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A STUDY OF WAVE SYNTHESIS BY MECHANICAL MEANS

Part I.—DESCRIPTION OF THE APPARATUS

Wave synthesis concerns the building up of a complex wave from simple harmonic waves, and it is, therefore, the opposite of wave analysis. Generally speaking, one is not so concerned with the former as with the latter, which is fortunate, for the analysis of any complex wave can fairly easily be carried out with the help of mathematics, and mathematical expressions for the most complex of waves are straightforward. It may be suggested that the reverse must hold and that mathematics can also express the synthesis of a group of simple waves. This is so in one sense, but in the particular subject with which the present paper deals, we are concerned not with the synthesis wave as a whole, but with its envelope (more strictly its rectified envelope), the shape of which is of the greatest importance.

Unfortunately in respect of this envelope shape, in some cases mathematics are quite unable to assist, at least so far as giving any lucid ideas on the subject; and it was with the idea of being able to study this feature, as well as for the purpose of demonstrating the general principles of wave formation to Students at the Marconi School at Chelmsford, that the author devised the mechanical model about to be described.

The paper will, for convenience, be divided into the following two parts:—

(1) *Description of the Model and its method of operation.*

(2) *Uses to which the Model may be put, in particular those relating to wireless practice.*

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(1) Description of the Model and its Method of Operating.

Preliminary.

Before designing the present model the author explored the many ways in which instantaneous values of motion may be integrated mechanically, and after some preliminary experiments, came to the conclusion that the principle adopted by Lord Kelvin in his tide machine was by far the simplest and most suitable method to work upon. This delightfully simple principle involves integration by means of a connecting cord and from Fig. 1, which shows two motions to be added coupled by the connecting cord, the rough idea can be followed.

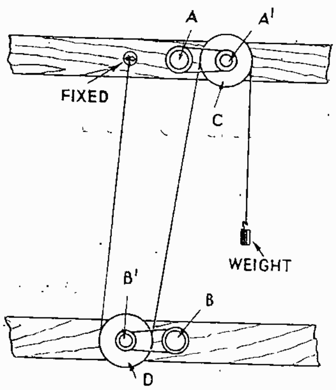


FIG. 1.

The cranks A and B, which can be moved as required, give the motions to be added, and in general they will be rotated at constant speed so as to provide sources of harmonic motion. The crank pins A′ B′ support loose pulleys C and D, over which runs the integrating cord. One end of this cord is attached to a fixed point whilst the other end hangs free, is weighted, and can hold a marking point. Due consideration of the system shows that the movement of the free end of the cord will sum the movements of the cranks, provided the rotation of the top crank is opposite to that of the bottom crank, or alternatively that they are set in antiphase.

Thus if a slip is passed laterally across a marking point held by the free end of the cord, a linear record of the resulting waveform would be obtained, although actually the movement of the free end of the cord gives double the sum of the individual movements, because we have here the second order of pulleys; hence if a correct amplitude record is required some form of reduction system is necessary.

General Features.

In designing the Model certain important features had to be borne in mind. The machine was to be of use largely for demonstration and instruction and not so much for the purpose of obtaining strictly accurate results. An important feature for demonstration which is unimportant otherwise, is that all component frequencies must draw out their trace simultaneously with the resultant. Further, these traces should all mark at the same relative position on a "time" base. Another feature is that the working model should give a good visual idea of the process and provide some clear mental pictures of the meaning of wave synthesis.

General Description—Motions Used.

Referring back to the elementary cranks given in the first figure, it can be seen that if the amplitude of any crank is at all large, the top and bottom motions would need to be spaced a very great distance apart if any accuracy is required; otherwise the sideway motion given to the loose pulleys would throw the cord out of vertical alignment and an undesired alteration of cord length would result. To get away from this undesirable feature and in order to obtain a correct trace of the component frequency an infinite connecting rod motion is used.

This is shown in Fig. 2, and using this type of crank and rod motion, the top and bottom rows of pulleys need to be spaced only the width of the recording paper apart. Such a design also enables adjacent cranks to be mounted quite closely together.

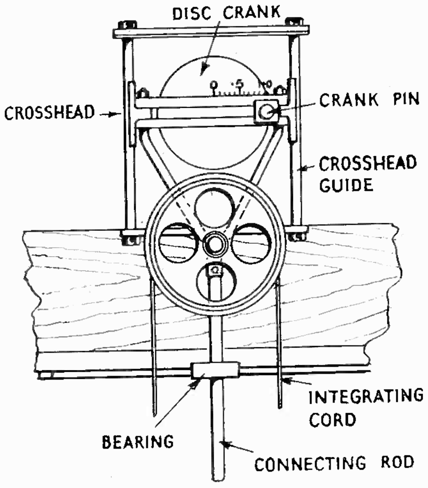


FIG. 2.

The model is arranged to add six component frequencies and so designed that the six frequencies involved lie in line and not opposite one another. The advantage of this is that phasing of each component is clearly defined, and one has no reversal to worry about due to position.

Fig. 3 shows the front elevation of the model from which most of the general features can be seen. The component harmonic motions are obtained by continuously rotating cranks, and the six disc cranks 1 to 6 with their link work are seen to be mounted in line upon an upper horizontal beam. The crank pin for each motion is adjustable and amplitudes from 0 to 1·0″ can be obtained. In the original model the following arrangement was made for obtaining any desired amplitude. The face of each disc crank was drilled across two diameters with a succession of holes. These holes were staggered so as to obtain a series of amplitudes from ·05″ to 1·0″ in steps of ·05″. If it was desired to get amplitudes between ·05″ this was done by means of an eccentric crank pin. Thus means were provided for obtaining any amplitude between the limits.

In the present design of this machine shown in the photograph an improved arrangement has been adopted for obtaining a gradual variation of amplitude. This consists of slotting the face of the disc with a mortice shaped groove and providing a sliding which can be locked in any desired position by the crank pin. The amplitude position is observed by a pointer indicating on an engraved scale.

The design of the crosshead and connecting rod is such that the latter moves with true harmonic motion and hence a marking point attached to the connecting rod will give an accurate record of the movement of the crank pin.

Linkwork.

In order that each component frequency may mark at the same position on the "time" base, every connecting rod carries a rigid light drilled aluminium angle piece, I, which can be locked to the connecting rod in any desired position in the vertical plane by milled headed screws. The end of this aluminium rod holds a

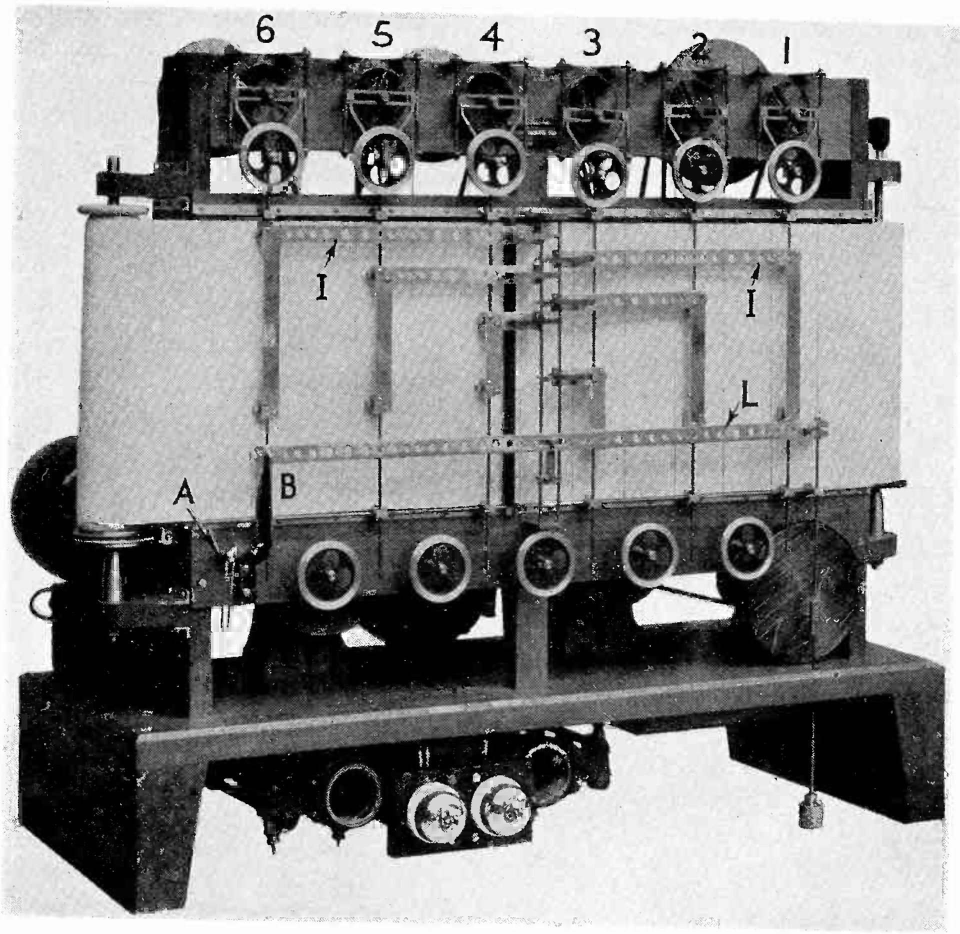


FIG. 3.

small brass cylinder pointing to the board into which a pencil holder is slid, pressure being obtained on the outer end of the pencil by a light steel adjustable spring designed to give constant pressure.

To take the outward thrust due to the pencil an additional steel spring is attached to the end of the holder in the form of a bow, the back of the bow bearing on the inner edge of a vertical rod. Thus no torque has to be taken by the connecting rod, the pencil pressure being counteracted by corresponding pressure immediately behind it and therefore in line with it. In spite of the length of pencil arm (the longest is 15″) there appears to be no appreciable whip at the pencil as can be seen by the records taken, although of course any inaccuracies here do not affect the resultant curve in any way.

The two rods taking the back pressure of the six pencils (three on each side) are also used to carry the pencil slider of the integrating motion and this constrains the motion of this pencil to a vertical plane.

The loose pulleys carrying the integrating cord are attached to the cross head forks and hence these loose pulleys will only move in a vertical plane. By such a design no inaccuracy due to misalignment of the cord out of the vertical will result, and the model has been kept more campact.

Attached to the lower edge of the model board is a second set of loose pulleys which are simply to make the necessary reversal of cord direction between successive cranks.

