THE
RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC
PROGRESS IN RADIOTELEGRAPHY
AND TELEPHONY

VOL. II JANUARY, 1921 NO. 1

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  Abstracts of Articles and Patents
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tor : Prof. G. W. O. HOWE, D.Sc., M.I.E.E.   Asst. Editor : PHILIP R. COURSEY, B.Sc., A.M.I.E.E.

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THE RADIO REVIEW

INFORMATION FOR CONTRIBUTORS

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THE
RADIO REVIEW

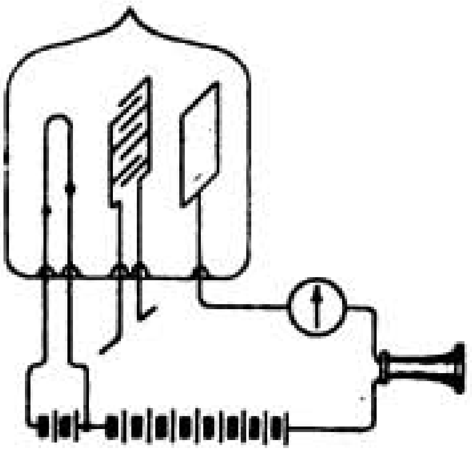
VOL. II JANUARY, 1921 NO. I

Editorial.

The New Volume.—With this the first number of our second volume, we introduce several improvements with the object, firstly, of making the Radio Review of greater interest and usefulness to its present readers, and secondly, by broadening the scope of the articles published, to appeal to a wider circle of readers. We appeal to our readers to bring the Radio Review to the notice of any one interested in wireless telegraphy who is not already a subscriber. It is only by obtaining an increased circulation that we can hope to be able to make further improvement in the character of the Radio Review.

In connection with the paper by Mr. G. C. Southworth on "Electrical Measurements at Ultra-Radio Frequencies," which we publish in this issue, it is interesting to note that the determination of frequency by the measurement of the length of stationary waves on wires was tried for wavelengths up to 1,100 metres at the Reichsanstalt in 1908. The parallel wires passed through an open window and across the grounds. The experiments were described by Diesselhorst in the *Jahrbuch der drahtlosen Telegraphie*, 1, p. 262, 1908.

On page 38 of this issue we publish a short abstract of a paper read by Professor Fleming before the Wireless Society of London on "A Four-electrode Thermionic Detector." In this connection it is interesting to recall the four-electrode detector described by Majorana in 1912 (see *British Patent* 23024/1912; *Lincei Rendic*, p. 274, 1912; *Jahrbuch der drahtlosen Telegraphie*, p. 462, 1913). Although differing in construction from that described by Professor Fleming, it sufficiently resembles it in principle to make a comparison of the two interesting. We reproduce the figure from the Patent Specification. The grid is made in two parts between which the P.D. to be detected is applied. Majorana says that the potentials of the two parts should be equally above and below that of the filament. The plate current is reduced whichever direction the P.D. is applied to the divided grid, which the inventor calls the "electron deviator"; hence an applied alternating P.D. causes a reduction



of the plate current and gives a deflection on the galvanometer. Majorana points out that it can thus be used as a relay.

It is interesting to note that he points out that it is a potential operated device and that sensitiveness can therefore be increased by using an oscillatory circuit with large inductance and small capacity, so as to obtain a large P.D. between the deviating electrodes. He goes on to say that one can reduce the capacity until one has only that of the deviating electrodes, as described by Professor Fleming under the name of resonance spirals.

Wireless Service between England and Geneva.—In agreement with the Swiss Federal Government Marconi's Wireless Telegraph Company, Ltd., have installed a 6 kW continuous wave valve station at Geneva for the especial use of the numerous newspaper correspondents attending the first conference of the League of Nations. Besides being the first radio station to give priority to Press messages the Geneva station was remarkable for the speed with which it was erected. It was not until late October that the project was first discussed between the Swiss authorities and the Marconi Company, and on November 3rd not a single part of the gear, all of which, including a 200 foot steel tower, had to be transported from England, had arrived at Geneva. Yet on November 9th the preliminary trials were carried out. The station was completed and the service commenced on November 15th, the day the conference opened. On that date no less than 10,000 words were cleared within a few hours after the commencement of the sitting. In addition to the primary service to a specially-erected station at Witham, Essxx, communication was effected with Csepel (Hungary), Nauen (Germany), Centocelle (Italy), and Barcelona (Spain).

Notwithstanding the haste observed in the construction there was nothing makeshift about the Geneva station; on the contrary, it was an example of the last word in radio engineering.

The transmitting apparatus comprised one Marconi standard 6 kW continuous wave valve telegraph set of the coupled circuit type, fitted with six "power" and four "rectifying" valves. The power was taken from the Geneva Supply Company and supplied to a 30 B.H.P. 500 volt 2-phase motor from which a 23 kW 110 volt D.C. dynamo was driven by belt. An emergency power plant was provided consisting of one 18 kW 110 volt D.C. Austin oil-engine generator. Each power set was provided with a slate panel switchboard. One 6 kW motor alternator was installed, taking supply from the 110 volt D.C. circuit giving a single phase supply at 500 volts 300 cycles. The voltage was raised to 7,500 by a step-up transformer, at which pressure it was fed to the valve transmitter panel.

The signalling circuit comprised special high-speed keys operated by a Wheatstone transmitter, the tape for which was "punched" on a Gell keyboard type perforator. The aerial was of the umbrella cage type with six radial members, supported by a single lattice steel self-supporting tower 200 feet high, each radial member being carried out to a 50 foot pole at a distance of 300 feet from the central tower. The earth system consisted of the usual galvanised iron plates and earth wires buried in the ground.

Five miles from the transmitting station was a separate receiving station erected so as to permit of duplex working. This station was provided with a special aerial constructed on the latest directional principles, and was connected to the transmitting station by landline. From the central receiving office in Geneva the messages were passed to the transmitting station over a landline, this service being augmented by a squad of motor-cyclist messengers.

The receiving station in England was located at Witham, near Chelmsford. It was equipped with the latest type of directional aerial and in addition to up-to-date valve receivers was provided with dictaphone apparatus for the reception of high-speed messages.

For transmitting the necessary acknowledgments, service messages, etc., a 15 kW valve transmitter at the Marconi Company's works, Chelmsford, was operated direct from the receiving station at Witham by landline connection. Witham was also in direct landline communication with the Marconi Company's London offices to which the messages were finally transmitted by high-speed automatic apparatus.

Many thousands of words were daily handled by this service, which, besides relieving the Continental telephone and telegraph lines of an enormous weight of traffic, thus enabling the delegates of the League of Nations a freer use of these means of communication, was an excellent demonstration of the value of radiotelegraphy in the quick dissemination of news.

In our next issue we hope to publish an article giving a more detailed description of the installations employed in this service.

The Creed Printer as a Wireless Recorder.—At the inaugural address of the current session of the Royal Society of Arts delivered by Mr. A. A. Campbell Swinton on Wednesday, November 17th, 1920, a demonstration was given of one of the latest developments of wireless recording instruments. The lecturer prefaced the demonstration with a few introductory remarks outlining the methods of radio communication and then briefly described the Creed perforating and printing mechanism which were used for the demonstration. A special message was sent by arrangement from the Eiffel Tower, Paris, both for this meeting and for the meeting of the Wireless Society of London which was held in the same hall on the following day. A short account of the latter meeting will be found elsewhere in this issue together with a reproduction of part of the printed strip received on that occasion.* Although a few mistakes are noticeable in the final message as printed by the Creed machine it will be readily seen that these are of a minor character due mostly to the omission or addition of a dot signal. Some of these disturbances were possibly due to atmospheric effects.

The Creed instruments that were used were of the ordinary type customarily employed for landline telegraphic work and the novelty of the demonstration lay in their successful adaptation to wireless telegraphic reception. We hope in a future issue to deal with this subject more fully and to publish a detailed description of the apparatus that may be used for this purpose.

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* See pp. 37–38.

Commercial Progress in Aircraft Wireless.

By R. H. BARFIELD, B.Sc.

It is evident that progress in aeronautics must have an all-important bearing upon the development of aircraft wireless and it is also evident that wireless must form an important contributory factor in the future development of aeronautics. Progress in aeronautics has been phenomenally rapid in the last few years, and, notwithstanding the fact that since the incentive of war has been removed an appreciable slackening down has taken place, it is reasonable to anticipate that a steady rate of advance will be maintained and later, when accumulated experience and improved facilities have resulted in a greater measure of reliability, there will be an accelerated rate of development accompanied by an extended use of wireless.

In aeronautics much depends upon the possibility of reliable communication with the ground and, to a lesser extent, between aircraft in flight; and wireless provides the only means by which this can be achieved. The advantages accruing from such communication may be classified under two heads. Firstly, those which are connected with navigation and control and therefore make for increased safety and reliability and secondly those which add to the convenience and perhaps to the comfort of passengers and so tend to popularise the service. Owing to the relatively high speed of aircraft and the consequent brief duration of the journeys undertaken the second consideration is comparatively unimportant at the moment but it is probable that, as the length of aerial routes increase and their use by the public becomes more general, it will merit more serious attention. The principal technical difficulties have been overcome and it is now possible to establish communication, partly by wire and partly by wireless, between an office in London, for example, and a machine on the London-Paris route. The linking of the air route wireless stations to the Post Office telephone system is all that is necessary to bring this service within the reach of the public.

In its use for the purposes of navigation and control, wireless performs somewhat analogous functions in the air and on the sea but the conditions differ to such an extent that it has markedly greater possibilities in the former than in the latter sphere. The aerodrome is more to the aeroplane than the harbour to the ship for, unlike the ship, the aeroplane cannot anchor or stand off indefinitely when conditions are unfavourable for landing, hence it is important that the pilot shall be in touch with his objective in order that he may be acquainted with conditions there and diverted to an alternative aerodrome if necessary.

Navigation at sea is in the hands of a qualified officer who is in a position to devote time and care to the performance of this duty. In the absence of astronomical observations he can carry on and proceed for days by dead reckoning, *i.e.*, by compass and log, and in shallow waters he has a check in the use of the lead. Definite information is at hand regarding ocean currents and the tides and he can always heave to or anchor if desirable. Navigation by astronomical observation is hardly practicable in the case of commercial aeroplane traffic and indeed it would be of little use in the case of journeys of the length at present contemplated. Aircraft navigation by dead reckoning alone is liable to enormous errors due to the very large drift allowances necessary, the uncertainty regarding the strength or even direction of wind at different altitudes and the very high speed of travel. The wireless direction finder provides a means of checking position at intervals, however, so that navigation can be carried out with the aid of wireless under conditions when it would be impossible otherwise owing to the absence of landmarks or their obscuration by cloud, fog or darkness.

Important as is the *rôle* of wireless at sea, it will be agreed that an even more important *rôle* is assigned to it in the air where, under frequently prevailing conditions, it forms the sole means of communication between aircraft and the ground and the sole agency by which navigation becomes possible. The design and development of suitable wireless equipment for communication between aircraft and the ground and for aircraft navigation becomes, therefore, an important item in the programme of those engaged in the production of wireless apparatus.

It will be of interest to consider what special problems arise in connection with this particular branch of wireless engineering, how they have been dealt with and on what lines the various difficulties are being overcome. In the case of the apparatus for installation in aircraft as distinct from the corresponding ground equipment there are special difficulties associated with the necessity for drastic economy in weight and space. This consideration operates in more than one way; it limits the power of the transmitter and the size of the aerial, both of which affect the range, and it renders impracticable, or at any rate undesirable, the carrying of an expert whose attention may be solely devoted to the care of the wireless gear. The installation must therefore be of a simple nature capable of operation by a person unskilled in wireless matters and who has other duties to perform. Now complexity of apparatus cannot be dispensed with beyond a certain point without detriment to its performance hence the problem resolves itself into the provision of apparatus which may be described as normal or nearly so from the point of view of general wireless design though especially light and compact and at the same time simple to operate.

The introduction of the three-electrode valve has been the controlling factor in the developments which have taken place. It has made reception in aircraft a practical proposition and has brought into being telephonic transmission whereby the necessity for a trained "Morse" operator is dispensed with and speed of transmission, a most important factor, has been increased tenfold.

Reception in aircraft is carried out under what are probably the worst possible conditions and the difficulties were at first sufficiently great to put a stop to any serious attempt at reception, with the result that wireless in aircraft originally took the form of one-way working with the transmitter in the aeroplane. The overwhelming noise produced by the unsilenced engine made impossible the reception of any but the very strongest signals, the presence of intense vibration rendered the use of the ordinary contact detectors impossible and when highly sensitive valve amplifiers were introduced induction from the magneto circuits gave serious trouble.

The receiver must be sensitive and must provide considerable amplification in order that loud signals may be obtained and the whole installation must be of a robust nature capable of withstanding the most severe conditions of weather, vibration, temperature changes, etc., and at the same time must be so simple in its working as to be capable of operation by any one without special knowledge of the subject.

A brief description of a commercial installation of recent design will serve to indicate the stage of development at present reached. The apparatus referred to is that manufactured by the Marconi Company, and installed in aircraft of the leading aerial transport lines. It consists of a combined transmitter and receiver primarily intended for wireless telephony, but capable also of being used for either " tonic train " or continuous wave telegraphy. A single three-electrode valve generates the high frequency oscillations and an air-screw generator provides power for the whole of the set. The employment of a system of remote control enables the apparatus to be operated and adjusted by the pilot, and as the small unit which contains the controlling handles occupies very little space it can be mounted in the most convenient position. When once the preliminary adjustments have been made operation becomes extremely simple. The pilot on wishing to speak to any station with which he is in range has only to set the change-over switch on his remote control to the " send " position and call up the station by name. When he has finished his conversation he sets his switch

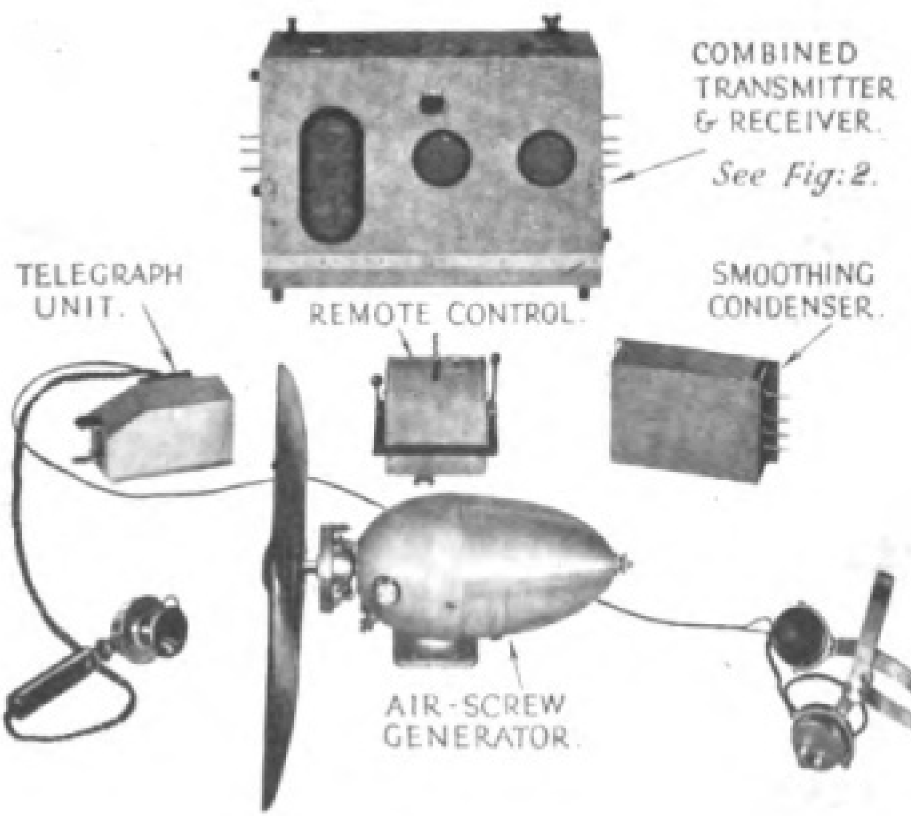

Fig. 1.—Aircraft Transmitter and Receiver (Combined Type). Assemblage of Units.

to "receive" and awaits the reply. Normally the switch will be in the "receive" position and as he will be wearing the telephone head-gear at all times the pilot will always be ready to hear any one who may be calling him.

Fig. 1 shows an assemblage of the units which go to form the complete installation. The unit method of construction makes it possible in mounting the set to take advantage of odd spaces on the aeroplane which would otherwise be useless. It also enables a damaged unit to be replaced or repaired independently.

The apparatus comprises:—

(1) The transmitter and receiver mounted either in one box or in two separate boxes, which, in either case, are protected from vibration by suspension on rubber shock absorbers.
(2) The remote control unit (see Fig. 6).
(3) The generator (with air screw).
(4) Smoothing condenser.
(5) Microphone and head receiver.
(6) The telegraph unit.
(7) Aerial and winch and earth connection.
(8) Six-volt battery.

The complete set, installed in an Airco D.H.6 machine which is now employed on Continental transport work, is illustrated in Figs. 3, 4, 5, and a simplified diagram of connections of the transmitter and receiver is shown in Fig. 7.

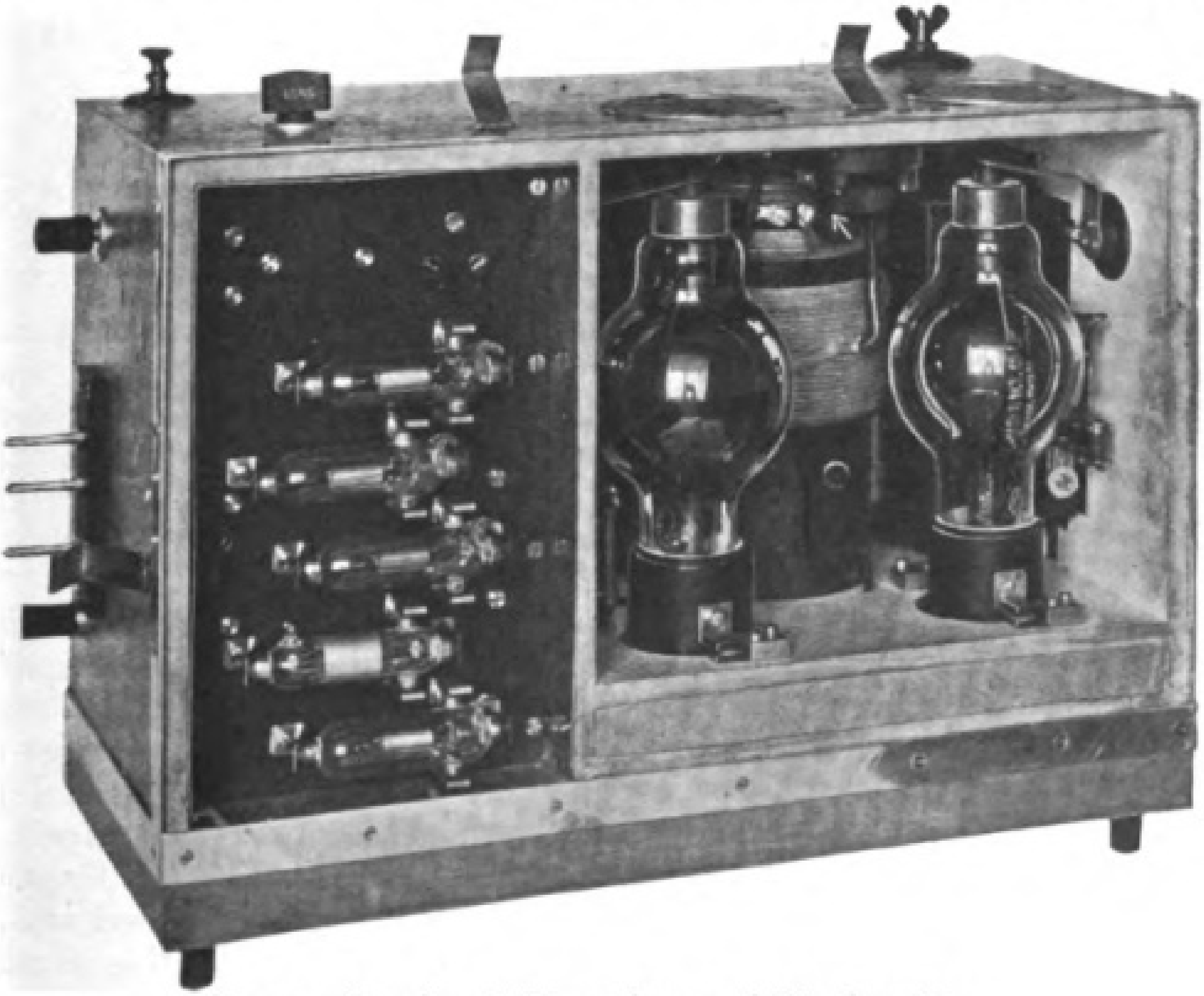

FIG. 2.—Interior of Transmitter and Receiver Box.

The transmitter consists of an aerial circuit coupled directly to the plate circuit of the oscillating valve. The amplitude of the oscillations in the latter are variable by means of a control valve, both valves being supplied with high-tension direct current energy from the air-screw generator. Variations in current produced by speech in the microphone are impressed on the grid circuit of the control valve through a step-up transformer, and a "speech" choke is inserted in the high tension supply circuit common to the two valves. Two working wavelengths are provided, either one being put into use by means of a wave-changing switch. Fine adjustment of the aerial circuit is obtained by means of the variometer, which when once set on the test flight needs no further attention.

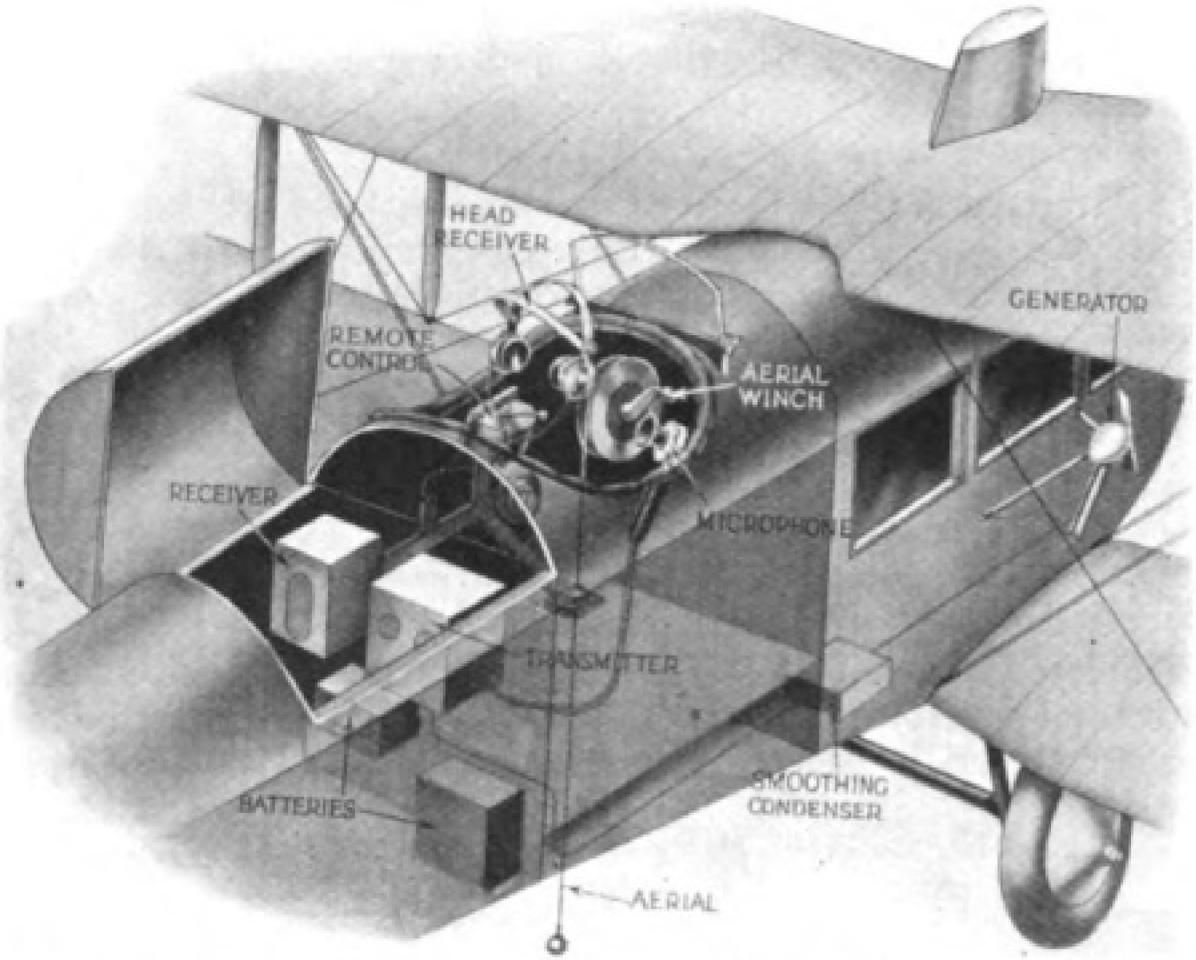

Fig. 3.—The Complete Set mounted on an Airco Machine (Type D.H.6).

