THE

RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. II **FEBRUARY, 1921** NO. 2

Editor:
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Editorial.

We publish in this number the first instalment of an interesting paper by Professor Vallauri of Leghorn who has done much experimental work on the measurement of the strength of the electromagnetic field produced by a transmitting aerial. We recently described his measurements of the strength of the field produced in Italy by the transmitting station at Annapolis. The present article deals with measurements at distances of two or three wave-lengths, that is before the effects of absorption, reflection or refraction become appreciable. Such measurements serve to determine the effective height of the transmitting aerial considered as the upper half of an ideal Hertzian oscillator or dipole, but they require to be carried out with extreme care if trustworthy results are to be obtained. Professor Vallauri's results appear to leave nothing to be desired in this respect. In his discussion of the factors affecting the effective height he draws attention to the effect of the parasitic currents in masts, guys, etc., an important matter often overlooked.

Hertz—the Unit of Frequency.—In an article in the *Elektrotechnische Zeitschrift* of July 29th, 1920, K. W. Wagner of the Physikalisch-Technischen Reichsanstalt suggests that in honour of the great physicist Heinrich Hertz, his name be given to the unit of frequency, viz., one cycle per second. Wagner proceeds to act on his own suggestion by using the term throughout his article, and the ordinary alternating current power supply is referred to as having a frequency of 50 Hertz. If the usual custom were followed this would become in English 50 hertz, the capital being dropped when the word is used as the name of a unit and not as the name of a man. We cannot but feel, however, that the name of Hertz is more suggestive of a frequency of a million cycles per second than of one cycle per second.

A Persistent Fallacy.—When an electromagnetic wave is propagated over the surface of the earth as in radiotelegraphy, the horizontal magnetic field and the vertical electric field are related in such a way that, if at any moment the magnetic field at a given point has its maximum value, the electric field at the same point has its maximum value at the same moment. A quarter of a period later the magnetic field strength will pass through zero, and the electric field strength at the same point will pass through zero at the same moment. At this latter moment the displacement current at the point, which is proportional to the rate at which the electric field strength is changing, has of course its maximum value.

In a paper read before the British Association in 1913 we drew attention to this fact, and pointed out that some of the earlier text books on the subject had unfortunately contained very explicit descriptions and diagrams based on the assumption that the electric and magnetic fields occurred alternately at a given point and not simultaneously. This wrong idea seems to have taken root and to be very difficult to eradicate. On page 160 of Vol. I. of Stanley's Text Book of Wireless Telegraphy is a diagram which represents the fields quite correctly, but then the author proceeds as follows: "Imagine that we could see the strains in the ether as colours, that an electric strain acting downwards is represented by red, one acting upwards by blue, a magnetic strain in one direction by yellow and in the opposite direction by green. Then a person standing in the ether would see a red colour of electric strain which will grow in intensity and then die out giving place to a yellowish colour of magnetic strain which grows in intensity as the red dies out. As the yellow fades away it will give place to a blue colour of electric strain; this deepens and then fades away giving place to a green magnetic one. As the green one fades away the red will come on again and the whole cycle will be repeated."

It is regrettable that such a beautiful colour scheme should be employed to impress such false conceptions upon the mind of the reader.

Wireless Telephony in Forestry.—We notice that at the congress recently held at Vancouver in connection with the logging industry it was reported that wireless telephone installations had been erected during the summer at a number of land stations and on a number of launches used by the forest rangers. Although some interference had been experienced both from large wireless stations and from street car services in the neighbourhood of Vancouver, the telephone sets had proved very useful especially in giving early reports of forest fires. The programme for 1921 contains a considerable addition to the number of these stations.

The Range of Wireless Stations.—On December 15th Captain Trench read a paper on "The Range of Wireless Stations" before the Wireless Section of the Institution of Electrical Engineers. The most interesting feature of the paper was the list of suggested empirical factors to be introduced into the Austin-Cohen transmission formula in order to allow for all the various conditions likely to be met with in practice, *e.g.*, mountains, bad earths, etc. In the proof of the paper an error entered into many of the formulæ owing to the author introducing the correction for the distributed capacity twice, once as a reduction of effective height and once as a reduction from mean aerial current to current at base; these are of course alternative methods and should not both be employed. In seeking for an explanation of the smallness of the received current compared with that calculated from the dipole formula, the author puts forward the suggestion that the receiving aerial drains the ether in its neighbourhood in such a way that the E.M.F. induced in the aerial is less than that given by the usual formulæ. This suggestion contains a certain amount of fact; the receiving aerial does modify the electromagnetic field by superimposing upon it its own radiated field. This is allowed for, however, by adding to the actual resistance of the receiving aerial a fictitious resistance, which causes the received current to be smaller than would be calculated without this fictitious resistance.

The real explanation of the apparent smallness of the received current is to be found in the excessive values often assumed for the effective heights of aerials. Every mast and stay has a current induced in it, which is in opposition to that in the aerial and which has the same effect as a reduction of effective height. Austin's results over short distances are in perfect agreement with theory if the aerials be assumed to have an effective height of a little more than half the total height above water level.

A point which is often overlooked in discussing radiation and radiation resistance is the large amount of power radiated by the long horizontal part of a bent aerial and which contributes but little directly to the useful radiation power because of the direction of the oscillator. T aerials should be superior to Γ aerials in this respect the currents in the two halves of the roof tending to neutralise the effect of each other. They should also be superior with respect to earth losses, either with a direct earth or with a counterpoise.

The Lafayette Radio Station.—On December 18th, 1920, Admiral Magruder on behalf of the American Ambassador handed over to the French Government the high-power wireless station erected during the war at Croix d'Hins. This station which is known as the Lafayette station was built by the United States Navy in co-operation with the French military radiotelegraphic authorities. On p. 85 in this issue we give a description of some of the details of this station together with some interesting particulars of the preliminary tests that were carried out with it.

This station is intended to work with the New Brunswick station in the United States, and as a result of an agreement arrived at between the French Government, the Compagnie Générale de Télégraphie sans Fil and the Radio Corporation of America this station will handle traffic with the United States between the following hours: 0900 to 1200 and 1700 to 1900, G.M.T. The normal wavelength of transmission is about 23,400 metres.

It may be of interest also to note that this same agreement arranges for additional traffic to be handled from Lyons station on a wavelength of 15,000 metres between the following times:—0100 to 0300, 0500 to 0700, 1300 to 1500, and 2100 to 2400, G.M.T. [1976]

A New Slide Rule.—On December 10th, 1920, Mr. J. St. Vincent Pletts read a paper before the Physical Society of London describing a new slide rule of his invention, which possesses some advantages over the ordinary patterns customarily employed, in that the rule is made easier of operation for the calculation of the more complicated mathematical functions. The same rule was exhibited at the Physical Society Exhibition in January, and will be described briefly in connection therewith in our next issue.

The Effect of the Heaviside Layer on the Apparent Direction of Electromagnetic Waves.*

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

Numerous attempts have been made from time to time to explain the vagaries of long distance wireless telegraphy as the results of the action of a conducting layer of the upper atmosphere.

In particular the theories of Fleming and Eccles are on these lines and invoke the aid of what is generally known as the "Heaviside conducting layer" which is supposed to exist at the height of 50 to 100 km above the surface of the earth. Although we know very little as yet of the nature and constitution of this conducting layer there seems very little doubt as to its existence.

Schuster has shown (*Phil. Trans. Royal Soc.*, Vol. 208A, p. 182 (1907)) that the diurnal variation of the magnetic elements at the surface of the earth can be accounted for by the currents produced by the tidal motion of such a layer in the earth's permanent magnetic field. The presence of ultra-violet rays in the sun's radiation will ionise the air and make it conducting, and Swann has calculated that this conductivity will increase very rapidly with the height above the earth's surface; direct experiments on the number of ions produced at great heights on mountains, etc., confirm these calculations.

In this paper an account is given of phenomena which afford striking additional evidence of the existence of this conducting layer, and which give an insight into some of the processes which go on in this region of the upper atmosphere.

The development of "direction finding" by wireless has put a powerful instrument in the hands of the investigator, and it is with material derived from this source that the paper deals.

In its simplest form the electrical direction finder is just a closed loop of wire which can be rotated about a vertical axis, and which is coupled to some wireless receiving device. If this loop is tuned to receive wireless waves from any transmitting station then when the plane of the loop is perpendicular to the line joining it to the transmitter no signals will be received. The reason for this is that in a plane wave the magnetic force is everywhere perpendicular to the direction of propagation, and there is therefore no flux linked with the loop in this position, and no E.M.F. induced.

The property of closed loops can be utilised to find the directions of transmitting stations, and the method is the simplest of all that have been devised for so doing.

The rotating loop, which, for mechanical reasons, is limited in size, is consequently insensitive, and the more sensitive "Bellini-Tosi" system has therefore been devised.

* Received May 14th, 1920, and in final form, December 3rd, 1920.

This consists of two large closed aerials in perpendicular vertical planes which are connected to the two fixed coils of an instrument called the goniometer. This instrument has two coils fixed in perpendicular planes each connected to one of the two large aerials. A third smaller coil which can turn about an axis which is the intersection of the central planes of the two fixed coils is connected to the receiving instrument.

The currents induced in the two aerials by the incoming waves are in phase and produce a resultant magnetic field R, the direction of which depends on the relative strengths of the currents in the two aerials, *i.e.*, upon the direction of the ray from the transmitter to the receiver. When the plane of the movable (or search) coil is perpendicular to this ray no signals will be received. The determination of this null point therefore gives the direction of R, and it is easy to show that this can be arranged to read off directly the direction of the transmitter.

All operators who have worked with this instrument agree that bearings taken in the daytime, that is, from about one hour after sunrise to one hour before sunset, are very fairly consistent, and that the probable error of a single bearing is about $\frac{1}{2}°$ in the most favourable circumstances, varying to 1·5° to 2° in less favourable cases.

These day bearings are liable to systematic errors which in certain cases may be considerably greater than 2°, due, for example, to refraction of the ray at a coast line, but the accidental errors appear to be chiefly, if not entirely, errors of observations. For instance the probable error of a station which gives weak signals is much greater than that of a station which gives strong signals, for the difficulty of measurement is very much greater in the former case.

When a large number of bearings are taken on a fixed station the probable error of the mean may be less than $\frac{1}{10}°$, and the plotted bearing often passes within this limit of the true bearing. These figures will give an idea of the accuracy which can be obtained in the daytime. On the other hand bearings taken at night may be quite unreliable. They are subject to large fluctuations and variations, and it is very often impossible to get a well defined minimum at all, so that the bearings are indefinite.

The liability to fluctuation appears to be greater in southern latitudes (*e.g.*, Cairo and Salonika) than in northern latitudes (*e.g.*, England and France). They are particularly liable to occur when the ray from transmitter to receiver passes over mountainous country; when the ray passes over the sea or open country the bearings are comparatively free from these fluctuations. They only occur when the transmitter is more than about twenty miles from the receiver, and they appear to reach a maximum when the stations are separated by about 300 to 400 miles of land. In northern latitudes the variations appear to be most marked at about sunset, or a little later, but further south the fluctuations continue throughout the night with unabated vigour. They occur on all wavelengths from 300 to 5,000 metres and upwards, and they do not appear to be specially marked on any wavelength in this range.

The following examples give an idea of the variations of the night bearings.

The first is an example in which there appears to be very little systematic error (*i.e.*, the errors are as much positive as negative).

The transmitting station at Damascus was situated about 400 miles from the receiver at Cairo. The intervening country is partly hilly, partly dry desert sand and partly well irrigated alluvial country. It was a high power station working regularly on a 2,600 metre wavelength. The bearings fluctuate over a large range in the course of a few minutes, and deviations from the mean as great as 25° have been observed. The attached curve (Fig. 1) illustrates the results. The true bearing is 50·5° and the mean of the night bearings is 49·5°. The standard deviation from the mean is 12° which is large compared with the standard deviation of the day bearings (about 0·5°).

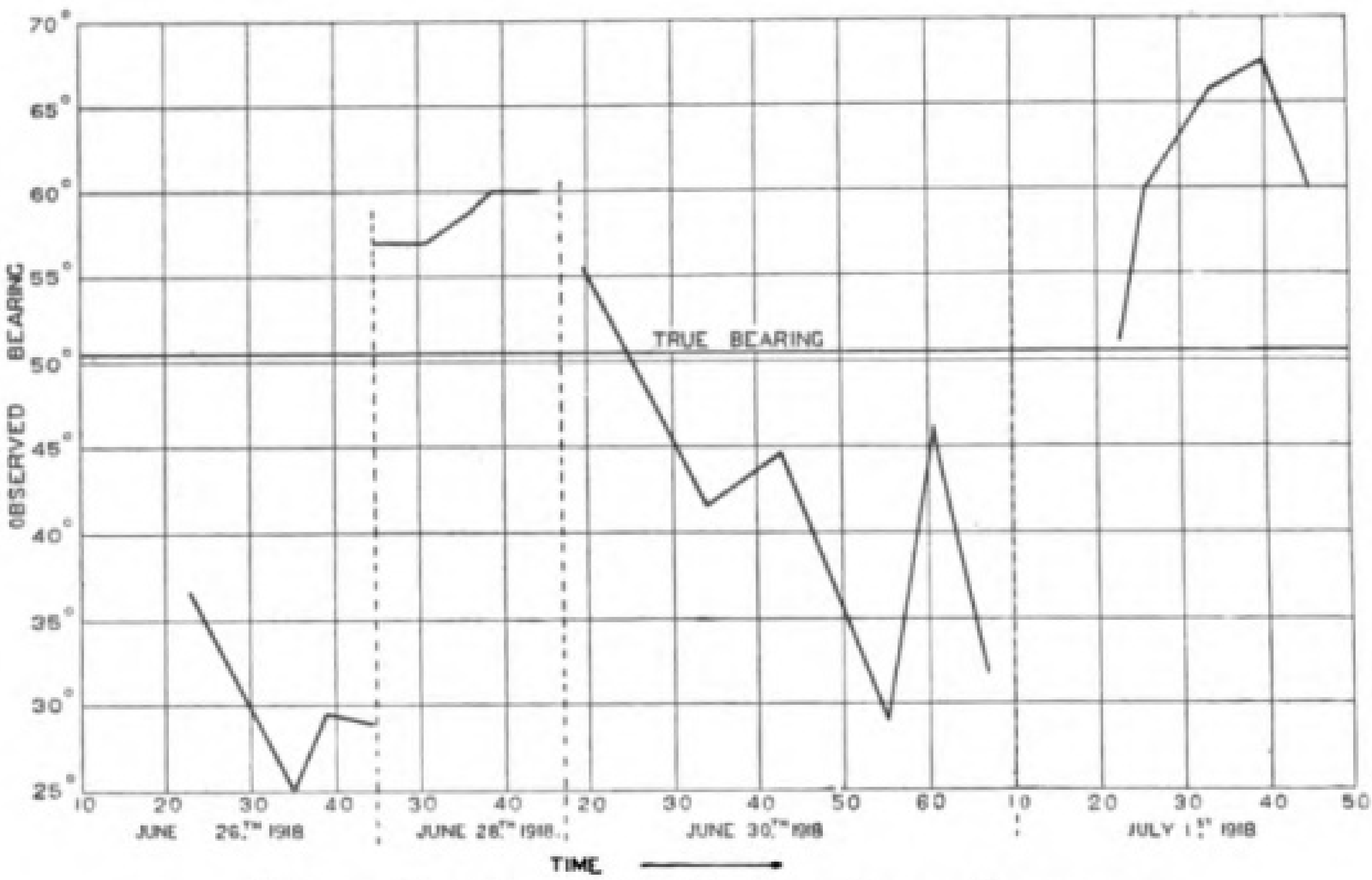

Fig. 1.—Variation of Night Bearings taken on Damascus.

The second is an example of a station which gives a well marked systematic error at night. The transmitting station was situated at Jamboli about 300 miles from the receiving station, which was at Salonika, and the intervening country was very mountainous, the ranges reaching a height of 7,000 or 8,000 feet in some places. The true bearing of the station was 55°. The mean of twenty-three night bearings was 73°, and the probable error of this mean (estimated in the usual way) was 1·25°. The systematic error 18° (73° — 55°) was therefore fifteen times the probable error of the mean and more than three times the probable error of a single observation. As far as the observations went there appeared to be no tendency for the systematic error to vary over ranges greater than its probable error.

The following example is interesting as the bearings show a marked contrast in behaviour at two receiving stations a considerable distance apart. The transmitting station (at Sofia) was situated in very mountainous country. The receiving station (1) at Salonika was about 100 miles away and No. 2 at Cairo was about 800 miles away. The bearings at station (1) were so indefinite at night that it was practically impossible to get any results at all (the day bearings were quite accurate). At station (2) bearings at night were all fairly consistent, errors seldom exceeding 2° or 3°. Similar errors were obtained at night when the waves passed over fifty or sixty miles of desert in the Northern Sinai Peninsula.

Instances of this kind might be multiplied almost indefinitely, but enough has been said to give a good idea of the nature of the fluctuations.

It is not difficult to find an explanation which, in the present state of our knowledge, is sufficient to account for these results. The theory is that these results are due to rays reflected or refracted at some upper conducting layer of the atmosphere, and it will be proved later that this theory is at least an approximation towards the truth.

In a very crude form the theory put forward is the following. The essential fact to be explained is that the loop can receive signals from a transmitting station even when the plane of the loop is perpendicular to the line joining the two stations, *i.e.*, the ray from the transmitting to the receiving station. Now it can be shown that if an electric wave passes over the surface of separation of two media (one of them being conducting) in a direction parallel to the surface, the magnetic force in the wave front must be parallel to the surface of separation and perpendicular to the direction of propagation so that it can produce no E.M.F. in the loop so long as the plane of this is perpendicular to the normal to the wave front (*i.e.*, the ray). We may therefore infer from the presence of an E.M.F. induced in the loop the presence of some other ray from the transmitting to the receiving station reflected or refracted in either a horizontal or a vertical plane, or both.

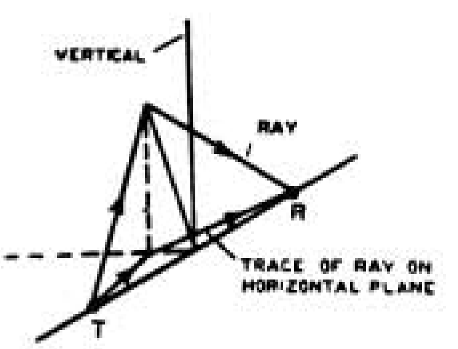

FIG. 2.

The theory put forward is that the effects observed are chiefly, if not entirely, due to the ray reflected in the *vertical plane*. It may be well to emphasise the fact that the observed deviations of bearings do not necessarily imply that the ray from transmitter to receiver is tilted to one side or the other (see Fig. 2). It will be shown later that a ray, which remains entirely in the vertical plane passing through the transmitter and receiver, is capable of producing the effects observed.

Of course neighbouring mountain masses will reflect the waves in a horizontal plane to a certain extent, and the passage of the waves over earth of varying conductivity will subject them to a sort of refraction in a horizontal plane (indeed there is direct experimental evidence of this), but there are many reasons why this sort of reflection or refraction cannot account for the fluctuations observed at night. In the first place it cannot account for the difference between the day and night bearings, and the rapid variations of the latter are unexplained. Again a mass of mountains will reflect at least as much energy from a station situated a few miles away from it as from a distant station. But it is only the bearings of comparatively distant stations ($d >$ twenty miles) which are subject to error, which cannot therefore be due to this cause, *i.e.* reflection in a horizontal plane. These facts alone would be sufficient to dispose of the hypothesis without taking into account the fact that the errors are observed in flat countries where considerable reflection in a horizontal plane is impossible.

To return to the former theory, the existence of a ray reflected in a vertical plane presumes the presence of some more or less well defined reflecting layer in the atmosphere; such a layer might, for instance, be due to a sudden change of density or to the presence of free ions or electrons. The change of density seems quite insufficient to produce any marked reflection, so we are driven to consider the effect of a conducting layer due to the presence of free ions or electrons. If the lower surface of this layer is fairly well defined there will be a considerable amount of reflection, but if the change of conductivity is sufficiently gradual the amount reflected will be small.

This brings us to the second essential fact to be explained, that is the existence of the fluctuations by night but not by day. This would be explained if the lower surface of the conducting layer were sharply defined at night but ill-defined in the daytime. Now this is roughly what we might reasonably expect; for the ionisation of the atmosphere is largely due to the action of the ultra-violet rays of the sun, so that in the daytime the lower regions of the atmosphere will be penetrated by the rays and become ionised. On account of the absorption of these rays there will be a gradual decrease of ionising power as the rays approach the surface of the earth, so that we should be led to expect an increase of conductivity up to some limiting height where the pressure is so low that there are insufficient molecules to provide ions to produce any conductivity. Now the conductivity depends upon the number of ions N and the velocity of these ions under unit electric force (which is nearly inversely proportional to the pressure). According to the theory of Swann, N, the number of free ions, is nearly constant over a considerable range at great height, and the increase of conductivity with the height is due to the decrease of pressure which is accompanied by a corresponding increase of the velocity of the ions under unit electric force.

Where N is approximately constant the rate of re-combination of the ions will be nearly proportional to the re-combination coefficient α, $\left(\frac{\partial N}{\partial t} = -\alpha N^2\right)$ which, in its turn, is nearly proportional to the pressure, so that at great heights where the pressure is low the rate of re-combination may be so small during the night that the number which re-combine during this period may be neglected; at lesser heights the rate of re-combination, which is proportional to the pressure, will be greater, and the ionisation will rapidly disappear after the removal of the ionising agent, *i.e.*, the ultra-violet rays of the sun. This process results in the existence of a more or less permanent layer at great heights accompanied by a state of ionisation varying with the light intensity at lower levels.

Now if the curve (1) in Fig. 3 represents the variation of conductivity with the height during the daytime curves (2), (3) and (4) will represent the same variation at increasing intervals after sunset. Now it is obvious that whatever the form of curve (1) (so long as σ increases gradually with h) the curves (2), (3) and (4), etc., show a much more abrupt transition from the non-conducting to the conducting layer of the atmosphere than the curve (1), and the lower edge of the layer is therefore much more sharply defined at night.

