THE MARCONI REVIEW

No. 4. *January, 1929.*

Technical Editor: H. M. Dowsett, M.I.E.E., F.Inst.P., M.Inst.R.E.
General Editor: W. G. Richards.

THE INFANT HERCULES

A REMARKABLE CARTOON

A LITTLE more than 25 years ago, on the 30th March, 1903, *The Times* published the first transatlantic Marconigram, and *Punch*, true to its reputation for interpreting the public opinion of the day, signalised this event in its issue of the 15th April, 1903, by the cartoon which is reproduced on the next page.

It symbolises something more than the potentialities of a new invention; the sturdy virile growth of the Infant Hercules, nurtured by science and cradled in the Marconi Company, suggests that with the vision of the inventor is associated constructive ability, and a dynamic organisation capable of consolidating development and marking out a clear line of irresistible progress, cleaving a way between the Government Land Telegraphs and the well established interests of the Ocean Cables, the two recognised means of signalling which up to that date had divided the communications of the whole world between them.

In the old Greek legend Hera sent two serpents to destroy the new-born Hercules, but he overcame and strangled them.

Needless to say the artist did not intend the analogy to be taken too literally; at no time has any one of the protagonists been in danger of extermination at the hands of one of the others, the aggressive enterprise of wireless being countered by an improved public service and attempts at restrictive control, proposed and supported by the established systems, and as each possesses a sphere of operation in which the others cannot encroach, the healthy rivalry engendered has resulted in the steady but hard won progress of wireless and a gain to the communications of the Empire considered as a whole, and of the world in general.

Bearing this in mind, it may be worth while to recall the events which made Wireless history about the year 1903 and thereby gave rise to this cartoon.

Following the preliminary trials across the Atlantic on December 12th, 1901, the possibility of establishing effective communication was placed beyond doubt by authenticated tape records obtained on the S.S. Philadelphia during Mr. Marconi's next voyage to the United States in February, 1902, and the general public then began to realise that the cable companies had a live competitor.

Other long distance tests followed. Signals were received from Poldhu on the Italian cruiser Carlo Alberto at Kronstadt in July, at Spezia in August, and across the Atlantic at Sydney, Nova Scotia, in October.

The station under erection at Cape Breton was far enough advanced for an inaugural message to be sent by the Governor-General of Canada to King Edward VII. and to the King of Italy on December 21st, 1902, and on January 19th, 1903, the President of the United States, Mr. Roosevelt, sent a message of greeting to King Edward through the newly completed station at Cape Cod. At length, greatly daring, the Marconi Company opened a limited public service across the Atlantic, the first paid news message being sent to *The Times* on the 30th March, 1903.

For a few months there was a rush of messages to and from Canada and the United States, and then both services were brought to a temporary standstill by plant failures, transatlantic wireless telegraphy in its early stages being no less subject to interruption than was transatlantic cable telegraphy at the beginning of its career.

Turning now to another branch of wireless development, that of ship to shore telegraphy, in the year under review, the Marconi Company having installed apparatus at several signal stations belonging to the Corporation of Lloyds, was working through coast stations at Caister, North Foreland, Niton, The Lizard and Holyhead in England; Malin Head, Rosslare and Crookhaven in Ireland; The Nantucket Light Vessel, Babylon and Sagaponak in the United States; and conducting a successful public service to numerous ships of various nationalities equipped with Marconi apparatus, the first British Merchant ship to be fitted being the ss. Lake Champlain, on the 21st May, 1901.

The Company had evolved a system of wireless telegraphy applicable to the ships of all nations, so that in case of distress they could inter-communicate and co-operate with one another. The organisation which had been created to operate the instruments and handle and clear the traffic was working efficiently, and the system of accountancy which had been devised to cover the prepayment of messages on board ship to destinations in various countries having their own land charges—through rate cards being introduced in 1902—had solved a very important problem, and allowed the traffic to be handled on practical business lines.

In the United Kingdom messages for ships were addressed to the Marconi

PUNCH, OR THE LONDON CHARIVARI.—APRIL 15, 1903.

THE INFANT HERCULES.

station, and those received from ships were sent to the local post office either by hand, or at a later date they were transmitted by private wire.

The British Post Office, while it possessed a monopoly of all communication by land line telegraphy, had no power of control over the transmission of ether-borne messages. It was not until August, 1904, when the Wireless Telegraph Act was passed, that it became the supreme authority in this country.

The first International Conference on Wireless Telegraphy for the regulation of the use of Wireless at sea was held in Berlin, in the month of August.

In other directions development work was yielding useful results. Tests carried out in March, 1903, between Poldhu and The Lizard, had shown that with two transmitters working 100 yards apart, one on a transatlantic wave and the other on a ship wave, the signals could be received on one aerial and separated out by means of two tuned receivers, and this led to the introduction of the long distance Press service to ships at sea by transmission from Poldhu, which started on August 18th, 1903.

The account of the year's work would not be complete without a reference to the co-operation which existed between the British Admiralty and the Marconi Company, which led to a new and more complete agreement being concluded in July, 1903, in place of the limited agreement for the supply of wireless apparatus to the Navy, entered into in 1901, and to a demonstration being given in October, 1903, of the use of long distance transmission to the Fleet during the voyage of H.M.S. *Duncan* to the Mediterranean with Captain Jackson representing the Admiralty and Mr. Marconi on Board.

Undoubtedly 1903 was a notable year in Wireless history.

Coming now to our own time and the subject of this article, with the passage of more than 25 years, the Wireless Hercules has attained maturity. Channels of communication straddle the earth and reach out to the mobile ship, the aeroplane and even the submarine.

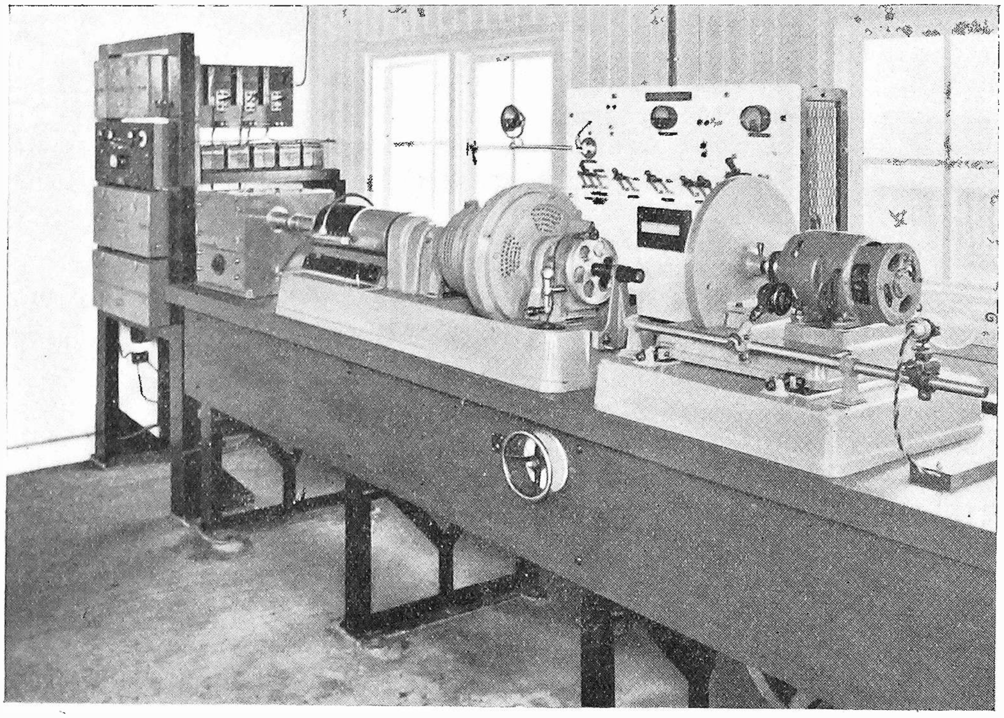
Land line telegraphy and telephony have, in the interval, learnt much from Wireless, and valve amplifiers and carrier wave methods are now common to both. The close association which is commencing between Wireless and the Cables gives to the *Punch* cartoon another meaning, which is the reason for its reproduction here, the entwining of the three systems being from the new point of view one of affinity in service with a difference of function, such as should enable all the needs of world communications to be most effectively met.

H. M. D.

MARCONI-WRIGHT FACSIMILE SYSTEM

PRESENT POSITION OF DEVELOPMENT

FACSIMILE transmission, or the accurate high speed transmission of print, pictures, finger-prints, etc., by land line or by wireless telegraphy, has a very wide field of application for general communication purposes, and in particular for press work.



As distinct from "picture telegraphy," it provides a more exact reproduction of the original than that which is necessary to satisfy the usual light and shade requirements of a picture.

For several years past high speed facsimile transmission has been the subject of extensive research work, but it was only as a result of recent developments that it could be said to have reached the stage which ensures commercial success.

The apparatus which the Marconi Company is now placing on the market is very dependable, speedy, simple to operate, and when used on a Post Office land line of good quality, gives excellent reproduction.

The same type of apparatus has for some months been employed on short wave wireless experimental transmission of facsimile between the United States and England, and, under suitable wireless conditions it has given very satisfactory results.

It is found, however, that short wave transmission of facsimile over great distances is less satisfactory than over a good land line, due, not to any defect in the apparatus, but to distortion effects which are produced in the radiation as it passes through the medium between the two stations. The research engineers of the Marconi Company are now concentrating their efforts to overcome the difficulties introduced by this new factor.