In the receiver a simple aerial circuit is variably coupled to a five-valve amplifier, of which the first three valves are for high-frequency amplification, the fourth for rectification and the last for note magnification.

A coarse wavelength adjustment is provided by means of a three-way switch connected to a subsidiary inductance in the aerial circuit. This switch, which is mounted on top of the box, enables a wavelength of from 450 to 1,000 metres to be obtained. Fine tuning is carried out by means of a small condenser incorporated in the remote control unit and shunted across the aerial and earth. The pilot is thus able to make the necessary adjustments for small variations which may be found in the wavelengths of stations transmitting to him though nominally all tuned to the same standard wavelength.

The aerial circuit is inductively coupled to the first high-frequency valve through a coil, which, when the coupling is loose, has a natural wavelength equal to that of the standard wave to be worked to. On tightening the coupling, however, the increased mutual inductance brings in two possible resonance points, one higher and one lower than that obtained with loose coupling. Thus, by varying the coupling the secondary circuit is tuned, and by varying the coarse wavelength switch in combination with the remote control condenser, the aerial circuit is tuned. In this manner the advantages of loose coupling are obtainable on the standard wave, and tuning to a large range of other waves is obtained by a simple adjustment.

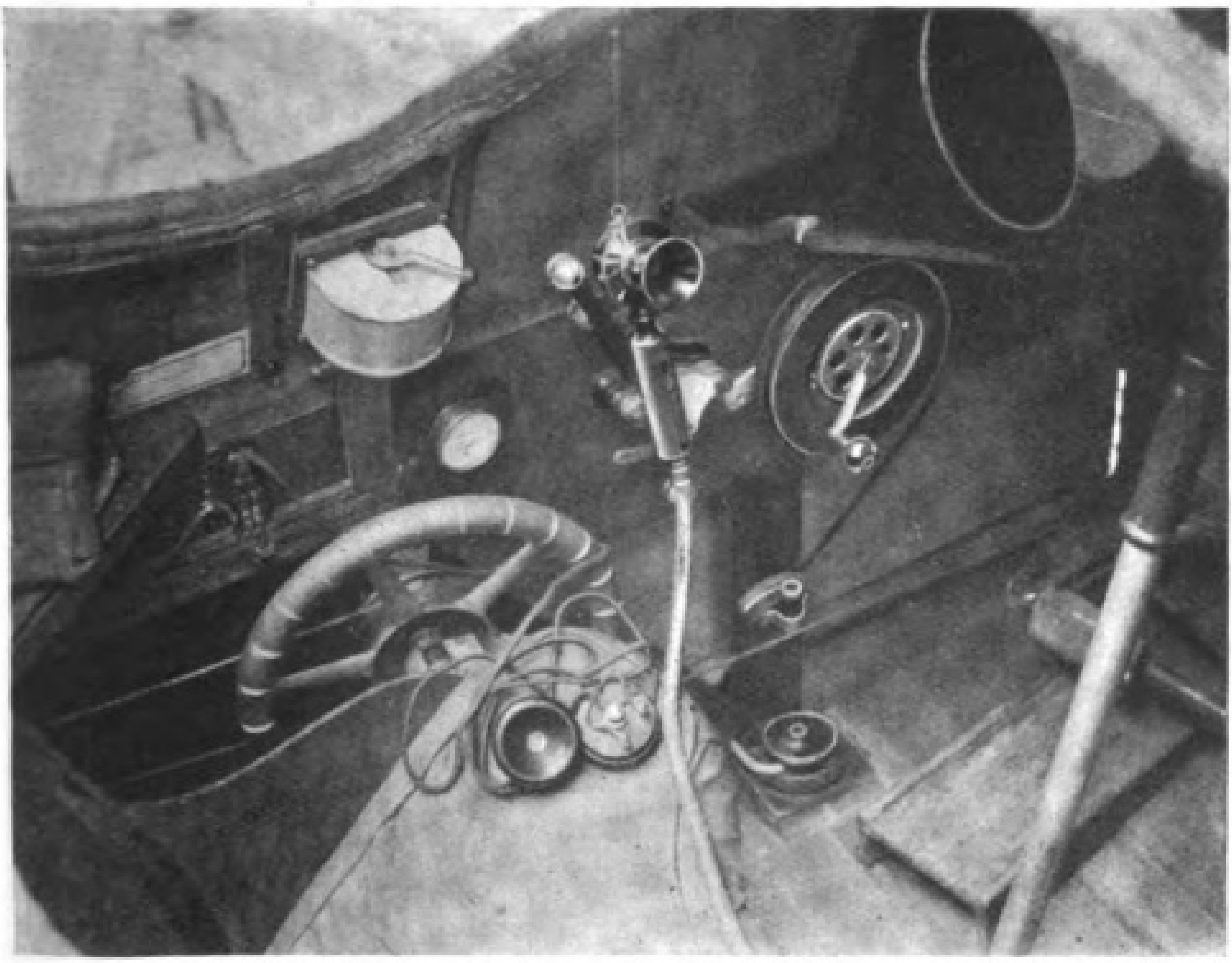

FIG. 4.—Pilot Cockpit, showing Control Gear and Aerial Winch.

Screening is carried out very thoroughly. In order to prevent interference by induction from the engine ignition circuits, screening of the magneto leads and, if necessary, the magneto itself, is resorted to and is carried out by means of wire gauze which is earthed, also the whole of the high-frequency circuits are screened in one metal box, and further, the coupling and aerial coils are screened themselves from the high-frequency transformers. This prevents undesirable oscillation, and makes for stability. Reaction is arranged for so that the set can be made to oscillate and work as an auto-heterodyne circuit for the reception of continuous waves, or brought into a condition of increased sensitivity for the reception of weak signals. These adjustments are made by a twist handle mounted below the coupling handle. If used as a pilot-operated set, this handle is fixed so that a maximum of sensitivity is obtained consistent with stability.

The high-frequency transformers are damped very heavily so that the amplifier is sensitive over a wide range of wavelengths and the reaction adjustment is fully controllable and practically unaffected by wavelength changes or filament brightness.

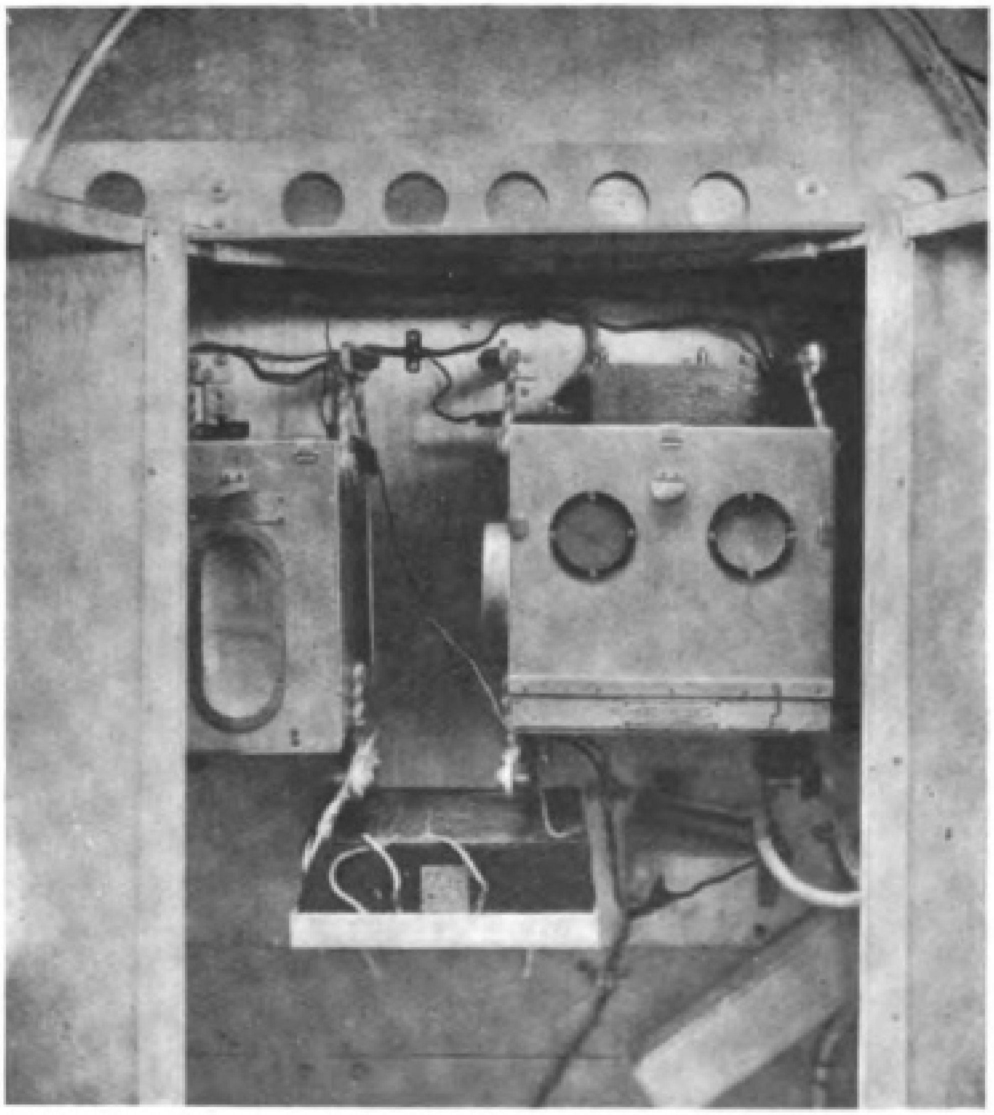

FIG. 5.—Rear Cockpit, showing disposal of Transmitter and Receiver Boxes with Batteries.

The strength of signals is varied by means of the remote control variable resistance which is in series with the filaments of the valves.

The telegraph unit * contains a key, a buzzer and a switch. The switch controls the method of transmission. In its first position the key is connected in the grid circuit of the oscillatory valve for continuous wave transmission. In the second position, for "tonic train" telegraphy, the grid circuit is closed so that the set is continuously oscillating and the key now controls the buzzer which is connected to the step-up transformer in the

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* This unit is not included in the equipment shown in Fig. 3.

grid circuit of the control valve. In the third position connections are the same as in position two, except that the microphone is substituted for the buzzer and key.

The aerial is of the trailing type and consists of a flexible phosphor-bronze wire 200 feet long, carrying a $2\frac{1}{2}$ lb. spherical weight at its lower end. When not in use it is coiled up on a specially designed winch. When the machine is in flight, the pilot releases the winch and the aerial trails out beneath the machine. Earth connection is made to all metal parts of the machine by means of a "bonding" strip which runs along the fuselage.

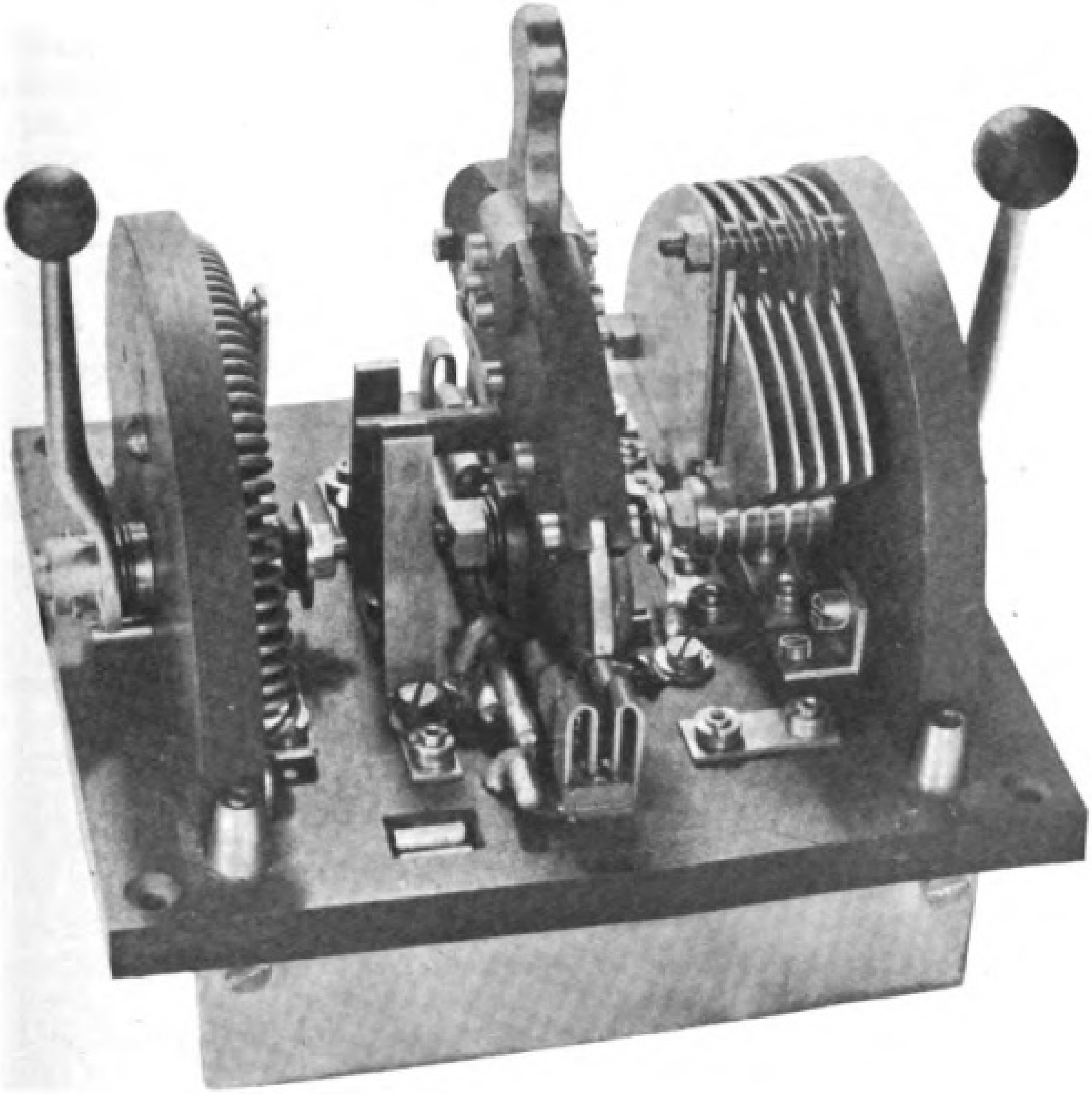

FIG. 6.—The Remote Control Unit.

The complete installation weighs only some 60 lbs. and the ranges under normal conditions are approximately 200 miles for C.W. telegraphy, 130 for "tonic train" telegraphy and 100 miles for telephony.

Ground stations for working with aircraft have been standardised and on an aerial route these stations are erected at intervals designed to ensure continuous communication with machines using the routes. In these stations, in addition to apparatus for telegraphy and telephony, a complete direction finding installation is provided and, by means of this, bearing can be obtained of any machine from which signals are received. Where auxiliary direction finding stations are available, simultaneous observations are made, a " fix " obtained and the information communicated to the pilot through the main station.

The whole station is under the control of a single operator by means of a small switchboard or control unit. The transmitter and power plant are usually housed at some distance from the room in which the receiving and control instruments are contained. A separate aerial 70 feet high, 200 feet long is employed for transmitting, and direction finding aerials are used for normal reception purposes.

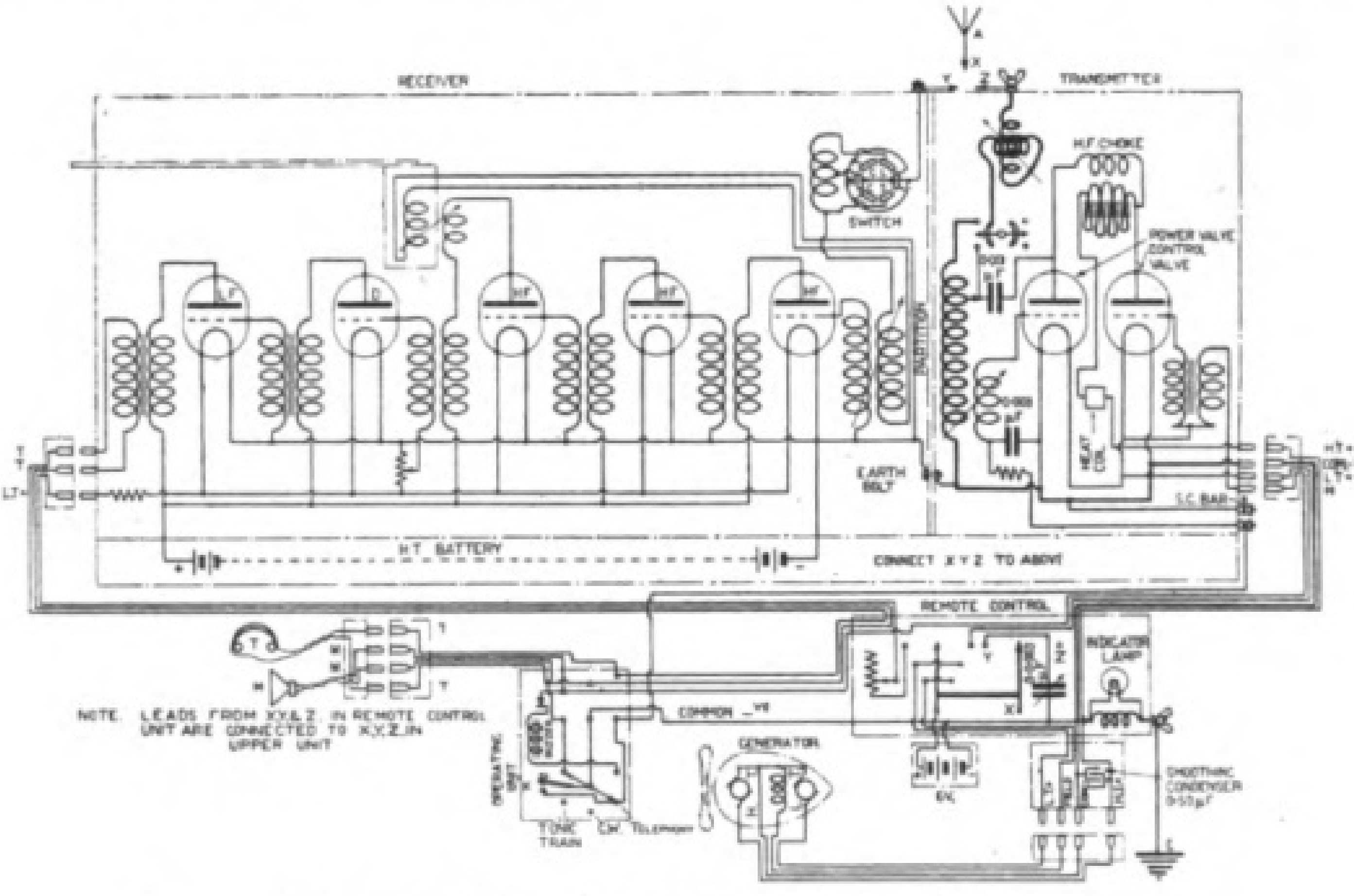

FIG. 7.—Diagram of Connections of Aircraft Transmitter and Receiver.

The transmitting installation comprises the power unit, consisting of a motor-generator and switch-board, the high-frequency generating apparatus with speech control apparatus and the tuning circuits with wave-changing gear ; the whole being operated by a system of relays which are manipulated from the control room.

A wavelength range of from 300 to 3,000 metres in suitably graded steps is obtainable, the change from one wave to another being effected by means of a simple switching system.

The extremely long wavelength range over which the installation is capable of transmitting necessitates the employment of two systems of speech control. The " damping " method of control is employed when working on wavelengths of the order of 900 metres and upward, whilst for shorter wavelengths the " choke " or " anode " system of control is employed.

In both cases two control valves are connected in cascade—an arrangement which ensures the powerful control necessary in a transmitter designed to operate with weak speech currents from a land line circuit.

The simplified diagram (Fig. 8) shows the connections of the valve apparatus for generating high-frequency oscillations and indicates how both methods of control are carried out.

Landline connection is obtained by operating a switch mounted on the control board which enables the operator to put his wireless microphone and receivers on to the landline and call up the terminal station or exchange in the usual way. A second switch enables him to connect the wireless apparatus through to the line, allowing him to listen in during the conversation for the purpose of " changing over " when necessary.

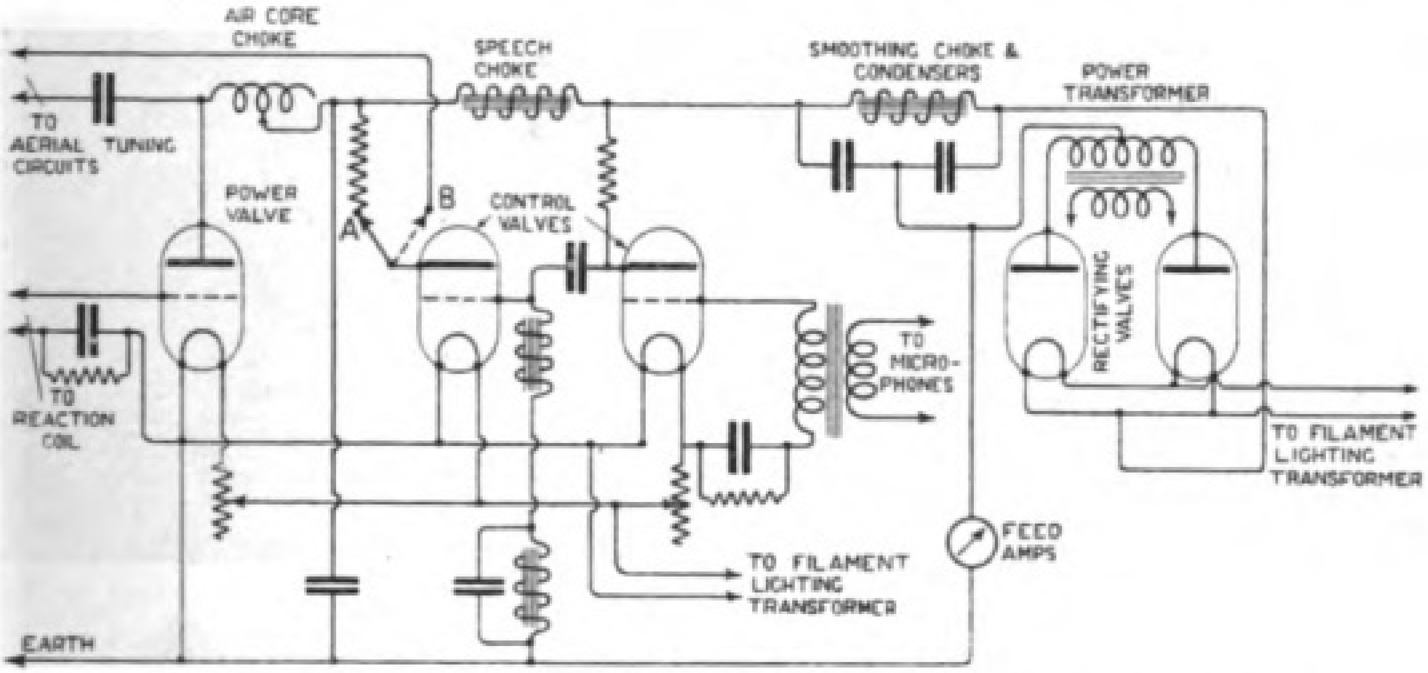

FIG. 8.—Simplified Diagram of Ground Station Valve Transmitter (Telephony Arrangement).