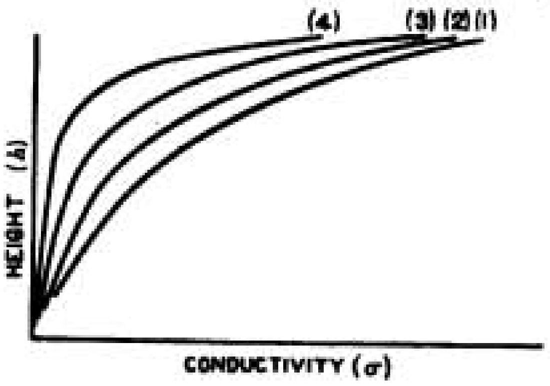

FIG. 3.

We should therefore expect a large amount of reflected energy at night and only little, if any, in the daytime.

Hence, this hypothesis will explain the difference between the effects observed at night and those observed during the daytime. This rather crude expression of the theory requires a critical mathematical treatment before it can be accepted with a degree of confidence. It must be shown that it can account for the facts quantitatively as well as qualitatively.

Before attempting this I will describe experiments which prove :—

(1) That there is a ray reflected in a vertical plane at night and not by day.
(2) That the magnitude of the error in bearing (fluctuation) varies in proportion to the strength of the ray.
(3) That the intensity of the ray is of the right order of magnitude to produce the effects observed.

As a preliminary the conditions under which an E.M.F. can be induced in a frame situated on the surface of the earth with its plane perpendicular to the direction of the transmitting station, will be investigated.

Now, so long as the magnetic force is in the plane of the loop the total E.M.F. induced in it will be zero. We have therefore to examine under what conditions there can be a magnetic force in the direction of the ray. We will assume at the outset that the distance between the transmitting and receiving stations is so short that the curvature of the earth in the interval may be neglected; on the other hand we will also assume that the stations are so far apart that the waves at the receiving station are approximately plane. Under these conditions the problem assumes a very simple form.

(To be continued.)

The Easthampton Radio Station.

The Cutting and Washington Radio Corporation has recently opened up a new commercial radio coastal station at Easthampton, Long Island, U.S.A.

The location of this station was the first important consideration for the company's engineers and Easthampton was decided upon only after most careful study of the necessities of ships entering and leaving New York. It was found that with the great number of vessels coming into and leaving the harbour great difficulty was experienced in handling the radio traffic and it seemed advisable to locate a station at a point sufficiently distant from New York to avoid the interference and at the same time near enough to arrange all details of docking, transmitting of commercial messages and allowing ample time for making up of abstracts and other details of accounting.

Direct telephone and telegraph wires to New York, together with a selected corps of experienced operators, insure accurate and speedy trans-

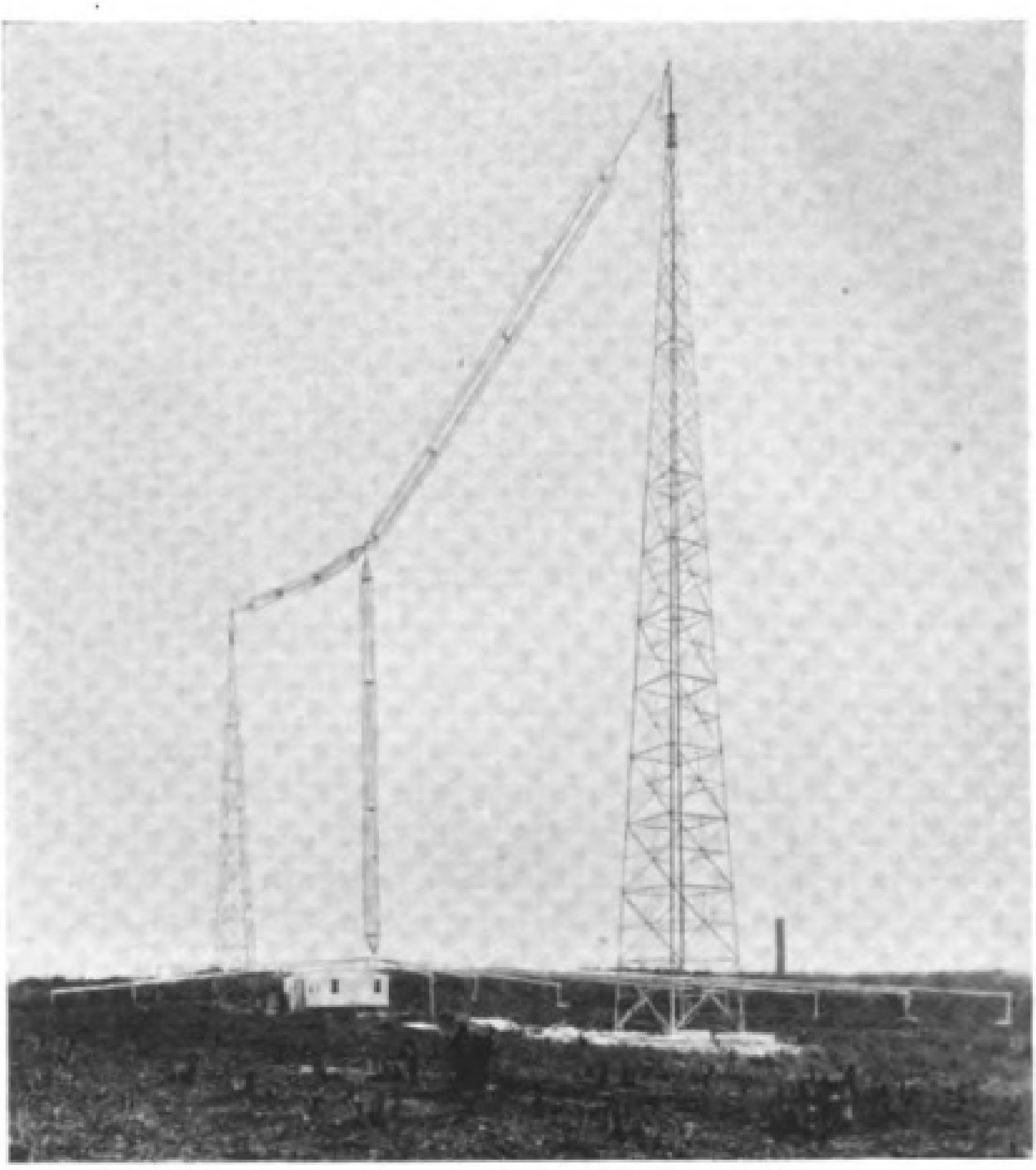

FIG. 1.—The Easthampton Radio Station.

FIG. 2.—Easthampton Radio Station, showing buildings, and arrangement of aerial lead-in and counterpoise.

mission of all messages sent through this station, the call letters of which are **WSA**.

Easthampton is one of the fashionable summer resorts located on the south shore of Long Island. It is 103 miles from New York and is one of the earliest settlements on Long Island in that section, noted in the early days for its whaling interests.

The location of the radio station is on one of the highest knolls in the town about one mile from the shore. It occupies a plot of ground some six acres in extent. The two galvanised steel towers are 300 feet apart and are 165 feet high, surmounted with wooden masts which bring the total height of the antenna to 175 feet above the heavy concrete foundations.

The latest developments in antenna and counterpoise are used, the antenna being of the cage type found so efficient on battleships during the war; the counterpoise is a series of wires radiating from one corner of the radio building and practically covering six acres (Fig. 2).

The power supply is obtained from the local electric light company and is brought to the station in a conduit 1,200 feet long. Two thousand volts alternating current is stepped down to 220 volts from which a motor generator unit produces the 110 volts direct current used in the operation of the radio set. One of the well-known "Delco Light" units in conjunction with a storage battery is used as an auxiliary to provide against breakdown.

The radio "shack" is equipped with hot-water heating, shower and toilet facilities, rest room for operators off duty and complete office equipment for handling the clerical work necessary at the station.

The two photographs show the general arrangement of aerial and towers and the method of leading-in from the aerial and from the insulated counterpoise.

Nauen and Togoland: A Tragedy of Radio-Telegraphic Development.*

By Dr. R. ROSCHER.

INTRODUCTORY: WIRELESS ESTABLISHMENTS IN THE GERMAN PROTECTORATES.

For a long time insuperable obstacles prevented the execution of the plan of employing wireless telegraphy in the various German Protectorates. It was no easy matter to transport, work and keep in order such complicated apparatus and machines which, in the tropics, are exposed to special risks; increasing distances from the railway or the coast accentuated these difficulties. In the tropical Protectorates electrical disturbances were so violent that the receipt of messages was only possible on rare undisturbed nights and days. It was not until the musical quenched spark system was elaborated by the Telefunken Company that some hope was afforded of overcoming such difficulties. This system possesses various advantages, the chief of them being the production of a pure musical note which can be readily discerned amidst the hissing, gurgling secondary sounds caused by atmospheric disturbances. With the help of this system it became possible to construct a series of efficient wireless stations in the German Protectorates. In March, 1911, the wireless stations of Muansa and Bukoba on Lake Victoria, German East Africa, were opened. These were followed by a series of wireless stations on the coast, for instance in Swakopmund, Lüderitzbucht (German South West Africa), Duala (Kamerun), Dar es Salem (German East Africa), Lome (Togo), destined to communicate with ships trading with Africa.

Independent of these, there was constructed in the German South Sea possessions a network of large wireless stations. Its centre was the station on the island Jap in the Carolines which communicated through the German-Dutch cables with the general cable system. Further large wireless stations were erected in Rabaul (Gazelle Peninsula), in Nauru and Apia (Samoa).

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* Abstracted from *Archiv für Post und Telegraphie*—see Abstract No. 1426 in this issue.

The idea suggested itself that it might be possible to utilise this new and increasingly important means of communication in order to effect a direct exchange of news between Germany and her colonies. This was all the more desirable, seeing that telegraphic communication between the German Empire and its African Protectorates was only possible through cables belonging to foreign companies. The dependence on foreign countries resulting from this state of affairs might, especially in times of political complications, be attended with the most disadvantageous consequences, not only from a military and political point of view, but also because of the harm it might inflict on trade and commerce. Even in times of peace, all news concerning political and economic events as well as that concerning details of administration was liable to the practical supervision and the one-sided colouring of foreign cables. No change in this undesirable state of things could be made except in respect of the West African Protectorates, which were to be joined up with the contemplated German South American cable from Monrovia. It was not to be expected that any German cable communication with German East Africa could be effected in the immediate future in view of the expense entailed and the great difficulties of obtaining the necessary landing points for the cables in foreign territory. An over-land connection with the German cable on the west coast would also have to pass through foreign territory, the Belgian Congo. Even if all the African Protectorates were joined by German cables and land lines with the mother country, the danger remained that these lines might in time of war be destroyed by the enemy, and the colonies thus be entirely cut off from telegraphic communication with the mother land.

PREPARATORY WORK. EXPERIMENTS BETWEEN GERMANY AND CENTRAL AFRICA.

Accordingly, in spite of the desirability of a wireless connection between Germany and her colonies, and in spite of all the technical progress made, the peculiar difficulties in the way of this connection were not to be underrated. The distances in question were of 5,500—6,000 km. Besides that, the receipt of messages was subject to the same violent atmospheric disturbances as in the case of the smaller stations working within the Protectorates or communicating with ships; these disturbances were bound to be even more appreciable on account of the larger receiving antennæ. In the given conditions, geographical and other, the first purely German wireless connection considered desirable was that between Germany and Kamerun (distance about 5,500 km). This question was discussed as early as June, 1908, in the "Committee for co-operation in the domain of wireless telegraphy" and subsequently on many occasions. From the outset it was evident that, notwithstanding the important contributions of science to progress in wireless telegraphy, the present problems could not be solved by theoretical investigations and laboratory research, but only by experiments carried out under practical conditions. And it was essential, if the experiments were to be carried out adequately and economically, to proceed from the less to the greater. The first experiments were thus arranged in the autumn of 1909 at the instigation of the Imperial Post Office, the Imperial Colonial Office, and the Imperial Naval Office, and with the means at their disposal the Telefunken Company had equipped its large experimental wireless station at Nauen, previously worked on the rare spark system, with the musical quenched spark, and raised the power supplied to the antennæ from 6 kW to 20 kW, that is to say, to the amount which appeared necessary, in the light of the experience then available, to cover a range of 6,000 km. As there was no station equipped with the latest technical devices to test the required size of the distant wireless station, the structure and height of its towers, the form and area of the antennæ, etc., an adequate substitute was provided by two Woermann steamers fitted with receiving apparatus in order to ascertain on the journey to and from Kamerun at what distances it was possible to receive a message from Nauen. The experiments carried out in the year 1909 with wavelengths of 1,000, 1,500, 1,600, and 2,000 m proved that, whereas isolated signals were received as far off as 4,600 km, a message as a whole was clearly intelligible at only half the distance of Kamerun and that single words were received as far as 3,600 km. On thoroughly investigating the result of the experiments, the conclusion arrived at was that the ship's antenna was insufficient for receiving at such great distances, because, on account of its small size, it picked up little energy ; and its efficiency was reduced owing to the necessity of loading it to the wavelength of the large wireless station. The necessity of good resonance between transmitter and receiver was confirmed by further experiments between Nauen and the large wireless station in Pola, built for the Austrian Government by the Telefunken Company (with waves of 1,500 and 2,000 m), since considerably greater receiving intensities were established than in communications with the ships lying close to the wireless station; with a wavelength of 1,600 m the signal intensity received was twenty-one times, and with a length of 2,000 m, twenty-eight times greater.

In the spring of 1910, experiments carried out with the steamer *Bosnia* on the journey to New York gave, with a 2,000 m wavelength, a range of almost 5,100 km.

After this result, it was felt that further successes might be hoped for when the experience thus gained was utilised. In the budget for 1911, therefore, 200,000 marks were provided for continuing the long distance experiments. In these renewed experiments an attempt had to be made to increase still further the power of the transmitting station, and to substitute for the small ship antenna one whose magnitude electrically speaking was approximately equal to that of the transmitting station. That was only practicable on *terra firma*. The Company offered to erect a corresponding receiving station, with a portable hut and the necessary apparatus, in Kamerun and to test it for receiving from Nauen. The establishment could not be set up on the Duala coast, since the Kamerun mountain, lying in the direction of Germany, would have formed an obstacle. Should the atmospheric disturbances in Kamerun prove too great, the experiment was to be tried in Togo.

In view of greater accessibility (telegraph line, interior railway) and more favourable geographic conditions, it was subsequently decided to make the initial tests at Togo. The Company was to find a suitable situation in the neighbourhood of Atakpame or Sakode by preliminary experiments. It was stipulated that the Company should further increase the umbrella antenna of the large wireless station at Nauen in order to raise its efficiency, should increase the power supplied to the antenna to 35—45 kW and should erect a second plant with an antenna power of at least 80 kW and increase the height of the lattice tower from 100 m to 200 m. The antenna power was raised to 35 kW in 1910—1911. For the duration of the experiments the Company was to set up for work in Togo a wireless receiving station corresponding to the dimensions of the establishment at Nauen. The antennæ of this station were to be supported by three lattice towers of angle iron, 75 m in height erected behind one another on stone foundations at distances of 225 m. From the tops of the towers the antenna wires were to be stretched horizontally in the form of a roof. Series of experiments lasting over forty-two days—apart from preliminary experiments with a balloon antenna in Togo—were stipulated, and the large wireless station at Nauen was to send two messages daily on forty consecutive days at fixed hours of day and night and with an antenna power of at least 80 kW. The Imperial Government might also demand tests with the 35 kW transmitter, and that experiments be carried out in Kamerun. If these tests were successful, the Committee resolved in May, 1911, to construct one large wireless station in Togo or Kamerun, and two large stations in East and South West Africa joining these two Protectorates with one another and with the large station, in Togo or Kamerun, which was to be constructed either then or later. The construction of these establishments in Africa was to be independent of the smaller wireless stations designed for coastal communication.

The situation ultimately decided upon by the Company's representatives for the receiving station in Togo was near Anae, a day's journey north of Atakpame, the terminus of the hinterland railway, on the road to Sakode. Instead of the easily transportable Rendahl masts, consisting of light steel tubes, which need no foundations, which can be readily set up in a short time and which had been selected that they might be set up at different places for the various tests, a heavier mode of construction had to be chosen. The Rendahl masts proved incapable of withstanding tropical conditions. A tornado overthrew two already constructed towers and shortly afterwards three completely erected masts were in their turn overthrown and destroyed. At last three frame masts of angle iron were set up capable, so far as one could calculate, of resisting any tornado.

In the night of June 6th—7th, 1911, for five minutes signals were for the first time successfully received from Nauen with the help of a captive balloon 150 m high which served to support the antennæ after the fall of the towers, the total length of the receiving wire being 300 m. Besides the signs from Nauen, the station had also received signs from the large English wireless station at Poldhu, although individual words could not be deciphered.

Thus for the first time radio-telegraphy bridged the long distance separating us from our African colony, and in little more than ten years progress had been made almost unparalleled in the annals of practical application of technical inventions. It is just this rapidity of success in the face of huge difficulties that earns the highest recognition for German achievements, far surpassing those of other countries at that time, in radio-telegraphy.

THE PRELIMINARY TESTS NAUEN—KAMINA (TOGO).

These successes were encouraging, although it was obvious that much remained to be done before communication could be thoroughly reliable.

The place for carrying out experiments was subsequently changed from Anae to a more favourable situation further south in Kamina, near Atakpame, in the immediate vicinity of the railway, 3·5 km from the terminus Agbonu.

In the meanwhile the work of increasing the dimensions of the station at Nauen had been continued; the height of the tower was increased to 200 m, and the horizontal antenna area from 15,000 m^2 to 140,000 m^2. The antenna was supported in the middle by the high tower, at its outer edge by eighteen wooden masts distributed in a circle at a distance of 400 m from the foot of the tower. The oscillating power of 80 kW was produced by the musical quenched spark system from an initial power of 200 kW and also in the form of undamped oscillations by means of a high frequency alternator.

In the beginning of January, 1912, further experiments followed with an antenna power of about 35 kW which was gradually raised to 80 kW, and with a wavelength of 3,000, 3,500, and 5,000 m. Although a few signals were received in Kamina from the wireless station at Norddeich, they could not be deciphered. On the other hand, nothing was received from Nauen. In February and March, however, a few coherent sentences of the text transmitted from Nauen with 50 kW antenna power were legibly received. Messages were also received from the European stations at Madrid (3,760 km), Rome (Coltano 4,200 km), Clifden (5,100 km), and Poldhu (4,900 km), from the African wireless stations Duala (1,100 km), Lüderitzbucht, Massana, Tenerife, etc., as well as from the American wireless station Glace Bay (7,100 km). The telegrams in these experiments were still legible when the atmospheric disturbances were twenty times as strong as the signals reaching the station. It was shown that a wavelength of 5,000 m was insufficient, and that it had to be increased to 7,000 or 9,000 m. In Togo a bent antenna was used with three masts 75 m high standing in a row, 200 m apart, in the reverse direction from Nauen; the capacity area was 35,000 m^2. Atmospheric disturbances in receiving were greater with long waves than with short. Morning hours proved better for receiving messages than evening hours; although the sound intensity in the morning was not so great as in the evening, atmospheric disturbances were weaker. The observations made by the wireless stations Duala, Swakopmund and Muansa in order to detect messages transmitted from Nauen met with no success.

The tests were long delayed by the collapse of the 200 m tower in Nauen on March 30th, 1912. A directive antenna was set up at Nauen consisting of twenty wires and supported by two frame masts of iron and two Rendahl masts each 120 m in height. It was not until the spring of 1913 that the experiments could be continued. In Togo the receiving antenna was supported by one tower 120 m, and three 75 m in height. The transmitting antenna at Nauen was at first 900 m, and later 750 m long and was supplied with a power of 100 kW. Tests were carried out on fifty-two days in all. Messages were received on thirty-seven days but only on seventeen days was there a legible text. The greatest number of text-words received in any one section of transmission was 535, the greatest sound intensity 7 ohms (parallel to the 4,000 ohm telephone receiver). The most suitable wavelength proved to be 4,500 m. Whenever the sound intensity was best, atmospheric disturbances were likewise most perceptible. The intensity of the disturbances was often less than 0·1 ohm. No law could be established regulating the occurrence and intensity of the disturbances. The results were, in spite of everything, considerably better than those in the spring of 1912 and gave ground to hope with some certainty that the proposed aim would be achieved.

Further tests were observed by wireless stations on board ships, and these likewise proved that messages might be satisfactorily received. On the journey to America signals with 50 ohms sound intensity were heard between 6 a.m. and 7 a.m. at a distance of 3,431 km and single words with 400 ohms sound intensity at a distance of 5,093 km. One ship's station heard, on the way to Africa, signals at a distance of 3,177 km during the night.

A second series of tests began on May 4th. Within a space of twenty-one days legible messages were received on only six. The experiments were therefore discontinued on May 24th. After this date attempts were made, by altering the antenna in Togo, to attain more favourable results, but without success. The sound intensity of the messages received in Togo did indeed improve as compared with that of the first experimental period; but the violent atmospheric disturbances occurring at this season of the year made it impossible to receive news except on rare nights.