These transatlantic tests should not be confused with the commercial service employing the Ranger system, which has been in operation now for two and a half years and giving good results. This is a slow speed method, and has been confined to long wave working.

The illustration gives a comprehensive view of the Marconi-Wright facsimile apparatus at the transmitter end. The apparatus on the right shows the chopper disc and driving motor, with controlling switch board for the whole apparatus. In the centre is the optical rotor and lens system, and on the left are the amplifiers, etc., mounted in box form on a frame.

A potassium argon light cell is used at the transmitter end in the Marconi system, and a Kerr cell at the receiver end.

A complete description of the apparatus will be given at a later date, in The Marconi Review.

THE DESIGN OF TRANSMITTING AERIALS FOR BROADCASTING STATIONS*

By Capt. P. P. Eckersley & H. L. Kirke,
of the British Broadcasting Corporation, *and*
T. L. Eckersley, B.A., B.Sc.,
of the Research Department Marconi's Wireless Telegraph Company.

This paper deals with an important technical aspect of the problem of transmitter design—the design of the transmitter aerial. If this matter is dealt with scientifically, and the recommendations are followed by Continental organisations, something might be done to improve the service to European listeners. The proper method of attack against the problem of mutual interference between stations and the all too limited service area of stations is to attempt to design an aerial so as, ideally, to make it a radiator which only produces a direct ray or ground ray, i.e., *a ray initially parallel to the earth's surface. It is the existence of the indirect ray which produces all the difficulties inherent to the production of a good broadcasting service, not only because such an indirect ray interferes with other very distant stations, but also because it produces fading and bad quality in the local service area. Further, all energy radiated upwards is, in broadcasting, lost energy.*

Obviously the more an aerial can be made to radiate only in a direction tangential to the earth's curvature at the base of the aerial, the more the ideal conditions will be approached. If all the aerial energy could be directed to produce this type of radiation there would be no indirect ray, no fading of signals, less interference with certain other stations at night, and greater power efficiency of the aerial. Certainly we might expect some interference, but at a skip distance, not everywhere as at present. Thus it is important for broadcasting engineers to consider the aerial only in regard to its ability to produce radiation normal to its vertical portion. It is further important, however, to enable an engineer to specify the extent of service area, to know the rapidity at which these rays will be attenuated. This paper thus deals, in the second section, with considerations of attenuation, and gives a complete set of attenuation curves for various broadcasting wavelengths.

Theoretical Considerations of Aerial as Radiator.

THE behaviour of a high aerial situated on a perfectly conducting earth is well known, and has been fully worked out by Stuart Ballantine. In any actual case, however, the earth's resistivity has to be taken account of. One of the writers has concluded, on the basis of Sommerfeld's analysis of the case, that the behaviour of an aerial situated on ground of conductivity σ differs only slightly from this ideal case when the conductivity is so large that $\sigma\lambda c$ is large compared with K, the specific inductive capacity of the earth.

The effect of the finite conductivity of the earth is as if a constant small resistance Ro, independent of the height of the aerial, were added to the radiation resistance calculated in accordance with the ideal case. We are therefore justified in using Stuart Ballantine results if due attention is paid to the extra resistance on account of earth loss.

* Summary of paper read at a meeting of the Wireless Section of the Institution of Electrical Engineers, on 18th Dec., 1928.

One aspect of these results is illustrated in Fig. 1, where the polar diagrams (in the vertical plane) of a $\frac{1}{2}$ wave aerial and one small compared with $\frac{1}{4}\lambda$ are shown. These are drawn for the same metre-amperes in the aerial so that the field strength in the horizontal plane is the same in the two cases. It is obvious from a direct inspection of the figure that the directive efficiency in the horizontal plane is much greater for the $\frac{1}{2}\lambda$ than the $\frac{1}{4}\lambda$ or small aerial. The latter wastes much of its energy by upward radiation, which is not present in the case of the $\frac{1}{2}\lambda$ aerial because of the phase cancellation of the radiation from the widely separated elements of current in this aerial. It is obvious from this figure that a given signal strength can be obtained with much less input power with a $\frac{1}{2}\lambda$ aerial than with a $\frac{1}{4}\lambda$ aerial, say. Fig. 2 shows the relative power necessary to produce a given signal strength as a function of the height of the aerials. The higher the aerial up to $\lambda/2$, the less the power. These curves are given for various dead loss resistances. It is important to realise that the gain of a $\frac{1}{2}\lambda$ over a $\frac{1}{4}\lambda$ aerial is almost independent of this resistance so long as this is small, compared with the 100-ohm. radiation resistance of the $\frac{1}{2}\lambda$ aerial. The results to be expected from an experimental test are therefore confined to fairly narrow limits, and a good confirmation of the theory will be obtained if the results are within these limits.

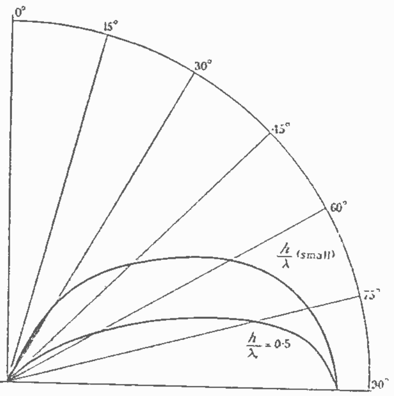


FIG. 1.—*Vertical polar diagram of radiation for $\frac{1}{2}\lambda$ and $\frac{1}{4}\lambda$ (or less) aerials. Drawn for the same maximum radiation intensity in the horizontal plane.*

It will be seen that the reduction in high angle radiation occasioned by the use of a $\frac{1}{2}\lambda$ aerial should reduce fading.

Experimental Tests.—It was thought important to test this theoretical analysis in terms of full-scale experiments. To this end the British Broadcasting Corporation approached the Air Ministry with a view to hiring a captive kite balloon to support various lengths of aerials.* The site of the experiments was Larkhill, near Amesbury, on Salisbury Plain.

The first experiment was to determine whether, for the production of a given field strength, the necessary power in the aerial was decreased, as theory indicated, by changing from a $\frac{1}{4}\lambda$ to a $\frac{1}{2}\lambda$ vertical aerial.

* The authors' most grateful thanks to the Air Ministry are expressed more fully in the conclusion to the paper.

Difficulty was at first experienced in the mechanical arrangement for supporting the vertical wire of the aerial, but the final scheme adopted was to attach the earth end of the aerial wire firmly to an anchor on the ground, while 60 ft. of rubber shock-absorber was interposed between the balloon and the free end of the aerial.

The power was fed in from the B.B.C. transmitting lorry, which contains a 1 kw. valve transmitter, the power being derived from an alternator clamped to the chassis and driven by the engine of the lorry.

The earth for the aerial consisted of 40 wires radiating from a point immediately under the aerial, each wire being 250 ft. long, and buried in a plough furrow about 6 in. deep.

In order to take account of changing winds the lorry carrying the winding gear for the hauling up and down of the balloon was moved from place to place.

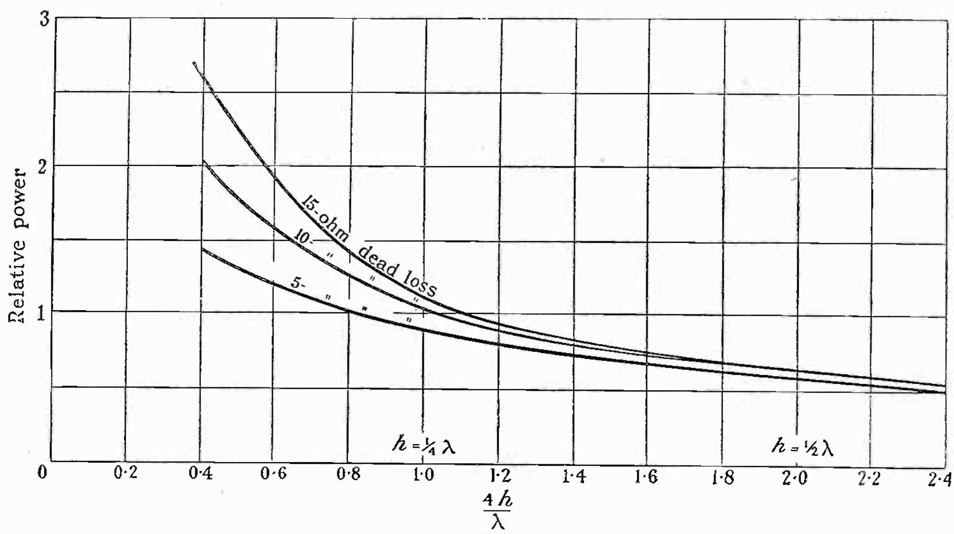


FIG. 2.—*Relative power required to produce a given value of metre-amperes.*

To leave no doubt as to the results, the usual wire hawser for the captive balloon was substituted by a hempen rope. No one made the ascent in the balloon, which was, as a matter of fact, condemned for purely service conditions.

It will be appreciated that one of the greatest practical difficulties was to take accurate readings of the current in the $\frac{1}{2}\lambda$ aerial, as the maximum current occurs half-way up the aerial. Specially large ammeters were, however, constructed, and the readings were taken by telescope.