Repeaters are employed as connecting links between the landline and wireless so that the necessity for metallic connection is obviated.

The remote control switchboard (illustrated in Fig. 9) has mounted on it five switches which put the operator in complete control of the station.

These switches perform the following operations :—

No. 1.—The transmit-receive switch enables the change over from sending to receiving conditions or *vice versa*, to be effected. The switch, when placed to transmit, controls a relay switch which energises the wireless transmitting circuits. At " receive " the transmitting circuits are made inoperative by the same means and the receiver is switched into operation.

No. 2.—The motor switch controls a relay which starts or stops the transmitting power plant.

No. 3.—The transmission switch controls the method of transmission. At "Telephony," relays are actuated which energise the control valves and the microphone is switched into operation. At "Tonic Train" the switch inserts a buzzer in series with a key and battery in place of the microphone. At "Telegraphy" the control valves are cut off and the key is connected so as to control the keying relay in the oscillating valve circuits.

No. 4.—The line hold switch; when this switch is changed over from "clear" to "hold" the exchange line is automatically held so that the operator can call up the distant wireless station which the subscriber on the exchange line is asking for.

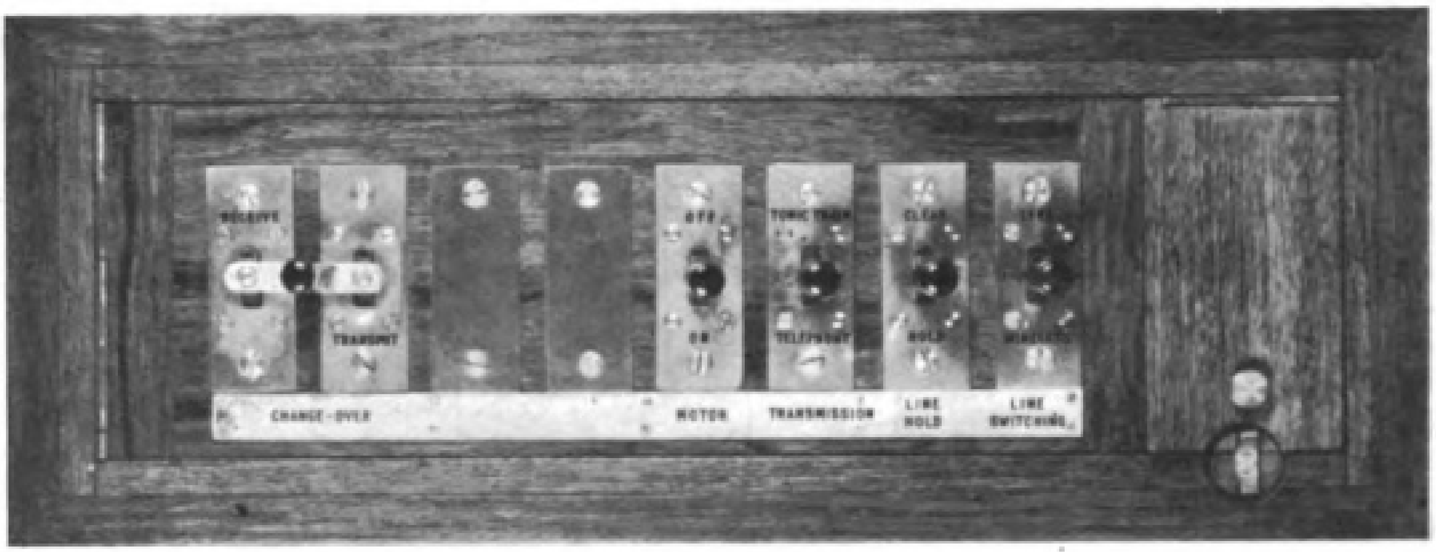

FIG. 9.—The Remote Control Switchboard (Ground Station).

No. 5.—The line switch has three positions, in the first—"Wireless"—the wireless instruments are entirely independent of the exchange lines. The second position is the "Through" position and the distant wireless station is then put into communication with the subscriber on the landline and the operator "listens in."

In the third position—"Line"—the operator is connected so as to be able to converse with the line subscriber. The switch is only put into this position when the change-over switch is at "Receive."

The receiving apparatus is similar to the well-known standard Marconi Direction Finder in which is incorporated a six-valve amplifying detector. For ordinary "all round" reception the aerials are bunched together and put to earth through a coil which is tightly coupled to the tuning circuit but for directional reception they are connected to the fixed coils of the radiogoniometer. The present standard pattern incorporates an arrangement of circuits which enables the "sense" to be determined as well as the direction and this very much increases the value of the readings taken by an individual station.

The Heterodyne Method of Wireless Reception, its Advantages, and its Future.*

By MARIUS LATOUR.

It is generally known that at the present time wireless antennæ are supplied with alternating current produced by arcs, or by alternators similar to those used for power purposes but of higher frequency. Although this frequency has recently been lowered to about 12,500 cycles (in the Bordeaux Station), we cannot yet receive this current in the ordinary telephones because their sensitiveness is very small for frequencies above 2,000.

We must therefore look for another method of detecting these high frequency currents with the telephone, and of transforming the inaudible signals into audible ones.

M. Maurice Leblanc was the first to devise a means of making high frequency currents directly audible. While Elisha Grey in America was the inventor of multiple harmonic telegraphy based on the simultaneous utilisation of currents of as many different frequencies as there are messages to be sent, Leblanc was the inventor of a similar system of multiple telephony using currents of higher than the speech frequency. These high frequency currents were modulated by the microphone itself. In other countries the invention of high frequency multiple telephony is generally attributed to General G. O. Squier, who however did not put forward his suggestions until a long time afterwards.

In *La Lumière Electrique* of April 17th, 1886, in a paper on "Multiplex Telephony," M. Leblanc showed how it is possible to vary the amplitude of an inaudible high frequency current, so as to make it audible. He endeavoured to devise a special telephone to respond to the effective variations in the intensity of a high frequency current without using either detector or rectifier. This instrument was based on the principle of the electrodynamometer. It consisted merely of two circular parallel coils connected in series, one being fixed and the other attached to an ebonite diaphragm (see Fig. 1). It is obvious that the effective variations in intensity of the high frequency current will cause variations in the attraction between the two coils, which will produce vibrations of the ebonite diaphragm.

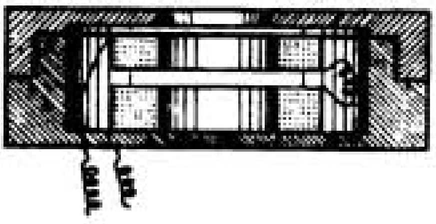

FIG. 1.

In a note sent to the General Electric Company at Schenectady in September, 1904, we proposed to receive radio signals by producing "beats" between two simultaneous radiations of different frequencies. Two alternators coupled to two distinct antennæ and working at frequencies of

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* Received November 12th, 1920.

29,000 and 30,000 respectively would emit a note of 1,000 ~. This note may be received directly by a telephone of the electrodynamometer type such as that suggested by Leblanc.

In practice however it is not necessary for the two transmissions to be effected at the same place. One of these can be set up at the receiving station itself. This in fact constitutes the principal feature of Fessenden's invention. The distant transmission to be received being of frequency 30,000, a feeble local oscillation of 29,000 cycles is set up in order to establish the beat note of 1,000 cycles. Fessenden has termed this little generator for use at the receiving station to produce the local oscillations a "heterodyne."

Using this local oscillation generator it is possible to design a special telephone which, like that of Leblanc, permits the reception of a high frequency current without detection or rectification. Fessenden described the following arrangement. An electromagnet (see Fig. 2) able to attract a diaphragm P carries two windings e_1 e_2 through one of which passes the current from the local source, while the antenna current passes through the other. These two currents have frequencies $\frac{\omega_1}{2\pi}$ and $\frac{\omega_2}{2\pi}$ respectively, and they set up a resultant flux in which the effective intensity has a periodicity corresponding to $(\omega_2 - \omega_1)$.

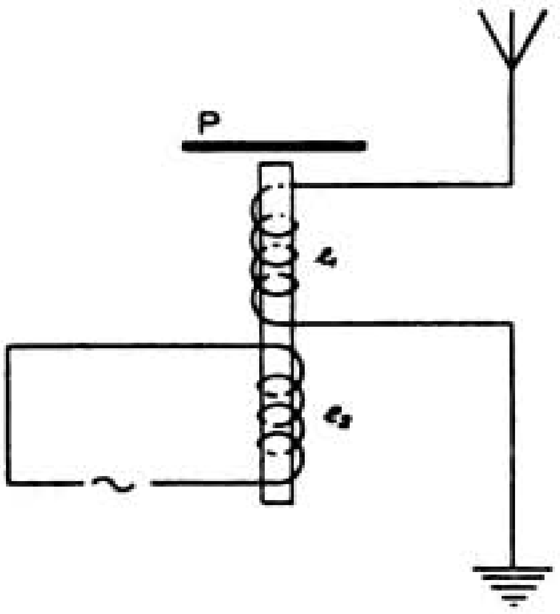

FIG. 2.

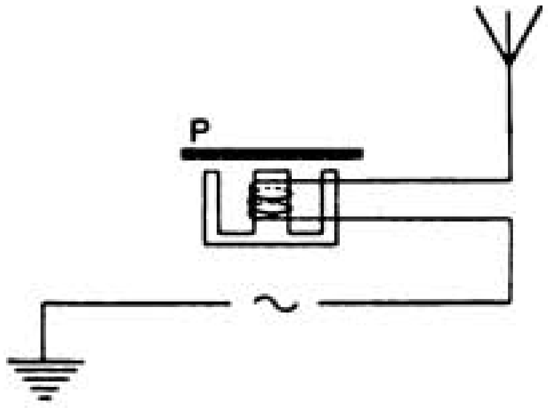

FIG. 3.

Working on this principle we have successfully made telephones on the lines of Fig. 3,* with which we have received the large radio stations without any other detector. By using in the magnetic circuit of the telephone very fine wire such as is now obtainable commercially, the windings e_1 e_2 may be combined into one, a simplification of great practical importance. We have also described the use of a local oscillation of greater strength than the received signal.

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* See British Patents Nos. 100281 and 111475.

The telephone circuit is traversed simultaneously by the local current $I \sin \omega_1 t$ and by the received current $i \sin \omega_2 t$. The resultant flux is proportional to $I \sin \omega_1 t + i \sin \omega_2 t$; the attraction of the diaphragm is proportional to the square of the flux,

$$i.e., \text{ to } I^2 \sin^2 \omega_1 t + i^2 \sin^2 \omega_2 t + 2Ii \sin \omega_1 t \sin \omega_2 t \quad \text{or}$$

$$\frac{I^2}{2} - \frac{I^2}{2} \cos 2\omega_1 t + \frac{i^2}{2} - \frac{i^2}{2} \cos 2\omega_2 t + Ii \cos (\omega_1 + \omega_2) t + Ii \cos (\omega_1 - \omega_2) t.$$

The first five terms of this expression give rise either to continuous attraction of the diaphragm or to vibrations of a very high frequency of twice the frequency of the local received current, a frequency which the telephone diaphragm would not be able to follow. The last term represents, on the other hand, a periodic attraction which may be of musical frequency, if the difference $\omega_1 - \omega_2$ be sufficiently small.

It should be noticed that this attraction is not only proportional to the received current, but also to the local current. It is therefore possible to increase the sensitiveness of reception by increasing the local current, but at the same time it must be remembered that the permanent attraction represented by the first two terms in I^2 tends to prevent the vibration of the diaphragm.

The analogous case of the ordinary telephone which we have analysed in a previous paper in the *Lumière Electrique* of June 28th, 1916, obviously applies here, as the local high frequency source may be regarded as replacing the permanent magnet or the source of excitation of continuous current in the case of the electromagnetic telephone. A high frequency telephone without a predominating local high frequency source, with $I = i$ for instance, would have a very small sensitiveness, like Leblanc's telephone, and could not be used in practice.

The amplitude of the vibration of the diaphragm is proportional to the current i, and distant or weak stations as well as strong stations will be received with strength proportional to the received antenna currents. This matter will be referred to later.

However, it is curious to notice that even if the property of rectification had not been already discovered (such as in the case of coherers, crystals, valves, etc.) the reception of wireless telegraphy signals would still have been possible by purely engineering methods, and by the means employed in electrodynamic machines. As the wavelength is increased, that is to say, as the frequency is diminished, this method of direct reception becomes more and more practicable. If we add that the currents for both transmission and reception can be produced by high frequency alternators, we see that the utilisation of the magnetic properties of iron alone is sufficient for all wireless communication.

It is noticeable that the sensitiveness of the telephone described previously is very small for atmospherics, as these cannot give true beats with the local current. We have therefore a telephone without a permanent magnet which is sensitive only to beats produced by a local H.F. current, and thus a strong current of 1,000 frequency in the aerial circuit of Fig. 3 would give but a comparatively feeble sound. Apart from special telephones for the reception of H.F. currents, an attempt has been made to use a local source, or heterodyne, for reception by beats, in cases where the high frequency current is detected or rectified.

This arrangement is the usual one at the present time. It is indicated in Fig. 4, where a secondary circuit is shown. D is the rectifying detector, and T the telephones which are of the ordinary type. In comparison with direct reception without heterodyne this method has an extraordinary sensitiveness for weak signals. In an article published in the *Electrical World* (New York), April 24th, 1915, the now well-known simple explanation of this fact was given for the first time.

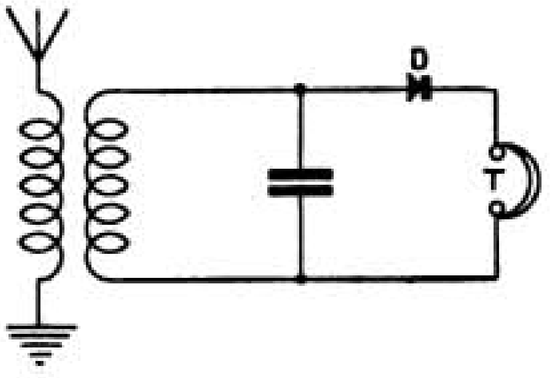

FIG. 4.

At the discussion on "The Probable Progress in the Reception of weak long-distance Radio Signals," held in March, 1914, by the Société Française des Électriciens, M. Henri Abraham said :—

"We know, but it is a fact little comprehended, that crystal detectors, valves and many other forms are really rectifiers of alternating current only when used for strong currents. But when they are actuated by weak long-distance wireless waves giving an E.M.F. often less than one volt, experience shows that *the rectified current from the detector is directly proportional to the square of the applied E.M.F. The output of the detector is proportional to the power of the oscillations to which it is subjected.*

"Besides the progress which is sure to be made in the transmitter, by increasing the power of the stations, the increase in the wavelength, and the improvement in the methods of aerial excitation, there remains much to be accomplished by improvements in the methods of reception. *It is essential that weak signals should produce as much response as the stronger ones.* Thus full effectiveness will be given to musical note transmission, and to sustained waves."

The heterodyne method of reception fulfils these conditions.

This progress depends not only on the beat method of reception, but also on the utilisation of a local generator. By this means, in fact, we can always obtain a current which may be as strong as desirable for good rectification, however weak the signals themselves may be. Consider the resultant of a local current $I \sin \omega_1 t$ and the received current $i \sin \omega_2 t$, referring everything to the frequency of the former we have :—

$$\begin{aligned} I \sin \omega_1 t + i \sin \omega_2 t &= I \sin \omega_1 t + i \sin \{\omega_1 + (\omega_2 - \omega_1) t\} \\ &= \sin \omega_1 t\,[I + i \cos (\omega_2 - \omega_1) t] + \cos \omega_1 t\,[i \sin (\omega_2 - \omega_1) t]. \end{aligned}$$

If $(\omega_2 - \omega_1)$ is small compared with ω_1, consider an interval of time very small compared with $\dfrac{2\pi}{\omega_2 - \omega_1}$ but several times as great as $\dfrac{2\pi}{\omega_1}$, then at a time

t, the maximum amplitude of the resultant current of frequency $\frac{\omega_1}{2\pi}$ will be the square root of the sum of the squares of the factors sin $\omega_1 t$ and cos $\omega_1 t$, *i.e.*, $\sqrt{I^2 + i^2 + 2Ii \cos (\omega_2 - \omega_1)t}$. The detector will give a rectified current proportional to the square of this expression, viz.,

$$I^2 + i^2 + 2Ii \cos (\omega_2 - \omega_1)t.$$

The first terms of this expression being constant, it will be the second, of the audible frequency corresponding to $(\omega_2 - \omega_1)$, which will be heard in the telephones. The sensitiveness of reception will be proportional to the local current I, and the signal strength proportional to the received current i. Evidently it is not possible to indefinitely increase the sensitiveness of the receiver by increasing the local current I. As a matter of fact, this sensitiveness will reach a maximum as we have previously indicated * for that value of the local current I corresponding to the critical value beyond which the rectified output of the detector is directly proportional to the current passing through it.

Without the heterodyne, a very small received current becomes, after detection, a quantity of the second order of smallness, whilst in heterodyne reception it remains of the same order. Thus we see at once the decided advantage of this method for weak signals. Heterodyne reception is much more suitable for undamped than for damped waves. We have elsewhere suggested † the use of the heterodyne in reception in wireless telephony in order to increase the sensitiveness. In view of the above it seems that the future of reception by heterodyne and detector is assured. However we must note the following points :—

By the use of the modern high frequency amplifier it is possible before detection to so magnify up a weak signal that the advantages of the heterodyne referred to above are no longer effective.

Recently M. Abraham introduced into France the reception of American stations without heterodynes. A sustained high frequency transmission simply gives place after detection to a continuous current the value of which can be recorded.

To fully appreciate the superiority or inferiority of this method of reception compared with that using the heterodyne, we must first take the point of view of the protection which they afford against atmospherics—always an important factor. Now as far as experiments have been made it still remains to be seen if, in reception by recording the received currents without heterodyne, we can hope to eliminate at least partially the recording of atmospherics. In an auxiliary receiver detuned from the incoming wave we can receive alone the same atmospherics as those which appear in the main reception, and can thus, as has already been shown, arrange the two records in opposition in order to obtain a single record of the signals. In order to obtain the same results with the heterodyne, we must use a supplementary detector to recover the continuous current. Besides being more complicated

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* French Patent No. 502041, February 11th, 1915.

† See French Patent No. 493924.

we lose when using this method the advantages of the sensitiveness of the other.

Another mode of reception comparable with the heterodyne as regards the elimination of strays, is that based on the modulation of the transmitter at low frequencies in order to render the signals directly audible after detection. M. Bethenod in 1908 suggested the use of a high frequency alternator excited by a low frequency alternating current. This excitation, on which we can advantageously superimpose a continuous current excitation (such as we have elsewhere suggested) can only be adopted in certain types of alternators having laminated inductors. Another means of modulating the transmitted current consists in introducing into the antenna circuit a reactance or inductance which can be varied. Messrs. Leonard and Weber in *L'Éclairage Électrique* of July 21st, 1906, suggested using the variation in the permeability of iron with its degree of saturation, not only to double the frequency of an alternating current with two transformers in accordance with the now well-known scheme, but also to vary at will the reactance of an iron-cored inductance, by more or less saturating its magnetic circuit by means of an auxiliary current. This arrangement, recently revived by different inventors, has been called a magnetic amplifier by Alexanderson. Fig. 5 gives a diagram of an antenna circuit including a variable inductance on the lines suggested in French Patent 501473. A central coil A is included in the antenna circuit, and the current for controlling the magnetic state of the iron is passed through the side coils BB. If these lateral coils are traversed by an alternating current at low frequency, the maximum values of which saturate the magnetic circuit, the radiation will be modulated at twice the frequency of the alternating current. But as we have said, by superimposing a direct current on this alternating current the modulation can be effected at the same frequency. We have also suggested making a variable inductance by mechanical means by inserting a small variable reluctance alternator in series in the antenna.

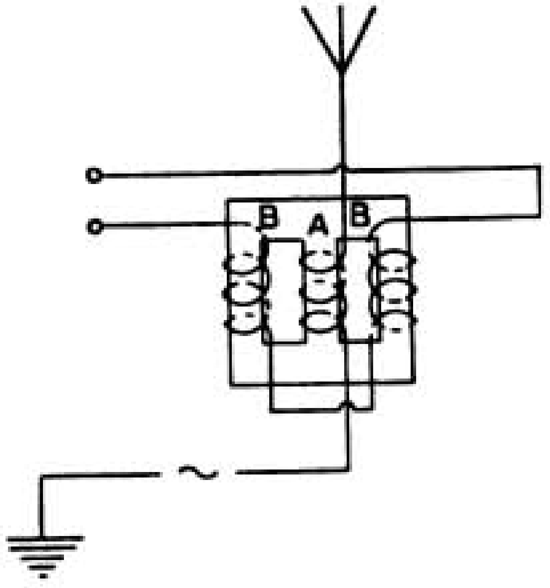

Fig. 5.

By all these methods we can obtain a high frequency transmission of $I \sin \omega t$, of which the strength varies periodically at low frequency corresponding to a pulsation α. The transmitted current will be $I \sin \omega t\,(1 - \sin \alpha t)$; it will pass through a maximum of $2I$ and a minimum of 0. The received current at low frequency with a detector which rectifies the high frequency current perfectly, will always be proportional to $2I$.

At the same time we can see the amount of energy supplied by the local generator or heterodyne in beat reception, and how much less can theoretically be used at the transmitter for the same signal strength. Using an ideal rectifier we should obtain the same telephone current in heterodyne reception as with the modulated transmission indicated above, in which the maximum value of the steady high frequency current is I. The heterodyne generator, if we compare the extreme instants where the local current and the received current are in phase and in opposition respectively, will be well within these conditions, and the effect will be the same as if the transmission were of intensity $2I$. In these two cases the energy in the antenna will be in the ratio of $\frac{3}{2}:1$ to produce equal effects in the receiver.

The reduction of power thus possible for a given signal strength using the heterodyne, though appreciable is far from being such as to be able to explain the great sensitiveness of this method of reception for weak signals, as several authors have claimed. As we have already said, the fundamental cause depends essentially on the modification of the rectifying properties of the detectors, when the strength of the high frequency current to be rectified is increased. It would therefore seem that modulation of the transmission ought to be the better method.

In practice in heterodyne reception, the musical note is determined at the receiving station by the frequency of the local generator itself. It is not a characteristic of the transmitting station. In modulated transmission on the contrary, the received note is a characteristic of the transmitter itself.

If we assume in the first case that a strong atmospheric discharge makes the antenna vibrate at the frequency to which it is tuned, that is to say at the frequency of the transmitting station, for a time long enough to produce beats, this discharge will of itself give rise in the receiver to the same note as that given by the transmitter. Doubtless the possibilities of this phenomenon will be reduced by receiving on a low note, as an oscillatory discharge must then last longer in order to give the same note as that of the transmitting station. The phenomenon is, however, always likely to occur.