The Telefunken Company then carried out on various occasions experiments to test more suitable antenna forms, different wavelengths and improved receiving apparatus. In the course of these experiments a far more satisfactory reception of messages in Togo was achieved than in those of the spring of 1913. In September, 1913, a frame mast of iron 250 m in height was begun in Nauen to replace the Rendahl masts of 120 m. It was finished by the end of March, 1914. In February, 1914, it was resolved to carry out a further series of tests extending over a space of forty days, and the conditions made by the Imperial Post Office (see below) were to be considered as having been complied with if, during each of three consecutive five-day periods, 1,200 words were received without a mistake. The tests took place as from February 10th. Messages were transmitted from 9 p.m. to 6 a.m. with a wavelength of 4,500 m, by means of the quenched spark transmitter, for twenty minutes commencing at every hour, and in addition, on Sundays, from 8 a.m. to 11 a.m. for sixteen minutes commencing at every hour with a wavelength of 9,400 m, and for sixteen minutes commencing at every half-hour with a wavelength of 6,800 m. No text could be received with the wavelength of 9,400 m, although the sound intensities were good, because the disturbances were far greater than with smaller wavelengths. The above-mentioned minimum was achieved in the first fifteen days of the experiments. In the first five-day period 1,619 words were received in Kamina, in the second, 1,721, and in the third, 1,540. From March 6th to March 18th inclusive, from five to ten telegrams were handed in daily by the Imperial Post Office to the station at Nauen for transmission to Togoland. The messages were received in Kamina by means of the already definitely completed receiving antenna which ran from north to south, was 3,755 m long, consisted of a wire rope about 11 mm thick, and was supported by three towers of 75 m in height and four towers 120 m in height (Fig. 1). The main tower at Nauen had reached a height of 200 m; the antenna was fixed at the time of the experiments at a height of 180 m. The

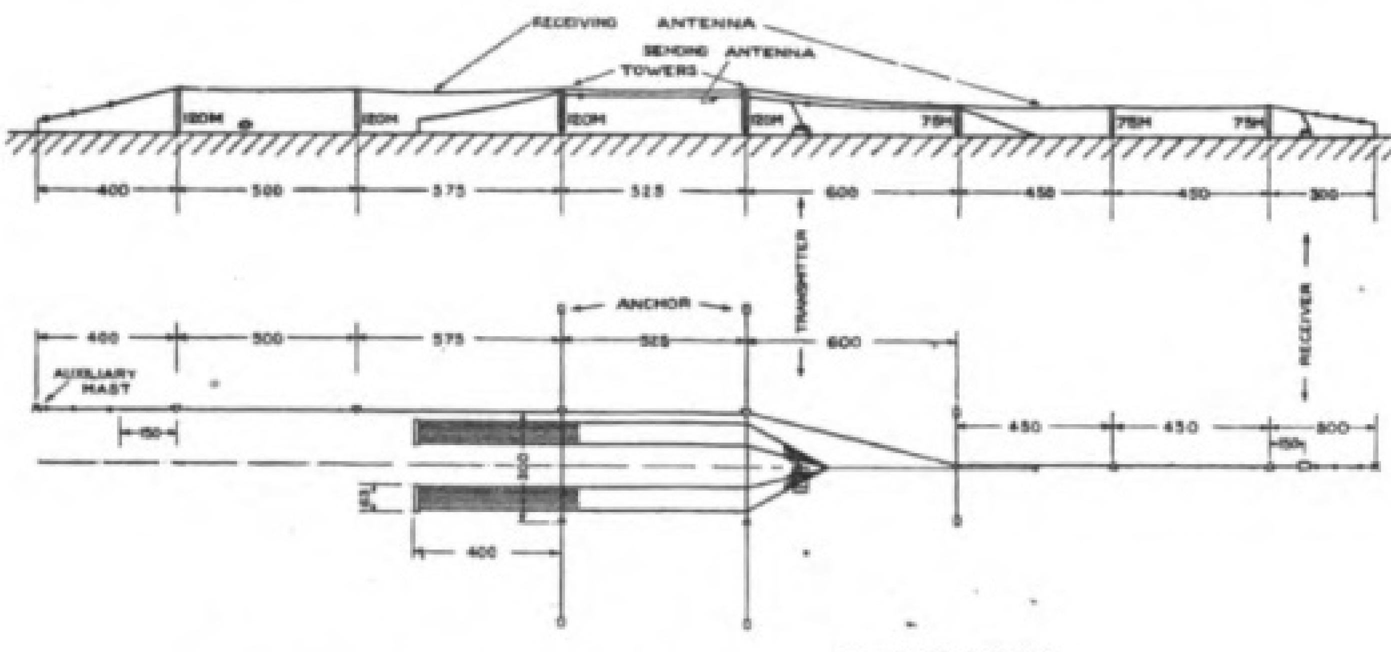

FIG. 1.—ELEVATION AND PLAN OF THE KAMINA ANTENNA.
(Dimensions are in metres.)

signals received in Kamina were amplified by means of Lieben valves; they were most distinct in the early evening hours (9 to 11 mid-European time) and in the early morning hours (5 and 6 o'clock mid-European time). From midnight till 4 a.m. thunderstorm disturbances were usually so great, or the signals arrived so weak, that they could not be received. The lowest sound intensity was measured with a shunt of 50 ohms, the highest with a shunt of 1 ohm, whilst the atmospheric disturbances were variously measured with shunts between 2 and 0·01 ohms. It was still possible to receive the text transmitted from Nauen when the intensity of the atmospheric disturbances (measured by parallel ohms) was not more than thirty times that of the arriving signals.

The wireless station Muansa observed the range tests. It heard, indeed, with a sound intensity of 200 ohms, signals which might reasonably be supposed to proceed from Nauen; but in consequence of atmospheric disturbances, which made themselves perceptible in the receiver by constant roaring, cracking, gurgling and hissing sounds, no coherent words could be heard; twice only individual letters were received.

Owing to the satisfactory results obtained, the Company received from the Imperial Government the promised subsidy of 192,700 marks for carrying out the experiments in due form.

The first attempts at transmission from Kamina took place in the night of March 31st to April 1st. On this occasion the signals from Kamina were received in Nauen with a sound intensity of less than 1 ohm; the Lieben valve was used to magnify the sounds thirtyfold.

Shortly afterwards the writer of the present article heard in Nauen the signals so distinctly that he could receive the text without difficulty.

(To be continued.)

The Ionisation Potential of Helium.*

By B. S. GOSSLING, and J. W. RYDE.

In a paper recently read before the Physical Society of London, Dr. F. S. Goucher described measurements of the critical potentials for helium made by the method used in the experiments of Davis and Goucher, these being compared with the ionising potential of mercury vapour taken as a standard.

Assuming the ionising potential of mercury to be 10·4 volts, two critical potentials occur in helium, one at about 20 volts and the other at about 26 volts. These critical values agree well with those obtained by Horton and Davies.

The effect of radiation alone on the metal parts of the apparatus was studied under conditions which would yield evidence of use in the interpretation of the results obtained when the production of both ionisation and radiation was taking place simultaneously.

The conclusion was reached that the lower critical potential was a radiation potential, though some ionisation was produced also at this potential. This, however, was attributed to the presence of impurity, probably hydrogen. The higher critical potential was that at which ionisation took place.

In his paper Dr. Goucher gave an illuminating critical discussion of his results, while in the discussion of the paper, the present writers pointed out that material furthering this discussion may perhaps be found in some observations that they made last year in the laboratories of the G.E.C. (London) bearing on the question of the existence and effect of impurities.

The object of the experiment was actually to trace the variation with time of the effects of a small quantity of impurity known to be present at the beginning. The apparatus and method of observation was that described in a recent paper † which in the light of these later results requires qualifica-

* Abstract of a paper on "Ionisation and Excitation of Radiation by Electron Impact in Helium," by Dr. F. S. Goucher, and of the subsequent discussion at a meeting of the Physical Society of London on November 26th, 1920.

† G. Stead and B. S. Gossling, *Philosophical Magazine*, 40, pp. 413—425, October, 1920. RADIO REVIEW Abstract No. 1440 in this issue.

tion in respect of the statement that the ionisation potential of helium is 21 volts.

The invariable final result shown in the cases here considered and in a very similar case described by Horton and Bailey,* is that no positive ions appear until voltages considerably higher than 20 or 21 volts are reached. This indicates that the lower ionisation point is not a characteristic of pure helium, but is due in some way to an admixture removable either by particularly thorough exhaust, or, as we have found, by the discharge itself.

The observations were made on about a dozen valves all of which behaved in a generally similar manner. These were subjected to a more severe exhaust with heating by electronic bombardment lasting an hour or more on a better pumping system than that used by Stead in the earlier case, but

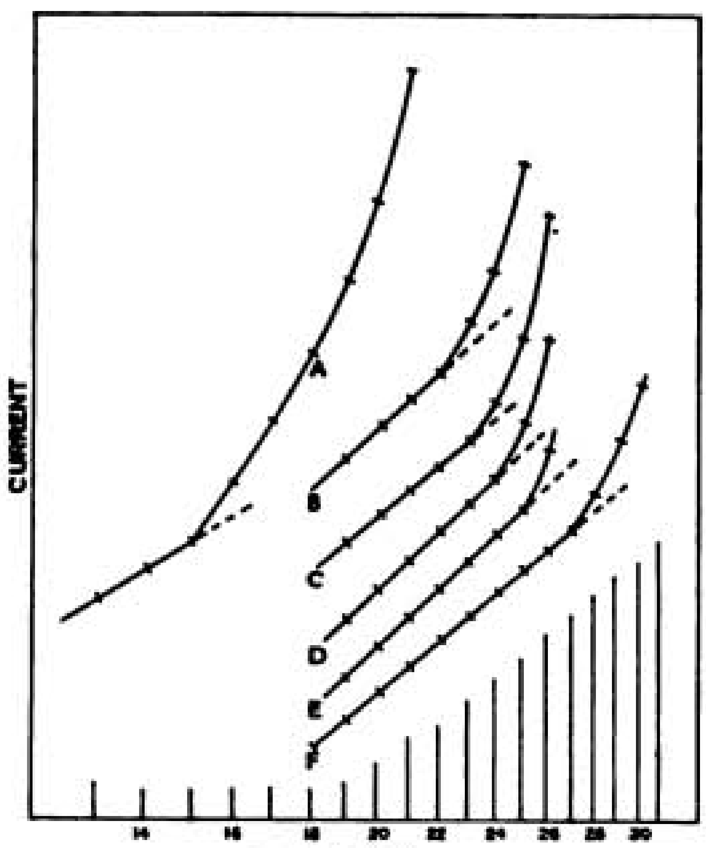

Fig. 1.

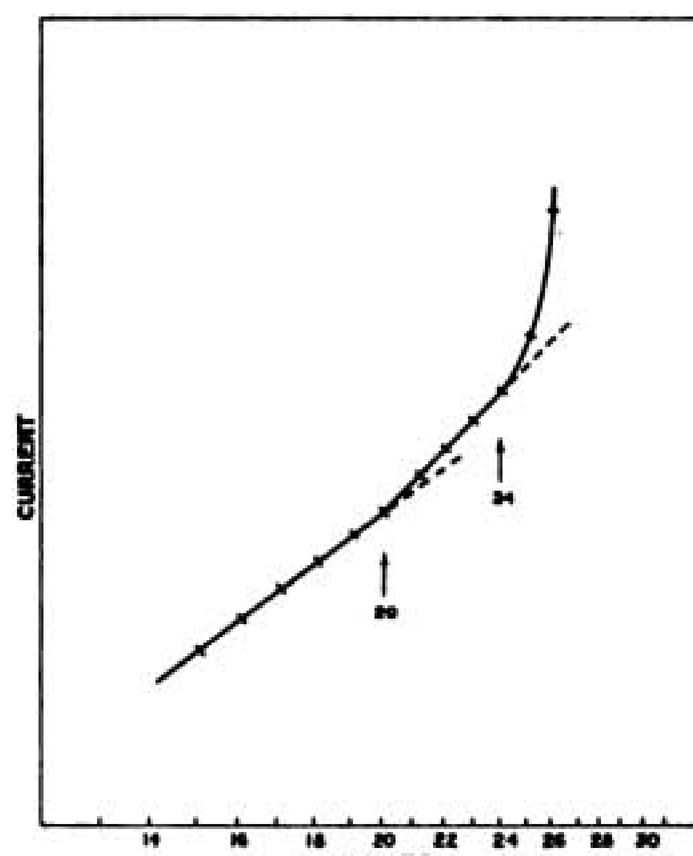

Fig. 2.

after filling with helium to 0·7 mm pressure they were generally sealed off instead of being left over charcoal and liquid air.

Taking the current voltage curves for a typical case and plotting the logarithms of current and voltage so that the " no gas " curve is very nearly straight, and the curvature at the various voltage values where ionisation sets in correspondingly more distinct, we find (Fig. 1) first a pronounced breaking away from the " no gas " curve at about 15·5 volts, indicating the presence of a very considerable amount of impurity presumably hydrogen or carbon monoxide, or both. After half an hour's running, however, with an anode potential of 150 volts there is a very marked change, the curve obtained

* *Philosophical Magazine*, 40, p. 440, 1920.

being very like Stead's with the critical point rather above 21 volts. But later curves taken after seven, nine and twelve hours show a further, but much slower, progressive change, and finally no positive ions are found to appear before 25 volts at the least. In some of the sealed valves the final critical voltage was well above this value, and there were two cases (see Fig. 1, Curve F) when the valve was left over liquid air where the first definite curvature is at 27 volts. In a few sealed valves (Fig. 2) curves were obtained showing, like Dr. Goucher's, two critical points, at 20—21 V and 24—25 V.

What was happening seems to be that with the exhaust treatment given, the valve was left in such a state that the impurities disappeared under the action of the discharge just as they would have done had the helium not been there.

Pumping with the electrodes cold will not remove the last traces of impurity, nor will charcoal, as Dr. Goucher and Mr. Stead agree. Very possibly the impurity is "condensed" on the surfaces of the electrodes and is ionised *in situ*. The use of gauze electrodes of large total surface would favour this. A given quantity so condensed would give many more ions than the same amount spread throughout the tube.

On the other hand, prolonged passage of the discharge does as a first step put a stop to the formation of positive ions between 15 and 20 volts, apparently by removing the impurity, even in a sealed tube, to a place where it is no longer ionised by impact. Above 20 volts the impurity may still be accessible to helium radiation for a time, but ultimately its effects disappear and we are left with an ionisation at between 25 and 27 volts of which there is a better probability that it is really due to helium.

The considerations here put forward seem to apply to the recent work of Compton * equally with that of Dr. Goucher.

Measurements of Radiation of Radiotelegraphic Aerials.

By G. VALLAURI.

1. General Remarks.—It is well known that for the emission of a radiotelegraphic signal, a transmitting aerial is used (called also: sending antenna, oscillator, radiator, etc.) in which either damped or undamped oscillatory currents are set up. It is also well known that of the power P, which must be given to the aerial in order to maintain the oscillations, a portion P_p (usually very preponderating) is dissipated locally, owing to the resistance of the earth connection, the metallic resistance of the conductors, the parasitic currents induced in the surrounding bodies, the corona effects,

* *Philosophical Magazine*, 40, p. 553, 1920.

the dielectric hysteresis in the insulators, and in general by the effects of every phenomenon which causes a local consumption of energy. But another portion of the power supplied to the aerial is not dissipated locally; it is spent in the creation of electromagnetic waves which are propagated over the surface of the earth, and produce in the aerial of the receiving station the phenomena which allow the reception of the signal. This second portion of the oscillatory power communicated to the aerial, represents the useful effects in connection with radiation and it is called the "radiated power, P_i." The relation between it and the total power is called, therefore, the efficiency of radiation of the aerial; $\eta_i = \frac{P_i}{P}$. This efficiency, in its turn, is only a factor of the overall efficiency of radiotelegraphic transmission, as it concerns only one of the many transformations of energy which the transmission requires—namely the conversion from the condition of energy of an oscillatory current circulating in a conductor to that of electromagnetic waves which are propagated over the earth's surface.

The knowledge of the radiation efficiency is a very important element in projects of aerials and for the working of plants; it requires the measurement of the total oscillatory power P supplied to the transmitting aerial, and the measurement of the power P_i radiated by it. It is with the measurement of radiation which we wish to deal in this note since it represents a very interesting aspect of the rapid progress accomplished by radiotelegraphy in these last few years, after having thrown overboard empirical criteria very often rough and sometimes erroneous and adopting instead more accurate quantitative methods of investigation.

2. Radiated Power.—Since the electrical magnitude which usually can be measured most easily in a transmitting aerial is the effective value I of the oscillatory currents in the neighbourhood of the earth connection (that is to say in most cases in about the centre of the oscillator) the total oscillatory power P supplied to the aerial is usually expressed as a function of the current I and of a total equivalent resistance R which satisfies the relation.

$$P = RI^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The distinction between the power P_p dissipated locally by all the causes of loss of energy mentioned above and the radiated power P_i can then be made by the consideration of two distinct parts, R_p and R_i, of the total resistance $R = R_p + R_i$, putting

$$P = P_p + P_i = R_pI^2 + R_iI^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The determination of the radiated power P_i is thus referred to that of the radiation resistance R_i, when also the intensity of current I is measured; and the efficiency of radiation becomes

$$\eta_i = \frac{R_i}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

We cannot see how it would be possible to measure directly the radiated power by the means at present available to science. It would be necessary to use an apparatus, capable of integrating in the unit of time the flow of energy through a closed surface embracing the oscillator, without its presence causing perturbations in any way to the development of the phenomenon.*

In reality the measurement of radiation reduces itself to the measurement of an electromagnetic field carried out at a certain distance from the oscillator, remembering that from the knowledge of the electromagnetic field, Poynting's theorem allows us to deduce the flow of energy through a surface element surrounding the point considered. The problem however, would be extremely difficult, if no hypothesis could be made as to the form and distribution of the electromagnetic field, because in such a case we should have to repeat the determination of Poynting's vector for all the points of a closed surface embracing the oscillator and we should have to make the integration over the same. On the other hand a single determination may be sufficient, when the figure of the field is already known which the oscillator produces and which depends on the form of the said oscillator.

* Here it is necessary to observe that the very definition of efficiency of radiation or, if it is so desired, the distinction between radiated power P_i and power dissipated locally by the effects of the losses P_p is not absolutely exact in the case of ordinary radiotelegraphic aerials earthed at one end either directly, or even indirectly through the intermediary of a capacity counterpoise. In fact in such a case it is difficult to define the shape to be given to the limiting surface across which the flow of the radiated energy should be measured. This is owing to the effect exerted by the earth and it can be emphasised by the help of Figs. 1 and 2, which represent diagrammatically a simple vertical aerial traversed by persistent oscillations, the

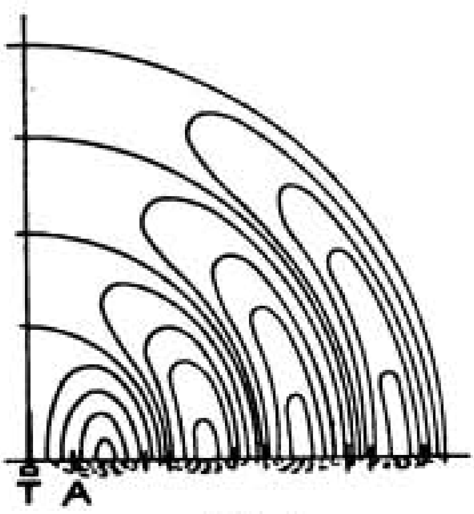

FIG. 1.

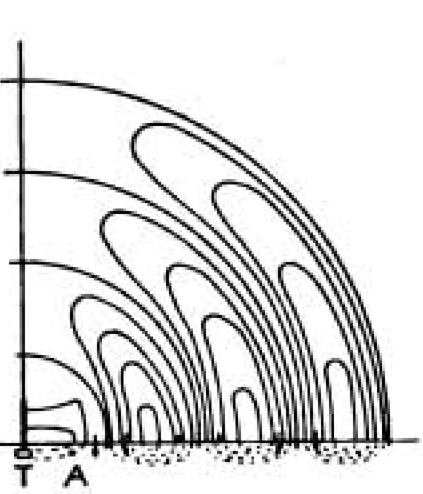

FIG. 2.

approximate form of the lines of the electric field at the moment of no current (Fig. 1) and at the moment of maximum current (Fig. 2). Those lines, which are lines of the electric field in the air, are closed, through the conducting soil, by lines of electric current (dotted in the figures). If the soil were infinitely conducting, the lines of current would not give rise to any loss and they would be limited to a surface stratum infinitely thin. But as the soil, on the contrary, is an imperfect conductor the currents which are set up in it give rise to losses. The power corresponding to these latter is a portion of the total power P supplied to the oscillator, but is it to be attributed to the power lost locally, P_p, or to the radiated power P_i? To this question we might reply that the losses due to the currents, which are closed on the earth conductors T (Fig. 1) of the aerial, still belong to the aerial losses P_p, whereas those due to the currents which are closed exclusively through the lines of the field in the air, form a portion of the radiated power P_i, inasmuch as they correspond to energy subtracted from the waves

3. Radiation of the Dipole.—The simplest case of a radiator is that of the so-called "dipole" that is to say of an ideal oscillator (Fig. 3) of length $2h$, in which it is supposed that the whole capacity is concentrated at the ends, so that at a given instant the same value can be attributed to the current for the whole length of the oscillator. If the current I is simply a sinoidal function of time with frequency f or with the wavelength $\lambda = \frac{u}{f}$ (where u represents the speed of propagation of the electromagnetic waves or the speed of light), it is known that in a point M placed at a distance d from the oscillator, much greater than its length ($2h$ $d >> 2h$), the electric field F and the magnetic field H are two alternate sinoidal vectors orthogonal to each other and with reference to d, orientated in such a way that F lies in the plane of d and of the oscillator, and H is therefore perpendicular to the said plane. The two vectors have the same phase and this is displaced with respect to the phase of the current I, by a retardation in proportion to the distance d. The effective values of the two vectors are expressed respectively thus :

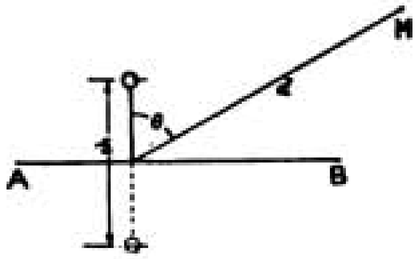

FIG. 3.

$$\left.\begin{aligned} F &= 4\pi\sqrt{\frac{\mu}{\epsilon}} \cdot \frac{Ih}{\lambda d} \cdot \sin\theta \\ H &= 4\pi \frac{Ih}{\lambda d} \cdot \sin\theta \end{aligned}\right\} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4)$$

where μ and ϵ are the magnetic permeability and the electric permeability (or dielectric constant) of the medium, connected with the speed of propagation by the well-known relation $u = 1/\sqrt{\mu\epsilon}$. It is understood that in the relations cited, every dimension must be expressed in units belonging to the same system of measurement.*

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propagated in space and therefore already radiated by the oscillator. But not even this distinction allows us to define the closed surface across which the flow of energy corresponding to the radiated power P_i should be measured, because it is easy to see, that there are infinite points (as that indicated in the figures by A) in which the losses belong alternately to one category (Fig. 1) or to the other (Fig. 2) according to the moments in which they are considered.