It was most unfortunate that after the first week the unusually fine weather broke. Great difficulty was experienced due to gales of wind, and a great deal of the time was wasted in waiting for "flying weather." On one occasion the whole rigging collapsed.

Method of Measurement of Constants of Aerials.

Power.—It was essential to have an exact knowledge of the power in the aerial. For the $\frac{1}{4}\lambda$ aerial this was obtained as follows :—The circuit and current distribution were as shown in Fig. 3. The voltage (V) between aerial and earth and the aerial current (I) were measured at various frequencies, and Z, the impedance, was taken to be V/I. The aerial was said to be in tune when Z was a minimum. The power in the aerial was then $Z_{\frac{1}{4}\lambda}I^2$. For the $\frac{1}{2}\lambda$ aerial the connections were as shown in Fig. 4. Z was again compared with frequency, and the aerial was said to be in tune when Z was a maximum. The power in the aerial was in this case the square of the current I_a at the base of the aerial multiplied by the total impedance, $Z_{\frac{1}{2}\lambda}=V/I_a$ (where $Z_{\frac{1}{2}\lambda}$ is a maximum).

Field Strength.—The field strength was taken as the average of six measurements at different points on a circle around the aerial. Each reading was taken at 2 km. from the aerial. The results are given in tabulated form on page 13.

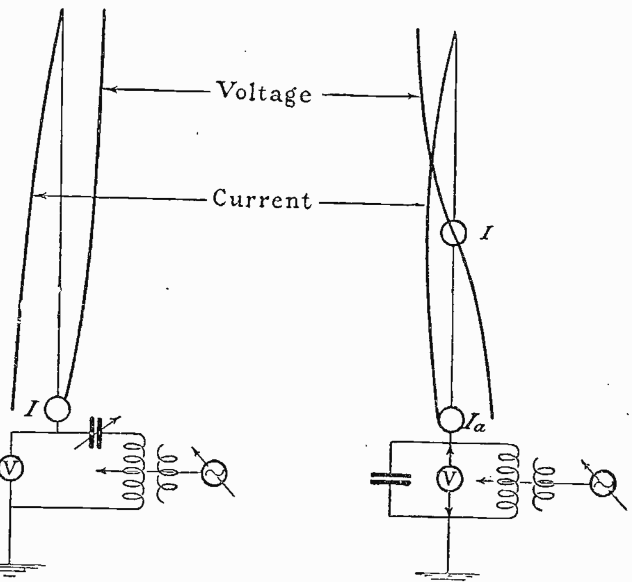


FIG. 3. FIG. 4.

Observations on the Results.

General.—Assume the aerial in both cases to have a 10-ohm dead loss. It is not an unlikely figure, and it is perfectly just to assume the same loss in both aerials, the major loss in any aerial system being due to the field intensity around the aerial. It will then be seen (Fig. 2) that the ratio of power with $\frac{1}{4}\lambda$ to $\frac{1}{2}\lambda$ aerials to produce a given field strength with a 10-ohm dead loss is theoretically 1/0·61 and in the practical measured case 1/0·625—a remarkable confirmation if a 10-ohm dead loss is a fair assumption. Putting the matter still more generally, it can be seen that at any rate there is a substantial gain in the use of $\frac{1}{2}\lambda$ aerials.

Attenuation.

The second factor in the determination of the broadcast performance of a given transmitter is attenuation. Deviations from the ordinary Hertzian formula for transmission over a perfectly conducting plane are occasioned by the imperfect conductivity of the earth.

These deviations are taken account of in Sommerfeld's formula, some of the implications of which are discussed in this paper. In particular, it is shown that the attenuation curve for any wavelength may be derived by a geometrical construction from the observed curve on some standard wavelength, say.

The effect of the earth's conductivity enters into the attenuation formula, though the quantity $d_n = \frac{\pi x}{\lambda} \frac{1}{2\sigma\lambda c}$, which Sommerfeld calls the numerical distance, and the curve (Fig. 5) is useful in representing the factor by which the Hertzian formula must be multiplied in order to give the actual signal strength as a fraction of d_n which contains the unknown quantity σ. Experimental tests to determine this, to test the Sommerfeld formula, and to determine the family of attenuation curves, were carried out by the B.B.C.

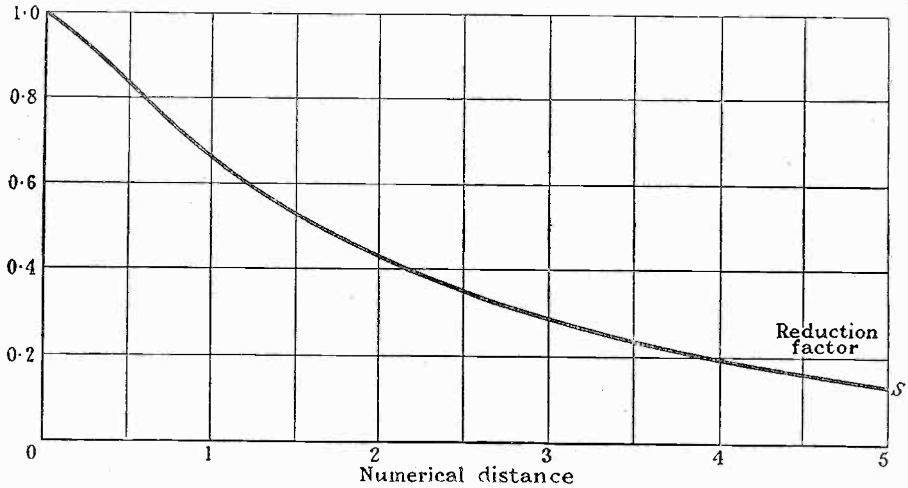


FIG. 5.—*Sommerfeld's Theory.*

Experimental Tests.

The British Broadcasting Corporation undertook to attempt to find in a given territory attenuation curves for all frequencies of emission between 500 and 1,500 kilocycles per second. To this end a site was chosen (which will ultimately become the site of the London regional transmitter) near Potters Bar, on the north side of London, for the erection of an aerial, the radiation from which could be measured in terms of field strength up to a distance of 100 km. The aerial consisted of 95 ft. of vertical wire, and was of the same form for all wavelengths. The masts were 110 ft. high, and were placed 300 ft. apart, and their base and the stays were insulated from the ground.

Tests made near to the aerial showed that radiation was strictly equal in all directions.

In effect the method of procedure was to adjust the current in the aerial so that the field strength was the same whatever the frequency of emission at the same point close to the aerial. This meant that the term $h_1 I/\lambda$ was adjusted to be the same for every wavelength. We can thus say that the curves are taken for the same radiated power at all wavelengths. It was seen that the points do not lie by any means on a smooth curve. Intelligent interpolation, however, gave a family of smooth curves for two directions.

The difficulty of taking readings in a densely populated country such as that found around London cannot be exaggerated, and the authors feel somewhat diffident in placing too much reliance upon the results. At points a few wavelengths apart, the field strength may vary 50 per cent., even though care is taken to avoid the proximity of telephone wires, houses and trees.

An experimental test of the geometrical construction for transferring the results of one wave to another, showed a very fair agreement between observation and theory, confirming the validity of applying Sommerfeld's analysis to this case.

We have so far considered the experimental verification of the theory of transference of the points from one curve to another for different *wavelengths*. It is also important to see whether the theory of transference of points for different values of σ is correct in practice. Although not a great deal of accurate experimental data is available, it is nevertheless interesting to consider the question of the value of σ, the earth's conductivity, as derived from the experimental results. An analysis can be given as follows :—

Any two transmitters having the same value of $h_1 I/\lambda$, *i.e.*, the same metre-amperes factor, can be said to be similar transmitters, and we can therefore write

$$\frac{377\, h_1 I}{\lambda} = \text{B (a constant)} \quad \ldots \quad \ldots \quad (2)$$

therefore $E_o = (B/x)\, S$, where x is the distance of the point of measurement from the aerial.

If there were no earth losses and other losses on the surface of the earth due to houses, trees, etc., the field strength would be given by $E_o = B/x$.

The multiplier S can therefore be called the reduction factor, and is shown by Sommerfeld to be a function of the quantity d_n, the numerical distance, where $d_n = (\pi x/\lambda)\{1/(2\sigma\lambda c)\}$ (see page 11).

Fig. 5 gives the relation between S and d_n, and is derived from the Sommerfeld theory. It is now our object to test the accuracy of the Sommerfeld attenuation formula and to determine the necessary value of σ.

Take the mean attenuation curves mentioned above. With x = 60 km. and $\lambda = 248$ m., E = 0·63 mv./metre. Since these curves are for a radiated power of 1 kw., E_0, the field strength apart from attenuation, will be given as

$$E_0 = \frac{377\sqrt{\left(\frac{1{,}000}{1{,}580}\right)}}{x} = 5 \text{ mv./metre}$$

Experimental Tests.