Integrating Cord.

The fixed end of the integrating cord is attached to a slotted strip for adjustment, shown by A, and after running over all the loose pulleys the end of the cord is held taut by a weight of something under half a pound; this is found quite sufficient for most purposes and at the highest speeds used no noticeable jumping occurs.

To obtain good results, it is necessary to use a cord which will not stretch in any way, but at the same time it must be perfectly flexible, and the cord adopted consists of a stranded phosphor bronze wire consisting of nineteen strands of No. 42 gauge wire laid up like a Bowden cable, that is, with reversed lay so as not to stretch or twist. The choice of this wire resulted after trial with cords of many types and it is found satisfactory.

Integrating Arm.

When considering the action of the model it was shown that the amplitude of the end of the integrating cord was double the correct amplitude and hence to obtain a record to scale, a reduction gear of 2 to 1 must be used. The long aluminium strip "L" shown in Figure 3 across the face of the model is the integrating arm, this arm being pivoted on a pin attached to the bracket "B," its other extreme end being linked to the cord. The centre of this arm is slotted and through the slot a pin is attached to a pencil slider, and so arranged as to fall in line with the other pencil holders. Thus the former moves at half the amplitude of the end of the cord, the guide rods previously mentioned as giving pressure support to the pencil holders, keeping its movement in a vertical plane. As the length of arm is so great it is not strictly necessary to provide horizontal sliding motion for the arm attachment to the cord, although in the present model this refinement has been introduced.

Of course, should it be desired to obtain a resultant record of greater amplitude than is correct, this can be done by fastening the marking point to any desired position between the centre of the arm and the free end, although it is pointed out that the phase of the resultant wave will have to be corrected for on the slip.

Method of Driving Cranks.

The method of driving each component crank can be seen clearly from Fig. 4, which shows the model set up for the demonstration of a square wave. In this case all six cranks are in use, of frequency 1, 3, 5, 7, 9 and 11.

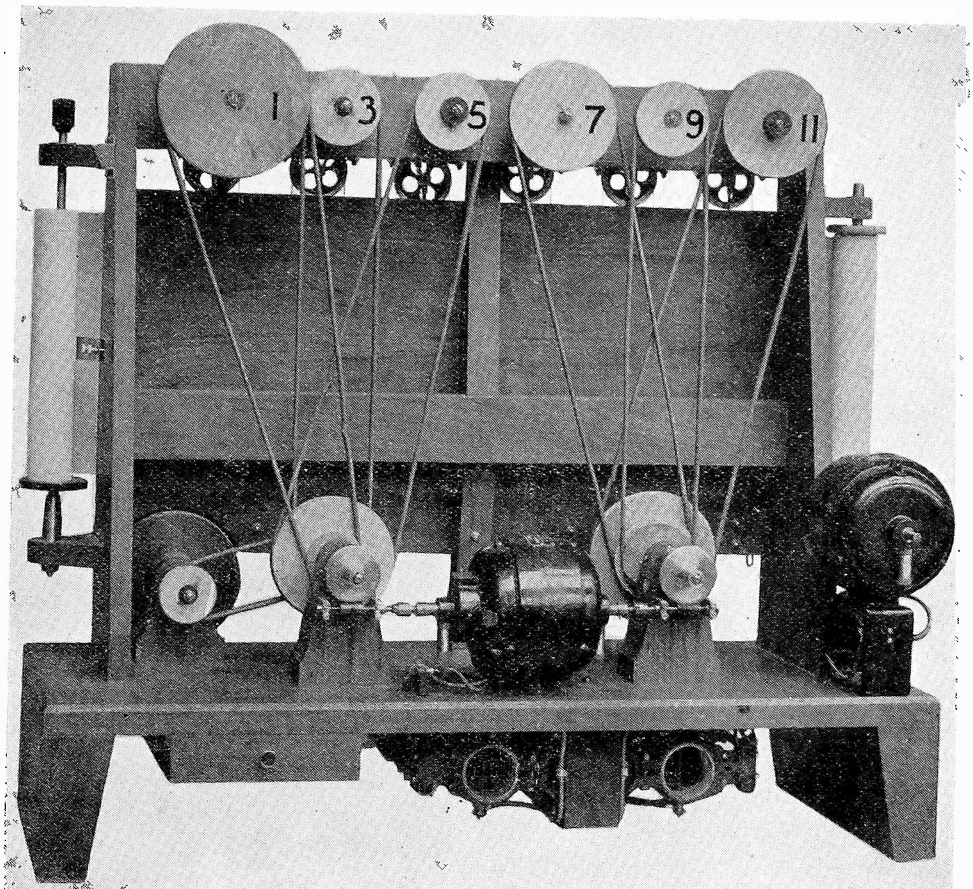


FIG. 4.

A small motor drives two countershafts through worm gearing which can be altered as desired. Each countershaft in turn can feed three cranks by leather belting and ordinary grooved pulleys. These belt drives after a certain amount of experiment have turned out entirely satisfactory and constant speed for a very considerable number of revolutions can be obtained. At one time it was feared they were introducing a variable error but this has since been disproved and they can now be said to be operating in an entirely consistent and satisfactory manner.

The secret of successful working lies in making the pulley grooves rounded so that the belt definitely beds on the bottom and just takes up some of the drive on the sides.

In order to make demonstrations of various phenomena it is, of course, necessary to change the various pulleys and gear wheels of the driving system and a quick standard method of fitting these pulleys has been adopted, which is of interest. Squares are always unsatisfactory for driving, as it is almost impossible to fit them accurately, taper shafts are sound but there again accurate fitting is necessary and expensive, and they do not allow lateral movement, so a split shaft method is used.

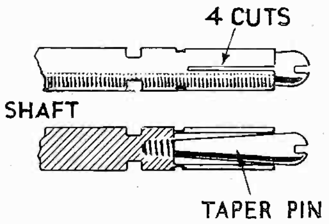


FIG. 5.

The ends of all driving shafts are made to a standard diameter and hollowed out. They are turned to a neck along the shaft, then split and a taper key screwed into the end of the shaft so that after a pulley has been pushed on, it can be locked by tightening up the taper key, the detail of this arrangement being as shown in Fig. 5. This forms a very quick and accurate method of fitting the driving pulleys.

Drive and Paper.

A vertical board between the top set of cranks and the lower set of pulleys provides a surface across which the indicator paper is racked. This paper is twelve inches wide and ordinary drawing office detail paper is used, a standard roll being cut into three for the purpose. The roll is slipped on to a disc with a short coned axle, and a steel rod dropped through the centre of the roll on to the coned axle, holds the roll in a vertical plane, provision being made by the fitting for easy rotation. Suitable spring tension is provided against the surface of the roll to prevent the record from bulging across the surface.

The drum drawing the paper across the board is located on the opposite side of the model and this drum is rotated by means of a separate motor worm drive of 200 to 1 reduction. A separate motor is essential in order that records can be "opened out" or "closed up" as desired. A free wheel attachment (simply a taper pin) is embodied in the drum so that any paper record can be unrolled from the drum without difficulty.

In order to keep the paper perfectly flat against the board as it passes the marking points (which move in a vertical plane) a polished ebonite roller is used, which is held tightly against the board by two flat springs pressing on to its end bearings. This is shown in Fig. 3 at the centre of the model.

Marking Points.

The method of recording in the present model is by means of ordinary lead pencil. Short pieces of pencil are fitted into the ends of small brass cylinders, the latter being fitted to the various holders on the model, as previously described. In order to obtain a clean record, a highly buffed hard brass strip is let into the face of the record board in line with the pencils, the record paper running across the surface of this polished strip.

There appears to be much uncertainty about the relative merits of ink and pencil recording for a model of the type described, but from the records obtained the pencil has proved very satisfactory on the whole.

Objections to pencil recording are :—

(1) The pressure requires to be fairly great.

(2) The record is not permanent (although it can be made so).

(3) The record is not too visible.

(4) Pencils have to be sharpened frequently as only a soft lead (B) of (HB) can be used.

Objections 1 and 2 can be overcome, whereas objection 4 does not enter into the present case very much as only short records are ever required.

Ink recording would have got over the above difficulties but there are two serious objections to the use of ink which prevented its being adopted.

First, in the case of the reproduction of curves such as are obtained for modulated waves, the paper is run very slowly and as the motion changes rapidly the curves are run very much together, so much so that any type of ink recorder would "smudge" for a considerable part of the cycle. Further, the present model is used only at intervals, for a few minutes at a time, and hence recording pens, if used, would have to be cleaned out each time in order to prevent them from drying up.

Chiefly therefore, on account of these two reasons, pencil recording was decided upon and except for the fact that the record is not as visible as it might be, it has been found satisfactory.

A. D. Ladner.

A SHORT WAVE AIRCRAFT RECEIVER

TYPE A.D.20

In the last number of THE MARCONI REVIEW, *a short account of the A.D. 21 aircraft transmitter was given, and it was there mentioned that this transmitter was intended for use in conjunction with the Type A.D. 20 receiver, a description of which is given below.*

The employment of short waves for aircraft communication has the advantage that fixed aerials can be used, thus enabling service machines which normally fly in close formation, and fighting aeroplanes to use these sets, since no trailing aerials are present to hinder the manœuvring powers of the aircraft.

TWO editions of the Marconi Receiver Type A.D.20 are made—the A.D.20 and the A.D.20A. The first of these has a waverange of 40–60 metres, and the second of 80–180 metres. As the design of these two are almost identical, it will be sufficient to describe the A.D.20 in detail and to point out in what respects the A.D.20A differs from it.

The receivers are suitable for the reception of continuous wave, interrupted continuous wave, and telephony signals, and have been designed with a view to providing an efficient instrument for the reception of short waves in aircraft of all types.

Simplicity and ease of operation have been the first consideration in the design of these receivers. The ignition system of the aircraft is more likely to interfere with reception on short wavelengths than on long wavelengths, and it is therefore necessary to pay particular attention to the efficient screening of the whole of the engine ignition system.

The receiver is contained in a copper-lined box which forms a complete electrical screen to prevent as far as possible direct pick up in the tuning coils, and to eliminate hand capacity effects. The box itself is made of metal, fitted with a removable front. The removable front covers an aluminium panel which carries the various receiver controls.

A photograph of the set is shown below and the position of these controls, etc., will be obvious.

Aerial System.

The receiver may be used with widely varying forms of aircraft aerial.

