THE

RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. II APRIL, 1921 NO. 4

Editor:
PROFESSOR G. W. O. HOWE, D.Sc., M.I.E.E.

Assistant Editor:
PHILIP R. COURSEY, B.Sc., A.M.I.E.E.

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Editor: 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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Editorial.

Range of Wireless Stations.—The current number of the *Journal of the Institution of Electrical Engineers* contains the paper with this title recently read by Captain Trench together with the discussion thereon. A perusal of the discussion impresses one with the lack of data upon which to base any calculation of the power required to cover a given distance. The most important and fundamental figure which one requires to know is the strength of the electric field required at the receiving station in order to guarantee easily-readable signals twenty-four hours per day and seven days per week, local thunderstorms excepted. This will depend to some extent on the frequency employed, on the geographical position of the station, on the efficacy of any devices employed for the elimination of atmospheric disturbance, on the speed of working and on other factors. Attention was drawn to the fact that Captain Trench based his calculations upon a power in the receiving antenna only a fifth of that assumed in our article in the September number of the RADIO REVIEW. This discrepancy is a confession of our ignorance of the actual field strength required in any given case to ensure continuous reception with the best modern apparatus. It would be of great service if data could be collected of actual stations of modern design in all parts of the world which can just receive continuously or for say 90 per cent. of the time from other stations of known characteristics.

It is well known that all the early estimates of the power required to cover a given distance have been falsified. Experience has shown that far greater powers are necessary to ensure a reliable service.

In his reply to the discussion Captain Trench says that he leaves it to the verdict of general experience to say whether 2 kW in the aerial would not give easy communication over 4,000 km with modern valve reception and amplification.

We fear that the verdict has already been given by all those engineers who have been responsible for long-distance radio stations. It is a verdict based upon bitter experience and is exemplified in such things as 1,000-kW arcs and discussions as to the possibility of the parallel running of 500-kW radio frequency alternators.

Some Thermionic Tube Circuits for Relaying and Measuring.—A paper with this title by Dr. W. H. Eccles and Miss W. A. Leyshon was read before the Wireless Section of the Institution of Electrical Engineers on March 16th. The underlying idea embodied in the paper was the use of a saturated diode as the load in the plate circuit of a triode. To obtain a large voltage amplification it is necessary that the load in the anode circuit should have a high resistance to oscillations, whereas its resistance to continuous currents should be as small as possible in order to avoid the necessity of a high E.M.F. in the anode battery. Expressed mathematically $\frac{dV}{dI}$ should be big and V/I small. An inductance has this property, but in a degree depending on the frequency; a saturated diode maintains the same current ($dI = 0$) for all variations of dV over a certain range, and dV/dI is therefore infinitely great. The use of a diode in this way has been suggested by several physicists. The authors of the paper used it in order to determine the voltage ratio of the tube $\partial V_p/\partial V_g$ when the plate current I_p is kept constant. The saturated diode in the plate circuit relieves one of any trouble in maintaining this latter condition. It should be pointed out, however, that the geometrical conception of the voltage ratio implies that the total emission current is kept constant; as soon as the grid is made sufficiently positive to take an appreciable current, a new factor is introduced which has no connection with the geometrical conception of the voltage ratio. This was clearly shown in the curves given in the paper, the voltage ratio being constant under all conditions only so long as the grid current was zero.

The Effect of Emission on Filament Temperature.—A short but interesting paper on this subject by Mr. G. Stead was read before the Wireless Section of the Institution of Electrical Engineers on March 16th. The experimental work was done three years ago for the Admiralty. Pyrometrical observations were made at various points along the filament with various values of emission current, keeping the filament current *as read on an ammeter in the positive filament lead* constant. The resulting temperature changes which are plotted in the paper are due to two causes, viz., (1) the cooling due to the energy carried off by the emitted electrons and (2) the variation of current along the filament due to the emission. The paper serves to emphasise several points which are always a source of uncertainty in connection with thermionic devices. The characteristic curves are very dependent upon the filament temperature and it is therefore important to specify it as accurately as possible. If an ammeter is inserted and its reading kept constant, different results will be obtained according to whether it is connected in the positive or negative lead since the emission current divides between the two limbs, increasing the current in one and diminishing it in the other. By inserting three ammeters, one in each limb and one in the anode circuit, one can calculate the true filament current and the two parts of the emission current and can keep the former constant if this is required.

Some experimenters have tried to keep the filament temperature constant, but here again one is in difficulties since the distribution of temperature along the filament depends on the emission current.

Another matter of interest is the difference which must exist between the static and dynamic characteristics since when the emission current is varying with a high frequency the filament temperature will not follow the rapid fluctuations but will assume a mean value at each point. Deductions based on the static characteristics must therefore be modified when applied to high-frequency oscillations.

To the Authors of Scientific Papers.—The editors of seventy German scientific journals have issued a joint notice to all their contributors with the object of increasing the general efficiency of such publications. The notice appears in the February issue of the *Jahrbuch Zeitschrift für drahtlose Telegraphie*. It embodies eight paragraphs and is commendably brief and to the point. We give here a translation and commend it to all our contributors:

(1) Before starting scientific work find out exactly what has already been published on the subject.
(2) Every article should be carefully planned and the sub-divisions made clear. The manuscript should be ready for the printer, preferably typewritten on one side of the paper; bad handwriting and subsequent alterations add considerably to the cost.
(3) Keep the article within the narrowest limits, avoid foreign words and choose the most careful German; omit lengthy introductions, developments, and unnecessary calculations.
(4) As far as possible replace lengthy descriptions by diagrams. Insert all scales and figures in drawing-office style. Brief particulars under the diagrams increase their value and replace long descriptions.
(5) Diagrams should only contain the essentials; omit secondary details or well-known matter. If already published elsewhere give references.
(6) Carefully observe editorial suggestions for shortening the article. Generally speaking, the shorter the article the greater its effect.
(7) Before sending in criticisms for the correspondence columns try to come to some agreement with the author.
(8) Never offer an article to a second journal until the first one has declined it. Any second publication should contain only short abstracts from the main publication.

The Lafayette Radio Station.—As a result of the preliminary tests and working of this new high-power station referred to in our February issue (pp. 85—93) it appears from a report published in *Radioélectricité*, that while its power is ample for communication with the United States, it is still insufficient for continuous traffic with South America or with the East—*i.e.* over ranges of 10,000 kms or more. The signals at these distances are seriously interfered with by atmospherics. For example at Hanoi the signals from Croix d'Hins can be heard strongly between 2100 and 0500 G.M.T., but at other times they fade. Similarly at Shanghai the signals are unreadable between 1700 and 1900, although they are strong at 2100 G.M.T., and throughout the morning. This is apparently one of the reasons underlying the project for the large Paris Radio Centre upon which work has now been commenced. Further details of this project were published in our March issue. [2120]

Some Recent Designs for Ship Radio Installations.*

By H. R. RIVERS-MOORE, B.Sc., A.M.I.E.E.

Some standard equipments suitable for ship or other stations, which possess several features of interest, have recently been developed by Messrs. R. M. Radio, Ltd. The larger sets, of 1½ and ½ kW respectively, are similar in general conception, and a description of the latter will sufficiently indicate the main features of both. The set is of the rotary spark type with the familiar inductively coupled arrangement of circuits (see Fig. 1) and the design aims particularly at the achievement of simplicity and accessibility with small bulk, with a view to providing an equipment which can easily be fitted and maintained in vessels having limited space, and which offers little complication to the operator in charge.

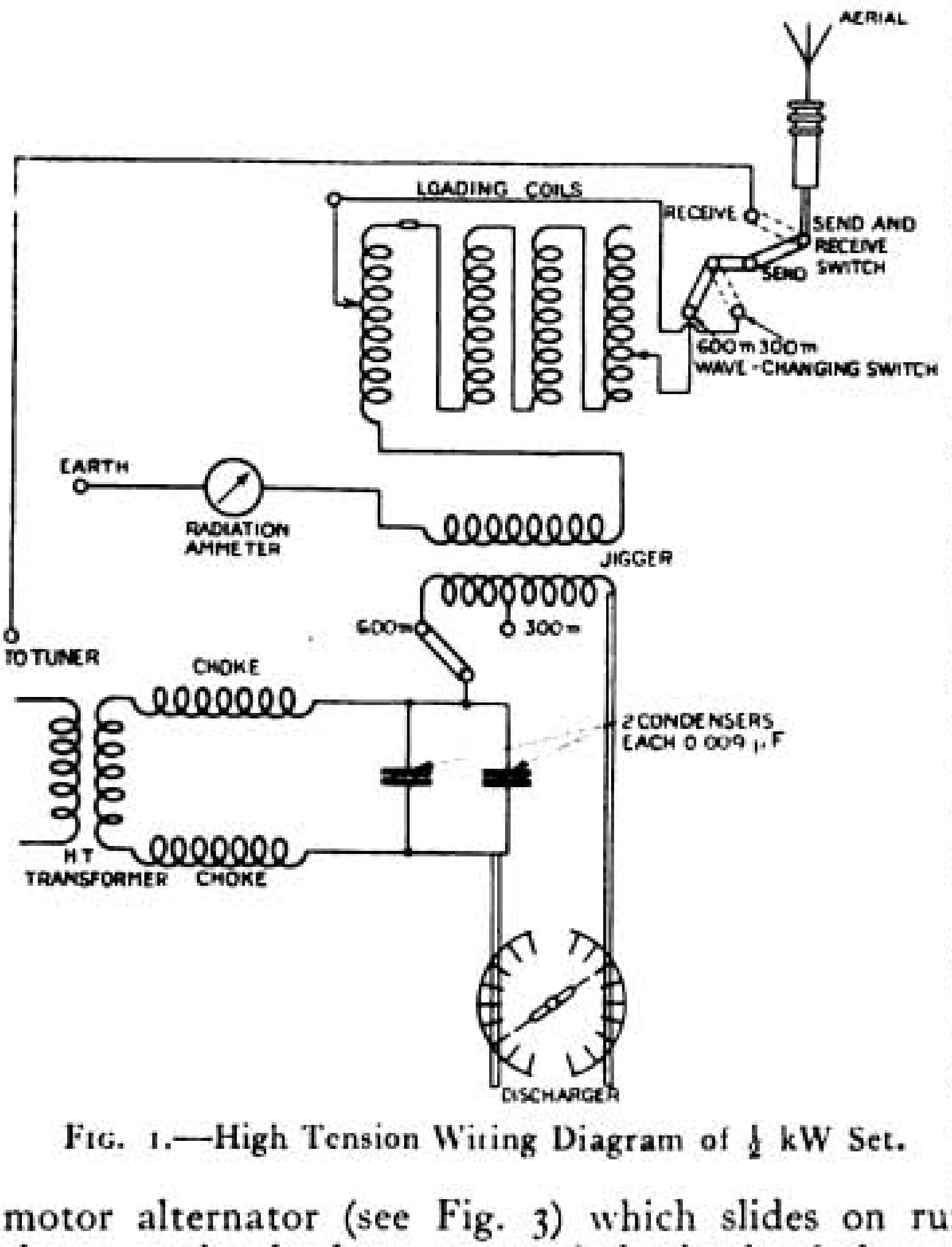


FIG. 1.—High Tension Wiring Diagram of ½ kW Set.

Transmitter and receiver are fitted in a single cabinet (Fig. 2) which also embodies the operating table. This cabinet is only 3 feet wide and both sides are kept clear of projections or controls so that this represents the total width of space needed to accommodate the set.

Advantage is taken of the absence of any physical connection between the primary and secondary oscillating circuits, to build up the former entirely on the motor alternator (see Fig. 3) which slides on runners into and out of the space in the lower part of the back of the cabinet. The runners are continued on the inside of the falling door which encloses the primary transmitting unit, and thus, on opening this door, the whole unit can be drawn forward into an accessible position. The leads to motor and alternator are

* Received March 16th, 1921.

of strong workshop flexible and are connected to terminal strips inside the cabinet. They are of sufficient length to allow of the machine being drawn out and run in the exposed position if required.

To the generator carcase, at the alternator end, is fixed the cast aluminium discharger housing, which has a flat top on a level with the top of the machine Covering the whole is a teak platform on which the primary high tension

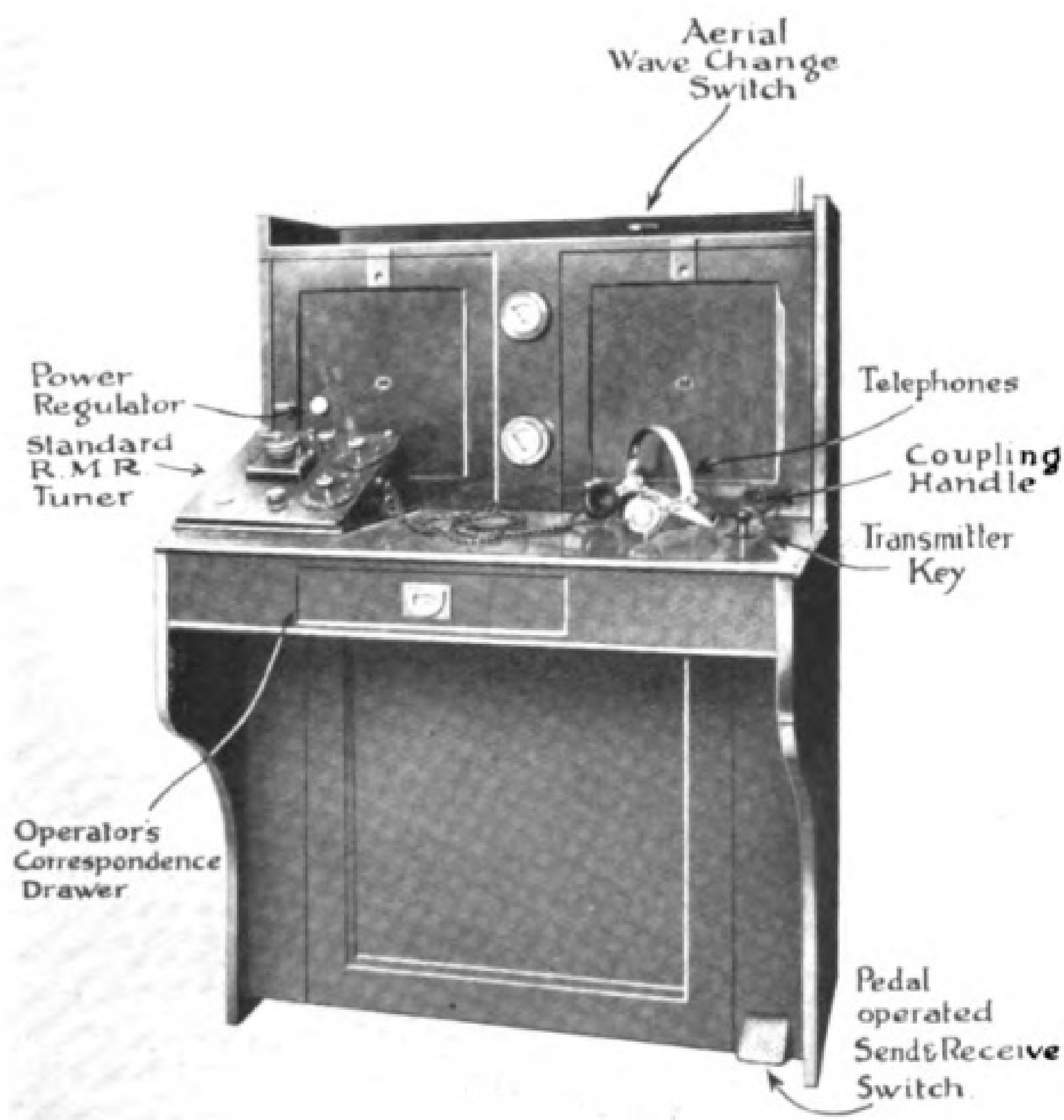


FIG. 2.—½ kW Spark Set.

unit is built up. At one end is the high tension transformer and about the middle a bank of Dubilier condensers and a pair of air-core protecting chokes constructed to be of the same size as one of the condensers. The condensers and chokes are all contained in a teak outer case from which they can readily be removed by sliding them out. The transformer is mounted on a small hinged piece so that it can be tilted out of the way and the high tension leads from the transformer, which are only about 2 inches long, terminate in plugs which engage in sockets in the choke coils. Thus the replacement of a condenser is only a matter of seconds.

The arrangement of the connections of the primary oscillating circuit adds to the ease of changing condensers and also avoids the use of flexible connections, while keeping the area enclosed by the circuit a minimum. It will be seen from Figs. 3 and 4 that the air core chokes and the condensers are provided with heavy copper clips in lieu of terminals and that these

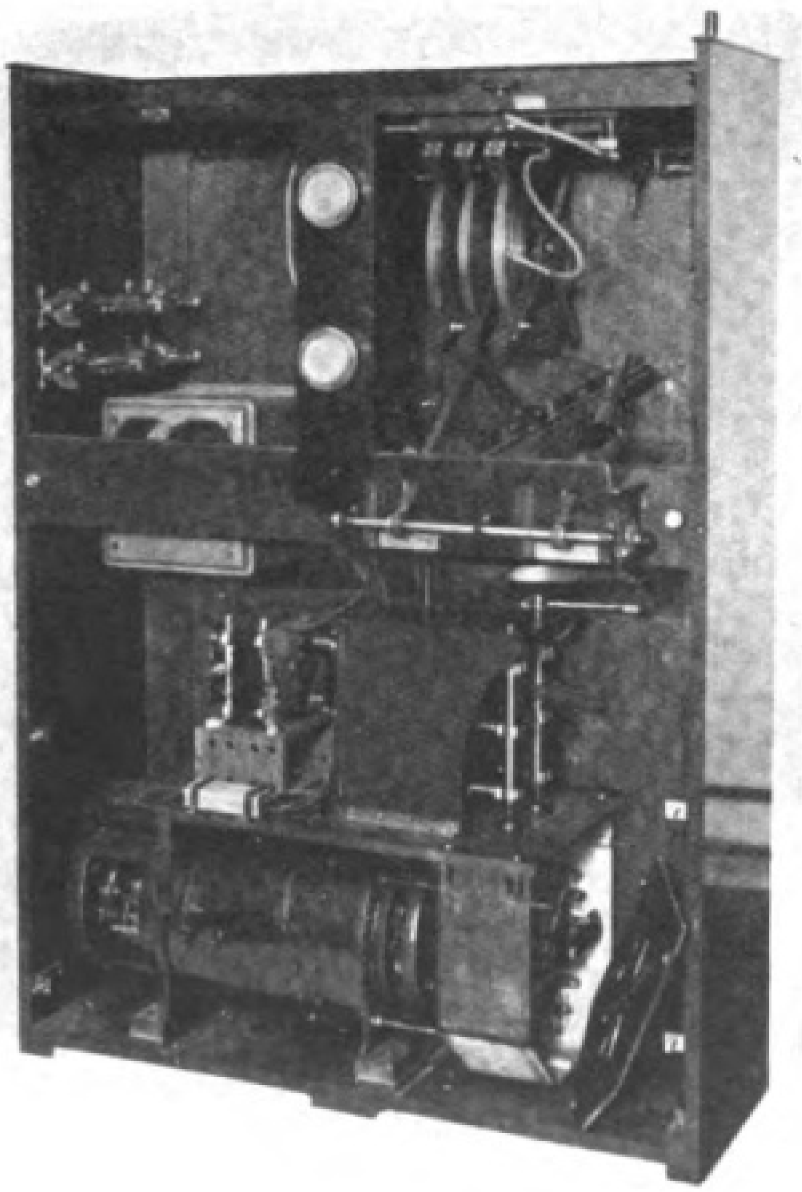


FIG. 3.—Interior of Set.

clips engage with tubular copper connectors running vertically. The tube on the left in Fig. 3 interconnects one choke and one side of each condenser and is extended by means of a copper rod into the discharger housing below, where it connects to one side of the discharger. From the other side of the discharger a rod runs concentrically up through the right-hand tube, and insulated from it throughout by an ebonite tube, and is screwed into a boss which forms the centre and starting point of the pancake winding of the jigger primary, of heavy copper strip. This rod in fact supports the jigger

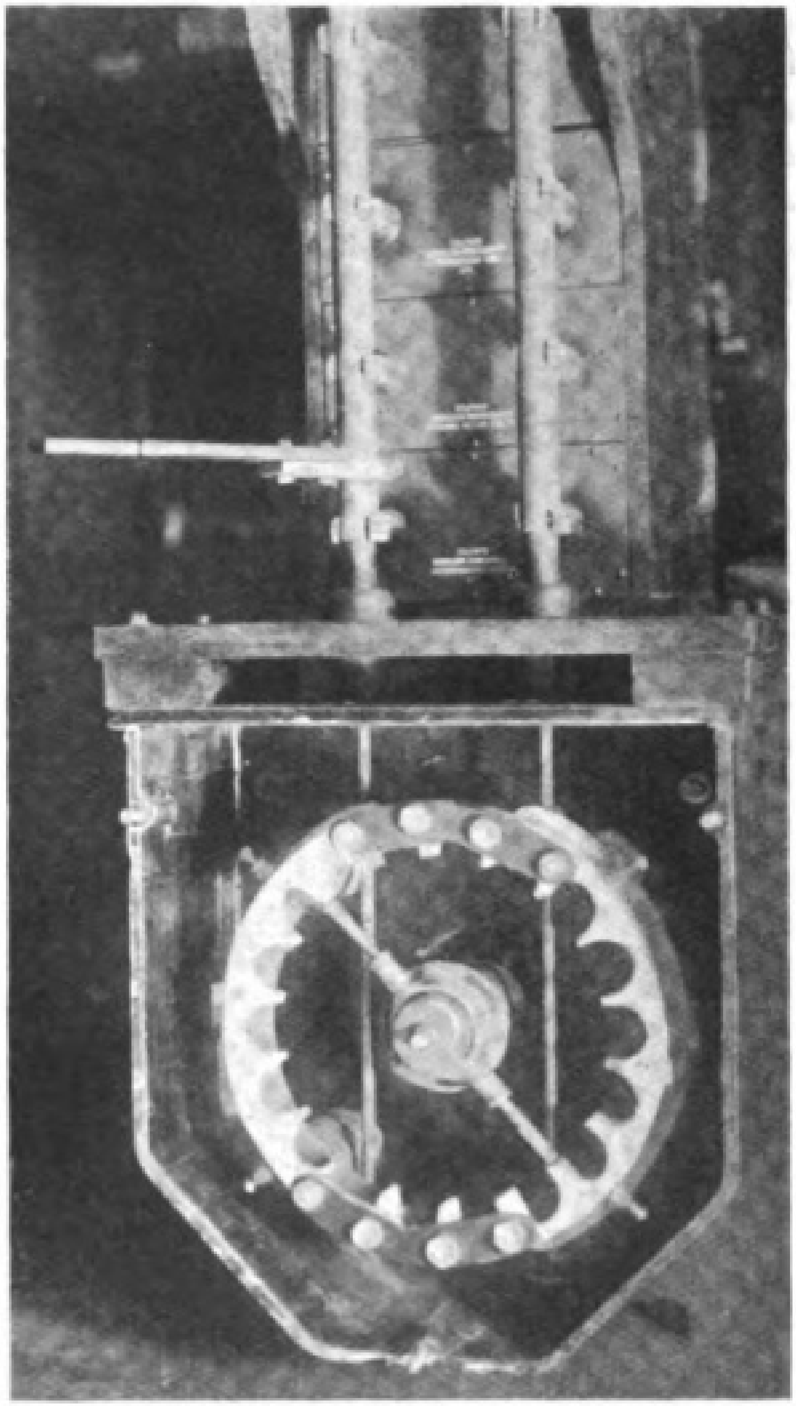


FIG. 4.—Rotary Spark Gap and Condensers.

primary which however is also upheld and steadied by ebonite pillars at the extremity of two of the cross arms. At proper points on the jigger primary to give the required wavelengths special contact clips are attached which can be seen projecting downwards. They can be adjusted to any required position. The right-hand tube already mentioned carries a contact arm or blade corresponding to each of the wavelength clips, and as these blades are gripped by friction clamps on to the tube, they can be set into positions corresponding to those of the jigger clips with which they have to engage, in such a way that a fixed angular movement of the tube will cause engagement of a particular blade with its corresponding clip, wherever the latter may have been placed. Thus a wave-change switch is provided which has the advantage that it involves neither flexible leads nor pivot contacts. Where however more than three waves are required it becomes difficult to keep the blades and clips sufficiently separated for insulation purposes and a modified form is used involving short flexible leads and fixed contact clips.