Type of aerial, h/λ	Height of aerial, h	Wave-length, λ	Voltage (V) between base of aerial and earth	Current at base of aerial (I_a for $\frac{1}{2}\lambda$ aerial)	Aerial current I (max. current in aerial)	Impedance		Power in aerial
						$\frac{1}{4}\lambda$ aerial, $Z_{\frac{1}{4}\lambda} = \frac{V}{I}$	$\frac{1}{2}\lambda$ aerial, $Z_{\frac{1}{2}\lambda} = \frac{V}{I_a}$	$\frac{1}{4}\lambda$ aerial, $W = Z_{\frac{1}{4}\lambda} I^2$
	metres	metres	volts	amp.	amps.	ohms.	ohms	watts
$\frac{1}{4}$	70	288·5	108	—	2·6	41·5	—	281
$\frac{1}{2}$	140	288·5	1,350	0·375	2·1	—	3,600	—

Type of aerial, h/λ	Power in aerial	Field strength, E, at 2 km.	Effective height (practical), $h_1 = \frac{E\lambda d}{377\,I}$	Effective height (theoretical), $h_1 = \frac{2}{\pi}h$	Radiation resistance			Total resistance, $R_T = \frac{W}{I^2}$
					$\frac{1}{4}\lambda$ aerial		$\frac{1}{2}\lambda$ aerial	
	$\frac{1}{2}\lambda$ aerial, $W = Z_{\frac{1}{2}\lambda} I_a^2$				Practical, $R_R = \frac{A_3^* h_1^2}{\lambda^2}$, where $h_1 = \frac{E\lambda d}{377\,I}$	Theoretical, $R_R = \frac{A_3 h_1^2}{\lambda^2}$, where $h_1 = \frac{2}{\pi}h$	Theoretical, from Fig. 2	
	watts	mv./metre	metres	metres	ohms	ohms	ohms	ohms
$\frac{1}{4}$	—	64	38	43·5	27·5	35	—	41·5
$\frac{1}{2}$	506	109	79·5	87·0	—	—	103	115

Type of aerial, h/λ	Dead-loss resistance			Metre-ampere efficiency, $\frac{h_1^2}{\lambda^2} R_T$, where $h_1 = \frac{E\lambda d}{377\,I}$	Relative watts in aerial to produce given field strength		Relative field strength at same distance with equal power	
	$\frac{1}{4}\lambda$ aerial		$\frac{1}{2}\lambda$ aerial					
	$R_D = R_T - R_R$, R_R (practical)	$R_D = R_T - R_R$, R_R (theoretical)	$R_D = R_T - R_R$ (theoretical)		Practical	Theoretical	Practical	Theoretical
	ohms	ohms	ohms		watts	watts	mv./metre	mv./metre
$\frac{1}{4}$	14	6·5	—	$4{\cdot}17 \times 10^{-4}$	1,000	1,000	1	1
$\frac{1}{2}$	—	—	12	$6{\cdot}66 \times 10^{-4}$	625	610	1·26	1·28

* A_3 is a constant.

therefore $S = E/E_0 = 0{\cdot}126$.

From Fig. 5, $d_n = 5{\cdot}2 = \frac{\pi x}{2\pi^2 \sigma c}$

therefore $\sigma = 10^{-13}$

with $x = 60$ km. and $\lambda = 503$ m.,

$E = 3$ mv./metre and $S = 0{\cdot}6$.

From Fig. 5, $d_n = 1{\cdot}22$, and $\sigma = 10^{-13}$.

Therefore from these curves we find a value of σ of 10^{-13}. The value of σ found,

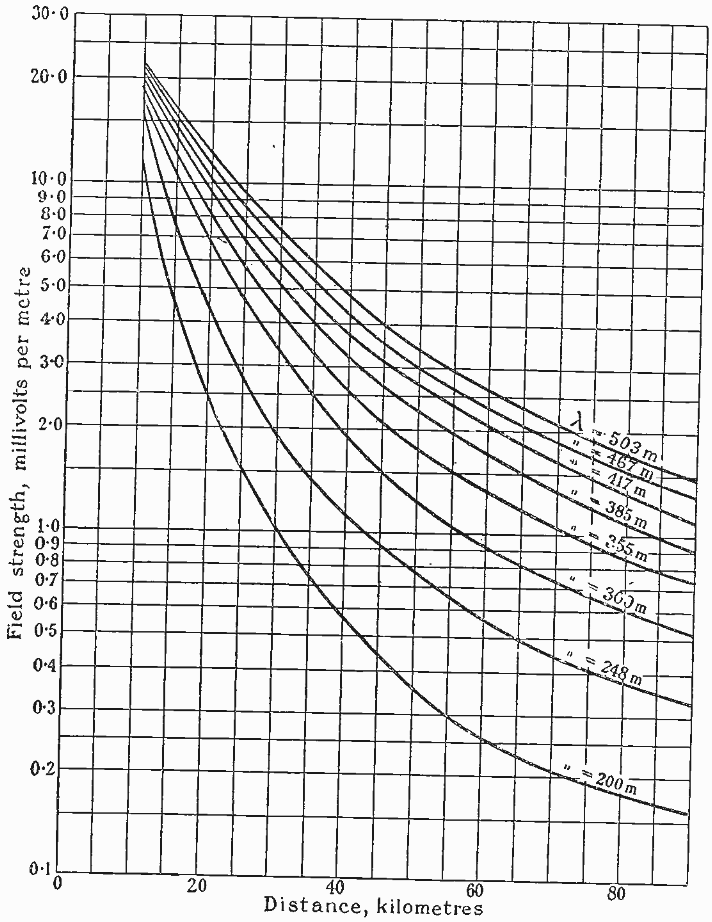


FIG. 6.—*Mean attenuation curve for* $\frac{1}{4}\lambda$ *transmitting aerial with* 10-*ohm dead loss and* 1 *kw. input to aerial.*

as a result of our experiments, lies between the wide limits of from 0·66 to 5×10^{-13} given by other observers, and found by different methods. It is suggested that it is premature to assume that the total value of σ can be accurately subdivided into, for instance, earth loss and vegetation loss. In the generality of cases it would seem unnecessary to assume that there is any loss over and above the earth loss. Exceptions to this are found, however, where the waves traverse large cities or deeply wooded country. More and more "irreproachable" attenuation curves must be taken before this point can be accurately determined, but the labour involved is so considerable that some years must pass before the figures can be expressed with any real certainty. It will, however, be realised that Fig. 5 gives a broadcasting engineer data of the right order needed to forecast the service area of any broadcasting station using wavelengths of between (say) 600 and 200 m.

Conclusion.

The paper contains too little experimental verification of the theory outlined therein. A conclusion should, however, deal with generalities, and it is obvious from what has gone before that certain incontrovertible principles can be stated. It is time that they were stated before more damage is done by organisations who appear to concentrate on making an undignified scramble for the all too limited facilities rather than thinking how best to use what are, in plain fact, the actual facilities available.

The facts which emerge are these :—

(1) The design of aerials for broadcasting should aim at using the energy to produce the strongest possible horizontal radiation while diminishing upward radiation.

(2) To produce this desirable end, high aerials are a *sine qua non.*

(3) Nothing, however, that is done with special aerial design will prevent a serious limitation of service area, relative to that obtained with the longer waves, when the shorter waves are used.

(4) That, nevertheless, organisations must employ such waves which are more efficiently used by the employment of high aerials.

Responsible technical authorities have in the past been chary of using waves below 300 m. for their broadcasting stations because of their expectation that such stations will have too limited a service area under practical conditions. This may be true in certain cases, but it is to be remembered that limitations are inevitable, and it is better to have a limited service than one which suffers continual interference. The use of shorter waves is perfectly economical in densely populated districts. It is hoped that this final analysis will help engineers to gauge the extent of the usefulness of all waves so that existing facilities may be most efficiently used.

MARINE DIRECTION FINDERS: TYPES 11G. AND D.F.M.3

With the increased use of Ship Direction Finders has come the need of an efficient and selective, though simple, class of instrument.

The 11G. and D.F.M.3 types of direction finder attempt to meet this demand in a very complete manner, the difference between the two receivers being described below.

The extreme simplicity of the apparatus, combined with high efficiency, make these two models peculiarly adapted to the needs of mercantile vessels which aim at perfection in the design of their direction finding gear.

THE 11G. Direction Finder is designed for use on board all classes of mercantile vessels as a navigational instrument. It is intended to supersede the Type 11F. Direction Finder.

The chief difference between the two types mentioned above lies in the Amplifier. By means of the use of two Marconi S.625 screened grid valves, a short description of the action of which has been given in the November issue of the "Marconi Review," greatly increased amplification has been obtained.

In considering the design of this receiver, it is necessary to bear in mind the fact that accommodation for it will, in many cases, be very limited, that it will be subject to extreme vibration, and that it will occasionally be operated by semi-skilled personnel.

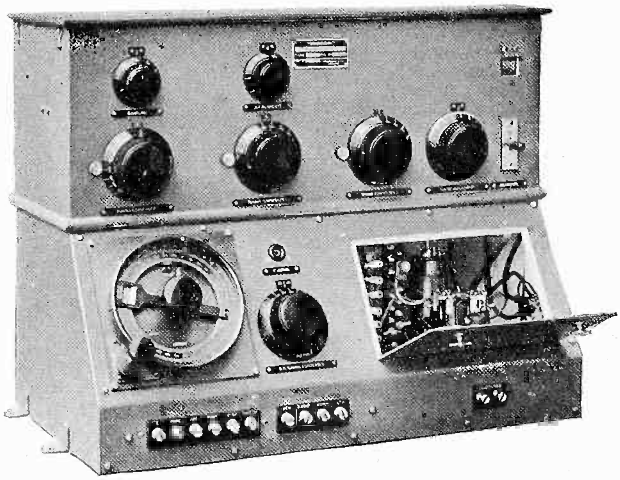
The receiver has consequently been designed

(A) In as compact a form as possible.

