called upon for an expression of opinion on the subject, as to whether the members generally think that the admission of ladies would conduce to the usefulness of our Society. No doubt it would lend attraction to our meetings, but I suppose we ought really to look at it from the point of view as to whether it will be useful. The matter is open for discussion, and we shall be very pleased to hear if anybody has anything to say on the subject. I suppose the best way will be to have a vote, but perhaps some gentleman will wish to make some remarks in the first place. I do not propose to call upon anybody, and if nobody has anything particular to say, we will take a vote: but, of course, the vote may be affected by anything said.

Mr. Holubowicz: Mr. President, considering this is a scientific Society, I do not see why there should be any objection to admitting ladies to membership.

Mr. F. Hope-Jones: Mr. President, ladies and gentlemen, I have always been impressed with the idea that wireless telegraphy was not merely a gentleman's job, but a lady's job also. I think it has certain domestic attractions, and with the advance generally into all spheres of life there seems to be no reason at all why the wife should not share the husband's enjoyment of wireless telegraphy at home. I see no reason at all why the Society should close its doors to ladies. I do not think the Committee have yet had an actual application for membership. There is a certain modesty and shyness which has prevented that, perhaps, and probably when it is generally known—as it would be as the result of a vote—that no objection is raised to the admission of ladies, we shall have, if not a large accession to the membership, certainly a good number who would like to become members of the Society. I hope that some expression of opinion will be made on the subject generally, because I think it is one where the Council and Committee are quite right in asking for guidance from the membership generally.

The President: I may point out, perhaps, that of course different societies have different regulations on this subject. In the case of the Institution of Electrical Engineers, it was held some time ago that there was nothing in their rules to prevent a lady being elected a member. I know that some years ago there was only one lady member, Mrs. Ayrton; she was elected some years ago, and remains a member. Quite recently the question has cropped up at the Institution of Naval Architects. There the legal advisers of the Council gave the opinion that it was not competent for ladies to become members unless the rules were altered. At a recent meeting of the Society of Naval Architects the rules have been altered, and ladies have now been made admissible. I do not know that there is any rule on the subject with regard to the Institution of Civil Engineers, in whose room we are at present meeting; but I am not aware of any lady civil engineer. Mrs. Ayrton has read a Paper before the Institution of Electrical Engineers.

Mr. H. Rees: Is any alteration of the rules and regulations necessary to make ladies eligible for membership?

The President: We have not taken legal advice, but we think not. But we thought that in a comparatively new Society like this, it would be best to have an expression of opinion from the members before we interpreted the rules. So far, everybody who has spoken, as far as I understand it, is in favour of admitting ladies. I do not know if there is anybody holding the contrary view. It might be well to have the contrary view expressed, if there is anybody who has got feelings of that kind on the subject. If not, I will put it to the meeting.

The voting was unanimous in favour of admission of ladies.

The President : I have to announce that all the members, thirteen in number, who have been ballotted for, have been elected, and I have also to announce that Major Basil Binyon has kindly promised us a Paper, illustrated by experiments, at our next meeting.

Then we have, in accordance with the request sent out, a number of interesting exhibits, which perhaps those who have been good enough to send them would like to describe. I do not know if Mr. Scott-Taggart wishes to add anything to what he has already said.

Mr. J. Scott-Taggart : No, sir.

The President : There are a number of others, and I may as well call upon them in order.

Captain H. de A. Donisthorpe : Mr. President and members, I have one or two small items which may be of interest to the members of the Wireless Society. The first is the wireless pocket-book, which I have just patented (Fig. 5). It consists of an ordinary pocket-book, as shown, and contains inductances in the two covers, which are joined together by a hinge. The inductances are so connected that they oppose each other when the book is closed, so that when you open the covers you have the full inductance. The crystal for this set is fixed in one end of the loop of the book and adjusted by means of a little knob, and in the other end there is a plug socket for the telephones. The aerial and earth connections are made by means of wires attached to the corners of the book. I might add that I have got signals off this apparatus which are comparable with those on the most sensitive of crystal receivers. I have to thank the President for his kindness in loaning me this particular edition, which I presented to him at the last meeting, as we have not any more in stock. The second item is a universal tuner This is really a further advance on the pocket-book, and consists of two inductances (Fig. 6). In one position the two inductances help each other, and in turning them round they can be made to oppose each other. The aerial and earth are connected to the terminals shown. Similarly, the crystal and telephones are connected in series across the two terminals. By means of this little instrument you can get ranges of 300 to 3,000 metres with the ordinary Post Office aerial. The third instrument

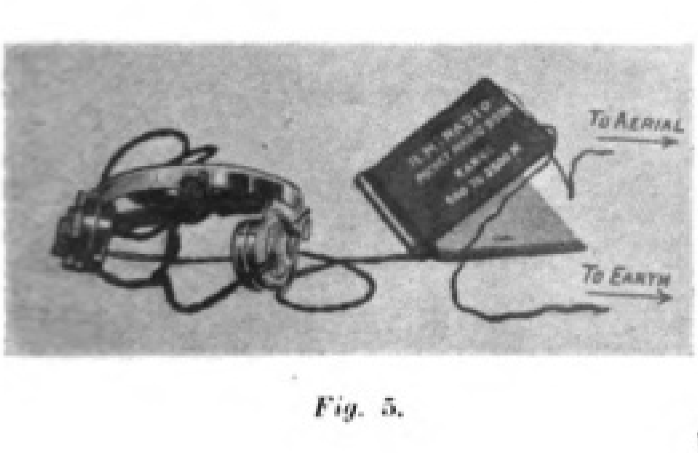


Fig. 5.

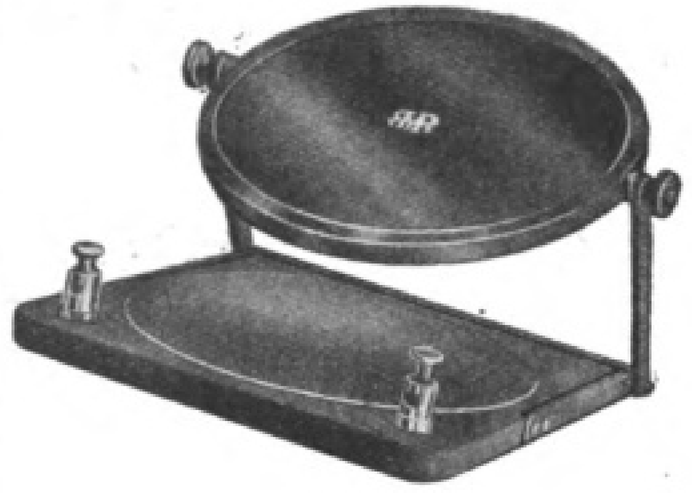


Fig. 6.

which we have here is what we call the "R.M.R. Unit" (Fig. 7). This is a receiver, or, rather, it is an adaptor for putting on to a tuner. There is a four-plughole socket arrangement, inside which is contained a grid condenser and a leak. Attached to these are a number of leads for the aerial, high-tension positive, high-tension negative, low-tension positive, low-tension negative, and earth. This fastens on to four plugs on the side of the box. By attaching a further unit by the four plugs shown on the other

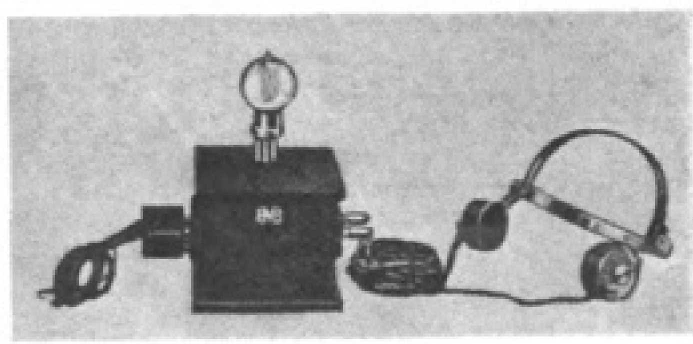


Fig. 7.

side of the box, and then putting the two end plugs into the terminals marked T.T. of the second unit, you then have an amplifier. By adding any number of these units you get an amplifier of any desired number of stages.

The President : I may say that I have used the book arrangement that Capt. Donisthorpe has described. I tried it on a small aerial that I have in my house, and it is surprisingly effective. I hardly believed that such a simple thing would have worked so well. We have an instrument here from Gamages'.

Mr. H. Rees : I invented it. I did not know it was going to be here until I arrived in town this morning. This set (Fig. 8) covers the range from 450 metres up to actually 33,000 metres—much higher than is really necessary now ; but I made it high to provide for future contingencies. The instrument on the left is the essential one.