This discussion however has no appreciable practical importance, because according to what experience has demonstrated, the conductivity of the materials constituting the crust of the earth is for the most part so high that up to a distance of many times the length of the wave of the oscillator, the power subtracted from the waves by the losses in the soil, is negligible. In fact it happens that between such limits the intensity of the electromagnetic field decreases in inverse ratio to the distance, as should happen where there are no losses in the soil. The result is that the energy radiated is detached from the transmitting aerial almost exclusively from the hemisphere above the earth's surface and that, during the propagation, a small portion of it, falls progressively into the soil where it is consumed by the effect of losses, giving rise to those phenomena of attenuation which can only be begun to be noticed experimentally at distances of the order of hundreds of times the wavelength.

* It must be pointed out once more, how necessary is it to express general relations in such a way as shall satisfy the condition of homogeneity and therefore that they shall be valid in

Considering only the radiation emitted by the half oscillator of height h in the hemisphere above the equatorial plane A B (which may be identified with the surface of the earth supposed flat and of perfect conductivity), and applying Poynting's theorem to the hemispherical surface with radius d, we deduce the expression of the radiated power :—

$$P_i = \frac{(4\pi)^2}{3}\sqrt{\frac{\mu}{\epsilon}}\left(\frac{h}{\lambda}\right)^2 I^2 = R_i I^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

in which wishing to express P_i, I, and R_i in practical units (watts, amperes and ohms respectively) we get for the ether and appreciably also for the atmosphere $\sqrt{\frac{\mu}{\epsilon}} = 3 \times 10$ or

$$R_i \text{ (ohms)} = (4\pi)^2\, 10\left(\frac{h}{\lambda}\right)^2 = 1{,}600\left(\frac{h}{\lambda}\right)^2 \text{ approximately} \quad . \quad . \quad . \quad (6)$$

4. Effective Height of Aerial.—The case of the simple linear oscillator of length $2h'$ (Fig. 4) can be treated when oscillating with its natural wavelength in an analogous manner to that of the dipole. It is sufficient to substitute $\frac{2h'}{\pi}$ for the value h, as it is easy to deduce by attributing to the current no longer a uniform distribution along the conductor, but rather a sinoidal distribution, applying equations (4) to each element of the said conductor and integrating.

In the two cases just mentioned we see how easy it is when the effective length of the oscillator $2h$, the wavelength λ and the current intensity I are known, to deduce the electric and magnetic field without the need of other experimental data by (4) and the power radiated in a hemisphere by (5). Similarly, by measuring the electric field F or the magnetic field H, at a given point (r, θ) and knowing two only of the three dimensions, h, λ, I, it is possible to deduce the third. In particular by measuring λ and I for the oscillator or sending antenna, and measuring the magnetic field H at a given point (r, θ), the effective height h can be deduced.

The radiation measurements which are now being made in the technique of radiotelegraphy, are based precisely on the measurement of the magnetic field H (or of the electric field F) and on the deduction of h by the relations (4) and (5). They are based, therefore, on the convention of identifying, at

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any system of units. In practical formulæ with numerical coefficients, such as for example equation (6), which cannot satisfy such a condition, the units by which it is intended to measure the various dimensions should be always stated.

From this point of view there are to be found, very often, in scientific memoirs and in text-books, certain oversights which can easily lead one into error. For example, nowhere, if I am not mistaken, is the first of equations (4) expressed in the manner shown here, but instead of the factor $\frac{\mu}{\epsilon}$ sometimes the symbol of the speed of light u is found (Zenneck-Seelig, "Wireless Telegraphy," *McGraw-Hill Publishing Company*, 1915 edition, p. 35). In this way however the equation is not homogeneous.

least approximately and in connection with distant effects, the effective aerial with half a Hertzian dipole and by calling the height of radiation or effective height h of the aerial that of the equivalent half dipole, or of a half dipole connected with the earth, which carrying the same current I, with the same wavelength λ, gives rise at that point to the same electromagnetic field. On the basis of this definition and on what has been stated above, the effective height of a simple linear aerial (Fig. 4) oscillating with its own wavelength, is $h = \frac{2}{\pi} h'$ where h' is the geometric height of the aerial, that is to say, the length of the conductor which constitutes it.

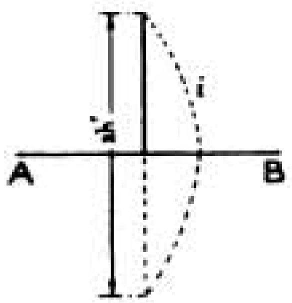

FIG. 4.

5. Receiving and Measuring Aerials.—The measurement of the magnetic field H (or of the electric field F) is usually effected for sending antennæ connected with the earth, by a receiving aerial which is itself placed in proximity to the ground, at such a distance and in such a position that we may consider the earth as flat and therefore put $\theta = \pi/2$. The receiving aerial may be of either of the two types most in use to-day, that is to say, a half oscillator connected with the earth like the sending antenna, or a frame aerial with one or two coils, polygonal in shape isolated from the earth and constituting a closed circuit. In both cases the measurement of the field is related to a measurement of the effective intensity of the received current I_r, on the basis of the following considerations: If the receiving aerial is a half oscillator connected with the earth; if it is admitted that the electric field F is vertical; if the aerial is identified with a half dipole of height of h_r; and finally, if persistent oscillations be considered, we get that the E.M.F. induced by the waves in the receiving aerial is

$$E = h_r F \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

If, on the other hand, the receiving aerial is a plane closed circuit, lying in the vertical plane which includes the receiving station and the axis of the sending antenna (or forming with it an angle α), if it is admitted that the magnetic field is perpendicular to this plane and if the horizontal extension of the receiving aerial is small in comparison with λ, the E.M.F. induced in the aerial is

$$E = 2\pi \frac{u}{\lambda} S_r \mu H \cos \alpha \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where S_r is the total area of the receiving closed circuit (or, if the circuit consists of several co-planar or parallel spirals, S_r represents the sum of their separate surfaces, *i.e.*, if there are N equal coils each having a surface of S_1, $S_r = NS_1$ *).

* An equation exactly equivalent to (7) can be obtained expressing the E.M.F. as a function of H instead of F, depending on the fact that the receiving aerial cuts the lines of magnetic flux which are propagated horizontally. In the same way, (8) can be replaced by a relation

In both cases, the current I_r, generated by the induced E.M.F. E, is expressed by

$$I_r = E/Z_r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where Z_r represents the total impedance of the receiving oscillatory circuit, and, in the case in which the receiving circuit is tuned to resonance,

$$I_r = E/R_r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9a)$$

where R_r is the total equivalent ohmic resistance, that is to say, that which represents all the losses of energy to which the oscillation induced in the receiving aerial is subject.

It is seen that the determination of the electric field F, by (7), requires first of all, the knowledge of the effective height h_r of the receiving aerial at the given frequency. This can be deduced, λ being given, from the geometric dimensions of the aerial if they are very simple and well defined, or it will have to be found by special radiation experiments.*

In the case of the closed circuit and of the relation (8) it is likewise necessary to know the geometrical dimensions of the said circuit. In both cases then, the measurement of the received current I_r is required as well as that of the impedance Z_r (*i.e.*, of the resistance R_r, if the receiving aerial is adjusted to resonance) of the receiving circuit.

6. Measurement of the Received Current.—The measurement of I_r is a particular case of the measurements of weak oscillatory currents which very often occur in radiotelegraphic technique. When it is a question of extremely small currents as in the case of the measurement of the electromagnetic field produced by very distant emissions, it is necessary to resort to indirect methods,† but in the ordinary case of measurements of radiation which are carried out, as we shall see, at distances of two or three wavelengths from the transmitter, the I_r values to be measured are generally of the order of tens, hundreds and even thousands of microamperes and therefore one can have recourse advantageously to direct measurements by thermal methods. These are carried out generally by one of the following methods :—

(*a*) Inserting in the aerial circuit the heater wire of a thermo-couple and connecting the ends of the couple to a galvanometer.

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in terms of F, deduced by the consideration of the size and phase of the elementary E.M.F.'s produced by the electric field in every element of the receiving closed circuit. These relations naturally satisfy the relation $\sqrt{\epsilon}F = \sqrt{\mu}H$ which is deduced from (4).

* According to a combination method proposed by Commander Pession, if there are three aerials available, of which at least two can function as transmitters and two as receivers, it is possible to determine with three measurements the effective height of each of the aerials. (See an article by G. Pession, "A Particular Case of the Measurement of the Effective Heights of Radiotelegraphic Aerials," which will be published in a forthcoming issue.)

† G. Vallauri, "Measurement of the Electromagnetic Field of Transoceanic Radiotelegraphic Waves" (*L'Elettrotecnica*, 7, p. 298, June 15th, 1920), and Publication No. 9 of the Royal Naval Electric and Radiotelegraphic Institute.

[See also RADIO REVIEW, 1, pp. 652—655, October, 1920.]

(*b*) Inserting in the aerial circuit the heater wire of a "Duddell" thermo-galvanometer, which is merely the combination in a single instrument of the couple and galvanometer.

(*c*) Inserting in the aerial circuit a bolometer connected to a Wheatstone bridge, which allows the variations of resistance of the wire to be measured.

It may be said that these three methods are given in the order of increasing sensitiveness. Naturally the greater the sensitiveness the greater are the difficulties and the greater the delicacy of the measurements. The first method can be brought to be equal to the second, making use of good couples enclosed in vacuum bulbs and very sensitive reflecting galvanometers, but the difficulties of the two methods are then equivalent. In the case of very powerful transmissions, of short distances and very extensive receiving aerials, I_r may attain such a considerable value that it can be easily measured with direct reading instruments, such as Duddell's thermomilliammeter or even with a hot-wire ammeter of great sensitiveness. As is well known, if it is desired to attain the maximum degree of sensitiveness, it is necessary to choose for the heater of the couple, or of the thermogalvanometer, or for the bolometer wire, a resistance of the same order of magnitude as the total impedance of the aerial.

All these instruments, besides, must be calibrated in order that it may be possible to obtain from their readings the effective value of the I_r current. The calibration can be easily carried out by direct current in the case of the thermogalvanometer. In the case of the couple, on the contrary, the calibration may be rendered uncertain by a direct shunting of direct current through the galvanometer, independently of the thermoelectric

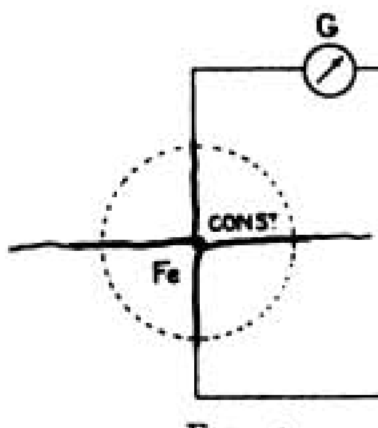


FIG. 5.

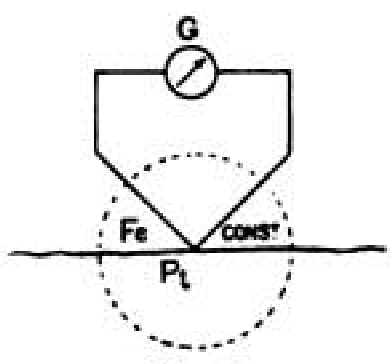


FIG 6.

phenomenon. This defect is so accentuated in the "cross" couples (Fig. 5) that calibration by direct current is rendered unreliable: in fact, it often happens that, on reversing the direct current, the galvanometer deviation not only changes in amplitude, but even in sign. On the other hand, in the case of couples where the junction makes a very limited contact with a continuous heating wire (Fig. 6) the deviation of the galvanometer depends almost exclusively on the thermoelectric effect; this can be checked by reversing the direct current and verifying that the two deflections thus obtained differ very little or not at all. For the purpose of calibration the mean of the two deflections is taken.

In the case of the crossed couples it is necessary to effect the calibration with alternating current. The same holds good for the bolometer, on account of the use of the bridge device which would be directly perturbed by the continuous calibration P.D. This is the greatest drawback of the bolometer, because as it is a question of very weak currents, it is usually necessary to fall back on the thermogalvanometer for the comparison of alternating currents and then calibrate in turn the thermogalvanometer by direct current. Moreover the bolometer is exposed to the drawback that one portion of the alternating current communicated to the heating wire tends to propagate itself to the other branches of the bridge and one portion of the direct current of the bridge tends to pass into the frame-shaped aerial and this renders necessary the use of inductances and capacities for protection.

On account of all these reasons it has been considered opportune to prefer usually the use of the thermogalvanometer which combines the advantages of simplicity and ease of handling with those of precision and sensitiveness.

(*To be continued.*)

The Lafayette Radio Station.*

The Lafayette radio station situated at Croix d'Hins 25 km to the south of Bordeaux is now completed and was put into service on December 18th, 1920. The construction of the Croix d'Hins station was decided upon during the war and dates back to the last months of 1917 after the intervention of the United States in the European conflict. The transatlantic cables which were liable to accidental damage or to attempted destruction by the enemy constituted a precarious means of communication. France it is true had at its disposal the radio stations at the Eiffel Tower and at Lyons, but the normal transmission programmes of these stations for military communications and propaganda work were already too full to admit of a further extension of their traffic.

From the first test carried out with these stations to determine their suitability for this purpose, it was found that the station at Lyons was the one best adapted to ensure regular communication. Its signals were generally heard in America as strongly as those from Nauen, but it was well known that during the summer season when atmospherics were prevalent the reception of European stations, German or French, left much to be desired. The reception of the signals from this station was made the subject of special study by French radio engineers who proceeded to America for this purpose.

From the information which they were able to gather it was evident that in the event of an interruption of the cable communications, the Lyons station even if assisted by the one at Nantes, which had just been completed

* Abstracted from information contained in the articles referred to in Abstracts Nos. 1423, 1424, and 1425 (in this issue).

by the French naval service, could not deal with the enormous traffic which would fall upon it.

It was therefore decided to build a new radio station capable of ensuring at any season and at any hour a permanent service with the United States and, at that time, devoted entirely to military needs. To achieve the desired results it was estimated that it would be essential to employ a current of about 500 amperes in an antenna supported by towers 250 metres high, the antenna capacity being of the order of 0·05 mfd and the resistance being not greater than 1·5 ohms. This estimate of the requirements which at the time seemed somewhat exaggerated has been proved by subsequent tests to be perfectly justified.

For the construction of the station the United States Navy and the French military radiotelegraphic organisations combined together, the former undertaking to provide the radio frequency generators, and their accessories as well as the antenna towers, while the latter undertook the provision of the earthing system, the erection of the antenna, the construction of the buildings and the power lines from Bordeaux to Croix d'Hins. The negotiations that took place on the subject resulted at the beginning of 1918 in the conclusion of an agreement fixing the character of the collaboration between the two nations, and the work was actively pushed forward from that date.

The buildings and towers were partly completed when the Armistice of November 11th, 1918, temporarily interrupted the Franco-American col-

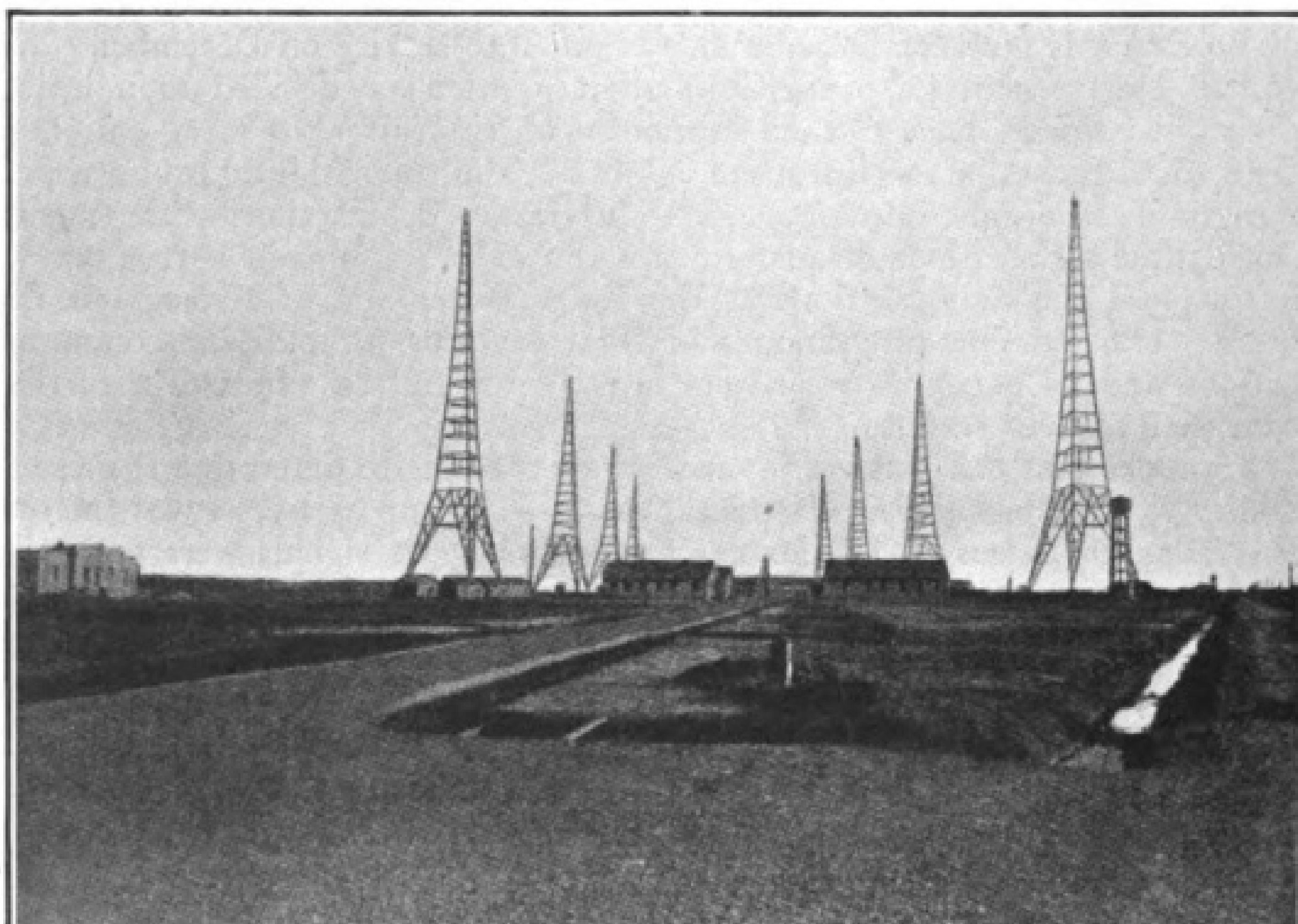


Fig. 1.—General View of the Lafayette Station.

laboration. At that time the United States offered either to take back or to hand over to France their material not then installed but the French Government preferred to profit by the work already accomplished and to carry on the completion of the work. A Convention dated February 11th, 1919, between the two countries fixed the conditions for the completion of the station. After an interruption of six months the American Navy resumed its work with the result that the towers were completed by the end of 1919, while in August, 1920, the station was ready to undergo its preliminary tests.

The station occupies the site of an old aviation camp of about 1,230 acres adjacent to the Bordeaux-Arcachon-Bayonne railway. A central roadway through the side leads to the main building marked "Radio Building" in Fig. 2, passing a large workshop containing a transformer sub-station and

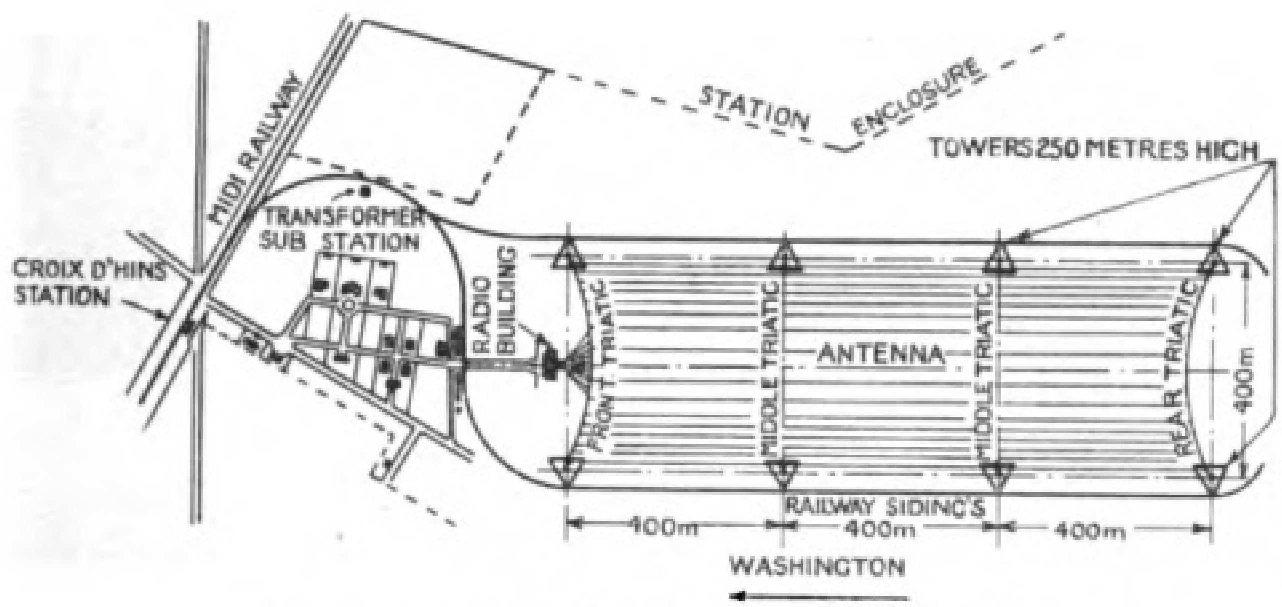


FIG. 2.—Plan of the Lafayette Station and Aerial.

the accumulator rooms as well as a store. Four buildings are devoted to a laboratory, a canteen and accommodation for the staff. A transformer station (stepping down from 50,000 to 2,200 volts), with accommodation for the electricians, accommodation for the chief officer of the station and his assistant, a garage and the water towers complete the list of subsidiary buildings. A branch railway line about three miles in length leads to the stores, the station and the eight towers, and is connected with the lines of the Chemin de fer du Midi. A near view of the station buildings is given in Fig. 3.

