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THE MARCONI-WRIGHT FACSIMILE SYSTEM

DESCRIPTION OF THE APPARATUS—II

In the February issue of THE MARCONI REVIEW, *a general description was given of the Receiver and Transmitter used in connection with the above system of facsimile transmission.*

The vital parts of such a system are:—

(1) *The photo-electric cell or other device used in converting the light energy at the Transmitter end.*

(2) *The light-shutter which converts the electrical energy back to light energy at the Receiver end.*

In the second part of this article, therefore, a short description will be given of the action of the photo-electric cell, and of the light shutter, which, in the Marconi-Wright apparatus, utilises the Kerr effect in nitrobenzine.

Finally, a general description will be given of the electrical circuits used in the apparatus.

The Photo-electric Cell and Transmitter.

THE photo-cell used in the apparatus is of the gas-filled type and depends on the photo-electric effect, or the emission of electrons from the surfaces of some metals when light falls upon them. These electrons can be collected by a suitable positively polarised electrode in the circuit of which will flow a current varying with the degree of light falling on the sensitive surface of the cell.

Now, the response of such a cell is not linear, that is to say, the current does not increase in direct proportion to the frequency of the interrupted light falling on the cell. In any circuit employing such a cell, therefore, some correcting circuit must be employed and adjusted to give a steady voltage across its output circuit for a considerable variation in the frequency of the received light.

The signals from the photo-electric cell are amplified by a cascade amplifier and are passed through filters, etc., to the line (Fig. 1). It is found that a certain amount of filtering is necessary in order to cut out all low-frequency components produced by microphonic action of the photo-cell, valves, electrical induction from commutators, etc.

The signals from the line are applied to the input of the power-transmitter, and modulate its carrier wave in the usual way.

Check circuits are provided to enable the voltage of the outgoing signals from the photo-cell amplifier to be read, in order to obtain a relative measure of the signal being put to line. In practice some definite signal strength is decided upon and the signal is maintained at this strength by adjustment of the photo-cell polarising voltage.

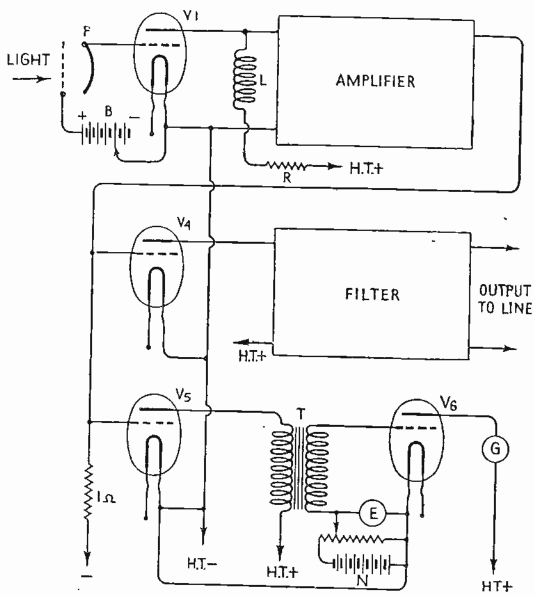


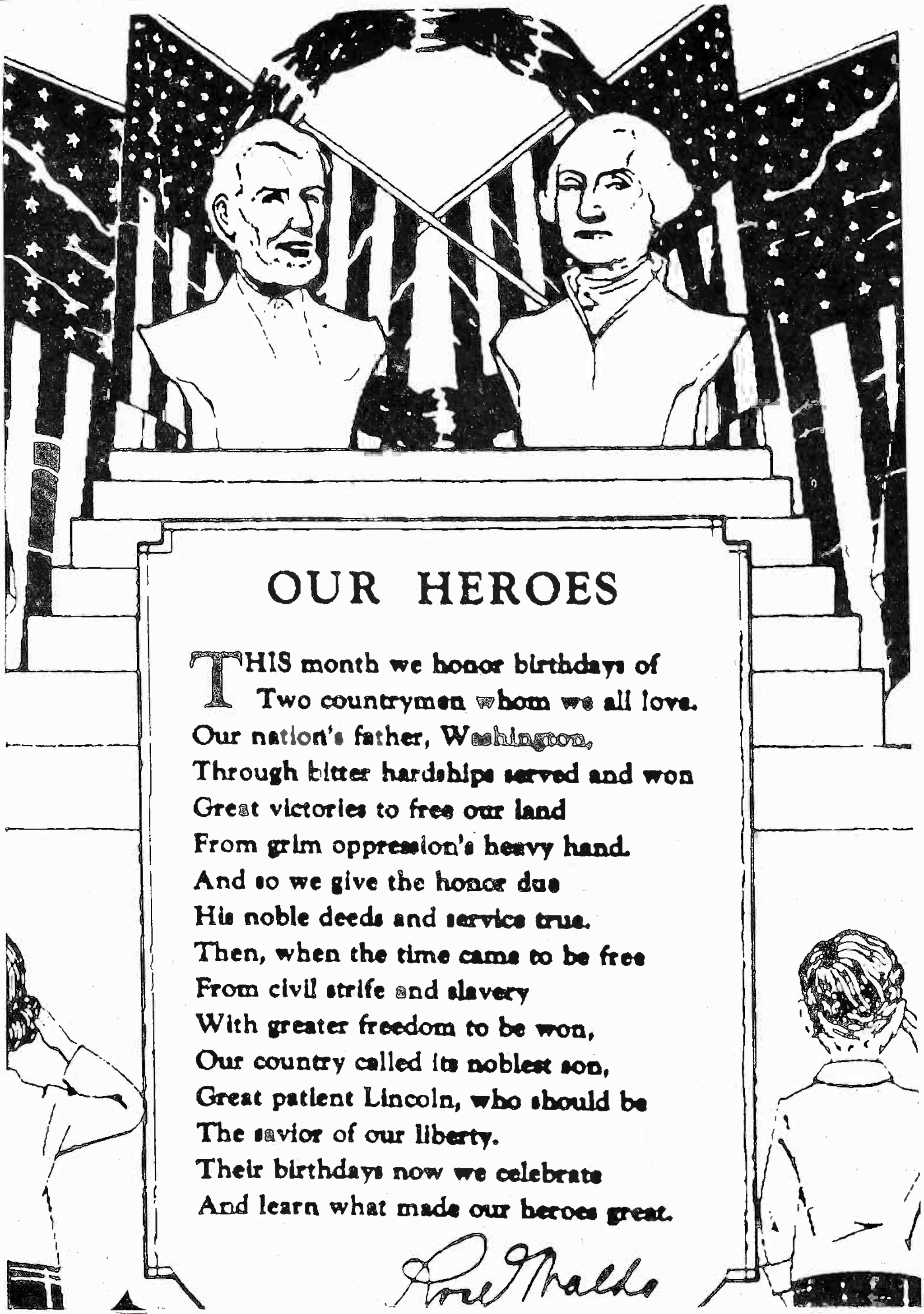
FIG. 6.

The photo-electric cell is contained in a box together with its polarising battery. Potentiometer control of this battery is arranged so that its voltage can be conveniently and quickly varied.

The amplifier, filter system, etc., are housed in metal-shielded units which are supported in iron frames. A control switchboard is provided with all necessary instruments for correct setting of H.T. and L.T. voltages, feeds, etc.

Action of Kerr Cell.

The "light shutter" depends for its action on a physical phenomenon investigated by Kerr in 1875. Kerr found that certain substances exhibit the property



Full scale reproduction of part of a facsimile received across the Atlantic by the Marconi-Wright system.

of double refraction when subjected to an electric stress. The manner in which this effect is applied can be seen by a consideration of Fig. 2.

