THE MARCONI REVIEW

October, 1928

FOREWORD

By SENATORE G. MARCONI, G.C.V.O., LL.D., D.Sc.

IT is a very great pleasure to me, as one of the very few persons still living who has been intimately and continuously associated with the development of Radio Science and Art from its earliest inception, to wish all possible success to the "Marconi Review."

In a period of little over thirty years, "Wireless," as we first called it, has exceeded even my expectations, by not only establishing itself at sea and on land as the most direct and rapid method of long distance telegraphy and telephony, but also by entering the home through Broadcasting, and thereby becoming the most universal and potent method of instantaneous communication which the world has ever known.

By its latest telegraphic and telephonic developments, Radio has given us a permanent system of International and Imperial communication to which distance is no obstacle. It has multiplied in a most wonderful manner our possibilities for disseminating, extending and receiving instruction and entertainment; it has reached out to the Opera, the Stage, the Concert Hall and the Pulpit. It has entered the Motion Picture industry with its system of synchronous sound and sight; it has allied itself with photography through photo-radio and facsimile transmissions; and now it is going to give us Television, and perhaps, some day, transmission of power, besides other things which we most probably are unable even to foresee at the present time.

Although I find it quite impossible to visualize any definite limit as to what more may be achieved in even the not far distant future, I feel convinced that further rapid progress must be dependent in no small measure on a still closer relationship between industrial attainments and advanced Scientific Research. Without the aid of pure Science and Scientific Research, Radio would not now be in existence, but at the same time we must also recognise that without the powerful means, and encouragement which Industry, or even the hope of industrial success, have been able to place at the disposal of Radio research, many of the far reaching discoveries and inventions, which alone have brought it to its present position as a world-wide factor, might not have been made, or might have been delayed for generations.

One of the principal objects of this new Review is to make known what is being achieved by the combination of Industrial and Scientific Research, and to endeavour to show that swiftly moving scientific progress and rapid technical advance, which together can bring about achievements useful to mankind, demand industrial flexibility rather than industrial stabilization.

It may also help to demonstrate that progress in the Radio Art is not only dependent on the genius, intuition, and learning of the scientific workers, but also on the courage, intuition, flexibility of mind, and self-protecting progressiveness of the executives who happen to be in control of great industrial and commercial enterprises.

G Marconi

A CHAPTER IN THE HISTORY OF THE MARCONI BEAM

Less than two years ago, in October, 1926, the first Imperial Wireless Beam Service operated on the Marconi System was inaugurated between Great Britain—with stations at Bodmin and Bridgwater—and Canada, with stations at Drummondville and Yamachiche, and following each other at short intervals, a number of other Imperial Wireless Marconi Beam services have since been opened, which, at the present time, not only girdle the globe, but have revolutionized the art of radio communication ; and they are all commercially successful.

Apart from its many long wave wireless services with foreign countries, the strategical position of Great Britain as regards long distance Imperial wireless communication, previous to 1926, was weak. Great Britain was only in direct two-way wireless communication with one Dominion (Canada) and one Protectorate (Egypt). To-day, thanks to the Marconi Beam, no other nation is so well served by wireless for defence or commerce. These results provide a fitting conclusion to a remarkable chapter in the history of wireless development, the details of which are discussed in the following article.

EARLY in 1924 the Marconi Company put before the British Government its proposals for an Imperial Wireless network based on the Beam system, and by abandoning the use of high-power long wave wireless stations in favour of low-power short wave Beam stations for transmission over maximum world distances, announced a change of policy radical enough to appear dramatic, involving as it did a complete departure from traditional long wave design in every feature of the installation, and employing for propagation to a very much greater extent the characteristics of the uncharted regions of the upper atmosphere with their known variability, in preference to the more stable characteristics of the lower atmosphere favoured by long waves.

Although the decision followed so quickly on the report of the successful results of Senatore Marconi's tests on the S.Y. "Elettra" as to suggest that there had been scarcely time enough to give sufficient consideration to the possible difficulties involved, the position had really been very carefully studied in the light of a mass of data which had been steadily accumulating, and was surprisingly complete at that date, having regard to the very wide area of research which the short wave Beam development had opened up.

In point of fact, there had been overlapping development in both long wave and short wave working for some years.

Mr. C. S. Franklin's paper on " Short Wave Directional Wireless Telegraphy," read before the Institution of Electrical Engineers in May, 1922, gives a fairly complete history of the research work which had been done on short waves and reflectors up to that date. But no one but Senatore Marconi and his assistants had been working in this field. As Senatore Marconi himself pointed out in a paper on " Radio Telegraphy," read in June, 1922, before a joint meeting of the American Institute of Electrical Engineers and the Institute of Radio Engineers, practically all through the history of Wireless, the study of the characteristics and properties of short electrical waves had been sadly neglected, and when he resumed his work in 1915 it was because he could not help feeling that by confining all experimental work to long waves, research workers had perhaps got into a rut, and that further investigation of short wave phenomena was likely to develop in many unexpected directions and open up new fields of profitable research.

How true this forecast was we now know, but at that date the general view was that the application of short waves and reflectors was limited to short distance work only.

In 1923-1924, however, the rate of progress with the research and experimental work, although it covered valve design, new short wave circuits, aerials, reflectors and receivers, was so rapid and satisfactory, finally reaching a climax with the successful long distance tests between Poldhu and the S.Y. " Elettra," that the Marconi Company was enabled to present a strong case for the consideration of the British Government at a moment which proved opportune, and before too much expense had been incurred in the erection of the high-power long wave Imperial Stations.

Long Wave v. Short Wave.

It will be remembered that following the findings of the Government Committee in 1923, that the British Post Office should own and operate directly all wireless stations for communicating with the various parts of the British Empire, the Post Office commenced the erection of the Rugby high-power long wave station, and the Marconi Company, in agreement with the Dominion Governments, put in hand the erection of stations, either of their own or in partnership with these Governments, of somewhat similar size in Australia, South Africa, and India, each employing 800-ft. self supporting aerial towers and a 1,000 kw. transmitter designed to work on wavelengths of 20,000 to 30,000 metres, at a cost per installation of about £500,000.

But wireless research has always been unconfined and has never stagnated. While these super stations were actually under construction and the solution of the big problems they presented to receiver experts of providing for the reception of heavy traffic on a varying field strength and above the high noise level and interference associated with long wave working was receiving the closest attention from the Marconi Research Staff, Senatore Marconi himself was obtaining results on the S.Y. "Elettra" on his short wave tests with Poldhu which held out possibilities of future development that could not be ignored.

The object of the first series of tests carried out in April, May and June, 1923, was primarily to note the results when the Beam principle was applied on a large scale, and was a continuance—as foreshadowed in Senatore Marconi's 1922 paper—of the earlier research work on reflectors when wave lengths of 3, 6 and 15 metres had been employed.

While carrying out some duplex telephony tests across the North Sea between Southwold and Zandvoort in August, 1921, employing a 100 metres wavelength with about 1 kw. to the aerial, it was found that good speech could be received every night and sometimes during the day at Oslo, some 450 English miles distant, and in choosing a wavelength for the tests at Poldhu these results carried some weight, particularly as 100 metres wavelength appeared to be about the maximum limit one could use with reflectors of practicable dimensions. The logical order of testing also was to try out the longest wavelength first, particularly as it was then generally believed that the shorter the wavelength the less was the daylight range.

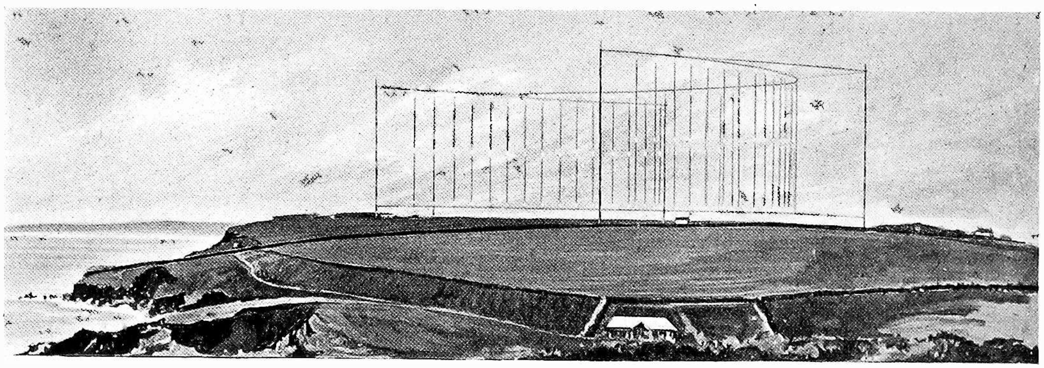


FIG. 1.—*Reflector Aerial at Poldhu in* 1923.

The height of the Poldhu masts was therefore increased to 325 ft. and allowing for the sag of the triatics supporting the reflector wires which fixed the maximum height of the reflector, the relation between the length of the reflector wires and the half wave aerial resulted in the wavelength finally used at the start of the tests being 97 metres. A view of the system is shown in Fig. 1.