Both by its size and its height the antenna of the Lafayette station constitutes one of the largest in the world. It is of the same height and size as that to be employed at the French colonial station at Saigon. It consists of a horizontal part having sixteen parallel strands and a vertical down lead with ten strands. It is supported by eight steel towers 250 metres (830 feet) in height arranged in two rows 400 metres (1,330 feet) apart, the towers in each row being also 400 metres (1,330 feet) apart. The area covered by the antenna is thus 480,000 square metres (118 acres). The two central cross

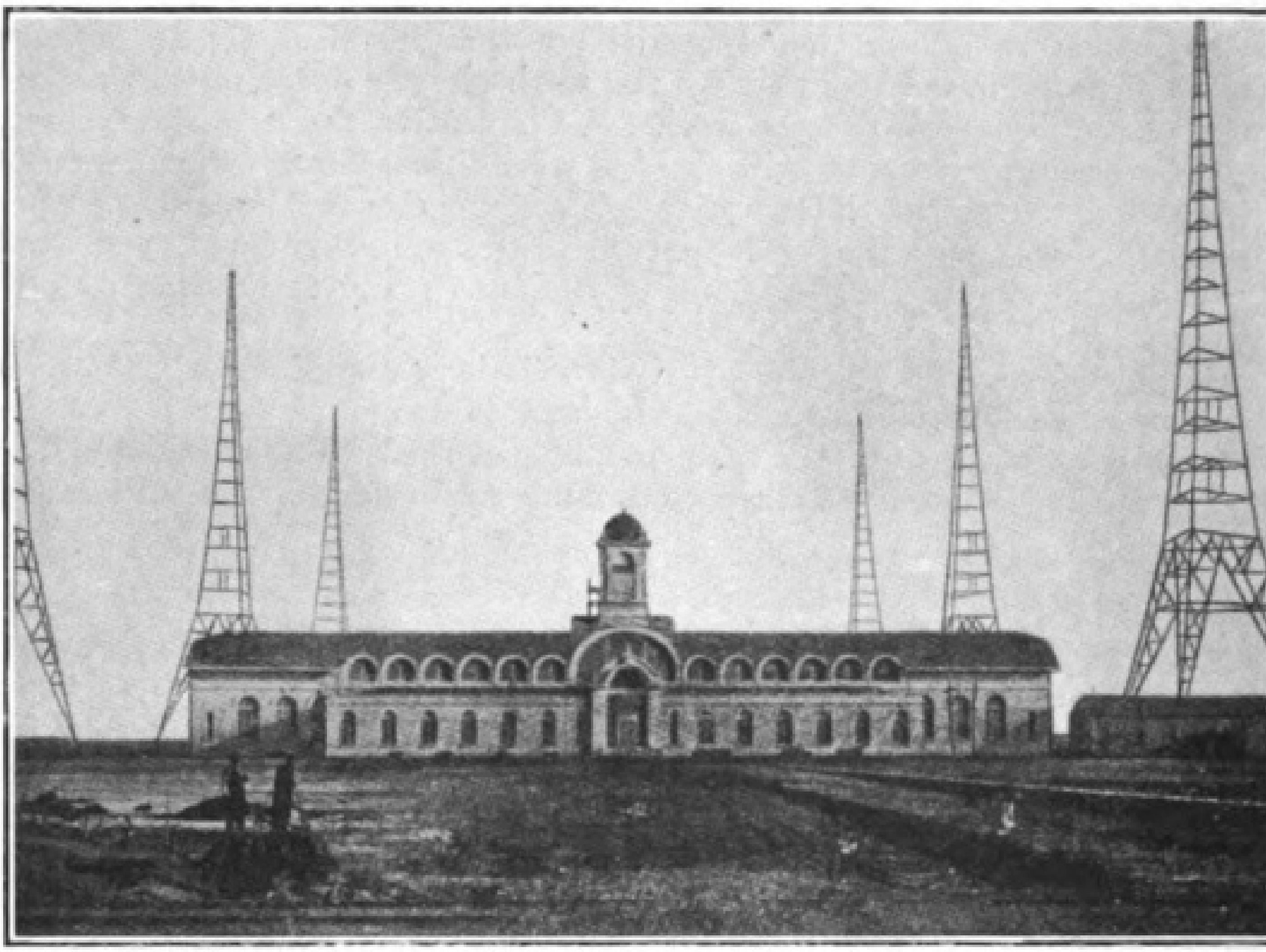
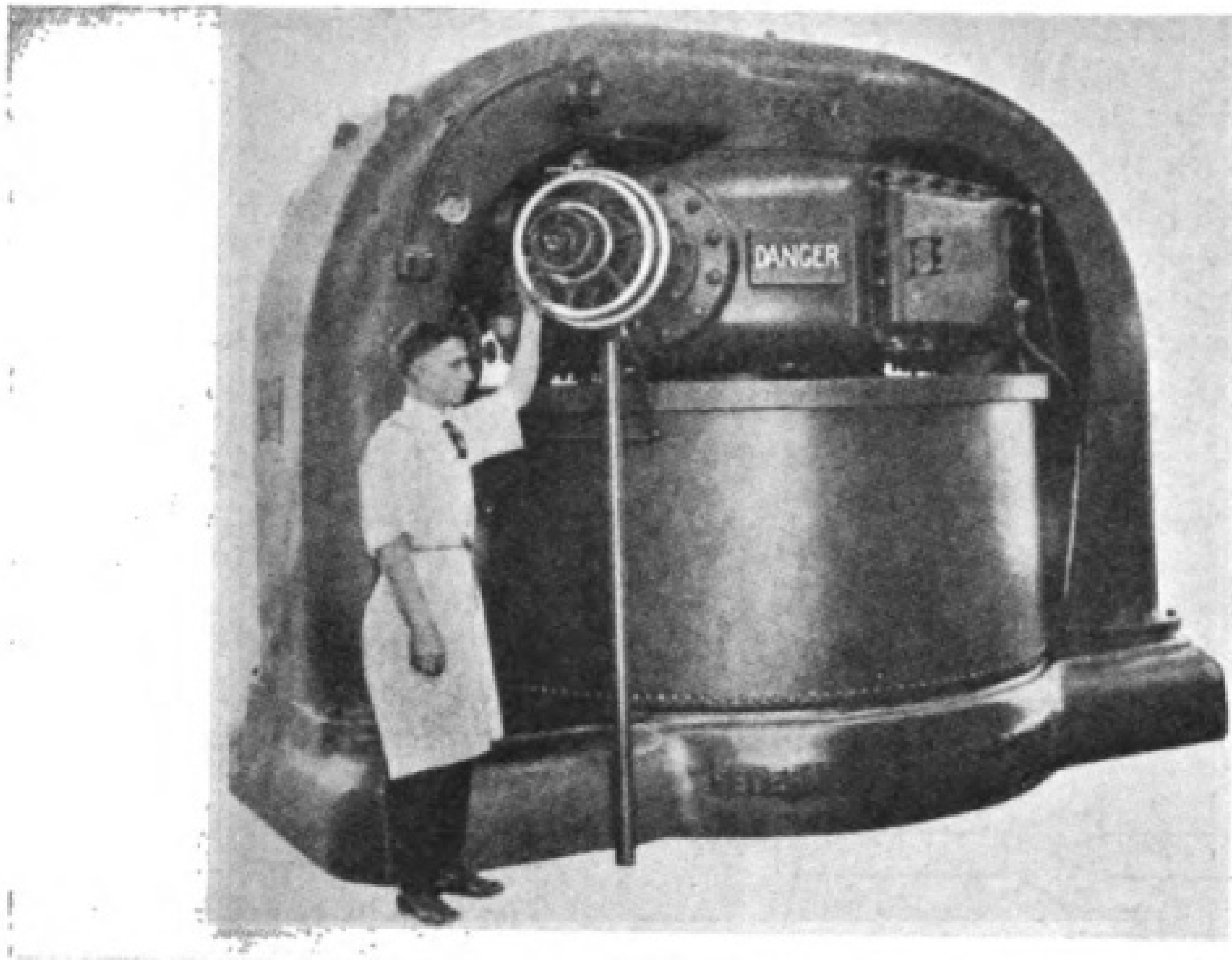


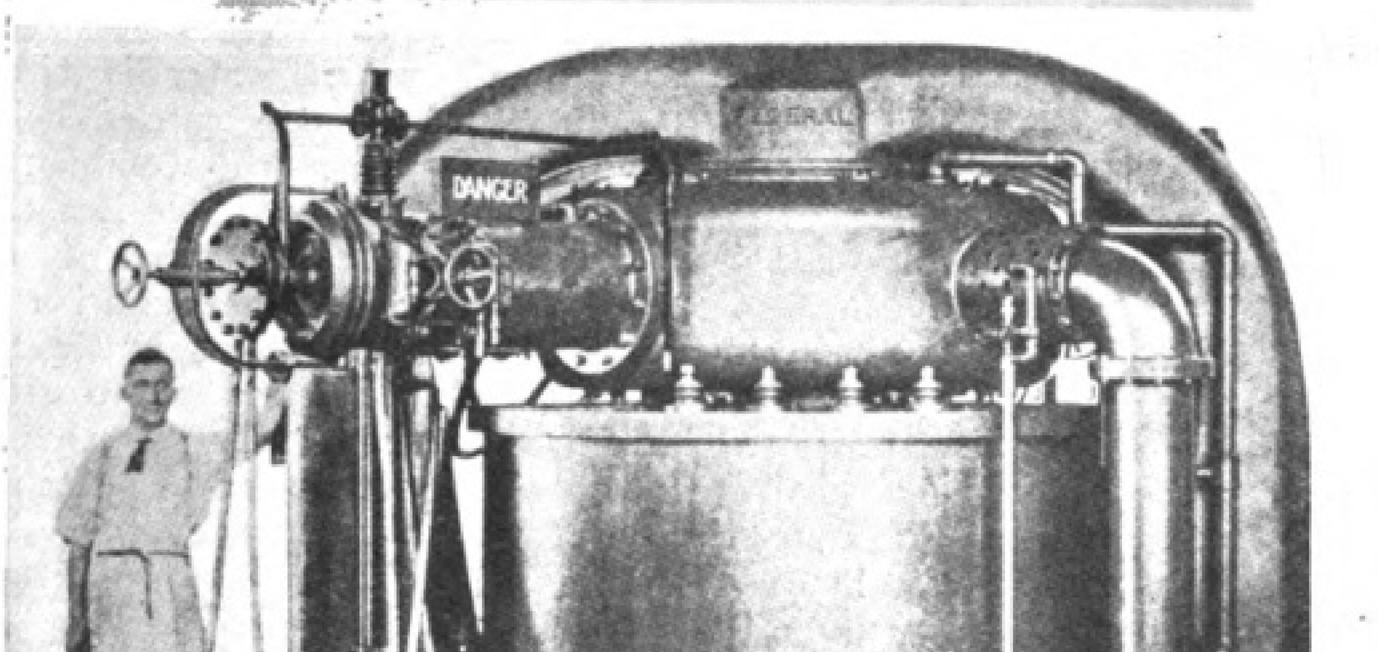
Fig. 3.—View of the Station Buildings.

supporting wires, or triatics, of the antenna each carry at their point of attachment to the towers a normal load of three tons and have a sag of 25 metres (82 feet). They are designed so that even with a high wind the load which they have to carry remains well below their safe working stress. Double insulators are used for the first triatic cable and single insulators for the remaining three. Each insulator consists of a porcelain cylinder 180 cm (71 inches) long, weighing 160 kg and having a tensile strength of about 15 tons. The antenna is designed for a normal wavelength of from 20,000 to 25,000 metres. The towers are of the American navy type, being of tripod form and having a triangular base of 65 metres (212 feet) side.

The earth connection consists of a double system of buried plates and tubes. Copper plates 115 cm × 140 cm (45 inches × 55 inches) are buried 1½ metres (5 feet 10 inches) below the surface, and are each provided with lugs for connection to the neighbouring plates. The tubes are each 25 metres (82 feet) long and are arranged in two circular rings, the first having forty tubes connected together and each connected to the buried plates and the second having eighty tubes also connected together and to the plates. In addition to the above a further ring of earth plates has since been added and to still further improve the earth connection they were joined to the towers and to the railway lines.

The two arc converters which were manufactured by the Federal Telegraph Company form the most interesting part of the installation.





FIGS. 4 AND 5.—The 1,000 kW Arcs. Cathode and Anode Sides respectively.

While the arc at the Lyons station yielded an output of 180 kW high-frequency energy in the antenna circuit those at the Lafayette station can each give 500 kW in the aerial. A further comparison of the two arcs is also interesting. The former has a total weight of about 7 tons of which the

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magnetic circuit contributes 4 tons. The second weighs approximately 80 tons, seventy being contributed by the magnetic circuit. Apart from the remarkably robust character of the Federal Company's arc the disproportion between the weights of the two types arises from the fact that in the French arc the magnetic circuit is designed only for the conditions under which the apparatus is normally intended to be used, whereas the American arc is designed to operate over the largest possible limits and can be used in very diverse circumstances. Two views of the arc are given in Figs. 4 and 5.

With an air gap of 18 cm (7·1 inches) the magnetic field strength can reach the value of 17,000 gauss. The magnetic circuit carries two windings one being joined in series with the supply circuit to the arc while the other is fed from a special auxiliary machine. The second winding can either add or oppose its effects to that of the main winding so that a fine adjustment of the field strength is thus possible. The general arrangement of the magnetic circuit is indicated roughly in Fig. 6. The main details of the arc are as follows :—

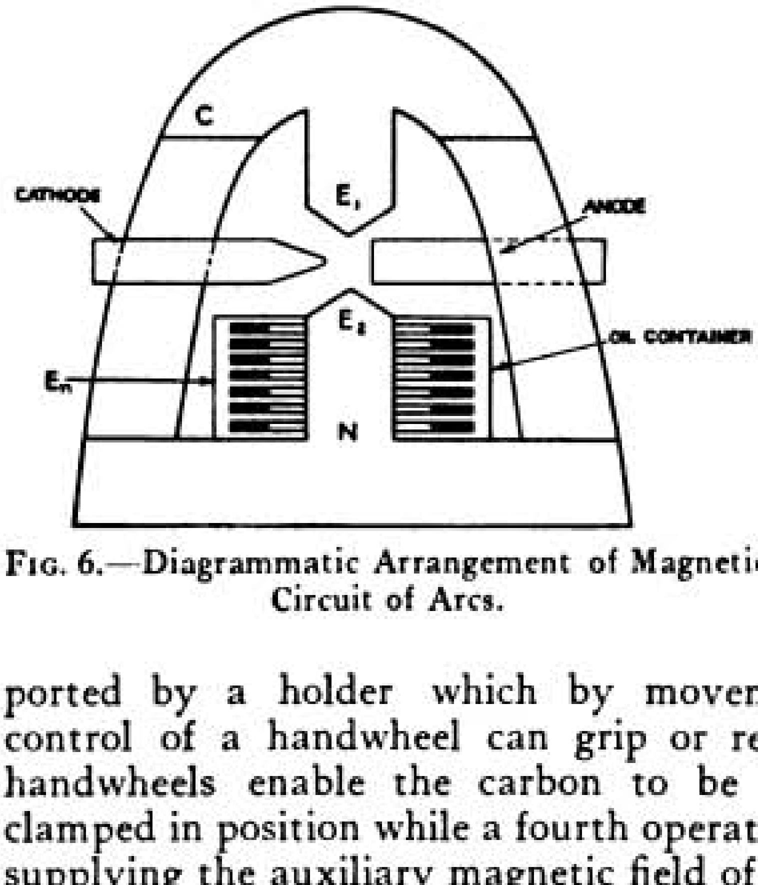

FIG. 6.—Diagrammatic Arrangement of Magnetic Circuit of Arcs.

The anode consists of a tube 2 cm (0·79 inches) diameter through which water is circulated, the anode carrier being insulated from the combustion chamber. The cathode is a carbon cylinder of about 4 cm (1·58 inches) diameter and is supported by a holder which by movement in conical guides under the control of a handwheel can grip or release the carbon rod. Two other handwheels enable the carbon to be moved backwards or forwards or clamped in position while a fourth operates the field rheostat of the generator supplying the auxiliary magnetic field of the arc. The combustion chamber is provided with double walls and is water cooled. The waste gases from this chamber pass out through a collecting pipe 30 cm ($11\frac{3}{4}$ inches) in diameter to special exhausting pumps while precautions are also taken to prevent damage in the event of explosion. Both water and oil circulation systems are provided for cooling the arc, the latter serving for cooling the magnetising windings. By appropriate valves the circulating systems can be connected to either of the arcs.

The power used in the station is furnished exclusively by the Société de l'Énergie Électrique du Sud-Ouest in the form of alternating current at 50,000 volts. No emergency supply installation has been provided. The power is supplied from a special central station which has been built at Floriac near Bordeaux. In case of necessity the supply may be taken from a transformer station at Cenon near Bergerac on the River Dordogne. The power lines cross the Garonne by a 500 metre span after which they have a run of 28 km ($14\frac{3}{4}$ miles) to the transformers at the radio station. A special transformer station has been installed near the radio station and contains two 3-phase transformers each of 2,500 kVA capacity which may be connected to the lines either singly or in parallel. These transformers reduce the voltage to 2,200.

A smaller transformer sub-station has also been installed in the workshop of the station for supplying the auxiliary services other than the main radio apparatus. In this sub-station two 2,200/200 volt transformers have been installed for feeding motors driving battery charging generators and the workshop motors. In a separate room a 220 volt 350 AH battery has been installed and is used solely for emergency lighting.

Four cables are run from the main transformer station to the busbars in the radio building to which are connected two 1,000 kW, three-phase, 2,200 volt, 50 cycles, synchronous motors which drive the generators furnishing the continuous current for the arcs. These motors are started up as asynchronous machines with a squirrel cage winding on the rotor under reduced voltage from an auto transformer. In addition to the usual indicating instruments these machines are provided with specially graduated meters connected to resistances incorporated with the windings of the stator so that the temperature of the windings is indicated directly. The 1,000 kW D.C. generators driven by these machines and used for feeding the arcs are compound-wound machines having six main and commutating poles. They give 1,250 volts when running at 750 r.p.m. and are provided with an exciter on the same shaft. They have an independent field winding fed from the exciter, a series winding on the main poles, a series winding on the commutating poles and a compensating series winding. All the series windings are provided with diverters. An overload relay is joined in series with each machine so that in the event of an overload it interrupts the auxiliary starting circuit of the arc and causes the contactors which short circuit the series resistances in the arc leads, to be opened.

The negative poles of the generators and the cathodes of the arcs are all joined to the main earthing system, the earth connections of the former being made through four resistances and an overload relay. The ends of these starting resistances are joined to four contactors by means of which they can be short circuited. The positive poles of the arcs are joined to the positive busbars of the machines through appropriate circuit breakers, so that the circuit from the machine thus comprises the series windings of the arc, the arc and the earth connections.

The starting controllers have eight positions which perform the following functions :—

(1) Opening of the water circulation valves.

(2) Opening of the valves admitting alcohol into the combustion chamber.

(3) Starting of the cathode driving motor.

(4) Closing of the circuits supplying the arc and the supplementary excitation of the arc.

(5) to (8) Short-circuiting of the four resistances in series with the arc.

A safety arrangement is provided which prevents the arc being started up if there is insufficient pressure in the water circulation pipes, and which opens the arc circuits if the water pressure should fall below the predetermined limit. This apparatus consists of an ordinary pressure gauge provided with two contacts, the upper one of which when closed completes the circuit through the main contactor in the arc leads which is then automatically retained in the closed position. If the water pressure falls sufficiently to cause the lower contact to be closed the holding-on coil of the contactor is short-circuited and the main circuit of the arc thus interrupted.

The antenna loading inductance is constructed of large section flexible cable consisting of strands of wire twisted round a hemp core, the wire strands as well as the cable being insulated. The cable is supported round twelve insulators arranged in a ring on a concrete base, and the coil is placed in an hexagonally shaped room outside the body of the main building. This room is provided with a network of earthed wires to screen the main building from the inductive effects of the coil. The wavelength changes are effected by means of motor driven switch arms which are arranged in the manner indicated in Fig. 7. The contacts and switch arms of these switches are mounted on insulators on a switchboard near the loading coil. The switch arms are moved by a ¼-H.P. 115 volt motor through suitable gearing. The motor also operates a five-way rheostat in the field circuit of the 30 kW generator which provides the auxiliary magnetising current for the arc, so that the magnetic field-strength is automatically adjusted to a value appropriate to each wavelength.