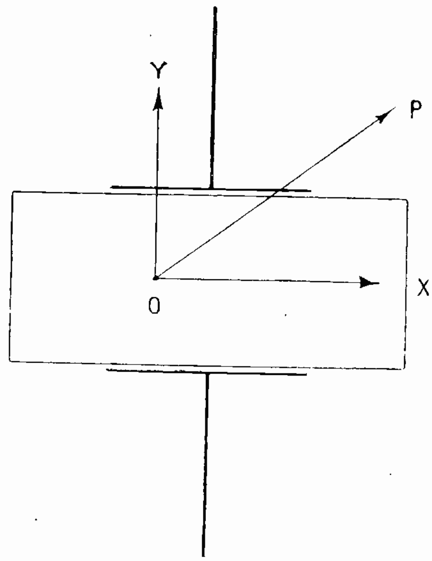
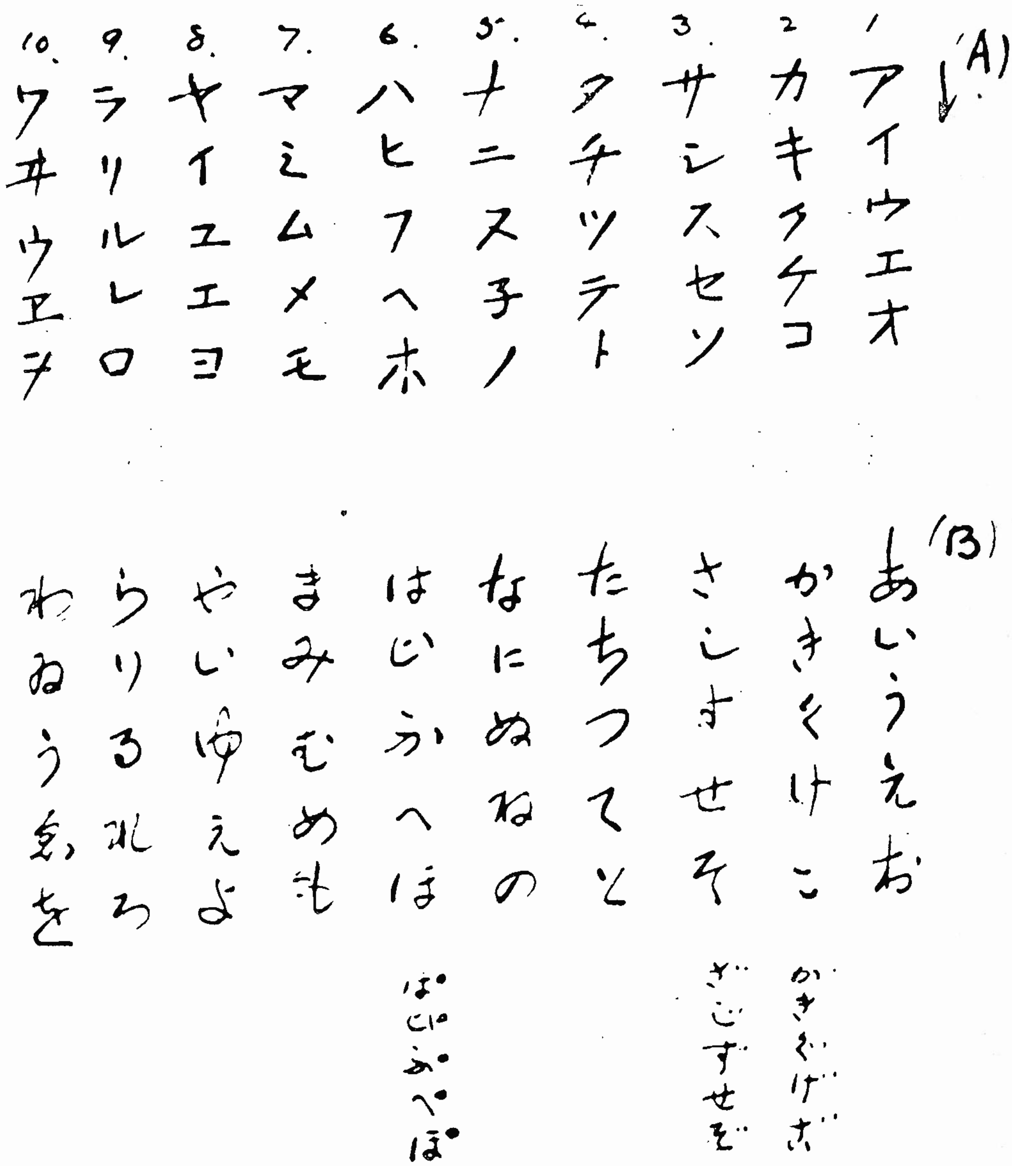


FIG. 7.

In this figure is shown a piece of dielectric interposed between a pair of plates. By applying a voltage to these plates we can stress the dielectric. Now consider a ray of light O passing through the dielectric in a direction perpendicular to the plane of the paper and polarised in the direction OP. This ray can be resolved into two rays polarised in the directions OY and OX. When the transparent dielectric is unstressed these two components pass through a medium with equal velocities, and arrive at its further boundary in phase. The plane of polarisation OP of the initial ray is therefore unchanged, but if an electric force be applied between the pair of plates, then it is found that the component OY, whose direction coincides with that of the lines of force, travels with a different velocity from the component OX at right angles to the direction of the force. The result is that there is a phase difference between the two components on emerging from the dielectric, and consequently the resultant ray is elliptically polarised. This effect is utilised in the receiving machine in the following manner.

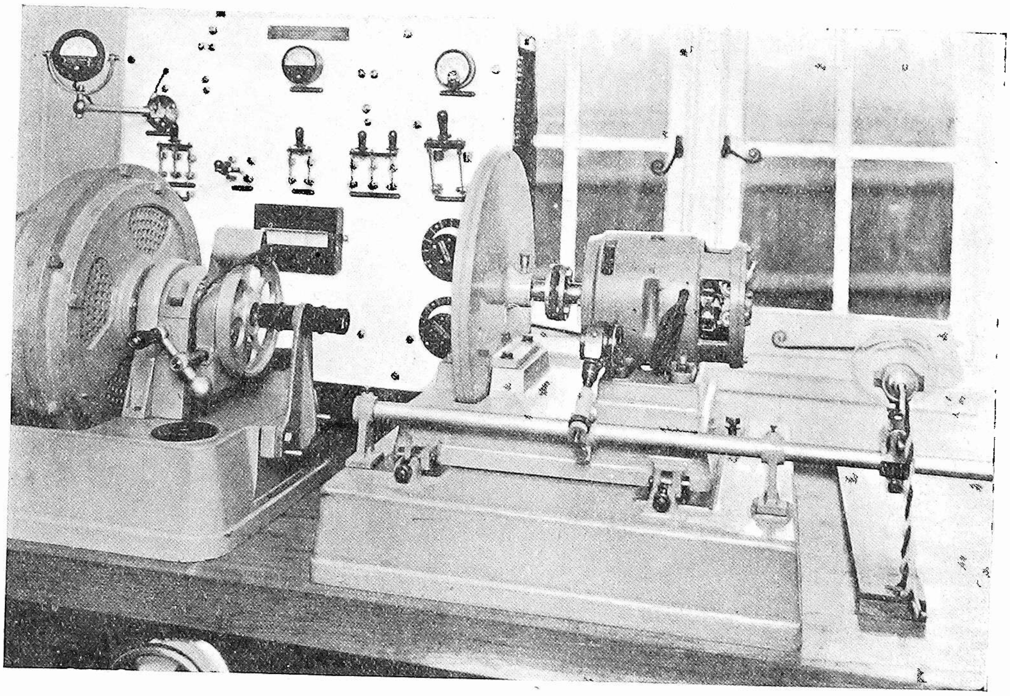
A nicol prism polarises a ray of light in the direction OP (*i.e.*, at 45° to the direction of the applied electric force). After traversing the dielectric, which in this case is nitrobenzine, a second nicol prism is arranged so that the light is completely cut off when there is no potential difference applied between the electrodes. If now a sufficiently intense potential difference be applied to the electrodes, then since the emerging light is elliptically polarised, it is no longer completely cut off



Full scale reproduction of part of a facsimile illustrating the capacity of the system to deal with oriental script. The limiting size of the picture is 9 ins. by 7 ins.

by the second nicol prism, with the result that light can now pass through the complete combination. This device is extremely rapid in action, the lag being quite negligible for the highest frequencies involved in picture reception speeds at present contemplated. It should also be noted that since pure nitrobenzine is a fairly good insulator, the power required to operate the device is very small.

The Kerr cell used simply consists of a glass chamber having parallel sides in which are supported a pair of rounded electrodes. One electrode is carried by a micrometer head, whereby the working gap can be conveniently adjusted to the best length. The Nicol prism is supported in a brass holder by means of cork insets, the whole being finally fixed by running in paraffin wax. The mounting is closed at each end by glass optical flats forming a completely dust-proof case. This protection is necessary inasmuch as the prisms are easily damaged permanently by finger marks on the end surfaces. The general arrangement of the optical parts has already been shown in the first part of this article in the February issue (Fig. 5). The lamp L is contained in the cylindrical box at the right-hand end of the optical tube. This lamp is supported in such a manner that it can be traversed sideways, or raised and lowered by the milled heads which can be seen on the base of the lamp



Photograph illustrating chopper disc on the right and stroboscopic device for synchronisation mounted on the motor shaft on the left.

box. The lens A is supported inside the optical tube, and its distance from the lamp can be adjusted by means of a knurled ring situated close to the lamp box. A knurled ring also operates the nicol prism carrier and is used for adjusting the relation between the plane of polarisation of the light and the axis of the gap in the Kerr cell. A second knurled ring is provided for adjusting the distance between the lens C and the electrodes in the cell. The cell itself is carried in a box, and its position can be set by means of four screws seen, which are afterwards locked. The position of the lenses A and C are so adjusted that a sharp image of the lamp filament of suitable size is formed on the gap in the cell. The lamp is a standard 12v. motor-car head lamp. The light emerging from the cell is collected by the lens D which is capable of adjustment. The position of this lens is set so that a sharp spot is formed on the message surface. The second nicol prism E can also be accurately adjusted with respect to the rest of the system.