The test procedure was as follows:—

(1) Transmission took place at Poldhu.

(2) Polar curves of field strength were taken on land at several wavelengths distant from the transmitter.

(3) Field strengths were measured on Senatore Marconi's yacht at different distances up to the maximum practicable, and also across the width of the Beam.

(4) Reports of signal strength were also obtained in the later tests from stations in different parts of the world.

Not only did the reflector experiments as such give very encouraging results, but the 97 metres wavelength proved to be unexpectedly efficient.

All previous long distance tests on short wave—that is on wavelengths of 200 m. and less—had been carried out during the hours of darkness on very low power, with critical adjustments of transmitter and receiver, and had given results of extraordinary variability which were generally considered freakish and quite unsuitable for traffic purposes. But Senatore Marconi's "Elettra" tests showed that with well designed apparatus which was stable in operation, and with a reasonable amount of power supplied to the aerial, much of the variability of the transmission disappeared.

Not only could a good night range be obtained, but atmospherics were found to be comparatively weak, and the day range also was considerable.

The signals at St. Vincent, 2,300 nautical miles from Poldhu, even with the input power reduced from the maximum of 12 kw. to 1 kw., were found to be so much above the noise level as to justify the belief that a reliable commercial service could have been carried on between these two points for the greater proportion of the 24 hours.

At the end of a report to the Directors of the Marconi Company on the results of the S.Y. "Elettra" receiving tests, dated 12th June, 1923, Senatore Marconi wrote: "I have little doubt, however, that with our present knowledge and with stations using only about 12 kw. it would be possible to maintain daily a 10 to 14 hours' service between Europe and Brazil, and, perhaps, even with the Argentine."

Short Wave Beam Proposed for Imperial Stations.

As nothing like such good results could be expected from any form of commercial long wave transmitter using the same small power and employing the same low effective height of aerial, the Marconi Company which for 17 years had made it its mission to insistently keep the problem of Imperial Communications in front of the attention of the Government of the day, and holding the unique position of being the only authority in the world able at that time to weigh up from the results of practical experience the probable advantages and disadvantages of the long wave and short wave methods of transmission when applied to long distances, in both of which it was vitally interested, after earnest consideration submitted a proposal to the British Government for the employment of the short wave Beam at the Imperial Stations.

Already the range achieved was great enough to satisfy the requirements of the 1919-1920 Imperial Wireless scheme, which contemplated the employment of relay stations 2,000 to 2,800 miles apart, and the short wave signals at St. Vincent were stronger and more free from interference than those received from the first of these long wave stations opened at Leafield by the Post Office in 1921, and which employed a 250 kw. arc transmitter.

A very wide field of investigation was opened up as a result of these negotiations, and before contemplating a change of wavelength other no less important factors had to be considered.

The programme for the further trials between the S.Y. "Elettra" and Poldhu, which took place in the spring of 1924, therefore included the systematic testing of improved receiver and transmitter circuits, increasing the power of the transmitter up to 20 kw. by the aid of cooled anode valves specially made for these tests, and the testing out of various modifications of the aerial and reflector system, also, what was of supreme importance, the collection of reports on the results of the transmission as received at Montreal, New York, Rio de Janeiro, Buenos Aires and Sydney, N.S.W.

Government Contract Signed.

With the receipt by Sydney of ordinary telegraph signals on the 3rd April, 1924, even without a reflector, and telephony a month later, the expectation that the short wave transmission would be received at the antipodes was fulfilled, and the British Government—which had appointed a sub-committee of the Cabinet to examine the proposals put forward by the Marconi Company— no longer hesitated to conclude an agreement with this Company for the construction of wireless stations on the Beam principle, of 20 kw. to the valve anodes, for communicating with Canada, South Africa, India and Australia, which was signed on the 28th July, 1924. Acceptance was to be conditional on a continuous seven days' test working duplex, at not less than 100 words per minute simultaneously both ways, and exclusive of any repetitions necessary to service accuracy, for 18 hours per day on the Canadian circuit, 11 hours on the South African, 12 hours on the Indian, and 7 hours on the Australian circuits.

Considering what little was actually known at that date of the transmission characteristics of different parts of the short wave spectrum, the clauses as to high speed working and the number of hours per day the stations must communicate, appeared to be very onerous for the Marconi Company. So much apparently depended on what happened to the waves in the upper regions of the atmosphere, and this was a question on which experts disagreed.

It was one of those critical occasions which sometimes occur in the life of a great public Company. Events had compelled a quick decision on a question of great moment, and the effects would be far reaching. Technical as well as commercial risks would have to be faced, and liabilities incurred, which included the scrapping of large assets of the long wave stations and heavy expenditure on research and development for the new short wave stations. In 1923 the Imperial scheme, for which the Marconi Company had laboured so long, was in process of realisation, but in the light of the research work of 1923 and 1924, the long wave stations projected would have probably been out of date before they were completed, so that in the view of the Marconi Company events were only being anticipated by the Beam contract, and the whole weight of the Company's resources was now concentrated on the achievement of this undertaking.

The Position in July 1924.

The position, from the point of view of the Marconi Company, was as follows :—

(1) The beam had proved to function as a beam at a very considerable distance.

(2) The 100 metre wave over a long distance had proved to be unexpectedly efficient.

(3) It had been shown that the new type of cooled anode power valve could be employed in short wave transmitters.

(4) Signals could be received at the greatest distances by short wave.

The points that remained yet to be determined were :—

(1) The number of hours per day that communication would be possible at different periods of the year in the various countries.

(2) The complete specification of the transmitting constants in terms of the aerial power, wavelength, and angular width of beam required to maintain signals at sufficient strength to provide the average speed of working for the requisite number of hours per day.

(3) The development of keying and recording apparatus which would function with the minimum of attention and renewals at speeds providing a wide margin above that of the guaranteed average speed of working, in itself a problem of no small magnitude.

It was known that on short wave it should be theoretically possible to work at much higher speeds than on long wave, and it was expected that the speed of 70 or 80 words per minute, which at that date was about the practical limit for long wave, although a higher speed was possible, would have to be increased up to 200 or even 400 words per minute if the hours of working on the beam proved to be too short to enable the traffic to be cleared otherwise.

The undeveloped possibilities in reserve were :—

(1) The certainty of improving the efficiency of the transmitter, the amplification and selectivity of the receiver.

(2) The strong probability that by further research the aerial and reflector systems could be made more efficient.

(3) The possibility of obtaining still more favourable propagation characteristics by working on a wavelength or wavelengths yet to be determined, other than 100 metres.

Very little however was known of the adaptability of short waves for long distance transmission, the mechanism of propagation was not understood, it was too early to draft any empirical or working formula, and a definite technical risk had to be faced that further research might not give more favourable results. Relying therefore mainly on the effectiveness of the Beam principle, that at long distance the wave energy would still remain concentrated within a narrow angle, the power to the aerial, and the efficiency of the receiver—the Marconi Company accepted this technical risk as one of those unavoidable unknown factors which have to be reckoned with in many a good business enterprise.

The progress made in beam development during the period 1923-1924 covered by that section of the Poldhu—" Elettra " tests, which were carried out previous to the signing of the agreement with the Post Office, can be summarised as follows :—

TECHNICAL DEVELOPMENTS

The Reflector.

The employment of parabolic cylindrical reflectors of sheet metal had for some years been superseded by the use of reflectors of similar shape composed of a number of vertical wires separated about $\frac{1}{8}$ to $\frac{1}{10}$ wavelength apart. The focal distance of the parabola was made equal to either $\frac{1}{4}\lambda$ or $\frac{3}{4}\lambda$, and the aerial was placed at the focus of the reflector.

It was an accepted principle that the reflector should be large compared with the wavelength, and it had been proved that long reflector wires gave best results when broken up into a series of insulated half-wavelengths.

The divergence of the beam within the distances covered by the " Elettra " tests was proved to agree with the angle calculated, and was a function of the aperture of the reflector in terms of wavelength.

To obtain a 10° beam on a 100 m. wavelength with a parabolic reflector necessitated an aperture several wavelengths wide, involving a costly structure of supporting masts covering a large area of ground, and this cost would militate against the commercial success of the system. An endeavour was therefore made by Mr. C. S. Franklin to obtain a narrow beam of radiation by other means. This resulted in the first mesh aerial which was referred to in Senatore Marconi's paper read at the Royal Society of Arts on the 2nd July, 1924. It consisted of a number of vertical wires, Fig. 2, divided into half-wavelengths by condensers, connected together by horizontal wires of suitable length, and resistances where necessary so that the currents in the vertical parts were all in phase, when the resultant field produced a highly directive radiation at right angles to the plane of the mesh. The back radiation could be used to reinforce the radiation in the direction required by employing a similar system spaced a $\frac{1}{4}$ or $\frac{3}{4}$ wavelength behind the first, as a reflector.