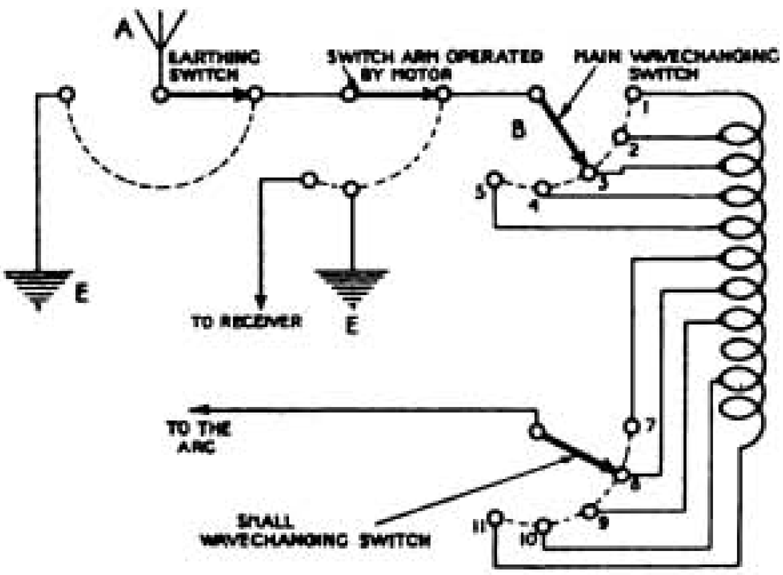

Fig. 7.—Wave-changing Switches.

On account of the fine sub-division of the aerial loading coil the resistance of the whole coil does not exceed 0·25 ohm. The inductance values when the small switch arm is on contact 11 (Fig. 7) are approximately as shown in the table.

Position of Switch Arm B.	Wavelength in Metres.	Inductance in Henries.
1 (whole coil)	23,460	0·003
2	21,240	0·0024
3	18,940	0·0018
4	16,420	0·0013
5	13,840	0·0009

For signalling purposes, at high speeds, the arrangements are briefly as follows—the first relay, operated by a Baudot telegraph relay, operates in its turn twenty-eight relays in two stages; these last operate seventy-eight signalling contactors arranged on a frame round the aerial loading coil. These contactors short circuit windings in series with one another, independent of but adjacent to the main coil, thus changing the effective inductance of the aerial circuit. The transmitting apparatus is controlled in Bordeaux by means of a Wheatstone transmitter with a Kleinschmidt perforator. The speed of signalling obtained up to the present has been fifty words per minute giving a total of 72,000 words per day. It is intended later to operate the station direct from Paris and in all probability high-frequency alternators of the Bethenod-Latour type will be installed.

The first tests of the station were made by the American Navy from August 21st to September 21st, 1920. When using the normal generator voltage the antenna current was found to exceed 500 amperes; it easily reached 600 amperes with a slight overload of the machines, and in all respects the whole of the installation operated in a satisfactory manner. Tests of long duration showed that the arcs are perfectly adapted to ensure a continuous traffic at high power. It is too early yet to give complete information on the commercial ranges which can be achieved by the Lafayette station but the reception tests which were carried out on the occasion of the testing of the station have yielded some interesting results. They were made by the most important American stations situated in various parts of the world—America, Hawaii, the Philippines, the Pacific Islands—and also by the French colonial stations. Most of the operators at these stations were only able to receive the long wavelength of 23,500 metres with experimental receivers and the majority of the tests were not picked up for a sufficient duration of time to enable satisfactory conclusions to be deduced. From these tests the following conclusions may, however, be drawn: firstly, that communication between France and America appears to be certain at all times and under all conditions; secondly, that for longer ranges it can be stated that at all points on the earth the Lafayette station can be heard every day, during the most favourable hours.

From measurements made at San Francisco it was found that the strength of signals received from Lafayette was from four to eight times the strength of the signals received from Nauen. Summarising then, it can be stated that from the commercial point of view the Lafayette station will be able to guarantee excellent communication at all times with the United States and practically always also with the French colonies.

In addition to the above advantages the station at Croix d'Hins will doubtless be of great scientific importance for the special study of high-power work and transmission problems as well as for meteorological and astronomical work such as the accurate determination of longitudes, while it will doubtless also serve to draw closer the ties of friendship between the two great Republics of France and America.

[See further notes on this station on p. 59.—ED.]

The Physical Society's Exhibition.

The eleventh annual exhibition of the Physical Society of London, and of the Optical Society was held at the Imperial College of Science and Technology, Imperial Institute Road, South Kensington, S.W., on January 5th and 6th, 1921. As is the usual custom of this exhibition, it was open in both the afternoons and evenings of the two days, and in addition to the exhibits, discourses were delivered on various subjects. Among the exhibits, were a number of instruments, and apparatus of wireless interest, including testing and measuring apparatus for high and low frequency currents. Of these exhibits, a few particulars of the most important and interesting are set out below :—

MESSRS. H. W. SULLIVAN's exhibits included the following :

C.W. Heterodyne Wavemeter.—A continuous-wave wavemeter with a range of from 600 to 6,000 metres which can be used also as a plain oscillation generator for use in the separate heterodyne method of C.W. reception.

The circuit used is shown in Fig. 1, the oscillatory circuit consisting of the variable air condenser C and the two variometers V_1V_2, the circuit being closed to high-frequency oscillations by the fixed capacity C_1 of a sufficiently large value not to appreciably affect its natural frequency.

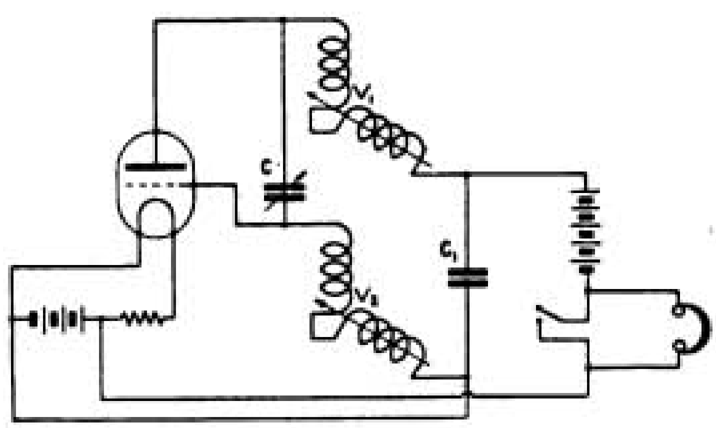

FIG. 1.

The variometers and the variable condenser are all simultaneously variable, one coil of each variometer being fixed to and rotated with the moving plate system of the condenser, and the other two coils secured to the fixed plate system. By this method a greater wavelength range is obtained in the one scale, with the added advantage of a straight line law connecting wavelength and angular movement of scale.

In order to open out the wavelength scale the range of the variable condenser is altered by a three position switch by connecting its two insulated sections either in series or in parallel or by using one section alone.

Single Valve Amplifying Receiver for extra wide wavelength range (600 to 20,000 metres).—The set, of which Fig. 2 is an exterior view, is completely self contained, the aerial and earth leads being brought direct to it. The only apparatus required external to the set are the 4-volt accumulators, 50-volt anode dry battery and a pair of high resistance telephones.

Single circuit tuning is employed, the inductance being a continuously variable multi-coil variometer, Fig. 3, in which an exceedingly high range of mutual inductance variation is obtained. The coils of the variometer are very flat and are embedded in insulating discs, one of which D_1, may be rotated between the other two D_2 and D_3. This arrangement gives an evenness of scale throughout the whole 180° of movement.

An inductance range of 3,500 to 50,000 microhenrys is obtained on the long wavelength scale, whilst a two position multi-functioning switch S alters the internal variometer connections to obtain a short wavelength inductance range of 200 to 3,500 microhenrys. An inductance ratio of 250 to 1 is thus obtained throughout the range of the instrument.

FIG. 2.—Single Valve Amplifying Receiver (*H. W. Sullivan*).

The variometer is used in conjunction with an adjustable bank of fixed condensers which may be placed either in series or in parallel with the variometer by means of a series-parallel switch giving the wavelength range stated above.

The variometer is also fitted with a set of reaction windings which are embedded in the disc D_4 and rotated relative to the main inductance on a spindle concentric with the spindle of the latter, the two operating handles H_1 and H_2 being conveniently placed one above the other.

The mutual inductance between the variometer coils and the reaction coils (the latter being also changed by the long-short wave switch S may be adjusted to such values as will produce self-oscillation of any frequency corresponding to wavelengths between 600 and 20,000 metres.

The whole of the moving system is supported in upper and lower bearings carried by a framework F of rigid construction, which also supports the fixed system. Connection is made to all moving units through contact rings and fingers C.

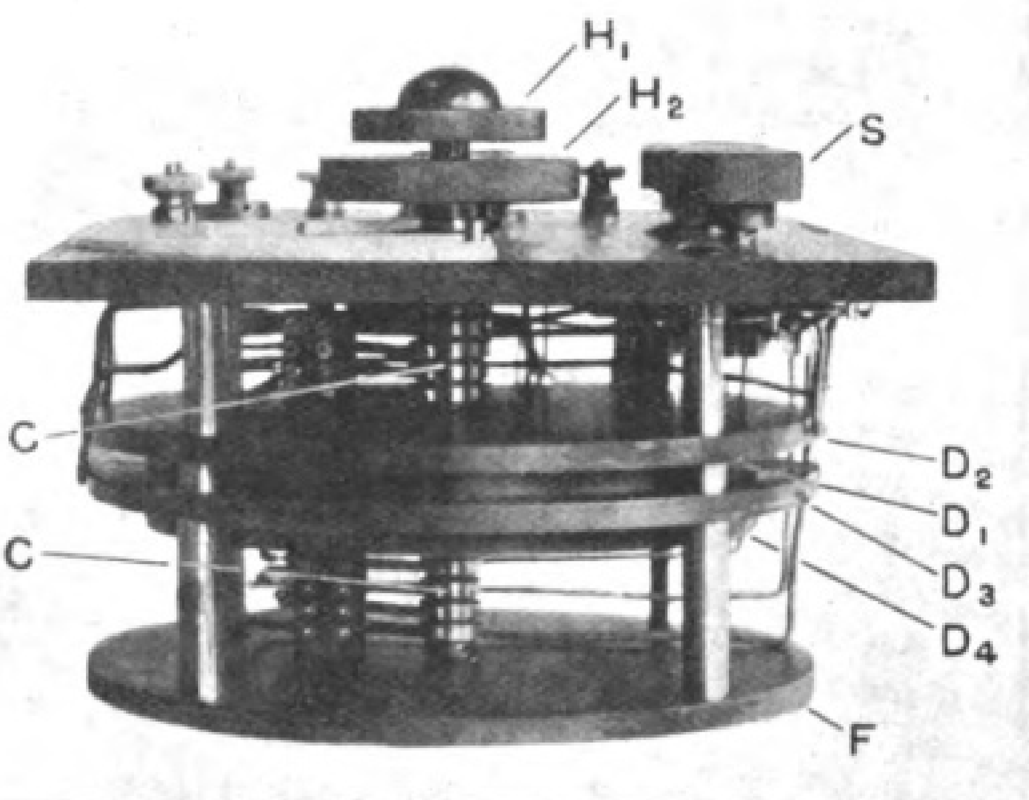

FIG. 3.—Long-range Variometer, Interior View (*H. W. Sullivan*).

Standard Experimental Valve Amplifying Receiver Panel.—On this panel a selected group of standard components has been arranged with a view to making possible the greatest number of variations of circuits using one, two, three, or more valves.

A Three Valve Amplifying Receiver having loose coupled tuning circuits, and reactance-capacity intervalve coupling.

Selenium Amplifier.—In this arrangement due to K. C. Cox a sectional selenium cell is acted upon by the light beam reflected from the receiving galvanometer, when the apparatus is employed for cable reception. The selenium sections are arranged as a series of bridge arms, and the received signals thus cause correspondingly large current changes in the selenium bridge circuit, in which circuit is placed the local receiving instrument or relay. By a suitable addition of other apparatus, this instrument could evidently be adapted to other uses, in which amplification of telegraphic signals is required.

Standard fixed and variable condensers, high frequency apparatus for laboratory measurements, etc., were also shown, THE ZENITH MANUFACTURING COMPANY showed a number of regulating resistances, potentiometers, etc., suitable for use in conjunction with wireless apparatus, as well as for other purposes.

THE DUBILIER CONDENSER COMPANY had on exhibition samples of various types of condensers suitable for wireless telegraphy and telephony, as well as for power-line protection and other purposes.

MESSRS. CREED & CO., LTD., exhibited their high speed receiving perforator and printer, and gave demonstrations of its application to the reception and recording of wireless messages. This apparatus has already been briefly described in these columns (see pp. 37–38, January, 1921, issue) where some samples of the tapes were also reproduced.

THE MARCONI-OSRAM VALVE CO., LTD., showed receiving, amplifying, and rectifying valves of the latest types, and in various sizes, including a number of valves with a new type of filament exhibited by the research laboratories of the General Electric Co., Ltd., London. The filament of these valves runs at a very much lower temperature than the ordinary tungsten filament in the types of valves in general use.

The advantages so gained are of considerable importance. In the first place the life of the valve is much longer since at the lower temperature there is little or no disintegration of the tungsten. Secondly, the watts required to heat the filament are reduced to about one-sixth of the usual values for filaments of the same size. The advantage does not end here, however, for the increased strength resulting from lower temperature permits the use of finer filaments, the watts for heating these being only about one-twentieth to one-fortieth of usual valves. Thus it is possible to work a six-valve amplifier with a current consumption of half an ampere from a single accumulator cell.

The vacuum in these valves is uniformly high and their characteristic curves are very similar to those of existing types for use in wireless telegraphy, but in one respect there is a marked improvement. Owing, apparently, to a change in the " contact potential " between the filament and grid there is a reduction (in the proportion of at least 10 to 1) in the current in the grid circuit when the grid is in conducting connection with the negative end of the filament. In consequence the application of a negative priming voltage to the grid to reduce the energy expenditure in the input circuit becomes in many cases no longer necessary.

With these valves the spontaneous " crackling " noises in sets of high amplifying power due to sudden changes in the internal action of the earlier valves of the cascade are absent, a result which with the ordinary tungsten filament can be achieved only by very careful selection of the filament metal.

The valves shown represented standardised types not isolated specimens; the work of developing the processes of preparation was carried out by Mr. M. Thompson of the laboratory staff.

(To be continued.)

Notes.

Personal.

The Liebman Memorial Prize has been awarded by the Institute of Radio Engineers to R. A. Weagant for his work on the elimination of the effects of atmospheric disturbances in radio communication. [1822]

The editor of the RADIO REVIEW, Professor G. W. O. Howe, is resigning his position at the City and Guilds Engineering College, South Kensington, on his appointment to the National Physical Laboratory, where he will take charge of the electrical standards and general electrical measurements, including wireless and high frequency work. [1929]

The death is announced of Dr. F. Dolezalek on December 10th at the age of forty-eight. In 1907 he succeeded Rubens as Professor of Physics at Berlin, where he afterwards founded and directed the Institute for Physical and Electrical Chemistry. [1877]

We regret to announce the death on December 13th last of Dr. Alexander Muirhead at the age of seventy-two. Dr. Muirhead, as is well known, was associated with Sir Oliver Lodge in the latter's early work in connection with wireless telegraphy. [1964]

Commercial.

A NEW WIRELESS STATION AT NORTHOLT.—We have received some interesting details of a new wireless station which is being erected by the Post Office at Northolt, which is quite close to London and lies half-way between Uxbridge and Harrow.

The aerial system will consist of a triangular network each side of which will be 650 feet in length, and the aerial will be supported by three Elwell wooden lattice towers each 446 feet in height. The earth system will consist of a network of copper strip connected to metal plates buried at the bottom of the excavations made to receive the stay wire anchorages and tower and building foundations. The transmitting equipment, both primary and secondary, will be Elwell-Poulsen arc generators fitted with remote control. It is interesting to note that alternative tenders were obtained for arcs, valves and alternators and it was decided to instal the arc immediately. In the near future a valve set employing the very latest practice in valves, viz., the high-power silica valve, will also be installed. And when this has been done comparative tests will be made to ascertain which system is the more economical and reliable in commercial operation.

The specification calls for a minimum output of 50 amperes in the aerial, and arrangements are being made for the emission of a single wave when transmitting, and the complete suppression of radiation when spacing, instead of the usual de-tuning.

We believe that this will be the first arc station of any size to operate commercially on this principle. It is unnecessary to state at length the many advantages gained by being able to stop radiating when spacing, such as the saving in power, and the freedom from jamming which will result. Although the output to the aerial is quite considerable, the station will be operated directly from the Central Telegraph Office, London, at speeds of about sixty words per minute, but provision has been made for the installation of high-speed signalling at more than 100 words per minute.

The whole of the wireless equipment and masts have been placed in the hands of Mr. C. F. Elwell, who is at present also completing the two imperial wireless stations at Oxford, and at Cairo.

The object of the new station is to give direct working to Central Europe, and the rates per word will be the same as the existing telegraph rates. The service should be vastly superior, however, as the use of lines passing through many different foreign countries will be eliminated. [1977]

A NEW VALVE COMPANY.—A new company has been formed under the name of the Mullard Radio Valve Co., Ltd., for the manufacture of radio valves and apparatus. The directors are Sir Ralph Ashton (chairman), B. Binyon of the Radio Communication Co., Ltd., C. F. Elwell, whose name is associated with the development of the Poulsen arc, and S. R. Mullard (Managing Director). Mr. Mullard's name first came before the public as the inventor of the "Pointolite" lamp, but to wireless men he is known chiefly as the inventor of the carbonised cellulose grid leak and anode resistance and as a maker of both small and large thermionic valves. [1922]

WIRELESS TELEPHONY AT AMSTERDAM EXCHANGE.—Communication between Amsterdam Telephone Exchange and the provincial exchanges is to be maintained by wireless telephony. [1926]

WIRELESS STATIONS IN MEXICO.—The Mexican Minister for Public Works has called for tenders for four wireless stations, two of which are to be situated at Manzanillo and Morelio Platz. The Mexican Government estimate amounts to three million dollars. [1927]

A NEW TRANSATLANTIC STATION.—It has been announced that a new transatlantic station is being erected by a French firm at Banjica near Belgrade. It is to operate on the Marconi system. [1979]

PUBLIC WIRELESS SERVICE TO FRANCE.—A new public telegraph service between England and France was opened on Saturday morning, January 8th, 1921. High-speed duplex wireless transmission is employed, and it is hoped that the additional means of communication between England and the Continent will afford considerable relief to the present congestion. The service will be conducted by Marconi's Wireless Telegraph Co., Ltd., and the Compagnie Générale de Télégraphie sans Fil, these companies operating under licences from the British and French Governments. The current telegraph rates between the two countries will apply. For this service the latest high-speed automatic apparatus such as was used so successfully between Geneva and London during the sitting of the Assembly of the League of Nations will be employed. [1914]

NEW BELGIAN WIRELESS STATION.—The *Libre Belgique* announces that the Department of Railways will shortly begin in Belgium the construction of a powerful wireless station which will be capable of transmitting messages to North and South America and to the Congo. [1915]

ANOTHER BIG WIRELESS STATION FOR FRANCE.—The foundation of the largest wireless station in the world was laid on Sunday, January 9th, at Saint Port near Melun, by M. Deschamps, Under-Secretary for the French Posts and Telegraphs. The work of construction will take at least two years. [1916]

The Union Government of South Africa has acquired the radio station at Windhuk which was erected by the Germans. It is to be re-equipped for communication with England *via* Cairo. [1723]

General.

At a joint meeting of the Institute of Radio Engineers, New York, and of the New York Electrical Society on November 10th last, Dr. E. F. W. Alexanderson outlined some of the constructional features of the high-power radio station which is to be built on Long Island by the Radio Corporation of America. Alexanderson high-frequency alternators are to be installed and in the discussion of the paper considerable interest was expressed in the multiple antenna arrangements which have been developed by Dr. Alexanderson. [1823]

A NEW WIRELESS JOURNAL.—We have received the first number of the *Journal of the Dutch Radio Society*. Its contents consist of a list of officers and members of the society and the paper by Dr. van der Pol on the amplitude of the oscillations in triode-generator circuits which was published in the November and December (1920) numbers of the RADIO REVIEW. [1947]

In connection with the air mail service between San Francisco, Salt Lake and Cheyenne, U.S.A., lamps have been fitted to the aeroplanes and connected to the radio apparatus so that the lamps light up when the planes are within a certain path about 200 feet wide. Approach to the destination is indicated by the flashing of the lamps. [1789]

Review of Radio Literature.

1. Abstracts of Articles and Patents.

Radio Stations and Installations (General and Descriptive Articles).

1423. **L. Chaulard.** The Lafayette Wireless Station at Croix d'Hins. (*Annales des Postes, Télégraphes et Téléphones*, 9, pp. 504—515, December, 1920.)
See pp. 85—93 in this issue for abstract.

1424. **Cabanne.** The Lafayette Radiotelegraph Station. (*Génie Civil*, 77, pp. 473—482, December 11th, 1920.)
See pp. 85—93 in this issue.

1425. The Lafayette Radiotelegraphic Station. (*Radioélectricité*, 1, pp. 78—81, July, 1920. *L'Elettrotecnica*, 7, pp. 567—568, November 5th, 1920—Abstract.)
See pp. 85—93 in this issue for abstract.

1426. **R. Roscher.** The High-power Radio Station at Kamina (Togo). (*Archiv für Post und Telegraphie*, pp. 241—266, August, 1920.)
See p. 68 in this issue for abstract.

1427. Marconi's Wireless Telephone. (*Scientific American*, 123, p. 207, August 28th, 1920.)
Gives details of a 15 kW apparatus.*

1428. Which System for Long-distance Communication? (*Radio Nieuws*, 3, pp. 219—223, August, 1920.)
A comparison of the various systems.

1429. **H. S. Pyle.** An Oriental Radio Set. (*Wireless Age*, 7, pp. 18—20, May, 1920.)
A description with illustrations is given of a radio installation on the Japanese vessel *Tosida Maru III*.

1430. Wireless Telegraphy in Submarines. (*Produccion*, 11, April 15th, 1920.)
A short account of work done in France and America on the installation of wireless receiving apparatus on submarines to enable reception and transmission to take place when submerged.†

1431. **G. W. O. Howe.** The Generation of Large Powers at Radio Frequencies. (*Chemical News*, 121, p. 63, August 6th, 1920.)
See RADIO REVIEW, 1, pp. 490—491, July, 1920.