In order that the condition of the gap may be readily inspected, a right-angled prism is fitted at the end of the optical tube, and by pulling out a knob, this prism can be interposed in the path of the ray when the gap can be inspected and any necessary adjustment made. A general view of the receiving machine has been shown in Part I of this article, and calls for little comment. It will be observed, however, that the flexible band for traversing the message receiving surface in this case consists of a thin piece of celluloid. A transparent band is used in order that the position of the received message on the bromide paper may be observed during reception. Since the transmitting and receiving rotors are revolving in synchronism,

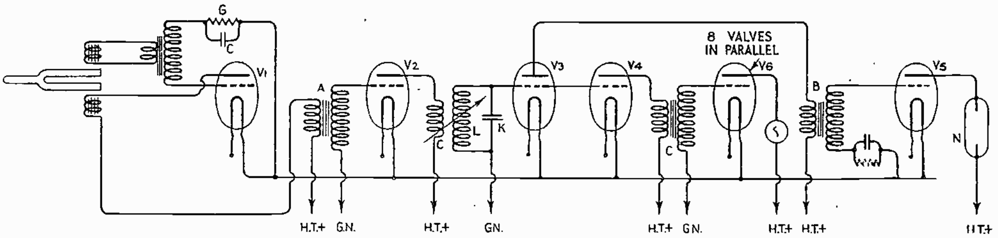


FIG. 8.

the position of the arriving message in the receiving machine can at once be seen by eye, as owing to the persistence of vision the transmitted message appears as a white streak on the receiving surface, and its edges are quite clearly defined. Should

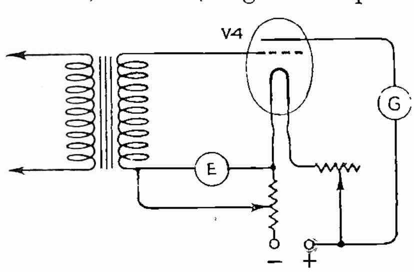


FIG. 9.

this streak not be visible completely from end to end, then it is at once known that the receiving rotor is not in phase with the transmitter, and the necessary adjustment can be made.

The manner of carrying out this phase adjustment is as follows: A handle situated immediately in front of the driving motor is geared to the carcase of the driving machine; this machine is mounted in trunnions just as was explained in the case of the transmitter, and by means of the handle the whole field magnet system can be rotated, and so the phase position of the rotor adjusted. The synchronism and speed control gear is precisely the same for both transmitter and receiver, and calls for no further comment here. A diagram of the tuning fork circuit is shown in Fig. 3. The tuning fork T is maintained by the valve V_1 in the usual manner. The valve V_1 is coupled to the valve V_2 by means of the transformer A. V_2 is arranged to give an output wave form which is rich in harmonics. In series with the anode of V_2 is a coupling coil inducing an E.M.F. in the resonant circuit LK. This circuit is arranged so that either the fundamental or the second or fourth harmonic of the fork frequency can be selected. In this way the current flowing in LK can be adjusted to be either 300, 600 or 1,200 cycles. This allows of speed adjustment of the optical rotor without changing the frequency of the tuning fork itself.

The alternating potential across LK is applied to the grids of the two valves V_3 and V_4. The output from V_3 is utilised, *via* the transformer B and the valve V_5, to produce a glow discharge in the neon tube N. This tube illuminates the stroboscope wheel on the driving motor spindle, and is used for the operation of sychronising. The output from V_4 is applied through the transformer C to the grids of the bank of eight valves V_6. The anode current to these valves passes through the armature winding of the synchronous motor in the driving machine, thus maintaining it in synchronism with the frequency of the tuning fork or with that of some selected multiple.

A peak voltmeter mounted on the receiver switchboard is provided for indicating when the correct voltage is being applied by the received signal to the electrodes of the Kerr cell (Fig. 4). This indicator is merely a normal "slide-back" voltmeter applied to a few turns on the core of the Kerr cell transformer. The transformer is mounted behind the switchboard.

The switchboard calls for little comment, being similar to that employed for the transmitter.

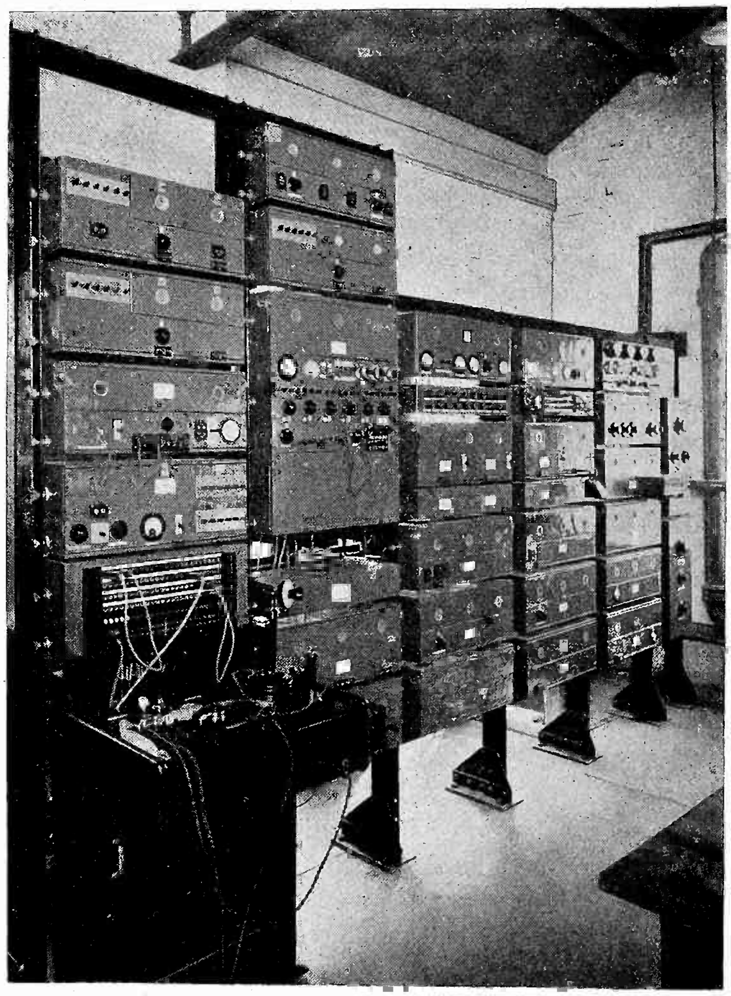
The general methods of operation are identical with those described in connection with the transmitter. The same mechanical arrangements for clutching and declutching the message carrying band being employed in both cases.

G. M. WRIGHT.

THE MARCONI-MATHIEU METHOD OF MULTIPLEX SIGNALLING

DEMONSTRATED BETWEEN BEAM STATIONS

ON the 20th May, 1928, the first demonstration of Multiplex working across the Atlantic was given by the Marconi Company between the Beam Stations in Canada and England. As on this occasion a Multiplex receiver was not available for the Canada end, simplex multiplex working only could be shown.



Lately, a second receiver has been installed in Canada, and a series of duplex multiplex tests which were carried out on Friday, March 1st, 1929, before officials of the Marconi and Canadian Companies with excellent results, have fully justified all the claims that have been made for the apparatus.

The illustration shows a comprehensive view of the multiplex receiver. A complete description of this will be given shortly in THE MARCONI REVIEW.

The system, as developed at present, permits of the super-position of three modulation channels of communication—two telegraph and one telephone—on one transmitter carrier wave. These three modulations are separated at the receiver end and individually transmitted over their respective landlines to their destinations.

Ingenious methods for the almost complete elimination of fading, the worst enemy of short wave reception, are provided for in the receiver, both in the case of telegraphy and telephony.

These anti-fading devices are based in the well known selective fading properties of the short waves.

The equivalent of sending simultaneously the same messages by two transmitting stations sending on slightly different wavelengths is obtained by modulating the transmitter with frequencies of the order of 7,000 and 9,000 cycles, thus producing side bands respectively 14,000 and 18,000 cycles apart. At the reception these side bands are separated, amplified and the direct current component of the rectification recombines to produce the signals.

It can be shown that the strength of the rectified signal depends on the strength of its carrier. That is to say, if the carrier fades to a very low level or disappears entirely, the side bands, although possibly very strong, will produce no signal after rectification. The new system, therefore, provides for the suppression at the receiving end of the variable carrier, and its reintroduction at the receiver by means of a strong and steady local oscillation.

In the case of the telephone channel, the variable carrier wave is used to work an instrument called the Automatic Gain Control which regulates, by means of relays, an attenuating distortionless network connected between the output of the detector circuit and the low frequency landline repeater.

The photograph shows not only the Multiplex receiver, but also the telephone terminal equipment which permits the extension of the radio 4-wire circuit to any 2-wire subscriber line. These apparatus involve a new system of echo suppressors and measuring apparatus, which will be described later.