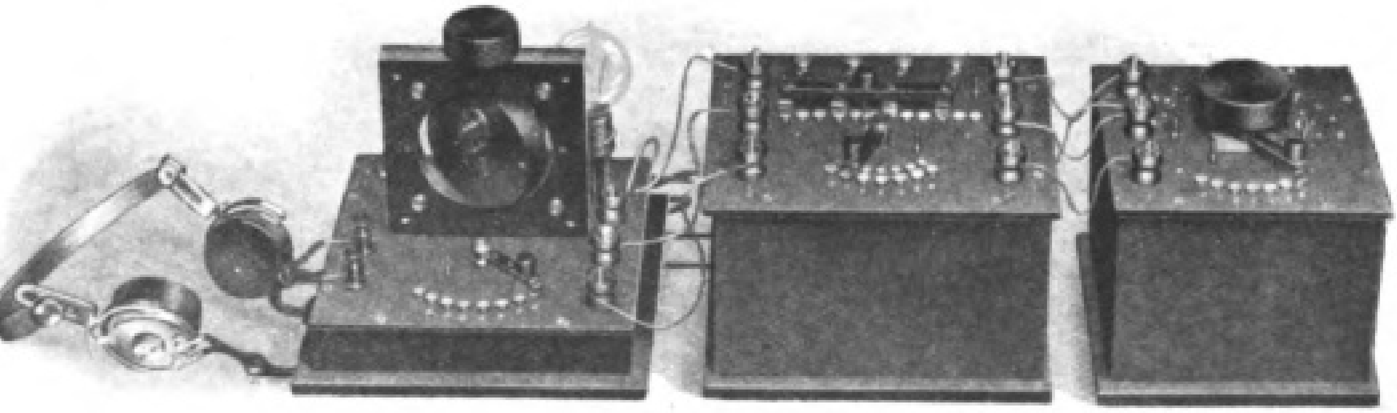


Fig. 8.

oscillation being obtained by varying the degree of coupling. This instrument is complete in itself, and its range is from 750 metres upwards. With the condenser in that I have been using with it, it goes up to 3,300. On the middle instrument there are three terminals corresponding with the three on the left-hand one, with which they are connected as shown. When the first is used alone the ordinary classic circuit is employed, with the aerial joined to the grid, through the grid leak and condenser. But when the second instrument is in use, there is an entirely different circuit; you get a considerably lower range of wavelengths. The third instrument on the right is for the long ranges. The switch on the centre instrument enables you to use the range of wavelengths on either of the three instruments.

Mr. A. W. Knight: My principal exhibit to-night is our No. 2 Valve Detector (Fig. 9). This is a complete unit, which is very compact and is greatly appreciated by experimenters who already possess the necessary tuning devices.

Mr. Knight also showed and described other apparatus (lent by Messrs. F. L. Mitchell & Co.,

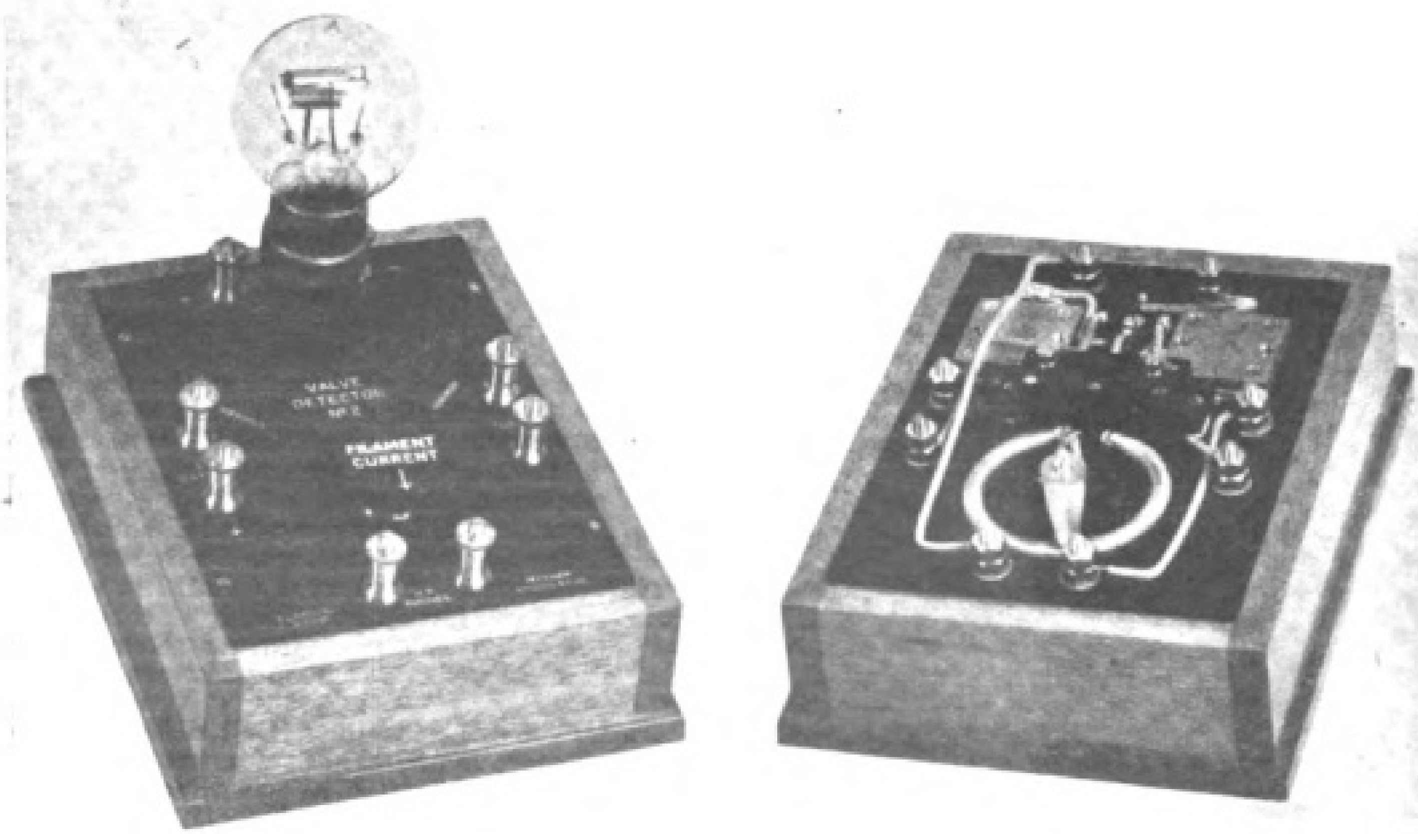


Fig. 9.

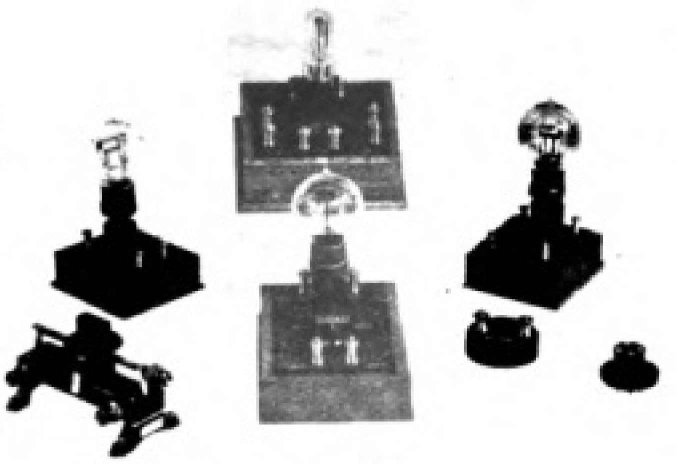


Fig. 10.

Ltd.), such as valve panels, potentiometers, condensers and valve-holders, such as shown in Fig. 10.

The President: I think these exhibits of apparatus are of general interest. If anybody wishes to see them more closely they will be able to do so. I think you would wish to pass a hearty vote of thanks to these gentlemen, who have so kindly brought their apparatus for us to see.

The vote of thanks was unanimously accorded, and the meeting adjourned at 7.40 p.m.

In Fig. 11 is a view of the group of apparatus used by Mr. Broadwood at the meeting for demonstrating the existence of harmonics in a C.W. circuit sustained in oscillation by a valve. The harmonics were rendered audible by the loud-speaking telephone connected to the 3-valve note magnifier on the right. The heterodyne wave meter in the centre was tuned to various frequencies and a "chirp" was obtained in the telephone each time its frequency was adjusted near to that of a harmonic of the oscillating valve.