On the contrary in the case where the note is formed by the modulation of the transmitted current no discharge will be able to give rise to a note identical with that of the transmitter. We must therefore conclude that acoustic resonance to the received note should be more useful for protection against atmospherics when the note is given by the transmitting station itself than when it is obtained by means of a local heterodyne. Doubtless future experiments will bring out this point.

Hence although we have shown the extraordinary sensitivity of the heterodyne and detector system for weak signals, we feel that we must conclude this paper with some degree of reservation as to the future of this system.

We have received a letter from M. Latour in which he points out that the term "wire radio" should be replaced by the more appropriate one "high frequency telephony and telegraphy." This system is older than radio-telegraphy, having been invented by M. Maurice Leblanc in 1891 and 1893 (French Patents 215901 and 239785). The use of power lines for high frequency telegraphy is described by Neu in French Patent 355442 of 1905.—ED.

The Breakdown and Protection of High Voltage D.C. Machines supplying Spark Transmitters.*

By K. W. WAGNER.

High-voltage D.C. machines were first used in spark transmitting stations by Marconi, who installed them at Clifden and Glace Bay. The diagram of connections is shown in Fig. 1. The battery B was installed to protect the dynamo from breakdown due to the spark gap. This battery, which proved expensive and troublesome, was removed and the inductance of the dynamo reduced by compensating windings. Fig. 2 illustrates an arrangement due to Lepel, which was in use for some time at Königswusterhausen. There are two sets of gaps in series, a rotating set at UU_1 and a quenched set at F. There are two condensers C, C_2 of which the latter is so connected to the rotating gap that it is reversed between successive sparks as shown diagrammatically in Fig. 2. The rotating gap acts as a reversing commutator. Arcing is here impossible since the circuit is never closed except through condensers. At the end of a discharge C and C_2 have equal voltages, during the succeeding interval C is charged to a higher voltage from the source whilst C_2 is reversed so that when the next spark occurs the voltages of C and C_2 are added. The current from the dynamo is thus stored in C until a spark occurs when C shares its charge with C_2; the charge of C_2 is then transferred from U to U_1 by the rotation of the commutator. The aerial is coupled to the coil L in the usual manner. The sending key K is shunted by a condenser C_u in series with a damping resistance to prevent damage to the contacts of the key by the discharge of C_u. C_1 represents a protective condenser if such be employed; if not it may be taken to represent the self-capacity of the dynamo. The first high-voltage dynamo employed broke down and was replaced by a 10,000-volt machine belonging to the Reichsanstalt which also broke down after a very short time. No protective

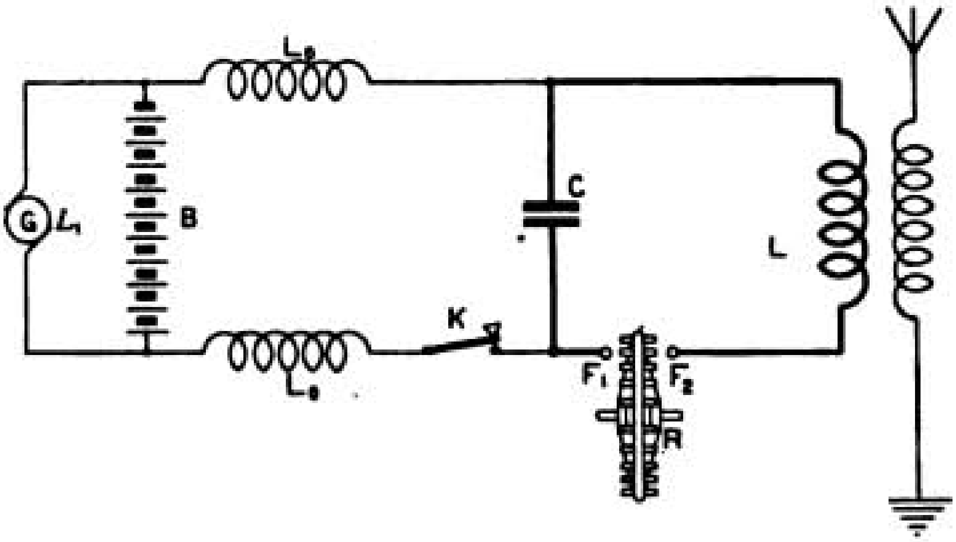

FIG. 1.

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* Abstracted from the *Elektrotechnische Zeitschrift*, July and August, 1920. See RADIO REVIEW Abstract No. 1388 in this issue.

condenser C_1 was employed. The failure of these two machines led to investigations as to the nature of the phenomena accompanying the discharges in the spark gap circuit. Calculations and tests agreed that the cause of the breakdown lay in the resonance of the whole charging circuit, consisting of the dynamo, the two choke coils L_0 L_0 and the main condenser C. It was also found that unless the key condenser C_u had a greater capacity than the main condenser C the greatest danger arose on opening the key.

The charging of the condenser C is oscillatory; assuming the capacity C to be $\frac{1}{3}$ μF, the inductance L_1 of the dynamo to be 24 H and the combined inductance L_2 of the choke coils to be 36 H, the resonant frequency is found to be 35·6 cycles per second. The self-capacity of the dynamo is negligible in this connection. As the rotating commutator gave 250 sparks per second,

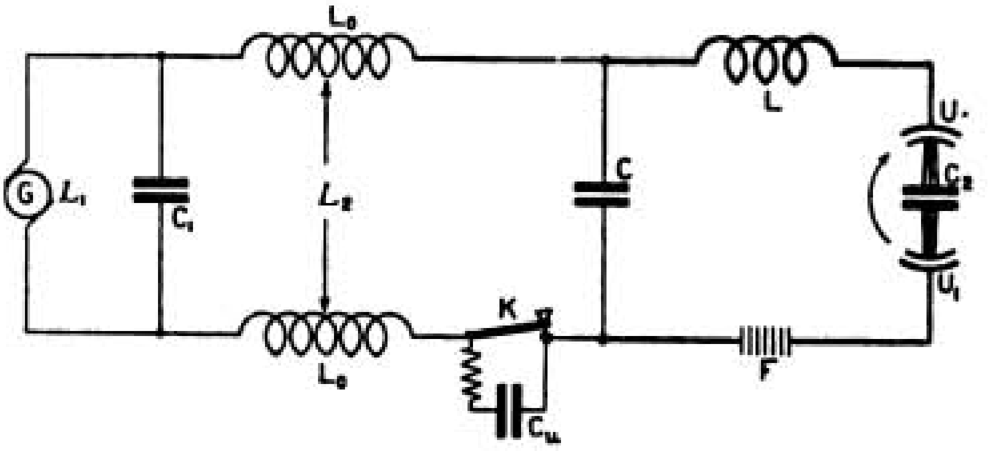

FIG. 2.

the charge occupied but a fraction of the resonant period of the charging circuit. (In the Marconi arrangement, on the other hand, it is customary to tune the charging circuit to resonance with the periodic discharge.) The spark discharge occupies a very short time during which the dynamo current cannot change appreciably; hence this current must have the same value at the beginning and end of the charging interval during which the current passes over the crest of its curve as shown in the upper part of Fig. 3. The voltage of C increases from V_e to V_a, then the spark occurs and C shares its charge with C_2 which still has a voltage of V_e but reversed. This reduces both to V_e, hence if C and C_2 have equal capacities as was the case $V_a - V_e = 2V_e$ and $V_a = 3V_e$. In the actual case V_a was 12,000 and V_e 4,000 volts. The voltage across C has therefore the saw-tooth wave-form shown in Fig. 3. If drawn to a larger scale, however, the vertical lines would be replaced by short intervals equal to the duration of the spark during which the voltage makes a damped oscillation as shown in Fig. 4. These sudden changes in the P.D. across C cause surges to travel along the choke coils in so far as their inductance is short-circuited by their capacity. The best method to protect the dynamo from the surges is to use air-core choke coils of small capacity to earth. This is preferable to the use of a large condenser shunted across the dynamo.

The P.D. of saw-tooth wave-form between the terminals of C contains very strong harmonics, some of which may cause resonance with the natural frequency of the circuit made up of the self-capacity of the dynamo winding together with the inductance of the dynamo and in parallel thereto the path through the choke coils and C, which has such a large capacity compared with C_1 that it may be regarded as a short circuit. The capacity C_1 can therefore discharge through two paths in parallel, viz., the generator ($L_1 =$ 24 H) and the choke coils ($L_2 = 36$ H). With no condenser connected across the dynamo terminals C_1 is due entirely to self-capacity and is estimated at $0{\cdot}875.10^{-8}$ F. This gives a resonant frequency of 450 which is dangerously near the frequency of the second harmonic, since the spark frequency was taken up to a maximum of 250 per second. The amplitude of the *n*th harmonic of the saw-tooth diagram in Fig. 3 is given by the equation—

$$E_n = \frac{E}{n\pi}.$$

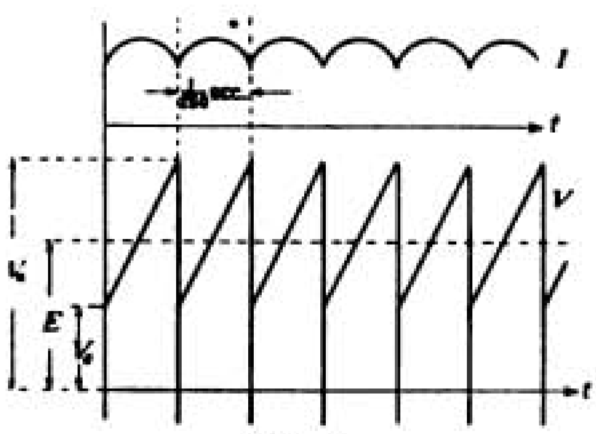

FIG. 3.

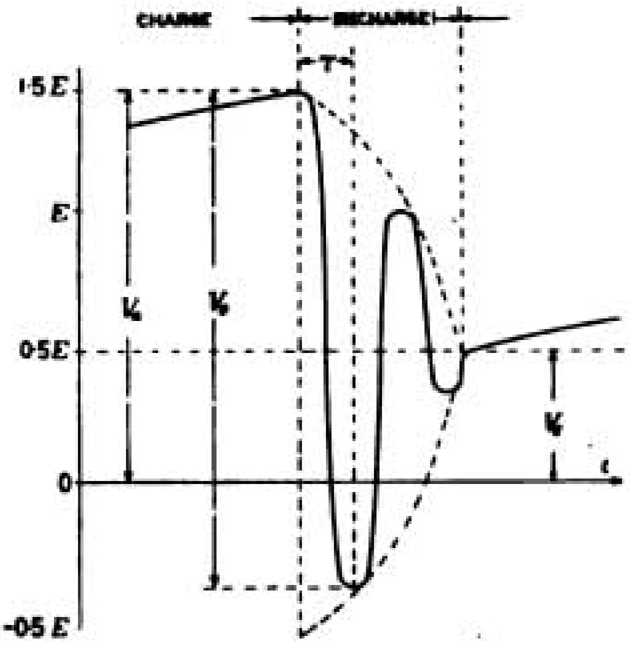

FIG. 4.

With an estimated value of 9,000 ohms for the effective resistance of the oscillatory system, it is possible to calculate the amplitude of the voltage due to the second harmonic, the value obtained is 14,500 V, which superposed upon the continuous pressure of 8,000 V gives a total of 22,500 V.

Another cause of excessive voltage is the sudden opening of the circuit on releasing the key K. The energy stored in the magnetic fields of L_1 and L_2 surges into the condensers C_1 and C_u thereby charging them to excessive pressures unless C_u is of sufficient capacity. At Königswusterhausen C_u was equal to $2C$ and it can be shown that this is ample to guard against trouble from this cause.

A model was made up to test the conclusions by means of an oscillograph; the results agreed with the calculations.

Two devices are suggested for minimising the effects of resonance. The first consists in connecting two condensers in parallel across the machine terminals with a resistance, however, in series with one of them. The latter absorbs energy and limits resonance effects, whilst the former prevents sudden pressure rises due to steep-fronted waves transmitted back from the spark gap. The second device which may be used alone or in conjunction with the first consists in shunting a portion of one of the choke coils with a suitable resistance; the same result can be obtained by putting the resistance across an independent winding on the same iron core as the choke coil, or even by making the core solid and utilising the eddy current losses as a means of damping.

According to Lepel who was in charge of the station at the time, the breakdown of both machines was due to a very simple fault, viz., to the breaking down of the insulation of the air-cored choke coils thus subjecting the machines to the effects of the spark gap with no protection beyond the iron-cored choke coils the capacity of which was too great to make them effective as a protection against the sudden changes of potential.

[In a paper in the *Archiv für Elektrotechnik* * Rogowski has published a mathematical investigation into the causes of the same breakdown. He disagrees with Lepel's explanation and maintains that the breakdown of the insulation of the armature was due entirely to resonance phenomena.—ED.]

Electrical Measurements at Ultra-Radio Frequencies.†

By G. C. SOUTHWORTH, M.S.

INTRODUCTION.

In a previous paper‡ sources of alternating currents of ultra-radio frequencies were described. Methods were also given for measuring the length of standing waves produced on a parallel wire circuit when excited by a very high frequency source. The sharpness of resonance obtained for this type of tuning suggests that various other electrical measurements may be made with a similar accuracy. This as we shall see is true. The methods involved are similar to those used by Drude§ in measuring the dielectric constant of liquids but are simpler and more accurate because of the use of continuous oscillations.

Measurements at radio frequencies are usually made in simple circuits consisting of localised inductance and capacity with the resistance reduced to a minimum. A determination of frequency merely consists of adjusting the circuit to resonance with the impressed E.M.F. and computing the frequency from known circuit constants. This condition of resonance is sometimes expressed in terms of the length of the wave that would be radiated at that frequency.

Determinations of inductance and capacity are made by forming resonant circuits involving the unknown coil or condenser. Later an adjustable standard replaces the unknown and the resonant condition is reproduced. This requires that suitable standards be maintained. Standards of capacity when properly constructed may be calibrated at low frequency, and this calibration may be assumed to hold for radio frequencies. A coil on the other

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* *Archiv für Elektrotechnik*, 9, p. 191, September, 1920. (Abstract No. 1387 in this issue.)

† Received November 9th, 1920. ‡ RADIO REVIEW, 1, pp. 577—584, September, 1920.

§ *Wiedemanns Annalen*, 61, p. 466 (1897).

hand possesses other properties than inductance which cause its calibration to change with frequency. The coils used as standards of inductance are compared with a calculable inductance consisting of a square several metres on a side.* After making corrections for distributed capacity, the various coils are cross checked when used in circuits involving condensers of known capacity. There are many objections to these standards of inductance, but up to the present time no better scheme has been proposed.

The damped sources of current formerly used permitted of radio measurements with errors of about 5 per cent. The use of the electron tube generator now enables such measurements to be made with errors of less than 1 per cent. In all cases radio measurements require a great amount of care and skill in eliminating the various errors. At frequencies of about 3×10^6, corresponding to a wavelength of 100 metres, measurements in circuits having lumped constants become very difficult. This is due to the necessarily small dimensions of the coils and condensers used and the uncertain distribution of the stray inductances and capacities introduced by lead wires and instrument cases. The measurements may however be made in a parallel wire circuit at all the frequencies from those used in radio to the highest yet obtained with the electron tube.

THEORY OF PARALLEL WIRE CIRCUITS.

In order to show that measurements of inductance and capacity may be made in circuits having distributed constants it is necessary to investigate the properties of such circuits (Fig. 1).

The method of treating them can only be outlined here.

Designating the inductance, capacity, and resistance per unit length by L_1, C_1 and R_1, we obtain for the fundamental differential equations

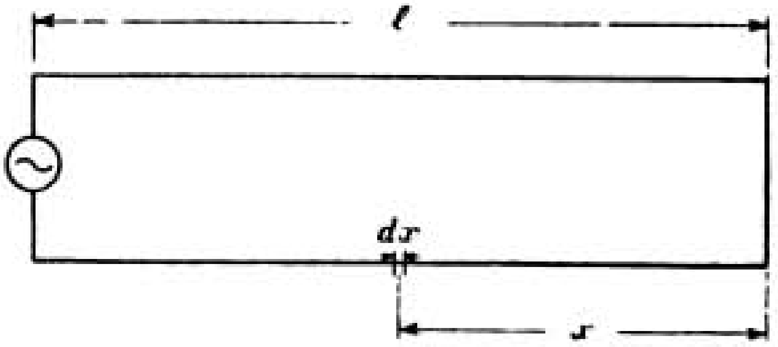

FIG. 1.

$$L_1 \frac{di}{dt} + R_1 i = -\frac{dv}{dx}$$

$$C_1 \frac{dv}{dt} = -\frac{di}{dx}$$

Assuming a sinusoidal voltage and current, these equations reduce to

$$L_1 j\omega i + R_1 i = -\frac{dv}{dx}$$

$$C_1 j\omega v = -\frac{di}{dx}$$

which after differentiating and separating the variables become

$$\frac{d^2v}{dx^2} = p^2 v \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

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* U.S. Bureau of Standards Circular 74, p. 100.

$$\frac{d^2i}{dx^2} = p^2 i \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

where $$p^2 = j\omega C_1(j\omega L_1 + R_1).$$

The solutions of equations (1) and (2) are

$$i = A\epsilon^{px} + B\epsilon^{-px} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

and $$v = \frac{p}{C_1 j\omega}\left\{A\epsilon^{px} - B\epsilon^{-px}\right\} \quad . \quad . \quad . \qquad (4)$$ [redacted] ok

where A and B are constants determined by the boundary conditions and p is the propagation constant which consists of a velocity constant

$$\beta = \sqrt{\omega^2 L_1 C_1 + \frac{R_1^2 C_1}{4L_1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (5)$$

and an attenuation constant

$$\alpha = \frac{R_1}{2}\sqrt{\frac{C_1}{L_1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

such that $$p = \alpha + j\beta.$$

To find the values of A and B we must state boundary conditions. The method is applicable to the case of a line with open or closed ends. In the case of a line with closed end—

when $x = 0$, $v = 0$, and $A = B$.

When $$x = l,\ v = E$$

and $$E = \frac{p}{C_1 j\omega}\left\{A\epsilon^{pl} - B\epsilon^{-pl}\right\}$$

or $$B = A = \frac{EC_1 j\omega}{p}\left\{\frac{1}{\epsilon^{pl} - \epsilon^{-pl}}\right\}.$$

Hence $$i = \frac{EC_1 j\omega}{p}\left\{\frac{\epsilon^{px} + \epsilon^{-px}}{\epsilon^{pl} - \epsilon^{-pl}}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (7)$$

which reduces to $$i = \frac{EC_1\omega}{\sqrt{\alpha^2 + \beta^2}}\sqrt{\frac{1 + \cos 2\beta x}{1 - \cos 2\beta l}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (8)$$

if the attenuation constant be neglected.

The periodic time function has been omitted because we are concerned only with the amplitude. Equation (8) shows the current distribution along the conductor as well as the maximum current for any adjustment of l.

When x is so chosen that $\cos 2\beta x = \cos 2\beta l$

$$i = \frac{E\omega C_1}{\sqrt{\alpha^2 + \beta^2}}\cot \beta l \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (9)$$

Taking $\frac{i}{E} = Z$ we get $$Z = \frac{\omega C_1}{\sqrt{\alpha^2 + \beta^2}}\tan \beta l \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (10)$$

Substituting the approximate values of α and β in equations (5) and (6), it follows that

$$Z = X = \sqrt{\frac{L_1}{C_1}} \tan l\omega\sqrt{C_1 L_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

is the effective reactance for the point $x = l$.

It may also be shown that for an open end line

$$X = -\sqrt{\frac{L_1}{C_1}} \cot l\omega\sqrt{C_1 L_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Plotting $X = \sqrt{\frac{L_1}{C_1}} \tan l\omega\sqrt{L_1 C_1}$, we obtain the familiar tangent curves shown in Fig. 2.

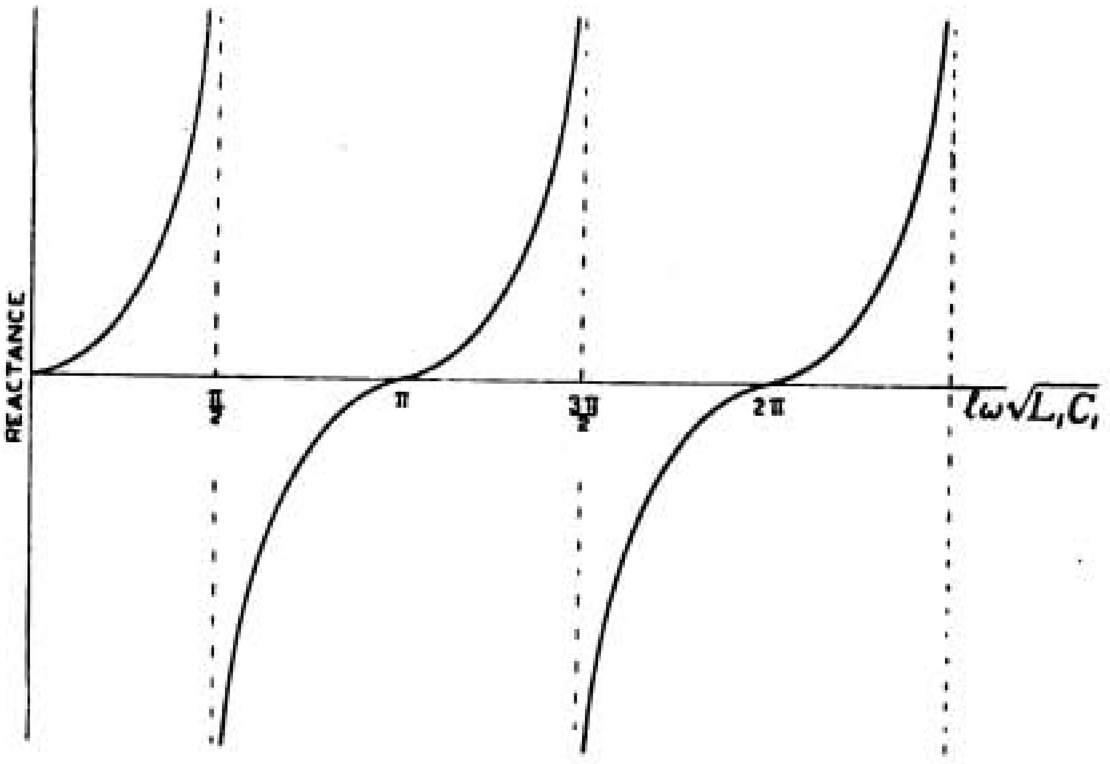

Fig. 2.

If $$l\omega\sqrt{C_1 L_1} = m\pi$$

the wavelength $$\lambda = \frac{2l}{m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$ ←

where m is any integer, since the velocity of propagation $c = \frac{1}{\sqrt{L_1 C_1}}$ and $\omega = 2\pi f = \frac{2\pi c}{\lambda}$.

If we place a reactance in the line where $x = l$ we may equate the sum of the reactances to zero to determine the condition of resonance. If it be an inductance,

$$\omega L + \sqrt{\frac{L_1}{C_1}} \tan l\omega\sqrt{L_1 C_1} = 0$$

or
$$L = -\frac{\lambda}{2\pi} L_1 \tan \frac{2\pi l'}{\lambda} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (14)$$

where l' is the length of the wires for resonance after the inductance L has been added. It will be seen that resonance is obtained when the angle $\frac{2\pi l'}{\lambda}$ is measured in the second or fourth quadrants. If $\frac{2\pi l'}{\lambda}$ is small, $L = l'L_1$.

If a condenser be placed in the end of the parallel wire system

$$-\frac{1}{\omega C} + \sqrt{\frac{L_1}{C_1}} \tan l\omega\sqrt{L_1 C_1} = 0$$

or
$$C = C_1 \frac{\lambda}{2\pi} \cdot \cot \frac{2\pi l'}{\lambda} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (15)$$

where C is the capacity of the condenser.