The whole receiver, etc., is built up on the unit system, and consists of copper-shielded boxes supported in steel frames. This construction facilitates modification of any circuit to meet special requirements.

THE MARCONI-FRANKLIN PRECISION WAVEMETER

This wavemeter has been designed to enable beam or short wave transmitting stations to adjust the wavelength of their radiation with great accuracy.

The large number of stations operating on the short wave band 10-60 *metres, necessitates the use of an instrument of considerable precision for wavelength checking.*

The Marconi-Franklin wavemeter allows readings of wavelength to be taken with a maximum error of ± 500 ∿ *between* 15 *and* 60 *metres.*

A PHOTOGRAPH of the wavemeter is shown below. It consists essentially of three condensers—two fixed, and one variable—and a main inductance frame, which, with the condensers, completes the resonant circuit. The three condensers are enclosed in a heavy brass cylindrical case fitted with an ebonite cover, on which are mounted the main inductance frame and the indicating circuit, the latter consisting of a coupling frame, valve and current indicator. The whole instrument is supported on three ebonite legs.

A diagram of connections of the wavemeter is shown in Fig. 1. The main tuning circuit is seen to consist of the inductance, a variable condenser, a fixed condenser, and an extra small condenser which can be switched into and out of circuit by means of a small push-button switch situated on the front of the brass case, and is clearly shown in the photograph.

The indicating circuit consists of a small single turn frame coupled to the main inductance, and connected, one end through a galvanometer to earth or to a source of negative potential, and the other end to the anode of the indicating valve. The grid of the indicating valve (a D.E.3 type receiving valve) is connected to + 40 v. H.T., and the filament of the valve is supplied with low tension current from two dry cells.

Four terminals, connected respectively to the galvanometer, grid, and the two ends of the filament, are provided on the instrument, and can be connected easily to the requisite batteries.

It will be seen that the indicating circuit is very loosely coupled to the tuned circuit, and, consequently, change of valve, H.T., etc., will have an inappreciable effect on the tuned circuit or its calibration.

The variable condenser of the tuned circuit consists of two fixed sets of plates, and a set of movable vanes which are insulated from the fixed plates. The movable vanes are rotated through a worm drive by a handle which projects from underneath the right-hand side of the base plate.

A pointer, which indicates along a scale on the front base rim of the case, is attached to the spindle of the vanes, so that no backlash can occur between the vanes and the pointer. The pointer is also fitted with a vernier scale to enable readings to be taken with extreme accuracy.

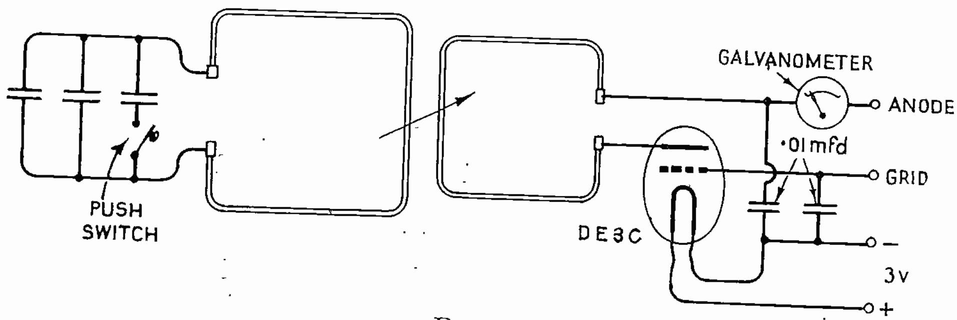


FIG. 1.

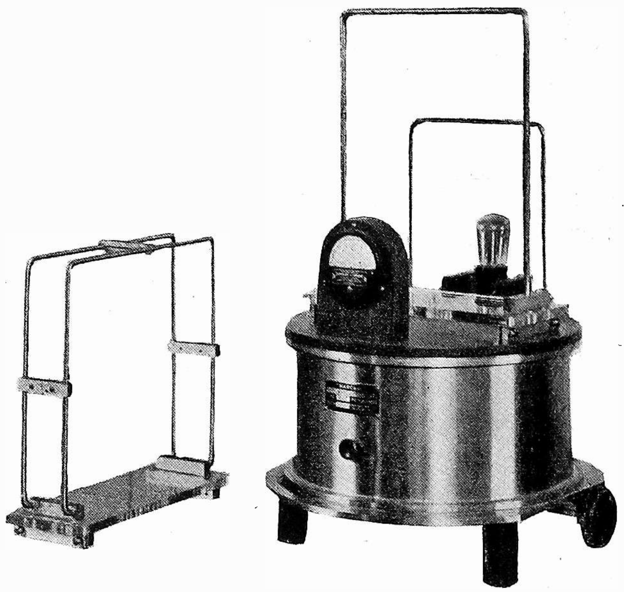
In parallel with this variable condenser is the main fixed condenser of such a relatively large capacity that the whole range of the variable condenser only covers ·5 metre to 1 metre change of wavelength, according to the inductance in use.

The interchangeable inductances consist of frames made of ¼-inch copper rod and supported on a glass base. The connections to the condenser are taken from plugs mounted on the ebonite cover of the wavemeter, which fit into brass sockets attached to the under side of the glass base, and to the frame by means of brass screws. This arrangement ensures complete and constant electrical connection, while permitting the relatively quick change of frames.

Operation.

The indicating valve acts as a rectifier. Until the potential of the anode is made positive by the oscillations impressed on the indicating frame from the main frame, no current will flow in the anode circuit of the indicating valve, because the potential of the anode is the same as, or lower than, the filament. When the main circuit comes into resonance, however, the current flowing in the main frame induces a voltage in the indicating frame, the valve proceeds to rectify and current flows in the anode circuit.

Now if we draw a curve connecting anode current and scale reading of the main variable condenser, we shall obtain such a curve as given in Fig. 2, where A corresponds to the resonance condition. But the curve at A is flat, *i.e.*, the point A is not determinable with great accuracy.



If we now decrease the capacity of our variable condenser till we reach a point B, the curve is very steep, and the point B is determinable with great accuracy. If then we add a small fixed capacity, we shall arrive at some point C on the other

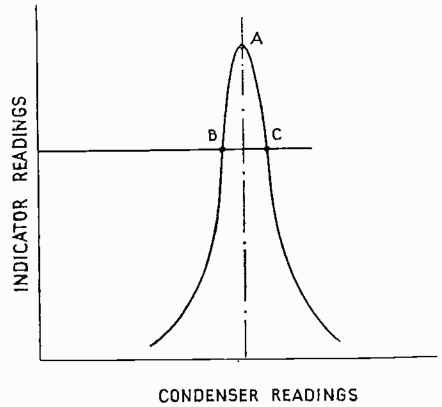


FIG. 2.

side of the resonance curve. We can arrange for the current at B to be equal to that at C by altering the setting of the main tuning condenser.

The scale reading corresponding to B can then be taken very accurately.

This is the principle of the Franklin wavemeter.

By adjusting the variable condenser until equal readings of the galvanometer are obtained with the key pressed or released, we can obtain a point corresponding to which we can read off the wavelength on the chart supplied.

The range of the wavemeter per frame varies from approximately half a metre at 15 metres to 1 metre at 40 metres. As the scale consists of 100 divisions, and the vernier allows an accuracy of reading of one-tenth of one division, it is clear that at 15 metres an accuracy of measurement can be obtained of ·0005 metre, which corresponds to 700 ~ approximately. Actually the scale can be read to a greater degree of accuracy than this, and an overall error of ± 500 ~ can be taken as fairly representing the accuracy of the wavemeter.

THE CALIBRATION OF PRECISION WAVEMETERS BY THE STEP METHOD

In a later article to be published in THE MARCONI REVIEW, *a description will be given of a means of calibrating precision wavemeters using a method based on harmonic selection. In the present article, an alternative method of calibration is given, in which a basic wavelength is accurately measured and other wavelengths obtained from this by stepping this initial wavelength up in small increments.*

The method has been found to give excellent results, and accuracies of the order of 1 *in* 20,000 *can be easily obtained by its use.*

A brief account of the methods usually resorted to in the measurement of short wavelengths by Lecher wires is also given.

IN the description of the Franklin wavemeter given in the previous article, we have mentioned that an accuracy of about 1 in 30,000 can be obtained. This corresponds to approximately 700 ∿ at 15 metres. Such accuracy is not of much use if correspondingly accurate methods of calibrating the wavemeter are not available.

In the system of calibration described below, if the value of the initial wavelength be taken as absolute, the limit of experimental error in calibration should be far less than this figure of 700 in 20,000,000.

It will at once be appreciated that the fixing of some basic wavelength presents the greatest difficulty. If we consider, however, a series of transmitters all tuned by wavemeters calibrated from the same standard this basic wavelength becomes of secondary importance when compared with the separation of the transmitter wavelengths one from the other.

This fact has been borne in mind in connection with the calibration of the wavemeter which was primarily designed to fix the frequencies of the series of beam transmitters erected throughout the world.