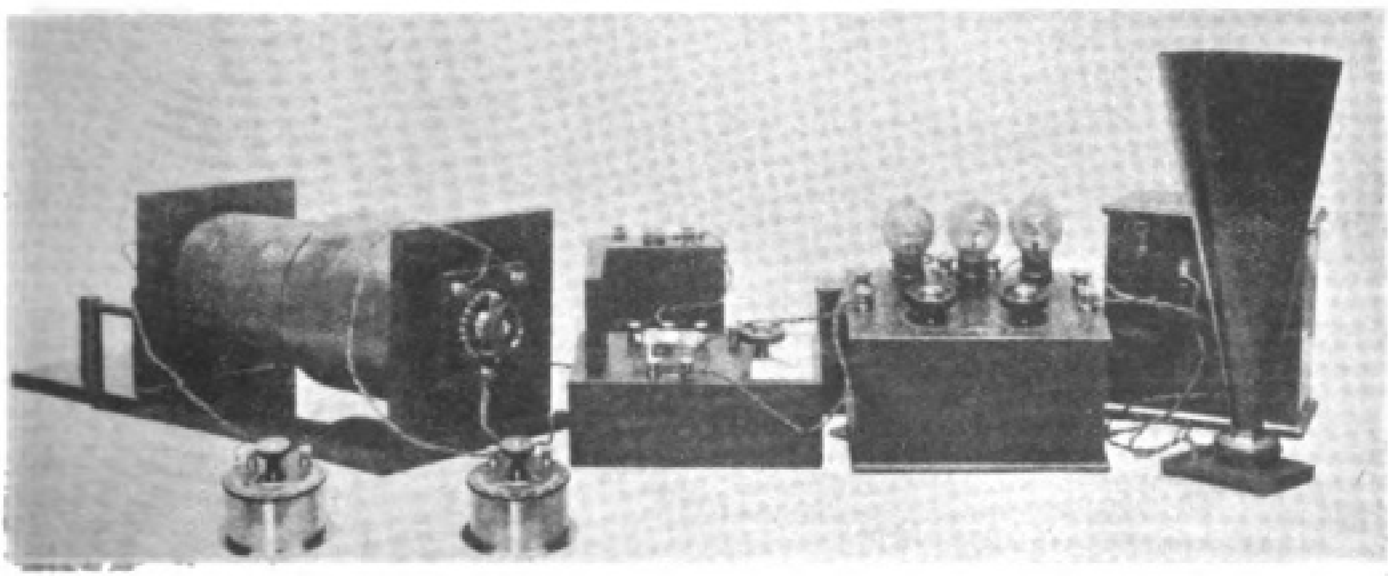


Fig. 11.

Apparatus used by Mr. Broadwood for demonstrations during his lecture

CAN WE UTILISE SOLAR ENERGY?

This is a question which concerns not only users of power, whether they be factory owners or thermionic valve enthusiasts, but the human race. Sooner or later the usual sources of energy, such as coal and oil, will fail, and if by that time man has not learned to avail himself of some other source the race will either deteriorate or die.

Inconceivably vast amounts of energy emanate from the sun, some of which benefits us; but far more is lost and serves no immediately useful purpose.

The question at the head of this paragraph will be discussed by Mr. Philip R. Coursey, B.Sc., A.M.I.E.E., in a future issue.

WIRELESS CLUB REPORTS

Wireless Society of London.

The date of the next meeting has been fixed for May 21st, and Mr. Philip Coursey, B.Sc., will read a Paper on "Some of the Problems of Atmospheric Elimination in Wireless Reception."

The Society have obtained permission for the erection of an aerial at the Institution of Civil Engineers, where lectures are at present held. Admiral of the Fleet, Sir Henry Jackson, G.C.B., has kindly agreed to serve on the Advisory Committee of this Society.

Our first lady applicant for membership (Mrs. Philip Coursey, B.Sc.) has been elected a full member of the Society, and, no doubt, others will now follow suit. Mrs. Coursey is a keen wireless enthusiast, and the Society may congratulate themselves on the inclusion among their number of so talented a lady.

Will old members who have not paid their subscription, due October last, and recently-elected members who have not yet paid their entrance fee and subscription, kindly forward same to the Honorary Treasurer, Mr. L. F. Fogarty, A.M.I.E.E., Dene Cottage, Manor Way, Ruislip.

The North Middlesex Wireless Club.

(Affiliated with the Wireless Society of London.)

The second Annual Meeting of the above Club was held on Wednesday, March 24th, at Shaftesbury Hall, Bowes Park, London, the President, Mr. A. G. Arthur, being in the Chair.

The Secretary and Treasurer, Mr. Savage, read out the Balance Sheet for the year ended 22nd March, 1920, which showed a balance in hand of £9 1s. 8d. He reported that the actual strength of the Club was 48, which number was continually increasing. During the past year, the Club became affiliated with the Wireless Society of London, and at the recent Conference Mr. A. G. Arthur had attended as delegate. Owing to the increased charges for rent, stationery, postage, etc., the Committee had decided to raise the subscription to 10s. 6d. per annum, and to 5s. per annum for corresponding members. There were also expenses in connection with the erection of the aerial, and installation of the instruments.

The Chairman then reported on the Library, and gave some figures showing how in the short time since its inception it had become one of the most popular institutions of the Club.

Mr. A. G. Arthur was then re-elected as President, Mr. Savage as Hon. Secretary, and the following members of the Committee offering themselves for re-election, were duly elected:— Messrs. Cartland, Holton, Midworth and Reed. Mr. Beckman was appointed as member for the year of the Wireless Society of London.

An attractive programme has been drawn up for the coming year, and the Club is looking forward to a period of great activity.

The 37th meeting of the above Club was held at their Meeting House, Shaftesbury Hall, Bowes Park Station, on the 21st April last, and was well attended by members, member's friends and a few casual visitors.

The chair was taken at 8.30 o'clock by the President (Mr. A. G. Arthur), who, after opening the meeting with a few general remarks on Club matters, called particular attention to the very interesting library that the Club had acquired for the free use of its members.

The Chairman then called upon Mr. Leonard Holton to give his promised lecture on "The Valve and its Employment in connection with C.W.", and as Mr. Holton was so thoroughly at home with his subject, the evening passed all too soon, so that much that he would have liked to have referred to, and many points that he would have liked to have elaborated, had to be left over. However, at the end of his most interesting and instructive lecture, which he freely illustrated with diagrams, the chairman, in passing a vote of thanks, suggested that, if possible, Mr. Holton should continue his lecture at the next meeting of the Club, which suggestion was heartily agreed to by those present and assented to by the lecturer. The members then showed their keen appreciation for the evening's lecture, and the meeting closed.

All friends interested in Wireless Telegraphy or Telephony are invited to the meetings held fortnightly, at Shaftesbury Hall, Bowes Park, N., and all requiring help or particulars should write to the Hon. Secretary, Mr. E. M. Savage, "Nithsdale," Eversley Park Road, Winchmore Hill, N.21.

Burton Wireless Club.

(Affiliated with the Wireless Society of London.)

A meeting of the above Club was held at the *Burton Daily Mail* Offices on Wednesday, the 14th April. Mr. A. Chapman presided over a large attendance.

Mr. A. V. Smith, temporarily acting as Secretary, read letters from the Derby Wireless Club regarding the possibility of arranging a lecture on Wireless Telephony. A Special Meeting will be called on this matter as soon as a decision has been made. The Chairman stated that since the last meeting he had been in communication with Marconi's Wireless Telegraph Company with regard to the developments of wireless telephony, particularly with regard to the supply of news to newspapers, and he had learnt that the Company had this matter in hand and had given it consideration. Technically, there were no insurmountable difficulties in the way, but other factors had to be taken into consideration.

Mr. W. C. Smith, B.A., Magdalene College, Cambridge, gave an interesting lecture on the Theory of the Thermionic Valve, giving also details of its invention; during the course of the lecture he described the various methods of Continuous Wave Reception.

The Woolwich Radio Society.

(Affiliated with the Wireless Society of London.)

At a General Meeting of the Woolwich Radio Society held on the 23rd April, Mr. James M. Ellam resigned his position as Secretary owing to his temporarily leaving the district.

Mr. Ellam much regrets that he is obliged to take this step, but he will continue to be a member of, and associated with, the Society.

In the short time that the Society has been in existence, Mr. Ellam has done everything in his power to further the interests of all concerned, and it is hoped that at an early date he will be able to resume the duties which he has so admirably carried out in the past. Pending other arrangements his duties have been taken over by Mr. P. G. Atkinson of 62, Granville Park, Lewisham, S.E.13, to whom all future communications should be addressed.

Wireless and Experimental Association.

(Affiliated with the Wireless Society of London.)

At a meeting on April 21st, at 16, Peckham Road, Mr. J. Claricoats read a paper on the subject of Wireless and Artillery in the recent war. His remarks were intensely interesting and as he gave a first hand account of his part in the great Somme battle it was more like a homely chat than a set paper.

The Secretary of the Association has resigned, and his place has been taken by Mr. G. Sutton, 18, Melford Road, East Dulwich.

Southport Wireless Experimental Society.

(Affiliated with the Wireless Society of London.)

A meeting of the above Society was held on Tuesday last, the 20th April, at the Society's rooms at 359, Lord Street.

The President, Lieut. E. R. W. Field, presided over a good attendance, and at the conclusion of the general business a very interesting paper was read by Captain Poulton dealing with the address delivered by Mr. Erskine Murray to the London Wireless Society. Much information was forthcoming with respect to the refractive influence of humidity upon the aetheric waves. Captain Poulton's paper was made particularly lucid by means of blackboard illustrations and sketches, and a very interesting discussion took place among the members at the conclusion of the paper.

During the evening, Mr. Christian (Hon. Secretary and Treasurer) reported the election of further new members to the Society whose numbers are steadily increasing.

It is pleasing to note that various members are launching out into specific investigation the interest of which will serve to unite the Society and maintain that live interest which is necessary towards its success.

Mr. Christian read a letter which he had received from the Secretary of the London Wireless Society relative to the wireless telephonic experiments and transmissions ostensibly from Holland on a wavelength of 900 metres.

Sheffield and District Wireless Society.

(Affiliated with the Wireless Society of London.)

The weekly meetings were resumed on Friday, April 9th, after the Easter holidays, when a paper on "Faults and Adjustments in W/T Gear" was given by one of the members, Mr. W. Burnet. The lecturer, who had considerable experience during the War with all kinds of transmitting and receiving apparatus, gave many useful and practical hints which will save his hearers many a pitfall when designing and working their sets.