When $\frac{2\pi l'}{\lambda}$ is large $C = l'C_1$. If the length of the parallel wire circuit be so chosen that $m = 1$ and its constants be computed, equations (13), (14) and (15) become

$$\lambda = 2l \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (16)$$

$$L = -Kl \tan \frac{l'}{l} 180^\circ \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (17)$$

$$C = K'l \cot \frac{l'}{l} 180^\circ \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (18)$$

which are convenient for application to measurements. These equations are based on the assumption that the velocity of propagation is independent of the wavelength and is the same as that of light in free space. This is correct if the resistance of the conductors is not too large compared with their inductance and the circuit is so arranged that no materials of high dielectric constant come within its field. By referring to equation (5) above, it will be seen that resistance errors are improbable for frequencies corresponding to wavelengths of one or two metres. At radio frequencies however this effect may be of considerable consequence.

EXPERIMENTAL.

In order to measure inductance or capacity with the apparatus described in the author's previous article, it is necessary to adjust the length of the parallel wires to resonance with the applied E.M.F. This length gives the value of (l) used in the formulæ above. The coil or condenser is then inserted in the end of the line and the circuit again adjusted to resonance. This gives (l'). Substituting these values in equations (17) or (18) the results follow with very little mathematical work.

This method has been used in obtaining data regarding the internal capacities of various types of electron tubes. It was found to be exceedingly rapid as well as accurate. If it is desired to measure several small capacities at a single wavelength, each value of (l') may be determined in a few seconds.

An experiment was made to determine the accidental error in measuring wavelength. Twenty independent observations were made with the generator set at a given frequency. The mean result was **188·330** cm. with a mean deviation of 0·050 cm. In order to determine the accidental error in measuring the capacity of a small parallel plate condenser, twenty observations were made at wavelengths varying from 115 to 270 cm. No progressive error could be detected. The result was **3·68** μμF with a mean deviation of 0·07 μμF. The method was applied to the measurement of the capacity between the plate and grid of an electron tube and an interesting progressive error developed as is shown by the table.

Wavelength λ cm.	Apparent capacity C_a μμF.	Corrected capacity C_0 μμF.
169·6	11·72	7·87
176·8	11·54	8·02
188·8	10·40	7·75
223·0	9·71	7·85
231·6	9·61	7·92
233·2	9·45	7·80

The progressive error in the capacity is readily explained by the inductance effect of the lead wires. If we assume it to be the case of an inductance and capacity in series it is equivalent to the reactance of a certain apparent capacity C_a

so that
$$\omega L_0 - \frac{1}{\omega C_0} = -\frac{1}{\omega C_a}$$

or
$$C_a = \frac{C_0}{1 - \omega^2 C_0 L_0}.$$

The third column gives the value of the capacity obtained by correcting the apparent capacity for inductance effects. The inductance necessary to explain this effect would be 0·034 μH. The measured capacity at radio frequencies is 7 μμF. The errors of the radio methods do not permit of any greater accuracy on such small capacities. It may be shown that the apparent capacity would decrease with increase of frequency if there were losses in the dielectric.

Five observations were made on the measurement of the inductance of a small coil of wire. The final result was 0·121 μH with a mean deviation of 0·002 μH.

Measurements of current and resistance have not been investigated, but this problem is not as easily solved. Possibly an expression for resistance may be obtained in terms of the relative sharpness of resonance curves. If standards of resistance are required, such methods will be applicable only to wavelengths greater than perhaps 30 metres ($f = 10^7$) because of the change of resistance of the standards with frequency.

Continuous oscillations have been used to measure the difference in the velocity of propagation along iron wires and those of copper and German silver. The dielectric constant of water has also been measured with continuous oscillations by two methods. ⟨In one the capacity of a condenser using water as a dielectric is measured and compared with its capacity when air is the dielectric. By the other method the Lecher system is immersed in a tank of water and the wavelength measured and compared with that for air. In the latter method the resonance points may be located very accurately by noting the changes in the plate current of the generator as the resonance points are approached.⟩

While the tests of the above methods were made at the shorter wavelengths, it is obvious that it is applicable to the entire range of wavelengths beyond those used in radio; however it would be rather inconvenient to work with a circuit 50 metres in length. It would be especially desirable to extend these methods to the radio frequencies in order to check the so-called standards of wavelength which at present are based on the standards of capacity and inductance described above, as any standard should be arrived at by more than one method. [See Note on p. 1.—ED.]

Yale University. *October 15th, 1920.*
New Haven, Conn., U.S.A.

Inaugural Address to the Wireless Section of the Institution of Electrical Engineers.*

By W. H. ECCLES, D.Sc. (Chairman of the Section).

The address opened with a few remarks concerning the formation of the Wireless Section of the Institution of Electrical Engineers, and continued with a brief review of the papers and lectures delivered before that Section summarising the war-time development of the various branches of radio work. Some of these papers, said Dr. Eccles, provoked a number of inquiries and suggested further research work. Notable among these was one by Mr. B. S. Gossling which described the results of several years' work on thermionic valve development in the Service laboratories.

In the use of these tubes certain results are obtained even in respect of such a fundamental parameter as the voltage factor which have not yet been fully discussed.†

The results of some measurements of voltage factor with varying grid voltage and filament current were shown in the form of curves, and of these an interest-

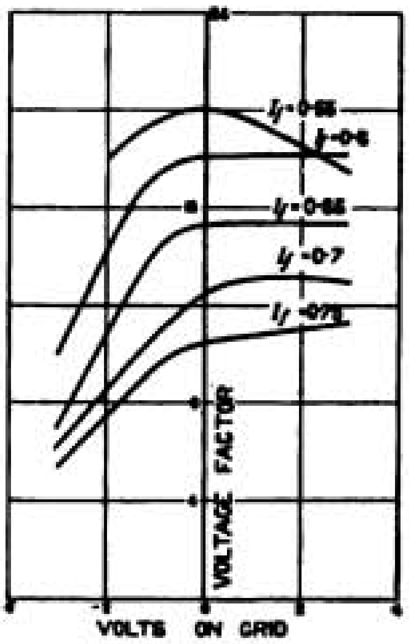

FIG. 1.

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* Address delivered at the opening meeting of the session on Wednesday, November 24th, 1920—abbreviated.

† See RADIO REVIEW, 1, pp. 283—285, March, 1920, for abstract.

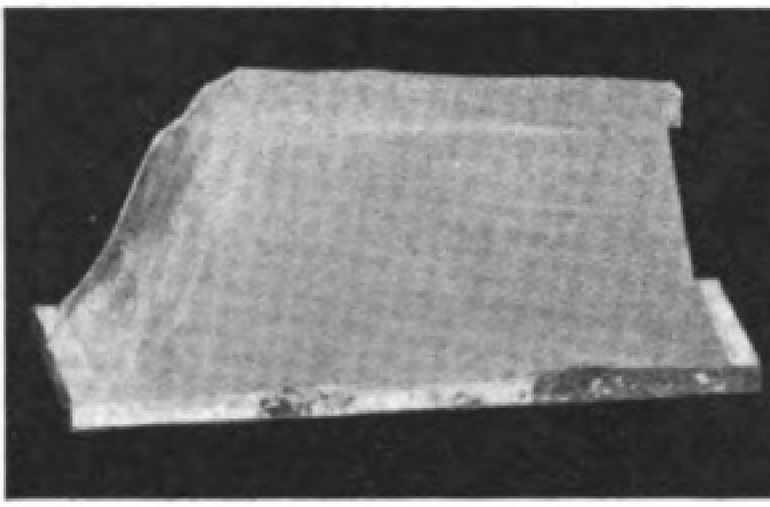

FIG. 2.

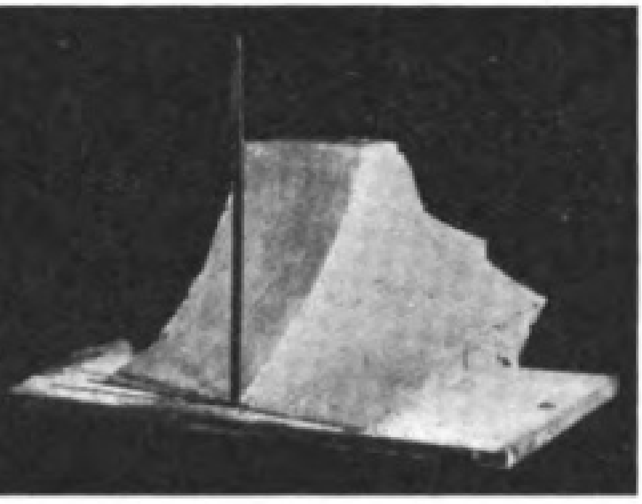

FIG. 4.

ing series is reproduced in Fig. 1. The reason for the variation of the voltage factor arises out of the unevenness of the temperature of the filament to some extent, but chiefly out of the drop of voltage along the filament.

Curves showing the variation of the average value of the voltage factor as the filament current is altered bear a striking likeness to the curves depicting the results of some measurements made by Dr. Vincent in 1919 on the change of the wavelength of the oscillations generated by a triode under certain conditions. Perhaps these changes owe their origin to variations in the average value of the voltage factor.

Among other insufficiently investigated properties of the triode are those associated with certain portions of the characteristic surfaces which may be used to represent all the principal properties of the tube. When the filament current and voltage are kept constant there remain four principal variables, namely, the anode current i_a, the grid current i_g, the anode voltage e_a, the grid voltage e_g. If we represent anode current and grid current separately each of these must be regarded as a function of the two independent variables e_a and e_g.

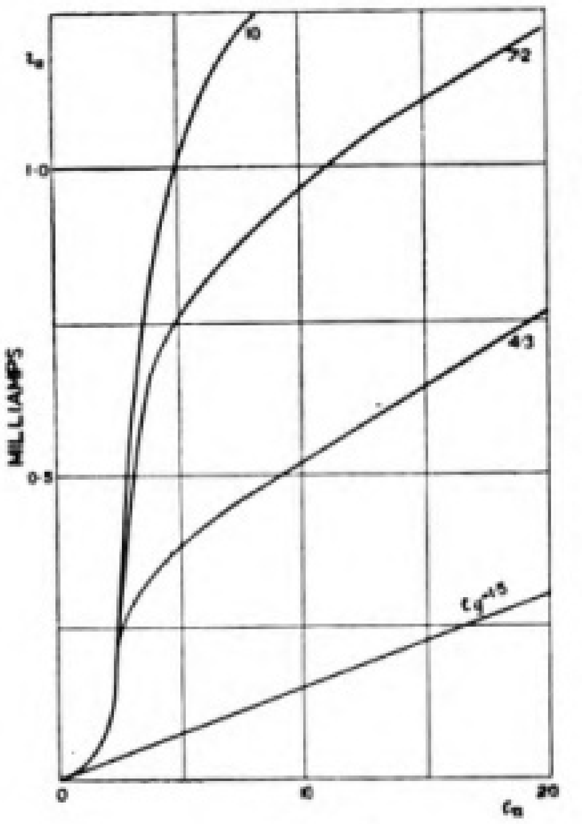

FIG. 3.

These variables may be represented by three axes at right angles, the anode and grid voltages being represented by the two horizontal axes, while the vertical one is used to represent either grid or anode current.

Upon these axes we may erect surfaces to represent the current flowing in a triode at any assigned values of the two voltages by measuring off to scale these voltages along the appropriate axes and erecting at the point so determined a vertical with two ordinates equal in value to the observed currents. When this is done we obtain for the anode current such a surface as is shown in the photograph of Fig. 2. The flat top represents the saturation values, the concave sloping surface at the right-hand side follows in the ideal case the three-halves power law, and normally only a small part of this area on the extreme right hand of the picture is utilised. On the left hand where the surface descends in a kind of cliff to the axis of the grid voltage we have a region little investigated and scarcely utilised as yet. This surface was constructed from curves such as those of Fig. 3 which are in fact sections of the surface made by vertical planes parallel to the axis of anode voltage and represent what happens to the anode current, at various constant grid voltages, as the anode voltage is increased. It will be noticed that at low anode voltages the anode current rises very rapidly. In the next figure (Fig. 4), which is a photograph of a model of a grid current surface, it is seen that at low anode voltages the grid current falls rapidly as the anode voltage is increased from zero. On the left hand of the sharp ridge are represented values of grid current when the anode voltage is negative, that is to say when practically no anode current is flowing. The concave sloping part obeys the three-halves power law and the flat top represents saturation. Fig. 5 shows shapes of the grid characteristics from which such a surface as that of Fig. 4 is prepared. All the familiar characteristics seen in books and papers can be obtained from these surfaces by making sections.

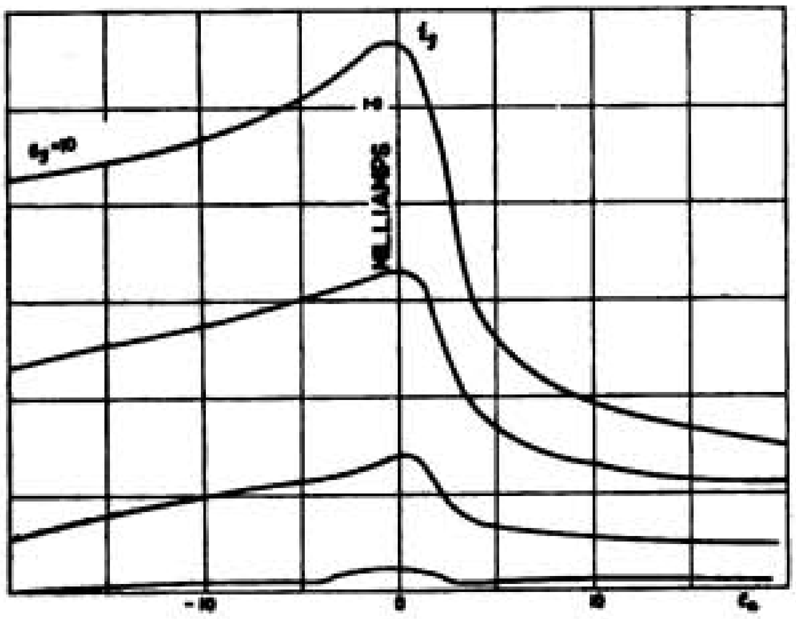

FIG. 5.

The rapid rise of anode current and accompanying fall of grid current in the region of low anode voltages requires explanation.

When the grid is slightly positive and the anode at zero voltage the electrons starting from the cathode with considerable normal velocity may perform wide orbits round the grid wire but are finally drawn into it.

But if the anode is slightly positive many of the electrons not passing too near the grid wire end their career on the anode. It may be shown that the grid current has the value $i_g = A'(e_a + \nu e_g)^{\frac{3}{2}} \exp\{-\alpha\sqrt{(e_a/e_g)}\}$ and that the anode current is given by $\log(1 + i_a/i_g) = \alpha\sqrt{(e_a/e_g)}$ at low voltages, when ν is the voltage factor and A' and α are constants that are different for each tube. For ordinary reception triodes α has the value 1·3 approximately.

These considerations call attention to a fact that does not appear to have received adequate notice, namely that the grid in a triode may exert two distinct types of action. The type just described which is characterised by having the bulk of the grid current contributed by electrons that have suffered great lateral deflections, may be called a snatching action; the other type of action which is that usually utilised in triodes, is of the nature of an acceleration or deceleration of the motion of the electrons from the cathode to the anode; in brief, one type of action by the grid is mainly a lateral attraction of electrons the other is mainly a longitudinal effect in the direction of motion. The steep surfaces near the axes of grid voltage in Figs. 2 and 4 are due to the snatching action.

In Fig. 6 is shown a surface representing by its ordinates both the grid and anode currents of an ordinary form of triode. It is seen that the snatching action that goes on between the grid and the anode at low anode voltages produces a gully separating the two surfaces. The question immediately arises: What is there beyond the region embraced by this figure? Very little published information is available for answering this question, but during the past eighteen months I have had parties of students studying the geography of the gully and the plateaux seen in Fig. 6. In particular I have to mention the work of Mr. L. Grinstead and Mr. T. W. Price in this connection. As a result I am able to give in Fig. 7 a photograph of a surface representing most of the properties of ordinary triodes. The gully noticed in the previous figure is seen to take a sharp turn. On the extreme right of the model a section taken at a fixed and fairly high anode voltage is seen, and this section is therefore the characteristic curve of the grid and anode currents as the grid voltage varies. On following the curve of section from front to back the anode current is seen to rise from zero to a maximum as the grid voltage rises to remain nearly constant till the gully is reached and there to descend suddenly; during this descent the grid current rises and becomes greater than the anode current. The plateau beyond the gully belongs to the grid current. This is not strictly what happens in an ordinary exception triode but certain types of tube give such a surface with fair reactitude. A form of triode described by Major Erskine-Murray gives a characteristic very like that shown by this section of the model.

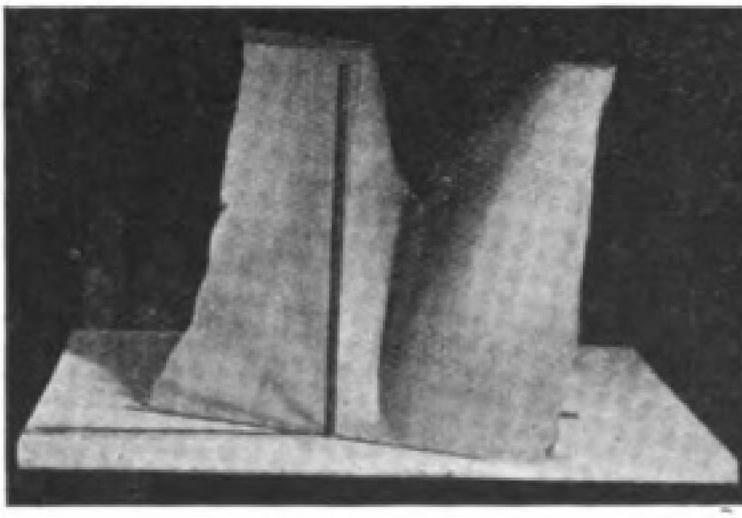
Fig. 6.

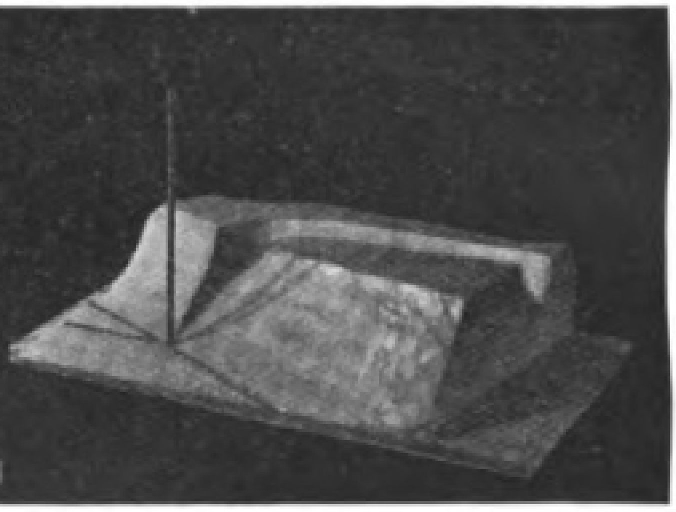
Fig. 7.

Another paper read before this section which was vastly provocative and stimulating was that by Captain H. J. Round on Directive Telegraphy. Captain P. P. Eckersley has suggested that much of the observed directional error might arise from the rotation of the plane of polarisation of the signal bearing waves by reflection at non-level portions of the Heaviside layer between the sending and receiving stations. I am not going to suggest another reason than that just stated for the production of waves with rotated planes of polarisation, but to show the errors caused by such rotation, however produced.

If the ray is represented by a straight rod fixed at an inclination to the horizontal, in the daytime the magnetic force which is perpendicular to this rod is horizontal and the frame will give true directions. For the receiving frame aerial to receive no signals it must be placed so that none of the magnetic force of the waves is linked with it, *i.e.* it must be set so that the direction of the magnetic force of the wave lies in the plane of the coil. But now suppose that at night the plane of polarisation is rotated in any manner, the frame must then be rotated also in order to satisfy the above conditions. That is to say the apparent direction of the source of the radiation, namely, the perpendicular to the frame aerial, is erroneous. It is easily seen that if γ is the error, α the inclination of the ray to the horizontal, and β the rotation of the plane of polarisation, then $\tan \gamma = \sin \alpha \tan \beta$. Thus if it be true that the trajectory of the ray always lies in a vertical plane through both stations, the error in azimuth enables us to compute the angle at which the ray descends to the receiving station. A model was shown to illustrate these effects.

But there still remains the problem of the cause of the rotation of the plane of polarisation. Those who have thought about the behaviour of an ionised atmosphere towards electric waves passing through it will see at once that the earth's magnetic field will introduce obliquity into the motion of ions propelled by the electric force of the waves. Waves passing over any particular ion evidently impart to it a to and fro motion of the same period as that of the waves but lagging behind the electric force of the waves by about a quarter period on account of inertia. The question is: What magnitude of magnetic field is required to produce an oblique component of velocity of the same order of magnitude as that produced by the electric force of the waves? On taking the case of an oxygen ion I find that a magnetic field of 1,700 C.G.S. units is required; for a hydrogen atom 100 units, for an electron 0·06 unit. Now the earth's magnetic field at the surface has a horizontal component of about 0·18 unit. Therefore if I have made no mistake in the arithmetic, a rotation such as is demanded by the observed facts of directive wireless telegraphy could be furnished by the passage of the waves through a space containing free electrons.

If part of the primary waves from the sending station get through to the receiver as well as those which have travelled through the upper levels of the atmosphere, the minimum will be ill marked—in fact the simultaneous reception of the primary waves and the secondary waves in time quadrature will be equivalent to reception of elliptically polarised waves. Leaving aside the primary wave, which does not necessarily cause any directional error, we can show that waves travelling from the south through a high layer of free electrons should give rise to a westerly error if the above conclusions are correct, waves from the north give also a westerly error; waves from the east and from the west give southerly errors. It ought to be possible to test these conclusions by observations.

The velocity gained by an electron in waves of the same field intensity is greater the lower the frequency. Thus long waves should give greater directional errors than short waves.

The information gained from observations made with directive aerials must be combined with the knowledge furnished by the analysis of the records of magnetic variations and magnetic storms. Magnetic storms are considered by Professor Chapman to be mainly due to currents in the auroral layers, and these never come lower than about 100 km. Below this is a layer about 50 km thick in which flow the currents causing much of the diurnal variation of the magnetic elements. Professor Chapman suggested that the auroral layer was conducting chiefly because of the presence of alpha particles that had come from the sun; I think that wireless investigators would suggest that the layer beneath the auroral layer is occupied by electrons that have come as beta rays from the sun.

It would seem that the base of this region charged with free electrons must be regarded as the ceiling usually known as the Heaviside layer. I suggest that the diurnally ionised layer below about 50 km is ionised by the gamma rays and other ultra-violet rays from the sun and involves the splitting of electrons from molecules to make positive ions; and at the gas pressures in fairly low levels many of the electrons will combine with neutral molecules to form negative ions. Both positive and negative ions of molecular size give rise to ionic refraction and the arched trajectory of the Hertzian rays, and incidentally to absorption also. Professor Watson's solution of the daylight propagation problem takes account at least partially of such a layer of conducting gas and from his result we may deduce that if the ionisation is effective down to 25 km the conductivity need not be a quarter as great as that of sea-water in order to ensure results such as are summarised in the Austen-Cohen empirical formula.

Dr. Graham Bell, whom we are so glad to welcome here to-night, has told us that this section of the Institution represents to him the advance guard of the British electrical world. It seems to me that in our subject we live nearer the growing edge of electrical science than in other branches of engineering. There is infinite scope for knowledge, discovery, invention and imagination; and I am delighted to know that Dr. Graham Bell is also of that opinion.