A preliminary investigation was first carried out to measure, as accurately as possible, some basic wavelength, and to obtain the reading of the standard Franklin wavemeter when tuned to it.

A system of Lecher wires was erected on the closed loop system.

Two parallel wires AB and CD each approximately 15·5 metres long and separated by about 5 cms. were suspended horizontally from insulators about 6 feet above the ground. The ends B and C were joined.

An oscillator capable of fairly wide frequency variation had its output coil coupled to one end of one of the wires and an indicating circuit was coupled to the wires to determine their resonant frequency. This indicating circuit consisted of a simple turn of wire closely coupled to the Lecher wires and having a crystal detector and galvanometer in series with it (Fig. 1).

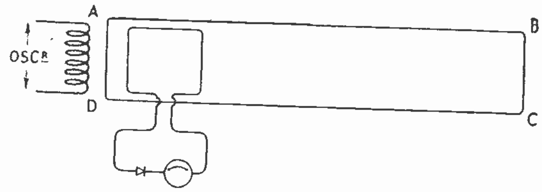


FIG. 1.

An alternative method of indicating the resonant wavelength of the wires would be to couple a powerful oscilator to them, with a milliammeter in the plate circuit of the oscillating valve. As the wavelength of the oscillator is varied a decrease in the reading of this milliammeter would indicate the resonant wavelength. Minor inaccuracies are introduced in both cases owing to the reactive effects of either the indicating circuit or the oscillator on to the wires.

The modes in which such a system of wires can resonate are shown below (Fig. 2) :—

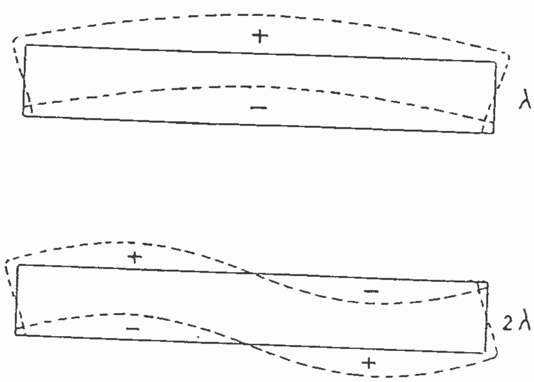


FIG. 2.

In either case it will be obvious that, at resonance, the total length ABCD of the wires will equal

$$\lambda, \; 2\lambda, \; 3\lambda \; \ldots \ldots$$

In the case under consideration, the wavelength of the oscillator was known to be of the order of 15 metres, and the length of the wires was measured with great accuracy. The wavelength of the oscillator was therefore known accurately and a reading was taken on the Standard Franklin wavemeter to serve as a basis for further calibration.

The greatest difficulty was found in designing some stable oscillating system which, while strong enough to operate the wavemeter, not only at the oscillator's fundamental wavelength, but at, maybe, its 3rd or 4th harmonic, would not be "pulled" to any degree by the reactive effect of the wavemeter on it.

Ultimately the form of oscillator shown below (Fig. 3) was adopted. It consists of a simple oscillator driving two stages of bridge coupled magnifiers to an output frame from which the radiation is received by the wavemeter.

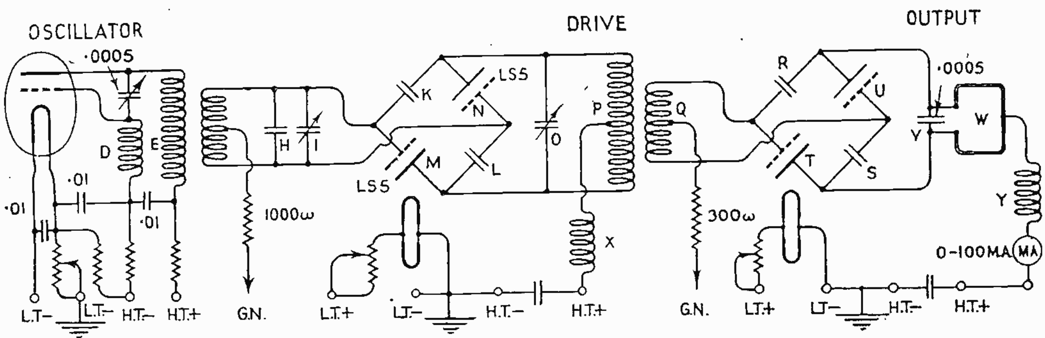


FIG. 3.

Both the input and output circuits of the first bridge and the output of the second bridge are tuned. In this way, both bridges can be tuned to any desired harmonic of the master oscillator.

At the commencement of calibration the master oscillator was set at a wavelength of about 45 metres and the bridges arranged to drive on the 3rd harmonic, a resultant radiation of approximately 15 metres being produced.

The standard wavemeter was set up at a distance of about 3 feet from the output frame of the oscillator and set at the point previously ascertained to be the reading at 15·407 metres. The main oscillator was next tuned accurately to this wavelength.

A subsidiary oscillator, detector and amplifier had been set up adjacent to the main oscillator, and a heterodyne note between the main oscillator and the subsidiary oscillator was obtained. This note was accurately adjusted to a frequency of 1,000 ∿ by tuning the subsidiary oscillator. A 1,000 ∿ electrically maintained tuning fork was set up, and the 1,000 ∿ current introduced into the loudspeaker in which the heterodyne note from the two oscillators was obtained.

When the subsidiary oscillator was tuned to give a heterodyne note of 1,000 ∿ the main oscillator beats could be heard between this note and the fork note. These beats were adjusted to as near a zero frequency as possible, when the subsidiary oscillator was tuned to a frequency 1,000 ∿ above the frequency of the master oscillator.

The scheme of connections is shown below. (Fig. 4.)

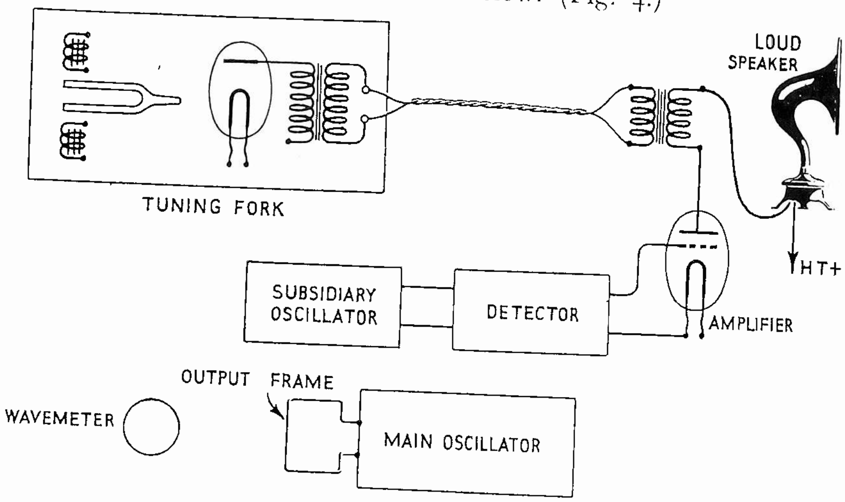


FIG. 4.

Coupling between the detector and the main oscillator was accomplished by means of a short aerial, 4 or 5 feet long, from the detector. Coupling between the subsidiary oscillator and the detector was by means of a coupling coil from the subsidiary oscillator connected to a coupling coil in the detector. The complete arrangement is shown below (Fig. 5).

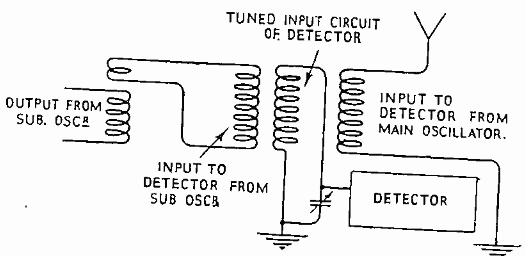


FIG. 5.

So far, then, we have the standard wavemeter set at the predetermined reading for 15·407 metres, the master oscillator radiating a wave of exactly 46·221 metres, and also a third harmonic of 15·407 metres which is being received by the wavemeter, and the subsidiary oscillator tuned to exactly 1,000 ∿ above this wavelength.

If the wavelength of the Master oscillator be now raised, the heterodyne note will pass from 1,000 ∿ through zero beat to 1,000 ∿ again, where it will beat again with the 1,000 ∿ note from the tuning fork.

The wavelength of the master oscillator is now 46·221 metres + 2,000 ∿. Hence the wavelength of the radiation which is received on the wavemeter frame is 15·407 metres + 3 × 2,000 ∿ or 15·407 metres + 6,000 ∿ since we are operating on the third harmonic. The wavemeter can be tuned to this new wave and a scale reading corresponding to 15·407 metres + 6,000 ∿ obtained.

In this way the main and subsidiary oscillators can be raised alternatively in steps of 6,000 ∿ and corresponding readings obtained on the wavemeter.