The discharger is somewhat unusual inasmuch as it consists of a crown of fixed electrodes and only two rotating electrodes. The arrangement is illustrated in Fig. 4. The crown is originally cast and machined as a single piece to ensure accuracy and it is then divided into two portions and reassembled with insulating clamps without upsetting the alignment. The whole crown is then fitted adjustably into brackets which are in electrical connection with the copper rods mentioned above. The crown is held by four pointed screws which fit into a V-groove running all round its outer surface and by their means it can be adjusted centrally with respect to the shaft of the motor-alternator which carries the two rotating electrodes. Leaving the four screws slightly loose in the groove the phase relation can readily be adjusted by rotation of the crown, after which all the screws are tightened up.

The more usual arrangement in which the whole housing carrying two fixed electrodes is swung for phase adjustment, does not lend itself to the rigid platform construction adopted for the primary unit. Apart from this consideration the fact that the two electrodes which have the heaviest work are in rapid rotation causes most efficient cooling and it is found quite unnecessary to provide a large mass of metal or any special cooling vanes for them. They are themselves of flat form and act as fans. The power needed to drive these electrodes should be less than in the case of a multiple rotating electrode. The spark obtained is of excellent quality and very penetrating. The spark frequency is 700 per second.

The spark occurs, of course, at different points round the circle in succession and the appearance produced is quite spectacular, as there is a crown of brilliant sparks and the rotating electrodes appear stationary and multiplied like spokes of a wheel. Any fear of the inductance of the circuit being varied owing to the spark occurring in different positions is overcome by the arrangement by which each half of the crown is connected electrically to its bracket at three points, namely the two at which it is held by the screws and an additional flexible lead of woven copper at the mid point, introduced as a safeguard.

Earthed condensers mounted on the platform of the unit serve to protect the windings of the machines.

Immediately over the jigger primary when the unit just described is in position in the cabinet (see Fig. 2) is the secondary, consisting of another pancake winding of copper strip, mounted on a frame pivoted along one edge and controlled by a handle conveniently situated for varying the coupling.

The remainder of the space in the right side of the upper part of the cabinet is occupied by the loading coils, of pancake form, and the secondary wave-change switch. In later forms it is proposed that a single handle shall control both primary and secondary wave-change switches. The loading coils are banked together with plug and socket connections so that only the actual number necessary with a given aerial need be fitted.

The send and receive switching arrangements call for comment. The aerial is connected to the apparatus by means of a plug which fits into a socket in a small leading-in insulator in the top of the cabinet. This socket is formed in the upper end of a brass rod which is actually the pivot of the send and receive switch and carries the switch blade at its lower, inside, end. Thus no current has to pass through any moving contact but as the switch blade turns from "send" to "receive" position the aerial plug makes a small angular movement which is easily absorbed by the flexible lead from the deck insulator.

The movement of the "send and receive" switch blade is controlled by a pedal beneath the desk and the same pedal gear operates a small switch which controls the automatic starter for the motor generator. Thus the entire switching operation is completed in about three seconds by merely depressing the foot. On removing the foot a spring pulls the aerial switch into the "receive" position and the automatic starter switch falls back into the "off" position. The switch pedal is quite light and no fatigue is involved in keeping it depressed and the whole arrangement is remarkably convenient and simple, leaving the operator's hands entirely free. An alternative hand control is provided and can readily be changed for the other if preferred.

Save only the automatic starter all switches are directly controlled by straightforward levers which are fully exposed by opening the cabinet. The operator has everything under observation and there is nothing intricate to get out of order.

Behind the left side panel of the upper cabinet are two sliding rheostats

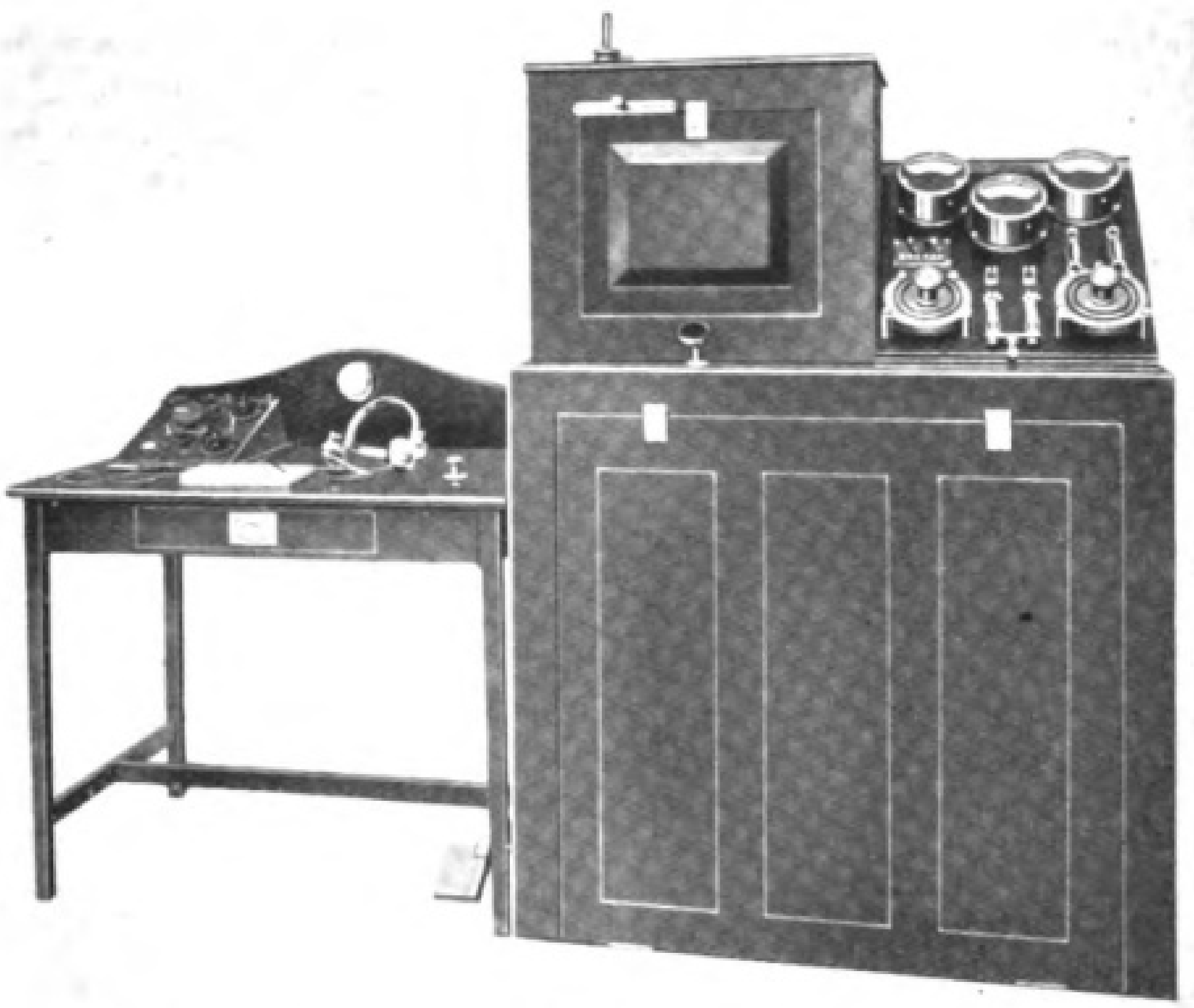


FIG. 5.—1½ kW Spark Set showing Cabinet and Operating Table.

controlling the speed and power of the generator by means of handles projecting through the panel. No other adjustments are provided in this set. There are two ammeters in the slip dividing the two removable panels of the upper cabinet, one of which indicates the key current and serves as an indication of power taken; the other gives the aerial current and is used for tuning and as an indication of power output. A low frequency choke is provided, of fixed value determined before the set is issued. The operator therefore has only to vary his power according to requirements and then vary speed until the best note and aerial current are obtained. The discharger once set should not be altered except as the electrodes burn away.

It will be seen that the object has been to provide minimum opportunity for throwing the set out of gear and to simplify the adjustments to those required by the authorities, namely wave change, coupling and power variation, with in addition a small speed variation for securing low frequency resonance and a good note.

The key is of the simplest and most usual description but is inverted and mounted beneath the desk with the knob only projecting above. Adjustments of travel and tension can be made by putting the hand beneath the desk and the key is connected by plug and socket and can be withdrawn readily for replacing contacts.

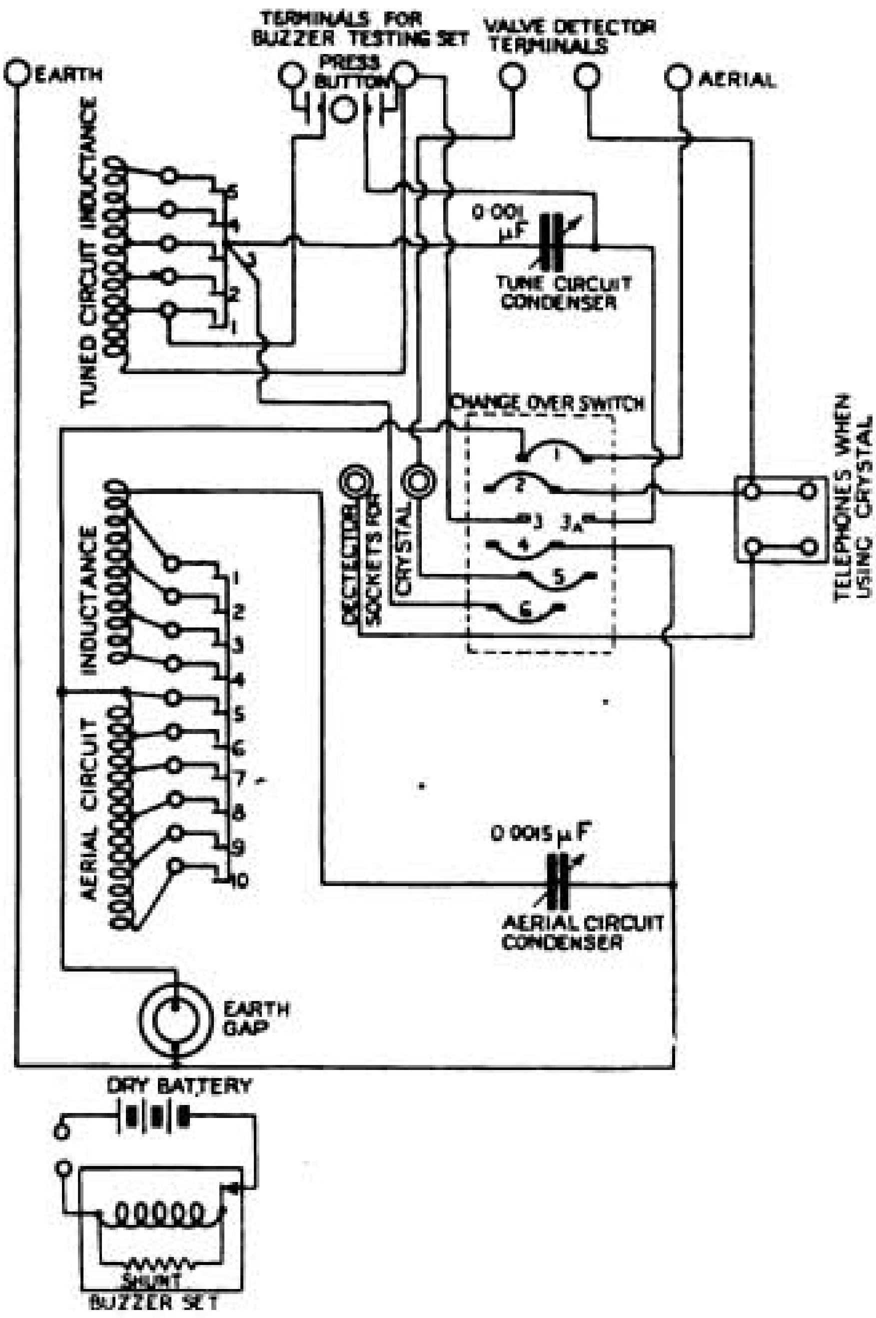


FIG. 6.—Wiring Diagram of Receiver.

The transmitter for the 1½ kW set (Fig. 5) differs in that the lower portion of the cabinet is a silence chamber with cork filled walls. A variable low frequency choke is provided, and a slate switchboard with instruments for measuring D.C. and A.C. volts and amperes. While retaining the main features and simplicity of the smaller set it provides rather more adjustments and facilities which can be utilised by an operator who wishes to get the best out of his instrument. The receiver and signalling key are fitted on a bench or table separated from the transmitting plant.

The standard form of receiver is the same for both ½ and 1½ kW sets. In the former case it is fitted into a recess in the operating desk, with the upper face, containing the adjusting handles, set at a slope for easy handling. The tuner provides aerial tuning inductance and condenser and there is a closed circuit similarly variable and coupled adjustably to the aerial circuit by a coil swinging on its own axis (see Fig. 6). The wavelength range is from 250 to 3,500 metres.

Provision is made for detection either by valve or crystal, the valve being fitted in the left side panel of the cabinet when required. This is not shown in the illustration and it is proposed in future to incorporate it in the tuner.

The tuner can easily be lifted from its recess and used as a wavemeter. Two terminals and a press-button are provided, connected to some turns of the closed-circuit inductance. A small separate case containing a buzzer and dry-cells is provided with contact pieces to engage these terminals and thus provide means for testing the crystal setting and also for using the tuner as a transmitter wavemeter. For testing the crystal the change-over switch should be placed in the " stand-by " position and the closed circuit brought into resonance with the aerial circuit. In order to avoid absorption of energy by the closed circuit when listening on the " stand-by " adjustment with the closed circuit coupled and set to the same wavelength, the change-over switch opens the " tuned " circuit when in the " stand-by " position. It is therefore necessary to provide an additional contact on the buzzer key to close the circuit automatically when the buzzer is used.

The object in having the buzzer and its battery in a separate box is merely for accessibility in changing the battery or adjusting the buzzer.

The tuner is provided with a safety earth gap of brass plates separated by a mica disc, the sparking surface being totally enclosed to keep out dust.

A valve of special form is used which we hope to describe fully in another article, but standard " R " valves can be used.

The crystal detector consists of a revolver drum, of ebonite, carrying eight small cartridges. The cartridges comprise a cylindrical body of ebonite within which are two very small crystal cups pressed together by a spring which is adjustable from the outside at one end by a small screw-driver. By turning the drum a fresh cartridge is brought into action and connected between a brass anvil below and spring contact above the drum, so that it is the work of a moment to change from a crystal which has become insensitive. Eight cartridges are carried in the drum and a further supply can be kept ready adjusted to replace these when required. The first set can then be re-adjusted at leisure in readiness for further use. If trouble is experienced from the transmitter rendering crystals insensitive, a " half-cock " position of the drum disconnects the cartridge completely and leaves only the very small brass mountings of the cartridge in contact with the crystals to pick up oscillations.

We hope in a later article to give a description of the several forms of ½ kW and emergency equipments manufactured by the same firm.

Measurements of Radiation of Radiotelegraphic Aerials.

By G. VALLAURI.

(Concluded from page 143.)

12. Experimental Results.—The first attempts at systematic measurements of radiation and the first applications of same to the rational study of the shape and properties of aerials, were probably made by the Royal Italian Navy. After a first phase of study and research work, standard measurements of radiation were made on September 13th and 19th, 1916, on the aerial of the Taranto Wireless Station (Fig. 7). In these measurements only half the aerial was used, consisting of three wires ($\lambda_0 = 1{,}500$ m; $C = 3{\cdot}62$ mμF), and it was excited by a 3 kW Poulsen arc generating a current of about 10 A with various values of λ between 2,500 and 4,500. The receiving aerial, placed on the Island of S. Pietro ($d = 12{\cdot}1$ km) was a closed vertical frame of rectangular form with an area $S_r = 680$ m^2. The induced currents were of the order of some tenths of milliamperes, they were measured by a thermoelectric couple in vacuo, connected with a reflecting galvanometer. The resistance of the receiving circuit was measured by the insertion of a known resistance both with impulse excitation produced by a buzzer, as well as by the excitation due to the wave transmission to be measured. The effective height in the direction considered, which formed an angle of 61° with that of maximum radiation (according to the known properties of bent antennæ), was found to be 56·5 metres.

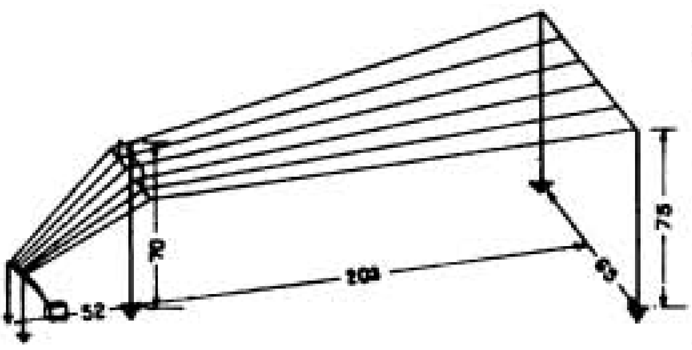


FIG. 7.

More exact measurements were carried out in 1917 for the Rome Wireless Station (San Paolo), by installing the receiving station on the beach of Fiumicino ($d = 23{\cdot}2$ km) with a closed rectangular aerial the area of which was 531 m^2, far from any disturbing local influence. The instruments were placed in a small shed. As receiver, a Duddell thermogalvanometer with a 4 ohm heater was used.

The calibration was carried out by inserting the Duddell galvanometer in a local circuit containing a resistance box and an accumulator, the voltage of which was measured at the same time by a precision voltmeter. From the readings δ_1 for different values of the resistance R of the box, and the zero reading δ_0 one gets the deflection $\Delta = \delta_1 - \delta_0$; and from the ratio between the value of the current $I = \dfrac{V}{R+4}$ and $\sqrt{\Delta}$ we get the constant of the thermogalvanometer $K = I/\sqrt{\Delta}$. For the measurement of the received current and of the resistance of the receiving oscillatory circuit, it had been agreed that the transmitting station (Poulsen arc) at determined hours should alternate constant emissions lasting ten minutes (each with a given wavelength), with pauses also of ten minutes duration. During every transmission, the opening minutes were devoted to carrying out the accurate tuning of the receiving circuit, the capacity being varied until the maximum deflection had been obtained at the galvanometer. After this the measurement was begun, following a regular programme of readings; viz.: δ_0 (open circuit zero reading), δ_1 (closed circuit reading containing a known supplementary resistance R' adapted for high frequencies), δ_2 (closed circuit with R' cut out) and then in order δ_1, δ_0, δ_1, δ_2, δ_1, δ_0, δ_1, etc. This succession of measurements is necessary in order to be able to eliminate the effects both of accidental errors and of the slow displacement of the zero. Calculating the mean deflections $\Delta_1 = \delta_1 - \delta_0$, and $\Delta_2 = \delta_2 - \delta_0$

we get $I_r = K\sqrt{\Delta_2} \qquad R = R' \dfrac{\sqrt{\Delta_1}}{\sqrt{\Delta_2} - \sqrt{\Delta_1}}$

from which $h = \dfrac{I_r}{I} \cdot \dfrac{dR\lambda^2 . 10^{-11}}{2{\cdot}4\pi^2 S_r \cos\alpha} \qquad (\mu = 1)$

The following is an example of such measurements :—

December 5th, 1917. Station at Fiumicino:

$d = 23{\cdot}2$ km $\quad S_r = 531$ m² $\quad \alpha = 0 \quad \lambda = 6{,}500$ m.

CALIBRATION OF THERMOGALVANOMETERS.

Resistance of heater = 4 ohms. Applied P.D. = 2·01 volts.

R	δ_0	δ_1	Δ	$I = \dfrac{V}{R+4} . 10^3$ milliamperes.	$K = \dfrac{I \text{ (milliamperes)}}{\sqrt{\Delta}}$
500	373	195·5	177·5	3·99	0·300
700	373	282	91	2·86	0·300
900	373·5	318	55·5	2·225	0·299
1,200	373·5	342	31·5	1·67	0·298
1,400	374	451	23	1·43	0·299
1,700	374	358·5	15·5	1·18	0·300
2,000	374·5	362·8	11·7	1·004	0·294
1,000	374·5	329	45·5	2·000	0·297
2,400	374·8	366·8	8	0·837	0·296
					Mean 0·298

MEASUREMENT OF RADIATION.

TIME.	δ_0	δ_1	δ_2
11 h. 34′ 30″	341·5		
		364·0	
			378·2
		364·4	
	341·2		
		364·5	
			378·5
		364·5	
	341·8		
11 h. 37′ 30″	341·5		
		364·5	
			378·4
		364·5	
	341·5		
		364·4	
			378·5
		364·8	
	342·5		

Mean values $\quad \Delta_1 = 13{\cdot}9_5 \quad \Delta_2 = 36{\cdot}7_3 \quad I = 83{\cdot}78$ A

$R' = 5{\cdot}68$ ohms $\quad R = 9{\cdot}13$ ohms $\quad h = 153{\cdot}7$ m.

As is known* in the Rome Station two different aerials supported by three wooden trellis masts 218 metres (714 feet) high were tried in succession. They are represented in plan and in general arrangement in Figs. 8 and 8A. The numerical example is taken from the tests on the first aerial shown

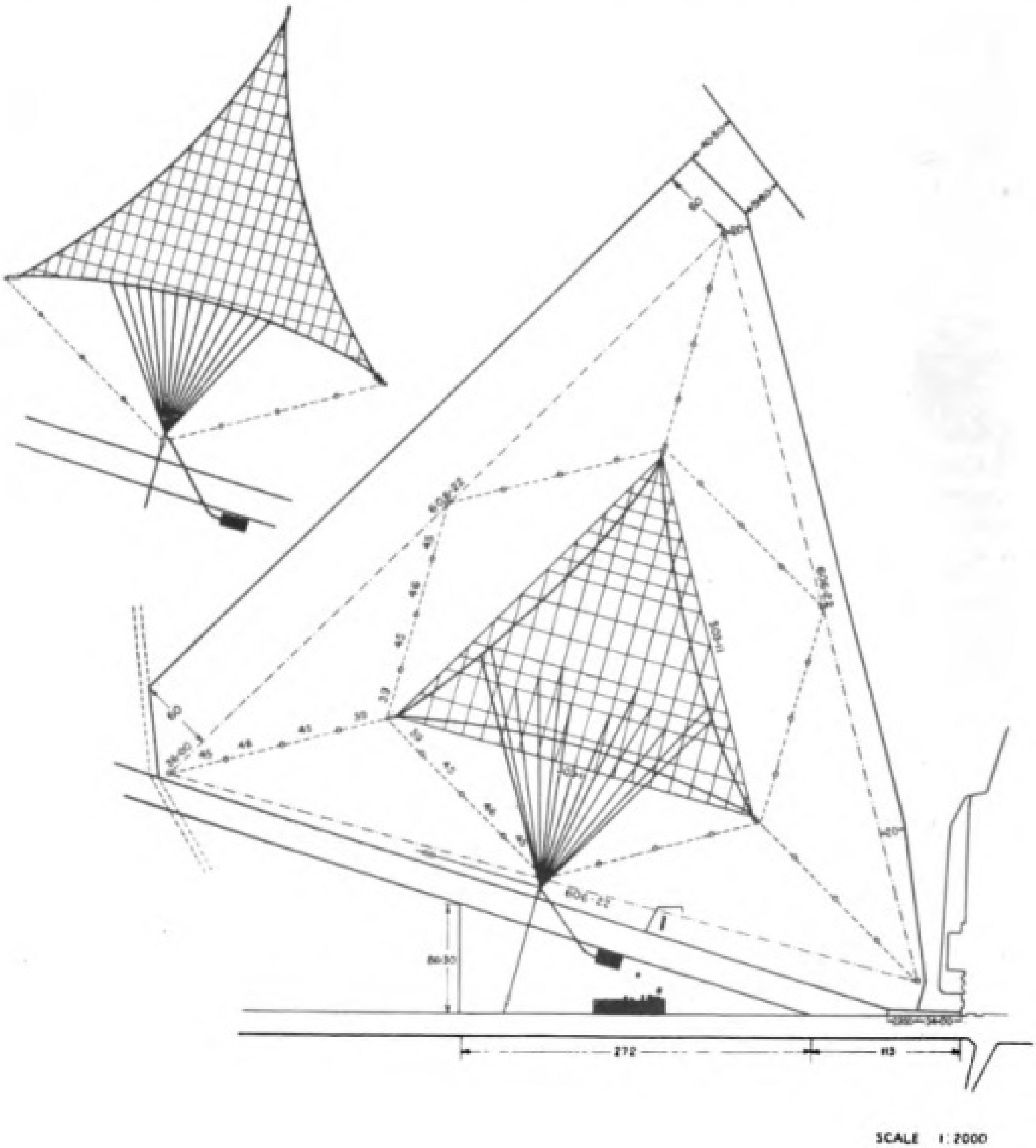


Fig. 8.