It is designed to be extremely flexible in this respect and a fixed aerial may be used, firmly attached to the structure of the aircraft, and supported and insulated as far as possible from the wings and fuselage, especially if these be of metal construction.

As the receiver is intended for use with the aperiodic type of aerial, the exact length of the aerial is not important.

Receiver.

A complete diagram of connections of the receiver is given below (Fig. 1), and the general lay-out of the components can be readily understood from this.

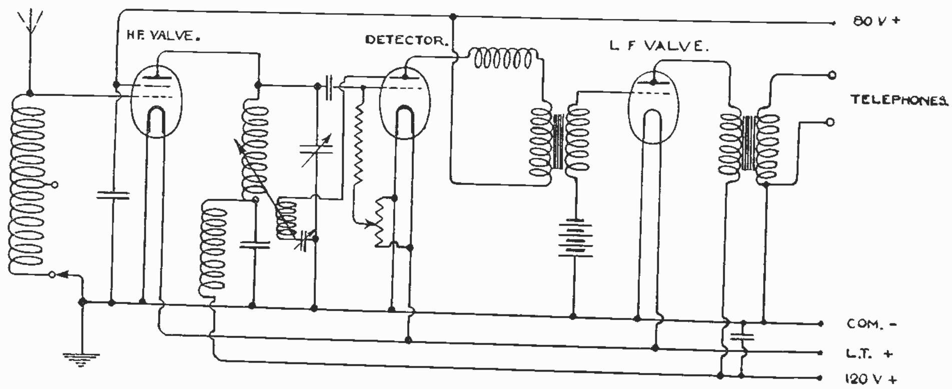


FIG. 1.

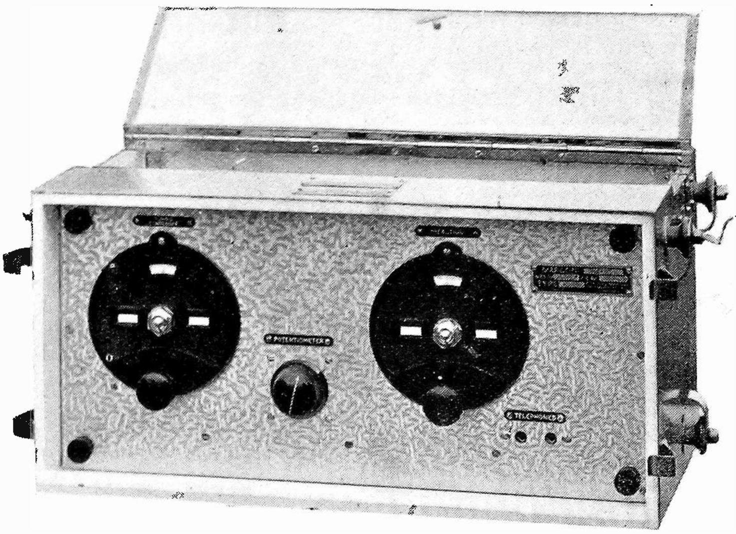
The receiver comprises a high frequency amplifier utilising a Marconi Screened Grid Valve Type S.G.215, coupled by means of a tuned anode to a leaky grid detector using a Type D.E.L.210 valve. The single note magnifier is transformer coupled to the detector, and uses a similar type of valve.

The aerial circuit consists of an aperiodic coil, coupled directly to the control grid of the first high frequency valve.

The necessary potential for the screen grid of this valve is obtained by a tapping on the anode battery at 80 volts.

The H.T. supply to this valve is obtained through a choke and tuning coil. This coil is tuned by means of a ·0003 variable condenser. The choke is provided to prevent any feed back of high frequency energy which might possibly cause distortion and oscillation in the later stages of the set. A ·01 mfd. fixed condenser is connected from the bottom of the tuning coil to earth in order to provide a virtual short circuit for all high frequency currents while still keeping the positive high tension supply of the anode from being shorted to earth.

Closely coupled to the tuning coil is the reaction coil from the detector anode. Variable reaction is provided by means of a ·00025 variable condenser. A small fixed condenser in series with this circuit protects the anode battery should the reaction condenser be accidentally short circuited.



A ·0001 condenser couples the anode of the first high frequency valve to the grid of the detector. The grid leak of this valve is connected to the variable contact of a potentiometer connected across the filament supply in order that the grid bias of this valve may be capable of very fine adjustment, and that best reaction conditions may be obtained.

The detector valve is supplied with high tension current from the 80-volt tapping on the anode battery via the primary of the intervalve transformer of the note magnifier and a high frequency choke. This choke is provided to prevent high frequency oscillations being fed back through the anode battery.

The third and last valve operates as a transformer coupled note magnifier. The circuit of this is quite normal and needs no special description.

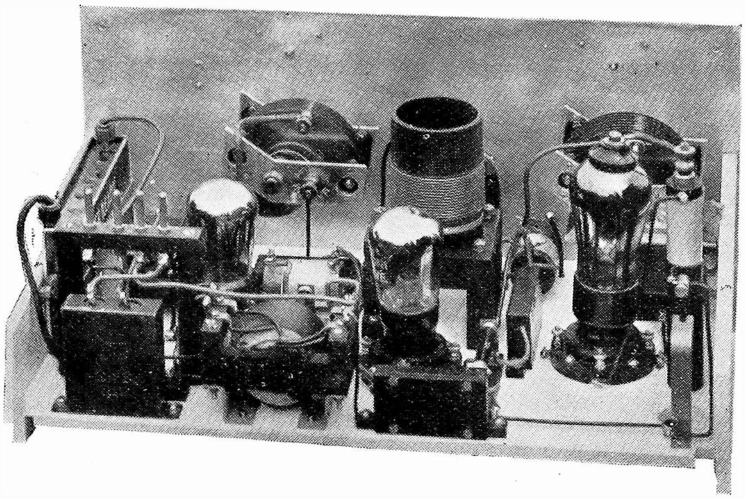
A 9-volt grid battery is provided in order that the grid of this valve shall have the correct bias, and may operate at its most efficient point. The correct amount of bias should be from 3–4·5 volts when using a D.E.L.210 valve.

As the set is intended for use with low resistance telephones, a telephone transformer is provided in the anode circuit of this valve, and one side of the secondary of this transformer is connected to earth.

Batteries, Cables, etc.

The batteries provided for use with the set consist of a H.T. dry battery of 120 volts with an 80-volt tapping carried in a tray underneath the receiver, and a 4-volt accumulator carried in a box fitted with fuses and terminals.

These batteries are connected to the receiver by a 4-way cable passing through a slot in the right-hand side of the instrument box and terminating in a 4-point socket which is connected to a corresponding plug mounted in the receiver box. A tumbler switch is provided for inserting in the low tension positive lead in order that the filaments may be switched off when the receiver is not in use.



When the receiver is used in conjunction with a transmitter the receiver accumulator may be dispensed with if desired, and the receiver L.T. leads connected across part of the transmitter L.T. accumulator, the negative lead being always connected to the negative terminal of the battery.

Operation.

The operation of the receiver is extremely simple as there are so few controls.

Signals are tuned in by the left-hand condenser and the receiver brought up to the oscillating point by varying the right-hand or reaction condenser control.

A calibration chart is provided in order that the receiver may be tuned approximately to the required wavelength thus facilitating searching.

Smoothness of reaction control is of the greatest importance in a short wave set, and it will be found that in the case of the A.D.20, the use of the potentiometer in conjunction with the reaction condenser allows the receiver to slide very smoothly into reaction.

A.D.20a.

The A.D.20A receiver is exactly similar in design to the A.D.20 with the exception that different windings are provided on the tuned anode and reaction coils.

AN INVESTIGATION OF SHORT WAVES*

By T. L. ECKERSLEY, B.A., B.Sc.

The following article is an abstract of a paper read before the Institution of Electrical Engineers on April 10th, 1929, by the present author. The conclusions arrived at are based on the results of a systematic study of signal strengths and signal directions from a number of stations observed over a period of twelve months by the Research Department of the Marconi Company.

One of the most useful results of the author's investigation is the explanation which it offers of the observed deviation of the bearings of Beam Stations from their true values. This is given in detail below, and is consistent with the theory forming the latter part of the original article, which has been omitted from this abstract for the sake of brevity.

In addition to this, two important conclusions are reached:

(1) *The existence of the phenomenon known as "scattering" of short wireless waves is placed beyond doubt.*

(2) *The previous conception of the Heaviside layer must be altered to conform to the latest experimental results obtained.*

Scattering.

IN a recent paper before the Institution of Electrical Engineers, the writer described results which indicated that short wireless waves were quite appreciably scattered in traversing the Heaviside layer. The effect of such scattering is to blur the dots and dashes of Morse signals and is therefore of importance in certain circumstances in high speed signalling.

Although blurring and short echoes are a symptom of scattering, the best method of investigating scattering is by means of suitably designed direction finders, and the results have been obtained largely by their use. Tests originally made years ago and described in a paper on Short Wave Transmission, in which a balanced frame and vertical aerial were used, indicated the probable presence of scattering in the skip region, but they were not decisive for, owing to the practical limitations in the size of the vertical aerial or coupling between this and the frame, it was not certain whether the observed absence of bearing was really due to the incidence of scattered radiation or whether it was due to radiation of such high angle that the balance adjustment was outside the limits obtainable on the apparatus.

An unequivocal test was arranged as follows: Two vertical aerials were used, set up at a distance apart of 13 metres and finally 30 metres. The object was to balance the effect of the two E.M.F.'s induced in the two aerials, and the circuit used for this purpose is shown in Fig. 1. A and B are two aerials, each tuned and loaded with similar inductances. The received energy is brought from the two aerials by two buried cables C_1 and C_2, the inner conductor being tapped up two turns of the inductances L_1 and L_2. The power from the two cables is delivered to two tuned circuits S_1 and S_2 by means of a tapping connection so adjusted that the impedance between T_1 and T_2 is the surge impedance of the cable. A reversing switch S was inserted between one of the cables and the tappings T_1, T_2. Each of these circuits was coupled to a coil forming part of the input circuit of the amplifier. The relative coupling between this and the two circuits could be varied by moving the coil across from one to the other.

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* Abstract of Paper read before the Institution of Electrical Engineers, April 10th, 1929.