Steps of 6,000 ∿ will, of course, only be obtained when using a 1,000 ∿ note tuning fork and operating on the third harmonic. In general the step will be $2nf$ where n is the harmonic number and f is the frequency of the tuning fork.

The number of readings taken per frame of the wavemeter will vary, of course, with the wavelengths covered by the frame. Actually the number varies from above 120 to 70.

The accuracy of the method is very high. Assuming a maximum accidental personal error in obtaining beat silence of 10 cycles, which is quite as much as occurs in practice the total error per frame varies from 700 ∿ to 1,200 ∿ which will correspond to an error of approximately the same order of magnitude as that occurring in the wavemeter.

MARCONI RECEIVERS FOR TIME SIGNALS AND PRESS BULLETINS

I.—R.G.12

Wireless time signals which are now transmitted by many stations throughout the world have provided surveying and exploring parties with an accurate method of determining longitude; and the development by the Marconi Company of their selective and sensitive receiving apparatus has considerably widened the field over which these time signals can be received.

In fact, with these receivers—known as Types R.P. and R.G.—it is now possible to receive time signals in almost any part of the world.

These receivers are also suitable for the reception of broadcast news bulletins and for official transmissions from such stations as Rugby, Nauen, Marion and the Eiffel Tower.

Most of these official news bulletins are transmitted by high-power long wave stations for the reception of which the Marconi Press Receiver Type R.G.12 working on a wavelength of between 10,000 and 25,000 metres is particularly suitable.

The selectivity of this receiver is of such a high order that two stations of great strength and lying in the same direction can be separated if their frequencies differ from each other by no more than 120 cycles per second.

The success of this receiver has been phenomenal and orders have been received for it from official and newspaper organisations in all parts of the world.

THE R.G.12 Receiver is primarily designed for press work, and combines high selectivity with great range. Reception of long distance signals is obtained by two stages of high frequency magnification, followed by ample audio frequency magnification, and selectivity is ensured

(A) by the directional properties that the aerial system possesses;

(B) by the tuning of the high frequency stages, the frame aerial circuit, etc.;

(C) by the system of note-filtering employed.

Two aerials are used on the receiver; one, a 35-foot vertical aerial, which is attached to the grid of the first or sense valve, serves to give a circle diagram; the other, a rotatable tuned frame, gives a figure of eight diagram. When used together, a cardioid polar diagram is produced, and the receiver can be used to determine both the direction and sense of any station.

A fair degree of high frequency selectivity is obtained by the use of a number of tuned circuits in cascade, and a high degree of overall selectivity by the addition of two stages of audio frequency tuned circuits.

The simplified diagram of connections of the receiver is given below (Fig. 1), and the following is a brief description of the individual components.

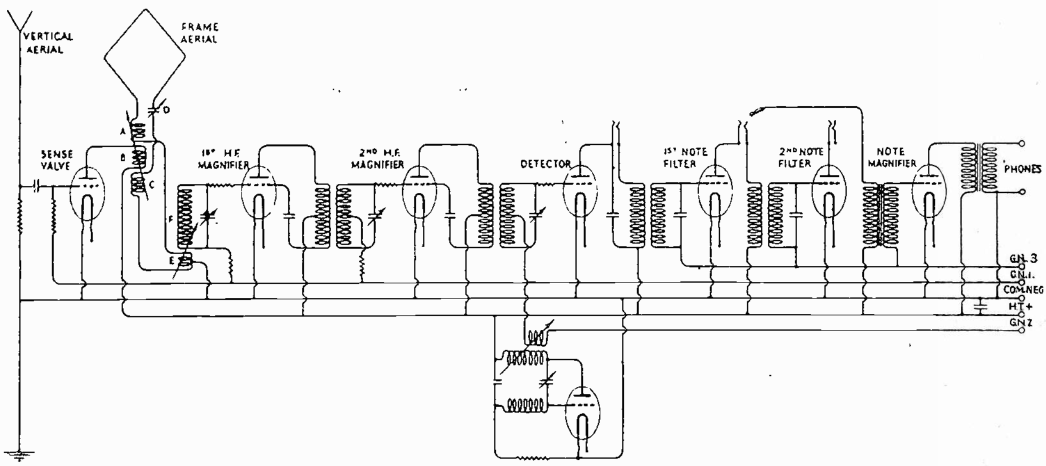


FIG. 1.

The frame aerial, which consists of a square frame of from 10 turns to 32 turns (depending on the waverange of the set), is tuned with a variable condenser in series with it to the wavelength of the desired signal. The vertical aerial is coupled to the sense valve as is shown later, and the amplified signal from this valve is passed through a coil which is coupled to the frame aerial coupling coil in which the frame aerial current is circulating. The resultant signal is applied to the grid of the first high frequency valve. After passing through two stages of high frequency amplification the signal is heterodyned to an audio frequency by means of a local oscillator incorporated in the set, and is rectified by means of an anode bend rectifier.

It is then passed through two stages of transformer coupled audio frequency amplifiers, the grid windings of the transformers being tuned to a frequency of 1,200 v. After passing through these filters the rectified signal is amplified further by an untuned transformer-coupled note magnifier, and is received on low resistance telephones through a telephone transformer.

As will be seen from the diagram of connections for the receiver, the signals from the vertical aerial, after having been amplified by the sense valve, are introduced into the frame aerial circuit by means of one coil B in the anode circuit of the sense valve coupling into the coils A and C in the frame aerial circuit.

The coupling coil E, which serves to transfer the resultant signal from the frame aerial circuit to the first high frequency valve, has its centre point connected to earth. This is done to ensure complete symmetry of current distribution in the coil and to eliminate "vertical."

A simplified diagram of the frame aerial circuit is given below.

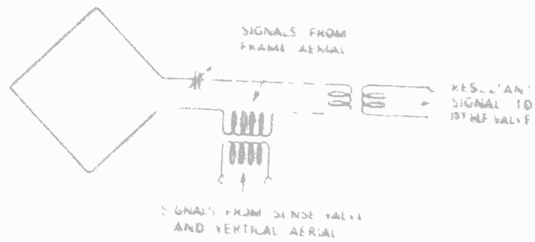


FIG. 2

If the values of signal intensity and orientation of the frame aerial are plotted for any given station, we shall obtain the usual figure of eight polar diagram, with the line YOY corresponding in direction to the direction of the station relative to the frame. Minimum signal strength will occur, of course, when the frame is at right angles to the direction of the station.

In the case of the vertical aerial, the polar diagram will be a circle. Suitably combining the signal amplitudes from these two aerial systems, we can obtain a cardioid. This is the condition used on a direction finder to obtain the sense of a station as distinct from its direction. It is used on the R.G. 12 receiver, however, to eliminate interference from unwanted signals.

If we take the case of a sinusoidal signal inducing an E.M.F. of maximum amplitude A in the open aerial, and of A′ in the frame, and arriving at an angle θ to the normal to the frame, we shall see that the E.M.F. induced in the open aerial is always in phase with the wave and can be represented by

$$A \sin \omega t$$

The E.M.F. induced in the frame is in quadrature with the above and can be given by

$$A' \sin \theta \cos \omega t$$

Referring to Fig. 1, the induced E.M.F. from the open aerial coupling coil to the frame coils will be in quadrature with this last, provided the reactance of the aerial is negligible compared with its resistance, and will be represented by

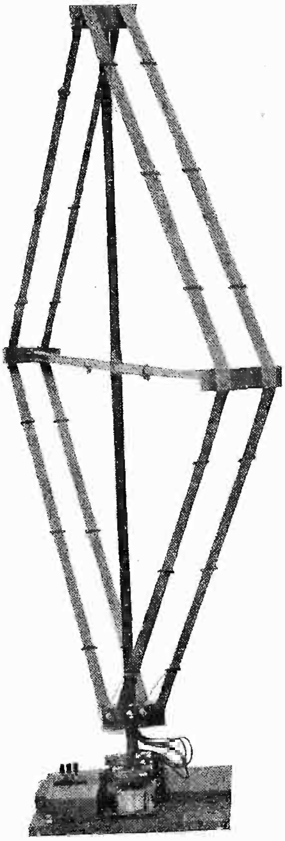
$$B \cos \omega t$$

The orientation of the frame for complete extinction of the signal will be given by the relation

$$A' \sin \theta - B = 0$$

In general this will give two values for θ, but these two will become identical when $A' = B$.

It will be seen from the above that to obtain only one minimum it is necessary to arrange that the E.M.F. induced in the frame aerial coupling coils from the open aerial signal shall be equal to that already existing in these derived from the frame.



Frame Aerial for R.G.12 Receiver showing Variable and Fixed Tuning Condensers on Base.

The vertical aerial coupling valve is employed to reduce the size of vertical aerial needed to give the above condition.