* B. Micchiardi, G. Pession, G. Vallauri, "The Rome San Paolo Radiotelegraphic Station." (*L'Elettrotecnica*, 7, pp. 218—224 and 241—244, May 5th and 15th, 1920, and Publication No. 8 of the Electrical and Radiotelegraphic Institute of the Royal Italian Navy.)

[Also: *Proceedings of the Institute of Radio Engineers*, 8, pp. 142—163, April, 1920; Radio Review Abstracts Nos. 538, July, 1920, and 840, September, 1920.]

in the top left-hand illustration of Fig. 8, for which we had $\lambda_0 = 2{,}960$ m., $C_s = 9{\cdot}9$ mμF (static capacity). From a large number of tests carried out on this aerial which agreed very well for three wavelengths, we found the following values :—

λ_{metres} =	6,500	8,200	10,150
h_{metres} =	153·2	150·8	149·6

These confirm the theoretical forecast of a small decrease of h with increase of λ. Similar tests were carried out on the second aerial (represented in the bottom right-hand of Fig. 8, for which $\lambda_0 = 2{,}930$ m., $C_s = 11{\cdot}2$ mμF from which we obtained

λ_{metres} =	6,830	8,700	10,860
h_{metres} =	138·4	138·4	138·0

These comparative results, compared with the various values of the current which the Poulsen arc was capable of maintaining in each of the two aerials, allowed of a rational choice between them. (See preceding footnote.*)

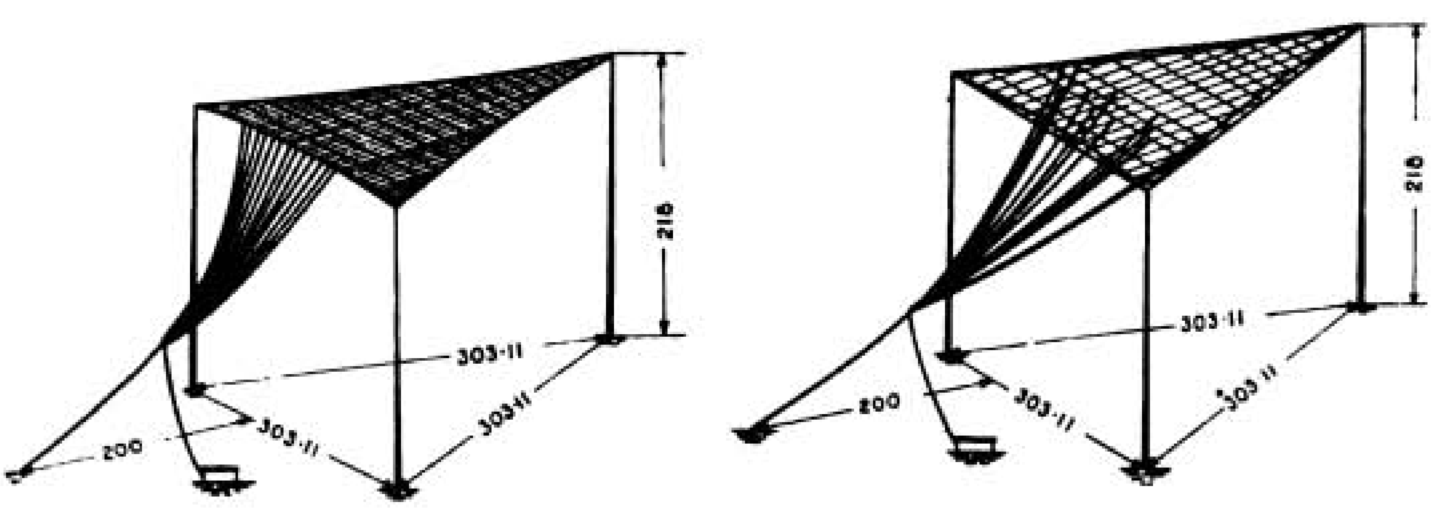


FIG. 8A.

Still more numerous measurements were carried out in January and February, 1918, on the Coltano aerial. The aerial used at that time shown diagrammatically in elevation and in plan by Fig. 9 consisted of thirty wires of which twenty-four were included between the masts and the other six divided into two sets of three and secured to the outside stays. The aerial, moreover, presented the noteworthy feature of being fed at the middle and the plant was still worked by the Marconi spark system (with an asynchronous disc discharger). On this occasion a small measuring plant was used, easily portable and quickly mounted.

The receiving aerial was a single triangular coil, supported by a bamboo dismountable mast of the Marconi field type, 21 metres high (68 feet 10 inches). The mast could be set up and the aerial mounted in a few minutes ; the necessary material together with the measuring instruments and the mast was transported in a motor lorry. In the rear cabin of the motor lorry the thermogalvanometer was placed (Fig. 10); on the footboard were placed the variable condenser, the resistances, the coupling inductance, the buzzer, etc.,

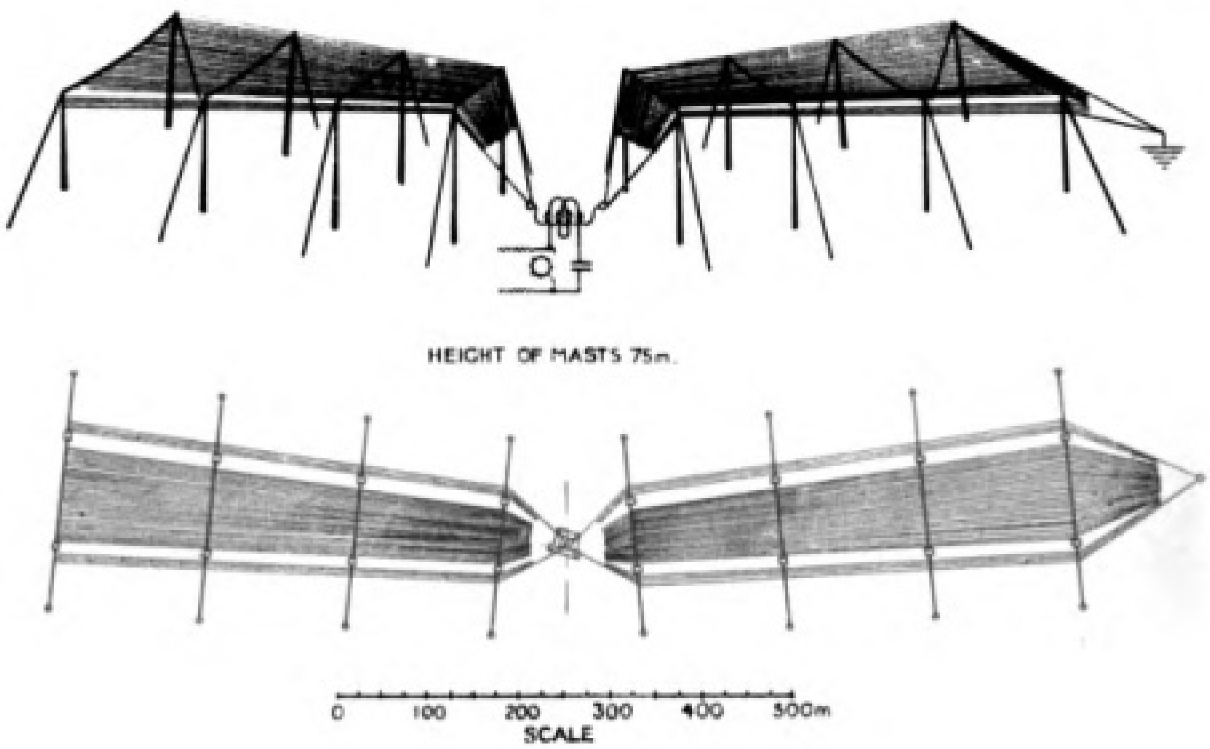


FIG. 9.

so that the operator might stand on the ground and the little lorry be perfectly steady, as is required for the stability of the galvanometer. A black hood supported by the two open rear windows of the lorry came down all round the observer and the footboard which acted as a table for the tests, so as to avoid any air currents and to allow reflection (mirror) reading. The insulation afforded by the rubber tyres of the lorry helped to exclude any risk of the measurements being falsified by the action of any current passing through the galvanometer, under the action of an E.M.F. induced, not in the closed circuit of the aerial, but between this and the earth. The measurement of the aerial resistance was effected by impulse excitation (par. **7**), produced by an aperiodic primary containing a cell and a good buzzer. As

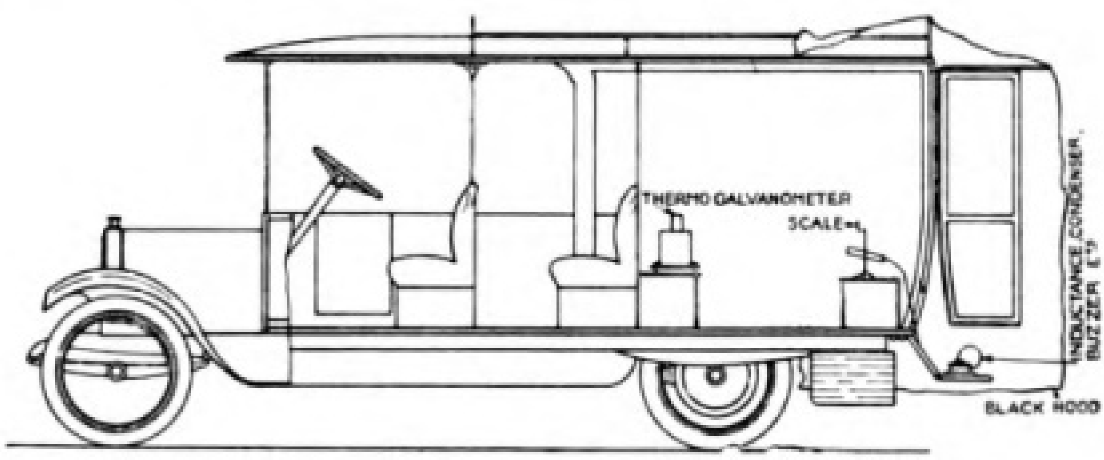
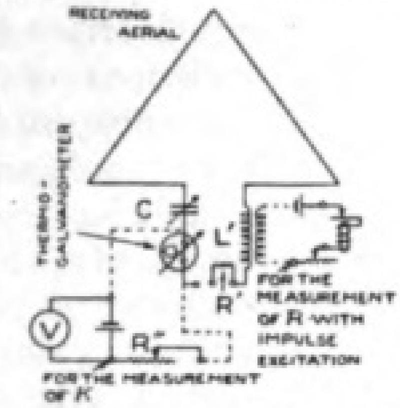


FIG. 10.



Measurement of the resistance R of the receiving aerial by means of impulse excitation:

$$R = R' \frac{\Delta}{\Delta_2 - \Delta_1}$$

Ditto, with continuous waves and very weak coupling.

$$R = R' \frac{\sqrt{\Delta_1}}{\sqrt{\Delta_2} - \sqrt{\Delta_1}}.$$

(N.B.—When the signals are C.W. they may be used for this measurement.)

Measurement of the constant K of the thermogalvanometer ($R_t = R'' + R_{galv.}$)

$$K = \frac{I}{\sqrt{\Delta}} = \frac{V}{R_t\sqrt{\Delta}}.$$

Calculation of the effective height $h = \frac{I_r}{I_t} \cdot \frac{\lambda d}{S} \cdot L \cdot \frac{\sqrt{\delta_r(\delta_t + \delta_r)}}{4\pi^2 \cos \alpha}$ cms

and for $\delta_t = 0$ (*i.e.*, with undamped oscillations): $h = \frac{I_r}{I_t} \frac{dR\lambda^2 \cdot 10^{-11}}{2 \cdot 4\pi^2 S \cos \alpha}$ cms.

$\Delta = \delta - \delta_0$ = Deflection of thermogalvanometer $\begin{cases} \Delta_1 = \delta_1 - \delta_0 \text{ with } R' \text{ included} \\ \Delta_2 = \delta_2 - \delta_0 \text{ without } R'. \end{cases}$

λ = Wavelength.
I_t = R.M.S. value of the transmitter current.
I_r = „ „ „ received current.
δ_t = Log. decrement per period of the transmitted oscillations.
δ_r = „ „ „ „ „ receiving aerial.
d = Distance between the two stations.

L = Total inductance of the receiving circuit in cms.
R = Total resistance of the receiving circuit in C.G.S. units.
S = Total effective (area × turns) of the receiving aerial.
α = Angle between plane of receiving coil and direction of station.
[h, λ, d and S are all in cm. or cm².]

Example — February 6th, 1918: Station Calambrone.

Measurement of the Aerial Resistance.

δ_0	δ_1	δ_2	δ_0	δ_1	δ_2
296			180		
	336			332	
		375			420
	336			298	
288			175		
	341			316	
		368			425
	335			304	
286			169		
	346			290	
		388			410
	348			305	
282			162		
	334			320	
		396			393
288	339·7	381·8	171·5	309·3	412·0
	288·0	288·0		171·5	171·5
	$\Delta_1 = 51·7$	$\Delta_2 = 93·8$		$\Delta_1 = 137·8$	$\Delta_2 = 240·5$
		51·7			137·8
		$\Delta_2 - \Delta_1 = 42·1$			$\Delta_2 - \Delta_1 = 102·7$

$R = 6·12 \frac{51·7}{42·1} = 7·51$ $R = 6·12 \frac{137·8}{102·7} = 8·21$

Mean R = 7·86 ohms.

Decrement of the Receiving Aerial.

$$\delta_r = \pi\sqrt{\frac{C}{L}}\ R.$$

$R_1 = 7·86 + 6·12 = 13·98$ $\delta_r' = 0·361.$
$R_2 = 7·86$ $\delta_r' = 0·203.$

Distance from Coltano . . . 10,700 m.
True azimuth with respect to Coltano . 231°
„ „ of the aerial 50·5°
α . . . . 0·5°
Base of the triangular aerial . 39·35 m.
Height „ „ „ . 18·20 m.
Area „ „ „ 358 m².

δ_0 δ_1 δ_2 readings of the thermo galvanometer with scale at 1 m, and 4 ohm heater.

R' . . . . 6·12 ohms.
λ . . . . 6,300 m.
L' . . . . 226 μH.
L_{total} . . . . 406 μH.
C . . . . 27·5 mμF.
δ_t . . . . 0·160

Calibration of the Galvanometer.
V = 1·98

$R_t'' + R_g$	$I \times 10^{-3}$	δ_0	δ_1	Δ	$i/\sqrt{\Delta}$
2005	0·990	202 202	239	37	0·163
1505	1·315	200 200	269	69	0·158
1005	1·97	197 197	352	155	0·158
905	2·19	195 194	385	190·5	0·158
805	2·46	188 187	432·5	245	0·157
705	2·81	184·5 185	509	324·8	0·158
				K mean =	0·158

Measurement of the Current at the Transmitter and Receiver.
(24 dashes each of 8 secs., with intervals of 22 secs., the first dash serving for tuning.)

I_t	δ_0	δ_1	δ_2	Δ_1	Δ_2
126	65 65		107·5		42·5
127	64·5 64·5	82·5		18·0	
132	64 64		108·0		44·0
132	63·5 63	82·5		19·3	
129	62·8 62·8		103·5		40·7
127	62·5 62·0	80·9		18·7	
132	61·7 61·5		104·6		43·0
134	61·0 60·8	79·5		18·6	
133	60·5 60·4		102·8		42·3$_5$
135	60·0 59·7	78·5		18·6$_5$	
132	59·5 59·3		102·5		43·1
132	59·0 58·8	77·5		18·6	
132	58·5 58·7		99·0		40·4
133	58·5 58·8	78·5		19·7$_5$	
126	58·8 59·0		103·0		44·1
125	58·8 58·5	78·2		19·5	
130·4			Δ	18·9	42·8
			I_r	0·687	1·034
				milliamperes	

Calculation of h

$$\frac{1·034 \times 10^{-3}}{130·4} \cdot \frac{6300 \times 10700}{358} \cdot 406000 \cdot \frac{\sqrt{0·203\,(0·160 + 0·203)}}{4\pi^2} = 4.179\text{ cm.}$$

$$\frac{0·687 \times 10^{-3}}{130·4} \cdot \frac{6300 \times 10700}{358} \cdot 406000 \cdot \frac{\sqrt{0·361\,(0·160 + 0·361)}}{4\pi^2} = 4,438\text{ cm.}$$

$\therefore h_{mean} = 43·1$ m.

FIG. 11.

P

the transmitting plant would have been too much endangered by a long duration of spark emission, it was agreed to execute for every series of measurements and at a predetermined hour, twenty-four emissions each lasting eight seconds and separated by pauses of twenty-two seconds duration. A duration of eight seconds was sufficient for the deflection of the thermogalvanometer to attain the steady value. The first emission served to regulate the tuning the others for the measurements.

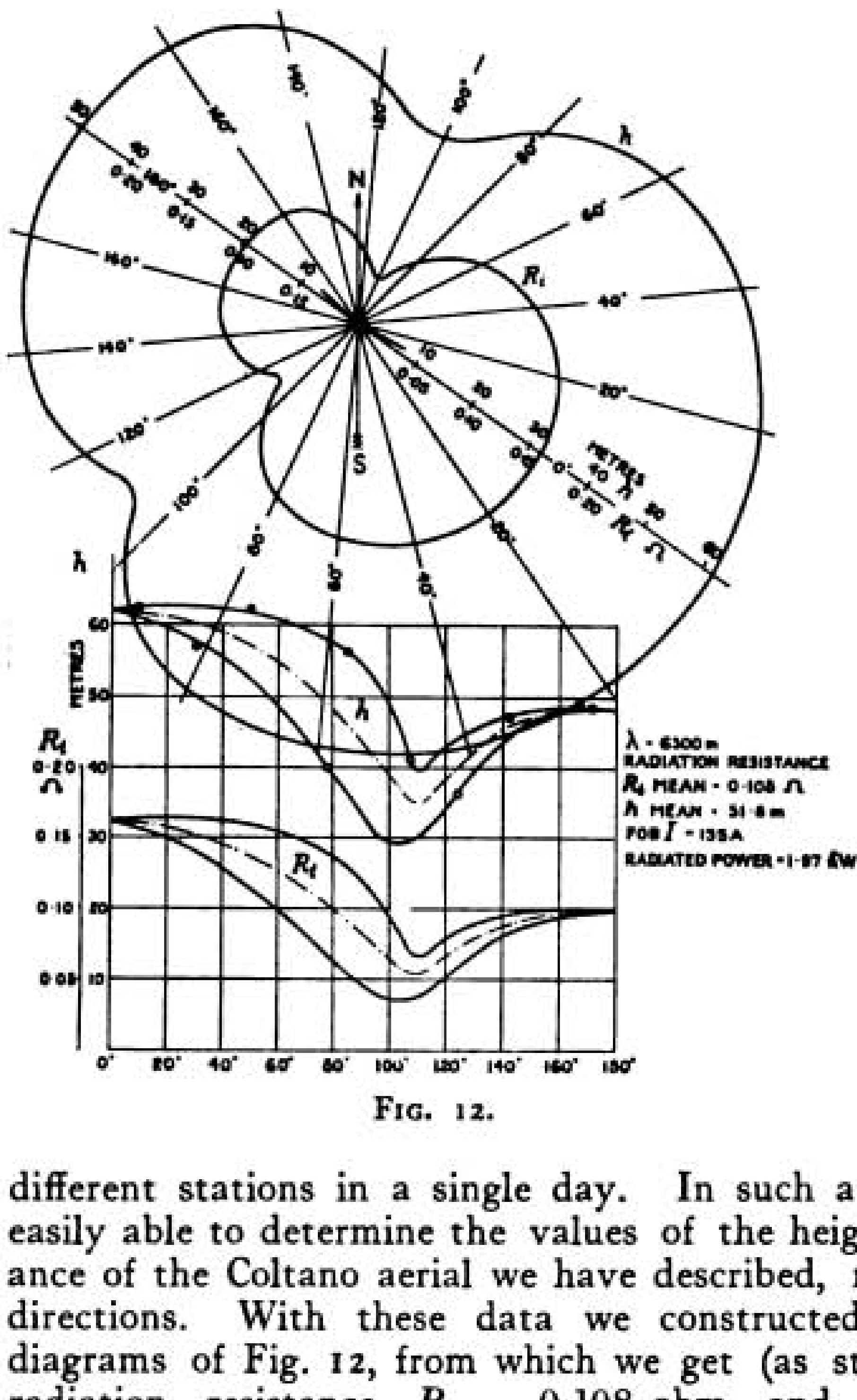


FIG. 12.

The scheme of the circuits, the formulæ and the principal instructions, together with a complete example of measurements and calculations, are reproduced in the table shown in Fig. 11, which was compiled and distributed among the Royal Naval Radiotelegraphic services in February, 1918, and serves as a guide for the current execution of radiation measurements.*

With the appliances described and with a fairly practised staff, it is easy to erect two or even three different stations in a single day. In such a way, for example, we were easily able to determine the values of the height and the radiation resistance of the Coltano aerial we have described, measured in eight azimuth directions. With these data we constructed the polar and Cartesian diagrams of Fig. 12, from which we get (as stated in par. 9) the mean radiation resistance $R_1 = 0{\cdot}108$ ohm and the corresponding height $h = 51{\cdot}8$ m., which may be compared with the height of the masts $h' = 75$ m. (consisting of 45 metres of metal trellis and 30 metres of compound wooden mast).

The diagrams of Fig. 12, the first of their kind if I am not mistaken, which refer to large aerials in active service, present the features of two maxima of different values in the axial direction and two minima in directions angularly

* The particulars given in this table (Fig. 11) have been translated before reproduction, the original chart being in Italian.

distant 100°—110° from that of the greater of the two maxima. Moreover, the appreciable influence of the fact that the two halves of the aerial are not exactly straight, but form an obtuse angle, is worthy of note. This produces a notable difference between the two halves, in which the radiation diagrams can be divided with respect to the lines of the maxima: The radiation appears remarkably larger on the side of the convex angle than that of the concave angle. Other experiments are now being made which are intended to verify whether at greater distances than those chosen for the experiments of Fig. 12 (distances equal to about 2λ), the effects of absorption or of diffraction would appreciably alter the radiation diagram.

Conclusion.—The object of the present note has been to supply to those who have to undertake the carrying out of the acceptance and the management of radiotelegraphic plants, a guide for carrying out the radiation measurements, which, in their turn, give substantial elements for judging of the efficiency of an aerial as transmitter and receiver of electromagnetic waves. For this purpose the principles are recalled on which the phenomenon of radiation is based, the analytical relations which connect the several elements of the same and which govern the variations are deduced, the approximations introduced in the calculations are discussed, and finally the several experimental methods are set forth, the particulars being stated and illustrated with practical examples which refer to certain typical shapes of aerials excited both by damped as well as by persistent oscillations.

Leghorn,
October, 1920.

The Effect of Modulation Waveshape upon Received Signals.

By A. S. BLATTERMAN.

(*Concluded from page* 151.)

Interrupted Sine Modulation.

This type of modulation is obtained by supplying the plate circuit of a transmitting vacuum tube with alternating voltage at audio frequency instead of the usual D.C. voltage. High frequency energy in this case is radiated only during the positive alternation of the audio plate voltage and the wave train to be considered is therefore that of Fig. 9.

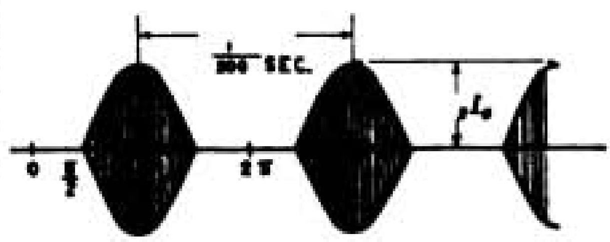


FIG. 9.