In considering the acton of this system, the simplest case is where the trace of the ray (supposing a definite ray to exist) is perpendicular to the line joining the two aerials. The currents induced in these two will then be in phase, and if the cables are made to be the same length the current in the two tuned circuits will also be in phase and the effects of the two can be added or subtracted in C by reversing the switch S. A slight adjustment of the position of C will enable the two to be balanced. If, however, the trace of the ray makes an angle with the normal to the line joining the two aerials, the currents in these will no longer be in phase, but this effect can be compensated by slightly mistuning each of the two tuned circuits S_1 and S_2, one longer and one shorter, so as to produce the requisite difference in phase.

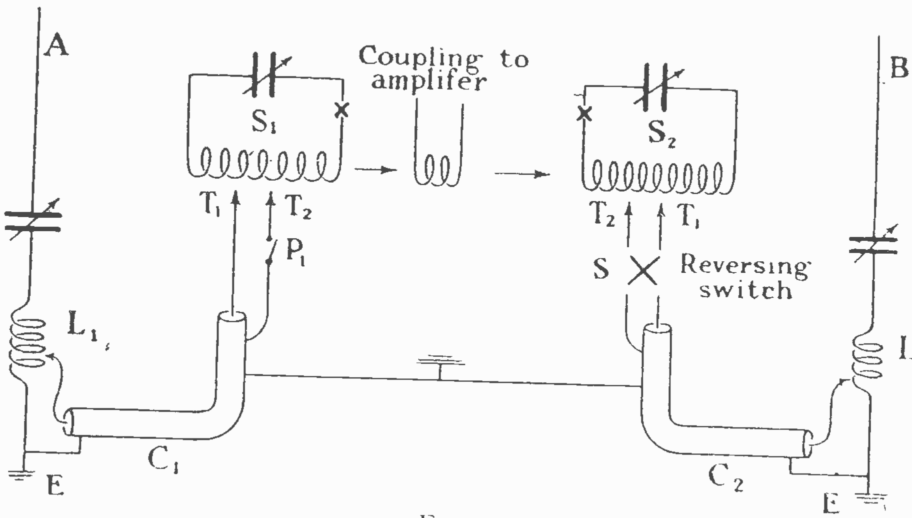

FIG. 1.

In this manner signals from any station not too nearly in line with the aerials can be balanced, provided the energy is travelling along any ray or set of rays in the vertical plane.

Results obtained.—The receiver was set up at Broomfield, a little over a mile from the Marconi Works, Chelmsford. Firstly, the signals from local stations, such as the works, Ongar and the Marconi College, could be balanced almost perfectly. The residual signals at the balance point, which were probably due to instrumental imperfections, remained constant and were a very small fraction of the unbalanced signals.

Secondly, the signals from stations within the skip distance, *e.g.*, Bodmin, Grimsby, the Dutch stations (at times), and AGB (Berlin) (at night time during the period of weak signals), could not be balanced with any adjustment of the circuits; in fact, any station which normally gave no balance on the cardioid receiver also gave no balance on this system.

Finally, long-distance stations, in particular the beams, Canada ($\lambda = 26$), Australia ($\lambda = 25$), India, South Africa, the North American stations (2XT, 2X5, 2XBC), Rio and Java, etc., generally showed an intermediate condition between these two extremes.

As is well known, the intensity of signals from long-distance transmitters fluctuates enormously in periods of 5 seconds and upwards, changes of intensity of 8 or 10 to 1 being quite common. It was found possible to balance the signals at the peaks of intensity but not at the minima. The balance at the peaks was not perfect, a residual strength of one-sixth to one-tenth of the maximum intensity being obtained ; in fact, this residual intensity was of the same order as the intensity at the minima of the fades.

If the switch S was left in the balance position, and the switch P_1 (say) was opened so that signals from one of the aerials alone were received, then if the switch P_1 was closed at a peak value of the signal so as to balance the two aerials, a large diminution of signal strength was observed. At the minimum of the fades, however, no change was produced on closing P_1, nor was there any change if P_1 was kept closed and S reversed.

As far as the author can see, there can be only one interpretation of these results. Close to the transmitting station the direct ray, with its definite direction of travel, is predominant and the signals from the two aerials can be easily balanced. The direct ray is attenuated very quickly, and at distances of a few miles (depending on the wavelength, nature of the transmitting aerial, etc.), this direct ray is swamped by radiation scattered from the Heaviside layer. It is easy to see that no balance can be obtained with this system in a field of scattered radiation, for the position of balance varies with the direction of each ray, and no single position of balance can be obtained, except, perhaps, momentarily when the main bulk of the energy is travelling instantaneously in one direction. On the average (even over quite short periods of time) the currents in the two aerials will be equal but of random phase difference. At great distances the evidence points to the existence of a main ray (which can be balanced on the two aerials) together with a scattered residue which remains when the main ray has faded out. These results were not of isolated occurrences, but were perfectly regular and normal, and they seem to put the existence of some sort of scattering beyond doubt. Scattering in this sense merely implies the existence of energy travelling to the receiver along more than one path in the horizontal plane. It might, as is most probable, be produced in the Heaviside layer, or from irregular objects on the ground, or it might arise rather as a single reflection from some vertical or semi-vertical surface of discontinuity in the Heaviside layer, the resultant two rays in the different horizontal azimuths giving rise to an imperfect balance. In fact the disturbing rays, as we might call those other than that in the great-circle path, may be single or multiple ; perhaps the term "scattering" should legitimately be applied only in the latter case and the term "irregular reflection" in the former, though of course scattering is, in its ultimate analysis, an irregular reflection. Perhaps it is best to class the two as single and multiple scatterings. There exist, no doubt, all gradations between the two.

Since the scattered signal travels by a different path from, say, the direct signal (not necessarily direct ray) there wlll be a time interval between the arrival of the two. The scattered signal may be said to be an echo signal, and the subject may be studied from the complementary point of view of echoes. Photographic records of signals show the existence of echoes of such short delays that they may well be produced by relatively local scattering (using this term in its general sense, as implying multiple paths in the horizontal plane). These short-period echoes have been studied chiefly by the Americans, whose results will be used here to supplement our own knowledge obtained chiefly by directional methods.

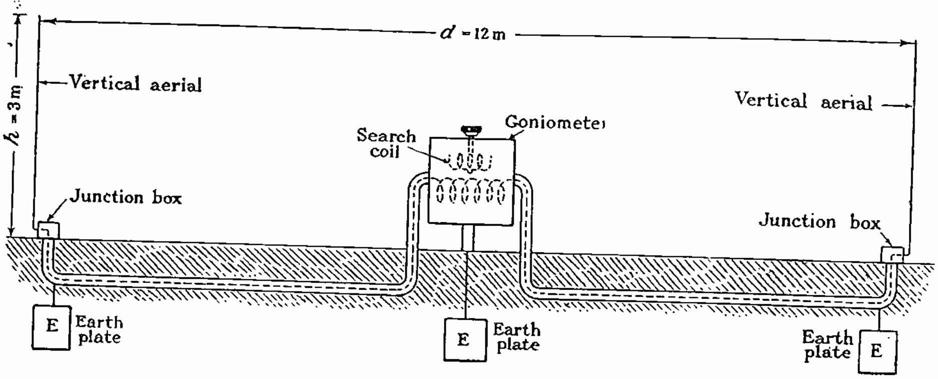

FIG. 2.

The success of the two-aerial system in interpreting transmission results led to the development of a form of goniometer or direction-finding apparatus specially suitable for studying scattering and other transmission effects. It may be worth while to describe it in some detail, as little appears to have been done elsewhere in the application of direction-finding to short waves. Perhaps it should be stated at the outset that the arrangement is better as a means of investigation of short-wave transmission phenomena than as a direction-finder. This is chiefly because of the absence of any marked direction in a large percentage of cases, the main ray along the great circle path being swamped by others.

It was early realised that short-wave direction-finding suffered from the worst kind of what is called "night effect," and that any directional receiver which had any horizontal force "pick-up" was bound to give spurious results. Efforts were therefore concentrated on a device with vertical antenna.

The arrangement employed is known as the Adcock aerial.* It has been used successfully on 400 metres by Smith-Rose and Barfield, and it seemed probable that the difficulties experienced by these workers would be less marked on short waves where the aerials can be spaced at a distance comparable with the half-wave of the signals employed, so that the differential effect between the two aerials was not too small compared with the E.M.F. on one and the balance need not be so carefully maintained.

Four vertical aerials 3 metres high were accordingly placed at the corners of a square 12 metres across the diagonal. These were connected to the core of buried lead cables (direction-finding cables with paper insulation) which were brought to the centre where a suitable shielded goniometer was placed. Each diagonal pair of aerials, cable and primary coil of the goniometer constituted a single circuit, as shown in Fig. 2.

The cables were buried to a depth of about 1 ft. and were well earthed by low-inductance strips to deeply buried earth plates. It is obvious that the E.M.F.

* R. L. Smith-Rose and R. H. Barfield: "The Cause and Elimination of Night Errors in Radio Direction Finding," *Journal I.E.E.*, 1926, Vol. 64, p. 831.

on each pair depends on the direction of the ray relative to the line joining the two aerials.

Thus the E.M.F. on $AB = E \sin \left\{ \frac{2\pi d}{\lambda} \sin \theta \right\}$

and the E.M.F. on $CD = E \sin \left\{ \frac{2\pi d}{\lambda} \cos \theta \right\}$

and if ϕ is the angle at which the search coil of the goniometer is balanced

$$\tan \phi = \sin \left\{ \frac{2\pi d}{\lambda} \sin \theta \right\} \Big/ \sin \left\{ \frac{2\pi d}{\lambda} \cos \theta \right\}$$

and if $2\pi d/\lambda$ is sufficiently small this is $\tan \phi = \tan \theta$, or $\phi = \theta$ when the coils of the goniometer are connected up properly. It is evident that the success of this arrangement depends on the elimination of any horizontal "pick-up."