A paper on "Transformers" was given on April 16th by Mr. W. E. Burnand, A.M.I.E.E., one of the Society's Vice-Presidents.

Mr. Burnand, in describing the many types of transformers, spoke of their limitations and possible developments in the future. As one of the pioneers in the manufacture of commercial transformers, the lecturer was listened to with great interest by the large number of members present. In concluding his remarks, Mr. Burnand briefly outlined the design and construction of a 250 watt step-up transformer for amateur use and suitable for either 100 or 200 volt 50 period circuits.

The present session, as regards meetings, finished on April 30th, but it is hoped to be able to make arrangements for an excursion into the country on Saturday, June 19th, for experimental work in connection with transmission and reception.—Hon. Secretary, Mr. L. H. Crowther, 156, Meadow Head, Norton Woodseats, Sheffield.

The Radio Scientific Society.

(Affiliated with the Wireless Society of London.)

The Radio Scientific Society of Manchester has regularly held meetings every Wednesday fortnight this year, and is steadily increasing its membership. The meetings are at present held in rooms allotted to the Society at the City School of Wireless, Manchester. Some very instructive addresses have so far been given.

The Society is very desirous of getting in touch again with pre-war members, and any such are strongly urged to communicate with the Hon. Secretary, Peter Thomson, 7, Brazennose Street, Manchester.

Manchester Wireless Club.

(Affiliated with the Wireless Society of London.)

March 21st.—The usual weekly meeting was held at the Headquarters of the Club, 335, Oxford Road, Manchester. All members took part in Morse practice.

The Committee held a meeting from 8.30 till 9.30 and arranged for a Whist Drive and Social to take place on May 1st.

April 14th.—The Club Room not being available, the usual meeting was held at the Fortuna Café, Oxford Road, and after the Hon. Secretary had read several letters relating to Club matters, the Chair was taken by Mr. J. C. A. Reid, who very ably led a discussion on the relative values of plate voltages as applied to valves.

April 17th.—A Special Committee Meeting was held at the Midland Hotel, Manchester, during which it was decided to acquire another room for the use of the Club and to install a first-class Receiving Set and later, a small Transmitting Set, for experimental purposes, subject to the approval of the P.M.G.

It was also decided that the Hon. Secretary should make arrangements for the members to visit the Power Station at Bury, which controls the Manchester to Bury Electric Train. The date was fixed for May 8th, and Mr. McKernan, a member of the Club, has very kindly consented to conduct the party.

April 21st.—Mr. J. C. A. Reid in the chair.—A lecture on Radio Telephony was given by Mr. A. Couyoumjdiam, who explained the subject in a very able manner, dealing exhaustively with the various kinds of microphones in use, and the method of connecting them in order to obtain maximum efficiency.

Unfortunately, Mr. Couyoumjdiam was unable to conclude his lecture, and very kindly consented to resume the same on April 28th.

A hearty vote of thanks was passed and the members showed their appreciation in the form of a warm applause to the lecturer.

During the month of April eight new members were enrolled.—Hon. Secretary, Y. Evans.

Liverpool Wireless Association.

(*Affiliated with the Wireless Society of London.*)

The usual fortnightly meeting of this Association was held at McGhies Café, 56, Whitechapel, Liverpool on April 14th. Additional new members were elected.

A further interesting paper was given by a member with regard to valve action and circuits, followed by an instructional article on the construction of a standard wavemeter for use by members of the Club.

The following gentlemen were elected as members of the Committee:—Messrs. Grindon, Henderson, Coulton, Moore, Hyde, Saunders and Williams. Mr. G. Irvine was elected as Hon. Treasurer, and Mr. S. Frith, 6, Cambridge Road, Crosby, Liverpool, was re-elected as Hon. Secretary.

The proceedings afforded lively interest and the meeting was a very successful one.

All interested in "Wireless" are cordially invited to the meetings.

A meeting of this Association was held at McGhies Café, 56, Whitechapel, on Wednesday, April 28th, when the subject of "Battery Power for Use with Valve Circuits" was gone into. The speaker dealt with the merits of different kinds of cells, and methods of assembling and regulation. New members invited; subscription, 5s. per annum. Honorary Secretary, S. Frith, 6, Cambridge Road, Crosby, Liverpool.

Halifax Wireless Club.

(*Affiliated with the Wireless Society of London.*)

A meeting of the above Club was held on Monday, 12th April. Mr. C. Oates, a member of the Club, gave a demonstration with a coherer set constructed about 15 years ago. The meeting was well attended and a great success.

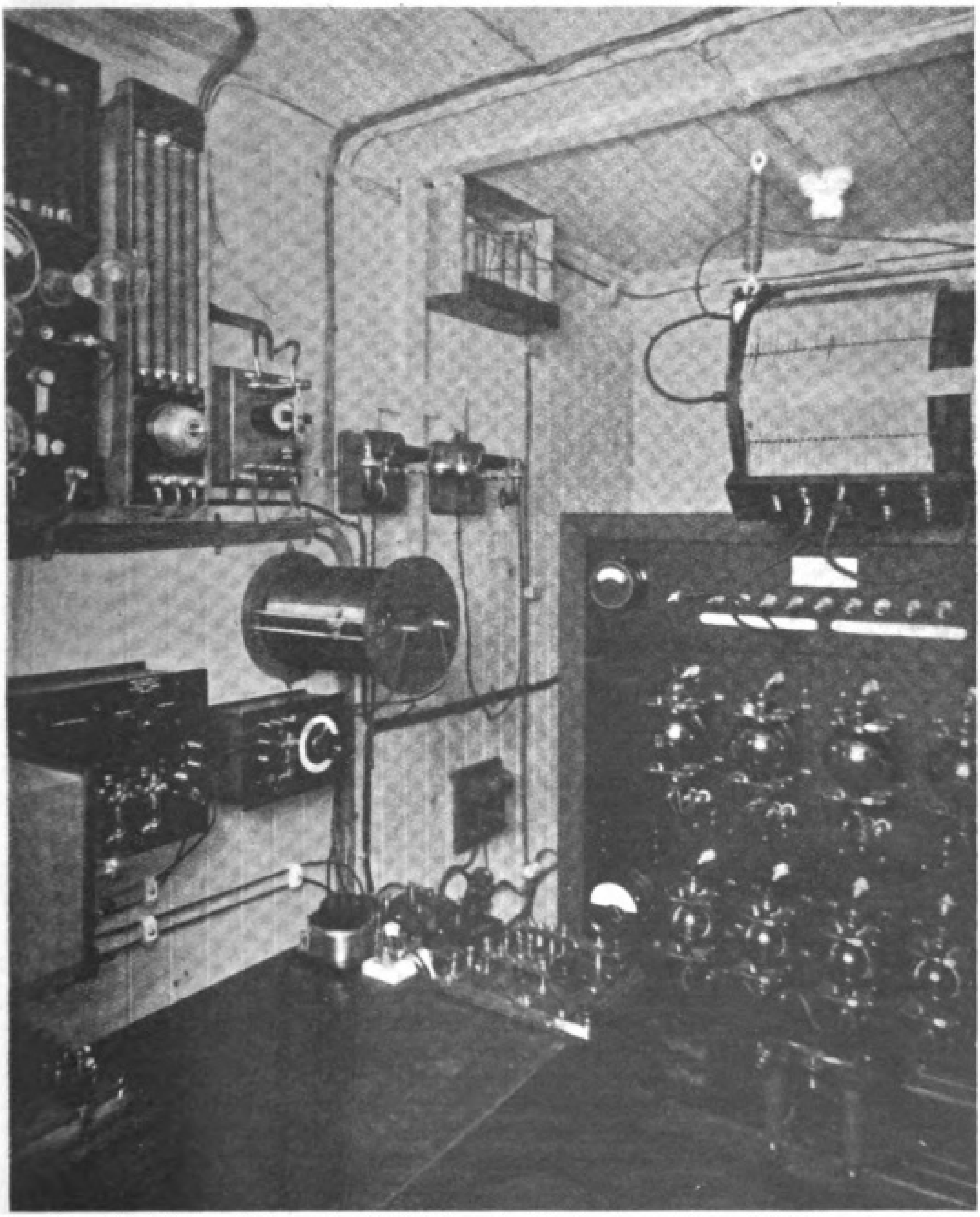
Application has been made to the Wireless Society of London for affiliation, and it is hoped to have the Club represented at next year's annual Conference.

The Postmaster-General is being approached for a transmitting permit. The result of this will be notified in due course.—Hon. Secretary, Mr. L. Pemberton, Y.M.C.A., Clare Hall, Halifax.

DETAILED DESCRIPTION OF LYONS TRANSMISSIONS.

NOTE I.—Lyons uses C.W. only. It has two transmitters, one a 250 K.W. Poulsen arc, and the other a 350 K.W. H.F. Bethenod alternator, which will replace the arc set as soon as it is permanently installed.