(B) As robustly as possible.

(C) As simply as possible.

As regards overall dimensions, the 11G. receiver has been made approximately the same size and general shape as the 11F. The copper screened teak cabinet of the 11F. has been replaced, however, by a sheet brass box, with all the screens, etc., of the same material well bonded to the main case. In this way greatly improved screening has been obtained; the instrument is robust; and the accessibility of the amplifier and tuner has been increased.



11G.

The apparatus operates on the well-known Marconi-Bellini-Tosi System, and incorporates a radiogoniometer, vertical aerial coupling system, two stages of screened grid high frequency magnification, an anode bend detector, and a resistance capacity coupled amplifier.

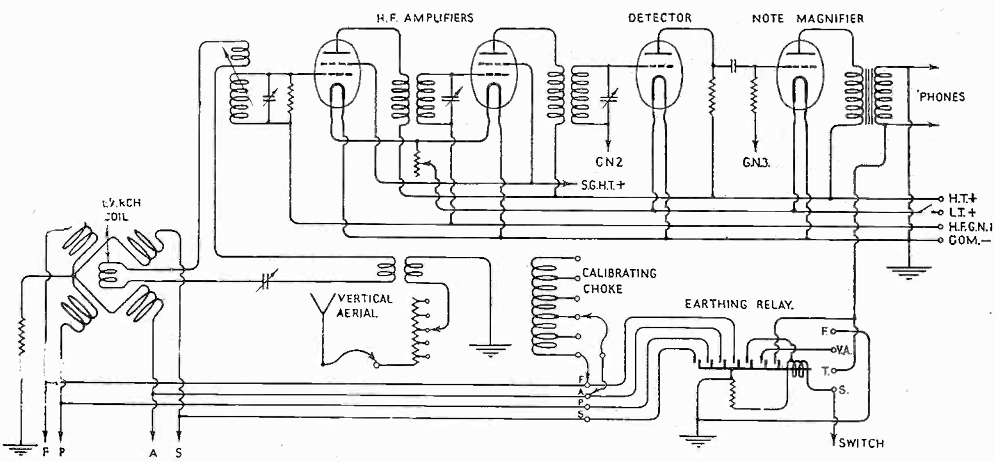


FIG. 1.

The instrument has a waverange of from 450-1,100 metres, and this is covered in a single range.

A simplified diagram of connections to the receiver is shown above (Fig. 1).

The radiogoniometer consists of two fixed coils of equal impedance, crossing each other at right angles. The four ends of these coils are marked "Port," "Starboard," "Fore," and "Aft," and are connected to the corresponding ends of the aerial loops, and the centre point of each coil is connected to earth through a resistance of 2,000 ohms. These coils are mounted on a hollow cylindrical former, and are well insulated from each other. A rotatable search coil is mounted symmetrically inside the former in such a manner that it can be set at any angle relative to the two field coils, and its direction read off accurately on a scale provided at the front of the receiver.

The vertical aerial itself is connected to the set by means of a plug which can be inserted into a socket on the front of the set. In this way either a figure of eight or cardioid diagram can be obtained.

The phasing resistance for the vertical aerial can be adjusted once for any particular aerial and then left. It will be found that this adjustment suffices to give a sharp minimum as long as this particular aerial is in use.

A calibrating choke is provided in parallel with one of the field coils of the radiogoniometer. This is to provide general compensation for the distortion of bearings by the metal work of the ship. The value of the inductance included in this choke can be altered by attaching a flexible lead to one of numerous tappings on the choke.

The earthing relay is provided for use when the ship's transmitter is working. It consists of a solenoid wound round a soft iron core, which operates contacts connecting aerial leads, telephones, etc., to earth when the magnetising current is cut off. While the relay current is on and the set is working, therefore, all the leads are insulated from earth, but as soon as the switch is broken, the whole aerial system is effectively earthed.

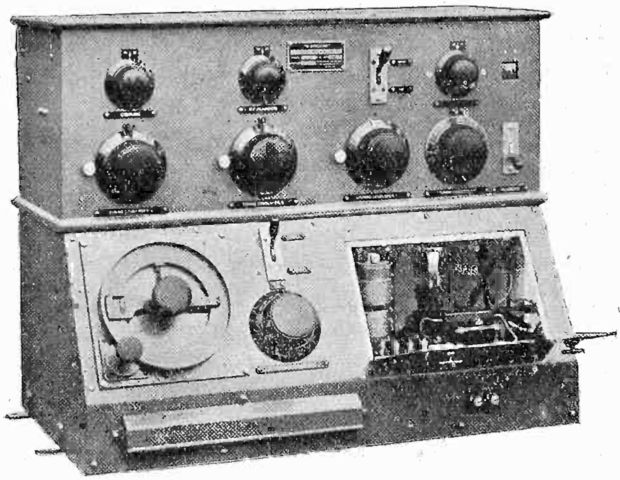
The switch operating the relay is ordinarily situated near the transmitting key.

The amplifier proper consists of two stages of transformer coupled screened grid amplifiers, a detector and note magnifier.

The high frequency transformers are wound in an efficient manner with stranded wire, and have their grid circuits tuned by means of variable condensers. Suitable grid negative is applied to the grids of these valves, and a filament control rheostat is provided.

The detector is of the anode bend type, and the note magnifier is resistance capacity coupled in the usual way.

A telephone transformer is provided for use with low resistance telephones, and has its secondary winding earthed when the set is not in use.



D.F.M.3.

It will be noticed that the set is not designed for use with continuous waves. This is, however, provided for in a modification of the 11G., known as the D.F.M.3.

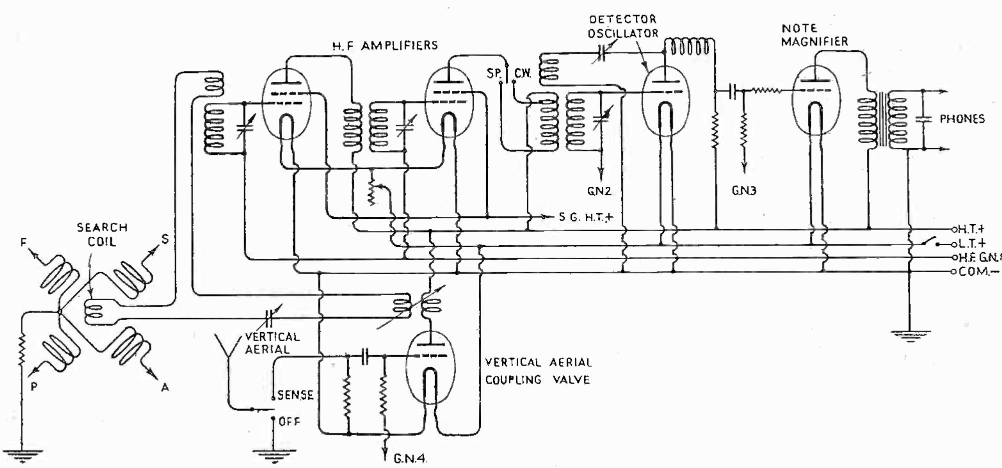


FIG. 2.

The D.F.M.3 has circuit connections very similar to the 11G. (Fig. 2), with the following exceptions:—

(1) Reaction is provided on the detector valve for continuous wave reception and for increasing the sensitivity of spark reception.

(2) The vertical aerial is coupled to the set by means of a valve. This method has the advantage of allowing the use of quite a small vertical aerial for obtaining "sense" indication by means of a heart-shaped polar diagram of signal strength.

(3) The vertical aerial is connected to the set by means of a switch, and not by a plug as in the case of the 11G.

(4) The D.F.M.3 does not contain an earthing relay. This is intended to be used as an accessory external to the receiver.

(5) A special tapping is provided in the anode coil of the second high frequency valve for the purpose of reducing the coupling during continuous wave reception. The necessary change is made by a switch marked "Spark" and "C.W."

(6) The detector has a coil in its anode circuit coupling back to the previous stage, and a condenser to enable reaction to be controlled.

In both the 11G. and D.F.M.3, S.625's are used in the high frequency stages, a D.E.H.610 for the detector, and a D.E.L.610 for the note magnifier.

LONG AND SHORT WAVE COMMERCIAL RECEIVERS

Considerable care must be taken with many points in connection with the design of short wave receivers, which may be neglected when dealing with long wave receivers. Experience shows, also, that the shorter the wave the more attention has to be paid to design, if efficiency is to be expected.

There is no doubt that commercial traffic on the short waves is now an accomplished fact, and that, consequently, short wave receiver design is becoming of increasing importance.

In this article an attempt is made to outline, very briefly, two typical receivers made by the Marconi Company.

(*a*) *The R.C.6 for long waves.*
(*b*) *The Beam Receiver, Type R.C.24, for short waves.*

THE commercial radio traffic of the World is at present divided into two main classes :—

(1) Long wave traffic.
(2) Short wave traffic.

Until quite recently it was thought that the longer the wave used, the greater distances could be reached. This was in accordance with all the partially developed and mainly empirical transmission theories of the time, and consequently, when the need for inter-continental wireless services became too great to be overlooked, it was to the long waves that experimenters first turned their attention.