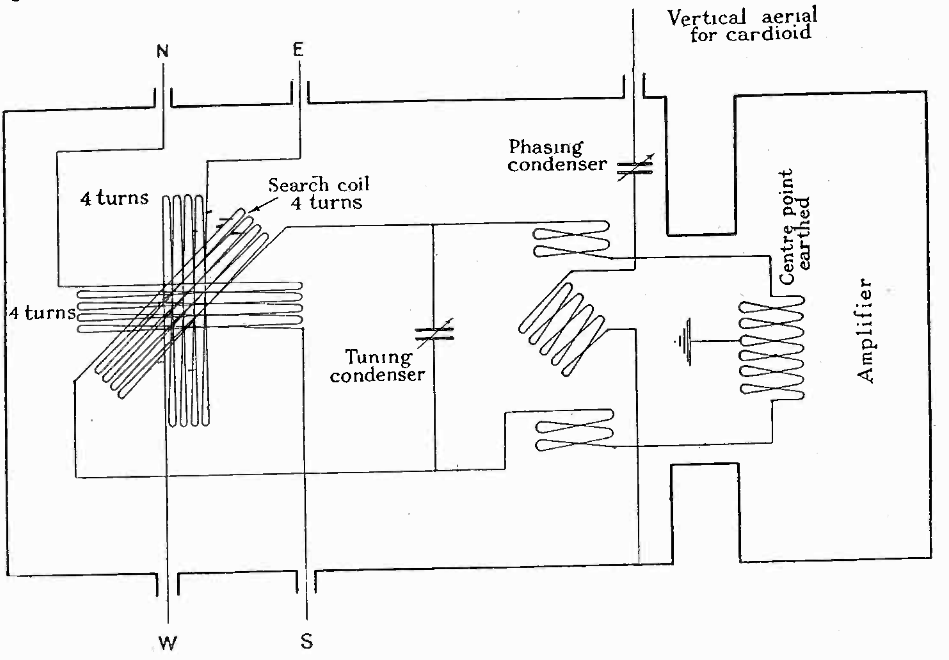

FIG. 3.

It is for this reason that the horizontal cables are buried and carefully earthed at the ends. These precautions seem to be successful, since the swinging of bearings noticed on the frame was almost entirely eliminated. There may be a small residual horizontal "pick-up" remaining.

It was found essential to have the lead of the outer shielding of the cable continuous with the outer shielding of the goniometer, so that the electrical field was wholly confined to the inside of the apparatus.

The goniometer was close-coupled with four turns on each primary and on the secondary (Fig. 3). It functioned quite well between wavelengths of 13 metres and 60 metres. A vertical aerial could be coupled to the search-coil circuit so that a unidirectional cardioid diagram could be produced. It will be observed that when $2\pi d/\lambda$ is not small $\phi \neq \theta$, and there is an octantal error which can easily be derived from the formula given.

It was with this receiver that the main results of scattering have been obtained. It will be realised that this goniometer will give a true bearing whenever such exists and will give no bearing at all in an isotropic field of scattering.

The results obtained with this direction-finder in over a year and a half's work are so diverse and varied as almost to defy classification. Perhaps the most convincing effects were obtained in studying the beams.

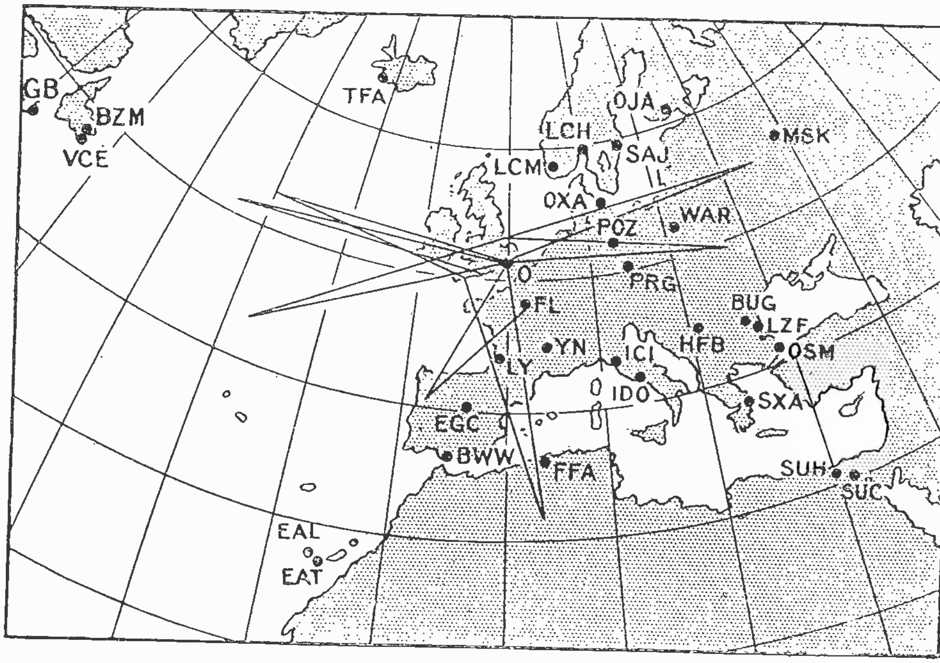

FIG. 4

Fig. 4 is a map showing the locations of the English beam transmitting stations at Bodmin, Dorchester and Grimsby, together with the great circles showing the mean line of the beams sent out (*i.e.*, the great circles to Montreal, South Africa, India, Australia, New York, Buenos Aires, Cairo, etc.). The position of the directional receiver at Broomfield, Chelmsford, is shown at O. The bearings of these beam stations have been observed regularly throughout a period of 9 or 10 months. The results vary from day to day, but it can be said that in practically no case is the true bearing of the transmitting station obtained. Occasionally there is no bearing at all, but in the majority of cases a more or less defined bearing is found which is close to the bearing of the station worked by the particular beam in question. A reference to the map will make this clearer. Take the station at Grimsby (GHB), wavelength 26 metres, working to Australia. The true bearing of this from Broomfield is about 350° or 10° West of North. The actual bearings were found to be as a rule from the West-North-West in the morning and from the East-South-East in the afternoon, and in fact they were close to the true bearings of

Australia. Similarly the bearing GBJ (Bodmin) working to South Africa was close to the bearing of VNB (S.A.) and so on.

The sharpness of the bearing varied from time to time, and the signals were obviously of the scattered type, *i.e.*, blurred and hollow-sounding, but the bearings were quite definite enough to obtain averages with probable errors of about 3°.

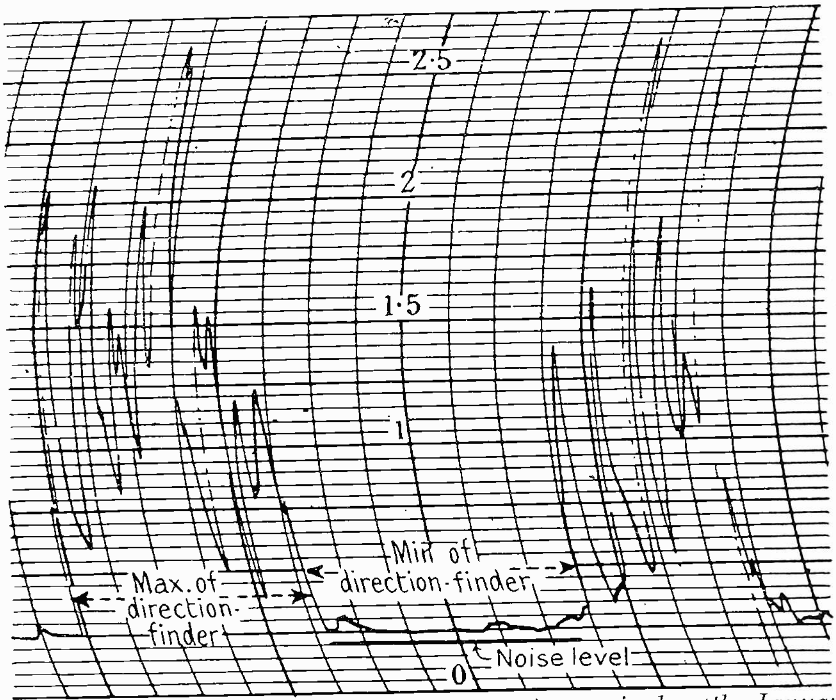

FIG. 5.—*Station WLL (New York, λ = 16·2 metres), received 25th January,* 1928, *on Adcock aerial direction finder. Unscattered signal.*

There was fortunately a sufficient variety of stations to ensure that the above was the general rule. One fact which puzzled the author for some time was that Dorchester (GLW) working to Rio always appeared to give its true bearing, whereas all the others appeared to give bearings nearly at right angles to their true bearings. The explanation is, of course, that the direction of Dorchester from Chelmsford is almost exactly the same as that of Rio. Other stations at Dorchester do not give the true bearing of Dorchester; for example, GLH and GLG working to New York both give approximately the New York bearing, GLL working to Cairo gives the Cairo bearing, etc. The explanation of these results, at first puzzling, is now clear. The direct rays from the beam stations are so weak as to be negligible. The rays received at Broomfield are those scattered back from the regions where the main transmitted beam penetrates into the scattering regions of the Heaviside layer. The case bears resemblance to that of a searchlight playing upon the clouds. Where the searchlight itself is hidden the point of intersection of the searchlight beam and the scattering or reflecting clouds appears to be the source.

Incidentally, these results show the existence of a very well defined beam, and direction finding observations are generally sufficient to determine whether any local transmitting station is a beam or not. By taking enough bearings to obtain a fairly well defined scattering direction, we can make a triangulation to determine the position of these scattering regions. The method cannot be very accurate, both because the base line is in general small compared with the distance of the scattering source, so that the triangle is very acute-angled, and because slight errors in the base angles make large differences in the actual distance. The inherent difficulty is the same as that experienced in obtaining the parallax of very distant stars, enhanced by the fact that accurate bearings cannot be obtained. To give an idea of the definition of the scattered bearings and to dispel the notion that these are too indefinite to base any conclusions upon, the records shown in Figs. 5 and 6 are given. The plate current from the amplifier was put through a recording

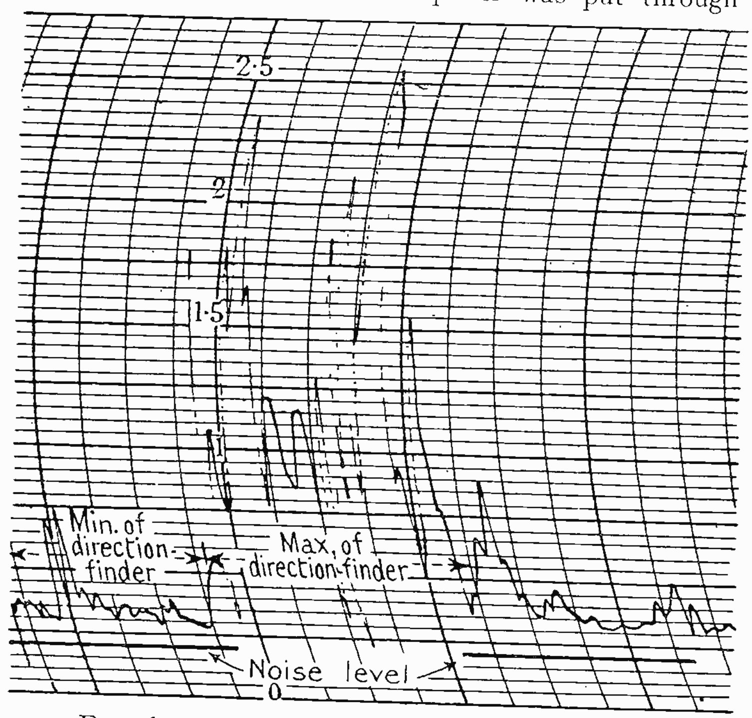

FIG. 6.—*Scattered signal from Station GBK.*

milliammeter and a record taken of the signals at the maximum and minimum positions of the goniometer. It will be seen that in the example shown the minimum signals are quite a small fraction of the maximum signals and a well defined direction can be obtained. Fig. 5 is an unscattered signal from WLL, while Fig. 6 is a scattered signal from GBK.