Time (G.M.T.).	λ (metres).	System.	Nature of Programme.
0.00 to 3.30	15,500	Alternator or Arc.	Duplex work with Annapolis (NSS), which works on 16,800 m. and 18,000 m. Poulsen arc. Also duplex with New Brunswick (NFF), which uses the Alexanderson alternator on 13,600 m.
3.30 to 4.30	8,000	Arc	Press.
5.30 to 6.30	8,000	Arc	Press.
9.10 to 21.00	15,500	Arc	Eventually duplex work with America.
21.00 to 22.00	8,000	Arc	Press to Holland, in French.



View of the Wireless Cabin on the R.M.S. Carmania, showing the new Marconi 3 K.W. set for C.W. Transmission.

PAGES FOR BEGINNERS

Under this heading we publish COMPLETE *instructional articles, forming a series specially designed and written for beginners in wireless work. Hardly any mathematics will be introduced, and we hope to present the fundamental facts of wireless in such a manner as will prove attractive to a much wider range of students than that for which this series is primarily intended.*

CAPACITY AND CONDENSERS.

IT is interesting to note that, in the early days of electrical science, many important results were obtained from experiments carried out with a totally different end in view. The property of the condenser, for instance, was discovered by two physicists, who were performing an experiment for quite another object. After the theory of the "electric fluid" was propounded there were many attempts to collect this "fluid" in a jar, or other receiver. In one particular case an attempt was made to lead the fluid into a glass jar, half filled with water, by means of a nail driven through the cork. The jar was held near an influence machine, and, on withdrawing it, the experimenter received a severe shock on accidentally touching the nail, while holding the jar in the other hand.

This type of condenser, in a modified form, is still used, under the name of a *Leyden Jar*.

Now, let us try and explain in what way the jar was possessed of sufficient electrical *energy* to cause a shock.

We know that a positively charged body, or sphere, will attract a negatively charged one. Further, if the two spheres are close together the positive charge is, so to speak, "tied" with the negative charge, and is incapable of inducing a charge on any other body which may be brought near. A diagrammatic view of the condition may be seen from Fig. 1

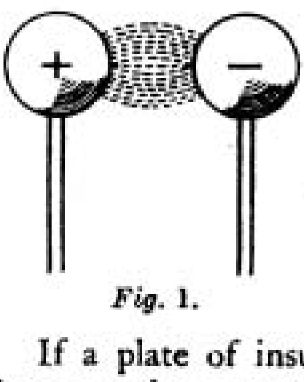


Fig. 1.

If a plate of insulating material is placed between the two spheres they will continue to attract one another, the insulator, as it were, leading the charge across, and it will also be found that either sphere is capable of being more strongly charged when near one of opposite charge, than when standing by itself. Or, in other words, its *capacity* is increased by placing near it an oppositely charged body. If the spheres are replaced by two sheets of metal fastened on each side of the insulating material, we have, in its simplest form, a *condenser*.

Applying these data to the explanation of the jar experiment referred to above, we have the conditions represented by Fig. 2. The water acted as one conductor or plate, the glass jar was the intermediate insulator, and the observer's hand formed the other conductor.

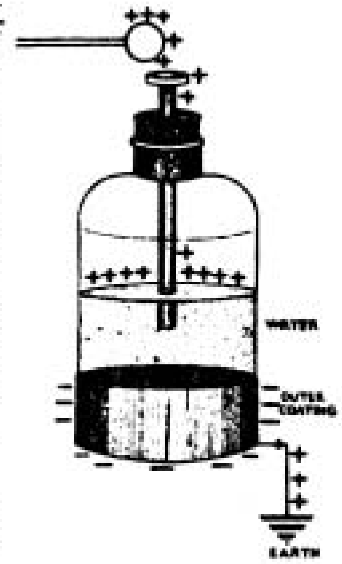


Fig. 2.

Suppose a positive charge was induced into the water. This would repel the positive electricity from the hand, or outer coating of the jar, to earth, leaving it negatively charged. These two opposite charges would be "tied," until a path was provided by means of which they could flow to each other.

It is obvious that a certain amount of energy is expended in charging the jar or condenser. This energy is stored in the form of potential energy in the condenser, and on joining the two conductors it is given out again in the form of heat and light (a spark), or in the form of a muscular shock to the body.

The modern form of Leyden Jar consists of a tumbler-shaped glass jar, coated on the outside with tin or copper foil. Inside the jar is an accurately fitting lining of sheet brass, having a knob attached to the middle (Fig. 3).

Fig. 3.

If the jar is charged, and the inner and outer coatings separated from the glass by means of an insulated stick, they will be found to possess no electrification. The question of where the charge has gone to is easily answered by testing the glass with an electroscope. One side of the glass is positively and the other negatively electrified. So, therefore, *the whole of the energy of the charge is stored in the glass.*

The insulating medium which separates the two plates of the condenser is termed the "dielectric." When the condenser is charged, the dielectric is put into a state of *strain*, which lasts until the condenser is discharged again.

It is clear that there must be a limit to the strain that the dielectric will stand. If we force energy into a condenser there will come a point at which the dielectric material will break down, and then a spark will pass between the two plates. It is analogous to applying an increasing force to a steel spring. A time will finally occur when the steel will snap under the strain.

The dielectric plays an important part in the capacity of the condenser If two plates are separated by air, they will have a certain capacity. If the air dielectric is replaced by glass, ebonite or paraffin wax, the capacity in each case is altered.

Now, as stated before, the dielectric leads the induced charge across from one plate to the other. If one material is capable of acting better in this respect than another, the capacity of the condenser is increased by using that material as a dielectric. Air is taken as the standard of comparison between dielectrics.

If two similar condensers were made, one having air as a dielectric and the other some insulator such as glass, the ratio between the capacities is known as the *specific inductive capacity*, or dielectric capacity, of glass. The specific inductive capacity (usually abbreviated to S.I.C.) of air is taken as unity.

The following table gives the approximate values of dielectric capacity for various materials :—

Air - - - -	1.
Glass - - - -	3–3·25
Ebonite - - -	2–2·25
Paraffin - - -	2.
Shellac - - -	2·75
Mica - - -	5–8

Another important factor in the capacity of a condenser is the size of the plates. The capacity varies directly as the area of the plates : thus a condenser having two plates of a certain area would have twice the capacity of one containing plates of only half the area.

We can express the capacity of a condenser (usually denoted by K, or C) by :—

$$C = \frac{K \times A}{4\pi b}$$

where K is the dielectric capacity, A is the area of the plates, and b is the thickness of the dielectric.

The reason for dividing the expression by "b" is apparent when we consider the effect of increasing the thickness of the dielectric. If we had a spring that extended a certain amount under, say, a pressure of 1 lb., on doubling the thickness of the spring it would only extend to half the previous amount. Or, electrically, the capacity of a condenser is halved by increasing the dielectric thickness to double its previous value.

Now, a word as to the units in which capacity is measured The standard unit of capacity is known as the *Farad* (usually denoted by F), which is said to be the capacity of a condenser which requires 1 unit of electricity to raise its potential by 1 volt. The unit of electricity, it will be remembered, is the coulomb.

On consideration it will be seen that such a condenser would have to be of enormous size. For practical purposes, therefore, the unit is subdivided into the microfarad (μF), which is $\frac{1}{1000}$th of a farad.

If we wish to find the capacity of a condenser in microfarads from the formula given above, it is necessary to divide by 900,000.

So far, no mention has been made of the number of plates of which a condenser may be composed. If we wished to construct a condenser of large capacity it would obviously be impracticable to make two plates of very large area. A simpler plan would be to divide each plate into two smaller plates of half the area and join these together. If each plate is separated by mica, or some other insulator, the arrangement will be as Fig. 4.

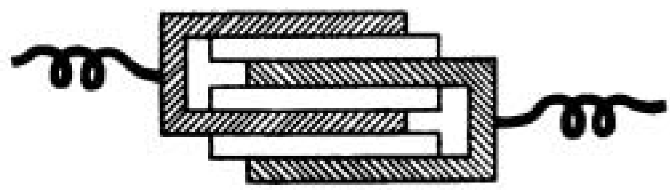


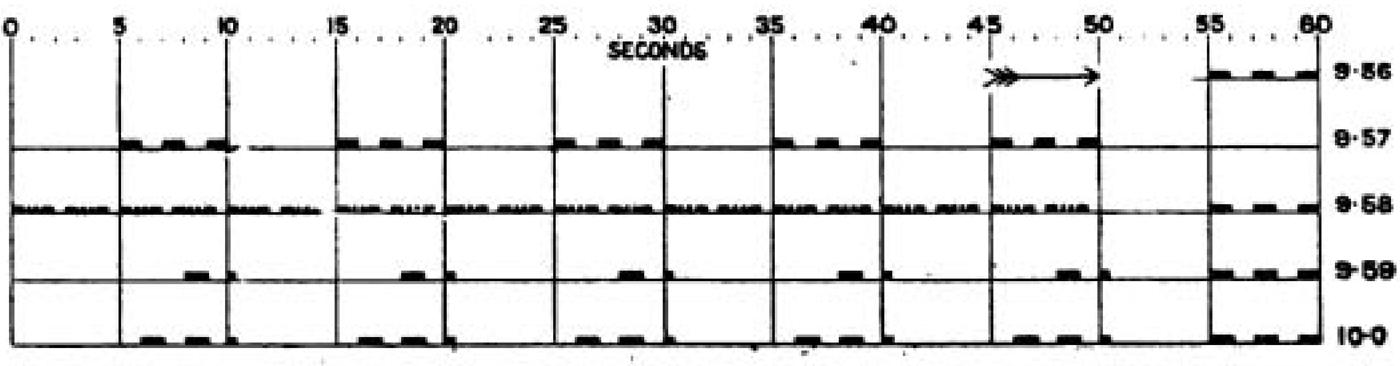
Fig. 4.