With this end in view, the long wave stations at Ongar and Carnarvon, etc., were erected in the British Isles, and for a time the problem seemed to have been solved in the best possible manner.

With the advent of the Beam system of radio communication, however, all this was changed. Short wave stations, with wavelengths of the order of tens of metres, as against the long waves of tens of thousands of metres, were erected, and it can now be definitely stated that traffic on the short waves is just as reliable and much quicker than on the long waves.

The success of any radio telegraphic system depends on the perfect functioning of three main components These are—

(1) The transmitter.
(2) The receiver.
(3) The land line intercommunication system.

In this article an attempt will be made to show the essential differences between the receivers used in the two cases—long and short waves—by a brief description of two typical sets. The R.C.6 for long wave working, and the R.C.24 Beam receiver for short wave Beam traffic.

The R.C.6. Long Wave Receiver.

The R.C.6 receiver is intended for inter-continental reception of signals of wavelengths from 6,000 metres to 25,000 metres.

It will be as well, possibly, if a few of the difficulties met with in long wave working are enumerated, and the methods used for overcoming them in such a receiver as the R.C.6 are shown.

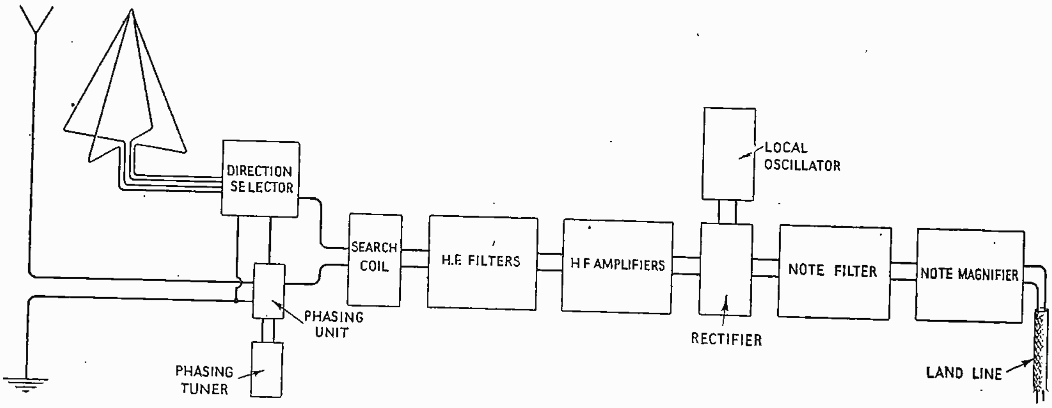


FIG. 1.

Firstly, the receiver used on such work must be reliable. A single breakdown may cause serious congestion of traffic and disorganisation of the service as a whole.

In general, the receiver must be regarded as a purely automatic relay between the transmitter and the Central Telegraph Office, and the attention paid to it, once it has been set up, must be reduced to a minimum.

The land line gear connecting the receiver to the Central Telegraph Office must also be of the simplest construction.

Selectivity is a very important point. The frequency separation of stations is small on the higher wavelengths, and due attention must be paid to this point in the receiver.

Atmospherics are prevalent on these wavelengths, and it is therefore necessary

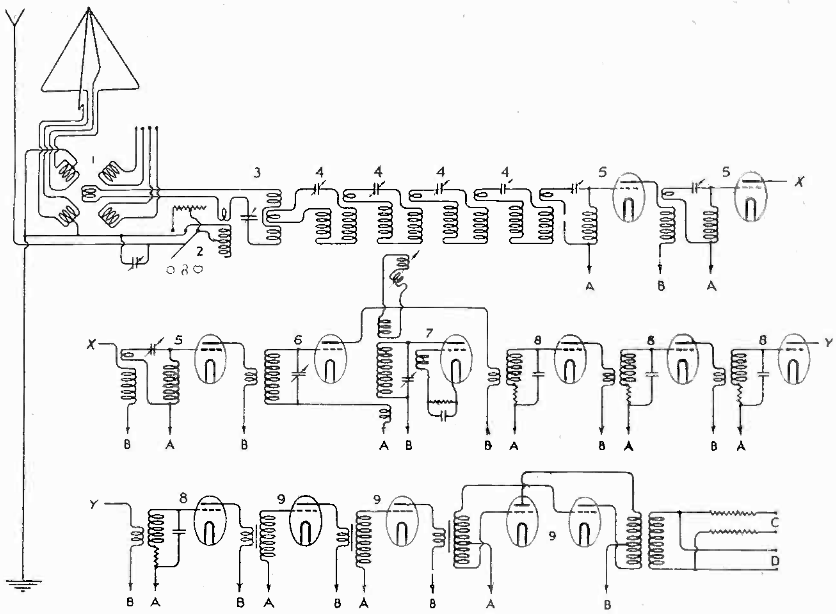


FIG. 2.—*Simplified Diagram of Connections, Type R.C.6c Receiver.*

1. Direction Selector.
2. Phasing Circuit.
3. Tuned Search Coil.
4. H.F. Filters.
5. H.F. Amplifiers.
6. Rectifier.
7. H.F. Local Oscillator.
8. L.F. Filters.
9. Note Magnifiers.

on account of this alone to adopt great precautions in the tuning circuit of long wave receivers.

The R.C.6 receiver obtains great selectivity by the following method :—

(1) Directive reception.
(2) Extensive H.F. filtering.
(3(Extensive Note filtering.

The receiver is designed on the unit principle, and the Beam receiver hereafter to be described is made up in much the same way. Signals are delivered to the land line at any required frequency from 1,000 ∿ to 2,500 ∿.

The following components are contained in the receiver, and will be briefly described below.

(1) Direction selector (Radiogoniometer device).
(2) Phasing unit.
(3) Tuned input circuit.
(4) Four H.F. filters.
(5) Three H.F. amplifiers.

(6) Rectifier.
(9) Four L.F. filters.
(10) Note magnifier.
(11) Local oscillator.
(12) Control panel.

A schematic diagram of the arrangement of the receiver is shown in the figure (Fig. 1).

The direction selector, input circuits and aerials are arranged on the Bellini-Tosi System, utilising a vertical aerial and two loops. By this means either "all round," "figure of eight" or "cardioid" reception can be obtained by suitable switching. The direction selector is of the double type, to enable several receivers to operate on the same aerial system.

High frequency filtering and amplification is carried out by four low damped tuned filtering circuits, after which are connected three high frequency neutrodyned amplifying units and an anode bend rectifier.

The low frequency amplification consists of four valve-coupled tuned low frequency note filters and a four valve note magnifier, the last two valves operating in "push-pull" to the land lines.

The connections of the receiver are shown in Fig. 2.

All voltages, etc., can be measured and controlled on the control panel from the front of the set, and all H.T. and L.T. supplies to the units are from a series of busbars on the back of the set.

The above description, though brief, will serve to indicate the general design of the set, and to enable it to be compared with the Beam receiver.

The Marconi Mathieu Short Wave Beam Receiver. Type R.C.24.

The short wave receiver used on the Beam system is specially designed to overcome difficulties which only present themselves where dealing with short waves. The chief of these difficulties are fading and alteration of frequency of the signal at the transmitting end. Each of these points is dealt with in a very complete manner in the Beam receiver.

The receiver utilises as its aerial, a system similar to that used at the transmitting end, *i.e.*, an aerial system and a reflector system, each consisting of numerous vertical wires suspended in a line, the length of this line being several wavelengths.

Such an aerial radiates or receives energy efficiently in one direction, this direction being normal to the part in which the aerials are placed.

It is found necessary in such a system to have the currents in all the aerial wires in phase with one another. This condition is obtained by the use of a feeder system, from which the aerials are supplied with energy, or in the case of the receiving station, a feeder system is provided to transfer the maximum amount of energy from the aerial to the receiver.

From the feeder system the signal passes through the receiver, the general arrangement of which is shown in Fig. 3, and a wiring diagram in Fig. 4.

The feeder from the aerial system is brought in to a tapped coil on the "R" unit. From thence it passes to the K and A units, where it is heterodyned and modulated at a frequency of about 1,200 ∿. It is now amplified by a series of push-pull amplifiers in the B and C units, and is heterodyned and detected to land line frequency in the "C" units. After this it is subjected to a further process of push-pull amplification in the I units, and is sent out on to the land line through an impedance changing filter to suit the input of the land line.

As it is intended to superimpose the wireless signals on existing telephone traffic, means have to be provided to introduce the telephone signals and to separate them from the wireless signals. This is done by a "separator" unit. In cases where the telephone signals are desired to be separated from the wireless signals and to be put back on the line, after passing through a sub-station, etc., a "junction" unit is provided. When the aerial line gives place to a cable, or *vice versa*, the impedance of the lines have to be altered to prevent reflection. A "Z transformer" unit can be introduced to achieve this object.

At the recording end of the land line, the signals are passed through another separator unit, and through a filter to a second detector, after which they are again amplified. They then pass through the limiting valve and operate the recorder by means of a marking and spacing valve.