The results of the triangulations are shown in Table 1 and on the map (Fig. 4), which is more or less self-explanatory. The figures for the triangulation were furnished by the mean bearings during the 9 months in which regular bearings were taken of the local beam stations. They therefore give average results, and seasonal changes, if any, are obliterated. There were not enough observations each month to make it worth while taking separate means for these, and any variations would probably not be significant.

The mean bearings were corrected in each case (especially for shorter waves), for the octantal error, which is known from the dimensions of the system. In obtaining the bearing of any transmitting beam A working to a station B we find, as described above, that the bearing of A is very nearly that of B. It is the difference between the bearings of A and B that is significant in the triangulation.

Where for any reason, *e.g.*, essential error in the goniometer, the bearing of B is in error by 2° or 3° or more, the bearing of A is corrected by this amount. This is essentially equivalent—except for the sphericity of the triangle—to making the small angle at the apex of the triangle equal to the observed difference of bearing of A and B. This, the author thinks, is the most accurate method where these small differences are concerned.

TABLE I.

Call Sign	Route	Wave-length	Delay	Distance of Scattering Source	
		m.	sec.	km.	
FW	Paris to Buenos Aires ..	14·6	0·0095	1,423	
GBJ	Bodmin to South Africa ..	16·15	0·0144	2,163	
GBI	Grimsby to India	16·2	0·0130	1,945	
GLH	Dorchester to New York ...	22·1	0·0144	2,166	
GBH	Grimsby to Australia ..	26	0·0150	2,260	
GBK	Bodmin to Canada ..	32·6	0·0131	1,967	Night
GBJ	Bodmin to South Africa ..	34·2	0·0895	1,341	Night
GBI	Grimsby to India	34·3	0·0144	2,163	Night
GLL	Dorchester to Cairo ..	21·85	0·0296?	4,440	Scanty result

The results in Table 1, though rather few in number, show on the whole (except for GBJ working South Africa on the longer wave at night, and for GLL working Cairo, for which the observations are few) a remarkable consistency, being mostly in the neighbourhood of 2,000 km., although FW is rather smaller.

The scattered ray in general has to travel nearly 4,000 km. further than the direct ray (if it exists). This would mean a delay of the order of 0·0133 sec. It is hardly necessary to emphasise how well this agrees with the delay of short-wave echoes observed by Taylor and Young,* etc., and in the later part of the paper there is further evidence confirming this figure.

It is obvious from these results that quite an appreciable amount of energy is scattered back from distances of about 2,000 km.—rather a remarkable result. The significance of these observations in explaining the scattered bearings from broadcasting stations is clear (broadcasting used in the general sense as being non-directional). It seems in particular that all regions of the layer are equally or nearly equally capable of scattering energy. The echo and direction finding results are not, in fact, due to reflection from some particular region of discontinuity in the Heaviside layer, as has been suggested by some writers. A broadcasting station will scatter energy uniformly or nearly uniformly all round the receiver.

The interpretation of the balance aerial experiments and other direction finding experiments on broadcast transmissions which gave no apparent bearings is com-

* "Proceedings of the Institute of Radio Engineers," 1928, Vol. 16, p. 561.

pletely confirmed. Observations of broadcast stations will, however, disclose any lack of uniformity in scattering if this exists in any marked degree, and the Dutch stations have given illustrations of this effect, but the beam bearings seem to show the existence of scattering in *some* degree *in all directions*.

The Balanced Frame and Vertical Aerial, giving a cardioid diagram, give a very clear indication of scattering.

The arrangement consists of a frame coupled to the receiver and a vertical aerial coupled to the frame aerial with a variable coupling M but not directly coupled to the receiver.

With an ordinary unscattered signal the E.M.F. in the vertical aerial can be made to balance that in the frame with suitable coupling M and phasing of the currents in the vertical aerial, and position of the frame, but under scattering conditions, say in the skip distance, the conditions are quite different, for it is observed that no balance position can be found and that the signal is a minimum when M is zero, *i.e.*, when the vertical aerial contributes nothing to the E.M.F.

The physical reason for this behaviour of the cardioid receiver can be expressed in a few words, if we assume that the received energy is scattered. The *energies* received by the aerial and frame are in this case added independently of phase, and there is always more energy when the two are coupled than when M is zero. Hence the minimum when M is zero. It seems impossible to explain these observations except in terms of scattering and we may consider them as another proof of the existence of scattering.

Multiplicity of Signals.

Short Echoes, etc.—It has been tacitly assumed that there are a large number of rays arriving simultaneously (or nearly simultaneously) at the receiver, when the signals are scattered. This, of course, implies multiple paths, and since these are not necessarily of the same length we should expect delayed signals and in extreme cases separate echoes. For this study the method of recording signals is undoubtedly the most fertile. Although we have not yet made a special study by this method, so much has been published that there is plenty of material to consider in the light of our scattering results. The two studies are complementary and neither alone tells the complete story. A casual study of the results obtained by E. Quäck,* Hoyt Taylor and Young,† Breit and Tuve, Tuve and O. Dahl,‡ Breit, Tuve and O. Dahl,§ R. A. Heising,|| Hoag and Andrew,¶ undoubtedly furnishes examples of multiple signals, but usually two, three or possibly four multiple paths, and not the large number of paths which our observations on local beams imply. It may, therefore, be well to reconsider the question in the light of these echo results, and to attempt a reconciliation. Consider at the outset the effect of two or three rays exhibited by the records of echo signals. Thus, for instance, two signals 90° out of phase and perpendicular to each other in the horizontal plane will produce a rotating field in the goniometer with no indication of direction, but this is only if the two signals are equal. If the phases were not 90° apart, a more or less well-

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A composite dot will consist of a number of separate contributions each of the shape of a dot, having between the elements time intervals depending on the difference of path length. The effect will be to broaden the dot and possibly to blur the start and finish. As a rule, unless the record of the received dot is compared with the record of the original there is nothing, except possibly the blurring, to show whether it has been broadened. There are, however, cases where, in effect, a broadened signal can be compared with the original. In certain cases there will be an echo which has traversed the globe, together with the direct signal. In such cases the echo signal will be but slightly scattered. These echo signals will always give good bearings, while the local dot will, in general, be scattered and composite, and therefore broadened. An example of this is shown in the records taken by Quack, where the initial signals in practically every case shown are of greater duration than in the echoes.

This effect was referred to in the author's previous short-wave paper, but the explanation did not occur to him until later. From the difference in length of the direct and echo signal we can get an estimate of the extreme difference in path between the elements of the composite scattered signal. Thus, in the case of the 15 metre station (AGA) at Nauen, received at Geltow, the initial dot is between 0·0129 and 0·0098 sec. longer than the echo signal. The end of the latter is not very well marked, hence the uncertainty. This corresponds to an extreme difference in path of between 2,940 and 3,600 km., and is in rough agreement with the figures arrived at by triangulating the source of the beam scattering.

Even the signals from 2XT (New York, $\lambda = 15$ metres) are slightly broadened in the short path as compared with the echo, there being a difference of time of 0·00444 sec., corresponding to a path difference of 1,332 km. With the correct set of conditions one might expect the short duration pulse signals used by Breit and Tuve and others to show a broadening. R. A. Heising has mentioned cases of these, but attributes them to movements of the layer. The blurring effect at the beginning and end of signals is shown in the records taken by Hoag and Andrew, in particular the wedge-shaped distortion labelled " B " in his type figure.

The experiments described here seem to put the existence of scattering beyond doubt, but as to the cause of this scattering only conjectures can be made. It seems clear in any case that the Heaviside layer must consist of patchwork structure of ionic clouds.

The mesh of this structure must be large compared with the wavelengths considered, and it seems probable from physical considerations of diffusion that the scattering layer cannot be much higher than 120 to 130 km. The existence of such scattering makes the theory of short-wave transmission, which is already complex enough, even more so, but in considering the usual ray theory, the existence of scattering will have to be taken into account before a complete theory can be formulated.

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A WIRELESS BEACON CABINET TRANSMITTER

TYPE W.B.2

The use of an automatically operated Wireless Transmitter situated on land and sending a code signal is unquestionably of great use for marine navigational purposes.

With the Marconi set to be described below, which is entirely self-operating with the exception of the manual winding of the clocks, only about ten minutes' attention is necessary once a week, with an occasional overhaul at protracted periods.

Such a transmitter is especially useful in times of fog, when the signal which is generally sent only a few times every hour, can be continuously transmitted.

THE Type W.B.2 Beacon Transmitter is designed in as simple a manner as possible to give the most efficient and constant automatic service that could possibly be desired in a set of this type.

The complete installation includes :—

1. The transmitter.
2. One clock switchboard.
3. Two Venner time clocks.
4. Two character wheels.
5. One A.C. switchboard.
6. Two 750 watt motor alternators.
7. Complete automatic charging plant and battery.