Any number of plates may be thus connected, a wire being finally brought from each set to form the condenser terminals.

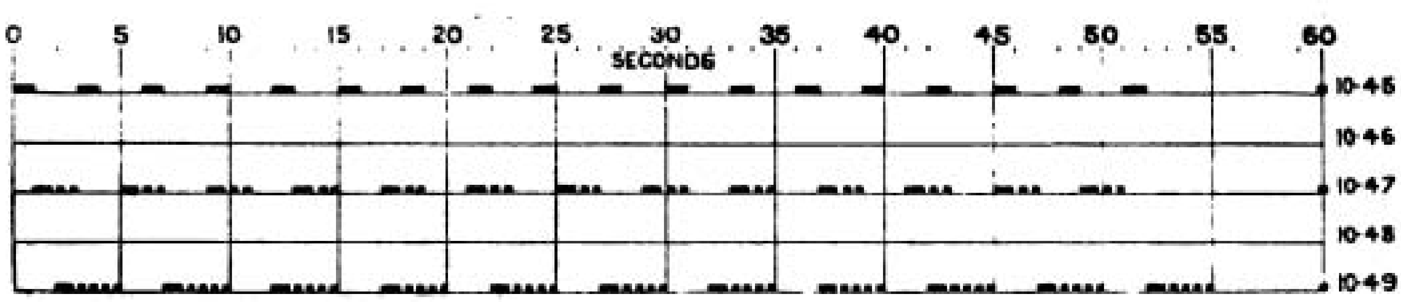
THE EIFFEL TOWER TIME SIGNALS

Time signals are transmitted by F L on the New System, commencing, as can be seen in the Figure, at 9 h. 55 m. 55 secs. The end of the third dash marks 9 h. 56 m Then comes an interval of five seconds, followed by three dashes and another silence of five seconds, and so on, until 9 h. 56 m. 50 secs. Then, after an interval of ten seconds, comes a series of the letter x, commencing at 9 h. 57 m. The Figure is self-explanatory.

Time signals on the Old System are transmitted at 10.44 and 23.44, and are illustrated in the other Figure. Note that 10 h. 45 m., 10 h. 47 m. and 10 h. 49 m. are indicated by dots.



Eiffel Tower Time Signals (New System). Sent at 9h. 55m, 55secs.



Eiffel Tower Time Signals (Old System.) Sent at 10.44 and 23.44.
Time and Weather Signals.

The CONSTRUCTION *of* AMATEUR WIRELESS APPARATUS

A Crystal Receiver with Valve Magnifier (Part III).

Potentiometers.—Two potentiometers will be required, and these can be made on the same lines as the filament resistance. No. 36 B.W.G. bare resistance wire should be used, which gives a resistance of about 1 ohm per 3" length. A neat former for the wire can be made by using a strip of Bristol board, 1/32" thickness, 8" long and 1¼" wide. Wind the former with the resistance wire, and at the same time wind an ordinary stout thread, the diameter of which is slightly less than the diameter of the wire. This will effectually insulate the turns of wire from each other. The wire may be soldered to an ordinary brass paper clip. One tag will hold the wire and the other tag a connection to go to a terminal. The average number of turns per inch of wire will be about 40; therefore, if we use 7" of the former, 280 ohms will be approximately the resistance of the total.

When the former is wound it can be mounted on a base similar to the filament resistance. The base will be required to be slightly higher to take the former, and the contact arm to be made so that it makes a light, springy contact, in order not to damage the fine wire

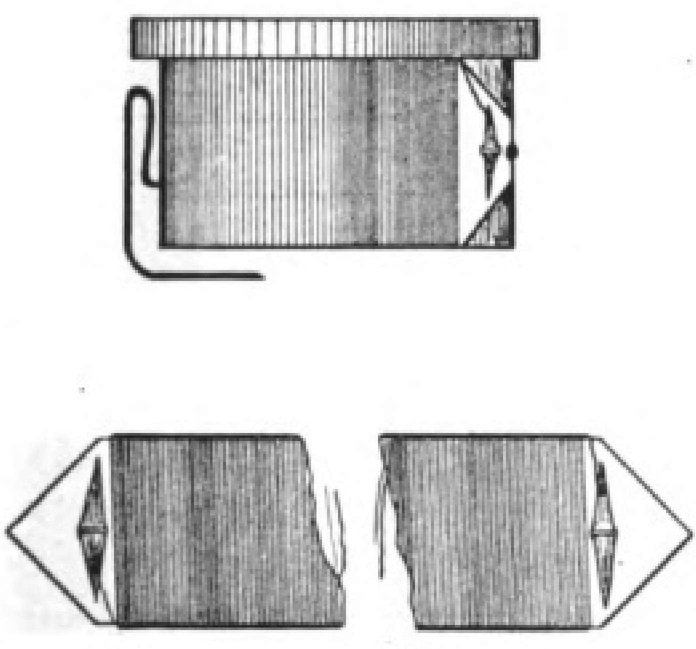


Fig. 1.

The sketches (Fig. 1) show all necessary details and give a general idea of the construction of this unit.

Connections and Adjustment.—In the foregoing paragraphs sufficient information has been given to enable the amateur to bring together quite a useful set of apparatus. It only remains now to consider the connecting up and adjustment of the set.

Arrange the apparatus on a bench, or table, in a compact manner, and make all connections as short and direct as possible, using leads sufficiently stout as not to introduce resistance into the circuit. Connect up as shown in Fig. 1, page 65, of THE WIRELESS WORLD, April 17th, and see that all terminals are tight, and both filament and plate batteries are insulated from earth. The grid of the valve is connected to the "top" of the aerial tuning inductance and the potentiometer slider to earth. We thus get the maximum potential changes across the grid and filament.

The plate of the valve and the crystal are connected to the variable lead to the jigger secondary—*i.e.*, the end of the secondary farthest from the "coupling." The positive of the plate battery and one side of the telephone transformer are connected to end of the secondary nearest the coupling coil. The other side of the telephone transformer is connected to centre point of the crystal battery, and the crystal potentiometer slider should be connected to the other side of the crystal. The crystal battery may be two dry cells. To work satisfactorily in conjunction with the valve, the carborundum crystal should be a good one, with not too low a resistance. If a good one cannot be obtained, try a zincite-bornite combination, in which case the crystal battery and potentiometer may be dispensed with and the crystal holder connected directly to the telephone transformer

The jigger secondary is in three sections, and provision must be made to connect the sections in series for the various ranges of wavelength. For range 1, only one section is used—that nearest the coupling coil. For range 2, the end of section 1 is connected to the start of section 2, and the end of section 2 to the secondary condenser and plate of the valve. For range 3, the end of section 2 is connected to the start of section 3, and the end of section 3 to the secondary condenser, etc.

For satisfactory working the closed secondary circuit should be "calibrated"—that is, the settings of the condenser for various wavelengths obtained. For this purpose a calibrated wavemeter is necessary. Buzz the wavemeter and place it near the secondary coil and pick up signals on the crystal. Set the wavemeter condenser to a known wavelength and tune up the secondary condenser for maximum signals, weakening the coupling between the two circuits to get the sharpest tuning. Observe the wavelength and condenser setting. Take seven or eight points for each range, and then plot the values on squared paper, plotting wavelengths against condenser readings. Draw a curve through the points. The curve should be regular in shape and must not be drawn from point to point in an irregular fashion. Should a point lie very much off the line, take a check reading. From these curves a chart may be made.

When the secondary circuit is calibrated a start may be made with the valve. Set the buzzer to a wavelength which will come on range 3 of the secondary, and tune up the aerial and secondary circuits on the crystal. Make the coupling between the two circuits weak by taking the sliding coil right out of the secondary. Switch on the valve and adjust its filament to glow brightly Set the grid potentiometer slider a little to the negative side and plug in the plate voltage. Then slowly push in the coupling coil and make slight adjustments of the tuning condensers and potentiometer.

Signals should then become much stronger, and, by careful adjustment and readjustment of the various units, good magnification can be obtained. If the coupling is made too tight the set will generate oscillations and the buzzer note will be turned into a scratchy hiss. It may be necessary to reverse the coupling coil connections, or to work on the tapping to obtain the best results. If a kind of fluttering noise is heard when pushing the coupling coil in and out, the circuit is said to be "floppy," and the filament brilliancy should be slightly reduced

C.W. RECEPTION

In the next issue will begin in this series a description of an Oscillator to work in conjunction with the receiver just described, as a C.W. receiver.

BOOK REVIEWS

A TEXT BOOK OF AERONAUTICS

By Herman Shaw, B.Sc.
London : Messrs. Charles Griffin & Co., Ltd.
pp. 260, 10s. 6d. net

THE author of a work on Aeronautics is more favourably placed, so far as his public is concerned, than most other writers on technical subjects.