1432. **F. H. Newman.** Thermionic Valve in Wireless Telegraphy. (*Beama Journal*, 7, p. 381, November, 1920.)
The uses of thermionic valve apparatus as detector, amplifier and oscillation generator are discussed.

Static or Transformer Frequency Raisers.

1433. **T. Kujirai.** Researches on Frequency Transformers. (*Journal of the College of Engineering*, Tokyo, 10, pp. 37—143, March 30th, 1920. *Journal of the Engineering Institute of Canada*, 3, Engineering Index p. 194, September, 1920—Abstract.)
The results of theoretical and experimental investigations on frequency changers are given. For a given flux density and current density the volt-ampere capacity of static frequency transformers is found to be a maximum when the copper space is equal to five-fourths of the iron space and under these conditions the maximum efficiency occurs when the iron loss per unit volume is equal to the copper loss per unit volume.

1434. **Marconi's Wireless Telegraph Company, Limited.** Frequency Changer. (*French Patent* 503084, November 15th, 1916. Published June 2nd, 1920.)
An alternator is connected to the primary of a closed core transformer so as to produce a

* See also RADIO REVIEW Abstracts Nos. 900 and 901, October, 1920.

† See also RADIO REVIEW Abstract No. 85, December, 1919.

rotating field and the magnetisation of the core is carried towards the saturation point. Secondaries which have a constant phase-difference are connected to the high-frequency mains, so as to establish a high-frequency current in them. For further particulars, see *British Patent* 14423/1915.

1435. **Compagnie Générale de Radio-Télégraphie.** Frequency Transformer. (*French Patent* 502202, May 8th, 1915. Published May 7th, 1920.)

A static frequency transformer has a number of shunt circuits which include inductances having different magnetic properties, acting on an unsaturated magnetic circuit which combines the fluxes produced by the currents in the shunts, whereby the resulting flux has a frequency which is a multiple of the primary frequency.

1436. **J. Zenneck.** A Contribution to the Theory of Magnetic Frequency Changers. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 468—491, December, 1920.)

A quantitative discussion of the well-known magnetic frequency doublers and triplers in which iron-cored one-to-one transformers, with (or without) supplementary D.C. excitation, are used. The relation $B = sH - s'H^3$ is assumed, where B is the magnetic induction, H the magnetic field and s and s' are constants.

A further assumption made is that the current harmonics are small compared to that of the fundamental. The derived formulæ are modified to allow for the effect of the hysteresis of the iron.

1437. **F. C. Ryan.** The Status of the Static Frequency Doubler in Radio Engineering Practice. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 509—524, December, 1920.)

Continuous wave generators are discussed under the following heads: (*a*) direct current arc oscillator, (*b*) power electron tube, (*c*) radio frequency alternators. The principles underlying the working of the Goldschmidt type of alternator, which is a combined generator and frequency-multiplying device, are investigated in detail. Mathematical expressions for the secondary voltages of the unloaded doubler of the polarised core type are derived, based on the empirical relation $B = A \tan^{-1} ax + Cx$ where B is the magnetic induction, x ampere-turns per centimetre length of magnetic circuit and A, C and a constants.

Alternators of the type considered (*i.e.*, medium frequency) can be operated in parallel, while if increased frequency is required two doubling stages may be introduced. Small frequency changes are obtainable through variation of alternator speed and larger steps by more or fewer doubling stages. Various methods of modulating the radio frequency energy are also discussed.

Thermionic Valves, Theory, etc.

1438. **Research Staff of the General Electric Company, London.** The Disappearance of Gas in the Electric Discharge. (*Philosophical Magazine*, 40, pp. 585—611, November, 1920.)

This research conducted by N. R. Campbell and J. W. Ryde is an attempt to determine the cause of the disappearance of gas under the electric discharge at low pressure, the discharge being in the form of electronic emission from an incandescent tungsten filament. Preliminary observations showed that the disappearance of gas was closely connected with the appearance of the glow in the containing vessel. The electrical conditions in which the glow appears are described briefly. It usually appears sharply at a definite P.D. between the electrodes called the glow potential. Observations are described on the relations between glow potential and (1) thermionic emission; (2) the pressure of the gas; (3) the nature of the gas; and (4) the form of the electrodes. The importance of the glow potential for determining the rate of disappearance of gas is pointed out.

1439. **F. Horton and Miss D. Bailey.** The Effect of a Trace of Impurity on the Measurement of the Ionisation Velocity for Electrons in Helium. (*Philosophical Magazine*, 40, pp. 440—450, October, 1920.)

1440. **G. Stead and B. S. Gossling.** On the Relative Ionisation Potentials of Gases as observed in Thermionic Valves. (*Philosophical Magazine*, 40, pp. 413—425, October, 1920.)

For determining potential differences necessary to cause positive ions to be produced in soft thermionic valves, the plate current—plate voltage characteristics are plotted. The occurrence of ionisation is indicated by a departure from the three-halves law for these characteristics. The deviations are most easily shown by plotting the characteristics on logarithmic co-ordinates. The method has been applied to six different gases giving the following results for the ionisation potentials in volts :—Mercury vapour 10·8; Argon 12·5; Hydrogen 15; Carbon monoxide 15; Nitrogen 17·2 and Helium 20·8. Reference is also made to the method described elsewhere in this REVIEW,* with which similar values were obtained. (See also pp. 75—77 in this issue.)

1441. **C. J. Fitch.** The Vacuum Tube as a Frequency Multiplier. (*Wireless Age*, 7, pp. 29—30, March, 1920.)
An arrangement is described for frequency trebling using three-electrode valves on the lower bend on their characteristics.

Radio Receiving Apparatus.

1442. **Société des Établissements Gaumont.** Receiving Apparatus. (*French Patent* 503240, March 8th, 1917. Published June 5th, 1920.)
The invention relates to an apparatus for recording the variations produced in an electric circuit. The apparatus comprises an electromagnet connected in the circuit in the field of which is disposed a vibrating plate carrying a pen or stylo which records the vibrations of the plate by impressing them more or less deeply on a suitable surface.

1443. New Development in Wireless Telegraphy. (*Elektrotechnische Zeitschrift*, 41, p. 898, November 11th, 1920.)
A vague reference to a Danish invention of **Rahbek** and **Johnsen** being developed by **Huth & Co.** of Berlin, of which further particulars are promised at a future date. It is apparently a relay depending on the variable mechanical force between a rotating cylinder of lime or stone and a conductor, when current passes between them.

1444. **L. B. Salt.** A Sectional Receiving Set. (*Wireless Age*, 7, pp. 38—41, June, 1920.)
Illustrations are given of parts of the set.

1445. **F. R. Pray.** A Sensitive Portable Receptor. (*Wireless Age*, 7, pp. 26—27, July, 1920.)
An illustrated description.

1446. **N. A. Nyquist.** Portable Receiver. (*Wireless Age*, 7, pp. 27—29, July, 1920.)
An illustrated description.

1447. **C. T. Jacobs.** A Universal Range Portable Receiver. (*Wireless Age*, 7, pp. 31—36, July, 1920.)
Constructional details with working drawings are given.

1448. **R. J. McAusland.** What the Amateur can Learn from the Navy. (*Wireless Age*, 7, pp. 13—15, June, 1920.)
The radio receiver type C.M.294C built by the American Marconi Company for the U.S. Navy is described and illustrated together with wiring diagrams.

1449. **R. A. Weagant.** Improved Connections for Two Element Vacuum Tubes. (*Wireless Age*, 8, p. 21, October, 1920.)
In the two-electrode valve receiver described in this article the filament connection is made to a special tapping brought out from the centre of the filament. It is claimed that this arrangement gives greatly increased strength of signals.

1450. **R. Evans.** Wireless Reception with the Electronic Valve. (*Sea, Land and Air*, 3, pp. 478—482, October, 1920.)
Deals briefly with various forms of valve receiving circuits.

1451. Regenerative Receiver and Vacuum Tube Units. (*Electrical World*, 76, p. 1001, November 13th, 1920.)
A short note illustrating a regenerative receiver type C.R.34 manufactured by A. H. Grebe & Co., New York.

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* RADIO REVIEW, 1, pp. 525—531, August, 1920.

1452. **E. T. Jones.** Audion Circuits. (*Wireless Age*, 8, p. 27, October, 1920.)
An arrangement is described by means of which it is possible to rapidly change over a given receiving circuit with single valve to operate in a number of different ways, as detector, amplifier, or regenerative receiver.

1453. **R. N. Jones.** Direct Coupled Radio Receiving Sets. (*Wireless Age*, 8, p. 28, October, 1920.)
A number of arrangements of a single valve direct-coupled receiver are described.

1454. **J. C. Morris.** A Successful Undamped Wave Circuit. (*Wireless Age*, 7, pp. 27—28, March, 1920.)
A valve receiver with regenerative coupling is described.

1455. **A. B. Ballhatchet.** Some Valve Circuits. (*Model Engineer*, 43, pp. 323—327, October 21st, 1920.)

1456. **P. Maurer.** The Reception of Undamped Waves. (*L'Électricien*, 51, pp. 413—415, October 1st, 1920.)
A general article including some constructional details.

Amplifiers.

1457. **M. Latour.** Valve Amplifier. (*French Patent* 503941, December 12th, 1917. Published June 21st, 1920.)
The invention relates to amplifiers of the multi-stage kind and more particularly for low frequency. Two arrangements of valve tubes are shown.

1458. **L. N. Brillouin.** Receiving Apparatus. (*French Patent* 503766, October 8th, 1917. Published June 17th, 1920.)
The invention relates to telephone receiving apparatus for wireless telegraphy employing a series of thermionic valves. For further particulars see *British Patent* 131055.*

1459. **Dr. Kooman's** Note Amplifier. (*Radio Nieuws*, 3, pp. 231—239, August, 1920.)

1460. **H. W. Lewis.** Regenerative Receiver *versus* Cascade Amplifier. (*Wireless Age*, 7, pp. 20—22, February, 1920.)
A critical discussion of the relative merits of these two receivers. A conclusion is reached in favour of the cascade amplifier particularly for short wavelengths.

1461. **A. H. Kluze.** A Two-stage Amplifier Cabinet. (*Wireless Age*, 7, pp. 28—29, June, 1920.)
An inductively coupled amplifier is described.

1462. **L. N. Brillouin.** Receiving Apparatus. (*French Patent* 503765, October 8th, 1917. Published June 17th, 1920.)
The invention relates to telephone receiving apparatus for wireless telegraphy employing a series of thermionic valves. For further particulars see *British Patent* 131054.*

Subsidiary Radio Apparatus (including Protective Apparatus, etc.).

1463. **M. Latour.** Valve Amplifier. (*French Patent* 502360, December 12th, 1918. Published May 12th, 1920.)
The invention relates to the excitation of vacuum tube amplifiers by means of a continuous current machine having two windings of high and low voltage respectively.

1464. **J. Bethenod.** Aircraft Wireless Apparatus. (*French Patent* 502670, December 18th, 1915. Published May 22nd, 1920.)
An installation for flying machines has the parts enclosed in a casing of a shape having a minimum resistance to flight through the air. The parts comprise an alternating current magneto and a rotating spark gap, driven by a propeller.

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* RADIO REVIEW Abstract No. 305, April, 1920.

1465. **F. Brocq and H. Olivier.** Aircraft Wireless Apparatus. (*French Patent* 502678, January 10th, 1916. Published May 22nd, 1920.)

The specification describes an alternating current generator for use in wireless telegraphy on a flying machine. The armature is fixed and carries polar projections and magnetising windings. The inductor is formed of permanent magnets mounted alternately of opposite polarity on the hub of the motor spindle. A form of spark gap is also described.

1466. **O. C. Cote.** A Remote Control Antenna Switch. (*Wireless Age*, 7, pp. 24—26, April, 1920.)

Constructional details with dimensioned working drawings of the switch are given.

1467. **M. P. Koopman.** A 1 kW Antenna Switch. (*Wireless Age*, 7, pp. 26—27, April, 1920.)

Constructional details are given with this article.

1468. **G. W. Benson.** An Original Antenna Switch. (*Wireless Age*, 7, pp. 23—24, April, 1920.)

Constructional details are given.

1469. **F. McGuist.** An Antenna Switch. (*Wireless Age*, 7, p. 28, May, 1920.)

1470. **J. Bethenod and E. Girardeau.** Transmitting and Receiving Apparatus. (*French Patent* 502280, June 3rd, 1915. Published May 8th, 1920.)

The invention relates to radiotelegraphic stations in which the antenna is excited indirectly, and it has for its object to permit the connection of the receiving circuit or the transmitting circuit by the operation of a single device, while at the same time obtaining an automatic protection against incorrect movements. For this purpose, there is arranged in the excitation circuit of the alternator a switch which varies the excitation of the alternator when the receiving or transmitting apparatus is connected to the antenna.

1471. **M. Wien.** Telephone Receiver and Ear Sensibility. (*Annalen der Physik*, 62, pp. 759—762, August 20th, 1920.)

W. Hahnemann and H. Hecht have found that the minimum audible power at a frequency of 1,000 is $1{\cdot}9.10^{-17}$ watts whereas Wien had found 16.10^{-19} watts. The former criticise the latter's experimental arrangements, but Wien points out that whereas they take the whole power striking the ear (11 cm^2), he took that striking the drum only ($\frac{1}{3}$ cm^2), this brings the difference within the range of experimental error.

1472. A High Voltage Mercury Vapour Rectifier. (*L'Elettrotecnica*, 7, pp. 454—457, September 5th, 1920; pp. 498—502, September 25th, 1920, and pp. 541—546, October 25th, 1920.)

A description of various types of mercury vapour rectifying apparatus and of its mode of action.

1473. **J. A. Weaver.** Combined Kick-back Preventer and Switch Panel for Experimental Radio Stations. (*Wireless Age*, 7, pp. 18—20, February, 1920.)

A switchboard panel is described with radio frequency protection for the supply circuit in the form of a 5,000 ohm resistance joined across the line.

1474. **T. Spooner.** High Frequency Iron Losses. (*Journal of the American Institute of Electrical Engineers*, 39, p. 808, September, 1920. *Electrical World*, 76, p. 745, October 9th, 1920—Abstract. *Revue de l'Ingénieur et Index Technique*, 27, p. 255, November, 1920—Abstract. *Science Abstracts*, 23B, p. 474, Abstract No. 894, October 31st, 1920—Abstract.)

1475. **C. Beaudouin.** Continuous Wave Transmitter. (*French Patent* 503937, December 5th, 1917. Published June 21st, 1920.)

A make and break apparatus for the production of electrical breaks of musical frequency, applicable particularly to wireless telegraphy, is characterised by the fact that the two circuits of the vibrator are electrically completely independent of one another, and that the breaks are produced by a vibrating plate which is vibrated continuously by means of an electromagnet.

Wave Transmission (Theory, Range Tests, Upper Atmosphere, etc.).

1476. **J. Wallot.** The Definition of Wave Velocity. (*Annalen der Physik*, 62, pp. 569—572, July 16th, 1920. *Science Abstracts*, 23B, p. 656, Abstract No. 1644, December 30th, 1920—Abstract.)

A discussion of individual wave velocity, group velocity and phase velocity.

1477. **A. Sommerfeld.** The Transmission of Waves in Radiotelegraphy. (*Annalen der Physik*, 62, pp. 95—96, May 20th, 1920.) And **H. Weyl.** (*Loc. cit.*, 62, pp. 482—484, July 8th, 1920.)

A discussion of Weyl's criticism of his division of the transmitted energy into space waves and surface waves, and Weyl's reply thereto.

1478. **J. J. Thomson.** On some Optical Effects including Refraction and Rotation of the Plane of Polarisation due to the Scattering of Light by Electrons. (*Philosophical Magazine*, 40, pp. 713—734, December, 1920.)

A section is included in this article devoted to the mathematical expressions for the rotation of the plane of polarisation of an electromagnetic wave by electrons under the influence of a magnetic field.*

1479. **G. Vallauri.** Measurement of Radiation of Radiotelegraphic Aerials. (See pp. 77—85 in this issue.)

1480. **T. L. Eckersley.** The Effect of the Heaviside Layer on the Apparent Direction of Electromagnetic Waves. (See pp. 60—65 in this issue.)

Atmospherics.

1481. **C. N. Keyser.** Detection of Storms and their Travel by Radio Equipment. (*Monthly Weather Review*, 48, pp. 263—264, May, 1920.)

Indicates the importance of observations of atmospherics for meteorological forecasting and points to the need for more accurate directional measurements of storms.

1482. **Marconi's Wireless Telegraph Company, Limited.** Eliminating Atmospheric Disturbances. (*French Patent* 503241, March 9th, 1917. Published June 5th, 1920.)

In a wireless system in which a vacuum tube operates as a current-limiting device, the action of atmospherics on the receiver is eliminated by applying a variable potential difference between the cathode and the grid of the valve. In one example, the aerial is coupled to the receiver through an inductance shunted by a capacity and connected across the anode and the grid of the valve. The potential-difference between the grid and the cathode of the valve is varied by a potentiometer. For further particulars of the invention, see *British Patent* 102822.

1483. **Marconi Wireless Telegraph Company of America.** Eliminating Atmospheric Disturbances. (*French Patent* 503024, August 25th, 1919. Published June 1st, 1920.)

The specification describes a method of reducing static interference. See also *British Patent* 138588.†

Interference and Interference Prevention.

1484. **J. Bethenod and E. Girardeau.** Transmitter. (*French Patent* 502721, February 12th, 1916. Published May 25th, 1920. *Annales des Postes, Télégraphes et Téléphones*, 9, p. 483, September, 1920—Abstract.)

This specification describes means for mixing up or jambing radio communications of neighbouring stations. The length of the emitted wave and the speed of emission is varied simultaneously. The arrangement comprises wave generating apparatus and automatic controlling means to obtain a continuous variation in the wavelength, comprising inductances

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* Compare address by Dr. W. H. Eccles on p. 35 of the January, 1921, issue.

† RADIO REVIEW Abstract No. 997, October, 1920.

and a switch for connecting the varying inductances in circuit, the switch acting at the same time on the spark gap apparatus.

1485. Some Results obtained by the Use of Filters. (*Annales des Postes, Télégraphes et Téléphones*, 9, pp. 343—346, June, 1920.)
An oscillographic investigation.

1486. **O. Scheller and C. Lorenz.** Wireless Receiving Circuit. (*German Patent* 298475, September 22nd, 1914. Patent granted October 9th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 154, August, 1920—Abstract.)
A circuit for the prevention of interference in which two or several circuits are so coupled that for long wave reception the efficient coupling for short waves is looser while for short wave reception the effective coupling for higher wavelengths is less effective.

1487. **H. J. J. M. R. de Bellescize.** Receiving Apparatus. (*French Patent* 501196, November 25th, 1918. Published April 6th, 1920.)
To increase the ease of selection the receiving circuit including the antennæ is enclosed in a Faraday cage forming an imperfect screen.*

1488. **H. W. Nicholls.** A Secret Radiophone. (*Wireless Age*, 7, pp. 23—24, March, 1920.)
In order to render the telephonic message unintelligible during its transmission between the two radio stations the modulating currents are caused to affect a telegraphone arrangement from which they are passed to the modulating valve and amplifying arrangement of the radio transmitter. The modulating impulses are stored up in the telegraphone wire and reproduced from that by means of another magnet which is mounted upon a cam mechanism so that it is in continuous motion relative to the recording magnet. The impulses picked up by this electromagnet pass from it to the modulating valve so that the waves radiated are modulated by the speech currents distorted by the moving magnet. At the receiver a similar telegraphone is employed with the recording magnet moved by the cam mechanism in synchronism with the magnet at the transmitting station. The received impulses may thus be restored to their original form before their reception in the telephones.

Duplex and Multiplex Radio Communication.

1489. **F. M. Ryan, J. R. Tolmie and R. O. Bach.** Multiplex Radiotelegraphy and Telephony. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 451—467, December, 1920.)
A critical discussion of the various systems of multiplex working seems to show that the most simple and practical method is that in which several radio frequencies are employed, selectivity being obtained by radio frequency tuning. In order to use the same antenna circuit in such a case it is necessary to use certain types of impedance networks in series with the antenna so that the reactance of the latter may be zero for the particular frequencies used. Fig. 1 shows the simplest application of this method, the antenna and loop circuits being coupled by means of the common inductance L_1'. The two radio frequency sources are loosely coupled to the antenna by means of the coils P_1 and P_2.

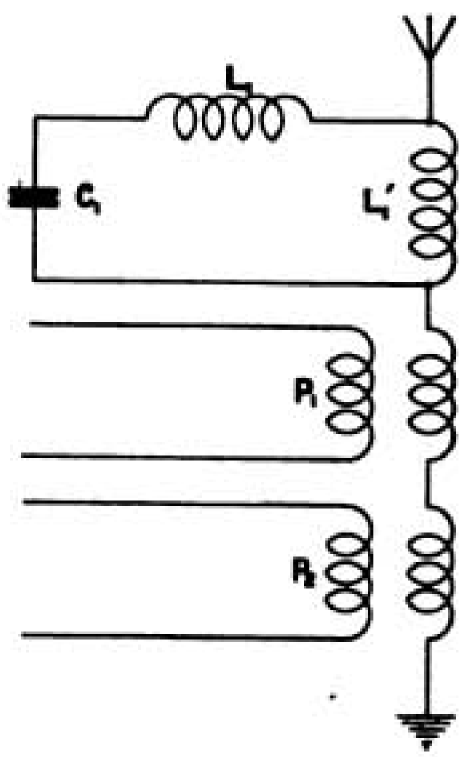

FIG. 1.

Tests of the practicability of such a method have been carried out over a distance of five miles, wavelengths of 1,890 metres and 2,100 metres being used. The Heising system of modulation (" constant-current " or " choke-control ") was employed in the transmitter, while the receiving antenna was of the same type as that at the sending station. Practically perfect separation of communication was possible so long as the frequency difference was greater than 15,000 in the case of telephony. For satisfactory telegraphy this frequency difference could be much reduced.
By increasing the number of loops (L_1C_1) it was found possible to carry out quintuplex radiotelephony and telegraphy over the same distance.