The Fourier series for the envelope curve is

$$i = {}_sI_0 \left\{ \begin{array}{l} \frac{1}{\pi} + \frac{1}{2}\sin(pt - 90^\circ) - \frac{2}{3\pi}\sin(2pt - 90^\circ) + \\ \qquad + \frac{2}{15\pi}\sin(4pt - 90^\circ) - \frac{2}{35\pi}\sin(6pt - 90^\circ) + \ldots \end{array} \right\}$$

Let us assume that the receiving circuit has a decrement of 0·02, the wave-length 600 metres, the modulation produced from a 500 cycle source; the note at the receiver will be essentially characteristic of 500 cycles. We have

$$\lambda = 600 \text{ m.}$$

$$\omega = 2\pi\, 500{,}000$$

$$p = 2\pi\, 500$$

$$\delta_r = 0{\cdot}02$$

$$S_0 = \frac{1}{\pi}$$

$$S_1 = \frac{1}{2} \qquad \phi_1 = \cos^{-1} 0{\cdot}955 = 17^\circ\, 20'$$

$$S_2 = -\frac{2}{3\pi} \qquad \phi_2 = \cos^{-1} 0{\cdot}85 = 31^\circ\, 50'$$

$$S_3 = 0$$

$$S_4 = \frac{2}{15\pi} \qquad \phi_4 = \cos^{-1} 0{\cdot}62 = 51^\circ\, 40'$$

$$S_5 = 0$$

$$S_6 = -\frac{2}{35\pi}$$

The detecting current is therefore, by (19) proportional to

$$\text{Constant} \times \left\{ \frac{\frac{\left(\frac{1}{\pi}\right)^2}{2} + \frac{\left(\frac{1}{2}\times 0{\cdot}955\right)^2}{4} + \frac{\left(\frac{2}{3\pi}\times 0{\cdot}85\right)^2}{4} + \frac{\left(\frac{2}{15\pi}\times 0{\cdot}62\right)^2}{4} + \ldots}{\frac{\left(\frac{1}{\pi}\right)^2}{2} + \frac{\left(\frac{1}{2}\right)^2}{4} + \frac{\left(\frac{2}{3\pi}\right)^2}{4} + \frac{\left(\frac{2}{15\pi}\right)^2}{4} + \ldots} \right\}$$

$$= \text{constant} \times \frac{0{\cdot}1208}{0{\cdot}1248} = \text{constant} \times \mathbf{0{\cdot}970} \quad \ldots\ldots \quad (20)$$

The bracketed term of (16b) gives the envelope curve of the received current and this is drawn for the case just considered on Fig. 10, together with the transmitted wave. The distortion owing to phase shift of the side frequencies is clearly evident.*

---

* The lower half of the wave is omitted in this figure for the sake of clearness.

Rectangular Chopped Modulation.

This type of modulation is produced by such devices as a rotary chopper directly in the sending antenna circuit. The time interval between the pulses, or the periods when the antenna is inactive may be made anything desired according to the construction of the chopper, but we will here consider the particular case wherein the active and inactive intervals are equal, giving the waveform of Fig. 11. The frequency of the pulses will be taken at 1,000 per second and the wavelength and receiver decrement the same as above; that is 600 metres and 0·02 respectively.

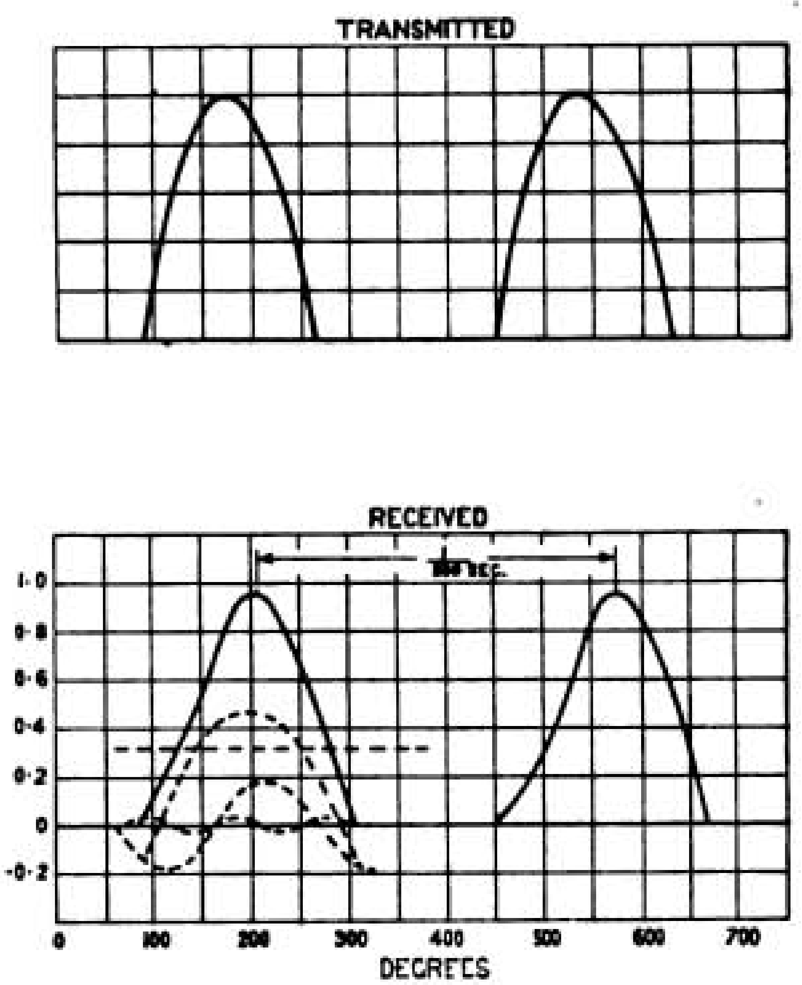


FIG. 10.

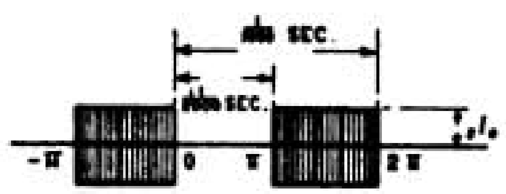


FIG. 11.

The equation of the rectangular envelope curve is, in this case

$$i = {}_sI_0\left[\frac{1}{2} - \frac{2}{\pi}\sin pt - \frac{2}{3\pi}\sin 3pt - \frac{2}{5\pi}\sin 5pt - \ldots\right]$$

therefore $S_0 = \frac{1}{2}$

$S_1 = -\,0{\cdot}637 \qquad \cos\phi_1 = 0{\cdot}847 \qquad \phi_1 = 32^\circ$

$S_2 = \ \ 0$

$S_3 = -\,0{\cdot}212 \qquad \cos\phi_3 = 0{\cdot}469 \qquad \phi_3 = 62^\circ$

$S_4 = \ \ 0$

$S_5 = -\,0{\cdot}127 \qquad \cos\phi_5 = 0{\cdot}303 \qquad \phi_5 = 72^\circ\ 20'$

The factor by which the detecting current is to be measured is, therefore, by (19).

$$\text{Constant} \times \mathbf{0{\cdot}829} \qquad (21)$$

The waveform of received current modulation is contrasted with that of the transmitter in Fig. 12. The distortion in this case is seen to be very marked.

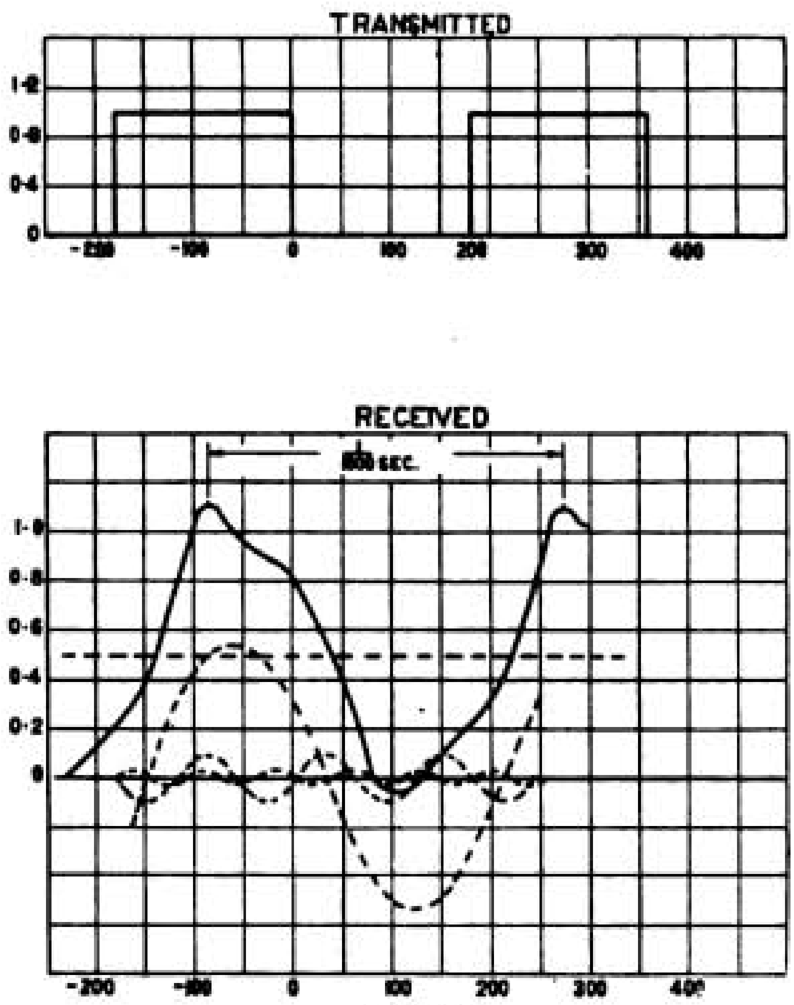


FIG. 12.

By comparing (20) and (21) it is seen that the rectangular modulation with equal antenna current at the transmitter should give weaker signals than the interrupted sine modulation in the ratio 829 to 970.

Spark Signals (Logarithmic Modulation).

In this case the transmitter current has approximately the waveform of Fig. 13.

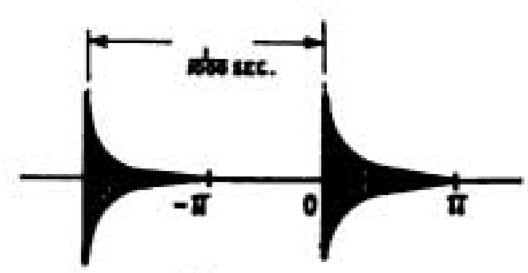


FIG. 13.

Assuming again $\lambda = 600$ metres, spark frequency 1,000 per second, receiver decrement 0·02, transmitter decrement 0·1, the equation to the envelope curve of Fig. 13 is

$$i = I_0 [S_0 + S_1 \sin (pt + \theta_1) + S_2 \sin (2pt + \theta_2) + \\ + S_3 \sin (3pt + \theta_3) + \ldots]$$

where

$S_0 = 0{\cdot}02$	
$S_1 = 0{\cdot}0398$	$\theta_1 = 82^\circ\ 50'$
$S_2 = 0{\cdot}0387$	$\theta_2 = 75^\circ\ 55'$
$S_3 = 0{\cdot}0374$	$\theta_3 = 69^\circ\ 50'$
$S_4 = 0{\cdot}0357$	$\theta_4 = 63^\circ\ 15'$
$S_5 = 0{\cdot}0339$	$\theta_5 = 57^\circ\ 55'$
$S_6 = 0{\cdot}0318$	$\theta_6 = 53^\circ$
$S_7 = 0{\cdot}0299$	$\theta_7 = 48^\circ\ 40'$
$S_8 = 0{\cdot}0282$	$\theta_8 = 45^\circ$
$S_9 = 0{\cdot}0264$	$\theta_9 = 41^\circ\ 30'$
$S_{10} = 0{\cdot}0259$	$\theta_{10} = 38^\circ\ 30'$

The envelope curve of received current according to (16) is then

$$i_r = \frac{k_s I_0}{r_r} \left\{ S_0 + [S_1 \cos\phi_1] \sin(pt + \theta_1 - \phi_1) + [S_2 \cos\phi_2] \sin(2pt + \theta_2' - \phi_2) + \atop + [S_3 \cos\phi_3] \sin(3pt + \theta_3 - \phi_3) \ldots . \right\}$$

where

where	$\phi_1 = 32° \; 10'$	$\cos\phi_1 = 0{\cdot}847$
	$\phi_2 = 51° \; 20'$	$\cos\phi_2 = 0{\cdot}625$
	$\phi_3 = 62°$	$\cos\phi_3 = 0{\cdot}469$
	$\phi_4 = 68° \; 20'$	$\cos\phi_4 = 0{\cdot}37$
	$\phi_5 = 72° \; 20'$	$\cos\phi_5 = 0{\cdot}303$
	$\phi_6 = 75° \; 10'$	$\cos\phi_6 = 0{\cdot}2565$
	$\phi_7 = 77° \; 10'$	$\cos\phi_7 = 0{\cdot}2215$
	$\phi_8 = 78° \; 45'$	$\cos\phi_8 = 0{\cdot}195$
	$\phi_9 = 80°$	$\cos\phi_9 = 0{\cdot}174$
	$\phi_{10} = 81°$	$\cos\phi_{10} = 0{\cdot}157$

The measure of received signal strength (equation 19) is therefore

$$\text{Constant} \times \frac{0{\cdot}000824}{0{\cdot}00295} = \text{constant} \times \mathbf{0{\cdot}279} \quad . \quad . \quad . \quad . \quad (22)$$

This calculation is the result of using ten terms of the Fourier's series. On account of the fact that the coefficients in the series for the transmitted current decrease much more slowly than those for the received current and are still appreciable at the tenth term, the factor just determined is somewhat high.

Fig. 14 shows the envelope curve of transmitting and received currents and the distortion is again plainly evident. It is to be noted that in this particular case of logarithmic transmitter modulation the mean square received antenna current as well as the shape of the envelope curve of same may be calculated by Bjerknes's formulæ, commonly stated in text books. Results obtained by these formulæ agree exactly with those given in this paper provided a sufficient number of terms are used in the Fourier's series in the latter case.

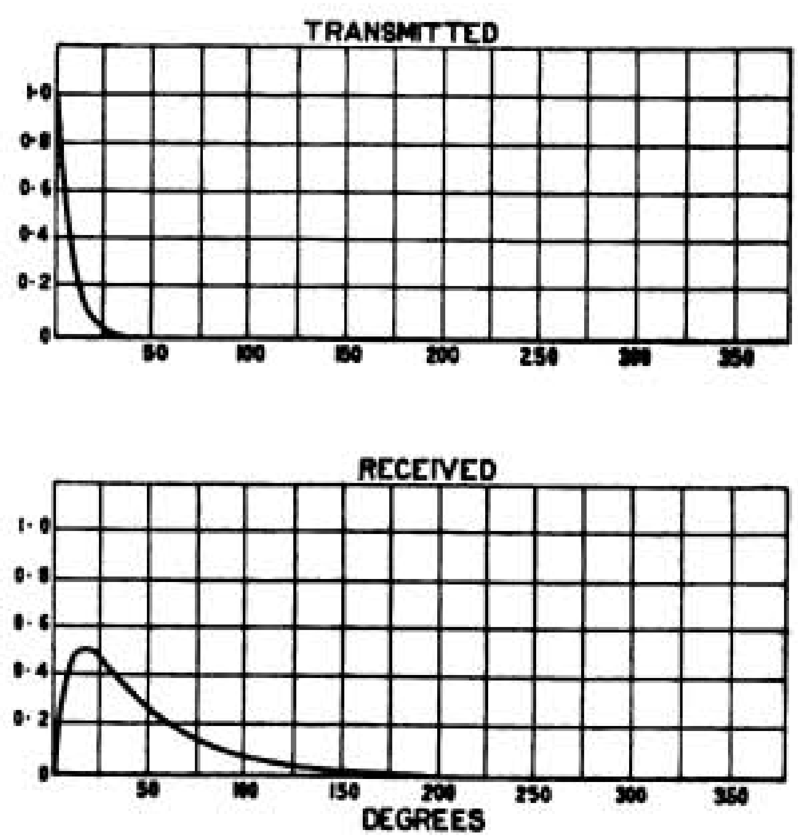


Fig. 14.

Double Rectified Sine Modulation.

This type of modulation is shown on Fig. 15 and is produced in practice by supplying the plate circuit of an oscillating vacuum tube from the source shown on Fig. 16A, or a pair of oscillating tubes may be used in some such circuit as that of Fig. 16B. In order to compare this case with those previously treated we may again take $\lambda = 600$ metres, supply frequency 500 cycles,

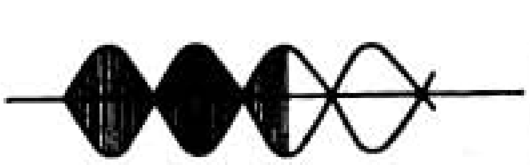


FIG. 15.

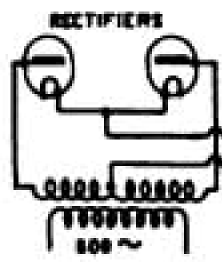


FIG. 16A.

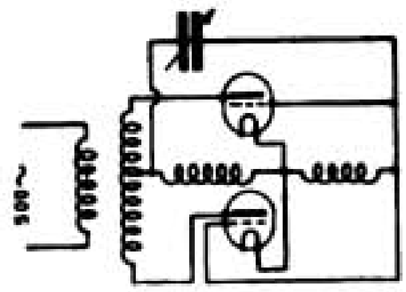


FIG. 16B.

receiver decrement 0·02. The received note will be characteristic of 1,000 cycles.

The equation of the transmitter current is

$$_si = \frac{2}{\pi}\,{}_sI_0 \left\{ 1 - \frac{2}{3}\sin(2pt - 90^\circ) + \frac{2}{15}\sin(4pt - 90^\circ) - \right. \left. - \frac{2}{35}\sin(6pt - 90^\circ) + \ldots \right\}$$

and we get

$$\begin{array}{lll} S_0 = 0{\cdot}636 & & \\ S_1 = 0 & & \\ S_2 = -0{\cdot}425 & \phi_2 = 31^\circ\,50' & \cos\phi_2 = 0{\cdot}85 \\ S_3 = 0 & & \\ S_4 = 0{\cdot}085 & \phi_4 = 51^\circ\,40' & \cos\phi_4 = 0{\cdot}62 \\ S_5 = 0 & & \\ S_6 = -0{\cdot}0364 & \phi_6 = 62^\circ & \cos\phi_6 = 0{\cdot}47 \end{array}$$

The reception factor by (19) becomes

$$\text{Constant} \times \frac{0{\cdot}235866}{0{\cdot}249837} = \text{constant} \times \mathbf{0{\cdot}944}.$$

It has been pointed out previously that the detecting telephone currents can only be taken proportional to mean square antenna current when the latter is completely modulated; when the modulation is not complete a correction factor must be applied. This correction factor for a sine modulation is given on Fig. 7.

The present case is one in which the modulation is incomplete since the received current is (according to (16))

$$_ri = \frac{k\,{}_sI_0}{r_r}\left\{0{\cdot}636 - 0{\cdot}361\sin(2pt - 121^\circ\,50') + 0{\cdot}0527\sin(4pt - 141^\circ\,40') - \right. \left. - 0{\cdot}0171\sin(6pt - 152^\circ) + \ldots\right\}\sin\omega t$$

Neglecting the small amplitude harmonics above the second, the percentage modulation of received current can be taken as approximately equal to

$$k = \frac{0{\cdot}361}{0{\cdot}636} = 0{\cdot}567$$

giving as correction factor from Fig. 7 the quantity 0·696. Applying this correction, the quantity to be used as measure of the detecting current becomes

$$\text{Constant} \times 0{\cdot}944 \times 0{\cdot}696 = \text{Constant} \times \mathbf{0{\cdot}657} \quad . \quad . \quad . \quad (23)$$

Sine Modulation.

This type of modulation has already been calculated above in connection with the explanation of receiving radio circuit distortion. It is shown again on Fig. 17.

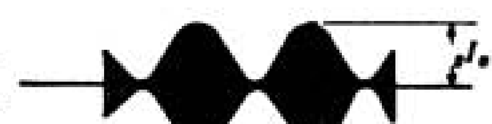


FIG. 17.

For the same wavelength and decrement as above and 1,000 cycle modulation the received current is

$$_ri = \frac{k_r I_0}{r_r}\left\{0{\cdot}5 + 0{\cdot}425 \sin (pt - 31^\circ\, 50')\right\} \sin \omega t$$

The percentage modulation at the receiver is $k = 0{\cdot}85$ giving correction factor from Fig. 7, $\sigma = 0{\cdot}902$ and the proportionality factor for detecting current (19) is therefore

$$\left(\frac{\frac{\overline{0{\cdot}5^2}}{2} + \frac{\overline{0{\cdot}425^2}}{4}}{\frac{\overline{0{\cdot}5^2}}{2} + \frac{\overline{0{\cdot}5^2}}{4}}\right) 0{\cdot}902 = \mathbf{0{\cdot}818} \quad . \quad . \quad . \quad . \quad (24)$$

MORE ACCURATE TREATMENT.

The foregoing treatment has neglected the distortion effects of the detector. The latter, as has been pointed out, tends to introduce changes in the amplitudes of the harmonics present in the envelope curve of received antenna current on account of its non-linear, imperfect rectification characteristics. This affects the quality as well as the intensity of the signal somewhat. The following formulæ permit calculations to be made of the detected (rectified) telephone current and signal strength upon the assumption that the detector characteristic is representable by the equation

$$i = a_1 e + a_2 e^2.$$

As has been shown, e has, in general, the form

$$e = U \left\{ A + B_1 \sin (pt + \alpha_1) + B_2 \sin (2pt + \alpha_2) + \right.$$
$$\left. + B_3 \sin (3pt + \alpha_3) + \ldots \right\} \sin \omega t$$

Substituting this in the characteristic equation, gives for the audio frequency detecting current, after dropping all terms of radio and zero frequencies and making certain transformations

$$
\begin{aligned}
I = \frac{a_2}{2}\Big\{ & 2AB_1 \sin(pt+\alpha_1) + B_1B_2 \cos[pt+(\alpha_1-\alpha_2)] + \\
& \qquad + B_2B_3 \cos[pt+(\alpha_2-\alpha_3)] + \ldots \\
& + 2AB_2 \sin(2pt+\alpha_2) + B_1B_3 \cos[2pt+(\alpha_1-\alpha_3)] - \\
& \qquad - \frac{B_1^2}{2}\cos(2pt+2\alpha_1) + B_2B_4 \cos[2pt+(\alpha_2-\alpha_4)] + \\
& \qquad + B_3B_5 \cos[2pt+(\alpha_3-\alpha_5)] + \ldots \\
& + 2AB_3 \sin(3pt+\alpha_3) - B_1B_2 \cos[3pt+(\alpha_1+\alpha_2)] + \\
& \qquad + B_1B_4 \cos[3pt+(\alpha_1-\alpha_4)] + B_2B_5 \cos[3pt+(\alpha_2+\alpha_5)] + \ldots \\
& + 2AB_4 \sin(4pt+\alpha_4) - \frac{B_2^2}{2}\cos(4pt+2\alpha_2) - \\
& \qquad - B_1B_3 \cos[4pt+(\alpha_1+\alpha_3)] + B_1B_5 \cos[4pt+(\alpha_1-\alpha_5)] + \\
& \qquad + B_2B_6 \cos[4pt+(\alpha_2-\alpha_6)] + \ldots \\
& + 2AB_5 \sin(5pt+\alpha_5) - B_2B_3 \cos[5pt+(\alpha_2+\alpha_3)] + \\
& \qquad + B_1B_6 \cos[5pt+(\alpha_1-\alpha_6)] + B_2B_7 \cos[5pt+(\alpha_2-\alpha_7)] + \ldots \\
& + \ldots \ldots \Big\} U^2
\end{aligned}
$$

In this expression terms of the same frequency have been grouped together, and the various frequencies corresponding respectively to pt, $2pt$, $3pt$, $4pt$, etc. follow each other in sequence. It will be seen that each of the series giving the component current of a particular frequency has the form

$$
\begin{aligned}
I_k = [M_1 \sin(kpt+\psi_1) + M_2 \cos(kpt+\psi_2) + M_3 \cos(kpt+\psi_3) + \\
+ M_4 \cos(kpt+\psi_4) + \ldots]Y
\end{aligned}
$$

which may be otherwise written in the form

$$
\left.
\begin{aligned}
I_k = \sqrt{\begin{aligned}\{ & M_1^2 + M_2^2 + M_3^2 + M_4^2 + M_5^2 + \ldots \\
& + 2M_1M_2 \sin(\psi_1-\psi_2) + 2M_1M_3 \sin(\psi_1-\psi_3) + \\
& \qquad + 2M_1M_4 \sin(\psi_1-\psi_4) + \ldots \\
& + 2M_2M_3 \cos(\psi_2-\psi_3) + 2M_2M_4 \cos(\psi_2-\psi_4) + \\
& \qquad + 2M_2M_5 \cos(\psi_2-\psi_5) + \ldots \\
& + 2M_3M_4 \cos(\psi_3-\psi_4) + 2M_3M_5 \cos(\psi_3-\psi_5) + \\
& \qquad + 2M_3M_6 \cos(\psi_3-\psi_6) + \ldots \\
& + \ldots\}\end{aligned}} \sin(kpt+\gamma_k) \,.\, Y \\
= [\beta_k \sin(kpt+\gamma_k)]\, Y \\
\text{where} \\
\gamma_k = \tan^{-1}\frac{M_1 \sin\psi_1 + M_2 \cos\psi_2 + M_3 \cos\psi_3 + \ldots}{M_1 \cos\psi_1 - M_2 \sin\psi_2 - M_3 \sin\psi_3 - \ldots}
\end{aligned}
\right\} \quad (25)
$$

The expression (25) may be used to calculate the amplitude and phase (γ) of any of the constituent frequencies in the telephone current ; and the effective value of the actual distorted telephone current wave is

$$ {}_aI_e' = Y \sqrt{\sum_{k=1}^{k=n} \frac{\beta_k^2}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

In making comparisons of this telephone current for different types of modulation it must be noted that the constant Y is proportional to the square of the maximum or peak value ${}_tI_0$ of transmitted current, and if the comparisons are to be made on the basis of equal R.M.S. transmitter currents in each case the equation (15) must be used as a divisor for the reduction of the values given by (26). For comparison purposes therefore we employ in each case the formula

$$ {}_aI_e = \text{constant} \times \sqrt{\sum_{k=1}^{k=n} \frac{\beta_k^2}{2} \cdot \frac{1}{\left(\frac{S_0^2}{2} + \frac{S_1^2}{4} + \frac{S_2^2}{4} + \frac{S_3^2}{4} + \ldots\right)^2}} \quad . \quad (27)$$

The numerical manipulation may become a little cumbersome in some cases. In order, however, to show the order of magnitude of deviation in the ratio of telephone currents for different modulation waveshapes, determined first upon the basis of M.S. antenna currents and then by the more accurate method where the detector distortion is taken into account, the formulæ (25) and (27) have been applied to two of the cases previously treated, viz.,

(*a*) Chopper modulation,

(*b*) Sine modulation,

with the results shown in the following tables :—

	Chopper modulation.	Sine modulation.
Fundamental	0·542	0·425
2nd harmonic	0·093	0·0904
3rd "	0·0995	0·0
4th "	0·0414	0·0
5th "	0·0385	0·0
$S_0^2/2 + S_1^2/4 + S_2^2/4 + \ldots$	0·242	0·1895
$\frac{{}_aI_e}{\text{Constant}} = \sqrt{\frac{\Sigma_1^n \beta_k^2/2}{(S_0^2/2 + S_1^2/4 + S_2^2/4 \ldots)^2}}$	1·615	1·640

The signal strength ratios,* when calculated by the approximate and accurate methods are then

* The term "signal strength" is used somewhat loosely. Obviously the discussion concerns the effective telephone currents.