And along some of the avenues of our particular technology we may catch glimpses of the radiant expanse of the dawning electrical age. The thermionic vacuum tube in itself contains for the engineer of vision some of the most resplendent of these vistas. For from the glowing filament the most subtile and potent of all the gases is evaporated, namely, the gas made up of pure electrons, a gas we cannot at present harness as easily as steam is harnessed, but which must take its turn as a servant of man. And in those future days strange engines of giant strength, utilising electrostatic forces and thermodynamic cyclics as yet unimagined, will be fed with electrons urged by millions of volts along vacuous conduits and will be presided over by matterless switches. And the people of that age will look back and wonder why we in the twilight of the age of steam were so long content to poke slow floods of electricity through the crowded atoms of copper cables.

Wireless Telegraphic Printing on the Creed Automatic System.*

By A. A. CAMPBELL SWINTON, F.R.S.

So far as the purely wireless instruments used for this demonstration are concerned they are nothing very special. We have a small aerial on the roof of the building, and connected to this through the ordinary tuning inductance and adjustable condenser there is a five-valve resistance amplifier working in conjunction with a three-valve transformer coupled note-magnifier, to which the telephones and other apparatus is connected. This latter consists firstly of a low frequency transformer connected to the grid of a separate single valve which has a 15-volt battery connected in its grid circuit to maintain the grid potential at a suitable negative value. In the plate circuit of this valve is a special relay designed by Mr. R. Carpenter of Messrs. Creed and Company, Ltd., which is connected to a standard P.O. relay through two resistances each of about 1,000 ohms. This P.O. relay in turn operates a power relay also of Mr. Carpenter's design. This last relay has no electrical contacts but its tongue operates directly the pneumatic slide valve of the Creed receiver to control the air supplied to a small cylinder the piston of which is therefore moved from side to side in accordance with the signals which actuate the relay tongue. The movements of this piston are transmitted by means of suitable mechanism to the valve controlling the double-acting piston of the main tape punching mechanism. The incoming wireless

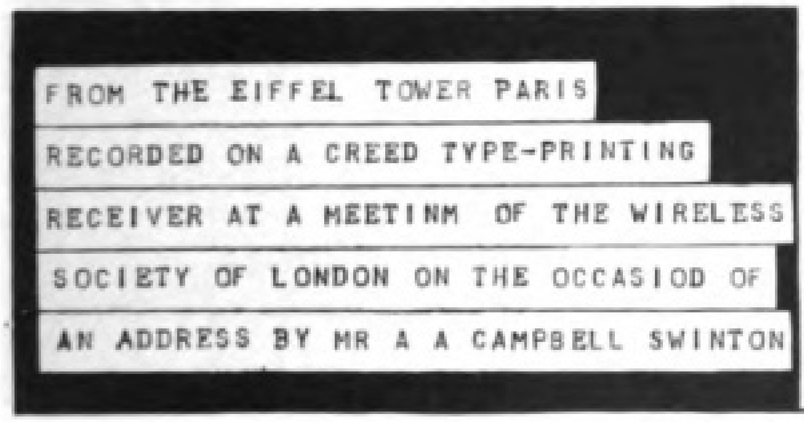
FROM THE EIFFEL TOWER PARIS
RECORDED ON A CREED TYPE-PRINTING
RECEIVER AT A MEETINM OF THE WIRELESS
SOCIETY OF LONDON ON THE OCCASIOD OF
AN ADDRESS BY MR A A CAMPBELL SWINTON

FIG. 1.

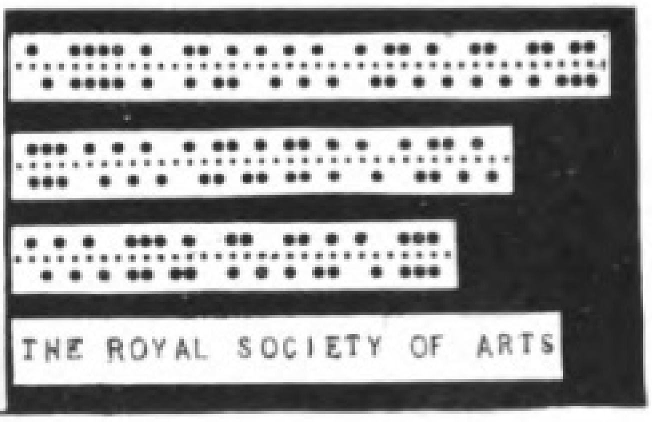
THE ROYAL SOCIETY OF ARTS

FIG. 2.

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* Abstract of paper read before the Wireless Society of London on November 18th, 1920.

signals are thus amplified up sufficiently to operate the mechanism of this punching machine and enable the message to be taken down in the form of an ordinary Wheatstone type of punched strip.

The remainder of the paper was devoted to an illustrated description of the slip perforating mechanism and of the printing machine through which the slip is subsequently passed in order to yield the final message printed in Roman characters.

A special message was sent from the Eiffel Tower, Paris, which was picked up by the apparatus at the meeting and taken down on the strip. A portion of this message as actually received is reproduced in Fig. 1, while in Fig. 2 is a sample of another portion of strip received on the instrument showing both the punched strip and the final strip printed in Roman characters.

A Four-electrode Thermionic Detector for Damped or Undamped Electric Oscillations of High or Low Frequency.*

By J. A. FLEMING, M.A., D.Sc., F.R.S.

The various forms of radio wave generator now in use give us three types of wave radiation with a great range of wavelength. It seemed to me therefore that it would be interesting to endeavour to design a simple thermionic detector and receiving arrangement which should be quite independent of the nature of the transmitter, and detect without change of apparatus or circuits undamped as well as damped waves of any wavelength. The following is a description of the construction of a four-electrode thermionic detector which I have found efficient for this purpose. While not approaching the sensitivity of the cascaded three-electrode amplifier it yet has some special advantages of its own. In a glass bulb 3 inches in diameter a short straight vertical tungsten filament about $1\frac{1}{4}$ inches long is mounted. This filament

Fig. 1.

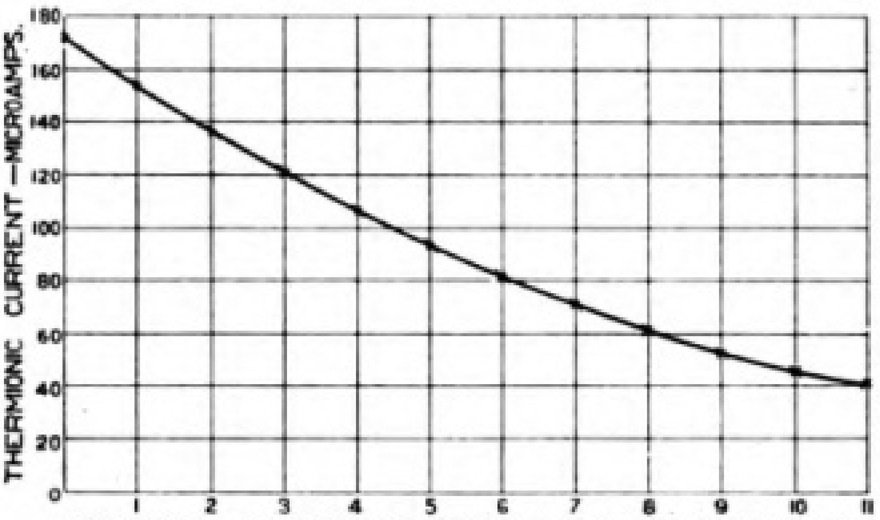

Fig. 2.

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* Abstract of paper read before the Wireless Society of London on December 10th, 1920. (See also p. 1 of this issue.)

is kept straight by a small spiral spring. Around the filament are arranged four narrow curved nickel plates about 1½ inches long by ¼ inch wide slightly curved about their long axis and set with convex faces towards the filament and 2 or 3 mm. from it. One pair of these plates, on opposite sides of the filament, which I refer to as the "potential plates," are connected to separate wires led out to the terminals of the bulb. The two remaining plates are connected together and to a fifth leading in wire. These plates are called the "collecting plates." The bulb is exhausted and the electrodes freed from gas in the usual manner employed in making hard valves. Fig. 1 shows the general appearance of the valve. .

The peculiar property of this thermionic detector is that if a small difference of potential whether of high or low frequency is set up between the potential plates the thermionic current passing between the filament and the collecting plates at once falls to an extent determined by this potential difference. We can therefore describe a characteristic curve by plotting the thermionic current to the collecting plates against the potential difference applied to the potential plates. Such a curve is shown in Fig. 2.

To use this device as a detector in wireless reception we need only connect the potential plates to the terminals of the tuning condenser in the closed receiving circuit and insert in the external plate—filament circuit of the valve some current detecting instrument which will indicate the change in the thermionic current. When so used the arrangement is about as sensitive as a simple crystal detector.

If we insert in the plate—filament circuit an ordinary telegraph relay (Fig. 3) the commencement of each received signal will cause the relay contacts to open.

In order to increase the sensitiveness of the arrangement it is evidently necessary that the potential difference between the potential plates shall be made as large as possible. We can achieve this to some extent by arranging the receiving circuit so that its capacity is small and inductance large. We can also amplify to some extent by the use of resonance spirals.* I may say I have not yet had time to determine the effect of a slight reduction of the vacuum upon the performance of this valve. By this means the thermionic currents could be increased while there should be little danger of shortening the life of the filament by positive ion bombardment since the potential of the anode plates is only a few volts.

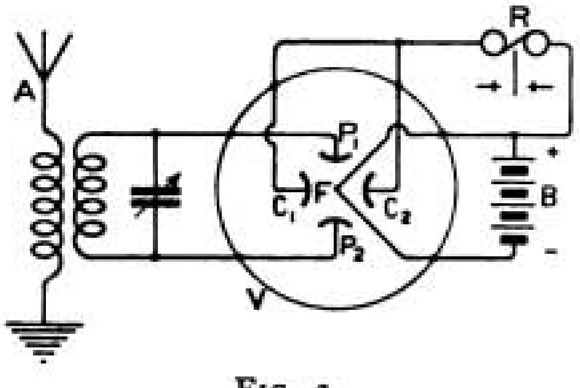

FIG. 3.

In connection with this subject a very simple type of bell call has been devised. It depends upon the insertion of an inertia relay in the plate-filament circuit of a valve of this type so that the call bell's contacts will not be closed unless the current through the relay is kept going without interruption for a couple

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* See RADIO REVIEW Abstracts No. 854, September, 1920, and No. 1392 in this issue for references to the uses of these spirals.

of seconds or so. The intermittent currents due to Morse signals will not last sufficiently long to cause the bell to ring.

I have not attempted as yet to make comparisons between the four-electrode valve and other detectors as regards sensitivity but from a few tests it appears to be about as sensitive as a good crystal detector. Even if it does not invade the field at present occupied by the three-electrode valve it may prove to be a useful adjunct. The valve will also have some laboratory uses for detecting small potential differences in alternating current bridge circuits. Again, we may use this valve to make an alternating current ammeter by connecting the potential plates to the secondary terminals of a transformer through the primary of which is passed the high or low frequency current to be measured. The thermionic current through the valve will be diminished to an extent which depends upon its alternating current. I think, therefore, that this four-electrode valve will prove to be of use in our laboratory measurements in addition to any applications in radio work.

Notes.

Personal.

Senatore Guglielmo Marconi, who is decorated with the " Ordine Civile " of Savoy, has been nominated by the King of Italy, on the proposal of Signor Giolitti, to be a member of the Supreme Council of the same Order. **[1864]**

Professor E. Branly, Membre de l'Institut, who is well known in connection with the early discoveries of coherer action, has recently been promoted to the grade of Officer of the Legion of Honour. Professor Branly was elected a Chevalier of the Legion of Honour in 1900. **[1660]**

Mr. G. C. Allingham, M.B.E., M.I.E.E., who was until recently chief engineer of the Tudor Accumulator Co., Ltd., has joined the staff of Mr. C. F. Elwell, Radio Engineer, Craven House, Kingsway, W.C. 2. **[800]**

Mr. A. E. Grocott, late of Marconi's Wireless Telegraph Company, Limited, has been appointed Telephone, Telegraph and Radio Engineer to the Siamese Government. **[1865]**

Commercial.

The French Government has just signed with the Cie. Générale de Télégraphie sans Fil a contract under which this company is authorised to establish wireless telegraph services for commercial traffic between France and all other countries of the world. The State will receive a share in the net profits after the shareholders have received a fair interest upon the capital of the company. The company has commenced the construction of two large radio-telegraphic centres which will be installed in the neighbourhood of Paris—one to be allocated to trans-oceanic communications, and the other to communications with European countries. **[1667]**

The recent consolidation of radio interests of the Radio Corporation of America and the General Electric Company in the United States has been followed by a merger between the Marconi Wireless Telegraph Company of Canada and the Canadian General Electric Company — a separate company from the American General Electric Company.

The officers and directors of the new organisation are: Frederic Nicholls, President; G. Marconi, A. E. Dyment and Robert Bickerdike, Vice-presidents: A. H. Morse, Managing Director: and, on the Board, Sir William MacKenzie, Godfrey C. Isaacs, G. M. Bosworth and C. G. Greenshields. Messrs. Nicholls, MacKenzie and Dyment are directors of the Canadian General Electric Company. **[1677]**

According to information from Pekin, negotiations between the Chinese War Office and Marconi's Wireless Telegraph Co. of England for a loan of £13,000,000 for the establishment of fifty wireless stations are now practically concluded. Owing to opposition of the Navy Department, however, there is some doubt whether the agreement will be finally signed and made effective.

Legal.—The most important recent change in legislation affecting radio working is the issue of a decree by the Belgian Minister of Railways, Marine, Posts and Telegraphs, setting forth the conditions regulating the establishment and working of receiving wireless stations for other than ordinary commercial uses. The details of this decree are as follows :—

Article 1.—Requests for authorisation must be addressed to the Director-General of Telegraphs and Telephones at Brussels.

The person making the request must indicate the precise place and functions of the proposed station and must furnish for approval a description of the apparatus.

The applicant must prove if such should be the case that he is of Belgian nationality.

Article 2.—Authorisation is granted :—

(*a*) By the Director-General of Telegraphs and Telephones when the applicant be of Belgian nationality.

(*b*) By the Minister of Railways, Marine, Posts and Telegraphs to whom the request should be transmitted by the Director-General, with his advice, if the applicant be a foreign subject.

Article 3.—The station authorised will be utilised exclusively for reception of time and weather signals ; the transmission of any other electrical signal is formally prohibited.

The use of amplifying valves is not allowed. However, the Administration of Telegraphs and Telephones may, in certain particular cases, which must be submitted for approval and after inquiry and examination of the reasons given by the applicant, grant an authorisation to use such apparatus under conditions to be determined by the Administration.

Article 4.—Under the penalty of immediate withdrawal of the authorisation, the applicant must scrupulously observe, and cause others to so observe, the secrecy of any information which is not intended for public use.

The contents of radiotelegrams other than meteorological telegrams which will eventually be received by the postal authorities, must be neither written nor divulged to any one outside the officials appointed by the Administration of Telegraphs and Telephones, or of the judicial authority. The withdrawal of the authorisation as a result of a contravention of this law, will be eventually carried out without prejudice to the applicant of any punishment provided for by law.

Article 5.—The applicant is forbidden to receive any payment or remuneration whatsoever for the reception of information by means of the station authorised.

Article 6.—The Government reserves to itself the right to examine installations authorised. When necessary the applicant will grant to the duly commissioned delegates of the Government free access to the said installations, and will facilitate by every means in his power such examination by the delegates.

Article 7.—The applicant alone is responsible for all consequences whatsoever, resulting from the present authorisation, not only from the point of view of mistakes which may be made, but also in regard to all matters connected with patent rights or of any other rights of a third party. The responsibility of the State is, and will remain, entirely separate in connection with the present authorisation.

Article 8.—The applicant is held responsible for notifying the Director-General of Telegraphs and Telephones of all alterations which he proposes to make to his apparatus. This must not be changed without the previously-obtained consent of the Administration of Telegraphs and Telephones.

This Administration may however, at any time and for whatever cause, suspend or revoke the authorisations granted, without the payment of any indemnity whatsoever or without giving any reason for such suspension or revocation.

This permission does not include any privilege either for this particular authorisation or for any subsequent authorisation of the same nature.

It is not transferable without the express permission in writing of the Administration of Telegraphs and Telephones.

At the request of the Administration of Telegraphs and Telephones the applicant must immediately place his apparatus out of working order.

Article 9.—The applicant must hold himself responsible for all expenses and charges whatsoever, occasioned by the permission granted to him.

Article 10.—The applicant will pay a fixed annual fee of 20 francs for every authorised receiving station.

The first payment will be made before obtaining the authorisation; it will cover the remainder of any year from the day of the authorisation to the following December 31st.

Subsequent fees will be paid during the month of January of each year. No refund will be made by the Treasury no matter for what reason the use of the apparatus previously authorised be discontinued.

This applies equally in the case of the station being discontinued by order of the Administration of Telegraphs and Telephones.

Article 11.—Stamp duties and subsequent registration fees will be charged to the applicant. **[1866]**

A change in the wavelength authorised for ship direction finding work has recently been made as regards the Canadian direction finding stations. A notice issued to the masters of merchant ships fitted with radio apparatus drawing attention to this change is as follows :—

On and after August 1st, 1920, the Canadian Radiotelegraph Direction Finding Stations at Chebucto Head, N.S., Canso, N.S., and Cape Race, Newfoundland, will use the wavelength of 800 metres exclusively for transmission and reception.

It will be necessary for all ships to have their transmitters adjusted to transmit on 800 metres if they desire to obtain bearings from the above stations.

All use of the wavelength of 600 metres by Canadian D.F. stations will be discontinued after August 1st, 1920. **[1867]**

General.

Notice has been given of a decree recently issued by the Soviet Government authorising the installation of a new high-power radio station in the neighbourhood of Chatoursk for ensuring continuous communication with America. The station at Tsarskoie-Selo is to be restored for communication with all European stations.—*La T.S.F. Moderne.* **[1665]**

An announcement has been made in *l'Électricité* of the formation of a Radio Club in France for the study of wireless telegraph problems. It is proposed to establish one or more experimental and research laboratories and workshops which will be at the disposal of members of the club, and to collect together a library of books and periodical publications dealing with radio work. Visits to wireless stations, laboratories and so on are also included in its programme, together with the establishment of suitable relations with similar societies in other countries. The address of the Club is 95, Rue de Monceau, Paris. **[1656]**

A meeting of the International Commission for Weather Telegraphy was held at the Air Ministry in London during the week, November 22nd—27th, 1920, at which delegates were present from the leading European countries for the purpose of discussing the coordination of the meteorological reports issued by wireless from the high-power radio stations of Europe. Agreements were also arrived at upon the codes for reports from ships at sea, and for special aviation reports. **[1846]**

Review of Radio Literature.

1. Abstracts of Articles and Patents.

Classification of Abstracts—In Volume I. of the RADIO REVIEW the abstracts of articles and patents included in this section were arranged as far as possible in the order of their subject-matter, although the details of this classification were not indicated. In this and future issues it is intended that the abstracts shall be grouped as far as practicable under leading headings with the idea of indicating to some extent the subject-matter of the article dealt with. A rigid classification of all radio literature is not easily adhered to unless the number of headings available is so large as to be cumbrous, so that with the arrangement that has been adopted the subject-matter of a given article may in certain circumstances probably be included in more than one heading. In the arrangement of the abstracts, therefore, every endeavour will be made to place the abstract in the group to which it refers primarily, while if possible the other classifications will be indicated in the Annual Index. Each of the main groupings into which the abstracts will be divided have been sub-divided into a number of sub-sections, but as a general rule these sub-sections will not be specifically designated in each issue of the RADIO REVIEW, although they will be available for indexing purposes. The following main groupings have been adopted :—

(A) General and descriptive articles on **Radio Stations and Installations,** including notes *re* new stations, etc. (B) **Spark transmitting apparatus,** including descriptions, etc., of the various forms of spark gaps. (C) **Arc apparatus.** (D) **High frequency alternators.** (E) **Static or transformer frequency raisers.** (F) **Thermionic valves** and valve transmitting apparatus, including theory and descriptions of the two and three-electrode valves and valve apparatus. (G) **Transmitter control or modulation** for radiotelegraphy or telephony. (H) **Radio receiving apparatus.** (I) **Amplifiers.** (J) **Subsidiary radio apparatus,** including generators transformers, switchgear, protective apparatus, rectifiers, telephones, materials, etc. (K) **Aerials,** including earthing systems, artificial aerials, masts, etc. (L) **Radio wave transmission,** including theory, experiments, upper atmosphere, etc. (M) **Atmospherics,** including anti-atmospheric devices. (N) **Interference and interference prevention,** including secrecy methods of signalling. (O) **Duplex and multiplex radio communication.** (P) **High-frequency circuits and measurements,** including theory and electric circuits, methods of measurement and measuring apparatus. (Q) **Short wave apparatus,** including applications of very high-frequency oscillations for measuring and other research work. (R) **Radio direction-finding**—descriptions of apparatus, theory of wave deviation, etc. (S) **Distant control by wireless.** (T) **High Frequency Wire Telegraphy and Telephony.** (U) **Miscellaneous methods of communication** other than wire telegraphy and telephony, including light, earth current, submarine and similar methods of communication. (V) **Traffic particulars** of radio stations, and programmes of transmission. (W) **Radio legislation**—laws, patents, agreements and litigation. (X) **Biographical and personal notes.** (Y) **Historical articles.** (Z) **Miscellaneous,** including miscellaneous applications of wireless, books and book reviews, nomenclature, etc.

Radio Stations and Installations (General and Descriptive Articles).

1331. **L. Faljau.** The New Radio Station at Lyons. (*Wireless Age*, 7, pp. 11—14, September, 1920. *Science Abstracts*, 23B, p. 550, Abstract No. 1045, November 30th, 1920—Abstract.)

An illustrated description of the station with some details of the 450 kW arcs and of the Bethenod alternator installed there.

1332. Official Opening of the New Nauen Station. (*Elektrotechnische Zeitschrift*, 41, p. 819, October 14th, 1920.)

An account of the opening on September 29th of the "greatest radio station in the world," in the presence of the President of Germany and many high officials. It has a range of 20,000 km and is used exclusively as a transmitting station the corresponding receiving station in America being at Chatham. In the reverse direction the sending station is at Marion and the receiving station at Geltow near Potsdam.

1333. **E. E. Bucher.** "WII"—New Brunswick. (*Wireless Age*, 7, pp. 11—17, July, 1920, pp. 13—23, August, 1920. *Technical Review*, 7, pp. 29—30, October 12th, 1920—Abstract. *Electrical World*, 76, p. 439, August 28th, 1920—Abstract.)

This article describes the high power station at New Brunswick which is equipped with Alexanderson alternators. Illustrations of the machine are given and of some accessories including a magnetic amplifier, and dimensions of the multiple antenna and of the counterpoise construction. Some particulars are included of the reduction in losses effected by the use of this type of antenna. The resonance voltage speed regulator is also briefly described.

1334. A New Wireless Transmitting Station at Geneva. (*Engineer*, 130, pp. 541—542, November 26th, 1920.)

Particulars of the installation of a high speed transmitting station for the use of the League of Nations meeting at Geneva, November, 1920. See also p. 2 in this issue.

1335. **R. H. Barfield.** Commercial Progress in Aircraft Wireless. (See pp. 4—14 in this issue.)

1336. **A. N. Goldsmith.** Radiotelephony across Oceans and Continents. (*Wireless Age*, 7, pp. 10—13, June, 1920.)

A general article dealing with the possibilities of long distance radiotelephony. A transmitting installation using 12 high-power valves at the College of the City of New York is briefly described and illustrated.

1337. **J. Usabiaga.** Wireless Telephony. (*Produccion*, 11, pp. 149—150, March 15th, 1920.)

1338. **C. G. Crawley.** Wireless Waves. (*Discovery*, 1, pp. 114—116, April, 1920.)