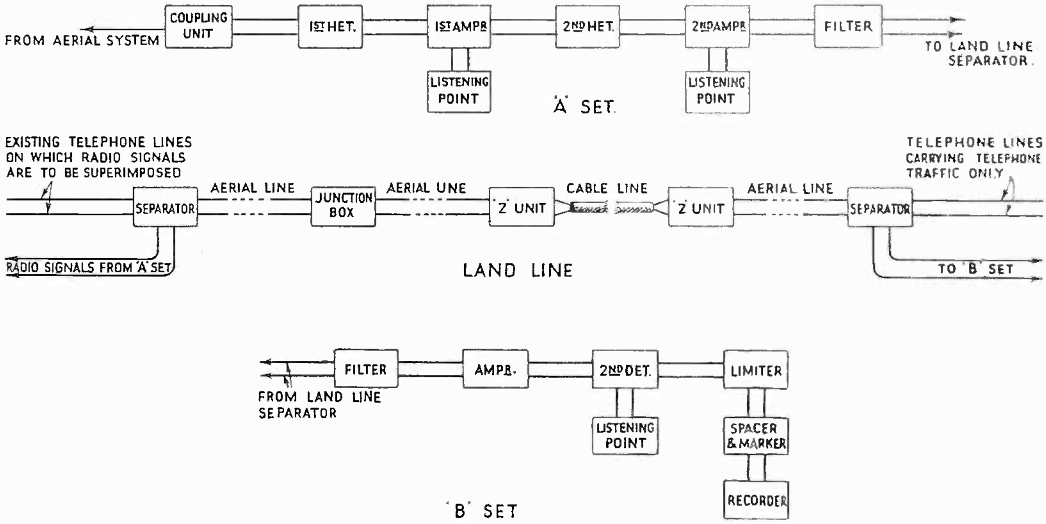


FIG. 3.

The frequency of the incoming Beam signal is from, say, 30,000 kc. to 5,000 kc.; after the first heterodyne the band of frequencies provided for is from 112·5 to 177·5 kc., and after the second heterodyne, the band is from 21 kc. to 54 kc.

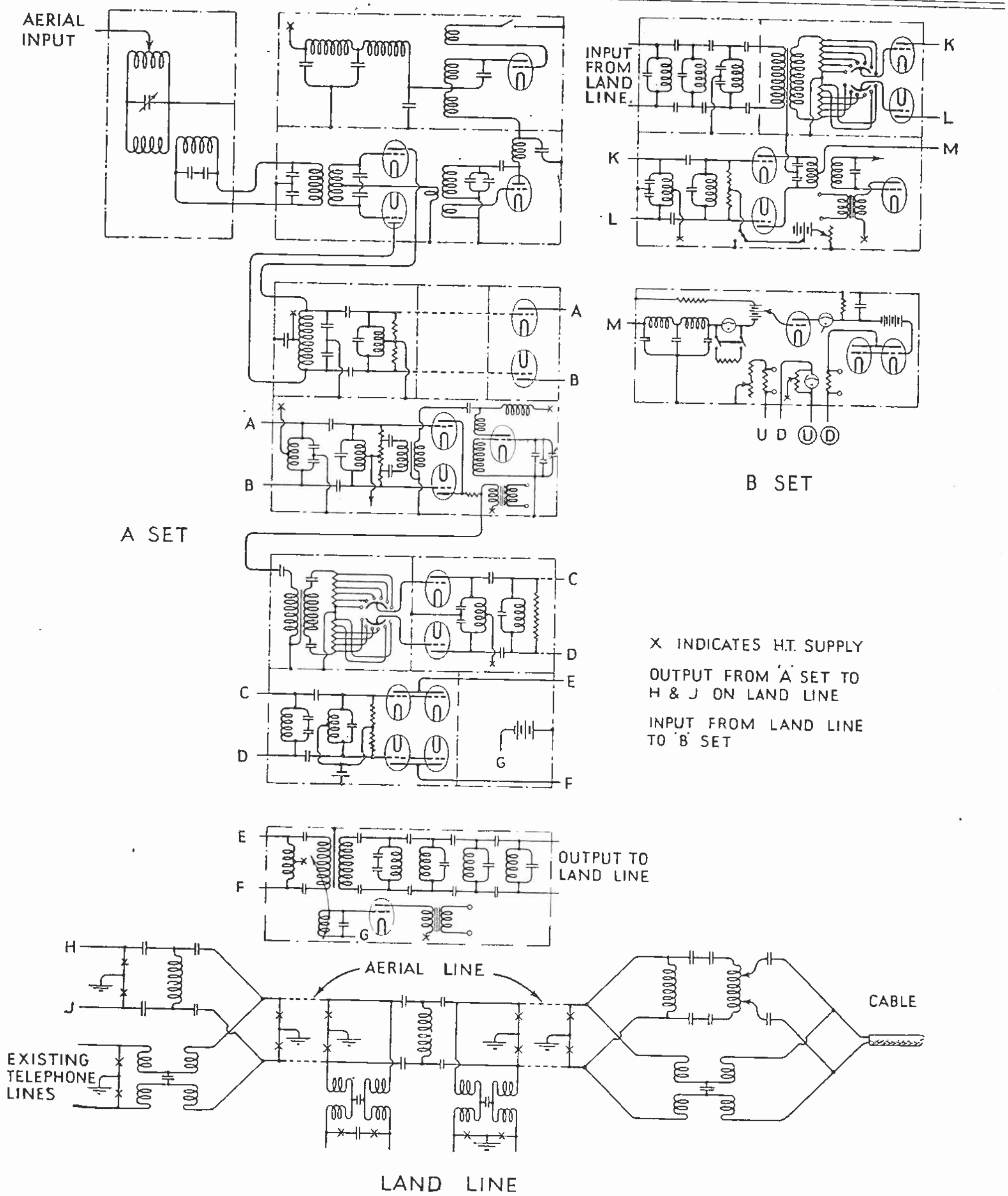


FIG. 4.

The Beam receiver allows for

(A) Variation in the frequency of the oscillation by the provision of "flat-topped" filter amplifiers, which give constant amplification over a small band of frequencies.

(B) Variation in the magnitude of the energy received at the receiving station through fading, by amplifying the signals largely, and then limiting them for recorder purposes.

NOTES ON BROADCAST TRANSMISSION

In the following article a figure of merit is arrived at which, when applied to a broadcast transmitter, will give some idea as to its capabilities.

A brief statement follows as to the degree of distortion which is permissible in such a transmitter, and the article concludes with a short comparison of the methods of modulation at present available.

The Motala transmitter, which is here illustrated, is a full power modulated set and has a normal rating of 40 kw. to the aerial.

THE design of a broadcast transmitter necessitates a more or less complete knowledge of the conditions under which transmission and reception will be carried out.

Broadcast radio receivers require field strength intensities of from ·02—20 millivolts per metre of effective receiver aerial height for satisfactory operation, depending on the type of receiver, and it is necessary that the transmitter should be designed with such ends in view.

To compare the useful effect upon a receiver of transmitters of various powers, it is necessary to obtain some sort of figure of merit for the transmitter. It is found that the best figure to use is given by the expression

$$P \times M$$

where P is the aerial carrier power

M is coefficient of modulation.

This figure is useful because the received signal strength is proportional to the product of the square root of the carrier power and to the square root of the side band power, *i.e.*, the total effect is proportional to $P \times M$. For example, a 50 kw. transmitter modulated 100 per cent. has a figure of merit of 50, while a 100 kw. transmitter modulated 50 per cent. has an equal figure of merit, so that judged by signal strength alone, these stations are equal. Obviously in the comparison, P should refer to the power actually radiated, so that in practice the stations must be assumed to have the same kind of aerial and the same wavelength.

As to which of the above alternatives should be adopted is a matter involving some complication, since the question of distortion arises in connection with the problem. It can be stated definitely that in the case of a single frequency modulating the transmitter 100 per cent. distortion will be apparent to the ear, but should the full modulation be made up by a combination of various simultaneous frequencies of comparatively small amplitude, the distortion will not be so noticeable.

There is, however, another factor requiring consideration, and that is the practical value of making provision in the transmitter for a very deep modulation. It must be remembered that the deeper the modulation allowed for, the lower the overall efficiency of the transmitter in the carrier condition, and also that the average modulation level as sent out from the studio is always comparatively low in order to allow of temporary increase in the speech or music. In practice the average level corresponds to between 20 and 30 per cent. modulation of the transmitter. Thus providing for the use of a degree of modulation which can seldom be attained, and even when attained is likely to produce distortion, is certainly extravagant, but there should be some degree of modulation which can be allowed for to give the most effective use under working conditions of a given input power. A reasonable compromise is probably about 70 per cent. or 80 per cent. modulation.

Distortion.

Theoretically all modulation is a distortion of the carrier wave, but in practice if a transmitter is said to give distortionless modulation over a certain range of audio frequencies, it is understood that, within that range, the aerial current will vary in a linear manner with the voltage input to the first modulator.

For instance, if distortionless modulation is guaranteed between 50 and 3,000 cycles up to 80 per cent. modulation, it implies that if an input voltage is applied to the modulator sufficient to increase the carrier aerial current to $\sqrt{1 + \frac{.8^2}{2}} = 1.15$ the unmodulated value, and if this input voltage is maintained constant at all frequencies between 50 and 3,000 cycles, the aerial current will remain constant. The term "distortionless" also implies symmetry of aerial current, that is, an equal rise and fall about the carrier level.