	By approximate method.	By accurate method.
Ratio $\frac{\text{Chopped}}{\text{Sine}}$.	$\frac{0{\cdot}829}{0{\cdot}818} = 1{\cdot}01$	$\frac{1{\cdot}615}{1{\cdot}640} = 0{\cdot}984$

and are seen to differ by less than 3 per cent. It is therefore fair to assume not only that the figures arrived at previously for the various types of modulation may be used for comparison of the effectiveness of these types among themselves, but also that the approximate method of calculation gives a way of comparing different modulation waveshapes, as far as signal strength is concerned, which is sufficiently accurate for all practical purposes.

SUMMARY AND DISCUSSION OF RESULTS.

It has been shown that the waveshape of modulation has *per se* an appreciable effect on the intensity of received signals. It has also been shown that different waveshapes of modulation are differently distorted, thus differently affecting the quality or timbre of the received note. Several types of modulation have been compared numerically on the basis of equal R.M.S. transmitting antenna currents in each case. The relative signal strengths have been calculated and formulæ for calculating the distortion have been given. In several cases the distortion has been shown graphically.

Two methods for investigating the problem have been presented. (*a*) An approximate method wherein the signal strength has been based on the square of the received antenna current and (*b*) a more accurate method in which the actual telephone current has been calculated. It has been shown that these two methods agree closely with one another as regards the determination of strength of signal.

Distortion occurs at two points in the receiving circuits, first in the tuned radio frequency circuits and secondly on account of the non-linear imperfect rectification characteristic of the detector. The first distortion is caused by the fact that the receiving antenna system is tuned to the carrier frequency of transmission. The side frequencies resulting from the modulation at the transmitter are therefore more or less out of tune. For this reason they are suppressed and shifted in phase to a greater or less degree, depending upon their divergency from the carrier frequency. When the carrier and the side frequencies are recombined at the receiver they therefore give a waveshape quite different from that originally transmitted.

The results of the investigation concerning the five types of modulation treated may be summarised in the following table. In this table the signal strength for a 100 per cent. pure sine modulation at the transmitter is taken as unity. The strengths of signals for other modulations are referred to this sine modulation as basis. The R.M.S. transmitting antenna current is assumed to be the same in each case, and the figures given are those determined by the approximate method described.*

Type of modulation.		Audibility.
Pure sine	(1,000 cycles) .	1·00
Spark	(1,000 cycles) .	0·341
Interrupted sine	(500 cycles) .	1·187
Double rectified sine	(1,000 cycles) .	0·802
Chopper	(1,000 cycles) .	1·014

In regard to the accurate method of calculating the phenomena it should be noted that this is based on the assumption that the detector characteristic can be represented by the equation

$$i = a_1 e + a_2 e^2.$$

This equation is very nearly correct when the load in the output circuit of the detector is pure resistance. If the load has appreciable reactance this reactance will obviously be different for each constituent frequency of the modulation wave and the coefficients in the equation are thus no longer, strictly speaking, constant. The error in assuming that the coefficients are fixed, however, is not serious and so greatly simplifies the analytical treatment of the problem, that it is believed to be justifiable.

The formulæ presented indicate that for given R.M.S. antenna current at the transmitter the strength of signal increases with decrease in the pitch of the transmission note. This, of course, takes no account of variation in sensitivity of the telephone receiver or the ear with changes in frequency which may to some extent alter this conclusion. The high value of signal strength for the 500 cycle, interrupted sine modulation is accounted for, at least in part, by the fact that the other modulations are calculated for 1,000 cycle note.

The comparatively low efficiency of the spark transmitter is noteworthy. Completely modulated sine transmission or the chopper give, theoretically, nearly three times as much telephone current.

Signal Corps Radio Laboratories,
New Jersey, U.S.A.

A New Design of Aerial Insulator.

The output of a high-power radio station may be seriously limited by inadequate insulation of the aerial wires from the cables by which they are supported. It has been the custom in some recently-built high-power

* These results are determined for a receiver decrement of 0·05. For higher decrements the differences indicated will be reduced, *i.e.*, there is less difference between the various strengths of signals. The waveshape of modulation is less important.

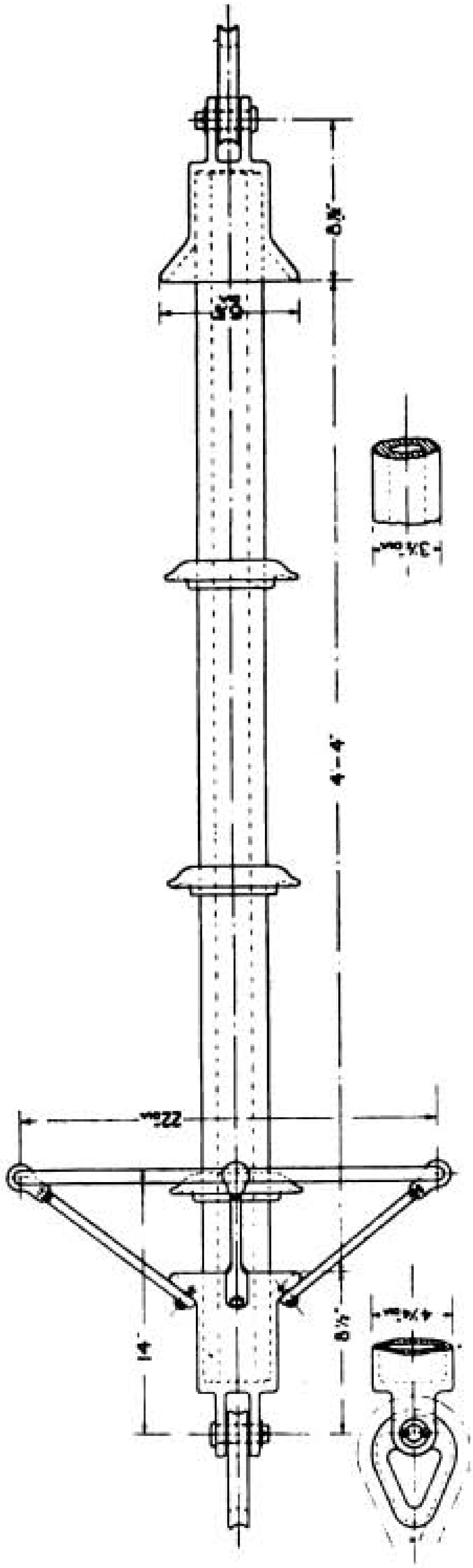


Diagram of new H. T. Aerial Insulator.

stations to employ strings of disc insulators of the type customarily used on high-tension overhead power distribution lines, but it has been found that these have certain disadvantages at high frequencies, chief amongst which are their comparatively high capacity, and the unequal distribution of the high-frequency voltage along the string. At the high-power station erected at Rome during the War as many as eighteen of these insulators were used in series. At the Horsea station several units of this type are employed, together with several others as well as one or more granite blocks—all in series.

As a result of a considerable amount of experimental work carried out by Mr. C. F. Elwell and others, Messrs. Bullers, Ltd., of Hanley, Staffs., have developed a new pattern of high-voltage insulator which is especially suitable for use on the aerials of high-power stations, although it will doubtless also have other important applications as well. The insulator consists of a long porcelain tube to the ends of which metal caps are cemented. The overall length of the insulator between the end shackles is 5 feet 9 inches, while the length of porcelain between the metal caps is 4 feet 4 inches. The lower end of the upper metal cap is belled out as shown in the accompanying drawing, so as to drain off the water from the surface of the porcelain. The lower cap is fitted with a metal ring 22 inches diameter—of $\frac{3}{4}$-inch diameter mild steel rod—to form a flux ring to ensure a more uniform distribution of the electrostatic flux lines at the high-voltage end of the insulator. Porcelain drip rings are also cemented to the insulator at several points along its length, and help to further increase the insulation resistance. When tested electrically under ordinary alternating voltages it has not been found possible to produce a breakdown, even when the insulator was at the same time subjected to a heavy precipitation of artificial "rain." With about 120,000 volts between the ends of the insulator when subjected to rain, the current flowing along the surface was less than 1 milliampere.

Before being put into service all such insulators are subjected to a tensile test of 10,000 lbs., while tests to destruction have indicated an average breaking stress of 7½ to 8 tons. When fracture occurs, it is found that there are no indications of flaws in the porcelain, but it always takes place where the cross-section is somewhat reduced at one of the serrations at the end. The caps do not pull off under this load.

The electrical capacity of the insulators is extremely small, so that the capacity currents flowing through the insulator when subjected to high-frequency stresses should also be small, resulting in less deterioration of the porcelain. The weight of a complete insulator is about 95 lbs., as compared with approximately 240 lbs. for one of the strings of eighteen suspension type insulators. The cost is also less.

Insulators of this new type have been installed at Honolulu, San Francisco, and other large American radio stations, while they have also been put into service at the recently constructed Lafayette station at Croix d'Hins. These insulators will also be used at the new Post Office stations being erected at Northolt, Leafield, and Cairo.

The leading dimensions of the insulators are indicated in the accompanying drawing, which also shows the method of attaching the metal flux ring.

Arc *versus* Alternator for High Power Work.

In a recent issue of *Le Génie Civil* an article by A. Bidault des Chaumes discusses the equipment proposed for the high-power station to be erected near Paris.*

In the course of the article the author discusses the relative merits of arcs and high-frequency alternators for high-power stations and in connection with the decision to instal high-frequency alternators at the new station he says:

It now seems certain that the arc systems which have rendered incontestable service in the past will gradually disappear from future installations on account of their numerous inconveniences. This assertion is justified by the following remarks:

In the first place the oscillations set up by the arc are more or less irregular and the useful wave is accompanied by many harmonics which cause interference at receiving stations within a considerable area round the transmitter. Thus the emission from the arc station at the Eiffel Tower possesses many harmonics corresponding to short waves of the order of 300, 600, 1,200 metres, etc., in addition to the fundamental wave of 7,000 to 10,000 metres wavelength. These harmonics which are constantly varying interfere

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* See Abstract No. 1639 in this issue; also pp. 125—133 in our last issue.

considerably with reception at stations which are accidentally tuned to one or other of these frequencies, even when the receiving stations are as much as 200 km from the Eiffel Tower.

The arc station at Salonica may also be quoted as a further example. This station uses a normal wavelength of 6,300 metres and a harmonic of 900 metres can be heard at distances of 100 or more kilometres, while it is even detectable at Crete 300 km from the transmitting station.

The usual process of signalling with arc transmitters consists in slightly varying the wavelength of the oscillations to the extent of from 2 to 3 per cent. in the intervals between the signals. A transmitting station thus radiates two waves with the same power and this fact is particularly harmful at the present time when we are trying to reduce the troubles of receiving stations arising from unwanted transmissions and the multiplicity of communications now necessary. This question will be brought up at the next International Conference and it is practically certain that the suppression of the harmful spacing wave will be rendered obligatory. This suppression, relatively easy in the case of small and medium-power stations, presents considerable difficulty when the power exceeds about 50 kW, while it becomes still more difficult as the power is further increased. In practice no high-power arc at present operates with such a system and the station at Croix d'Hins which is the most recent high-power arc station uses the compensation wave for signalling.

The decomposition of the hydrocarbon atmosphere round the arc which is indispensable to its operation gives rise to sooty deposits in the interior of the arc chamber, the removal of which necessitates frequent and long cleaning operations, so that it is essential to instal at least two arc converters in a normal installation, one being in service while the other is being cleaned. If the service is to be a continuous one a third arc is also necessary as a spare. Thus the power installed in the station is for a commercial service three times that which can be utilised at any time, while further a skilled staff is necessary to carry out the cleaning operations and the replacements of the cathodes, etc.

The irregularities in the arc oscillations give rise to excess voltages which endanger the life of the insulators, while when the compensation wave is used for signalling the insulators are practically always under electrical stress.

The preceding remarks are of a general nature and applicable to all arc stations, but the following refer principally to commercial equipments. Firstly, like the valve transmitter, the efficiency of the arc is low, the maximum theoretically possible being 50 per cent. In practice, the efficiency hardly exceeds 40 per cent. when the arc is carefully adjusted, while if this is not done it falls still lower.

The true overall efficiency is also influenced by the fact that the energy is radiated during the spacing periods while even if a non-radiating artificial aerial is used for the spacing wave the same energy is still wasted as heat in that circuit.

For the successful handling of commercial traffic high-speed methods of signalling are necessary. The methods of keying usually employed with arc transmitters seriously limit the transmission speed since large and irregular currents must be interrupted. When the power of the installation is greater than about 50 kW complicated arrangements become necessary involving a multiplication of the number of places where the circuit is broken. Such arrangements prevent the attainment of speeds approaching 100 words per minute such as are possible with other systems. As a matter of fact the large arcs working with America do not transmit at a greater speed than sixty words per minute and even this is not attained without detriment to the quality of the emission. The automatically transmitted signals from Annapolis for example are irregular and often unreadable, while on the other hand those received at the same time from Marion and from New Brunswick which use high-frequency machines (on less power than used in the arcs at Annapolis) are always clear and regular.

Practically the only advantage in favour of the arcs is the ability to change rapidly the wavelength over a considerable range, but the maximum power output is only obtainable on a given wavelength and falls off rapidly when departures are made from this optimum wavelength. High-frequency alternators now allow of a sufficient range of wavelengths (from 1 to 1·5) by means of rapid change-over arrangements. Large wavelength changes are practically only required for military stations, but for commercial services they are not necessary, as if each station uses a large number of wavelengths, the resulting troubles would interfere with the general handling of traffic.

The Physical Society's Exhibition.

A Description of the Exhibits *(continued from page 153).*

MESSRS. MARCONI'S WIRELESS TELEGRAPH CO., LTD., had a working exhibit of their latest pattern of Marine Direction Finder, known as Type 11a. The general arrangement of this instrument is the same as the earlier pattern (Type 11) manufactured by this firm, but with the addition of a special "sense" indicator to show which of the two directions given by the ordinary readings is the correct one.

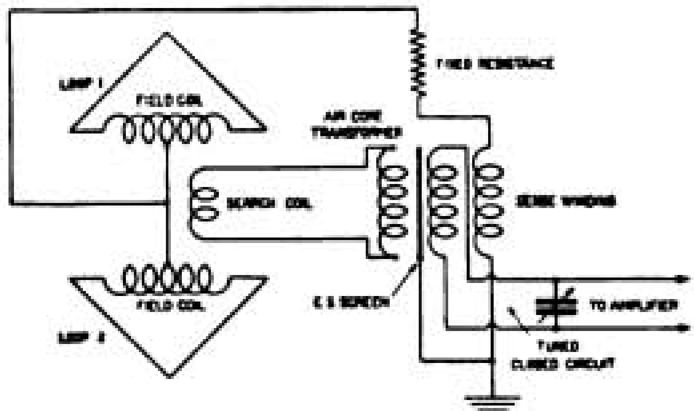

FIG. 5.

The action of "sense" finding in this apparatus is illustrated in the simplified diagram of connections shown in Fig. 5.

The tuned closed circuit from which the signals pass to the amplifier and telephones is influenced by two independent windings of an air core transformer. The first winding is connected to the search coil and thus has currents induced in it which vary in strength according to the position of the search coil with regard to the direction from which the incoming signals are being received. This is the ordinary direction finding effect. The second winding is connected on one side to earth and on the other to the common mid-point of both loops through a fixed resistance of a special value. It thus forms part of a simple open aerial-earth circuit and has induced in it currents which are independent of all directional effects and remain constant in value for all positions of the search coil.

The combination of these two effects on the secondary of the transformer —that is on the tuned circuit—produces a resultant current which varies in strength as the search coil is turned, but only rises to a maximum or dies to a minimum for *one* position of the search coil, which is determined by the actual direction in which the station lies.

It will be found that this maximum and minimum is not sharp enough for accurate results. In practice, therefore, the earlier method of direction finding is carried out as a preliminary operation. The operation of "sense" finding as described above being then resorted to as a method of determining which of the two diametrically opposed bearings obtained by the first operation is the correct one.

A special demonstration was also given by Professor C. L. Fortescue and Dr. Bryan illustrating some of the uses of a thermionic valve, for generating oscillations and other purposes. This demonstration was improvised at relatively short notice from ordinary laboratory apparatus, a few valves, a three-valve note magnifier and a loud speaking telephone. None of the apparatus was especially designed or made for the demonstration.

1. Characteristics of the Valves.

Apparatus was shown in which a spot of light was given two motions at right angles, one proportional to the current and the other to the applied

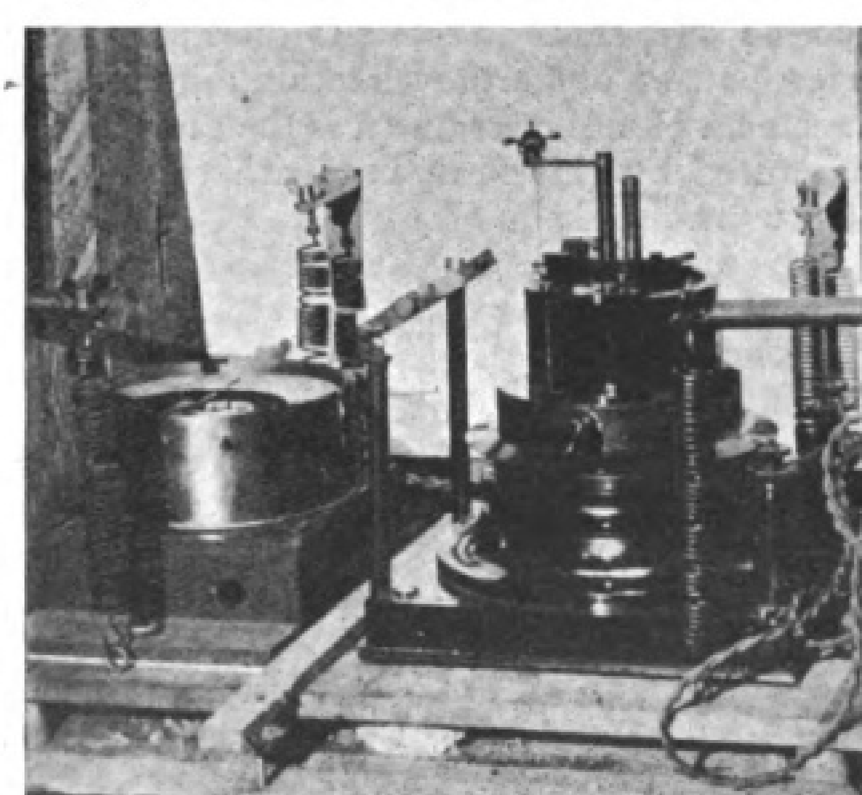

Fig. 6.

potential difference. By this means the characteristic curves and contour surfaces may be traced out in a minimum of time. Fig. 6 shows the arrangement of the two instruments and mirrors.

2. The use of the Valve as an Audible-frequency Generator.

A valve was shown generating alternating currents of from about 400 to 20,000 cycles per second. A very simple direct coupled circuit is used and the currents are made audible by means of a loud speaking telephone receiver.

3. The use of the Valve for Alternating Current Bridge Measurements.

A capacity bridge was shown in operation, the actual measurement being that of the effective resistance of a 60-volt dry battery. The audible-frequency valve generator just previously described was used and in order to render the sound audible to those present in the room a three-valve transformer coupled amplifier was connected up to a loud speaking telephone. The particular type of bridge chosen accentuates the effect of harmonics and combined with the amplifier shows the valve at its best and its worst. The bridge was balanced on the fundamental to about one part in 3,000.

4. The use of the Valve as a High Frequency Generator to illustrate the principles of heterodyne reception as used in wireless telegraphy.

For this purpose two valve sets were used, one representing the transmitting station and one the receiving station. At the latter the valve was used also as the detector, and by means of the amplifier and loud speaking telephone the incoming signals from the transmitter were rendered audible to the whole room. Several interesting experiments on beat reception were shown, one employing the beat principle twice and showing a degree of constancy of frequency of the oscillations generated of a few parts in 200,000.

5. An Experiment with Modulated Continuous Waves.

Mathematical theory shows that if a pure continuous wave of frequency f_1 is modulated in an irregular but cyclical manner at frequency f_2 then the resulting wave is made up of a series of waves of frequency $f_1, f_1 + f_2, f_1 - f_2, f_1 + 2f_2, f_1 - 2f_2$, etc.. The wave generated by the high frequency transmitter described in the previous paragraph was modulated at a frequency of about 20,000 cycles by means of the audible-frequency generator and the presence of the waves of frequency $f_1 + f_2, f_1 - f_2$, etc., was shown by means of the heterodyne receiver.

Notes.

Personal.

At the annual election of officers recently held by the Institute of Radio Engineers, New York, Mr. **E. F. W. Alexanderson** was elected President of the Institute for the year 1921. Mr. Alexanderson is chief engineer of the Radio Corporation of America and consulting engineer of the General Electric Company of Schenectady. **Foulton Cutting** was elected Vice-President ; **A. N. Goldsmith,** Secretary ; and **W. F. Hubley,** Treasurer. [2373]

Commander **C. P. Edwards,** O.B.E., A.M.E.I.C., the Director of Radiotelegraphs of the

Canadian Radio Service, has been elected Chairman of the Ottawa branch of the Engineering Institute of Canada. **[1736]**

Lieutenant **R. V. Ridges**, R.N.C.V.R., M.B.E., who was fleet wireless officer at Halifax during the war, has joined the engineering staff of the Marconi Wireless Telegraph Co. of Canada, Ltd., and is now stationed at the Montreal headquarters. **[2361]**

Mr. **C. V. Logwood**, who has been on the Pacific coast during the past few months, is returning to continue research work with the de Forest Company in New York. **[2356]**

W. R. Whitney, Director of the Research Laboratory, General Electric Company, Schenectady, N.Y., was awarded the Perkin Medal on January 14th by the American Section of the Society of Chemical Industry. Dr. Whitney received this honour for his many inventions in chemistry. **[2239]**

Wireless Services, etc.