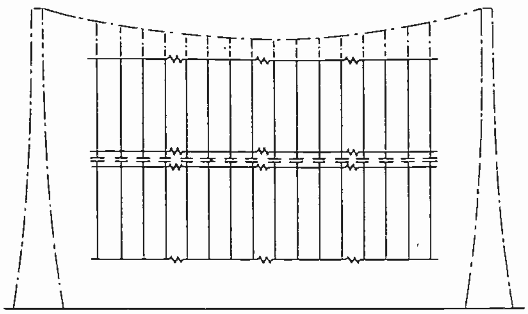


FIG. 2.

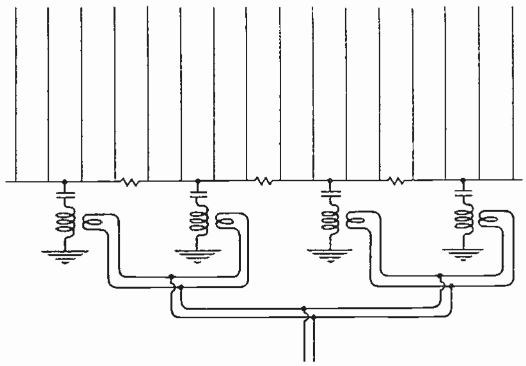


FIG. 3.

The limitation imposed on the concentration of the beam by the economic restriction on the size of parabolic reflectors was removed by adopting this type of construction, the ground area covered by the masts, reflector and aerial for a system of 2 wavelengths' aperture being now only $\frac{1}{10}$ what was formerly required.

The Aerial.

As in previous reflector tests, the Poldhu transmission commenced with the employment of a $\frac{3}{4}\lambda$ aerial, the lower part of which was non-radiative and coupled to the transmitter.

Attempts had been made to restrict the radiation in the vertical plane as well as in the horizontal plane by combining two half-wave oscillators at right angles and exciting them in quadrature, to produce a circularly polarised wave—and experiments had been made with a paraboloid reflector instead of a cylindrical parabola, with the same object, but the best practical result eventuated from a development of the mesh aerial, wherein the vertical half-wave components, one above the other in series in the mesh when brought into phase, had the effect of concentrating the radiation to a certain degree in the vertical field in a similar manner but to a less extent than the concentration effected in the horizontal field by the in-phase currents in the much more numerous and wider spaced parallel wires along the width of the aerial.

The Feeder System.

With the introduction of the mesh or multi-aerial system, the problem of coupling to the transmitter was no longer a simple one.

The single wire aerial employed with the parabolic reflector could be coupled at its base direct to the transmitter, but to obtain currents in equi-phase throughout the mesh it would have to be fed at several points, and this necessitated the employment of an intermediate coupling circuit. A coupling circuit several wavelengths long had been used with success between the half-wave antenna and the receiver on the S.S. " Royal Scot " during the Inchkeith tests, on a 4 metres wave in 1922, and, proceeding on similar lines, a suitable feeder circuit was evolved for the mesh aerial.

During the 1924 tests the mesh was sometimes fed at four points, Fig. 3, and sometimes at eight, so that part of the aerial was fed direct, but part had to be fed through other parts, the feed therefore having a series parallel character. At a later date the transverse connections of the mesh aerial were finally abandoned, leaving the simplified system of vertical aerials only, and the series feed gave place to an all parallel feed, which gave greater stability of direction to the beam.

It is interesting to note that the mesh aerial and the series feed, which, as mentioned above, were intermediate stages in the development of the Franklin aerial to its present type, have since been revived on the Continent and in America, and necessarily retain the defects which caused these methods to be abandoned by the Marconi Company.

The Power Valve.

The standard type of transmitting valve, which was satisfactory for long wave service, developed trouble at the seals when used on short wave, and the eight air-cooled valves, each taking 1½ kw. at the anode, employed in the 100-meter 1923 Poldhu tests, were specially made for the work. This was provisional. The water-cooled anode valve for long wave work was first placed on the market in 1922, and its design was modified by Franklin so that it could be used on short wave and with anode cooling by oil circulation, and these new valves, each taking 10 kw. at the anode, were ready for the tests carried out in the spring of 1924.

The Transmitting Circuit.

The eight air-cooled valves, each with its own oscillating circuit, were mounted in two metal panels providing good screening, and were used all in parallel to form a simple self-oscillator. This was only an experimental circuit, however, and as soon as the oil-cooled valves became available, four of the air-cooled valves were employed as before to form a self-oscillating drive circuit, while two oil-cooled valves were employed in the new bridge circuit forming a power amplifier, wherein the transmitting valve capacities were for the first time balanced out, see Fig. 4.

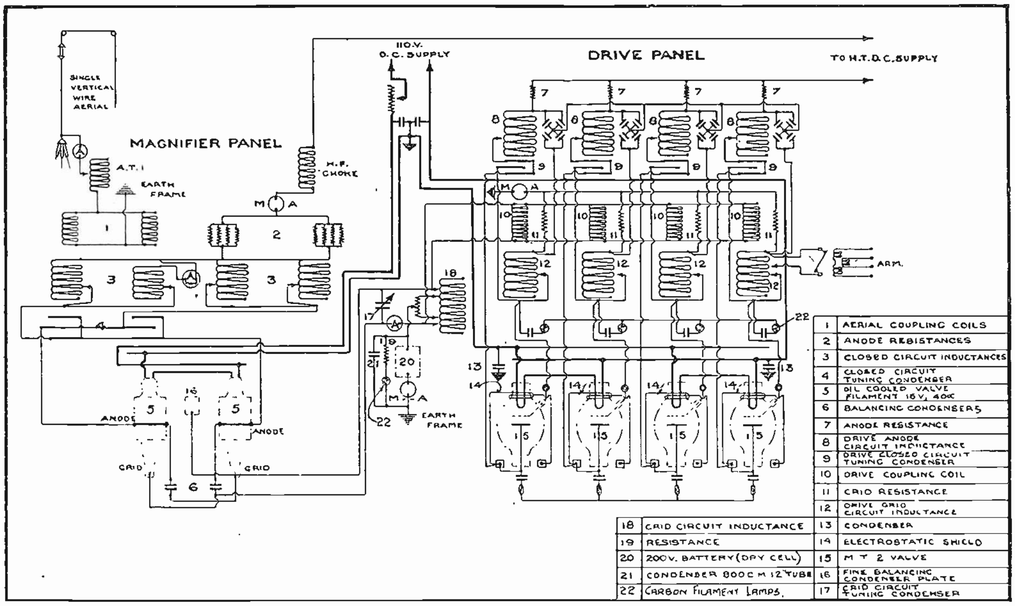


FIG. 4.

By this change, the transmitter benefited by an increase in power, in stability as an oscillator, and in constancy of wavelength.

(To be Continued)

SHORT DISTANCE COMMUNICATION

MARCONI PORTABLE SHORT WAVE MILITARY TRANSMITTER AND RECEIVER.—TYPE S.A.1

There is a constant need for some easy method of communication over short distances, on land and sea, by means of light, compact, and easily handled wireless equipment. The Marconi 25-40 watt short wave portable transmitter and receiver, which is the outcome of several years' intensive research, meets this need in the most effective manner.

For military purposes it has the following important features :—

1. *Secrecy.*
2. *An almost invisible aerial system.*
3. *Simplicity and ease of operation.*
4. *Compactness and portability.*

These advantages render the set particularly suitable for use as a trench set and for other short distance military communications.

The normal aerial is only 12 feet (3.75 metres) in height, and this may be reduced by approximately one-half if desired.

The aerial and transmitter are connected by a feeder cable so that the aerial can be erected in any convenient spot and the set itself placed in a bombproof shelter.

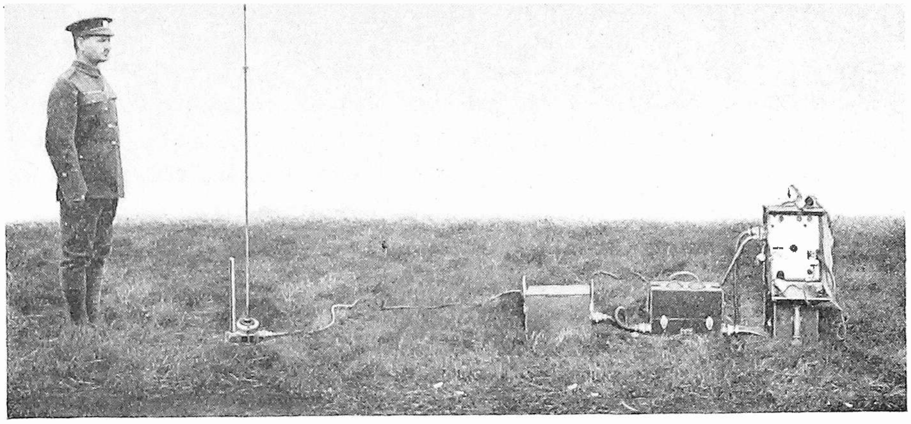
The total weight is only 155 lbs. (70 kilos.), and it can be carried either by wheel transport or on pack animals.

Owing to the short wavelength employed a number of these stations can be used on a limited front without causing interference.