Provided that he writes clearly, and with an eye to the range of the ordinary person who, even if not an expert in aviation, is not therefore necessarily devoid of intelligence, he is fairly certain to secure a wide range of readers.

Every "live" man is interested in the art of flying, and is anxious if possible to acquire an insight into the ways and means by which the aeroplane finally passes from the regions of ambition into the realm of achievement.

From this point of view, Captain Shaw's book makes a double appeal. Primarily it is a useful text book for those who want a precise and thorough introduction to the Science of Aeronautics, and yet at the same time it is so written that the average man can read it through and acquire much interesting and valuable knowledge on the subject with little or no difficulty.

The introductory chapter sets out in a concise and simple manner such elementary mechanical and hydrostatic principles as are necessary to approach the general problems of air-flow and pressure effects upon plane and curved lifting surfaces. This paves the way to a consideration of various wing "characteristics" in which the variation of "lift" and "drag" with the form and inclination of the aerofoil or lifting-surface, is fully explained. A point that may be of interest to the non-technical reader is the fact that the lift of the plane is due more to the suction that exists above the cambered wing surface than to the upward thrust exerted on the underside of the wing.

The dynamics of the aeroplane in flight, and the factors that determine its equilibrium and stability are treated in a sound, yet simple, manner. Construction in general, and the rigging, testing, and maintenance of the plane are dealt with in some detail, whilst a special chapter is devoted to the streamline formation of struts and other parts, and to the importance of careful design in this respect.

Considerable attention is given to aero-engines, most of the proved types being passed in review. Drawings of the original 80-h.p. Gnome and later 100-h.p. Monosoupape, or single-valve engine, together with the 80-h.p. Le Rhone, are included on large folding plates.

The chapter on air-screws is necessarily sketchy, but the subject is too complex to be dealt with in any considerable detail in a general review of aeronautics.

Other features of interest relate to the seaplane, balloons and airships, special instruments used by the pilot, and aerial navigation.

A special section is contributed by Major Tomlinson on "Wireless Telegraphy in Aircraft," which may prove of particular interest to readers of the Wireless World. It is quite a sound review of the principal types of wireless sets as used in the R.A.F. for air work during the war, and comprises schematic diagrams of both spark and valve transmitting circuits, and of crystal and valve receivers. The text is designedly framed for those who are not wireless experts.

In conclusion, the only criticism that lies against the work is that it attempts to cover too much ground within the limits of its 260 pages, and so it is necessarily scanty in parts. Apart from this, it is an admirable production both in text and in illustration, and is well worth its place on the book shelves, not only of the student of aeronautics, but also of every man who takes an intelligent interest in the progress of the latest and most fascinating achievement of applied science.

QUESTIONS AND ANSWERS

NOTE.—This section of the magazine is placed at the disposal of all readers who wish to receive advice and information on matters pertaining to both the technical and non-technical sides of wireless work. Readers should comply with the following rules.—(1) Questions should be numbered and written on one side of the paper only, and should not exceed four in number. (2) Queries should be clear and concise. (3) Before sending in their questions readers are advised to search recent numbers to see whether the same queries have not been dealt with before. **(4) The Editor cannot undertake to reply to queries by post.** *(5) All queries must be accompanied by the full name and address of the sender, which is for reference, not for publication. Queries will be answered under the initials and town of the correspondent, or, if so desired, under a "nom de plume."* **(6) Readers desirous of knowing the conditions of service, etc., for wireless operators will save time by writing direct to the various firms employing operators.**

SPARKS (R.N.) *asks* (1) *If there is any system in use whereby an operator transmitting with an arc can listen in at each break of the manipulating key, as can be done with a spark set.* (2) *If not, whether this is still considered impossible.*

We do not know of any case in which this is done, but the problem does not appear particularly difficult of solution. It is fairly evident that a solution could be obtained by suitable balancing-out methods, to name only one possible way. In deciding the utility or otherwise of any solution one would have to consider how much complexity and risk of trouble one was introducing into the circuits, and decide whether the results obtained justified the means taken.

H.K. (New Whittington) *asks* (1) *Can an ex-naval telegraphist apply for a first-class P.M.G. Certificate without taking instructions from a wireless school.* (2) *What school gives instruction in Marconi Engineering.* (3) *Why the shunt condenser in an arc discharges across the arc, in opposition to the D.C. current (? voltage). He suggests that this does not really occur, but that it merely discharges to earth.*

(1) Yes, if he is qualified to answer questions about, and work, commercial systems, and has a knowledge of the rules for handling commercial traffic.

(2) None, so far as we know.

(3) We presume that you are thinking of the case in which there is an actual reversal of current in the arc. This does happen at times, as can be shown by oscillograms; but we do not think the effect is as common as is generally supposed.

The initial effect is a simple discharge to earth as you suggest. But in a suitably designed circuit *e.g.*, one in which the damping is very small, the discharge which is evidently of an oscillatory nature is sufficiently violent and has sufficient electro-magnetic inertia to throw a reverse charge on to the condenser in spite of the tendency of the D.C. voltage to charge it again in the same sense as before. The reverse charge is of course never as big as the original one.

W.H.B. (Derby) *asks* (1) *How Eiffel Tower and Washington transmit to ships with ordinary receivers, using arcs.* (2) *The reason for the directive properties of a frame aerial.* (3) *Whether an error of 180° in a D.F. reading of the direction of a station is due to a constructional peculiarity of the apparatus, or a signal freak.* (4) *Whether Major Squier, in testing various X-stopping devices, tried the Weagant type, and if so, with what result.*

(1) Eiffel Tower generally transmits for ships on spark. Washington, if it uses arc to ships, probably only does so to Navy boats fitted with C.W. receivers. An ordinary spark receiver can only be used for C.W. by means of a tikker or similar device.

(2) The action is similar to that of a spherical coil coupled to a fixed coil in a receiver. In different positions of the spherical more of the lines proceeding from the fixed coil are linked with it than in others. In the positions in which most lines are linked the strongest effects are produced.

(3) The reason is not either of those suggested. Examination of the theory of the D.F., as given in any text-book will convince you that the simple D.F. can determine the line along which signals are coming, but cannot give any evidence as to which end of the line they are coming from. This is equivalent to an ambiguity of 180 degrees in the direction found for the signal.

(4) We do not think a test on the Weagant method formed part of the work you mention.

W.A.C. (Southall) *asks for instructions for making a transmitter for a range of a few miles, and a receiver for longer ranges.*

Transmission by amateurs not yet being allowed, we cannot give you the information you ask for with regard to transmission. For the receiver, consult A. D. Kent's article in the December number.

W.J.F. (Hull) *submits a simple valve circuit, and asks if it should give satisfactory signals.* (Fig. 1.)

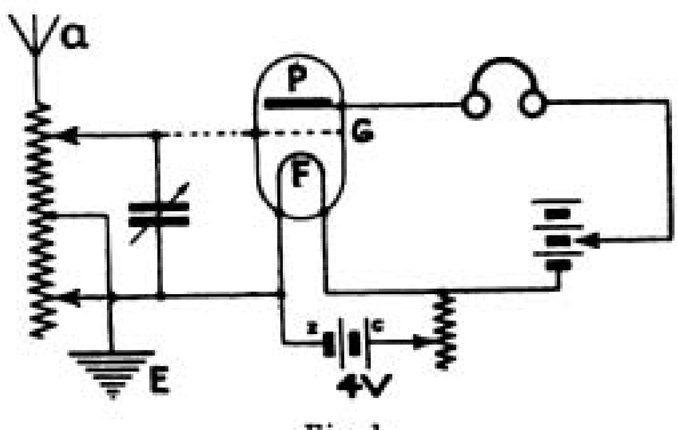


Fig. 1.

The type of circuit is fairly good, and the quality of the results you will get will chiefly depend on the suitability of the dimensions of the various parts. Keep the capacity of the grid condenser small. A telephone transformer and low resistance phones in place of high resistance phones in the plate lead would be preferable, as the latter method is liable to give shocks to your head from the H.T. battery. If you use the high resistance phones, it would be safer to put them on the earth side of the battery.

G.D.A. (Marlborough) *asks* (1) *For the rough dimensions of the windings for a loose coupler to work up to 3,500ms.* (2) *What resistance phones should be used with galena, and if 8,000 ohm Sullivans would be suitable.* (3) *If there is any advantage in using a transformer and low resistance phones instead of high resistance phones, and whether this method does not lead to a good deal of loss in the transformer.*

(1) For average small aerials and a suitable tuning condenser the following values should be suitable. Primary coil, No. 28 wire, on a former 24 cms long and 12 cms in diameter. Secondary coil, No. 30 wire, on a former 20 cms by 7.5 cms; the formers being wound full in both cases.

(2) Galena has not a very high resistance. A few thousands of ohms would be suitable. The Sullivans will probably be all right, and will at any rate be useful when you get tired of the vagaries of galena and go back to something more reliable.

(3) There is of course some loss in the combination, but it is not much more than in the high resistance phones alone. The reason for using the combination is that high resistance phones are expensive to make, liable to get out of order, and difficult to repair when they do. The combination of transformer and low resistance phones is much more robust, and give about as good results. There is no other reason for using it in crystal work.