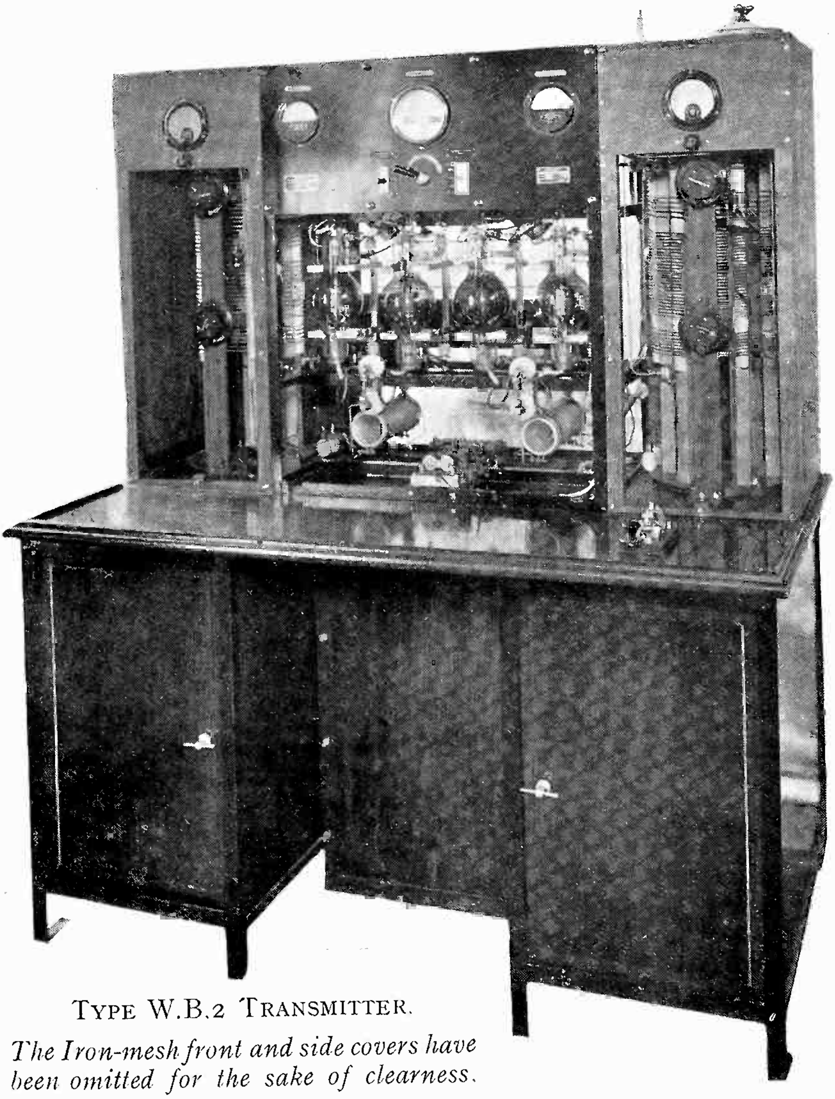
Transmitter.

The transmitter is designed to take a total input of 750 watts, and to operate on I.C.W. only. Consequently no smoothing system is provided. A diagram of connections of the transmitter is shown below. It will be seen from this that a system of double wave oscillation is employed. That is to say that each of the two valves employed only oscillates on that part of the input voltage which is positive with respect to its filament. This may be shown more clearly in Fig. 1, where the anode circuits of each valve are shown simplified.

It will be seen that the secondary of the power transformer has its mid point earthed, and this point will always be at a node of potential. The set is keyed from the primary of the power transformer.

The aerial is tuned by means of inductance taps and a variometer, and is coupled to the closed circuit by means of a variable coupling coil. The closed circuit also consists of an inductance tuned by means of taps and a variometer. Reaction is applied to the grids of the oscillators by means of a variable coupling coil in this circuit. A simplified diagram of the oscillation circuit is shown below (Fig. 2). In this diagram only one of the two valves is shown, and the positive half of the wave is assumed to be impressed on the anode.

The waverange of the set is nominally from 950—1,050 metres, but it is usually desired to work on a spot wave in the vicinity of 1,000 metres.



TYPE W.B.2 TRANSMITTER.
The Iron-mesh front and side covers have been omitted for the sake of clearness.

The two valves used for the oscillator are duplicated, so that in all four valves are mounted in the set. If either of the filaments of the two valves in use burn out, the alternative valves are connected and the old ones disconnected by the action of a hot wire relay, which, besides changing the valves causes a loud speaker connected to a transformer in the filament circuit of the valves to hoot, thus warning the custodian of the set that the first set of valves needs replacing. The valves used in the transmitter are T.250's. The filaments of the valves are also lit by A.C. from a separate filament lighting transformer. Apart from the above facts and the general sturdy and foolproof construction of the transmitter no further details need be given of this part of the installation.

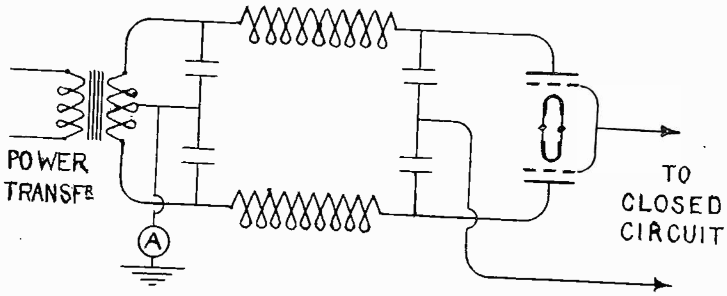


FIG. 1.

Action of the Transmitter.

As has been previously mentioned, this set is designed to send out pre-arranged signals at certain definite intervals of time. The whole installation is controlled and keyed by means of the Venner time clocks. Each of these clocks controls two sets of contacts. The first of these contacts on closing start one of the motor alternators and one of the character wheels. 45 seconds after the first contact has closed the second contact closes, and by engaging the clutch on the character wheel, keys the set.

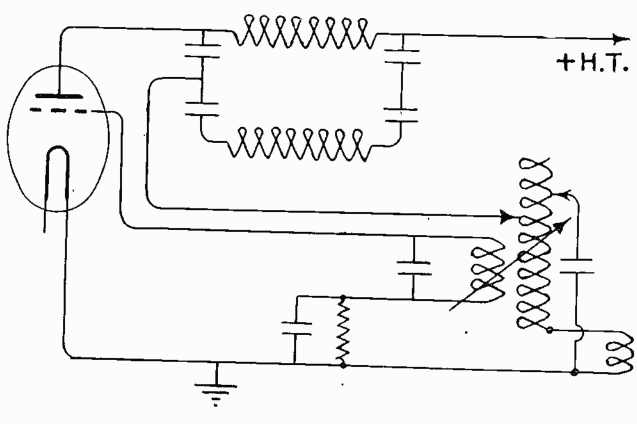


FIG. 2.

Two double throw switches on the switchboard are provided for changing the clocks and character wheels. A tumbler switch marked FOG/FINE enables a continuous series of signals to be sent in foggy weather. This is accomplished by shorting two contacts of the clock switch, thus rendering the No. 1 contacts of the clock inoperative and allowing the No. 2 contacts to key the set as in the FINE position.

A dimming resistance in series with the secondary of the lighting transformer allows the valves to be run with dim filaments when the set is on space. On mark the No. 2 contacts of the character wheel short this resistance, thus bringing the filaments of the valves up to their normal brilliancy.

In this way the life of the valves is considerably lengthened.

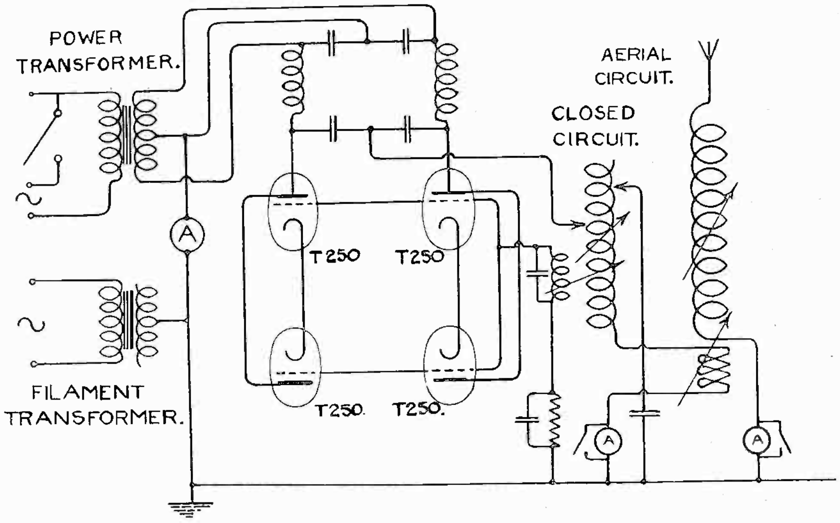


FIG. 3.

A simplified diagram of connections of the transmitter is shown in Fig. 3.

Character Wheel.

The character wheel consists essentially of a steel wheel on which certain projecting portions are cut corresponding to the signal that is desired. This wheel is driven from a worm drive from an electric motor. The wheel is normally separated from the drive by means of a clutch which is pulled in by means of a 50 volt solenoid provided with an economy resistance. The code wheel is provided with three contacts, whose functions are as follows :—

No. 1. Operated by code wheel itself and used to key the set.

No. 2. Used to operate the dash signal, which is normally of 10 seconds' duration.

No. 3. Closes shortly after the No. 2 contacts of the clock and connects two contacts in parallel with these No. 2 contacts. Its function is to take the load off the No. 2 contacts of the clock after these have been closed for 45 seconds only.

Power Supply, etc.

The power supply for the set is derived from a 50 volt battery of accumulators. These are charged from one of two Crossley engines. A master switchboard controls the whole of the charging and discharging arrangements. This switchboard is provided with a series of relays which cut in extra cells as the voltage of those in use drops; and when the cells are discharged, automatically starts one of the engines and arranges for the charge to be continued until the battery is completely charged again. The two engines are started alternately so that equal wear is given to both.

WIRELESS RECEIVING SETS

Marconi Company's Licence Upheld in Courts of Justice.

At the moment of going to Press, June 18th, two important decisions in favour of Marconi's Wireless Telegraph Co., Ltd., were given by Mr. Justice Luxmoore in the British High Court of Justice.

These judgments concerned the granting of licences to manufacturers under the wireless broadcast and valve patents controlled by the Marconi Company, and reversed decisions given in a Lower Court by the Comptroller of Patents, who granted compulsory licences in favour of the two manufacturing companies concerned.