1339. Long Distance Speech by Wireless. (*Sea, Land and Air*, 3, pp. 466—470, October, 1920.)

A general descriptive article dealing with the advances in thermionic valve development.

1340. Powerful Wireless Station for Belgium. (*Engineer*, 130, p. 514, November 19th, 1920.)

A short note referring to the plans for a powerful transatlantic wireless station to be erected in Belgium. An average transmission rate of 60,000 words per day is to be provided for and the station is to employ 750—1,000 kW.

1341. American Radio Stations. (*Scientific American*, 123, p. 217, September 4th, 1920. *Wireless Age*, 7, p. 9, June, 1920.)

It is stated that the American Government shore radio stations now number 135, of which twenty are in Alaska, nineteen in the Philippines, three in the Canal Zone, two in Hawaii, and one each in Porto Rico, Guam and Samoa. The Government ship stations total 470.

1342. Wireless in the French Colonies. (*L'Électricité*, 2, p. 6, August 15th, 1920.)

A short note giving details of the progress effected in the French colonial wireless stations now under construction.

Spark Gaps and Spark Transmitting Apparatus.

1343. **P. R. Coursey.** Sparks and Spark Gaps. (*Wireless World*, 8, pp. 341—343, August 7th, 1920. *Technical Review*, 7, p. 68, October 19th, 1920—Abstract.)

1344. **T. W. Benson.** A Spark Coil Panel Transmitter. (*Wireless Age*, 7, pp. 24—25, May, 1920.)

An illustrated description and details for constructing the set.

1345. **L. R. Fielder.** A 60 Watt Low Power Transmitter. (*Wireless Age*, 7, pp. 29—30, May, 1920.)

1346. **W. A. Remy.** The Design and Construction of a Low Power Transmitter for Local Use. (*Wireless Age*, 7, pp. 30—32, May, 1920.)

1347. **L. S. Butler.** A Low Power Transmitter for Local Use. (*Wireless Age*, 7, pp. 32—33, May, 1920.)

1348. **J. E. Bethenod and E. Girardeau.** Producing Oscillations. (*French Patent* 502594, February 2nd, 1915. Published May 19th, 1920.)

In a method of producing electric oscillations the discharge of a main condenser is timed by the discharge of an auxiliary condenser connected in parallel with it through an adjustable inductance and resistance. The discharge circuit of the main condenser is coupled inductively to the discharge circuit of the auxiliary condenser, the latter containing a rotary spark gap driven from the shaft of the supply alternator. For further particulars see *British Patent* 100058.

Arc Apparatus.

1349. **L. F. Fuller.** Improvements in Arc Generators. (*Wireless Age*, 7, p. 18, June, 1920. *Science Abstracts*, 23B, p. 398, Abstract No. 764, August 31st, 1920—Abstract. *Scientific American*, 123, p. 571, December 4th, 1920—Abstract.)

Abstract of a patent dealing with the design of magnet coils for arc oscillation generators. To avoid the necessity for providing a separate choke coil, the magnet windings are provided with extra heavily insulated turns on the outside and are connected in the positive lead instead of in the negative as is customary. The negative terminal of the dynamo as well as the dynamo frame may then be earthed.

1350. **G. M. MacKay.** An Improved Arc Generator. (*Wireless Age*, 7, p. 22, June, 1920. *Science Abstracts*, 23B, p. 548, Abstract No. 1041, November 30th, 1920—Abstract.)

In the apparatus described two fixed electrodes are employed in a partially exhausted enclosure containing hydrogen by preference. Means are provided for heating the cathode to start the arc. The heating current may be shut off when the arc is in operation.

Thermionic Valve Apparatus.

1351. **B. S. Gossling.** Development of Thermionic Valves for Naval Uses. (*Journal of the Institution of Electrical Engineers*, 58, pp. 670—703, August 19th, 1920. *Technical Review*, 6, p. 824, July 20th, 1920—Abstract. *Nature*, 105, p. 559, July 1st, 1920—Abstract. *Science Abstracts*, 23B, p. 581, Abstract No. 1112, December 30th, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 544—545, August, 1920, for abstract. The discussion by C. L. Fortescue, C. C. Paterson, G. W. O. Howe, J. St. Vincent Pletts, J. Scott-Taggart, W. H. Eccles, and H. M. Dowsett is included in the original together with the author's reply.

1352. **W. H. Eccles.** Inaugural Address to the Wireless Section of the Institution of Electrical Engineers. (See pp. 31—37 in this issue.)

1353. Testing Marconi V.T.'s. (*Wireless Age*, 7, pp. 20—21, March, 1920.)

A summary is given of the tests through which the triode valves manufactured by the American Marconi Company are subjected. In addition to the electrical inspection they are also subjected to careful inspection for mechanical defects. In the electrical inspection the tubes are first tested for gas and classified as (1) soft tubes for detectors and oscillators, or (2) hard tubes for amplifiers and oscillators.

The following tests are made : Filament testing for current and voltage.; plate voltage ; insulation resistance between plate grid and filament terminals after the tube has been in operation at normal current for some time ; sensitiveness as a detector (checked against standard tube) : oscillation tests at a wavelength of 250 metres using the plate voltage which gives maximum sensitiveness as a detector. Class 2 tubes are all subjected to a plate potential of 350 volts, their internal resistance and voltage amplification factors are also measured by means of a bridge arrangement. The article includes illustrations of the testing sets.

1354. **R. A. Heising.** The Audion Oscillator. (*Physical Review*, 16, pp. 216—237, September, 1920.)

This article deals almost entirely with the conditions that must be satisfied for the production of free oscillations in circuits attached to a three-electrode valve. A straight line characteristic is assumed. The bulk of the equations are derived for the " Hartley Circuit " in which the grid and plate circuits are coupled magnetically while at the end of the article the modifications necessary when a circuit of the Colpitts type is used are considered. No solution is given for the amplitude of the oscillation current set up but merely those for the circuit conditions necessary for the establishment of the oscillations. The paper is similar to another by the same author.*

1355. **F. K. Vreeland.** Improved Oscillator. (*Wireless Age*, 7, p. 26, September, 1920. *Science Abstracts*, 23B, pp. 549—550, Abstract No. 1044, November 30th, 1920—Abstract.)

In order to increase the purity of the oscillations set up by a triode valve it is proposed to employ a separate or " flywheel " circuit coupled to both grid and plate circuits of the valve by means of step-down transformers. In an alternative arrangement coupling may be electrostatic. Circuit diagrams of both arrangements are given.

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* RADIO REVIEW Abstract No. 1059, November, 1920.

1356. **M. Latour.** Continuous Wave Transmitter. (*French Patent* 502633, November 11th, 1915. Published May 21st, 1920. *British Patent* 147462, July 7th, 1920. Convention date November 11th, 1915. Patent not yet accepted but open to inspection.)

The aerial is connected through a condenser, an inductance and a transformer primary to earth (Fig. 1). The plate of the thermionic oscillation generator is connected to the filament through a battery and the inductance in the aerial circuit and the transformer primary. The secondary of the transformer is connected across the grid of the generator and the filament.

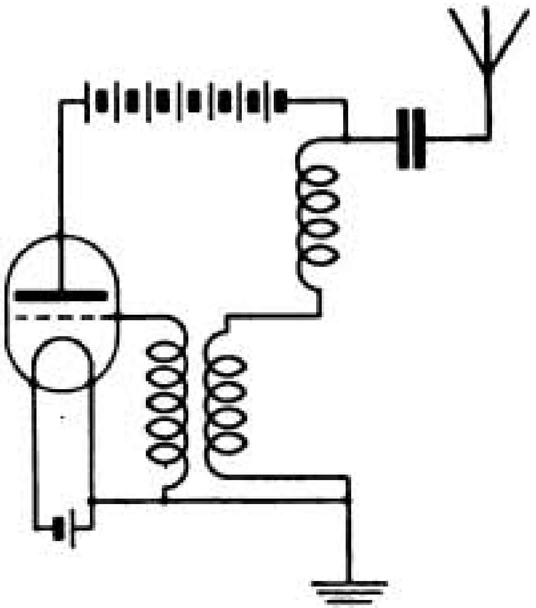

FIG. 1.

1357. A New Amplifying Relay. (*L'Électricien*, 51, p. 496, November 15th, 1920.)

The amplifying properties of the three-electrode valve are briefly described together with a mercury discharge apparatus possessing similar properties.

1358. **J. Bethenod.** Oscillation Generator. (*French Patent* 502519, November 5th, 1915. Published May 18th, 1920. *L'Électricien*, 51, p. 403, September 15th, 1920—Abstract.)

In an oscillation generator consisting of a vacuum tube having a cathode and two anodes, an alternating electric field produced by the action of the tube itself is used to oscillate the cathode beam from one anode to the other.*

1359. **M. R. Darmezin du Rousset.** Oscillation Generator. (*French Patent* 502512, October 28th, 1915. Published May 18th, 1920.)

The invention relates to tubes containing rarefied gases employed for the production or reception of electric oscillations. In the specific example described, the tube is of glass and contains, for example, rarefied neon, and at each end is an electrode mounted at the extremity of a copper or silver rod of large enough section to conduct the heat away rapidly. The electrodes are each connected to a radiation plate outside the tube, and the tube is supported in a magnetic field produced by two solenoids. The apparatus is placed in a cooling bath.

1360. **L. de Forest.** An Oscillating Current Generator. (*Wireless Age*, 7, pp. 17—18, June, 1920. *Technical Review*, 7, p. 357, December 14th, 1920—Abstract.)

The apparatus described consists of three bulbs exhausted to a low pressure and containing mercury vapour. A mercury arc discharge is set up between two of the bulbs which are connected to a suitable direct current supply. The third bulb contains an oil cooled plate electrode and a tubular grid electrode between the plate and the junction of the three bulbs. Oil cooling can also be provided for this grid electrode. The circuits used with the oscillation generator are somewhat similar to those often used with a triode valve, the arc discharge taking the place of the hot filament.

1361. **J. A. Fleming.** A Four-electrode Thermionic Detector for Damped or Undamped Electric Oscillations of High or Low Frequency. (See pp. 38—40 in this issue.)

Transmitter Control or Modulation.

1362. **L. F. Fuller.** Methods of Signalling with an Arc. (*Wireless Age*, 7, p. 25, September, 1920.)

In the arrangement described for signalling purposes one of the arc electrodes is attached to the core of a solenoid so that the arc is ignited or broken in accordance with the movement of the signalling key.

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* See also British Patent 126019—RADIO REVIEW Abstract No. 106, January, 1920.

1363. **A. Taylor.** Continuous Wave Transmitter. (*French Patent* 502767, April 24th, 1919. Published May 26th, 1920.)

The specification describes methods of controlling the emission of waves for signalling purposes particularly applicable to arc and other C.W. systems.[*]

1364. **E. F. W. Alexanderson.** A Modulator for High Power Work. (*Wireless Age*, 7, pp. 23—24, September, 1920. *Science Abstracts*, 23B, p. 549, Abstract No. 1043, November 30th, 1920—Abstract.)

The arrangement described is a modification of the shunt control method in which a portion of the antenna energy is shunted off through modulating valves, the effective resistance of which is varied in accordance with the modulating currents. In this modification a number of special double-anode valves are joined in parallel and connected across the secondary winding of a transformer included in the circuit between the oscillation source and the antenna. By joining resistances in series with each of the anode circuits of each valve it is claimed that the amount of energy which can be controlled in this manner varies approximately as the square of the number of valves used in parallel.

1365. **M. Latour.** Magnetic Modulator. (*French Patent* 501473, December 16th, 1918. Published April 5th, 1920. *British Patent* 148949, July 10th, 1920. Convention date December 16th, 1918. Patent not yet accepted but open to inspection.)

The specification describes a magnetic modulator for insertion in a wireless aerial circuit and comprises an inductance having an iron core, the reactance of which is varied by mechanically modifying the air gap. The magnetic circuit is closed except for an air gap formed between poles separated by slots. Between the opposite poles is an armature formed of parts which are alternately conductors and non-conductors, the former acting as magnetic screens to decrease the reactance of the coil when they are in position between opposite poles.

1366. **Allgemeine Electricitäts-Gesellschaft.** Circuit for Wireless Telegraphy and Telephony. (*German Patent* 303393, July 10th, 1917. Patent granted September 27th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 304, October, 1920 – Abstract.)

A method of modulating the oscillations from a generator G by means of impressed voltage variations from a subsidiary circuit M, Fig. 2.

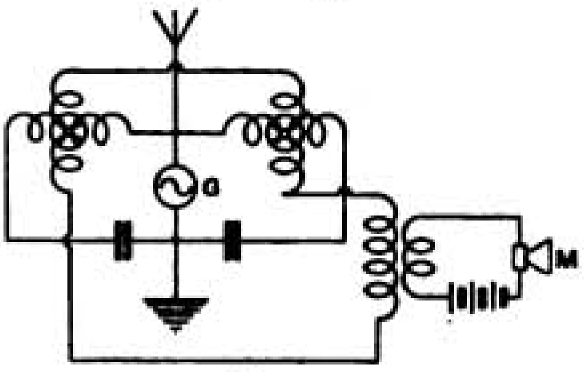

FIG. 2.

1367. **E. M. C. Tigerstedt.** Microphone. (*French Patent* 488251, January 2nd, 1918. Published September 17th, 1918.)

In the microphone described the terminals are formed by two parallel membranes between which is placed a ring of felt enclosing the necessary quantity of carbon granules; the two membranes, which are not enclosed, are mounted in but insulated from a ring provided with a handle in such manner that the microphone can be held so that it may be spoken to equally well on both sides. The rear membrane partially compensates for the violent vibrations of the front membrane.

Radio Receiving Apparatus.

1368. **R. E. Thompson.** Uni-control Receiver without a Coupled Tuned Circuit. (*Wireless Age*, 7, pp. 20—28, April, 1920.)

In the receiver described an aperiodic secondary is used and efforts are made to reduce its self-capacity as much as possible by using a spaced winding.

1369. **M. W. van Slyck.** A Modern Receiving Set. (*Wireless Age*, 7, pp. 27—28, May, 1920.)

The circuit described makes use of an elevated aerial connected to the primary circuit and an indoor loop aerial joined in series with the secondary. See also RADIO REVIEW Abstract No. 360, May, 1920.

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[*] See also British Patent 135111—RADIO REVIEW Abstract No. 332, May, 1920.

1370. **O. Scheller and C. Lorenz Aktiengesellschaft.** Receiving Arrangement for Wireless Telegraphy. (*German Patent* 299095, November 11th, 1914. Patent granted October 14th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 155, August 1920—Abstract.)

A receiving circuit in which primary or secondary reception may be utilised. The change from one type of working to the other is made by means of switch S (see Fig. 3).

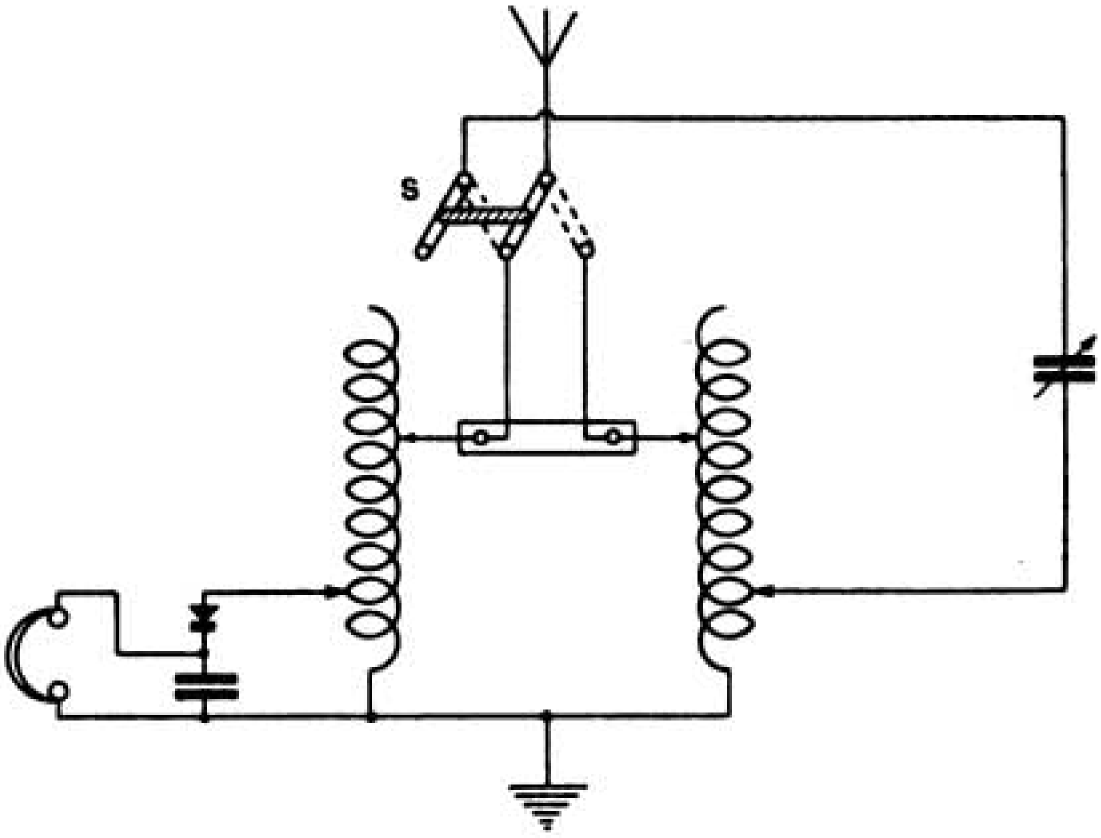

FIG. 3.

1371. **Gesellschaft für drahtlose Telegraphie.** Receiving Circuit for Wireless Telegraphy. (*German Patent* 307012, June 16th, 1915. Patent granted September 11th, 1919. Addition to German Patent 297907. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 150, August, 1920—Abstract.)

A primary or secondary receiver for portable wireless stations which may be used with the

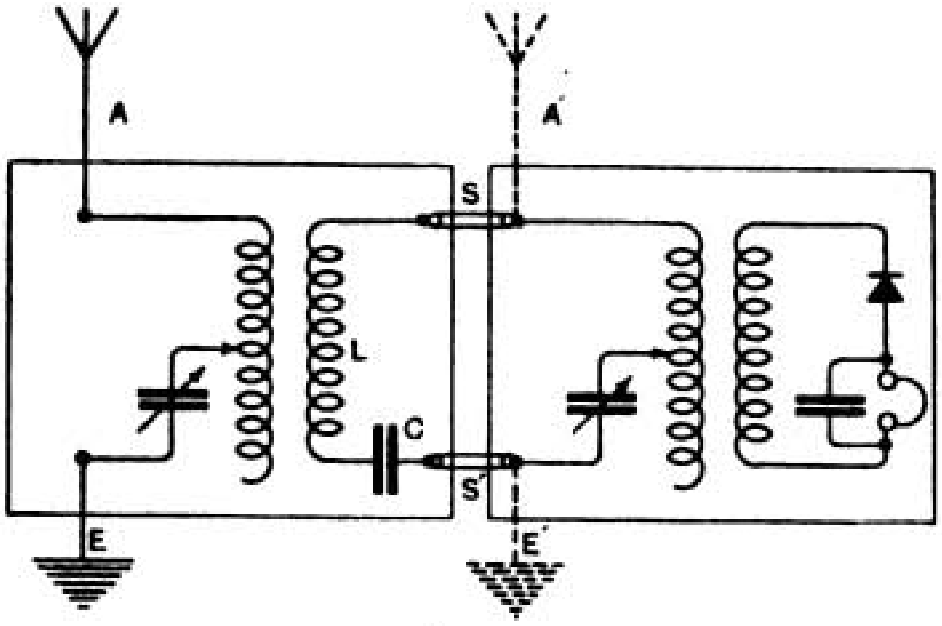

FIG. 4.

antenna and earth connected either at A and E or at A′ and E′ (see Fig. 4). By a proper adjustment of the values of L and C and suitable manipulation of switches SS′ the tuning for the primary and secondary arrangements may be kept identical.

1372. **E. A. White.** An unusually simple Circuit for Long Waves. (*Wireless Age*, 7, p. 22, February, 1920.)

Two circuits are described for use with cascade amplifiers, in the first a variometer is employed for tuning the aerial, the grid filament circuit of the first valve being joined in shunt to it, while in the second a variable condenser is used in parallel with the aerial tuning inductance in shunt to which the grid filament circuit of the first valve is again connected; capacity reaction is employed. Tuning is thus reduced to practically only one operation.

1373. **O. Scheller and C. Lorenz.** Wireless Receiving Circuit. (*German Patent* 303804, January 30th, 1917. Patent granted October 30th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 156, August, 1920 –Abstract.)

A receiver circuit consisting of a loop antenna inductance, and a capacity of which only the latter is variable. To provide high potential effects for the detector circuit a step-up transformer is used as link between antenna and detector circuits.

1374. **W. H. Kirwan.** Some Recent Amateur Apparatus. (*Wireless Age*, 7, pp. 38—40, March, 1920.)

Receivers covering a range of 200—20,000 metres are described.

1375. **E. F. Huth.** Wireless Receiving Circuit. (*German Patent* 310113, August 29th, 1917. Patent granted October 7th, 1918. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 296, October, 1920 –Abstract.)

A circuit with two detectors so arranged that both halves of the wave are used. The rectified current effects are transferred to the receiving amplifier A by means of the transformers shown in Fig. 5.

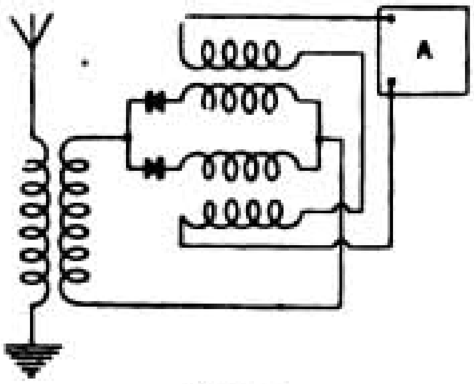

FIG. 5.

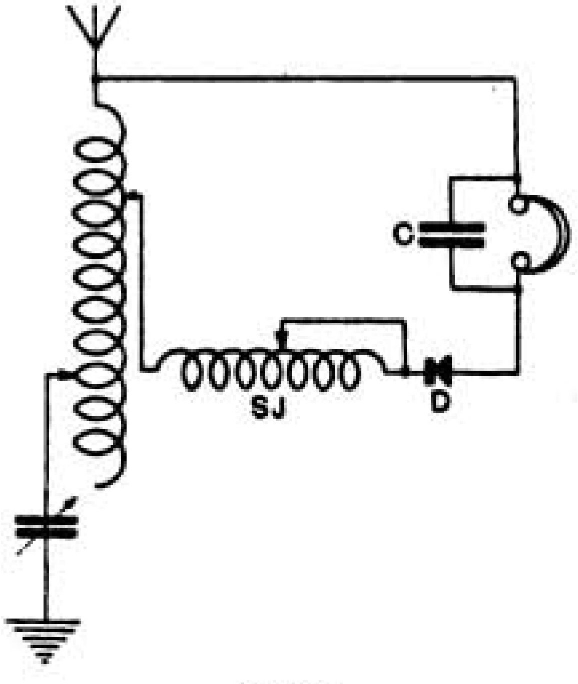

FIG. 6.

1376. **Deutsche Telephonwerke Gesellschaft.** Circuit for Wireless Receiving Station. (*German Patent* 315471, September 20th, 1916. Patent granted October 28th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 386, November, 1920—Abstract.)

A circuit (see Fig. 6) in which a coil of variable inductance SJ is included in the detector circuit (contact detector D of high ohmic resistance). With the exception of the blocking condenser C across the telephone no further capacity is included in the detector circuit.

1377. **A. N. Goldsmith and E. T. Dickey.** Radio Taste Reception. (*Telegraph and Telephone Age*, 38, pp. 560–564, November 1st, 1920.)