It is not surprising, therefore, that there has been a great demand for these sets in all parts of the world.

THE S.A.1. Transmitter and Receiver are designed for military communication, especially under conditions of war. The wavelength used varies from 7-8 metres, many advantages arising from the use of these very short wavelengths. It must not be supposed, however, that because the waverange of the transmitter covers only from 7-8 metres, the waverange is small. If we consider the waverange in terms of kilocycles, we can see at once that the minimum frequency is 37,500 kc., and the maximum frequency is 42,860 kc. The range of frequencies then is very large, and actually corresponds in, say, a 300 metre set to some hundreds of metres. Hence a considerable number of stations can work in the 7-8 metre band, even though all stations are very near one another.

The equipment includes all necessary apparatus for transmission and reception, including the generator for the transmitter, all batteries, etc. for this generator and for the receiver, spares, and aerial system.



Type S.A.1 Set with Quarter Wavelength Aerial ready for Operating.

The Transmitter.

The transmitter is constructed for both Tonic Train, or I.C.W. transmission, and telephony. The approximate effective range of the transmitter for Tonic Train is, in the case of the half wave aerial 8 miles, and in the case of the quarter wave aerial 4 miles. For telephony these ranges are approximately 6 miles and 3 miles respectively. The figures given above correspond, of course, to general performance. Certain freak results must, however, be expected with the use of wavelengths of this order of magnitude, and the ranges given may be greatly exceeded on occasions.

The oscillator of the transmitter (Fig. 1) is of the ordinary Hartley Type, and is made as simple as possible. This oscillator is grid controlled for telephony by means of a microphone transformer and microphone, and has its grid circuit broken by a rotary interrupter mounted on the shaft of the generator for Tonic Train.

As the transmitter itself is of such a simple nature, we shall spend but little time in describing its action and proceed to a brief discussion of the aerial system, which is one of the chief features of the set.

A diagram of the connections of the transmitter is given below (Fig. 1) and the simplicity of the circuit will be at once apparent. In all work on short waves, it is found that the simpler the circuit, the better the results which are obtained from it.

In the type of self-oscillator used in this transmitter we have, in addition to the magnetic coupling between the two coils A and B (Fig. 1), the capacitative coupling provided by the condenser G, which is made variable to permit of variation of wavelength. It is to be noted, however, that, even in the circuit shewn below (Fig. 2)

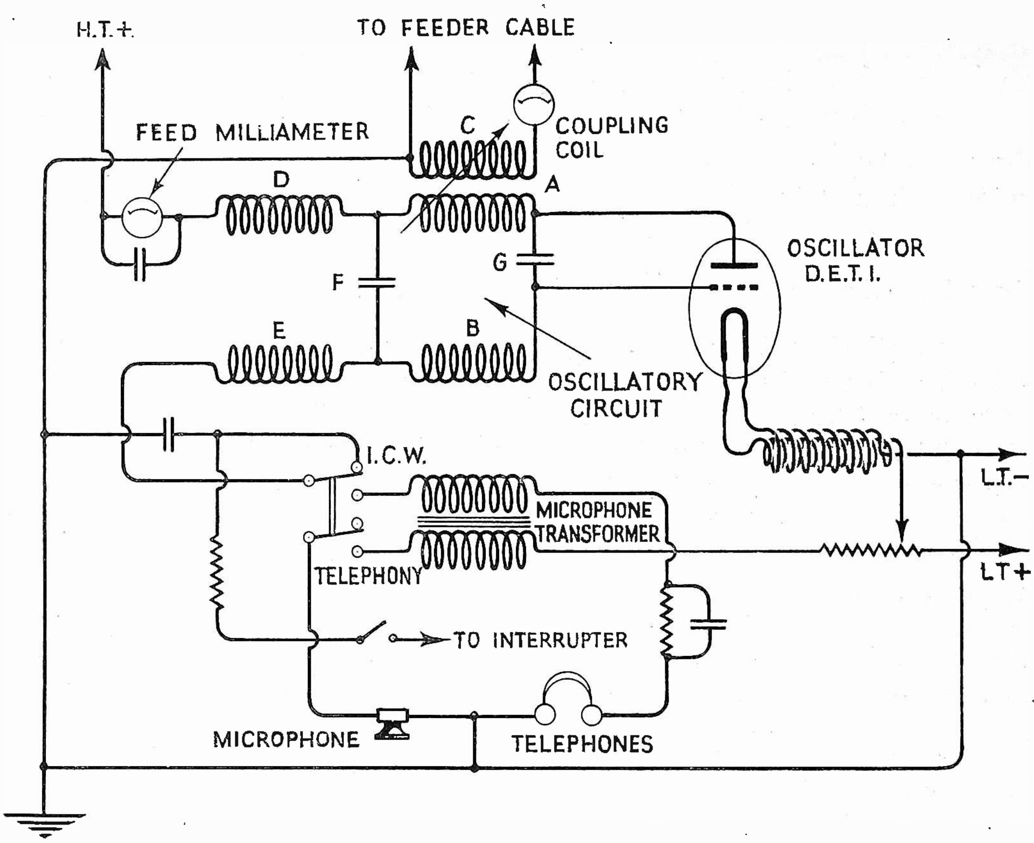


FIG. 1.

(a simple tuned anode oscillator) we have a certain amount of capacitative coupling between the coils due to the capacity existing in the valve itself between the grid and anode.

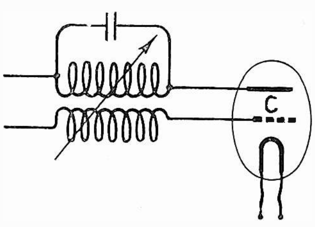


FIG. 2.

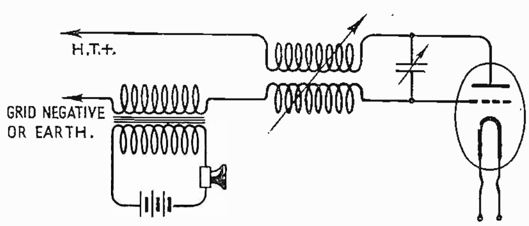


FIG. 3.

The condenser F (Fig. 1) serves merely to render the reactance across the generator negligible.

If the inductance of A is L_1, and that of B is L_2, and if M is the mutual inductance between the two coils, then the frequency of the oscillation generated will be given by

$$\omega = 2\pi f = \frac{1}{\sqrt{(L_1 + L_2 - 2M)\,C}}$$

where C is the capacity value of the condenser G. The critical condition for self-oscillation is given by

$$M_0 L_2 > L_1 + (M_0 - 1) M$$

where M_0 is the magnification factor of the valve used.

The method used for modulating the oscillator is known as the grid control method, and is undoubtedly the best and simplest method of modulating small power transmitters. The general arrangement of the microphone circuit is given above (Fig. 3). If the microphone is idle, the high frequency current from the oscillator will be constant, but if the microphone is excited by sound waves, a changing current will be produced in the primary of the microphone transformer which will be passed to the grid circuit through the secondary of the transformer. Hence the grid of the oscillator will have the low frequency E.M.F. of the secondary impressed upon it in addition to the high frequency E.M.F. of the oscillatory current. A modulated current will thus be radiated which will be a function of the sound waves impressed on the microphone.

The advantages of this scheme of modulation lies in the fact that the microphone need only be of very small current carrying capacity. Hence quite a large oscillator can be modulated with a small microphone.

The microphone transformer has its primary winding arranged to match the impedance of the microphone and its associated batteries, etc., and its secondary winding to suit the grid-filament circuit of the transmitting valve.

As we have stated above, the grid circuit is broken at a constant frequency for the transmission of Tonic Train, and no special explanation need be given of the method employed. Oscillations are simply started and stopped at the frequency of the interrupter on the rotary converter.

A coupling coil is provided to couple into the anode coil of the oscillator to supply the aerial. One side of this coupling coil is earthed, and the other side has a hot wire ammeter in series with it and the feeder cable to read the aerial current. We shall refer to this coupling coil later.

Chokes D and E (Fig. 1) are provided to prevent H.F. energy from getting back to earth and so being dissipated. A double astatic choke is provided in the filament circuit for the same purpose. The grid has a suitable bias applied to it by means of resistances connected between the grid circuit and earth. A milliameter, shunted by a condenser to bye-pass H.F. currents, is provided to enable the feed of the oscillator to be observed, and switches are provided for the change over from Tonic Train to Telephony and *vice versa*.

This description suffices to shew the general behaviour of the transmitter itself, and we shall now proceed to deal, rather more in detail, with the aerial system.

Aerial System.

The aerial system of the S.A.1. transmitter can be conveniently divided into four sections :—

1. The coupling coil from the transmitter.
2. The feeder cable.
3. The balancing coil.
4. The aerial.

1. The coupling coil from the transmitter consists of 5 turns of wire wound on a $1\frac{1}{2}$ inch ebonite former with $\frac{1}{4}$ inch spacing, and is variably coupled to the main oscillatory circuit. As we shall see later, this coil constitutes one of the terminal impedances of the feeder cable, and its impedance is therefore a point to be considered when the feeder cable is discussed. Apart from this point, no special attention need be paid to this coil.