The resultant signal then passes into the first high frequency magnifier. The grid circuit consists of two coils, astatically coupled, into one of which the input coil from the frame aerial circuit is coupled. This grid circuit is tuned by means of a ·001 mfd. variable square law condenser and three fixed condensers, which can be plugged in or out. Resistances are placed in the grid circuit to prevent spurious oscillations or squiggers occurring. The valve is supplied with grid negative to enable it to work at the correct point on its characteristic.

The anode circuit consists of two astatically coupled coils which are arranged so that one coil couples into the correspondingly wound grid coil and the other couples into the second grid coil. The sketch below makes this clear. H.T. is supplied to the centre point of the anode coils, and the neutrodyne condenser is taken from that end of the coil remote from the anode. This is the usual scheme of neutralising a valve. The grid circuit of the next stage of high frequency magnification is similar to the previous one, with the exception that the grid coils are centre tapped to G.N. to make the high frequency potentials on the grid winding symmetrical with respect to those on the anode winding.

After passing through the second stage of high frequency magnification, the signals are rectified in an anode-bend rectifier with tuned grid circuit and a coupling coil which is coupled into the local oscillator which serves to heterodyne the incoming continuous wave signal. This oscillator is of standard design and requires no special description.

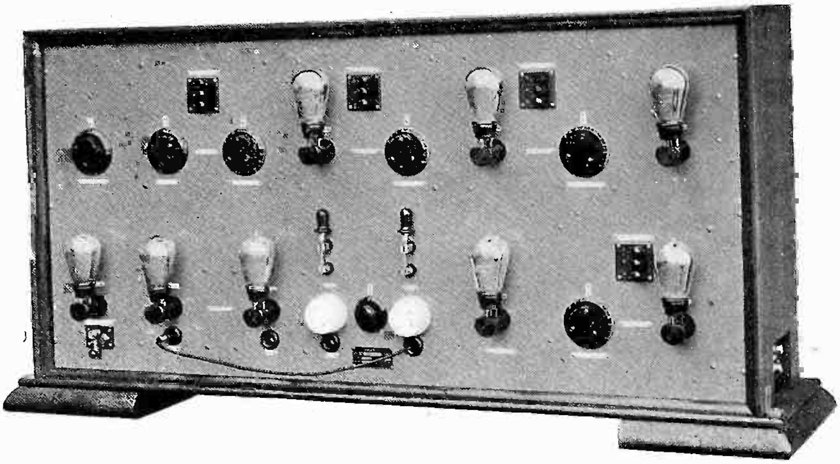
The anode bend method of rectification is used in preference to cumulative grid rectification because no signal, however strong, can block the grid and thus render it insensitive for a time to further signals. In long distance reception, when much static or atmospherics are sometimes experienced, this consideration is of the utmost importance.

The rectified signal next passes through two stages of note filters. These, as we have said, are simply tuned transformer-coupled amplifiers, with both grid and anode coils astatically coupled, and with grid circuits tuned by means of a fixed condenser to a frequency of 1,200 ∼. This frequency is chosen as being very suitable for aural reception. An ordinary note magnifier, transformer coupled with an Ideal 6 : 1 transformer, serves to amplify further the signals, and these are taken from the anode of the last valve through a step down transformer to the telephones.

Provision is made in the set to enable either none or one or two of the note filters to be used. This is achieved by jack plugs in the anode circuits of the respective valves. Terminals are provided in the anode circuit of the rectifier to insert a galvanometer to enable the exact behaviour of the valve to be noted. In this way the value of G.N. for the valve can be found which will give the best rectification.

Blocking condensers are provided where necessary to promote stability and to obviate battery noise, etc., and a bye-pass condenser is provided after the anode of the rectifier to shunt all high frequency currents which may have been carried that far. The presence of these currents would, of course, render extensive low-frequency amplification impracticable.

All the various units for the set are effectively screened by copper boxes, and are mounted on wood bases which are screwed on to the aluminium panel which forms the front of the set. The valves are carried on ebonite holders which project some three inches from the front of the set. The valves used are D.E.5's and D.E.5 B's. D.E.5 B's are used for the high frequency magnifiers and for the sense valve, and D.E.5's for all other purposes.



*R.G.*12.

Tuning throughout the set is performed with ·001 mfd. square law variable condensers, and each tuned circuit has, in addition, three fixed mica dielectric condensers of ·0008, ·0016, and ·002 mfds, which can be plugged in or out to obtain the various ranges. Tuning is readily carried out by means of the calibration charts, but will be found extremely sharp. This selectivity, combined with the directional properties of the receiver, and the system of note filtering employed, is one of the main features of the set, for however loud a signal may be received, it is the relative loudness of the signal over others that may be received at the same time which determines its readability by ear, or its usefulness for recording purposes. Hence it is just as important to cut out unwanted signals as to receive those that are wanted. The two note filters incorporated in the receiver ensure this, for a small change in frequency of an incoming signal will result in a very large change in the rectified and heterodyned signal, and the tuned circuits in the note filters will effectively stop these unwanted signals being passed through

The selectivity of the R.g.12 receiver is such that two signals of equal intensity and from the same direction, can be separated if their frequencies differ by 120 ∿ only.

The receiver is primarily designed for aural reception of signals, but can easily be adapted for recording work.

The R.G.12 receiver is made in three editions covering a waverange of from 1,600 metres to 25,000 metres. These are

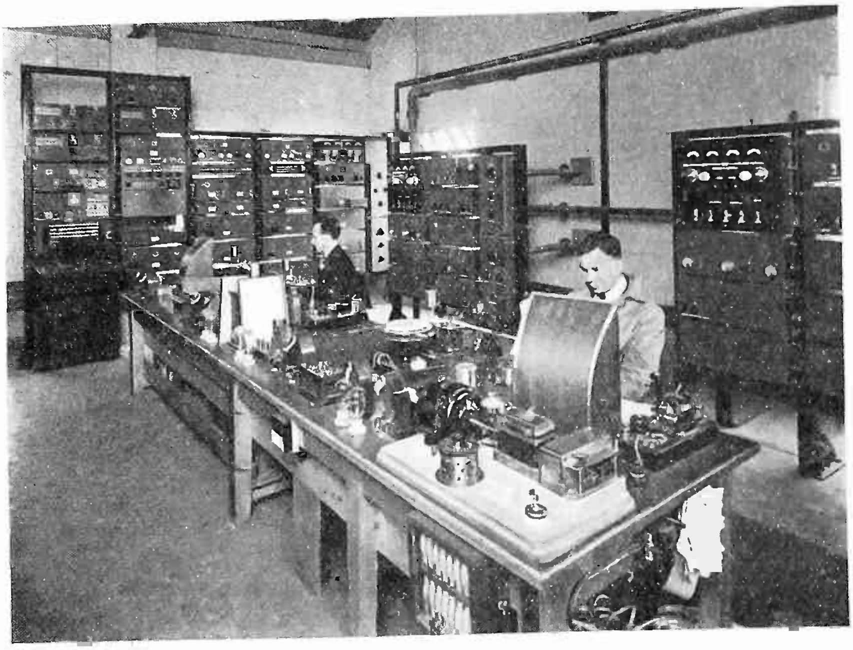
R.G.12	10,000—25,000 metres.
R.G.12a	4,000—10,000 ,,
R.G.12b	1,600— 4,000 ,,

The wavelength ranges have been so chosen as to include most of the stations transmitting Press bulletins.

MARCONI NEWS AND NOTES

THE MARCONI MULTIPLEX SYSTEM

COMBINED TELEPHONY AND TELEGRAPHY



Receiving Room at Bridgwater Beam Station showing Marconi-Mathieu Multiplex Receiver on left, and two Standard Beam Telegraph Receivers on right, with landline table.

SIR ROBERT DONALD, G.B.E., LL.D., who was Chairman of the British Imperial Wireless Telegraph Committee, wrote an important special article in the *Daily Mail* of March 4th, describing the duplex telephone test carried out between Canada and England on March 1st. This demonstration took place at the Beam Receiving station at Bridgwater in the presence of Sir Basil Blackett, K.C.B., K.C.S.I., Chairman of the newly organised Imperial Communications Company, Mr. David Sarnoff, Vice-President of the Radio Corporation of America, and the Rt. Hon. F. G. Kellaway, P.C., Managing Director of the Marconi Company.

The telephone conversation, which took place with the Vice-President of the Canadian Bell Telephone Company and the Vice-Chairman of the Canadian Marconi Company, who were in Montreal, was perfect, and Sir Robert Donald described the occasion as marking a " revolution in wireless telephony—another triumph for the inventive geniuses of the Marconi Company."

Sir Robert, continuing his description, said :

"We were witnessing the successful demonstration of transmitting speech over a distance of more than 3,000 miles on the same wave length simultaneously with two wireless telegraph messages. While we were using the desk telephone in the office of the station, the tape was running off written telegraphed messages in the operating room at the rate of hundreds of words a minute. These were being relayed to London without interruption.

"The invention is a unique combination of efficiency and economy. The system may be incorporated in all 'Beam' stations on the Imperial Chain, avoiding the necessity for erecting new stations for telephonic communication.