* Compare RADIO REVIEW Abstract No. 310, April, 1920.

A mathematical investigation of the antenna system possessing zero reactance for several frequencies pointed to results in good agreement with the experimental values.

1490. Duplex Wireless System. (*Wireless Age*, 7, pp. 21—23, January, 1920. *Science Abstracts*, 23B, pp. 279—280, Abstract No. 550, May 31st, 1920.)

An abstract, with circuit diagram, of a patent by **J. Mills** and **J. R. Carson**. The aerial system is given three degrees of freedom by connecting it to earth through three independent branches, one of which is tuned to the transmitting frequency, the second to the receiving frequency and a third to a frequency differing from both the transmission and reception branches. Rejector circuits are included in each of these branches, the third branch having two rejector circuits tuned respectively to the transmitting and receiving wavelengths. The second and third branches are connected to amplifiers and detecting valves with a common telephone receiver to which they are joined in opposition. A current at the transmitting frequency will therefore flow through each of these branches but their effects will be neutralised in the receiving telephones leaving only the signal from the distant station which affects one branch only. A similar reason holds as regards the reduction of interference from atmospherics when using this circuit.

High Frequency Circuits (Theory and Measurements).

1491. **A. Press.** Theory of Antenna Radiation. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 525—540, December, 1920.)

A mathematical discussion of the radiation from a finite vertical grounded antenna with a flat earth which differs from previous analyses in that the condition of the substantially sinusoidal distribution of voltage and current along the antenna is included. The derived expression for the vertical component of current density I at the receiving end is found to be of the form

$$I = \frac{a}{\sqrt{r}} \cdot \epsilon^{-\beta(r - \gamma)} \cdot \left(\frac{1}{r} - \delta\right)$$

where r is the distance between the stations and a, β, γ and δ are constants. This formula is in greater conformity with the expression suggested previously by Eccles than with the Austin-Cohen formula. The quantity $\left(\frac{1}{r} - \delta\right)$ is also suggestive of the Cohen factor $(1 + Ar)$ which was suggested to account for dispersion and diffraction.

The formulæ can be applied to the case of the horizontal antenna by considering the latter made up of two vertical antennæ combined with an image of the whole below the surface of the earth. In such a case it may be shown that "fading" of signals as a function of wave-length changes can be explained in terms of nodal spacings.

1492. **C. Breitfeld.** Skin Effect on Round Wires. (*Elektrotechnik und Machinenbau*, 38, pp. 537—543, November, 1920.)

A mathematical paper based on the assumption that Kelvin's results are not applicable at very high frequencies because of his neglect of the specific inductive capacity of copper, which the author assumes to be 9×10^{11} and thus obtains a high frequency resistance which does not increase indefinitely with increasing frequency.

1493. **R. N. Turner.** Electrostatic Coupling. (*Wireless Age*, 7, pp. 37—38, March, 1920.)

A receiving circuit is described using two variable condensers to provide an electrostatic coupling between the aerial and secondary circuits.

1494. **O. C. Roos.** An Impedance Curio. (*Wireless Age*, 7, pp. 26—29, August, 1920.)

This article discusses the question of reactive shunts.

1495. **W. Burstyn.** Coupling Phenomena with Undamped Oscillations. (*Elektrotechnische Zeitschrift*, 41, pp. 951—954, December 2nd, 1920.)

It is shown that inductive coupling can always be replaced by a branched circuit. An oscillatory circuit is first considered as coupled with an A.C. generator and then with an oscillatory circuit containing an A.C. generator, the apparent resistance being calculated as a function of the frequency. The case is also considered when the source is self-controlled as in a valve or arc and the phenomenon of the sudden frequency change or discontinuous resonance curve is explained.

1496. **A. Tobler.** The Use of a Valve Oscillator for the Measurement of Inductance and Capacity at the General Post Office, London. (*Journal Télégraphique*, 44, pp. 117—123, August 25th, 1920. *Science Abstracts*, 23B, p. 571, Abstract No. 1088, December 30th, 1920—Abstract.)

The application of a valve oscillating at an acoustic frequency to Wheatstone bridge measurements is described together with a rectifying arrangement for obtaining the plate voltages from an A.C. source.

1497. **C. J. Fitch.** Honeycomb Inductance Coil Mountings. (*Wireless Age*, 7, pp. 39—40, September, 1920.)

1498. **C. J. Fitch.** Wind your own Honeycomb Coils. (*Wireless Age*, 7, p. 25, June, 1920.)

1499. **M. K. Akers.** Dimensions of Inductance Coils. (*Wireless Age*, 8, pp. 20—21, October, 1920.)

The author discusses the difficulties of the design of a coil to have a given inductance. Using Lorenz's formula for calculating inductance, tables are worked out to assist in the design of coils. These tables give suitable alternative dimensions of length and diameter for different gauges of wire to give coils of various inductances.

1500. **G. de P. Foglietta.** Resistances and Inductances. (*French Patent* 504070, September 19th, 1919. Published June 24th, 1920. *British Patent* 151117, July 3rd, 1919. Patent accepted September 23rd, 1920.)

The sliding contact of a resistance or inductance for use in wireless telegraphy and wound in the form of a cylindrical coil has two curved resilient arms which bear against the wire.

1501. **T. W. Benson.** Variometers and their Construction. (*Wireless Age*, 7, pp. 23—24, February, 1920.)

An illustrated article giving constructional details.

1502. **C. Beaudouin.** Condenser. (*French Patent* 502345, November 20th, 1917., Published May 11th, 1920.)

The specification describes an electric air condenser comprising a pile of rigid laminæ of the same thickness, and of semi-circular shape, separated by carefully measured rings of the same thickness. A second similar pile of laminæ is arranged to project between the plates of the first mentioned pile, so as to vary the capacity, when one set of plates is rotated in relation to the other.

1503. **R. J. Fitzgerald.** A New Variable Condenser. (*Wireless Age*, 7, p. 19, June, 1920.)

In the vane type variable condenser described each plate is provided with enamel insulation to avoid the necessity of insulating plates between the fixed and moving vanes.

1504. **L. Bartholomew.** Further Data on Oil Dielectric Condensers. (*Wireless Age*, 8, p. 29, October, 1920.)

1505. A New Variable Condenser. (*Scientific American*, 123, p. 384, October 9th, 1920.)

An illustrated description.

1506. **M. Latour.** Condenser. (*French Patent* 493886, September 5th, 1917. Published August 23rd, 1919.)

The invention consists of a condenser of small dimensions with a shunt resistance arranged across its terminals for use in connection with valve apparatus.

1507. **E. G. Underwood.** Construction of Variable Condensers. (*Wireless Age*, 7, pp. 26—28, February, 1920.)
An illustrated article giving dimensional details.

1508. **E. Lübcke.** The Use of Interrupted Low Frequency A.C. for Telephonic Measurements. (*Zeitschrift für technische Physik*, 1, pp. 227—230, October, 1920.)
Instead of attempting to listen to the fifty-cycle telephone current, a buzzer is introduced giving an interruption of say 500 to 1,000 per second. The questions of tuning and amplification in such cases are discussed and experimental results given.

1509. **R. W. Goddard.** Heterodyne Wavemeter. (*Wireless Age*, 7, pp. 15—17, February, 1920.)
Constructional details and dimensions of a portable heterodyne wavemeter.

1510. **E. Singer.** An Efficient Wavemeter. (*Wireless Age*, 7, p. 29, September, 1920.)
A description is given of the method of constructing a simple form of wavemeter.

1511. **T. W. Benson.** Decrement and Tuning. (*Wireless Age*, 7, pp. 41—42, March, 1920.)
Simple methods of measuring the decrement of radio circuits are described.

1512. **E. P. Hurley.** A Simple Wavemeter. (*Wireless Age*, 7, pp. 36—38, July, 1920.)

1513. **A. H. Rice.** Construction of a Simple Wavemeter. (*Wireless Age*, 7, p. 24, June, 1920.)

1514. **F. C. Bockman.** The Design and Construction of a Simple Wavemeter—Range 150—300 Metres. (*Wireless Age*, 7, pp. 29—32, June, 1920.)

1515. **O. C. Cote.** A Simple Wavemeter. (*Wireless Age*, 7, pp. 32—34, June, 1920.)
Dimensions are given with an illustration of the completed instrument.

1516. **E. S. Herrick.** The Design and Construction of a Simple Wavemeter. (*Wireless Age*, 7, pp. 34—36, June, 1920.)

1517. **O. C. Roos.** Some Electrical Guides for Wavemeter Designs. (*Wireless Age*, 7, pp. 17—22, September, 1920. *Science Abstracts*, 23B, p. 581, Abstract No. 1111, December 30th, 1920—Abstract.)
The general requirements of a wavemeter are compared with those of a receiver circuit and the general design relations for the coil and condenser worked out. Some details—such as the unilateral connection of the detector, anti-capacity switches, low-capacity coils and the use of special windings are also discussed.

1518. **Trautwein.** The Electron Tube as a Measuring Instrument. (*Telegraphen- und Fernsprech-Technik*, 9, pp. 101—104, September; pp. 119—123, October, 1920.)
A discussion of the application of the triode to various electrical measurements, *e.g.*, voltmeter, form-factor meter, peak voltmeter. The accuracy obtainable is discussed and the insertion of suitable potentiometers and resistances considered with a view to improving this accuracy by modifying the characteristics.

Radio Direction Finding.

1519. **M. Dieckmann.** Wireless Telegraphy for Position Finding in Aeroplanes. (*Luftfahrt*, 26, pp. 57—59, April 1st, 1920. *Journal of the Engineering Institute of Canada*, 3, Engineering Index p. 221, October, 1920—Abstract.)

1520. **R. Mesny.** Radio Direction Changes and Variations of Audibility. (*Technical Review*, 7, p. 222, November 16th, 1920.)
See RADIO REVIEW, 1, pp. 532—540, August, 1920; pp. 591—597, September, 1920, for original paper.

1521. **L. Pungs.** Directive Wireless Telegraphy in the German Navy. (*Elektrotechnische Zeitschrift*, 41, p. 922, November 18th, 1920.)
An abstract of a general descriptive paper read before the telegraph section of the Elektrotechnischer Verein, Berlin. Some discussion by **Falkenthal** is also reported.

1522. **L. W. van Glyck.** An Indoor Loop Antenna. (*Wireless Age*, 7, p. 36, February, 1920.)
An illustrated article giving constructional details.

High Frequency Wire Telegraphy and Telephony.

1523. **E. Fischer.** High Frequency Telephony over the Wires of a Power-distributing System. (*Elektrotechnische Zeitschrift*, 41, p. 1021, December 16th, 1920.)

Referring to an article by Jewecke (see RADIO REVIEW Abstract No. 1325, December, 1920) the writer states that he carried out similar experiments in wireless telegraphy during the war. Particulars are given but the experiments did not lead to a practical application.

1524. **K. W. Wagner.** Multiplex High Frequency Wire Telephony and Telegraphy. (*Elektrotechnische Zeitschrift*, 41, pp. 1025—1027, December 23rd, 1920.)

A paper describing the German developments which was read at the annual meeting of the Verband Deutscher Elektrotechniker at Hanover on September 25th, 1920. See also RADIO REVIEW, 1, pp. 715—716, November, 1920, and also Abstract No. 1416, January, 1921.

Miscellaneous Methods of Communication.

1525. **Arendt.** Overhearing, its Prevention, and Earth Telegraphy. (*Telegraphen- und Fernsprech-Technik*, 9, p. 141, November, 1920. *Elektrotechnische Zeitschrift*, 41, p. 1040, December 23rd, 1920—Abstract.)

A description of the German systems used during the war, one of which is, as the author remarks, practically the same as the Fullerphone.

1526. Light Telephony. (*Scientific American*, 123, p. 402, October 16th, 1920.)

Brief reference to a German method of light telephony developed during the war.

1527. **E. Devaux.** The Guiding of Ships by Wireless. (*L'Électricité*, 2, pp. 1—2, September 15th, 1920.)

This article makes reference to some experiments on the control of ships by wireless signals and describes briefly some early experiments made by the writer about 1906 in which some very good results were obtained. The special feature of the arrangement appears to have been a selector mechanism controlled by the incoming signals by means of which any one of twelve possible orders could be transmitted to the ship.

1528. **H. V. Hayes.** Submarine Signalling. (*Engineer*, 129, pp. 491—493, May 14th, 1920. *Science Abstracts*, 23B, p. 395, Abstract No. 758, August 31st, 1920. *Technical Review*, 6, p. 589, July 6th, 1920—Abstract. *Electrical World*, 76, p. 136, July 17th, 1920—Abstract.)

A summary of various methods with constructional details of the Fessenden oscillator and of various microphonic arrangements.

1529. **G. Gaulois.** New York's Radio Pilot Cable. (*Scientific American*, 123, pp. 195 and 210, August 28th, 1920. Also *Wireless Age*, 8, p. 8, October, 1920. See also *Scientific American*, 123, p. 423, October 23rd, 1920.)

Some details are given with a map of the arrangements of a recently installed leader cable in New York Harbour. The arrangement of receiving coils with valve amplifier is given with some particulars as to the constructional details of the cable and its anchorages.

In the third of the articles referred to above reference is made to a recent test of the cable in which a destroyer was successfully piloted into the harbour by its use. An illustration of the installation on the vessel is given.

Traffic Particulars (Transmission Programmes, etc.).

1530. The Meteorological Service. (*Produccion*, 11, September 15th, 1920.)

A description of the service of wireless weather reports inaugurated in Spain on March 1st, 1920.

1531. Radio Message Circles the Earth. (*Wireless Age*, 8, p. 9, October, 1920.)

The text of the first message sent out from the Lafayette Station (Bordeaux) is given together with the reply from **Mr. Daniels**, Secretary of the U.S. Navy.

1532. Wide Expansion of Transocean Wireless. (*Wireless Age*, 8, pp. 7—8, October, 1920.)

Reference is made to agreements arranged by the **Radio Corporation of America** with other countries for long distance and high speed radio traffic.

Radio Legislation, etc.

1533. Big Companies agree on Expansion of Radio. (*Wireless Age*, 8, p. 8, October, 1920.)
Arrangements are referred to between the **American Telephone and Telegraph Company**, the **General Electric Company of America**, and the **Radio Corporation of America** for the combined use of their inventions and patents in the development of radio work. This exchange of patent licences has been encouraged by the U.S. Navy as leading in particular to a better development of long distance communications between shore and ships.

1534. Legal Restrictions and the Amateur. (*L'Elettrotecnica*, 7, p. 546, October 25th, 1920.)
A letter advocating the removal of legislation needlessly restricting the amateur in wireless telegraphy and pointing out the advantage which America gains from the work of the great army of amateur workers in radiotelegraphy.

Miscellaneous.

1535. **A. S. Eve.** Engineering and Physics. (*Journal of the Engineering Institute of Canada*, 3, pp. 527—528, November, 1920.)
Briefly refers to the difficulties of adequate education for radio research work.

1536. The Planet Mars and Interplanetary Communication. (*Produccion*, 11, pp. 149—150, March 15th, 1920.)

1537. Interplanetary Radio Signals. (*Wireless Age*, 7, pp. 11—15, March, 1920.)
A summary of a number of expressions of opinion by **G. Marconi, C. P. Steinmetz, E. Branly** and others on this subject.

1538. **S. R. Winters.** Wireless in Forest Fire Fighting. (*Wireless Age*, 8, pp. 11—12, October, 1920.)
The installations of the U.S. Forest Service are briefly described and illustrated.

1539. **L. D. Foucault.** Telephony and Metaphysics. (*L'Électricien*, 51, p. 485, November 15th, 1920.)

1540. The International Commission for Weather Telegraphy. (*Meteorological Magazine*, 55, pp. 237—240, December, 1920.)
Some further particulars are given of the conference held in London during November of which a note was published on p. 42 of our last issue. (Note No. **1846.**)

1541. **V. G. Werner** and **K. H. Warfvinge.** TELEPHONY. (*French Patent* 488316, August 21st, 1916. Published September 20th, 1918.)
This specification describes a system for corresponding by telephone with railway trains or similar vehicles in motion. The movable circuit consists of a coil L (Fig. 2) connected to a number of oscillatory circuits L_1, C_1; L_2, C_2; etc. The frequencies of these circuits are uniformly distributed according to the frequencies of the most important of the oscillations produced by speech. For further particulars see *British Patent* 101281.

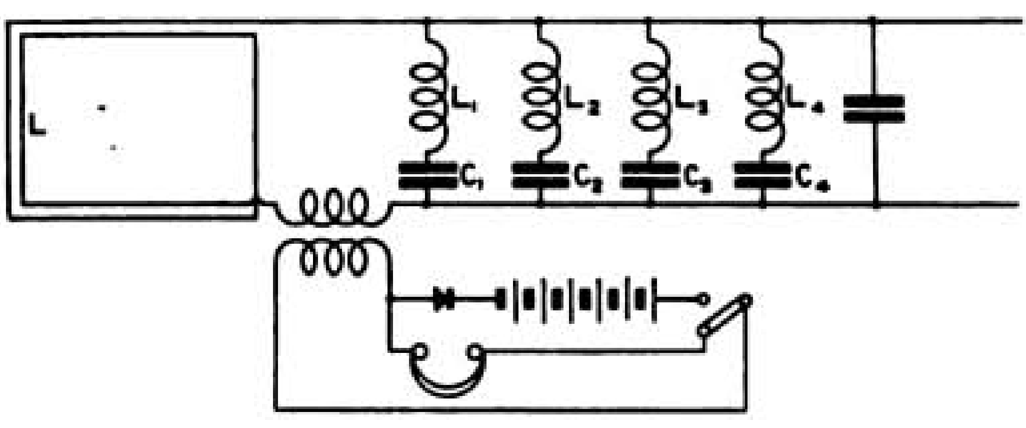

FIG. 2.

Index and Binding Cases. An announcement will be found in the advertising pages of this issue.

2. Books.

ELECTRIC OSCILLATIONS AND ELECTRIC WAVES. By G. W. Pierce, Professor of Physics in Harvard University. (New York: *McGraw Hill Book Co., Inc.* London: *McGraw Hill Publishing Co., Ltd.* 1920. Pp. ix + 517. Price 30s. net.)

This is one of the best books we know of on this subject; it should be on the shelves of every radio engineer who is interested in the mathematical theory of his subject. It forms an excellent text-book for a course of study of the phenomena of electric oscillations. As stated on the title page it includes applications to radiotelegraphy and incidental applications to telephony and optics. No attempt is made to deal with the physics of the subject, there is hardly any mention of spark-gaps, arcs or vacuum tubes, but a thorough mathematical treatment is given of the fundamentals of the theory of electric oscillations and electric waves. The volume is divided into Book I. on Electric Oscillations and Book II. on Electric Waves; these are almost independent and can be read in either sequence provided the reader has a fair knowledge of mathematics. Book I. contains seventeen chapters and Book II. nine. The first three chapters deal with oscillations and discharges in a circuit containing inductance, capacity and resistance, then follows one on the geometry of complex quantities which is then applied to the circuit with a sinusoidal impressed E.M.F. and thus to the problem of resonance. Chapters VII. to XI. are devoted to a very complete study of two coupled oscillatory circuits. The following chapter is entitled "Resonance Relations in Radiotelegraphic Receiving Stations under the Action of Persistent Incident Waves." Chapters XIII. and XIV. deal with various methods of coupling two or three oscillatory circuits and the various phenomena involved in tuning these combinations. Forty-four pages are then devoted to a study of the detector and blocking condenser shunted across the tuning condenser of the circuit coupled to the receiving aerial. Chapter XVI. deals with a subject of growing importance, viz. artificial lines and electrical filters; this subject is treated very fully. The concluding chapter of the first book is devoted to electric waves on wires in a steady state. The second book opens with a chapter on Gauss' theorem, Poisson's equation, etc., in electrostatics and magnetostatics, followed by a chapter on Maxwell's equations. Chapter III. deals with Poynting's theorem of energy transfer and Chapter IV. with the wave equations and the simple plane wave solution. Chapter V. is devoted to the reflection of a plane wave from a perfect conductor and Chapter VI. to the reflection and refraction by a homogeneous insulator. This is followed by a study of wave propagation through an imperfectly conductive medium. The radiation of electromagnetic waves from an oscillatory doublet is then applied to the Hertzian oscillator to determine its radiation resistance and in the final chapter to the radiation characteristics of an actual antenna. This concluding chapter is a very thorough attempt to determine the radiation resistance of an antenna. In an appendix several theorems in connection with the solution of differential equations are proved.

We have noted two or three misprints, but the book is remarkably free from such blemishes and we have no hesitation in recommending it both as a text-book and as a book of reference to all those who require something more than a mere qualitative knowledge of the phenomena occurring in alternating current and especially in high-frequency circuits.

G. W. O. H.

Books Received.

TELEGRAPHY, TELEPHONY AND WIRELESS. J. Poole, Wh.Sch., A.M.I.E.E. (London: *Sir Isaac Pitman & Sons, Ltd.* Pp. 120. Price 3s. net.)

EXPERIMENTAL WIRELESS STATIONS. Philip E. Edelman, E.E. (London: *Henry Frowde and Messrs. Hodder and Stoughton.* New and Revised Edition, 1920. Pp. x + 392. Price 16s. net.)

THE ELECTRICIAN'S HANDY BOOK. A Reference Book for the Advanced Electrician, and a Text-book for the Student. T. O'Conor Sloane, A.M., E.M., Ph.D. (London: *Henry Frowde and Messrs. Hodder and Stoughton.* Fifth Edition, 1920. Pp. 823. Price £1 7s. 6d. net.)

WIRELESS DESIGN AND PRACTICE. Part I.—Transmitters and Receivers. Part II.—Practical Circuits. M. B. Sleeper. (London: *Henry Frowde and Messrs. Hodder and Stoughton.* 1920. Pp. 246. Price 7s. 6d. net.)