2. The feeder cable consists of a lead covered cable, some 23 feet long, with the lead covering effectively earthed to the transmitter and aerial. The inner conductor is attached to the coupling coil at one end, and to a tapping on the balancing coil at the other. The whole feeder system now resembles that shewn in Fig. 4.

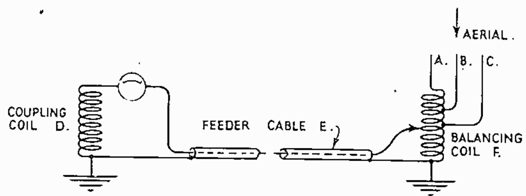


FIG. 4.

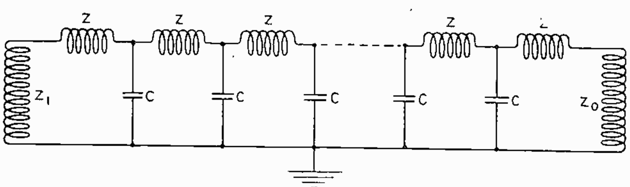


FIG. 5.

Now such a lead covered cable, terminated at its two ends by impedances (which are, of course, the coupling coil at the input end, and the balancing coil at the output end) can be represented by a series of sections as shewn in Fig. 5, where

Z_1 = impedance of coupling coil.
Z = inductance per unit length of feeder cable.
C = capacity ,, ,, ,,
Z_0 = impedance of balancing coil.

If a current be impressed on one end of this system, it will, in general, be propagated along the system meanwhile undergoing certain changes. These changes are

1. Attenuation.
2. Distortion.

We shall deal here only with the first; distortion occurs only to a slight degree, and is not of primary importance as regards the transmitted signal. When the input current has reached the output end, a fraction of it, which we shall call Y, is reflected back again in an opposite direction, and the rest is delivered to the aerial. This fraction Y now proceeds to the input end, where a part of it, say X, is again reflected. This process continues indefinitely. We see then that stationary waves are set up in the feeder system, owing to these reflections; and that these stationary waves indicate loss of useful energy. Now it may be shewn that

$$X = \frac{Zs - Zi}{Zs + Zi}$$

$$Y = \frac{Zs - Zo}{Zs + Zo}$$

where

Zs = a quantity known as the surge impedance of the system. This quantity is actually the impedance of the system neglecting the input and output terminal impedances.*.

Now the idea of the feeder cable is to transmit the energy from the oscillator to the aerial with as little loss as possible. Hence both X and Y must be made zero. In other words, both the input and output impedances must be made equal to the surge impedance of the cable. Under these conditions no loss will be experienced in the cable, and the cable will have no effect on the wavelength of the oscillation generated.

Let us next consider the aerial itself. This consists of a straight rod AB (Fig 6), with a flexible lead which can be attached at varying points on the inductance D, one end of this inductance being earthed.

* Zs for a system of this type $= \sqrt{\frac{L}{C}}\sqrt{1 - \frac{1}{4LC\omega^2} - \frac{jR}{L\omega}}$ where R = resistance per unit length of feeder cable.

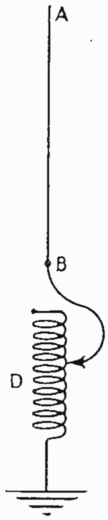


FIG. 6.

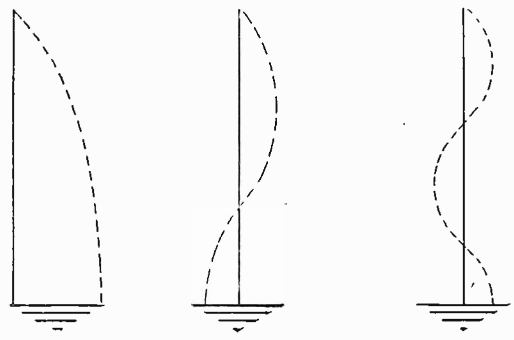


FIG. 7.

Now since the current in such an aerial is due to the passage of electrons into and out of a capacity, and since this capacity must be zero at A, and maximum at the earth end of the inductance; it follows that the current must be zero at A, and maximum at earth. Therefore if we wish the aerial to resonate (i.e. to radiate maximum energy) at a wavelength λ, it is obvious that the effective length of the aerial and loading inductance must be

$$\tfrac{1}{4}\lambda\ ,\ \tfrac{3}{4}\lambda\ ,\ \tfrac{5}{4}\lambda$$

or some odd number of quarter wavelengths.

The instantaneous values of current for these aerials are shewn in Fig. 7, and the corresponding voltage curves in Fig. 8.

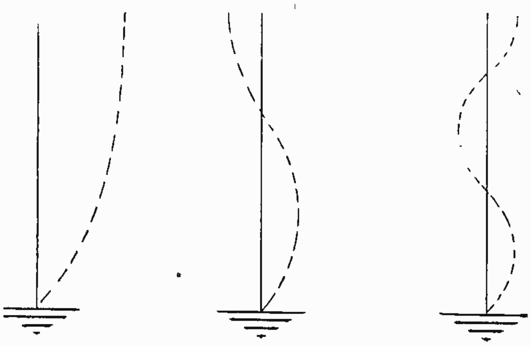


FIG. 8.

Hence we can easily see that, if the effective length of the aerial itself is $\frac{\lambda}{2}$, we must add inductance D to make the effective length of the whole system $\frac{3}{4}\lambda$. We shall then have a state of affairs as represented below (Fig. 9). If we consider any point P, some distance from the transmitter, we shall have the intensity from a point B on the aerial partially neutralising the intensity from a point A, since in one case the intensity is negative, and in the other case it is positive. Hence with an aerial of more than $\frac{\lambda}{4}$ long, we shall have a comparatively weak field. We have therefore two alternatives :—

1. To make the aerial exactly $\frac{\lambda}{4}$ long.
2. To prevent the part CB of the aerial radiating.

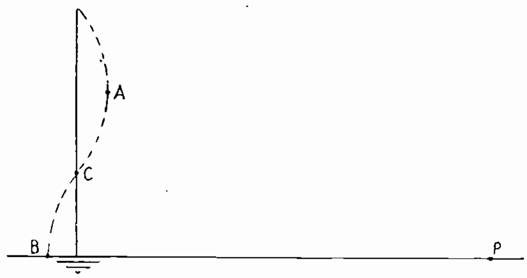


FIG. 9.

The second method is adopted in the case of the S.A.1. set. The coil in which the part of the current curve represented by CB takes place is shielded by an earthed screen and is thus effectively prevented from radiating.

Two aerials can be provided for use with the set. One of these is almost exactly $\frac{\lambda}{2}$ long, and is loaded to give an effective length of $\frac{3}{4}\lambda$. The other is slightly less than $\frac{\lambda}{4}$ and is loaded to give an effective length of $\frac{\lambda}{4}$.

The use of short waves has many advantages for such a set as the S.A.1. Firstly we can energise the aerial effectively, as an aerial of $\frac{\lambda}{2}$ in length is quite convenient to handle. Secondly, the $\frac{\lambda}{2}$ aerial is of such dimensions as to be practically invisible at short distances. Thirdly, the aerial itself can be placed in a position on the top of a trench or outside a dug-out where it forms an effective radiator and by the use of the feeder cable the set and operator can be safely housed below ground. Fourthly, the traffic on such a short wave is not liable to be picked up accidentally as might be the case if the transmission were made on, say, 300 metres, finally, on such short wavelengths interference from atmospherics is negligible and consequently combined with the present-day freedom from jambing on these wavelengths, communication under all conditions is very much more certain than is the case with any wavelengths of a lower order of frequencies.

S.A.1. Receiver.

The receiving system employed in the S.A.1. set is a modified form of Super-Regenerative circuit, and combines very great magnification with perfect stability. The control of the receiver is remarkably simple, and the tuning is very selective without being too sharp for manipulation.

There are three valves in the receiver. The first, a D.E.Q., operates as an autodyne detector, as will be explained later. The second operates as a long wave oscillator, and the third operates as a simple note magnifier.

The general theory of the receiver is as follows :—

In an autodyne or heterodyne detector, when continuous wave signals are being received, it can be shewn that the following relation holds.

$$\triangle\, I_p = \frac{EE^1}{2} \cos(\omega - pt) \frac{d^2I_p}{dE^2}$$

where

$\triangle\, I_p$ = change in plate current.

$E^1 \cos \omega t$ = periodic E.M.F. produced, in grid circuit of valve by self oscillation.

$E \cos pt$ = periodic E.M.F. impressed on grid circuit of valve by C.W. signal.

For ordinary continuous wave reception, p is made very nearly equal to ω. In this case cos $(\omega - pt)$ fluctuates very slowly, and produces an audible signal in the telephones which are in the anode circuit of the valve.