Experiments are described to test the possibility of receiving radio signals on aircraft and other noisy places by means of the sense of taste. Successful results were obtained using two or more stages of amplification provided that the initial signal strength was of at least 500 times audibility.

1378. **H. Hurm.** Crystal Detector. (*French Patent* 502760, March 21st, 1916. Published May 26th, 1920.)

The crystal detector has a number of contact wires with their inner ends bearing on the crystal and their outer ends connected to terminals which are engaged by a rotating arm, so that the point making the most sensitive contact is readily selected. The crystal is arranged to be rotated to vary the points of contact with the wires. For further particulars see *British Patent* 105905.

1379. **C. Florisson.** Rectification by Galena. (*Comptes Rendus*, 171, pp. 106—108, July 12th, 1920. *Revue Générale de l'Électricité*, 8, pp. 175—176, August 7th, 1920. *Science Abstracts*, 23A, p. 473, Abstract No. 1199, September 30th, 1920—Abstract. *Revue Scientifique*, 58, p. 444, July 24th, 1920—Abstract. *Electrical World*, 76, p. 840, October 23rd, 1920—Abstract. *Elektrotechnische Zeitschrift*, 41, p. 1040, December 23rd, 1920—Abstract.)

1380. **C. C. Henderson.** A Receiver-Transmitter. (*Wireless Age*, 7, p. 28, February, 1920.)

In the arrangement described the radiation from the receiving heterodyne is used for communication over short distances. Reference is also made to its use by the American Fleet during the war for inter-communication purposes.

1381. **M. Latour.** The Heterodyne Method of Wireless Reception, its Advantages, and its Future. (See pp. 15—21 in this issue.)

1382. **Compagnie Française pour l'Exploitation des Procédés Thomson-Houston.** Receiving Heterodyne Arrangement. (*French Patent* 500292, June 2nd, 1919. Published March 6th, 1920. *British Patent* 148131, July 9th, 1920. Convention date June 3rd, 1918. Patent not yet accepted but open to inspection.)

The grid current of a thermionic valve is arranged to vary inversely as the grid voltage over the operating range of negative grid potential. Such an oscillator is described as employed as a heterodyne receiver. The grid circuit of the valve consists of an inductance and a variable condenser in series, and a battery is arranged to give the grid a normal negative potential, the battery being connected through choke coils. The plate circuit includes a telephone shunted by a condenser.

1383. **M. Latour.** Receiving Arrangement. (*French Patent* 503047, October 21st, 1916. Published June 1st, 1920. *L'Électricien*, 51, p. 452, October 15th, 1920—Abstract. *British Patent* 148951, July 10th, 1920. Convention date October 27th, 1916. Patent not yet accepted but open to inspection.)

The signals are received by a cascaded amplifier and detected by a glow lamp by means of which they may be recorded photographically. For wireless telephony the photographic record is subsequently used in conjunction with a selenium cell for reproduction.

1384. **H. Abraham.** On Recent Progress in the Reception of Long Range Wireless Signals. (*Revue Générale de l'Électricité*, 7, p. 642, May 15th, 1920—Abstract.)

Abstract of an address delivered by M. Abraham to the Société Française des Électriciens on May 5th, 1920.*

1385. **J. Scott-Taggart.** A Vacuum Tube Trigger Relay. (*Wireless Age*, 7, p. 23, June, 1920. *Science Abstracts*, 23B, p. 494, Abstract No. 938, October 31st, 1920—Abstract.)

A description is given of the trigger relay arrangement due to W. H. Eccles and F. W. Jordan. See RADIO REVIEW, pp. 80—83, November, 1919, and pp. 143—146, December, 1919.

1386. **A. A. Campbell Swinton.** Wireless Telegraphy and Telephony. (*Wireless World*, 8, p. 639, December 11th, 1920. *Engineer*, 130, p. 503, November 19th, 1920. *Electrical Industries*, 20, p. 1466, November 17th, 1920.)

Notes relative to the first public demonstration of the application of the Creed telegraph apparatus to the reception of wireless signals. See also Wireless Telegraphic Printing on the Creed Automatic System. (Pp. 37—38 in this issue.)

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* See also RADIO REVIEW Abstract No. 826, September, 1920, for reference to the apparatus described.

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

1387. **W. Rogowski.** High Voltage D.C. Machines for Supplying Spark Stations. (*Archiv für Elektrotechnik*, 9, pp. 191—226, September, 1920.)

An investigation of the danger of breakdown in such machines due to resonance and surges with special reference to the failure of two machines at Königswusterhausen. (See also pp. 22—25, in this issue, and next abstract reference.)

1388. **K. W. Wagner.** The Breakdown and Protection of High Voltage D.C. Machines Supplying Spark Transmitters. (*Elektrotechnische Zeitschrift*, 41, pp. 581—584, July 29th; and pp. 605—606, August 5th, 1920. *Electrical World*, 76, p. 647, September 25th, 1920—Abstract.)

See RADIO REVIEW, pp. 22—25, in this issue for Abstract.

1389. **Gesellschaft für drahtlose Telegraphie.** High Frequency Generator. (*German Patent* 303895, October 14th, 1917. Patent granted September 26th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 82—83, January, 1920 —Abstract.)

A method of preventing the high frequency current of a continuous wave valve generator from reaching the direct current source by the insertion of an intermediary oscillating circuit tuned to the frequency of the generator.

1390. **F. Sarrart.** Advantages and Disadvantages of Various Systems of Transforming High Tension Alternating Current. (*Houille Blanche*, 19, pp. 101—106, May and June, 1920.)

A comparison of costs and efficiencies for various rectifier arrangements.

1391. **J. E. Lilienfeld and W. Hofmann.** Constant High Resistances for Measurement and Loading. (*Elektrotechnische Zeitschrift*, 41, pp. 870—873, November 4th, 1920.)

A new form of high resistance with the trade name "Multohm" consisting of a glass tube about 1 cm. diameter and 1 mm. thick with a carbon deposit on the interior. This deposit is made as a spiral to obtain very high values. Where greater constancy is required for measurement purposes a metallic oxide deposit is used instead of carbon. The allowable continuous loading is 1 watt per square centimetre of surface in air and three times this in oil. The application to radiotelegraphy is mentioned among other possible applications.

Aerials and Earthing Systems.

1392. **J. O. Mauborgne.** Resonance Wave Coils for Radio Transmission and Reception. (*Journal of the Franklin Institute*, 190, p. 743, November, 1920.)

A short note relative to a paper read before the Electrical Section of the Franklin Institute on October 14th, 1920. Various forms of resonance wave coils and their directive properties were described. Some consideration was also given to duplex and multiplex reception as well as to the use of these coils as wavemeters.

1393. **R. Villers.** Wireless Transmission of Energy. (*La Nature*, 48, pp. 292—294, May 29th, 1920.)

See RADIO REVIEW Abstract Nos. 701 and 702, August, 1920, where similar apparatus is described.

1394. Antenna Construction. (*Wireless Age*, 7, p. 23, January, 1920. *Science Abstracts*, 23B, p. 276, Abstract No. 543, May 31st, 1920—Abstract.)

Abstract of a patent by **M. Latour.***

1395. **L. T. Wilson.** A Coil Aerial. (*Wireless Age*, 7, pp. 18—20, April, 1920.)

A simple construction is described for a frame aerial for use as a direction finder.

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* See RADIO REVIEW Abstract No. 199, February, 1920, for reference and abstract. A drawing is also given of the construction of the loading inductance referred to in the patent and abstract.

1396. **C. C. Pidgeon.** Indoor Antenna. (*Wireless Age*, 7, p. 28, June, 1920.)
An account is given of some experiments with a simple form of loop aerial.

1397. **A. Pfeiffer and W. Schmidt.** Apparatus for Wireless Telegraphy. (*German Patent* 317553, January 13th, 1918. Patent granted December 22nd, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 138, August, 1920—Abstract.)
Trains of high frequency oscillations of extremely large initial amplitude and very large decrement are detected by means of an antenna with electrode plates PP immersed in a good conducting medium (see Fig. 7).

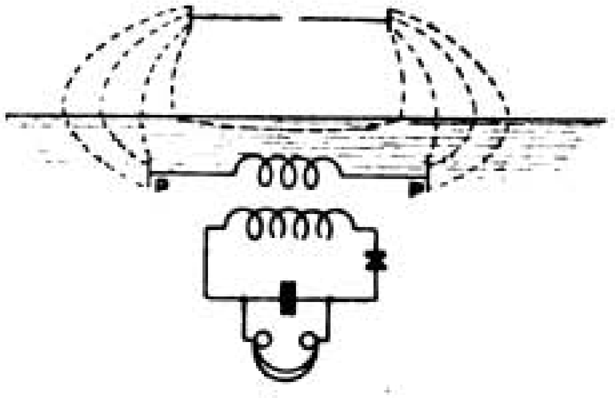

FIG. 7.

1398. **Gesellschaft für drahtlose Telegraphie.** Sending and Receiving Arrangement for Aircraft Wireless Telegraphy. (*German Patent* 317547, January 24th, 1918. Patent granted December 19th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 146, August, 1920—Abstract.)
The metal parts of the aeroplane are used as an antenna for very short waves. Electromagnetic coupling between the set and the antenna is used.

1399. **V. R. Fisher.** The Submarine Receiving Aerial. (*Wireless Age*, 7, pp. 26—27, March, 1920.)
The author criticises the claims made for the use of a loop aerial on submarines and mentions tests in which negative results were obtained. Some reference is also made to the frame aerial receiving arrangement used in France during the war for transatlantic reception.

1400. **C. R. Leutz.** A Portable Mast. (*Wireless Age*, 7, pp. 34—36, September, 1920.)
Constructional details are given and descriptions of the best method of erection.

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

1401. **S. Chapman.** A Note on Magnetic Storms. (*Philosophical Magazine*, 40, pp. 665—669, November, 1920.)
A short note in reply to criticisms of an earlier paper by the same author relative to the impact of streams of corpuscles into the earth's atmosphere.

1402. **C. F. Brooks and H. Lyman.** The Auroræ of March 22nd—25th, 1920, and Associated Displays. (*Monthly Weather Review*, 48, pp. 379—392, July, 1920.)
A full description is given of the phenomena associated with this display, and of its geographical distribution together with some of its effects on radio signalling. No marked increase of atmospherics was noticed but signals received from Arlington showed enormous variation in strength with an irregular slow periodicity.

1403. **W. J. Humphries.** The Physics of the Aurora. (*Monthly Weather Review*, 48, pp. 392—393, July, 1920.)

1404. Distance of 7,500 Miles covered by 80 kW Station. (*Elektrotechnische Zeitschrift*, 41, p. 141, February 12th, 1920. *Electrical World*, 76, p. 199, July 24th, 1920—Abstract.)

Atmospherics.

1405. **M. I. Pupin and E. H. Armstrong.** A Negative Resistance for Atmospheric Reduction. (*U.S. Patent* 1334165, September 17th, 1915. Patent granted March 16th, 1920. *Wireless Age*, 8, pp. 22—24, October, 1920—Abstract.)
The specification describes a receiving system in the aerial circuit of which a resistance is introduced sufficiently high to screen the system from disturbances, while for the frequency which is to be received the effects of this resistance are wiped out by means of a valve with reaction operating as a negative resistance.

1406. **Société Française Radio-Électrique.** Eliminating Atmospheric Disturbances. (*French Patent*, 502279, June 1st, 1915. Published May 8th, 1920. *British Patent* 147802, July 9th, 1920. Convention date June 1st, 1915. Patent not yet accepted but open to inspection.)

For the purpose of overcoming the effects of atmospherics, the receiving aerial is detuned and the signals are magnified by valve amplifiers with tuned circuits.

1407. **Marconi Wireless Telegraph Co. of America.** Eliminating Atmospheric Disturbances. (*French Patent* 502692, January 26th, 1918. Published May 22nd, 1920.)

To reduce or eliminate the effects of atmospheric disturbances a receiving system has two antennæ arranged at a distance of half a wavelength or less apart and in the direction of the signals to be received. Each antenna is formed of one or more coils, and a third coil is connected to the detector circuits and placed in the magnetic field of the coils connected to the antennæ in such a manner that the effects due to atmospherics operate differentially on the third coil, while the signal currents operate cumulatively on this coil.*

High Frequency Circuits (Theory, Components and Measurements).

1408. **E. H. Barton and Miss H. M. Browning.** Triple Pendulums with Mutual Inter-action and the Analogous Electrical Circuits. (*Philosophical Magazine*, 40, pp. 611—618, November, 1920.)

The theory of three mutually coupled electric circuits is given and a number of experiments with mechanically analogous pendulums are described. The article includes some reproductions of the traces from the pendulums.

1409. **E. Bellini.** Oscillation Generator. (*French Patent* 502719, February 2nd, 1916. Published May 25th, 1920. *L'Électricien*, 51, p. 429, October 1st, 1920—Abstract. *Annales des Postes, Telegraphes et Telephones*, 9, p. 482, September, 1920—Abstract.)

Two oscillatory circuits are coupled so as to produce oscillations having a single frequency by a combined magnetic and electric coupling, each having the same coupling coefficient.†

1410. **Compagnie Française pour l'Exploitation des Procédés Thomson-Houston.** Receiving Apparatus. (*French Patent* 500720, June 14th, 1919. Published March 23rd, 1920. *British Patent* 147811, July 9th, 1920. Convention date June 15th, 1918. Patent not yet accepted but open to inspection.)

The specification describes means for adjusting the resonance frequency of receiving coils for wireless signalling. In one example, the coil is formed in three portions connected in series and arranged radially round a common centre about which they may be turned so as to vary the distributed capacity and inductance. In another example, the coil sections are arranged co-axially and alternate sections are moved parallel to the other sections. By using a common operating bar, two such coils may be adjusted simultaneously. In a receiving circuit described and illustrated the receiving coil is connected across the grid and filament of a valve amplifier and the plate circuit is connected by a transformer to the grid circuit of a second valve whose plate circuit is connected to a telephone receiver. The secondary of the inter-valve transformer is formed similarly to the receiving coil.

1411. **F. V. Braemer.** Multilayer Inductance for Long Wave Work. (*Wireless Age*, 7, pp. 26—27, May, 1920.)

Multilayer pancake type coils of approximately rectangular cross section are described. Apparently no special precautions are taken for reducing self-capacity other than the insertion of a layer of paper between each layer of wire.

1412. **G. C. Southworth.** Electrical Measurements at Ultra-radio Frequencies. (See pp. 25—31 in this issue.)

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* See *British Patent* 132548—RADIO REVIEW Abstract No. 312, April, 1920.

† See also *British Patent* 126978—RADIO REVIEW Abstract No. 22, November, 1919.

1413. **O. C. Roos.** Universal, Honeycomb and Lattice Coils in General. (*Wireless Age*, 7, pp. 22—24, July, 1920; pp. 23—26, August, 1920; pp. 12—19, October, 1920; pp. 14—16, November, 1920; pp. 16—17, December, 1920.)

This article gives an exhaustive *résumé* of the different types of winding available for honeycomb types of multilayer lattice coils. The distinctions between the different types of windings are given together with winding details of different kinds of coils and an approximate theory of the best methods of winding. A large number of formulæ are also deduced for use in the design for these coils.

1414. **W. Gereach.** The Calibration of Thermo-junctions as A.C. Ammeters. (*Physikalische Zeitschrift*, 21, pp. 550—551, October 15th, 1920.)

The junction forms one arm of a bridge of which the others are resistances. The source is a battery with a reversing switch and adjustable resistance. The galvanometer of the bridge will show a steady deflection due to the thermal E.M.F., but when the resistances are balanced, this will not change on reversing the current. The galvanometer deflection is then a measure of the thermal E.M.F. The arm in series with the junction contains an ammeter to determine the current through the junction.

1415. **H. Abraham, E. Bloch and L. Bloch.** Amplifying Voltmeter. (*Bulletin de la Société Française des Électriciens*, 10, pp. 9—24, January, 1920. *Electrical World*, 76, p. 249, July 31st, 1920—Abstract. *Technical Review*, 6, p. 622, July 20th, 1920—Abstract.)

To read small voltages, they are amplified by means of triodes, then rectified and read on a moving coil instrument in the plate circuit. The pointer of this instrument is normally adjusted to zero by a potentiometer device. As many as five stages of amplification have been used. The set which was worked out in 1918 was constructed by Carpentier for the French military authorities. Details of the calibration of the instrument and a number of examples of its application are given.

High Frequency Wire Telegraphy and Telephony.

1416. **K. W. Wagner.** Multiplex Telephony and Telegraphy using High Frequency Currents (Wired-Wireless). (*Elektrotechnische Zeitschrift*, 41, pp. 706—710, September 9th, 1920. *Technical Review*, 7, p. 222, November 16th, 1920—Abstract. *Electrical World*, 76, p. 985, November 13th, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 715—716, November, 1920, for abstract.

1417. **G. Arco.** High Frequency Telephony on Overhead Power Transmission Lines. *Elektrotechnische Zeitschrift*, 41, pp. 785—788, October 7th, 1920. *Technical Review*, 7, p. 392, December 21st, 1920—Abstract.)

Paper read at the annual congress of the Verband Deutscher Elektrotechniker at Hanover. It gives a more detailed and illustrated description of the system than in a previous article in the *Elektrotechnische Zeitschrift.** Diagrams are given showing duplex working and intercommunication with the ordinary telephone system.

Traffic Particulars (Transmission Programmes, etc.).

1418. The New Meteorological Service from the Eiffel Tower. (*La T.S.F. Moderne*, 1, pp. 258—261, November, 1920. *La Nature*, 48 (2), Supplement p. 153, November 13th, 1920.)

Details are given of the revised programmes which came into force on November 1st, 1920.

1419. **P. Corret.** Transmission Programmes. (*La T.S.F. Moderne*, 1, pp. 275—279, November, 1920.)

1420. The Work of the German Wireless Stations. (*Elektrotechnische Zeitschrift*, 41, p. 593, July 29th, 1920.)

A brief note of the sending programmes of Norddeich and Königswusterhausen.

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* See RADIO REVIEW Abstract No. 1325, December, 1920.

1421. America and France Linked by Wireless Telephony. (*Wireless Age*, 7, p. 7, March, 1920.)
Reference is made to a test between the New Brunswick Station and France.

1422. Commercial Radio across Atlantic and Pacific. (*Wireless Age*, 7, p. 10, March, 1920.)
Reference is made to the reopening of high power stations in America after their release by the U.S. Government on February 29th. The text of a number of congratulatory messages is given.

2. Books.

THE HOW AND WHY OF RADIO APPARATUS. By H. W. Secor. (New York: *Experimenter Publishing Co., Inc.* 1920. Pp. 160. Price $1.75.)

This volume which is written mainly for the radio experimenter and practical man is built up of a series of articles, treating of different parts of radio equipment, that have been published in American journals—particularly in the *Electrical Experimenter*. In his preface the author states that he hopes also that the book will be of use to the commercial radio operator both to give him an insight into the working of his gear, and also to enable him to reconstruct or replace parts that may be damaged by an accident or breakdown. With this object in view the chapters have on the whole been well chosen, while the introductory material dealing with elementary electricity and magnetism that usually encumbers most books of this class has been omitted. Mathematical working has also been kept out except in the three final chapters which treat of the subject of the calculation and measurement of inductances and the main features of their design for specific purposes—such as receiving tuners. A number of formulæ are given together with graphical charts to aid calculation, and it is noteworthy that the author does not attempt to give *every* possible formula for calculating inductance but merely a judicious selection, although it is possible that even some further slight simplification might have been made here with advantage. P. R. C.

THE CONSOLIDATED RADIO CALL BOOK. (New York: *The Consolidated Call Book Company, Inc.* Second Edition, July, 1920. Pp. 160. Price $1.25.)

This book is correctly described by its sub-title "The Telephone Directory of the Sea." It contains the call letters and wavelengths of stations of all nations, together with the necessary information regarding the rates charged, etc. Particulars are given of radio compass stations, time signals, press schedules, weather reports, high power radio stations of the world, etc. A section is devoted to the call signals of American amateurs. The book contains much information useful to the wireless operator whether professional or amateur.

G. W. O. H.

New Books.

Announcements have been made of the early publication of two new volumes of interest to radio engineers—(1) "Wireless Design and Practice," by M. B. Sleeper, which is to be published by Messrs. Frowde, Hodder and Stoughton; and (2) "Wireless Telegraphy and Telephony," by L. B. Turner, M.A., which is to be published by the Cambridge University Press.

We hope to publish reviews of these books in a later issue.

Books Received.

THE WIRELESS EXPERIMENTER'S MANUAL, INCORPORATING HOW TO CONDUCT A RADIO CLUB. By Elmer E. Bucher. (New York: *Wireless Press. Inc.* 1920. Pp. 335. Price 12*s*. 6*d*. net.)

REPORT OF THE CHIEF SIGNAL OFFICER OF THE U.S. ARMY TO THE SECRETARY OF WAR, U.S.A., 1920. (Washington: *Government Printing Office.* 1920. Pp. 64).

REPORT OF THE DIRECTOR OF THE AIR SERVICE TO THE SECRETARY OF WAR, U.S.A. (Washington: *Government Printing Office.* 1920. Pp. 49.)

WIRELESS APPARATUS FOR RECEPTION. List W. 2. (London: *H. W. Sullivan.* Pp. 47. Price 1*s*.)

Correspondence.

THE R.A.F. DIRECTION FINDING SYSTEM.

To the Editor of the "Radio Review."

SIR,—In the November issue of the RADIO REVIEW there appears an article offering various criticisms of the method generally known by the above name, in which some of the remarks are strongly open to question.

I do not propose to deal with the question of whether this is a new system in principle or not; but during the last nine months I have been conducting a close investigation into the working of the above system, and my results in some cases differ very much from those suggested by Major Prince. The results will shortly appear at length in the RADIO REVIEW, but as the paper was completed before this article appeared, no special attention has been drawn in it to these points. The chief ones are as follows :—

(1) In the middle of p. 697 Major Prince states that the change of angle necessary in this system is the same as for the primitive loop. My results show that in many cases the change in this system is not more than 40 per cent. of that required for the primitive loop, and this figure could probably be improved on, as no effort was made to determine its minimum value.

(2) The 90° ambiguity (p. 697). This I have also shown in some detail is a very good point on paper, especially when the two coils are supposed equal, but such a ratio is never likely to be used in the R.A.F. system; and with the ordinary ratios if an attempt were made to determine this 90° bearing, equality of signal strength would be found to persist over an arc of 60° to 70°. No sane observer would mistake this for the real bearing.

(3) The argument (p. 698, line 7) and the reference (p. 696, line 12) as to the shapes of the curves. It is well known to anybody who has done much direction-finding work that the critical test is not the appearance of diagrams based on a formula which neglects small errors, but the behaviour in actual working. With an actual coil it is nearly always found that the zeros are neither total nor 180° apart, due to small subsidiary E.M.F.'s which are neglected in the simple cosine rule. In the R.A.F. system the effect of these (especially the first) is much less than with the primitive loop.

(4) The effect of increasing the number of turns (p. 699) has now been shown mathematically to be not more than a few parts in 10,000 with coils of normal size.

(5) There is one other point worth reference, namely the implication that, because by using a ratio of coil size somewhat less than unity, the results in the R.A.F. system are improved, therefore, the best results are obtained whether this is carried to the limit, when the system becomes the old single coil.

The results given above as to perception of least signal change disprove this, but an even greater factor is introduced by the errors. The problem of the blunt minimum on the single coil is a very old one, and has often been met by compensating devices. In the R.A.F. system by proper choice of the ratio it is possible, as shown above, to reduce enormously the effect of those errors without the use of such devices and without sacrificing the advantages of the reduced audible change.

For the sake of brevity I have only touched lightly on the main points, but there are several others of less importance which are equally open to question.

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December 3rd, 1920.

Binding Cases and Index for Volume I.

Binding cases for Volume I. of the RADIO REVIEW will be issued shortly, together with the index. An announcement giving full particulars with regard to these will be published in our next issue.