WIRELESS TRAFFIC BETWEEN ENGLAND AND GERMANY.—To improve wireless traffic between England and Germany the dispatch of wireless telegrams for the public has been begun recently. Stonehaven is the sending station on this side and the main telegraph office in Berlin acts as the German station. The charges are the same as the cable tolls. **[2183]**

In view of the existence of several wireless telegraph services with the Continent auxiliary to and at the same rates as those for the ordinary cables, the Postmaster-General notifies that he reserves the right to use these services for urgent, ordinary, or Press telegrams, except in cases where the original forms are marked thus "by wire." **[2182]**

WIRELESS SERVICE BETWEEN GERMANY AND BULGARIA.—A wireless service has been opened between Konigswusterhausen and Sofia at the same rates as wire communication, viz. 1.15 M. for ordinary and 0.60 M. for Press messages. **[2338]**

METEOROLOGICAL RADIO TELEGRAMS.—Commencing December 1st last, the Hungarian station of Csepel transmits daily at 11.30 (Central European time) the Bulletin of the Meteorological Institute of Budapest. **[2330]**

On December 16th last the Mayor of New York officially opened the radiotelegraph service of the Inter-city Radio Communication Company between the cities of New York, Cleveland, Detroit and Chicago. The radio stations used in this new service were designed and equipped by Mr. **E. J. Simon.** **[2357]**

NEW RADIO CALL LETTERS.—Owing to insufficient call letters having been reserved for Japan, the General Administration of Posts and Telegraphs of Japan will assign to Japanese ships call letters composed of four letters by means of the letter **A** at the end of the combinations of three letters commencing with **J.**

The call letters **OKA** to **OKZ** have been reserved for the Republic of Czecho-Slovakia. **[2374]**

WIRELESS TELEPHONE NEWS SERVICES.—In reply to a recent question in the House of Commons the P.M.G. stated that experiments had been made to distribute news messages by means of wireless telephony from a central station. So far as audibility of the speech was concerned the experiments were satisfactory, but the rate of transmission was slow due to the necessity for frequent repetitions. The news agency on whose behalf the experiments were made has not adopted the system. It was also found that the experiments caused interference with other stations and the trials have been suspended for the present. **[2054]**

FRANCE: WIRELESS COMMUNICATION WITH BULGARIA.—Wireless communication between Bulgaria and France has been established for private and Press correspondence. The fees are the same as those levied on ordinary lines, the messages bearing the words "non taxee : voie T.S.F." In case of overburdening or interruption of the wireless route, the offices concerned reserve the right of making use of the ordinary telegraph lines. **[2042]**

Commercial.

COMPAGNIE GÉNÉRALE DE TÉLÉGRAPHIE SANS FIL.—On December 3rd last it was decided to increase the capital of this company by 25 million francs, by the creation of 50,000 new shares of 500 francs each. **[2121]**

A NEW RADIO COMPANY.—On March 8th, C. F. Elwell, Ltd., was incorporated as a private limited company with a capital of £50,000. Some of the principal objects of the company are stated to be the development and working of inventions connected with radiotelegraphy and telephony and other methods of intercommunication, and the supply, working and maintenance of masts, arcs, machines, and other apparatus for use in connection with such methods of communication. The first directors are Messrs. J. H. Scrutton (*Chairman*), B. Binyon, C. F. Elwell, and B. E. Mittell. [2381]

The Polish Legation at Washington announces the signature of a million dollar contract with the Radio Corporation of America for the construction at Warsaw of the largest radio station in the world. The station is to have twelve 400-foot steel towers and is to be capable of handling 200 words per minute. [2368]

A NEW BELGIAN HIGH-POWER STATION.—The Belgian Government have decided to erect a 1,000-kW station at Temsche near Antwerp to communicate with the Congo and U.S.A. It will have eight towers 250 metres high. [2332]

A NEW WIRELESS STATION FOR SWITZERLAND.—Marconi's Wireless Telegraph Company have been authorised by the Swiss Federal Government to construct a wireless telegraph station for operation over a period of twenty-five years by a Swiss company. The station is to be erected near Berne about 1,000 feet above sea-level and will employ a valve transmitter of 25 kW capacity; the aerial being carried on two towers each 300 feet high. Up-to-date apparatus for high-speed automatic working will also be employed. The new station will be ready for use by journalists attending the second session of the Assembly of the League of Nations in September next. [2372]

The Australian Government is sending a party of experts to the Willis Islands, with a view to reporting on the possibility of establishing a wireless station there. It is thought that such a station would be of great service to the Commonwealth meteorological service.—*The North Queensland Register.* [2367]

WIRELESS ON ITALIAN VESSELS.—It has been announced that a decree has been published under date of December 27th last to the effect that all Italian motor and sailing vessels of over 1,600 tons and carrying passengers are to be equipped with wireless installations. [2371]

COMMERCIAL WIRELESS IN ITALY.—The use of radiotelegraphy for commercial purposes appears to be making good progress in Italy. Communication has been established with Germany, the United Kingdom, Spain, Switzerland, Rumania, Bulgaria and Serbia, and arrangements are in progress to link up with Hungary, Greece, Portugal, Czecho-Slovakia and Russia. The traffic between ships and coastal stations exceeded 500,000 words last year as compared with 80,000 words prior to the war. The stations on board ship have risen from fifty to more than 300. Two radiotelegraph stations will shortly be established between Sardinia and the Continent to obviate the inconvenience of possible interruptions of the cables. There is the possibility of an Italian company being formed to secure a concession for a group of stations to be used solely in the interest of the public service and of the national and international Press. The Marconi Company has already filed a petition for a concession, which will be examined by the permanent Board for Radiotelegraphic Service. [2382]

The Radio Research Board (Department of Scientific and Industrial Research) have been advertising for research workers of high academic qualifications. Applications should be addressed to the Secretary at 16 and 18, Old Queen Street, S.W. 1. [2211]

WIRELESS AND LONGITUDE.—To determine the exact position of the boundary between South and West Australia it is proposed to utilise wireless telegraphy. To ascertain the exact position of the longitude the use of time signals will be employed from a high power station situated at some point between the Greenwich Observatory in England and Sydney in Australia, the signals being received simultaneously at both places. [2056]

WIRELESS DEVELOPMENT IN AUSTRALIA.—Arrangements are being made for the establishment of wireless stations at Camoweal near the Queensland border, and Powell's Creek, in the Northern Territory. The initial cost will be in the vicinity of £4,000. It is also hoped that private persons will be encouraged to adopt wireless means of communication and that these two stations will act as collecting offices or exchanges for the private plants through which business will be conducted with the outer world. A special message fee will be charged for all such private messages. [2375]

WIRELESS TELEGRAPHY AND RAILWAY COMMUNICATION.—Experiments with wireless telegraphy as an auxiliary means of communication on railways have been conducted by the Marconi Co. between Euston and Crewe, and as soon as the Post Office grants a licence, extended trials will be made under commercial conditions. [2043]

JAPAN: NEW WIRELESS STATION.—The wireless station at Tomioka was opened on January 11th. It is the most powerful station in the Orient and is receiving messages direct from New York and other big world stations. Experiments in sending messages have proved very successful, and the station will commence about February 1st. [1997]

WIRELESS TELEPHONE ON LIGHTSHIP.—The installation of the wireless telephone on the Bar Lightship at Liverpool is stated to be the first of the kind for which a licence has been issued. It is intended to provide communication between the lightship and the Dock Board offices and a successful trial took place recently. To prevent interference with marine wireless traffic it has been necessary for the lightship set to be operated on a short wavelength. [2200]

NEW WIRELESS STATION FOR ARGENTINA.—The Argentina Government has granted a concession to the Cie. Générale de Télégraphie sans fil of Paris to construct a wireless station on the Argentina coast for direct radiotelegraphic and telephonic communication with France and other European countries. The duration of the concession is for thirty years. The station is to contain three sets of plant and will be of 800 kW capacity. [2397]

Recent announcements indicate that very good results have been obtained with the radiotelephone station fitted up for experimental purposes by the Westinghouse Electric and Manufacturing Co., Pittsburgh, U.S.A., ranges up to 1,600 miles having been obtained. A recent innovation has been the transmission from this station of the musical services from a local church. [2167]

Legal.

On March 3rd, an important judgment concerning radiotelegraphic work in this country was delivered by Mr. Justice Sargent in connection with the application for the prolongation of the Poulsen Arc patent (No. 15599/1903) which was made by Mr. Christopher Hage, The British and Overseas Engineering Syndicate, Ltd., and the Poulsen Wireless Telegraph Co., Ltd. This patent expired on July 14th, 1917, and the application for extension was lodged on July 5th, 1920. The early history of the patent in question as disclosed in the course of the evidence is extremely complicated, and indicates the difficulty of developing the commercial use of such an invention. Prior to the outbreak of war, the above-mentioned Christopher Hage had secured the sole rights of the patent. After the outbreak of war, the British and Overseas Engineering Syndicate (one of the applicants) was formed. The English patents and some of the foreign ones were sold to this syndicate, which entered into some onerous obligations with the Poulsen Company. By a deed of covenant between the Poulsen Company and the Marconi Company, the latter undertook to fulfil the obligations of the syndicate as regards the provision of capital, etc. Amongst the causes of loss cited by the applicants in connection with the application for the extension of the patent was that owing to the Treasury restrictions it was not possible to call on the necessary capital for the adequate development of the patent, but Mr. Justice Sargent pointed out that the applicants were in fact able to call on the requisite capital by virtue of the agreement with the Marconi Company. He further stated that he did not think that any substantial *prima facie* case had been made out by the applicants for saying that they have had a smaller user of their patents than they would have had if the war had not broken out; and that in his judgment, and having regard to the very strong case which has to be made by any patentee coming so long after the expiration of the patent, this is not a case in which the applicants have made a sufficiently *prima facie* case for it to be necessary to call on the Crown and on the opponents of the applicants. An extension of the patent at the present time could not be in force for more than fifteen months, and would be a hardship to others (notably the Post Office, and Mr. C. F. Elwell who has carried out considerable development work on the system) who had worked the system in the meantime on the understanding that the patent had expired.

The application was therefore dismissed with costs as towards the opponents. [2399]

Review of Radio Literature.

1. Abstracts of Articles and Patents.

Radio Stations and Installations (General and Descriptive Articles).

1633. **J. Komatsu.** The Choshi Radio Station. (*Pacific Radio News*, 1, pp. 259—261, February, 1920.)
An illustrated description.

1634. **G. M. Claus.** Soesterberg Wireless Station. (*Radio Nieuws*, 3, pp. 283—289, October, 1920.)
An illustrated description of this Dutch station.

1635. **J. C. N. Graafland.** The Lyons Wireless Station. (*Radio Nieuws*, 3, pp. 251—258, September, 1920.)

1636. **B. C. van der Nat.** Wireless Telephone Apparatus. (*Radio Nieuws*, 3, pp. 272—274, September, 1920.)

1637. **J. Corver.** Nauen. (*Radio Nieuws*, 3, pp. 319—324, November, 1920.)
An illustrated descriptive article.

1638. **Van Romunde.** Eighty Kilometre Radio-telephone Set of the S.F.R. (*Radio Nieuws* p. 363, December, 1920.)
A description of a set recently put on the market by the **Société Française Radio-Électrique.** A diagram of connections is given.

1639. **A. Bidault des Chaumes.** The Proposed Radio Station at Sainte-Assise, near Melun (*Génie Civil*, 78, pp. 73—78, January 22nd, 1921.)
A general description of the proposed station,* including a comparison between high-frequency alternators and arcs (see pp. 199—201 in this issue). A description is also given of the high-frequency machines manufactured by the Société Française Radioélectrique, together with the method of joining up two machines in parallel for transmission on the same aerial.

Transmitter Control or Modulation.

1640. **A. S. Blatterman.** The Effect of Modulation Waveshape upon Received Signals. (See RADIO REVIEW, pp. 187-196 in this issue.)

1641. **A. N. Goldsmith.** Controlling the Amplitude of Radio Frequency Continuous Oscillations. (*Wireless Age*, 7, pp. 20—21, June, 1920. *Technical Review*, 6, p. 725, August 31st, 1920—Abstract.)
In the arrangement described both the grid and plate circuits of the oscillating valve or valves form a part of the aerial circuit and in order that the audio frequency control may be more effective a low frequency reaction coupling is provided between the grid and plate circuits so that the modulation current first impressed upon the grid is magnified by the same valves used as low frequency amplifiers.

1642. **Société Française Radio-Électrique.** Wireless Telephony. (*French Patent* 503076, October 26th, 1916. Published June 2nd, 1920. *British Patent* 148955, July 10th, 1920. Convention date October 26th, 1920. Patent not yet accepted but open to inspection.)
The specification describes methods of modulating the exciting current of high-frequency alternators by means of a microphone.

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* See pp. 125—133 in the March, 1921, issue.

1643. **Cie. Française pour l'Exploitation des procédés Thomson-Houston.** Continuous Wave Transmitter. (*French Patent* 501320, May 10th, 1919. Published April 9th, 1920.)

The specification describes a transmitting apparatus employing modulated continuous waves in which the aerial is tuned to a frequency equal to the sum or difference of the wave frequency and the modulated or amplitude pulsation frequency, and the circuit of the source of oscillations is tuned to the wave frequency or the frequency of the source with the object of keeping the current supplied by the source in phase with the electromotive force.*

1644. **Société Française Radio-Électrique.** Condenser. (*French Patent* 503003, August 28th, 1916. Published June 1st, 1920.)

The specification describes a variable capacity condenser for microphonic currents in which the variation of the capacity is a function of a current in a telephone line. The variation in capacity of the condenser is brought about by vibrating discs of separate telephone receivers on which the magnetic fields of the receiver magnets act.

1645. **Le Matériel Téléphonique.** Continuous Wave Transmitter. (*French Patent* 505106, September 6th, 1918. Published July 23rd, 1920.)

The system is one in which a high-frequency generator is employed and a number of generators of lower frequency are connected through thermionic modulators to tuned circuits coupled with the circuit containing the high-frequency generator.

See also *British Patent* 132562—RADIO REVIEW Abstract No. 224, March, 1920.

1646. **Compagnie Française pour l'Exploitation des procédés Thomson-Houston.** Wireless Telephone Apparatus. (*French Patent* 505956, November 12th, 1919. Published August 11th, 1920. *L'Électricien*, 52, p. 21, January 1st, 1921—Abstract.)

For wireless telephony the vacuum tube is provided with two independent grids, one of which is connected in the high-frequency circuits and the other to a circuit carrying currents of audible frequency, such as a microphone circuit. The transmitting aerial is coupled to the plate-filament circuit and the circuit of the main grid and filament includes an inductance. The main grid is coupled to the plate by a variable condenser. The circuit of the auxiliary grid and filament is connected by a transformer to a microphone circuit. For further particulars see *British Patent* 110924.

1647. **E. W. Scripture.** Nature of Vowel Sounds. (*Nature*, 106, pp. 632—634, January 13th, 1921.)

An oscillographic investigation of speech waveforms, with estimates of the amplitudes of the harmonics therein.

Radio Receiving Apparatus.

1648. Time Signal Receiver Manufactured by the International Radio Company. (*Everyday Engineering Magazine*, 9, p. 250, June, 1920.)

1649. A Portable Receiver. (*Everyday Engineering Magazine*, 9, p. 352, July, 1920.)

A short illustrated description of a set manufactured by the **Esbro Company.**

1650. The Uni-control Receiver. (*Everyday Engineering Magazine*, 9, pp. 650—651, August, 1920.)

An illustrated description of a receiver manufactured by the **Wireless Improvement Company** in which all the adjustments are effected simultaneously by one control handle.

1651. **Gesellschaft für drahtlose Telegraphie, Berlin.** Continuous Tuning for Wireless Telegraphy. (*German Patent* 317543, March 7th, 1917. Patent granted December 24th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 384—385, November, 1920.)

A scheme for tuning an antenna system through a very large scale of wavelengths by means of several variable condenser systems and variometers geared together.

1652. **F. M. Clement.** Design of a Radio Receiving Set. (*Radio News*, 2, pp. 10—11, July, 1920; pp. 76—77, August, 1920.)

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* See also *British Patent* 130369—RADIO REVIEW Abstract No. 123, January, 1920.

1653. **M. B. Sleeper.** Some Ideals for a Crystal Receiver. (*Everyday Engineering Magazine*, 9, pp. 58—60, April, 1920.)

An illustrated article giving constructional details.

1654. **T. Harvey.** Detector. (*French Patent* 503972, December 18th, 1917. Published June 22nd, 1920. *British Patent* 126381, January 22nd, 1917.)

The invention consists of a mercury coherer for use in wireless telegraphy or cable code telegraphy employing alternating current or interrupted direct current. It consists of one or more globules of mercury placed between two electrodes in a rotating chamber or between two rotating electrodes.

1655. **A. Bonnefont.** Crystal Detector. (*French Patent* 506003, November 13th, 1919. Published August 12th, 1920.)

The device described in the specification comprises a stand carrying a terminal and a milled head which is easily turned by hand. The milled head controls in the interior of the stand a mechanism consisting of one or more movable parts which effect a movement, that is an advance, recession or rotation, to permit a suitable point to explore the crystal carried in the interior of the stand so as to find the most sensitive points of the said crystal.

1656. **H. Rohmann.** Contact E.M.F. and Rectification. (*Physikalische Zeitschrift*, 21, pp. 699—703, December 1st, 1920.)

Experimental investigation of fine micrometer contact phenomena between polished metal surfaces, leading the author to the conclusion that there are two badly conducting layers, the inner one giving the microphone effects and the outer the voltaic contact E.M.F. A platinum and silver contact the moisture of which contains a minute amount of iodine gave a very effective rectification, the resistance in one direction being more than 10^6 times that in the other. See also Abstract No. 1240, December, 1920, for reference to earlier experiments.

1657. **W. W. Inder.** Balanced Crystal Working. (*The Radiograph*, 2, pp. 10—12, July, 1920.)

1658. A Long Wave Receiver. (*Everyday Engineering Magazine*, 9, pp. 63—65, April, 1920.)

An illustrated description of the C.R.-7 set manufactured by the **A. H. Grebe Company.**

1659. **L. M. Clemont.** The Problems of Vacuum Tube Circuits: Detection with a Grid Condenser. (*Everyday Engineering Magazine*, 9, pp. 66—67, April, 1920.)

1660. **M. B. Sleeper.** Construction of a Portable Receiver. (*Everyday Engineering Magazine*, 8, pp. 408—411, March, 1920.)

An illustrated descriptive article of a single valve receiver for tuning between 200 and 2,000 metres wavelength.

1661. **S. D. Dimond and J. A. Hall.** Equipment for the Radio Station. (*Everyday Engineering Magazine*, 9, pp. 442—444, August, 1920.)

A valve receiver and 200 metre rotary spark transmitter are described and illustrated.

1662. **M. B. Sleeper.** A Short Wave Regenerative Receiver. (*Everyday Engineering Magazine*, 9, pp. 538—539, September, 1920.)

Constructional details are given for a single valve receiver for tuning between 150 and 600 metres.

1663. Detector and Amplifier Units. (*Everyday Engineering Magazine*, 9, p. 549, September, 1920.)

A short illustrated description of two units manufactured by the **Clapp-Eastham Company.**

1664. **M. Latour.** Relay. (*French Patent* 502476, September 27th, 1915. Published May 15th, 1920. *British Patent* 153319, July 12th, 1920. Convention date, September 27th, 1915. Patent not yet accepted but open to inspection.)

The specification relates to thermionic relays in which an alternating current is directly applied to the anode circuits of the receiving or amplifying valves. To eliminate the effects of this alternating supply voltage, two valves are used, fed from the same source through the primary windings of two transformers, the secondary windings of which are connected in opposition on the output circuit of the amplifier, so that the impulses of plate current through the two primaries cancel out. The input circuit is connected to the two grid circuits of the valves, so that the potential of one valve is raised when the other is lowered. This causes an unbalancing of the two plate currents, with the result that the two E.M.F.s in the output circuit no longer cancel. By inserting a detector in the output circuit the device may be employed for continuous wave reception, the low frequency supply to the anodes acting as a tikker.

1665. **E. F. Huth.** Circuit for Wireless Transmission and Reception. (*German Patent* 310774, October 5th, 1918. Patent granted October 1st, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 432, May, 1920—Abstract.)

A triode transmitter and receiver (see Fig. 1) in which one pole of the high tension battery is connected to the filament and the other through a large choking coil C to the grid condenser. The telephone T and blocking condenser B are cut out during transmission.

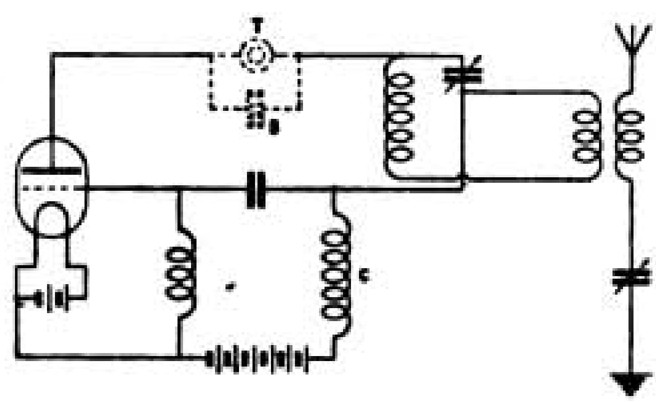

FIG. 1.

1666. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Receiving Apparatus. (*French Patent* 504250, September 26th, 1919. Published June 28th, 1920. *L'Électricien*, 51, p. 547, December 15th, 1920—Abstract.)

Means are provided in a wireless receiving system employing an electron discharge amplifier having resonant grid and plate circuits, for preventing the generation at all frequencies of oscillations due to the electrostatic and electromagnetic coupling between the grid and plate circuits. To prevent electromagnetic coupling of the resonant grid and plate circuits the inductances of these circuits are enclosed in metal boxes or are provided with closed iron cores. For further particulars, see *British Patent* 119365.

1667. **H. C. Harrold.** Thermionic Valves and their Application to Wireless Telegraphy. (*The Radiograph*, 2, pp. 72—74, September, 1920; pp. 95—97, October, 1920; pp. 121—123, November, 1920.)

1668. **P. F. Godley.** High Amplification of Short Wavelengths. (*Wireless Age*, 7, pp. 11—14, February, 1920. *Q.S.T.*, 3, pp. 5—9, February, 1920. *Electrical World*, 75, p. 1015—Abstract.) Also **P. R. Coursey.** The Most Efficient Methods of Reception of Short Waves both Spark and C.W. (*Wireless World*, 8, pp. 581—583, November 13th, 1920.) Also **H. W. Houck.** The Armstrong Super-autodyne Amplifiers. (*Radio Amateur News*, 1, pp. 403—405, February, 1920; pp. 469—471, March, 1920. *Radioélectricité*, 1, p. 70, June, 1920—Abstract.)

A description is given of a special amplifier for short wavelengths due to **E. H. Armstrong.** Circuit diagrams of the arrangements for open aerials and for loop aerials are given and constructional details are described for building the instruments. The principle of the arrangement is covered by the patents referred to in RADIO REVIEW Abstracts Nos. 983 and 992, October, 1920.

1669. **Gesellschaft für drahtlose Telegraphie, Berlin.** Continuous Wave Receiver. (*German Patent* 317544, June 26th, 1918. Patent granted December 22nd, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 385, November, 1920—Abstract.)

A heterodyne receiving circuit designed to make the radiation of the locally produced waves a minimum (see Fig. 2).