Now, from the above equation, it seems that the more violently the valve is oscillating (i.e. the larger E^1 is made), the more sensitive will the valve act as a detector. Actually the more E^1 is increased the smaller does $\frac{d^2I_p}{dE^2}$ become. Hence some condition must be found to give the best results, and it is found that, in general, the product $E^1 \frac{d^2I_p}{dE^2}$ will be a maximum for the condition in which the valve is just on the point of stopping oscillating.

In Fig. 10, a curve is given shewing the variation of I, the signal intensity, with M, the coupling between the grid and anode coils of the detector. It will be seen that the value of I increases rapidly with increase of M, until the critical value of M is reached, and the valve begins to oscillate. The signal now increases in intensity enormously, but loses all of its original wave-form, and even becomes broken up if it happens to be of a damped-wave character.

It is obvious then, that in the case of the S.A.1. set, where all the signals are either Tonic Train or Speech, that we must prevent the valve from oscillating, whilst keeping it as near to the oscillating condition as possible.

Actually the method used is as follows. The signal is impressed on the grid of the detector by means of a coupling coil G (Fig. 11), in series with the aerial system. The detector is arranged so that the coupling between A and B is just insufficient to start the tube oscillating with normal H.T. voltage. The whole input circuit is tuned by means of the condenser C to the wavelength required.

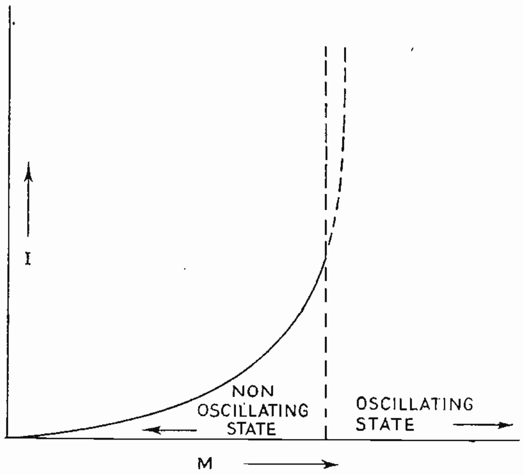


FIG. 10.

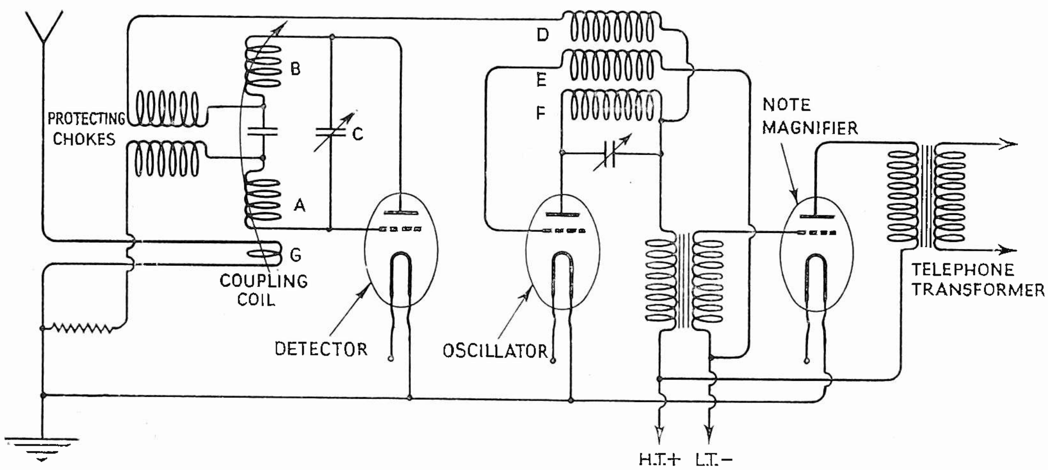


FIG. 11.

The oscillator is simply a tuned anode oscillator tuned to about 20,000 ∿ per second. A coupling coil D is in series with the H.T. supply to the detector. When the oscillator impresses a varying E.M.F. on this coil, the H.T. voltage on the detector is varied at a super-sonic rate, and causes this valve to start and stop oscillating, at a frequency of 20,000 ∿ per second.

In this way enormous amplification is obtained, and yet no audible distortion of the signal occurs; for the valve is only unstable for lengths of time which are too short to be heard.

The rectified signal is further amplified by means of a transformer coupled note magnifier, and taken to an output transformer, and from thence to the telephones.

A DISCUSSION ON SHORT WAVE FADING

Fading is examined on the assumption that it is produced by the accidental interference of two or more rays. The mean square variability is calculated, and a comparison with observed results shows that the actual variability is more than twice the calculated value.

A calculation is made of the reduction in variability occasioned by the addition of the rectified signals from two spaced aerials on the assumption that the effects in these two are statistically independent. These results show that the variability should be approximately halved.

A better comparison of the gain on using two aerials is obtained by comparing the number of fades to less than a prescribed fraction of the mean signal strength on the single and double aerial system. If this prescribed value is 38 per cent. of the mean signal strength, a gain of the order of 20 to 1 accrues, that is, if there are twenty fades per hour in the single aerial case, there will only be one when using the combined results of two aerials.

THE chief problem of short wave transmission is undoubtedly fading, as the interference due to atmospherics on the short wave band is practically negligible.

At the outset, it is suggested that there are two types of fading which must be considered. There are the long fades of half an hour to hours at a time, and the short fades of a minute to fractions of a second. The long fades of half an hour up to whole days at a time, which occur during magnetic storm activity, are almost certainly due to a practically complete extinction of all rays by widespread absorption in the upper atmosphere.

The only weapon against this sort of fading is the alteration of wave length to suit conditions, but, so far, this has not met with much success, for this type of fading seems to be prevalent on all waves in the short wave band, say 14 to 50, and the results obtained seem a little contradictory.

From our own experience it would appear that this type of attenuation (rather than fading) chiefly affects the Canadian and American circuits, and that the 15 to 16 metre wave band is not much less affected than the 26 M. band.

This was particularly marked on the occasion of the storm on April 14th, when Canada on 26 M. and the American short wave stations 2XBC 14M., 2XS 15M., 2XT 10M., and WLL were unheard all day until about 1610, and when CG and all the short wave American Stations appeared between 1545 and 1625.

Picard, in Proc. I.R.E., February, 1927, has shown that a very strong correlation exists between magnetic character and short wave signal fading ; a correlation factor as great as $-0\cdot89$ to $0\cdot06$ being obtained in transmissions between Chicago and Boston on a 22·5 metre wave early in 1926.

Theory.

It is generally supposed that magnetic storms are caused by the incidence on the earth's upper atmosphere of streams of charged particles sent out from disturbed areas on the sun's surface. The disturbed areas are often associated with sunspots, but not invariably so. These magnetic disturbances have a tendency to repeat themselves in 27-28 day periods, *i.e.*, the rotation period of the sun on its axis relative to the earth, showing their dependence on a particular disturbed area of the sun's surface which is carried round in 27 days by the sun's rotation.

Examples of the recurrence of bad short wave fading after 27 day periods are exemplified in a period of fading on September 20th, followed by one on October 14th.

Again, a period on March 16th, 17th, 18th, followed by another on April 11th, 12th, 13th, 14th.

On the other hand, it is impossible to predict any recurrence, for a given disturbance on the sun's surface may have died out during the 27 day period of rotation.

Magnetic observations indicate an increased conductivity of the Heaviside layer during the times of magnetic disturbance, caused no doubt by either the direct increase of the number of ions, or indirectly by their ionisation effect. (Increased reflection coefficient on long waves.)

Such an increase in ionisation, if the generally assumed theory of short wave transmission is correct, will result in increased attenuation. The attenuation is proportional to $N\lambda^2$ where N is the number of ions per cc., and an increase of N will increase the attenuation for all short waves.

The bending of the ray is also proportional to $\frac{\lambda^2 dN}{dh}$, where h is the height; it therefore follows that if the density is increased at every point in the layer in a given ratio r, say, so that if the final and initial distribution of ions is similar, then the attenuation will be increased in the ratio $r\lambda^2$.

Thus, if r is increased four-fold everywhere, a two-fold reduction of λ will leave the attenuation and bending of the ray unaltered, and the transmission on half the original wave length should be as good as before the increase of ionisation. Such an argument suggests that the use of sufficiently short waves might overcome this type of attenuation, but the actual facts do not give much support to this idea, and we must suppose that the original distribution of ions is altered by the eruption of ions from outside into the upper atmosphere. In the absence of any knowledge of how the ions are redistributed in the layer it is impossible to state what effect wave length changes will produce. The general opinion is that no definite rule for choosing the wave length so as to give the best results under disturbed conditions can be given in the present state of our knowledge.

There is just a possibility that a very short wave length, say 5 to 10 metres, may be of use during these periods.

Fortunately, these effects are mostly confined to the Canadian and American circuits, the rays from which pass relatively close to the North magnetic pole.

Quick Fading.

The quick fading from periods of a minute or two to fractions of a second is of an entirely different nature, and it is characterised by the fact that while extinction may occur at one particular moment and place, a slight shift in position or frequency will bring the signals in strong again.