In the first case, the Brownie Wireless Co. of Great Britain, Ltd., desired to commence the manufacture of valve receivers, but objected to the form of licence offered to them. They alleged that such licence would be injurious to their business, and was an abuse of the Marconi Company's monopoly rights, and they, therefore, asked the Comptroller to grant them special terms under particular patents in order to enable them to produce cheap wireless sets. The licence offered by the Marconi Company was the general form of licence granted by that Company to the majority of their licensees, who numbered at the time of the application over 2,000.

The Judge reversed the decision of the Comptroller of Patents, who had granted a licence in the terms asked, and held that the main conditions of the Marconi standard licence were reasonable. He held that no evidence had been brought to show that there was any dissatisfaction in the general wireless trade with this form of licence, or that there had been an abuse of monopoly rights, or that the Brownie Company were entitled to a different form of licence. The Brownie Company's application therefore failed, and the Comptroller's decision was discharged with costs.

The second case concerned an application by the Loewe Radio Co., Ltd., for a licence to manufacture multiple valves in Great Britain. Before proceeding with the manufacture of these valves under Loewe patents it was necessary for the Loewe Company to obtain a licence under the Marconi Company's broadcast and valve patents.

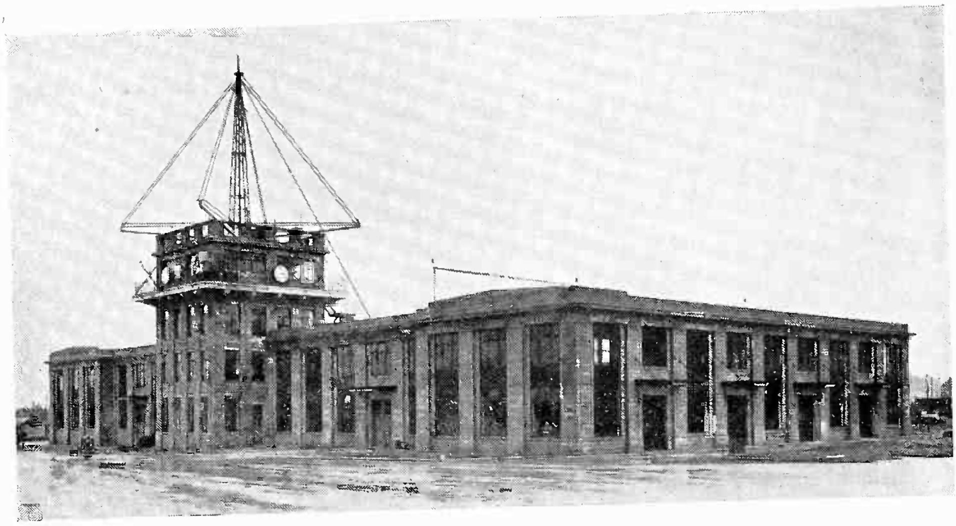
The Loewe Radio Company applied to the Marconi Company for a licence under certain patents. After negotiations had proceeded for some time the Loewe Company decided to apply to the Comptroller-General of Patents for a licence on terms which differed materially from those offered by the Marconi Company's standard agreement. The object of this proceeding was to enable them to manufacture their valves in England more cheaply, and thus reach a larger public. The Comptroller of Patents decided in favour of the Loewe Company's application, and granted a compulsory licence.

The Judge, on appeal, decided that no case had been made out for the granting of such a compulsory licence, and discharged the Comptroller's decision. The Judge expressed the opinion, however, that some form of licence should be agreed between the parties, and intimated what, in his opinion, should be some of the main conditions of that licence.

MARCONI NEWS AND NOTES

AIRCRAFT WIRELESS

VALUE OF WIRELESS DIRECTION FINDER IN FOG



London Air Port, showing Control Tower and Direction Finding Aerials.

THE use of wireless direction finding for navigation on the airways has become so much a part of the normal organisation that it hardly excites notice to-day, except when some notable achievement brings it to public attention.

Such an instance occurred on March 26th when the Prince of Wales flew from France to England. There was a dense fog over the Channel, but so experienced are the Airways pilots in making the journey in fog, with the aid of the Marconi Wireless Direction Finder, that there was no hesitation in making the trip with the Prince.

Describing the flight in an interview with a London newspaper, Captain O. P. Jones, of Imperial Airways, who was the pilot, said :—

> "We saw nothing but the floor of the cloud-tops beneath us from half-an-hour after leaving Le Bourget until we arrived at Croydon, but . . . with a multiple-engine machine and wireless direction finding, the risk of having to make a forced landing is negligible."

The London Air Port and all Imperial Airways passenger machines are equipped with Marconi Wireless apparatus. It is also used in over 30 other countries.

No. 2. Used to operate the dash signal, which is normally of 10 seconds' duration.

No. 3. Closes shortly after the No. 2 contacts of the clock and connects two contacts in parallel with these No. 2 contacts. Its function is to take the load off the No. 2 contacts of the clock after these have been closed for 45 seconds only.

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Other instances of the use of the Direction Finder.

The following letter, which has been received by the Marconi Company from the Société Anonyme Belge d'Exploitation de la Navigation Aérienne, is a further tribute to the excellence of Marconi aircraft wireless and direction finding apparatus, and to its value in aerial navigation :—

> " We beg to advise you that all the pilots of S.A.B.E.N.A. are delighted at the services rendered by the wireless and the land direction finding sets, and it is thanks to the installation of these sets that the S.A.B.E.N.A. is able to operate between Brussels and London with such well known regularity. As a case in point, on the occasion of the last voyage of M. Lippens, Minister of Aviation, our pilot M. Cocquyt was able, thanks to direction-finding and to the Marconi installation on board, to effect the flight above the clouds, for a period of more than 2 hours, without any land observation other than the radiogoniometric observations transmitted by wireless."

Instances of this kind are constantly being reported to the Marconi Company, and it will be remembered that Captain Wilcockson and other well-known Imperial Airways pilots have flown from Paris to Croydon in foggy weather with hardly a sight of the ground throughout the journey.

Captain Wilcockson's experience.

These circumstances show the degree to which the standard Marconi wireless apparatus used on Imperial Airways machines flying between Croydon and the Continent is relied upon, and Captain Wilcockson's experience in piloting a Handley Page Rolls Royce aeroplane from Paris to Croydon above a fog bank which obscured the ground practically the whole of the way, is worth recalling.

In spite of the denseness of the fog Captain Wilcockson completed his journey in 2 hours 26 minutes, which is a good average time for the trip from Paris to London. When he started from Le Bourget at 8 a.m. visibility was about 1,000 yards, and the weather report gave fog over most of the route except for patches of clear weather near the French coast and at Biggin Hill. Five minutes after leaving Paris Captain Wilcockson found himself in dense fog and had to rise 2,000 ft. to get above it. At this height the aeroplane was flying in bright sunshine and continued to do so for the greater part of the journey. It was, however, necessary to fly entirely by compass bearing. The pilot asked for several bearings and positions from Croydon during the journey and these brought him in on a direct line to the Croydon Aerodrome. There was one break in the fog, about 10 miles from Croydon, which enabled the pilot to recognise the ground and corroborate the fact that he was on the right bearing. The fog then closed in again and in his own words he " dropped right on the aerodrome," In an interview Captain Wilcockson said that this was one of the worst fogs he had ever experienced, but he had no doubt during the whole journey that he would get through in comfort as his past experience with his wireless apparatus had given him confidence that he could navigate on bearings through the fog, however dense it might be. "I had no difficulty at all in keeping in communication with Croydon at any time, whether I was in the fog, above it, or when coming down to the aerodrome, but it would have been impossible to have made the journey without wireless" Captain Wilcockson said. "The apparatus I was using was the ordinary A.D.6 apparatus and not any new or special apparatus."

There were five passengers on the machine. They had a very happy and comfortable journey and were quite thrilled with their novel experience.

Handicapped by lack of Wireless.

An instance of the handicap from which pilots suffer when they do not carry wireless on long distance flights was provided during the flight of Flight Lieutenant Moir and Flying Officer Owen of the Australian Air Force, from England to Australia. After taking off from the Isle of Sumbawa in the Dutch East Indies on May 17th no news of them was heard for ten days until, after diligent search, they were found by another flying officer near the Cape Don Lighthouse, Northern Australia.

As the *London Times* remarks in a leading article, "the only clear lesson of the adventure so far is the old lesson that machines for long and adventurous flights should carry wireless and be provisioned and equipped to meet emergencies." "Wireless," *The Times* said, "also appears indispensable for lighthouses like the Don, situated on coasts far from the aids of civilisation."

The Excellence of G5SW.

In the South African *Merry-go-Round* of May 15th appears a striking tribute to the efficiency of the London Experimental Short Wave broadcasting station—G5SW—which is operated at Chelmsford by the Marconi Company for the British Broadcasting Corporation. This station is described as the "star" station for South African listeners.

The writer in the *Merry-go-Round* continues :—

> "This station is experimenting with two types of aerials and reports are requested. Announcements regarding times of tests are put over at 10, immediately after the time signal. Antenna A is as perfect as I expect they will ever get it. The old complaints *re* wobbly note, poor signal strength and too many talks have all vanished, and instead we have a dead steady note with small loud speaker strength, and few or no talks after 9 o'clock. It is a real pleasure to listen to this station, and everyone I meet has nothing but praise for G5SW."

Marconi Installations for Entertainment at Sea.

A new Marconi installation, which is likely to have a wide appeal, was used for the first time on May 23rd, on board the "Crested Eagle," a pleasure steamer, belonging to the General Steam Navigation Company, voyaging between London, Margate and Ramsgate.

On board the "Crested Eagle."

The installation consisted of a central microphone and loud speakers, at various points, by means of which passengers were entertained, throughout the journey, by music and a description of the places of interest on the coast.

While the programme could be heard in comfort by passengers in nearly all parts of the ship, one part of the ship was reserved for passengers who preferred to sit in quietness. The installation was so arranged that loud speakers could be plugged in or disconnected at any point according to whether or not they were required.

At a luncheon given on board the "Crested Eagle" Mr. Stanley Sparkes, a Director of the Company, said the General Steam Navigation Company intended, with the aid of the Marconi Company, to make the journey more interesting by descriptions and information regarding places seen from the ship and by musical entertainment.

The accompanying photograph gives a view of the "Crested Eagle" and the passengers enjoying the broadcast music and descriptions during the voyage.