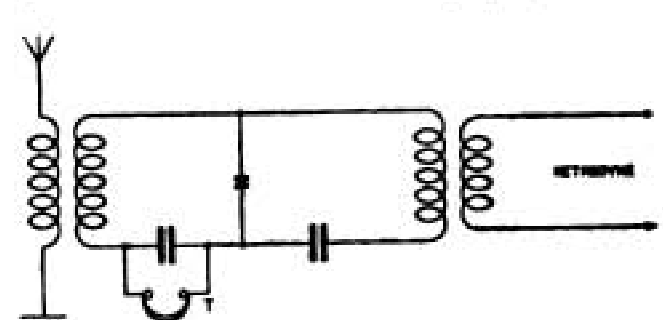

FIG. 2.

1670. **A. S. Blatterman.** Radio Frequency Amplification. (*Radio News*, 2, pp. 140—142, and 166—170, September, 1920.)

A mathematical discussion is given of the method of radio frequency amplifications using a supersonic beat frequency.* Formulæ are given to assist in the design of the amplifying transformers and it is concluded that the method should be freer from interference by atmospherics and highly damped spark stations.

1671. **E. H. Shaughnessy.** A New Wireless Call Arrangement. (*Electrical Review*, 87, pp. 68—69, July 16th, 1920. *Post Office Electrical Engineers Journal*, 13, pp. 263—267, January, 1921. *L'Électricité*, 2, p. 5, August 15th, 1920—Abstract. *Nature*, 105, p. 690, July 29th, 1920—Abstract. *Technical Review*, 7, p. 182, November 9th, 1920—Abstract. *Science Abstracts*, 23B, p. 493, Abstract No. 936, October 31st, 1920—Abstract. *Elektrotechnische Zeitschrift*, 41, p. 962, December 2nd, 1920—Abstract.)

A calling arrangement is described for wireless receiving depending for its operation upon the receipt of a prolonged dash of at least 15 seconds duration. In place of the usual telephone receivers a two or three valve note magnifier is arranged to be plugged in when the operator is not on watch. The output of this note magnifier is connected to a Turner valve relay. The output circuit of this relay is connected to the first relay of an electrical retardation device the function of which is to prevent the ringing of the bell for Morse signals or for short dashes or by atmospherics. The receipt of the signal causes the Turner valve relay to operate and thus to move the tongue of the first relay of the retardation device on to the marking contact to close the circuit of a 4 microfarad condenser on to a 12 volt battery through a resistance of 3 megohms which causes the condenser to charge up very slowly. On the cessation of the signal the tongue of this relay moves back and discharges the condenser through the second relay of the retardation device, the local circuit of the second relay including the call bell. Thus if the signal dash lasts for a sufficiently long period a charge will be accumulated in the 4 microfarad condenser of sufficient magnitude to operate the final relay and ring the bell. Reference is also made to some tests of the apparatus on the cable ship *Monarch* and in the Post Office research laboratories.

1672. **A. A. Campbell Swinton.** Wireless Telegraphy and Telephony. (*Engineer*, 130, pp. 592—594, December 10th, 1920.)

A full report is given of the opening address by the Chairman of the Council of the Royal Society of Arts. (See RADIO REVIEW Abstract No. 1386, January, 1921.)

1673. **L. B. Turner.** Relay. (*French Patent* 505712, February 13th, 1919. Published August 5th, 1920.)

The specification describes arrangements employing a thermionic or lamp relay.

See also *British Patent* 130408—RADIO REVIEW Abstract No. 196, February, 1920.

Amplifiers.

1674. **M. B. Sleeper.** A Radio Frequency Amplifier without Transformers. (*Everyday Engineering Magazine*, 8, pp. 414—416, March, 1920.)

Constructional details are given of a two-stage amplifier and detector with tuned circuit inter-valve couplings.

1675. **M. B. Sleeper.** A Two Step Audio Frequency Amplifier. (*Everyday Engineering Magazine*, 9, pp. 344—346, July, 1920.)

An illustrated descriptive article.

1676. **M. B. Sleeper.** Radio and Audio Frequency Amplifier. (*Everyday Engineering Magazine*, 10, pp. 56—58, October, 1920.)

Constructional details of a three-valve amplifier and detector.

1677. **F. Duroquier.** A Resistance Amplifier. (*La Nature*, 48 (2), Supplement pp. 83—85, September 11th, 1920; Supplement pp. 91—93, September 18th, 1920.)

Constructional details are given.

1678. **F. Duroquier.** The Construction of a Low Frequency Transformer Coupled Amplifier. (*La Nature*, 48 (2), Supplement pp. 115—197, October 9th, 1920.)

1679. **A. H. de Voogt.** Marconi's High-frequency Amplifier. (*Radio Nieuws*, 3, pp. 239—243, August, 1920.)

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* See also RADIO REVIEW Abstract No. 1668 in this issue.

1680. **J. Corver.** Short-wave High Frequency Amplification. (*Radio Nieuws*, 3, pp. 262—265, September, 1920.)

1681. **N. de Voogd.** High-frequency Amplifier. (*Radio Nieuws*, 3, pp. 338—341, November, 1920.)

1682. **Gesellschaft für drahtlose Telegraphie.** Reception of Continuous Waves. (*German Patent* 310733, November 9th, 1918. Patent granted September 20th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 233, September, 1920—Abstract.)

An arrangement of valves in cascade in which one valve acts both as amplifier and heterodyne. (See Fig. 3.)

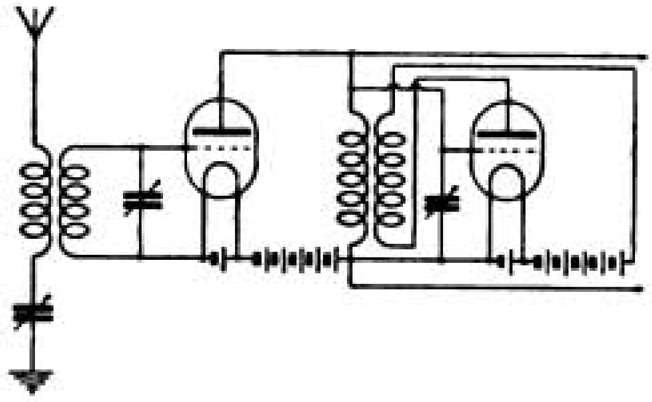

FIG. 3.

1683. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Amplifier. (*French Patent* 499563, May 5th, 1919. Published February 14th, 1920.)

An amplifier for telephone currents.

1684. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Amplifier. (*French Patent* 500618, June 11th, 1919. Published March 18th, 1920.)

This specification describes a method of amplifying telephone currents.

1685. **W. Tock.** The Vacuum Tube in France. (*Radio Amateur News*, 1, p. 466, March, 1920.)

A description of French multi-valve amplifiers.

Subsidiary Radio Apparatus.

1686. **M. Gouzon.** A Method of Prolonging the Life of Dry Cells used for High Tension Batteries. (*La Nature*, 48 (2), Supplement p. 117, October 9th, 1920.)

1687. **M. Marage.** The Threshold of Audition. (*Comptes Rendus*, 172, pp. 178—181, January 17th, 1921.)

A consideration of the sensitiveness of the ear to sounds of different types.

1688. **H. W. Secor.** Loud Talking Reproducer for Radio and Telephone Signals. (*Radio News*, 2, p. 211, October, 1920.)

Constructional details are given for an instrument of the electrodynamic type.

1689. Radio Buzzer Instruments. (*Everyday Engineering Magazine*, 8, pp. 417—419, March, 1920.)

Aerials and Earthing Systems.

1690. **J. Bethenod.** Aerial Construction. (*French Patent* 497313, April 20th, 1918. Published December 3rd, 1919.)

The specification describes a system of aerials for the emission of electromagnetic waves of great wavelength and produced by an arc or high frequency alternator, in which two or more aerials are directed orthogonally and are fed with out-of-phase currents. There are no drawings.

1691. **C. L. Allen.** A Simple Ready-made Aerial. (*Wireless Age*, 7, pp. 32—34, March, 1920.)

The use of rain water pipes and gutters as aerials for wireless receiving is described.

1692. **F. C. Brockman.** The Construction of a Portable Antenna. (*Wireless Age*, 7, pp. 30—31, September, 1920.)

1693. **A. H. Rice.** The Construction of a Portable Antenna. (*Wireless Age*, 7, pp. 31—34. September, 1920.)

1694. **P. H. Boucheron.** Concerning Aerials. (*Radio News*, 2, pp. 18—20, July, 1920.)

A general descriptive article.

1695. **M. B. Sleeper.** The Design and Use of Loop Antennas. (*Everyday Engineering Magazine*, 9, pp. 440—441, August, 1920.)

1696. **S. E. Moore.** The Tree Antenna. (*Radio Amateur News*, 1, p. 484, March, 1920.)

1697. **P. Dosne.** A Table Antenna. (*La Nature*, 48 (2), pp. 302—304, November 6th, 1920.)

The author describes the use of a frame aerial in a horizontal position for general reception purposes, the receiving instruments being mounted in the centre of the frame. The use of a telegraphone for recording purposes is also referred to.

1698. **A. Esau.** Frame Antennæ. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 486, June, 1920. Abstracted from *Elektrotechnik und Machinenbau*, 37, p. 401, 1919.)

1699. **A. Gradenwitz.** Braun Loop Antenna. (*Radio News*, 2, pp. 70 and 100, August, 1920.)

A general account of the development of frame aerials.

1700. **A. A. Hall.** Aerial Construction. (*French Patent* 505678, November 4th, 1919. Published August 4th, 1920. *British Patent* 142886, November 18th, 1918. Patent accepted May 18th, 1920.)

The usual aerials are not employed. The receiving and transmitting stations have a double earth connection spaced apart by a considerable distance. The connections to the earth are made by insulated conductors lying on the ground. The two earth connections are included in the anode circuit of either the transmitting or receiving valve, a reaction coil being provided for coupling to the grid circuit to enable the circuits to generate oscillations. For transmission a key is placed in one of the earth connections.

1701. Condenser Antennæ. (*Telegraph and Telephone Age*, 38, p. 650, December 16th, 1920.)

Describes briefly experiments carried out by the **Bureau of Standards** on aerials consisting of a pair of metal plates, the lower one of which is raised above the ground. For short wavelengths it is stated that these aerials give better signals than the more conventional forms.

1702. Submarine Radio. (*Telegraph and Telephone Age*, 38, p. 650, December 16th, 1920.)

A short note on experiments on communication with submerged submarines.

1703. **A. S. Blatterman.** Theory and Practical Attainments in the Design and Use of Radio Direction Finding Apparatus using Closed Coil Antennas. (*Journal of the Franklin Institute*, 190, p. 421, September, 1920. *Science Abstracts*, 23B, p. 546, Abstract No. 1036, November 30th, 1920—Abstract. *Technical Review*, 7, p. 428, December 28th, 1920—Abstract.)

A supplementary note extending the data given by the author in an earlier paper.* Test results are quoted for 4-foot and 6-foot loops having $\frac{1}{4}$-inch and $\frac{7}{16}$-inch wire spacing respectively. Three tables are given of the measured resistances at different wavelengths.

1704. **A. Esau.** Coil Aerials: their Inductance, Capacity and Natural Frequencies. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 162—199, September, 1920.)

Gives formulæ for the calculation of the inductance of rectangular and circular coils, the effect of unequal distribution of the current at high frequencies, both over the cross-section of the wire and along the coil, and the self-capacity of such coils. In all cases a number of measured values are given, showing the agreement with or deviation from the calculated values.

1705. **A. F. Murray.** A Loop Transmitter for Local Work. (*Wireless Age*, 7, pp. 25 and 41, July, 1920.)

Particulars are given of an installation using an elevated antenna for long distance work and a loop aerial for short distance transmission, the same equipment being transferred from one to the other with appropriate switches.

1706. **L. D. Dillenback.** A 100 Foot Radio Mast. (*Wireless Age*, 7, pp. 28—29, April, 1920.)

The mast described is built up of sections of iron piping screwed together.

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* See RADIO REVIEW Abstract No. 144, January, 1920.

1707. **F. H. Mulcahy.** An Easily Constructed Mast. (*Wireless Age*, 7, pp. 30—32, April, 1920.)
Constructional details are given.

Radio Wave Transmission (Theory, Tests, etc.).

1708. **G. W. O. Howe.** The Power required for Long Distance Wireless Transmission. (*Science Abstracts*, 23B, p. 543, Abstract No. 1029, November 30th, 1920—Abstract.)
Radio Review, 1, pp. 598—608, September, 1920.

1709. **P. Ludewig.** The Influence of Meteorological Factors on Wireless Telegraphy. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 479—480, June, 1920. Abstracted from *Elektrotechnik und Machinenbau*, 32, pp. 181—209, 1914.)

1710. **C. E. Snell.** The Function of the Earth in the Transmission of Electricity. (*Electrical Review*, 87, pp. 421—423, October 1st, 1920.)
Brief summaries are given of the various viewpoints from which the subjects of electrical current transmission through the earth and of electromagnetic wave transmission over the earth's surface have been attacked. Some experiments are quoted bearing on the subject of transmission of high frequency impulses along conductors from which it is concluded that for the transmission of electric waves over considerable distances the most efficient method is to connect the two points by a conductor of limited dimensions, and that this conductor must not make contact *en route* with any considerable mass of conductive material.

1711. **G. W. O. Howe.** Field Strength at Leghorn of Annapolis Signals. (*Technical Review*, 7, p. 391, December 21st, 1920—Abstract.)
Radio Review, 1, pp. 652—655, October, 1920.

1712. **G. Vogt.** The Reception of Wireless Signals in the East Indies. (*Radio Nieuws*, 3, pp. 291—294, October, 1920.)

1713. Wireless Telephony. (*Electrical Review*, 87, p. 146, July 30th, 1920.)
Reference is made to long distance wireless telephone communication with the S.S. *Victorian.*

1714. Wireless Telephony. (*Electrical Review*, 87, p. 627, November 12th, 1920.)
Refers to tests between Keyport (N.J.), U.S.A., and Aberdeenshire, Scotland, carried out by amateurs.

1715. **M. Sauzin.** On the Propagation of Undamped Electric Oscillations in Water and on the Dielectric Constant of Water. (*Comptes Rendus*, 171, pp. 164—167, July 19th, 1920. *Revue Scientifique*, 58, p. 473, August 14th, 1920—Abstract.)
Experiments are described using ultra-radio frequency oscillations from a valve generator, and stationary waves on parallel wires, which could be immersed in water for part of their length. Using wavelengths of 445 cms and 242 cms, the mean dielectric constant was found to be 73 for distilled water, and 75 for tap water (at Nancy).

Atmospherics and Anti-Atmospheric Devices.

1716. Forecasting Weather from Static. (*Radio Amateur News*, 1, p. 465, March, 1920.)

1717. **H. J. J. M. de R. de Bellescize.** Eliminating Atmospheric Disturbances. (*French Patent* 504782, October 10th, 1919. Published July 6th, 1920.)
For the reception of wireless telegraphy or wireless telephony a closed damping circuit is provided comprising an inductance in series with two resistances of considerably different values, and the two resistances and the inductance are shunted by a rectifying contact. The damping circuit is coupled to a feebly-damped resonator and by it parasitic currents are eliminated.

1718. A New Static Eliminator. (*Radio News*, 2, p. 71, August, 1920.)
An acoustic resonance method is described.

1719. **W. Gerlach.** On a Method of Reducing the Effect of Atmospherics. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 337—344, November, 1920.)
After a brief discussion of the different schemes which have been proposed to eliminate atmospheric interference the author describes experiments illustrating the difference between two types of atmospheric disturbance. The same atmospherics were registered by means

of a crystal and galvanometer, by telephone and also by means of a thermo-element and accessory galvanometer. Atmospherics of the strong type which last only a short time were registered by the crystal and galvanometer but not to any great extent by the thermo-couple. Weaker atmospherics of the growling type which are supposed to be of fairly long duration produced much bigger deflections on the thermo-couple galvanometer.

A method of reducing the effect of an atmospheric is suggested in which a conductor or cell of special type is used as a connection between a point on the aerial tuning inductance and earth. This conductor or cell must be such that its conductivity does not become appreciable until a certain potential difference is maintained between its ends (*e.g.*, carborundum). Experiments were made on a large antenna at Jena to test the efficacy of this method. Curves are given showing the relation between the ratio of the atmospheric effect before and after making the parallel connection mentioned and the particular points on the antenna inductance at which the connection was made.

Duplex Radio Communication.

1720. **Société Française pour l'Exploitation des procédés Thomson-Houston.** Duplex Working. (*French Patent* 503827, September 12th, 1919. Published June 18th, 1920. *British Patent* 150798, June 5th. Patent accepted September 6th, 1920.)

In a receiving system adapted for duplex telegraphy or telephony the receiving coil is in two halves having large mutual inductance and the junction point is earthed so as to provide a non-inductive path to earth for currents induced electrostatically by a neighbouring transmitting aerial.

1721. **H. J. J. M. de R. de Bellescize.** Duplex Wireless Systems. (*French Patent* 506141, January 22nd, 1919. Published August 14th, 1920.)

In duplex wireless systems in which there is a transmitting station having associated with it one or more receiving stations, the signals are received by the operator at the transmitting station by being transmitted thereto over telephone lines connected to the receiving circuits.

See also *British Patent* 134497, RADIO REVIEW Abstract No. 906, October, 1920.

High-frequency Circuits and Measurements (Theory, Components, etc.).

1722. **P. Boucherot.** A New Method of Calculation by the Separation of Power Applicable to Radiotelegraphy. (*Radioélectricité*, 1, pp. 73—81, July, 1920. *La T.S.F. Moderne*, 1, pp. 283—285, November, 1920—Abstract.)

The author suggests a simplification of the calculations necessary in connection with C.W. transmitting apparatus, by the application of the simple formulæ of ordinary alternating-current electrical engineering. The use of instantaneous values is dispensed with in favour of the use of expressions for "real" and "apparent" power of the type $IV \cos \phi$ and $IV \sin \phi$.

1723. **H. G. Cordes.** The Theory of Linear-sinoidal Oscillations. (*Physical Review*, 16, pp. 179—201, September, 1920. *Science Abstracts*, 23A, pp. 656—657, Abstract No. 1645, December 30th, 1920—Abstract.)

When a vacuum arc is shunted with a discharge circuit containing inductance, capacity and resistance, and is supplied with direct current through a large inductance the arc vapour is ionised and de-ionised periodically at a constant frequency. The author terms the variation of potentials and current in a discharge circuit "linear-sinoidal oscillations" and mathematical expressions are derived for their logarithmic decrement, frequency and other quantities. The relation between the values of the direct current supply and the effective currents through the arc and in the discharge circuit is established. It is also shown that the value of the series resistance required to produce stability depends upon the discharge circuit resistances and on the rate of de-ionisation of the vapour. Auxiliary means are required to stabilise the oscillations if required for radio signalling.

1724. **K. W. Wagner.** The Penetration of an Electromagnetic Wave into a Coil having Self-capacity. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 484, June, 1920. Abstracted from *Elektrotechnik und Maschinenbau*, 33, pp. 89—105, 1915.)

1725. **K. Zickler.** The Calculation of the Alternating-current Resistance of Iron Conductors of Circular Cross-section. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 486—487, June, 1920. Abstracted from *Elektrotechnik und Machinenbau*, 37, p. 449, 1919.)

1726. **J. Bethenod.** On the Influence of Antenna Height on the Range of Wireless Stations. (*Radioélectricité*, 1, p. 285, November, 1920.)

Assuming uniform electrical strain on the insulators supporting the antenna, and that the whole effective capacity of the aerial is concentrated in the upper flat part, it is shown that the dependence of the received signal strength on the height of the transmitting aerial is given by a factor $m = 1 + 2{\cdot}55H/R$ where H = height and R = effective radius of the upper flat part of the aerial. An increase of the height of an aerial from 100 to 200 metres would thus result in an increase of 33 per cent. only in the received signal strength.

Simple relations are also suggested for quickly determining the most economical height of the towers from the point of view of their cost.

1727. **P. R. Coursey.** Multi-layer Windings for Radio Receiving. (*Wireless World*, 8, pp. 473—476, October 2nd, 1920; pp. 505—508, October 16th, 1920; and pp. 539—541, October 30th, 1920. *Technical Review*, 7, p. 222, November 16th, 1920—Abstract.) Also Lattice-wound Coils. (*Wireless World*, 8, pp. 635—637, December 11th, 1920.)

Describes the various forms of multi-layer windings including the honeycomb and duolateral with similar modifications. Winding tables are also given.*

1728. Duolateral Type Inductance. (*Everyday Engineering Magazine*, 9, p. 254, June, 1920.)

1729. **K. H. Stark.** A New Development in Tuning Inductances. (*Everyday Engineering Magazine*, 9, pp. 446—447, August, 1920.)

An illustrated description of a multi-layer inductance winding for radio frequency consisting of a combination of lattice winding and ordinary spiral winding used in alternate layers.†

1730. Precision Radio Measurements. (*Everyday Engineering Magazine*, 9, pp. 542—543, September, 1920.)

A short illustrated description of a wavemeter, a variable condenser and a variable inductance manufactured by the **General Radio Company.**

1731. Variometer or Coupling Coils. (*Everyday Engineering Magazine*, 9, pp. 546—547, September, 1920.)

Constructional details are given.

1732. Variometer. (*Electrical World*, 76, p. 905, October 30th, 1920.)

A short note illustrating the variometer type Z.R.V. manufactured by the **Clapp-Eastham Company.**

1733. **J. Philips.** The New Inductance Coils. (*Radio Nieuws*, 3, pp. 244—245, August, 1920.)

A brief description of lattice windings.

1734. **Gesellschaft für drahtlose Telegraphie, Berlin.** Self-inductance for Wireless Telegraphy. (*German Patent* 309211, June 19th, 1918. Patent granted September 22nd, 1919 *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 235, September, 1920—Abstract.)

A coil (see Fig. 4) for use in valve work which has no external electromagnetic effect and so does not give rise to undesirable coupling.

1735. **H. C. Silent.** Banked Winding. (*Radio Amateur News*, 1, p. 411, February, 1920.)

1736. **O. C. Roos.** Anti-capacity Windings *versus* Coil Efficiency. (*Radio News*, 2, p. 85, August, 1920.)

The author concludes that a graded coil as regards size and separation of wires and pitch would improve the efficiency. The development of multi-layer windings is also traced.

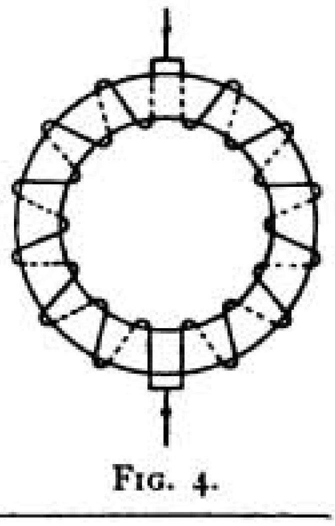

Fig. 4.

* See also Radio Review Abstract No. 1413, January, 1921.

† This winding is also described in the article referred to in Abstract No. 1727 above.

1737. **P. F. Geagan.** Inductances that Fit. (*Experimental Science*, 1, pp. 54—55, August, 1920.)

Deals with the design of transmitting inductances for 200-metre wavelengths.

1738. **A. Tobler.** The Use of a Valve Oscillator for the Measurement of Inductance and Capacity at the General Post Office, London. (*Journal Télégraphique*, 44, pp. 189—150, December 25th, 1920.)

A correction to the article referred to in Abstract No. 1496, February, 1921.

1739. **B. Ames.** Condenser. (*French Patent* 501024, June 24th, 1920. Published March 31st, 1920. *British Patent* 137003, May 29th, 1919.)

The specification describes a condenser of the type having alternate sheets of conducting and insulating material and in which alternate conducting sheets project in two different directions from the edges of the insulating sheets.

1740. **L. B. Turner.** Everyday Measurement of Inductance and Capacity in the Wireless Laboratory. (*Technical Review*, 7, p. 323, December 7th, 1920—Abstract. *Science Abstracts*, 23B, p. 515, Abstract No. 985, November 30th, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 585—590, September, 1920.

1741. **L. M. Clemont.** The Measurement of High Frequency Resistance. (*Everyday Engineering Magazine*, 9, pp. 252—253, June, 1920.)

Description of various arrangements of bridge and other high-frequency resistance measuring circuits.

1742. **V. L. Freeman.** A Simple Method of Measuring Inductances at Low Frequencies. (*Everyday Engineering Magazine*, 9, pp. 354—355, July, 1920.)

1743. **G. Pession.** Capacity of Aerials. (*L'Elettrotecnica*, 8, pp. 10—13, January, 1921. See also p. 1 in same issue.)