It is not a widespread fade in the sense that within a large band of frequencies all places are simultaneously robbed of energy, such as is the case with the magnetic storm fades just referred to, but is particular in respect of position and frequency.

In this respect there is hope of overcoming the fading by taking averages over a large band of frequencies or over large areas of space. Such a state of affairs can be most readily attributed to interference effects between two or more rays which for one particular frequency and place will interfere at one moment, and for neighbouring frequencies and positions at another moment. The irregular variation of the fading suggests a chance distribution, and one is led to consider the effect of the addition of a number of rays of random phase. These rays will sometimes add, and sometimes be in opposition, so that the resultant can be expressed as a function of the time of irregular varying amplitude. From the point of view of fading, the significant quantity is the variability of this curve. There is a mathematical method of assigning a number to this quantity, which can be explained as follows: Let the actual curve be represented in the figure:

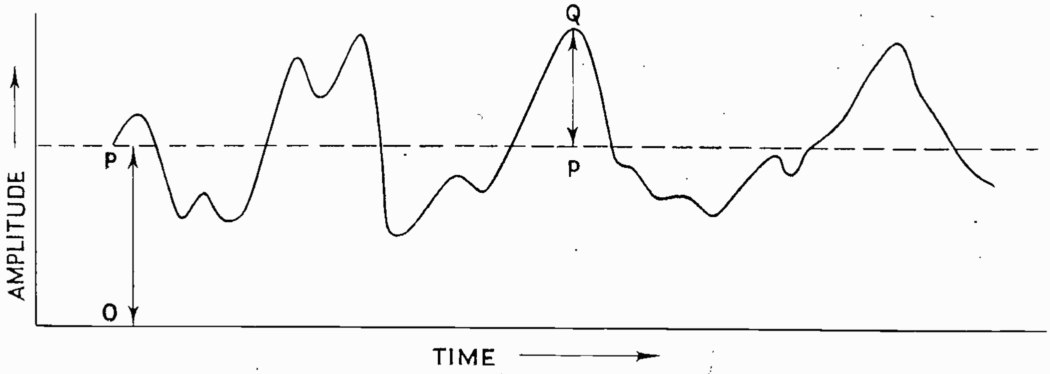


FIG. 1.

and let OP be the mean ordinate over a period which includes many peaks and valleys of the curve.

Then if we take the difference between the ordinates of the curve and OP, *e.g.*, QP and square them, and take the mean, we shall have a measure of the variability.

This quantity obviously vanishes when the ordinate is constant, and increases with the amplitude of the oscillations from the mean, and is therefore a good measure of the variability. It is possible to calculate what this variability should be on varying assumptions, including, of course, that in which it is considered as a statistical problem in which the phases of the component rays can be considered to be on the average chosen at random. Fading of this sort may be due to the interference of two or more rays, and the variability will be a function of the number of rays interfering.

Thus, we should expect that with a large number, N, of rays, the probability that all the phases should be arranged so that the resultant is zero, or N will be very small, whereas in the case of two rays this probability is relatively large, and we should therefore expect a much larger variability in the latter case than in the former.

But it is important to have actual figures so that we can determine of the actual fading, whether it is of the many ray type or of the few ray type.

In calculating the variability in the case of two rays, we may assume from physical considerations, and the fact that at times they practically completely cancel each other, that they are both of the same average intensity, E, say.

The resultant r of the two will then be :

$$r^2 = 2E^2(1 - \cos\theta) \quad . \quad . \quad . \quad . \qquad (1)$$

where θ is the phase angle between the two.

The probability that θ lies between θ and $\theta + d\theta$ is $\frac{d\theta}{2\pi}$, so that the probability that r lies between r and r + dr is $\frac{d\theta}{2\pi\, dr} \cdot dr$

$$2r\,dr = 2E^2 \sin\theta\, d\theta \text{ (from (1))}$$

$$\frac{dr}{d\theta} = \frac{E^2 \sin\theta}{r}$$

$$\frac{1}{2\pi}\frac{d\theta dr}{dr} = \frac{1}{2\pi}\frac{r\,dr}{E^2 \sin\theta}$$

$$\text{Now } \cos^2\theta = 1 - \frac{r^2}{E^2} + \frac{r^4}{4E^4} \text{ from (1)}$$

$$1 - \cos^2\theta = 1 - \left(1 - \frac{r^2}{E^2} + \frac{\frac{r^4}{4E^4}}{2}\right) = \frac{r^2}{E^2}\left(1 - \frac{r^2}{4E^2}\right)$$

$$\sin\theta = \frac{r}{E} \cdot \sqrt{\left(1 - \frac{r^2}{4E^2}\right)}$$

$$\frac{1}{2\pi}\frac{d\theta}{dr}\cdot dr = \frac{1}{2\pi}\cdot\frac{dr}{E\sqrt{1-\dfrac{r^2}{4E^2}}}$$

and the probability that r lies between O and 2E

$$= \frac{2}{2\pi}\int_0^2 \frac{dz}{\sqrt{1-\dfrac{z^2}{4}}} = 1,$$

as it should be.

The variability can now be calculated as follows:—

In the first place we have to calculate the mean square value. It is

$$\frac{2}{2\pi E}\int_0^{2E} \frac{r^2 dr}{E\sqrt{1-\dfrac{r^2}{4E^2}}} = 2E^2$$

and the mean square deviation or variability is

$$\frac{1}{\pi E}\int_0^{2E} \frac{(r-\sqrt{2}E)^2\, dr}{E^2\sqrt{1-\dfrac{r^2}{4E^2}}} = 4E^2\left(1-\frac{2\sqrt{2}}{\pi}\right)$$

and the ratio of this to the average value is

$$2\left(1-2\sqrt{\frac{2}{\pi}}\right) = 0.200$$

Application of Probability Theory.

In the case where n, the number of rays, is large, we can use the results given by Lord Rayleigh (*Theory of Sound*), where he shows that the probability that the resultant r of n vectors of random phase lies between r and r + dr is

$$\frac{2}{n}e^{-r^2/n}\cdot r\,dr$$

The mean square amplitude is

$$r_1 = \frac{2}{n}\int_0^\infty r^3 e^{-r^2/n}\cdot dr = n$$

so that the mean square deviation is

$$\frac{2}{n}\int_0^\infty e^{-r^2/n}\cdot r\,(r-\sqrt{n})^2\, dr$$

which can be shown to be $n(2-\sqrt{\pi})$, and the ratio to the mean square amplitude is therefore $(2-\sqrt{\pi}) = 0{\cdot}228$.

Considering the two results together, we find that the percentage variability for two and for many rays is very nearly the same.

The actual examination of observed fading curves, an example of which is given here, shows that the variability is much greater than can be expected from the random interference of either few or many vectors, and even were the vectors of different amplitude the expected variation would be less.

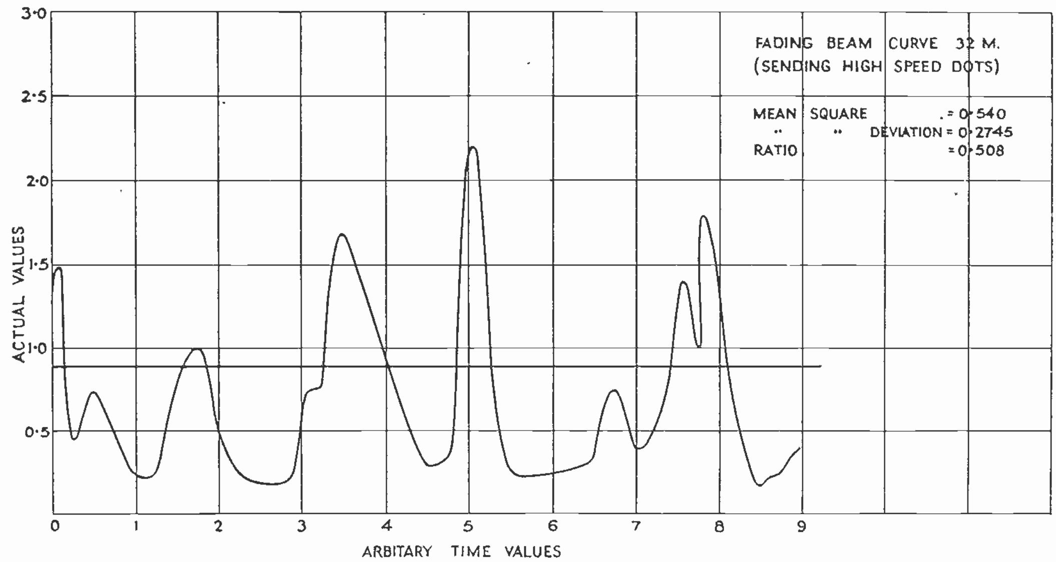


FIG. 2.

The pronounced peakiness of the fading curves on these lines seems very difficult to explain.

Under scattering conditions the signals appear to be much steadier, and the variability probably approaches the theoretical value 0·228 fairly closely.