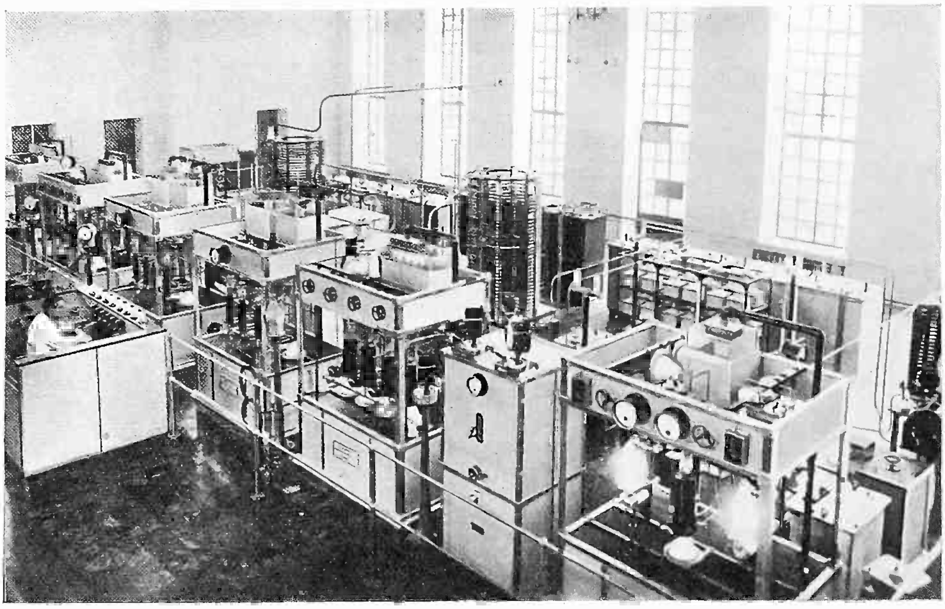
As to the range of frequencies over which distortionless modulation should be arranged for, considerable departure from the ideal of a flat characteristic can be permitted without the ear appreciating the discrepancies. In practice one may say that the ear cannot detect a difference of amplitude unless this exceeds ± 2 T.U., or a difference of 58 per cent. Hence for practical purposes we may regard a characteristic curve which does not vary more than 2 T.U. over a range of frequencies of 50—8,000 cycles as good enough.

Modulation of a broadcast transmitter may be accomplished in several different ways, but one of the following three methods is usually employed :

(1) *Full power modulation.* In this case the voltage on the anodes of the main oscillators is varied by modulators acting on a choke coil or transformer in the anode circuit.

(2) *Low power modulation.* Here a small oscillator is modulated by a small modulator, and the modulated carrier is amplified up to the required power.

(3) *Grid control.* In the third method the grid current of the main oscillators is varied by means of modulators acting as a variable grid resistance.



It is a little difficult to make useful comparisons between these methods, each having its own advantages and disadvantages.

Whatever method of modulation is used, however, the following points should be borne in mind.

(1) The carrier frequency should be maintained constant.

(2) The frequency of the master oscillator should not be affected by modulation of the transmitter.

(3) The radiated wave should be free from harmonics.

MARCONI NEWS AND NOTES

THE PHYSICAL SOCIETY EXHIBITION

At the Annual Exhibition of the Physical Society and Optical Society, held at South Kensington on January 8th, 9th, and 10th, the following apparatus was shown, and selected as being typical of the practical side of Wireless Research during the past year.

(1) A direction finder, Type 11G, fitted with an amplifier embodying two stages of screened grid high frequency magnification. This direction finder is intended for use on merchant ships, and is described in the present issue.

(2) A Type R.G.18 receiver, which has been developed for naval and military purposes. The amplifier includes two transformer coupled screened grid high frequency magnifiers, an anode bend detector, and an alternative note magnifier or note filter. A local oscillator is also provided in the instrument. A full description of the receiver will be found in last month's number of THE MARCONI REVIEW.

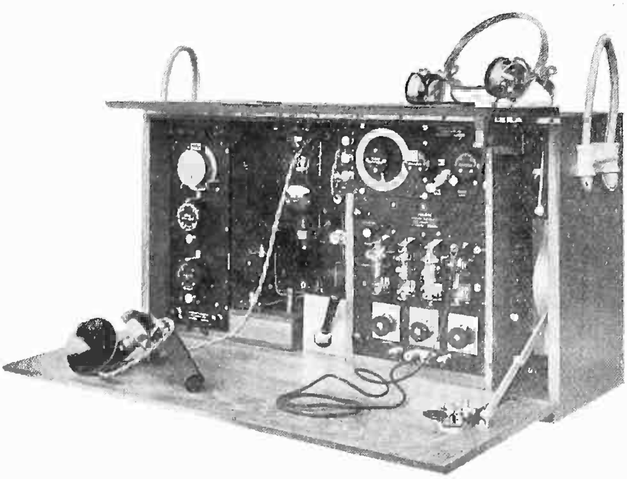
(3) An auto-alarm receiver and detector, designed for automatically receiving distress signals at sea. The distress signals consist of four-second dashes at one second intervals, which, on their reception by the auto-alarm, ring a bell. This instrument, it is hoped, will do much to eliminate the need of a constant watch being kept by operators on small vessels.

(4) A Type A.D.18 combined transmitter and receiver for aircraft. The transmitter has a waverange of 300 to 1,600 metres, and can be used on either telegraphy or telephony.

(5) A signal strength measuring set designed for use on all wavelengths from 14 to 5,000 metres. Signals from a local oscillator can be attenuated to any extent and made equal to the received signals, either by ear or by a recording device. This instrument is of great use in the determination of transmitter field intensities, etc., and supplies a long felt want.

(6) A component of the Marconi Facsimile apparatus, viz., the tuning fork and thermostat control used in synchronisation of the receiver and transmitter. The thermostat supplied enables the temperature of the fork enclosure to be maintained constant to within 0·1° F. A similar device would, of course, be used on fork controlled transmitters.

Wireless Apparatus for Harbour Work.



Marconi Portable Transmitter and Receiver. Type YB1.

Marconi wireless telegraph and telephone apparatus has given splendid service to the Authorities of the Port of Basrah in the Persian Gulf, according to a report received from the Basrah Port Directorate.

The wireless sets in use consist of :

Six sets type "YB1" 100 watts.

One set type "U" 500 watts.

The YB1 sets have been in use mainly in connection with the dredging of a new channel through the Bar at the entrance to the Shatt-al-Arab River, some 85 miles distant from Basrah, and they are manned by locally trained Indians under European supervision.

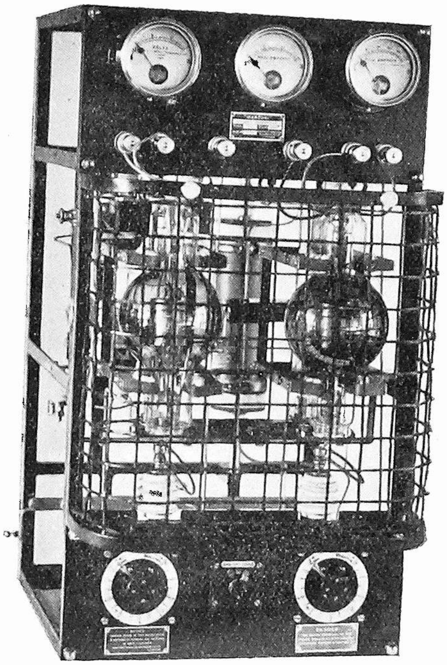
The sets are installed on the dredgers, pilot and control vessels, the Shore Engineering Depot at Fao and Headquarters at Basrah, at distances from each other varying from a few miles up to 85 miles.

The first three sets came into operation in May, 1925, and the remaining three during July, August and December of the same year. They have without exception given entire satisfaction, interruptions of service being very few indeed, and when occurring, have called for adjustments or normal attention to maintenance requirements only. Since their installation it is estimated that they have given an average of over 99 per cent. effective working hours.

Their use has permitted of close and constant supervision of difficult operations, carried out at a distance of 85 miles from Headquarters. Organization in general has been greatly facilitated, and the wireless installation has enabled each particular problem in the course of the work to be given direct personal consideration and be dealt with as it arose without loss of time.

It is difficult to see how the existing standard of efficiency could have been brought about without their assistance.

The "U" set is installed on the Light Tender "Nearchus," which vessel's duties include frequent periodic tours of the Persian Gulf as far as Muscat (780 miles) in connection with supervision and maintenance of Lights and Lighthouses.



Marconi Transmitter. Type U.

This set has been in use for a few months only but has given excellent service, and the advantages conferred by its provision are manifest in the conduct of the work.

Goods Telephone Ranges.

In respect to special results achieved the following facts are of interest.

On the occasion of the Dredger "Tigon" proceeding to Bombay for docking :—

Day speech communication was	carried out		up to	480	miles
,, C.W.	,,	,,	,,	850	,,
Night speech	,,	,,	,,	750	,,
,, C.W.	,,	,,	,,	1,400	,,

with YB1 Apparatus.

That these figures do not represent unusual characteristics is proved by the vessel on her return trip again getting into touch at 1,115 miles after which regular communication was maintained until her arrival at Basrah.

In respect to the "U" type set (500 watts) the Port Directorate is still more or less experimenting, but they have carried out satisfactory tests on 450 metres, up to a distance of 1,200 miles.

It should be rembered that extremes of climate in Iraq are very great, the temperature varying throughout the year from six degrees of frost to 129 degrees in the shade (Fah.), while the variation in humidity is equally extreme.