"The secret of the system is in reception. Up to now it has not been possible to use the same station for wireless telegraphy and telephony.

"When messages are transmitted from Montreal simultaneously on the same wavelength they are sorted out on reception. While the Morse code messages continue without further assistance, the spoken message is regulated by other inventions, in particular by a Gain controller and an "echo suppressor."

Efficiency and Economy

"The advantages of the Marconi-Multiplex System, as it is called, are many," Sir Robert continued. "It is more efficient and incomparably cheaper. It does not involve the reconstruction of stations. It enables a short wave to be used. There is great economy in power, and there is almost complete secrecy. No one could have listened to our conversations except through a similar installation. Part of a message could be heard, but the whole conversation could not be picked up.

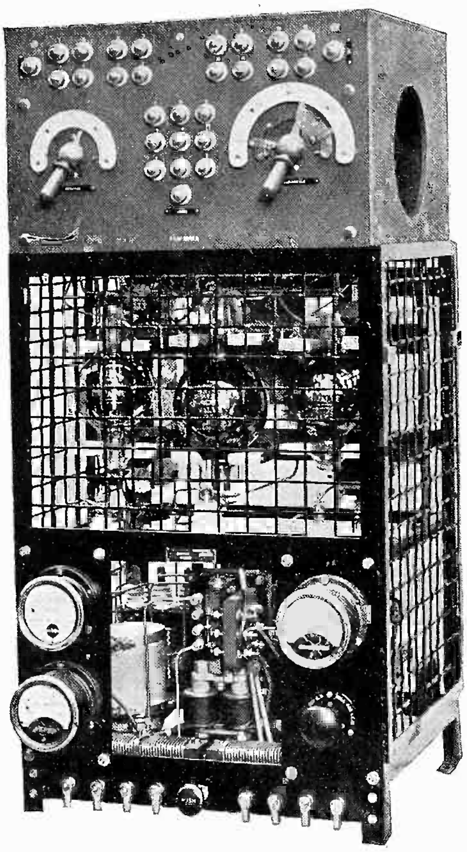
"What is being accomplished on the Canadian circuit can be carried out between other parts of the Empire. Already an apparatus is being made for the South African Beam station. The universal adoption of the system would enormously cheapen telephonic communication throughout the Empire.

"These new developments, which have now been brought to a commercial stage, have taken eighteen months to mature. They will make the British Empire more independent in its means of communication, and once all the home and overseas Beam stations are equipped with new reception apparatus conversations between England and the Dominions, will become almost as usual as they are to-day between London and the Continent."

This opinion of the Marconi-Multiplex System from an independent observer such as Sir Robert Donald, whose experience as Chairman of the Imperial Wireless Telegraphy Committee makes his views of unusual weight, will be of the greatest value to all who are interested in the establishment of wireless telephone services over long distances.

Wireless for Railway Steamer Services.

The value of wireless in maintaining time schedules and promoting efficient organisation on regular steamer services which are linked up with railway routes is becoming more and more widely recognised in view of the modern demand for rapid and efficient international transport services.



Marconi Type M.C.13 $1\frac{1}{2}$ kw. Transmitter as ordered for the London & North Eastern Railway Company's Steamers.

The London and North Eastern Railway Company, one of the "Big Four" British railway systems, has placed an order for its three new steamers for the Continental route, *via* Harwich-Hook of Holland, to be equipped with the latest type of Marconi Valve Transmitting apparatus. At the railway company's coastal wireless station at Parkeston a similar installation is being fitted, so that the steamers will be able to maintain contact with the railway authorities throughout the North Sea crossing, and also when they are in harbour on the other side.

Reduction of Interference

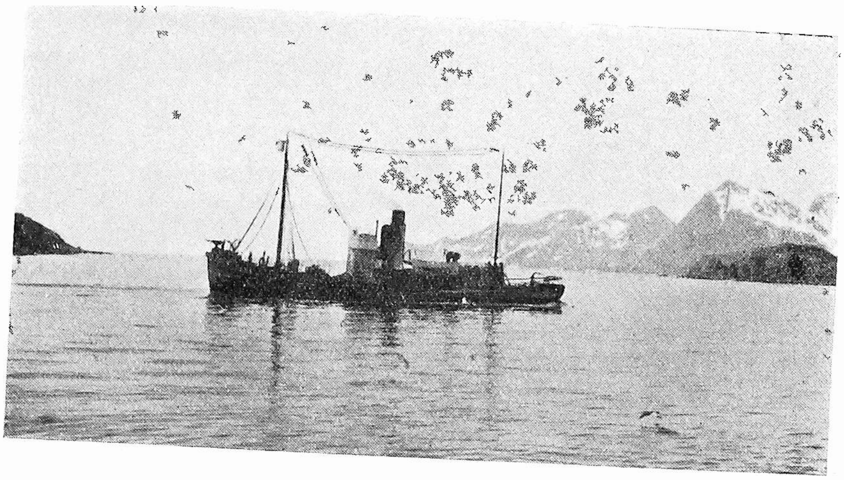
The North Sea is one of the world's busiest wireless traffic areas, and in consequence, special attention has been given to the reduction of interference on these railway steamer wireless services.

The Interrupted Continuous Wave (I.C.W.) method of signalling will be used, the employment of valve transmission instead of the old spark method of signalling, having many obvious advantages. Interference, even on the same wavelengths, can be reduced considerably; and arrangements are also made so that the power of transmission can be controlled down to about one quarter of the full range of the installation, a practical feat of great convenience for communication over short distances only, and also for reducing the amount of possible interference with other wireless services.

If the distant receiving station should complain of interference, an alteration in the speed of the generator of these transmitters will produce an alteration in the tone of the transmitted signals. This can be made sufficiently distinctive from the interference signal to allow communication to continue without delay.

The full power of the transmitters, which are known as the Marconi Type M.C.13, is $1\frac{1}{2}$ kw., and they will work on wavelengths between 600 and 800 metres.

Wireless Direction Finding in the Antarctic.



Whaler of Southern Whaling and Sealing Company in South Georgia Harbour, fitted with Marconi 500 watt Wireless Telephone Installation.

The value of the wireless direction finder as an aid to navigation on all the seven seas is fully recognised to-day, but the fact is not usually appreciated that in some parts of the world the wireless direction finder provides the only reliable means of taking relative bearings.

Observations previously made at the Poles have shown that as the magnetic North and South are approached the ordinary compass becomes highly erratic, which on many occasions has proved a considerable obstacle to exploring parties. Until the science of wireless direction finding attained its present pitch of practical perfection there was no means of obviating the difficulty of obtaining bearings when visibility was bad or doubtful. With this instrument, however, modern explorers are secured against the great dangers of getting lost as their ships approach the Poles.

Captain Byrd, whose scientific expedition in the Antarctic, with an aeroplane and the two base ships "City of New York" and the "Eleanor Bolling," has penetrated far into the Antarctic, has in a recent report made special mention of the value of his wireless direction finder. His report is as follows :—

> "Through the aid of radio direction finding equipment, with which both of the expedition's ships are equipped, Captain Brown picked up the whaling steamer 'C. A. Larsen' at a time when all the regular compasses on both the 'City of New York' and the 'Eleanor Bolling' were rendered completely useless because of the proximity of the magnetic pole."

Captain Byrd has also found his wireless telephone equipment of great value during his present expedition, as it has enabled him to keep in touch with the Antarctic whalers and whaling stations fitted with Marconi wireless telephone apparatus. The whalers have been equipped with Marconi ½ kw. telephone sets, with which they have on occasions been heard over distances of more than 2,000 miles. Normally communication is maintained between whalers and the factory ships and the whaling station at St. Georgia up to distances of 700 and 750 miles. A number of Marconi Direction Finders have also been fitted to these craft and have been found invaluable in assisting the navigators to return quickly to the base with their catch, and in emergencies to steer direct to other members of the fleet.

Before the advent of wireless in Southern Waters the movement of whalers from the Mother Ship frequently had to be considerably restricted owing to the unreliability of compass bearings, and even so it would sometimes be found that one whaler would discover more whales than it could deal with while others were searching in vain.

Marconi Wireless Telephones and Direction Finders have obviated both these difficulties.

Successful Transatlantic Test with T.N.7 Transmitter.

In a recent issue of THE MARCONI REVIEW a description was given of the Marine Type T.N.7 Short Wave Transmitter which had been specially designed for installation on all classes of naval vessels.

One of a batch of these transmitters was completed a few days ago and temporarily installed in a hut near the Marconi Works at Chelmsford, Essex, for the purpose of carrying out long distance communication tests.

Arrangements were made with Transradio Internacional Company of Buenos Aires to listen for a preliminary test transmission on the night of February 26th/27th. This test was duly carried out, and a few hours later a wireless message was received from Buenos Aires reporting that signals on both continuous and interrupted continuous waves were quite readable.

These very successful preliminary tests were made on a wavelength of 36 metres, the aerial current of the T.N.7 transmitter being 250 watts.