The reason for this is obvious if we consider the nature of scattered radiation, which consists of a large number of rays (*approximately of equal amplitude*) and of random phase.

(*To be Continued*)

MARCONI NEWS AND NOTES

THE MARCONI SHORT WAVE BEAM SYSTEM

While other pages of this Review will deal with scientific and technical problems and developments of wireless communication, this section will be devoted each month to a review of the commercial activities of the Marconi Company and the uses which are being made of its manufactures in carrying out wireless communication in all its forms in all parts of the world.

NO subject can be more appropriate for the first place in this series of notes than the astounding success that has followed the development of the Marconi Short Wave Beam System.

There are four groups of Beam services at present in operation :—

(1) The Beam stations built by the Marconi Company in England, for the General Post Office, for direct high-speed communication with the British Dominions and India ; with corresponding Beam stations in the Dominions and India.

(2) The Marconi Company's own group of Beam stations for communication " Via Marconi " with the United States of America, the Argentine, Brazil, Egypt and the Far East.

(3) The Beam stations built by the Marconi Company for the Companhia Portugueza Radio Marconi for communication with Brazil, Angola, Mozambique and the Cape Verde Islands.

(4) Marconi Beam stations purchased by other non-British countries for long distance wireless communication.

All these Beam services have attracted to themselves large volumes of traffic as soon as they have been put into operation, and the amount of traffic handled and the speed of transmission and reception has definitely established the Marconi Short Wave Beam system as the most efficient means of high-speed long distance wireless telegraph communication for the future.

The efficiency of this system is shown by the fact that the amount of traffic carried by the service between England and Australia has already grown to a figure approximating 9,000,000 words per annum ; while the traffic on the whole of the British Imperial services has been steadily growing at an average increase of approximately 3 per cent. per week, the total now standing at the substantial figure of over 40,000,000 words per annum.

The flexibility and carrying capacity of the Marconi Beam services is shown by the fact that, though they are normally worked at between 100 and 200 words per minute, much greater speeds are attainable, and 400 words per minute have been worked on commercial traffic during periods of pressure.

There are at present 26 Marconi Short Wave Beam stations in operation in :—

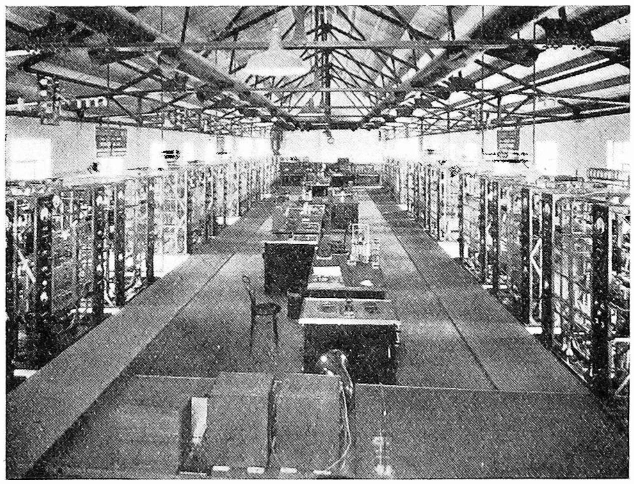
ENGLAND	CANADA	AUSTRALIA
SOUTH AFRICA	INDIA	EGYPT
PORTUGAL	MOZAMBIQUE (Portuguese E. Africa)	ANGOLA (Portuguese W. Africa)

and other countries.

It may be considered by some observers that the directional properties of the Beam limit the usefulness of this system, but there is little in this argument, as is shown by the flexibility of existing Beam stations and the fact that—

1. The width of the Beam may be varied by utilising one or more bays of the aerial system.
2. It is possible, while keeping the Beam at any desired width, to swing it, with but small loss of efficiency, over a small arc, by a few alterations in the circuit and without any structural alterations to masts or aerials. Thus, one set of masts may be used for one service on one side and for another service at an angle to the great circle bearing for which the masts are primarily aligned on the other side.

With the growing number of short wave stations now being established and the consequent possibility of congestion in the future, the value of the Beam will become increasingly evident as a means of avoiding interference from and with other stations.



Marconi Beam Station at Dorchester with Seven Transmitters.

The directional properties of the Beam also play an important part in the elimination of atmospheric interference; and the reflector not only tends to eliminate atmospherics from behind the station, but also interference due to echo, *i.e.*, waves which travel round the world in the opposite direction from the main signal.

Whenever an invention of a revolutionary character has been made, rival inventors, in order not entirely to be out of the picture, have suggested some modification in the detail of the application of the invention, and have made the claim on behalf of their modification that it has advantages over the original idea. It is not, therefore, surprising, and indeed it was inevitable that, following on the sensational success of Senatore Marconi's Beam system, other wireless inventors should have seized on his central idea, and, by modifying certain details of it, should endeavour to show that the Marconi Beam system is not the only directional system of wireless telegraphy. Even rivals have to admit, however, that the system they are putting forward is the Marconi Beam system with certain alterations in detail. The essential idea of these rival systems is the essential idea of the Marconi Beam system. All that the competitors have done, all that they claim to have done, is to have made certain small changes in the form of application of Senatore Marconi's invention.

The Marconi Beam system, however, is the only one which has been tried in commercial practice for any sufficient period of time. It is working over the greatest distance and under the most varied conditions, and it is carrying a larger volume of traffic than any other telegraph circuit in the world.

The Marconi technical staff have this advantage over the technical staffs of other wireless companies, that they have been able to observe the system in actual commercial working for two years, and no one supposes that they have been standing idle. It can be taken for granted that every claim which has been made by other inventors has already been anticipated by the Marconi technical staff, and that in regard to price, size of aerials and carrying capacity, the Marconi Company's system is at least two years ahead of any other.

It has been proved by the experiments carried out by the Marconi Company's engineers, that, whatever may be said to the contrary, a Marconi Beam aerial system gives better results than can be obtained by any of the various modifications of that system which are being put forward by competitors.

Marconi Aircraft Wireless.

No wireless company in any part of the world has had as much experience of wireless for aircraft as the Marconi Company.

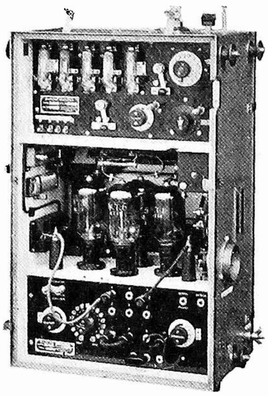
As early as 1912 the Marconi Company, which had already achieved outstanding success in other branches of wireless communication, began to devote serious attention to wireless communication for aircraft, and it was the first to design and manufacture a practical wireless set for use in aircraft.

It has maintained this ascendancy in all types of aircraft wireless apparatus for both civil and military purposes, as is shown by the fact that it is also used for Service or Commercial purposes in the following countries :—

Great Britain and British Dominions.

Argentine.	Czecho-Slovakia.	Italy.	Portugal.	Sweden.
Belgium.	Denmark.	Japan.	Roumania.	Switzerland.
Brazil.	Greece.	Mexico.	Russia.	U.S.A.
Chili.	Holland.	Persia.	Siam.	Uruguay.
China.	Hungary.	Poland.	Spain.	Yugo-Slavia.
Colombia.	Iraq.			

The London Air Port at Croydon has the most up-to-date and the most efficiently administered aerodrome wireless ground station in the world. It was built for the British Air Ministry by Marconi's Wireless Telegraph Company, and in its construction were combined the results of the experience and technical knowledge of the British Air Ministry, and of the Marconi Company.



Marconi A.D.6h Aircraft Wireless Set.

Marconi apparatus is the standard equipment for all British Civil aircraft, and its reliability and value to aerial navigation is shown by the regularity of the journeys made by Imperial Airways machines in all weathers.

Pioneer Flights.

Apart from its use in established air routes, Marconi wireless equipment has also a fine record of service in connection with pioneer flights, where its value for navigation and in maintaining communication with the outside world has been incalculable.

The Company's long experience has, of course, given it unrivalled knowledge of the requirements of such ventures, and it is the only company which has had experience of fitting wireless direction finders to all-metal flying boats such as those used by the Spanish airman Commander Franco on his flight to South America, and Captain Courtney, the English airman, on his attempt to fly across the Atlantic.

Discussing the technical lessons and experience of his flight, Commander Franco says :—

> "Wireless telegraphy has assisted us in such a manner that in future it should be considered indispensable for flights over sea or deserted land."

Captain Courtney, brought down at night after flying 700 miles of the journey from the Azores to Newfoundland, was able to determine his position by means of his direction finder, and after his rescue immediately sent the following telegram to the Marconi Company :—

> "Rescue entirely due to Marconi wireless."

The "Aeroplane," one of the leading English aeronautical periodicals says :—

> "The outstanding feature of the rescue of Mr. Courtney and the crew of the Dornier Wal was certainly the faultless functioning of the Marconi wireless apparatus."

If the flight had been successful a great deal of the credit would have been due to the Marconi wireless apparatus, which was in constant use in the earlier stages of the flight in sending messages and in taking wireless bearings.