F.E.B. (Blackburn) *asks* (1) *What is a suitable crystal for long range reception.* (2) *For a suitable aerial to comply with certain conditions.* (3) *If aerials could be placed in the upper storeys of a house.* (4) *Whether much interference would be caused by a few telegraph wires at right angles to the aerial near its middle point.*

(1) The suitability of a crystal is not greatly affected by the range of reception. Carborundum is very good. There are other more sensitive sorts, but these are all uncertain in action.

(2) Consult recent replies in this column. The double wire from window to window will be about the best you can do, unless you can contrive to get more height. It is highly improbable that you will be allowed to use the telegraph pole. A frame aerial is practically useless for crystal work.

(3) Indoor aerials are not sensitive enough for crystal work. They are too cramped, and too badly screened.

(4) Interference should not be serious. This relative disposition of the wires and your aerial is the one that will give you least trouble.

C.H.E.R. (London) *wishes to receive C.W. without using a valve. He suggests heterodyning the receiver by a buzzer excited circuit coupled to the aerial, and asks if this will give useful results.*

The scheme is possible. You will of course get some trouble from the buzzer note. The heterodyne note will be superimposed on this. The buzzer circuit should not be tighter than necessary or you will bring up the buzzer interference without improving signals. Make the condenser fairly large and the inductance small. Keep the resistance of the buzzer circuit as small as possible, as for success you must make the damping in this circuit low.

P.H.B. (Rothley) *asks* (1) *The area of the plates of tinfoil in a waxed paper condenser of 0.0002 mfds capacity.* (2) *What is the formula for calculating the capacity of a condenser of this type.* (3) *What are the S.I.C.'s of various substances.* (4) *A formula for the inductance of a single layer coil.* (5) *For particulars with regard to a circuit sketched.* (Fig 2.)

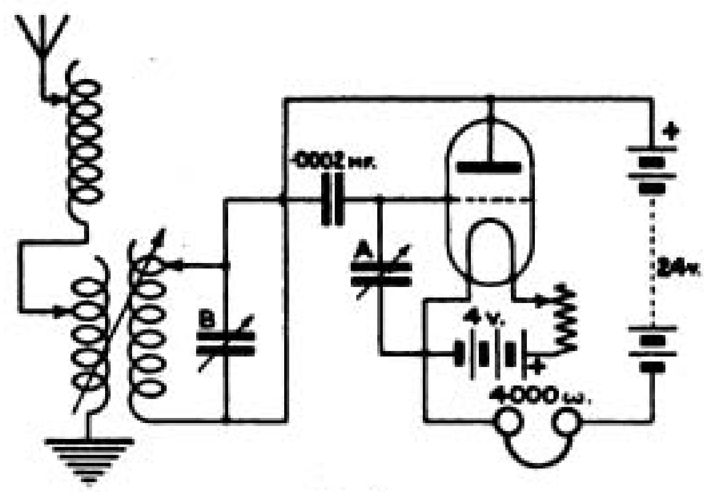


Fig 2.

(1) This depends entirely on the thickness of the paper. You can calculate it yourself from the next answer.

(2) Capacity in mfds $= \dfrac{1}{900{,}000} \times \dfrac{nAK}{4\pi t}$

Where n = number of plates of dielectric.
A = area of each metal plate.
K = S.I.C. of the dielectric.
t = thickness of the dielectric (all dimensions in centimetres).

(3) Glass, from 3 to 7, according to kind; mica, about 8; waxed paper, 2 to 2.5.

(4) Nagaoka's, about the best, was given in this column very recently.

(5) Circuit appears to be of a simplified ultra-audion type, with various parts omitted. We doubt if it will work well as it stands, especially with a hard valve. With an audion you would get better results, having a large choke in place of condenser A. If you use this condenser, make it small, and try a leak across it. B would have to be 0.001 mfd. with the coils you show. This is rather large. Circuits should give about the wavelengths you require, *i.e.*, up to about 6,000 metres.

A.D. (Dingwall) *asks* (1) *Why C.W. appears less affected by day and night variations than spark transmission, and* (2) *Why Chelmsford's recent telephony programmes appeared stronger by day than by night on his ship.*

(1) Explanation of the whole subject of these variations is still very speculative, and the most probable forms would appear to lead to similar results for C.W. as for spark. We are afraid we do not know any good reason for the difference, which does appear to exist.

(2) We believe the same power was used at night as by day. The effect might be due to extra leakage over the insulation on your set due to damp at night.

O.R.C.S. (London) (1) *Sends a diagram of a receiver for comment* (*Fig.* 3); (2) *Asks for an explanation why he gets no signals unless the A.T.C. is shorted*; (3) *He gets a loud humming noise in the phones, and asks the reason*; (4) *Asks for connections for phones in a buzzer practice set.*

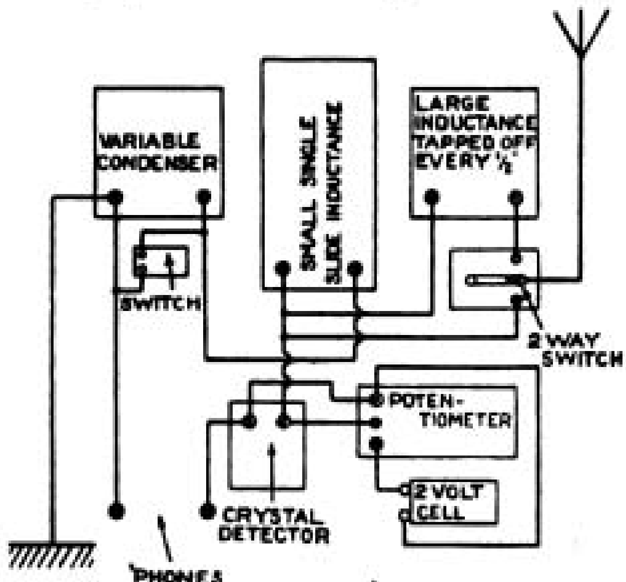


Fig. 3.

(1) The receiver is of the one-circuit crystal type, with the crystal in shunt across the A.T.C. and part of the A.T.I. This is bad; it should be shunted across the whole of the A.T.I., and not the A.T.C. as well. Potentiometer is not well put in, as it is in shunt across the crystal, giving an alternative path for the signals. Consult any crystal receiver diagram on this point.

(2) Remarks above *re* the tapping off of the crystal probably explain this. Also your capacity may be too small. You do not state the thickness or nature of your dielectric, both of which are important in determining the capacity.

(3) From the description the noise appears to be due to induction from neighbouring electric light or power lines. Have you any near the set? If so, your simplest remedy will probably be to alter the position of the set. By suitably turning the coils you may find a position in which the noise is not serious.

(4) The phones may be in series with the buzzer, but they should be shunted with a fairly low resistance.

A.F.H. (Bishop's Waltham) (1) *Wishes to make a wavemeter to work up to 2,500 ms, using a variable condenser of maximum capacity .0043 mfd, with an inductance of about 550 mhys. He asks whether this ratio of inductance to capacity is too high.* (2) *He sends a sample of a substance reputed to be molybdenite, and asks our opinion on it. He also asks how to use it as a detector.*

(1) No; the ratio you state should give quite good results.

(2) We have not been able to make an exhaustive analysis of your sample, but all the tests, chemical as well as physical, that we have made point to its being molybdenite. *If* it is not, it is an extremely clever substitute. You will find a description of it and its use in Pierce's "Wireless Telegraphy." To use it, make a holder of metal on which one side of a piece can lie flat. Use this holder as one terminal, and let the other terminal be a metal point resting lightly on the upper surface of the crystal. (*See* Fig. 4).

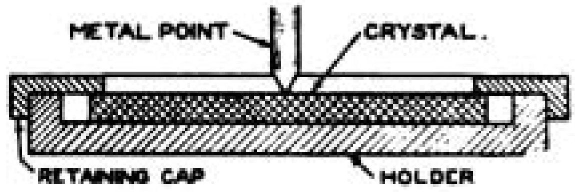


Fig. 4.

T.K.H. (South Shields) *asks* (1) *Whether a receiver on the lines of a Marconi Type* 31 *would be efficient for receiving up to, say,* 2,500 *metres on a small amateur aerial.* (2) *If an indoor frame aerial would be any use with a crystal detector.* (3) *If the receiver mentioned above would not be any use, what type would be better.*

(1) and (3) This type of receiver should be as good as any, but is perhaps rather more complicated than necessary for amateur use. Of course, no receiver will give very good results on long waves with a short aerial and a crystal detector only. You will find that a good deal more wire will be necessary for your A.T.I. than is supplied on with the type 31, owing to the smallness of your aerial.

(2) An indoor frame aerial is useless for crystal working, as it is much too insensitive.

J.B.K. (Huddersfield) *wishes to know whether we recommend him to purchase low resistance telephones in preference to those of high resistance.*

We recommend the low resistance telephones. You will find these just as efficient, used with a telephone transformer, as the high resistance instruments, and much more durable.

J.G.C. (Weymouth).—(1) Wireless telegraphy, we should think. (2) That depends upon his age and whether he possesses the qualifications required by the firm in question, to whom he should write for full particulars. (3) In all probability an ex Naval operator if he has not had previous experience, would certainly require to take the courses you mention.