A discussion of the static and dynamic capacities of aerials and the correct meaning to be attached to the latter expression. Accurate measurements on the San Paulo aerial at Rome are recorded, the static capacity was found to be 13 milli-microfarads and the equivalent capacity at the fundamental wavelength of 3,300 metres 11·8 milli-microfarads.

1744. **M. B. Sleeper.** A Heterodyne Wavemeter for 170 to 21,000 Metres. (*Everyday Engineering Magazine*, 9, pp. 247—250, June, 1920.)

An illustrated description with constructional details.

1745. U.S. Bureau of Standards Long Wave Wavemeter. (*Everyday Engineering Magazine*, 10, p. 64, October, 1920.)

An illustrated description.

1746. **H. Veenstra.** Direct Reading Wavemeter. (*Radio Nieuws*, 3, pp. 331—335, November, 1920.)

The arrangement described and illustrated is that referred to in connection with Fig. 3 on p. 721 of the RADIO REVIEW Abstract No. 1056, November, 1920.

1747. **J. S. E. Townsend.** High Frequency Measurements. (*French Patent* 499497, March 2nd, 1918. Published February 12th, 1920.)

The specification describes a variable inductance for use in measuring wavelengths and tuning in wireless telegraphy. It consists of a variometer comprising two coils, one rotatable within the other and a switch for changing the connections from series to parallel. For further particulars see *British Patent* 115876.

1748. **A. V. Ballhatchet.** A Wavemeter. (*Model Engineer*, 44, pp. 89—91, February 3rd, 1921.)

Gives constructional details.

1749. **W. Burstyn.** Measurement of High Frequency Energy. (*German Patent* 300043, November 24th, 1916. Patent granted December 15th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 379—380, November, 1920.)

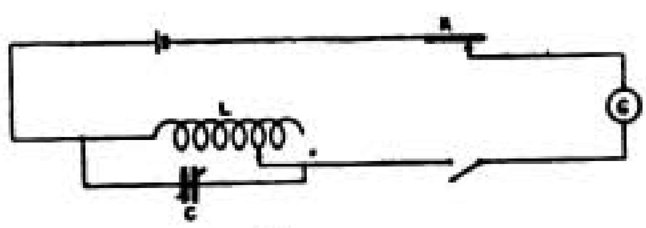

FIG. 5.

A method of measuring the high frequency energy associated with an oscillating circuit without a spark gap. The direct current circuit (see Fig. 5) is suddenly broken, the energy of the oscillating circuit then being $\frac{1}{2}LJ^2$ where J is the reading of the galvanometer when the key is closed. The time constant of the direct current circuit is made smaller than the time of contact by the insertion of a sufficiently high resistance.

1750. **C. T. R. Wilson.** On a Micro-voltameter. (*Proceedings of the Cambridge Philosophical Society*, 19, p. 345, February, 1920. *Science Abstracts*, 23A, p. 588, Abstract No. 1482, November 30th, 1920.)

An apparatus for the measurement of very minute quantities of electricity.

1751. **R. S. Whipple.** Some Notes on the Electro-cardiograph. (*Journal of the Institution of Electrical Engineers*, 57 Supplement, pp. 13—28, April, 1920. *Science Abstracts*, 23A, p. 660, Abstract No. 1657, December 30th, 1920—Abstract.)

The paper includes some particulars of the various patterns of Einthoven galvanometer manufactured by the Cambridge Scientific Instrument Co. The maximum sensitiveness quoted is 1 mm deflection on the screen at 600 diameters magnification for 0·000015 microamperes.

1752. **J. K. A. W. Salomonson.** The Limit of Sensitiveness of the String Galvanometer. (*Proceedings of the Koninklijke Akademie van Wetenschappen of Amsterdam*, 23, pp. 613—615, No. 4, 1921.)

The continuation of a paper published in 1918 on the sensitiveness of the Einthoven galvanometer. It is shown that the previously obtained results should be modified by the effect of the weight of the string and that when this is done the calculated deflection agrees fairly closely with the observed values.

1753. **W. Einthoven.** On the Observation and Representation of Thin Threads. (*Proceedings of the Koninklijke Akademie van Wetenschappen of Amsterdam*, 23, pp. 705—706, No. 5, 1921.)

Discusses the observation of very thin threads for Einthoven galvanometers and the limitations of their magnifications by means of a microscope.

1754. **B. van der Pol.** Discontinuities in the Magnetisation. (*Proceedings of the Koninklijke Akademie van Wetenschappen of Amsterdam*, 23, pp. 637—643, No. 4, 1921.)

The use of an amplifier is described for investigating the sounds occurring when iron is magnetised. The connection with the "breathing" sound of a magnetic detector is pointed out.

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2. Books.

A COURSE OF MODERN ANALYSIS. By E. T. Whittaker and G. N. Watson. (London: *Cambridge University Press*. 1920. Pp. xxiii + 608. Price 40s. net.)

The scope of the third edition of this well-known book is indicated by its sub-title, "An Introduction to the General Theory of Infinite Processes and of Analytic Functions; with an Account of the Principal Transcendental Functions." It is divided into two parts dealing respectively with the processes of analysis and the transcendental functions. It differs from the second edition by the addition of a chapter on Ellipsoidal Harmonics and Lamé's Equation, and by the rearrangement of the chapter on Trigonometrical Series so that the parts which are used in applied mathematics come at the beginning of the chapter. A large number of examination questions are given at the close of each chapter, together with a list of references to more specialised works in the subject of the chapter. The large number of references throughout the book greatly add to its value, as do also the tabulated list of the authors quoted and the very complete index. It is essentially a book for the mathematician and makes considerable demands on the reader's mathematical knowledge and power of abstract conception. To a physicist or engineer of modest mathematical attainments Chapter XVIII. on the Equations of Mathematical Physics will appear somewhat of an oasis; but even here a close examination may prove disappointing.

To the student of modern mathematical analysis the book will be indispensable.

G. W. O. H.

Elements of Radiotelegraphy. By Ellery W. Stone, M.Inst.R.E., Lieutenant, U.S.N.R.F. (New York: *D. van Nostrand Co.* London: *Crosby Lockwood & Son.* 1920. Pp. vii + 267. Price 16*s.* 6*d.* net.)

This book is, in the main, a *résumé* of a series of lectures delivered to the radio classes at the U.S. Naval Radio Station, San Diego, and on this understanding much of the criticism which might be levelled against it falls to the ground. Even the belief of the author that it will be found helpful in radio instruction in other military branches of the Government and in civilian radio schools merits our cheerful acquiescence. But that it possesses any special value for "the self-instruction of those interested in the subject" we must be permitted to doubt, without implying that as a source of information it is indifferent.

Lieutenant Stone's book contains 267 pages, including twelve covered by the Appendix and Index. Within this narrow scope are packed eleven chapters each of which deals with a number of subjects. In Chapter I., five and a half pages are devoted to the principles of radiotelegraphy, three and a half to electrical terms, between three and four pages to condensers, a page to inductances, less than thirty lines to electromagnetic induction and ten pages to alternating current.

One page only is devoted to the Marconi system of transmission, whilst the Telefunken system is dismissed in eleven lines. On the other hand eighteen pages are given up to the Poulsen arc transmitter and eleven pages to decremeters. The text referring to thermionic valves is in the form of brief, condensed notes.

These examples are sufficient to show that for self-instruction the student should look elsewhere.

The only references to direction finding or to the directional properties of certain antennæ occur in the notes on the inverted L and loop types, no mention being made of the Bellini-Tosi aerial. Only two pages are devoted to high-frequency machines, in which no pretence of detailed description is made.

The following might be improved: "A condenser or capacity is made of a piece of dielectric coated on each side with a conductor."

The book is well printed on good paper and the half-tone illustrations are well done.

E. Blake.

Report of the Chief Signal Officer of the U.S. Army to the Secretary of War (U.S.A.) for the year ended June 30th, 1920. (Washington: *Government Printing Office.* 1920. Pp. 64.)

This report is largely concerned with the activities of the Signal Corps in the occupied Rhine territory, especially Coblentz. It contains many interesting details and statistics and is illustrated with photographs showing different branches at work. G. W. O. H.

Report of the Director of the Air Service to the Secretary of War (U.S.A.) for the year ended June 30th, 1920. (Washington: *Government Printing Office.* 1920. Pp. 49.)

This report deals with the organisation of the Air Force, clearly set out under various headings. Chapter IV. on Air Service Accomplishments, and Chapter V. on Projects and Undertakings are especially interesting. Wireless work is apparently not referred to.

G. W. O. H.

Books Received.

Modern High-speed Influence Machines, their Principles, Construction and Applications to Radiography, Radiotelegraphy, Spark Photography, Electro-Culture, Electro-Therapeutics, High-tension Gas Ignition, the Testing of Materials, etc. V. E. Johnson, M.A. (London: *E. and F. N. Spon, Ltd.* 1921. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. Pp. viii + 278. Price 14*s.* net.)

Notions Élémentaires de Télégraphie sans Fil et Construction Pratique de Postes Recepteurs (Ondes Amorties et Entretenues). By Jean Remaur. (Paris: *Librairie Générale Scientifique et Industrielle Desforges.* 1921. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. Pp. 116. Price 7 fr. 50.)

CONTINUOUS WAVE WIRELESS TELEGRAPHY. By W. H. Eccles, D.Sc. (London: *The Wireless Press, Ltd.* 1921. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. Pp. vii + 407. Price 25*s*.)

ARITHMETIC OF TELEGRAPHY AND TELEPHONY. By T. E. Herbert and R. G. de Wardt. (London: *Sir Isaac Pitman & Sons, Ltd.* 1921. $7'' \times 4\frac{3}{4}''$. Pp. vii + 187. Price 5*s*. net.)

EINFÜHRUNG IN DIE ELEKTROTECHNIK UNTER ZUGRUNDELEGUNG DER VORLESUNGEN PROFESSOR SLABYS. Revised by Otto Nairz. (Leipzig: *J. A. Barth.* $10'' \times 6\frac{1}{2}''$. Pp. viii + 415. Price M.25.20.)

EDISWAN ELECTRIC BELLS, INDICATORS, PUSHES AND ACCESSORIES. (London: *Edison Swan Electric Co., Ltd.* $11'' \times 8\frac{3}{4}''$. Pp. 36.)
A well-illustrated catalogue.

THE YEAR BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY, 1921. (London: *The Wireless Press, Ltd.* 1921. $8'' \times 5''$. Pp. lxxxiv + 1355. Price 21*s*.)

Correspondence.

TRIODE CHARACTERISTICS WITH HIGH GRID POTENTIAL.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—In the course of some measurements of triode characteristics for the purpose of constructing the characteristic surfaces of the anode and grid current, it was noticed, that with a high positive grid potential (*e.g.*, 400 volts) and a lower anode potential (*e.g.*, 300 volts) the grid current was bigger than the normal saturation value. At the same time the *anode current* was flowing in the *opposite sense* than is usual with lower grid voltages. The algebraic sum of the anode and grid current however was the normal saturation value.

No doubt this phenomenon is due to secondary electron emission from the anode, this being caused by the impact of the primary electrons coming from the hot cathode.

With the constant + 400 volts on the grid and a varying anode potential the anode current showed a falling characteristic over a big part of its course. It was very easy therefore to obtain oscillations both of audio and radio frequencies by simply inserting in the anode circuit a self-inductance shunted by a capacitance.

As this phenomenon was obtained and described by Dr. A. Hull for a specially constructed tube called by him a dynatron, it may be of interest that an ordinary hard receiving triode (we used a Mullard valve) has exactly the same physical properties.

If it is possible to keep the conditions steady enough this way of using an ordinary triode (thus having a high negative resistance to changes of anode current) as an aperiodic amplifier is certainly a noticeable simplification of Mr. Turner's kallirotron. As to the degree of constancy when used as an amplifier, however, no experiments have been carried out as yet. When used as a generator of oscillations the constancy both of amplitude and frequency is of the usual high grade.

BALTH VAN DER POL.

Physical Laboratory, Teyler's Institute,
Haarlem, Holland,
February 15th, 1921.

[We believe that it is generally known that an ordinary valve can be used to demonstrate the principle of the Dynatron. The abnormal grid and anode currents are often obtained by students determining characteristics at high grid potentials.—ED.]

"THE HETERODYNE METHOD OF WIRELESS RECEPTION, ITS ADVANTAGES, AND ITS FUTURE."

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—I should like to take issue with M. Latour regarding one point in his paper on heterodyne reception. The particular point to which I refer is his statement as follows :—

"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 experiment will bring out this point."

Are the facts regarding this quite correct ? For years, with spark stations, which are a form of modulated C.W., we have been trying to use acoustic tuning to minimise X's with no serious effect against the X's. The X always kicked our acoustic resonator into the note with which it was tuned. As against this, heterodyne reception with acoustic resonance is having a marked effect on X reduction.

Suppose we examine an elementary case of modulation at the transmitting end.

About the simplest method of modulation is to transmit simultaneously with two wavelengths say from two C.W. stations near to one another. If the wavelengths are separated by a frequency n then a receiver without a heterodyne at a distance will hear a musical note of frequency n. If one of these stations stops sending Morse and makes a long dash, at the receiving end no difference will be noted as far as signals are concerned. X's will, however, be slightly altered by the action of the dash from the one transmitter during the spacing intervals. It can, however, be easily imagined that this dash cannot seriously affect the X, particularly when the signal is weak. Consequently there is no apparent difference between the two methods of sending.

Now the receiver could not tell if this dash sent by the one C.W. station were replaced by a heterodyne at the receiving station giving the same current and frequency to the receiving aerial particularly if the heterodyne were arranged to simulate direction as well as strength and frequency. So that obviously the modulation which M. Latour suggests is a property of the transmitting station resolves itself into a clumsy way of heterodyning—without several of the good properties of the heterodyne.

Every other type of amplitude modulation can be similarly analysed and although in many cases considerable ingenuity would have to be exhibited to get the necessary heterodyne —for instance in the case of a spark—nevertheless the result could be obtained.

Of course in the case of the two stations sending, the change in energy is twice that given by one and proper design of gear would take advantage of this, but far simpler gear would be obtained by concentrating the energy into one wave.

In the past, most of us have made the mistake of thinking that modulation, acoustic and super-acoustic, gave a definite and new character to a signal but I believe now that all the methods turn out to be merely methods of transmitting more than one wave simultaneously, sometimes, of course, particularly on short waves and with telephony, with obvious practical advantages.

If we could argue that modulation gives a character to a signal other than that given by the wavelength, then we should be able to give two modulations to the same station and receive two messages from it simultaneously. We can do this but it should be noted that such modulation produces separate wavelengths from the original wave—and why should we modulate at all ?—instead of sending these separate wavelengths.

Perhaps the time has come to recognise definitely that the impulses—which is what most experiments indicate the nature of the majority of X's to be—are very similar to white light, and a signal is a narrow band on the spectrum, comparatively broad for a spark infinitely narrow for a C.W. dash of constant frequency and of infinite length, and with some disagreeable fringes when high-speed Morse is being sent. That just as Lockyer separated the line spectrum of the sun's atmosphere from the white light spectrum by continuous expansion of the latter by a multitude of prisms leaving the lines still unexpanded, so we are reducing our atmospherics steadily by sharper and sharper receiver resonance. The only real distinction between C.W. signals and X's is that in the first, the energy is on one wavelength and in the second it is distributed over a large part of the spectrum.

M. Latour accentuates one powerful property of the heterodyne namely that of giving what may be called a straight line law of reception, a property also of the tikker and Goldschmidt tone wheel, which property is replaceable by high frequency magnification to any desired extent, but the heterodyne has two other properties almost as valuable.

(1) What might be called the floating zero of rectification.
(2) The power of enabling one to remove one's tuning to a wavelength where circuit losses are not so troublesome.

In receivers without heterodynes, any large X or signal remains in the low-frequency inductances and condensers attached to the rectifier for a sufficient length of time to apply E.M.F.'s to the rectifier throwing it off its rectifying point. Such an effect does not matter with the heterodyne, because with careful choice of rectifier and strength of heterodyne, quite large values of low frequency potential can be applied to the rectifier without in any way impairing its rectifying properties. Those used to working with a valve rectifier fitted with a potentiometer and independent heterodyne will remember that before the heterodyne is switched on the adjustment of the sensitive point for rectification is quite sharp whereas immediately the heterodyne is put into use the potentiometer does not alter signals over quite a long range of adjustment. The property is what I call a floating zero and its effect in reception is the absence of a certain type of "wipe out" which is particularly evident if any attempt be made to tune to a modulated transmitter in the low-frequency circuits of the receiver.

The second effect probably remains as the most valuable of all the heterodyne properties. Copper, iron and dielectric losses are easier to avoid economically on long wavelengths such as those of acoustical—or nearly acoustical—frequency.

It can quite easily be seen by examining the production of a beat tone produced with a damped wave of frequency n_1 and a heterodyne, that the damping of the beat tone frequency n_2 is n_1/n_2 times the damping of the damped wave, and from this it is easy to jump to the result obtained by applying acoustical resonance to the beat circuit on the original high frequency n_1.

A circuit of damping d applied to a beat tone of frequency n_2 is the same from the resonance point of view as applying a circuit of roughly damping $d(n_2/n_1)$ to the original high frequency. The reason such a frequency circuit as the latter is not used is on account of the great difficulty in reducing circuit losses at high frequency. No doubt, finally, this will be done by means of valve reaction, but at present, on account of the fact that reaction is variable with amplitude, the method is not very useful.

In the lower frequency beat tone circuit, however, the problem is simplified by the reduced losses and with the same amount of material a total over-all damping of a comparatively small value can be obtained.

Through all this I assume that such a straight detector characteristic is chosen that the result of signals and heterodyne is $A + B \sin 2nt$ where n is the frequency of the beat tone, and this can be done in practice fairly exactly by using a heterodyne far stronger than the signal or X and a detector characteristic practically straight through any amplitude the signals or X may have.

A secondary advantage of these beat tone circuits is that real intermediate circuits are possible without enormous shielding between primary and tertiary circuits such as is necessary when one is working in high frequency alone.

A point should be noted here, that the beat tone circuit is actually in tune with two wavelengths although only in tune with one note and it is necessary to have an element of high frequency tuning to separate out the one of these two wavelengths required.

Our real limitation is the fact that the Morse turns our line spectrum into a band and renders the finest tuning impossible, difficulties increasing in proportion to the speed of transmission and the wavelength used. When analysed out, no method such as scissors sending will improve the case although some slight improvement would undoubtedly come by using two wavelengths—one for sending dots and the other for dashes—making all the characters an equal length, a system quite easy with the arc or valve, but not very easy with the alternator.

When using the heterodyne without acoustic resonance, the ear does our tuning for us by separating out the musical from the unmusical sounds but it is now being seriously replaced by super-resonance and machine recording. A well-known American wireless expert once expressed the opinion to me that it was a pity our ears could not be put in opposition or cascade as it would render them still more useful.

Owing to the variability of transmitted wavelengths from the alternator on long waves and from arcs on short waves and even with valves on all wavelengths unless fair precautions are taken, we have not yet used to the full extent all the possibilities of the heterodyne method of reception but to the steadiness of good valve circuits on medium powers and wavelengths is due most of the advance that has been made in practice. I attach much more importance to this absolute constancy of wavelength than to almost any other point at the present time and until a new transmitter is invented, which has, whatever its other advantages, a wavelength constancy equal to that which can be given by the valve (although incidentally, it is not always given by the valves one hears), the latter will hold the field.

Until some genuine method is discovered of getting a new character into the signal when we have used our resonance to its practical limits, we have only directional properties to fall back upon, any development of which will probably be up against serious night-time difficulties. In various attempts to give this new property, the question of modulation of the frequency has been seriously considered by us. If the frequency of the transmitted oscillation could be varied at a frequency of the same order as the first frequency or preferably higher—but with an incmomensurable ratio between the two frequencies say by some method of varying inductance or capacity in a valve circuit and a receiver were constructed to receive this, by some method of varying inductance or capacity in the receiver circuit —not quite synchronously, a kind of heterodyne—a further property of signals might be developed.

Such a system seems to have quite new properties, if it could be made practically workable and if any authority could ever be persuaded that it would not jam the rest of the earth's wireless.

To illustrate exactly my meaning, I will state a case in wavelength. The middle wavelength of the system could be 10,000 metres ($f = 30,000$) and this wavelength could be varied from 8,000 to 12,000 metres at a frequency of $\pi \times 10,000$ (the π merely being inserted to render the ratio incommensurable).

If the scheme were carried out correctly, it would not seriously interfere with any sharply-tuned simple harmonic receiver as it would rush so quickly through the wavelength that no effect would be produced. The receiver would, conversely, not be interfered with by any ordinary simple harmonic transmitter. What would happen in the case of impulses? I am inclined to think that the final result of combining this new property with the older sharp-tuning properties would be a still further reduction of X's and I base this on the broad reasoning that as impulses are analysable into a sum of an infinite number of continuous waves of different wavelengths and as the new type of wave is not analysable into any combination of simple harmonic motions, therefore the X's will not get into the new receiving circuits. The limitation again being the length of the Morse characters but of course this question can be put to the test of the mathematician before ever it can reach a practical test.

H. J. ROUND.

Chelmsford,
February 16th, 1921.

DIRECTION FINDING.

To THE EDITOR OF THE "RADIO REVIEW."

SIR,—In the RADIO REVIEW for November, 1920, Major Prince criticised Captain Robinson's article on a "Method of Direction Finding." On page 699 speaking of Captain Robinson's method he says "the real essence of his method is the substitution of switching for rotation and that by the ingenious method of connection, difficulties of phasing are avoided." This statement, and the admission on the same page that there is some basis for the claim that equality of signals is a better subject of observation than the minimum strength, are together an indication of the novelty and utility of the invention. To these can be added the fact, that previous to the introduction of the method, no satisfactory results had ever been obtained in aircraft by any one else.

The rest of Major Prince's *critique* of Captain Robinson's article is interesting, and in some respects even entertaining, but as it is a piece of "special pleading" it need not be taken very seriously. Indeed how can one take seriously such statements as the following (on p. 696, line 25): "Except for secondary considerations (such as convenience; or accuracy) it is immaterial whether observations are made to the maximum or minimum," and on p. 697, line 20, "This constant signal . . . takes no part in helping to determine direction." In the first quotation he says that direction may be obtained by observation of a maximum, in the second that a maximum observation is useless. He cannot have it both ways, and the statement that "convenience and accuracy" are "secondary considerations" is somewhat strange from the only important point of view, namely that of practical navigation. Major Prince notes that in the Handley Page which was entered for the transatlantic flight in 1919, two years after the date of Robinson's patent, a modified Bellini-Tosi system was used with success. He does not mention however that the success of the first transatlantic flight, that of the U.S.A. flying boat N.C. 4, was largely due to the use of Dr. Robinson's apparatus, although in the published description in the *Proc. Inst. Radio Engineers* the invention has been ascribed in error to American officers.

The patents which Major Prince quotes, namely his own of 1912 and Captain Round's of 1909, have no real relation to Robinson's as the bearings given by both of them involve ambiguities far more serious than the 180° ambiguity. Thus in Round's patent, Fig. 1, it is obvious that equality of signals will be obtained not only in both senses of the direction shown in the drawing, but also at the other two intersections of the curves. In Major Prince's patent where the method of reducing signals to equality is employed, it is uncertain whether the angle determined relative, say, to the north-south axis should be east or west of this axis. Major Prince is therefore right in laying no great stress on these patents.

The claim that the Bellini method is "basic" shows some confusion of thought. The single turning coil is basic, as basic as the theory of electromagnetic induction, but the Bellini apparatus was no doubt invented because at that time no detector was sufficiently sensitive to give results on a single coil of manageable dimensions. The Bellini was thus a derived method, depending ultimately on the single coil, but with fixed collectors which allowed of the coil being moved in a stronger field than that of the waves from the transmitter. Mr. Round showed in his paper at the Institution of Electrical Engineers what a formidable train of errors becomes possible on account of these more complicated circuits. Even from the "minimum" point of view the Bellini method is not basic, for the truth is that except, perhaps, when used on a signal of just the right strength in a silent cabinet, the minimum method is a misnomer, and is in reality always carried out by a rough comparison of signal strengths on both sides of the minimum; but as in moving the coil from a comfortably audible signal on one side, to a similar one on the other, the signal passes through a gradation of decreasing and increasing strengths, the comparison can only be a rough one and by no means as accurate as in Robinson's method where the successive signals are of definite strength and without intervening variations.

J. ERSKINE-MURRAY.

Directorate of Research, Air Ministry, London.
February 17th, 1921.

ERRATUM.

Page 152, *line* 22, *for* log ax *read* $\log_e ax$.