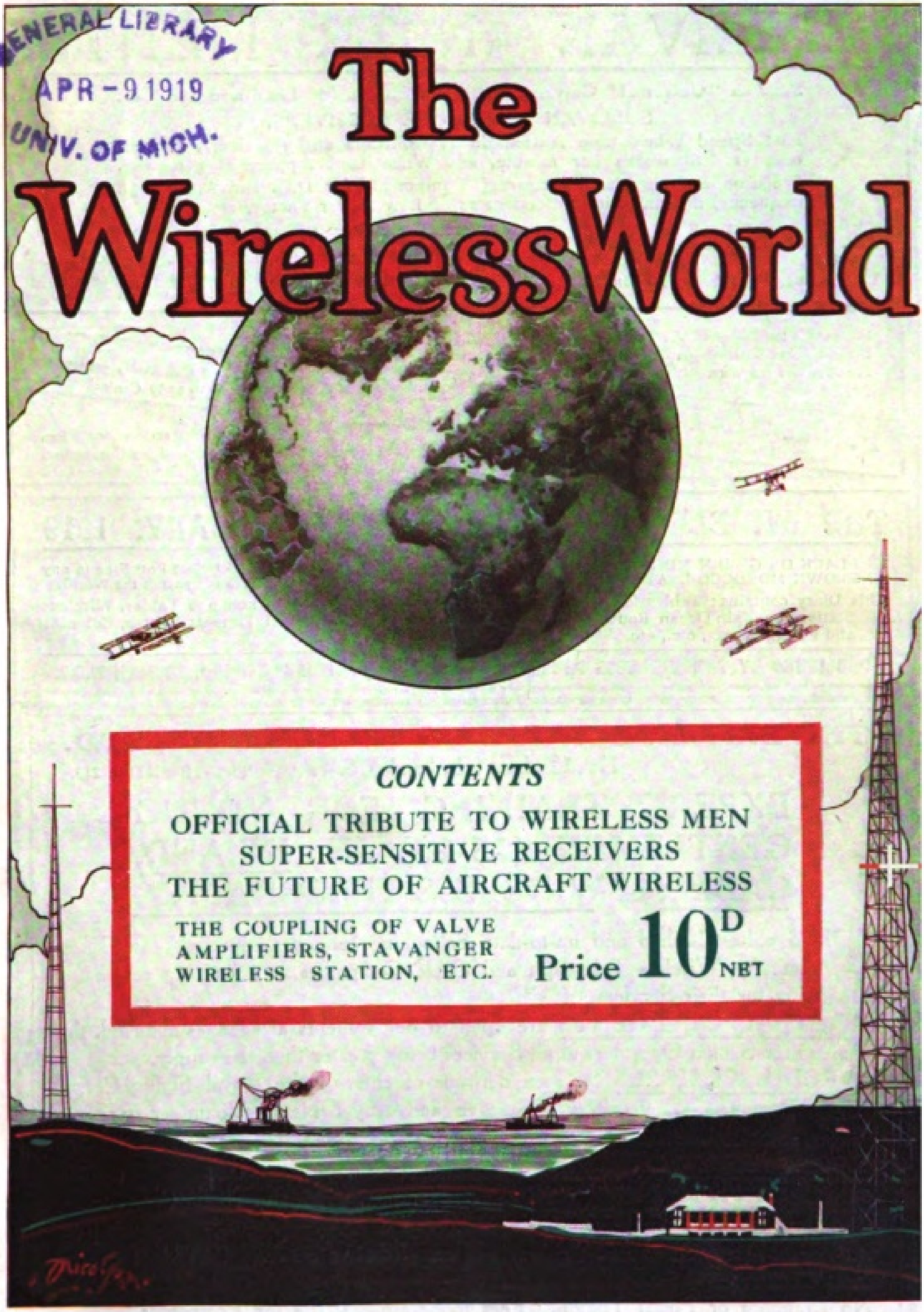
VOL. VI. No. 71. FEBRUARY · 1

The Wireless World



CONTENTS

Price 10^{D} NET

THE WIRELESS WORLD

With which is incorporated "The Marconigraph."

A MAGAZINE DEVOTED TO WIRELESS TELEGRAPHY AND TELEPHONY

Registered at the G.P.O. for transmission by Magazine Post to Canada and Newfoundland.

SUBSCRIPTION RATES.—United Kingdom and British Empire (outside North America), 12s. per annum, post free; United States, Canada, and Newfoundland, $2.00 per annum, post free; and Europe, frs. 15 per annum, post free.

Single copies, 10d. each, or post free 1s. 1d.

Articles submitted for acceptance by the Editor (which will be paid for on publication) should be addressed to Marconi House, Strand, London, W.C. *No responsibility can be taken for MSS. or Photographs sent without stamps to defray cost of return postage.*

Telegraphic Address: "Expanse, Estrand, London." Tel. No.: City 8710 (10 lines).

CONTENTS.

Telephone: 2168 Central

Telegrams: "Britannia, London"

BRITANNIA RUBBER AND KAMPTULICON CO., LTD.

7 NEWGATE ST.
LONDON, E.C.

EBONITE & VULCANITE

TUBES—RODS—SHEETS

WATERPROOF COATS

in great variety for all Climates

MECHANICAL RUBBER MATS — HOSE — TUBES

STEAM JOINTING AND RUBBER COMPOUNDS

DAVIS & TIMMINS,

LIMITED,

KING'S CROSS, LONDON, N.

TRADE DAVIS & TIMMINS LIMITED MARK.

Established 1878.

METAL THREAD SCREWS

Nuts, Bolts, Terminals &c.

Telephone: North 580 (2 lines).
Telegrams: "Conductivity, London."

DEMY 8VO. Bound in best cloth

STANDARD TABLES AND EQUATIONS IN RADIO TELEGRAPHY

By BERTRAM HOYLE, M.Sc. TECH., A.M.I.E.E.

PRICE 9/- NET. Postage 6d. extra

Formulæ, Equations and Tables for use in every branch of Wireless Engineering and Research

Published by THE WIRELESS PRESS, LTD.
MARCONI HOUSE, STRAND, W.C.2

The
WIRELESS WORLD

Volume VI. No. 71. FEBRUARY, 1919.

Great Wireless Stations of the World

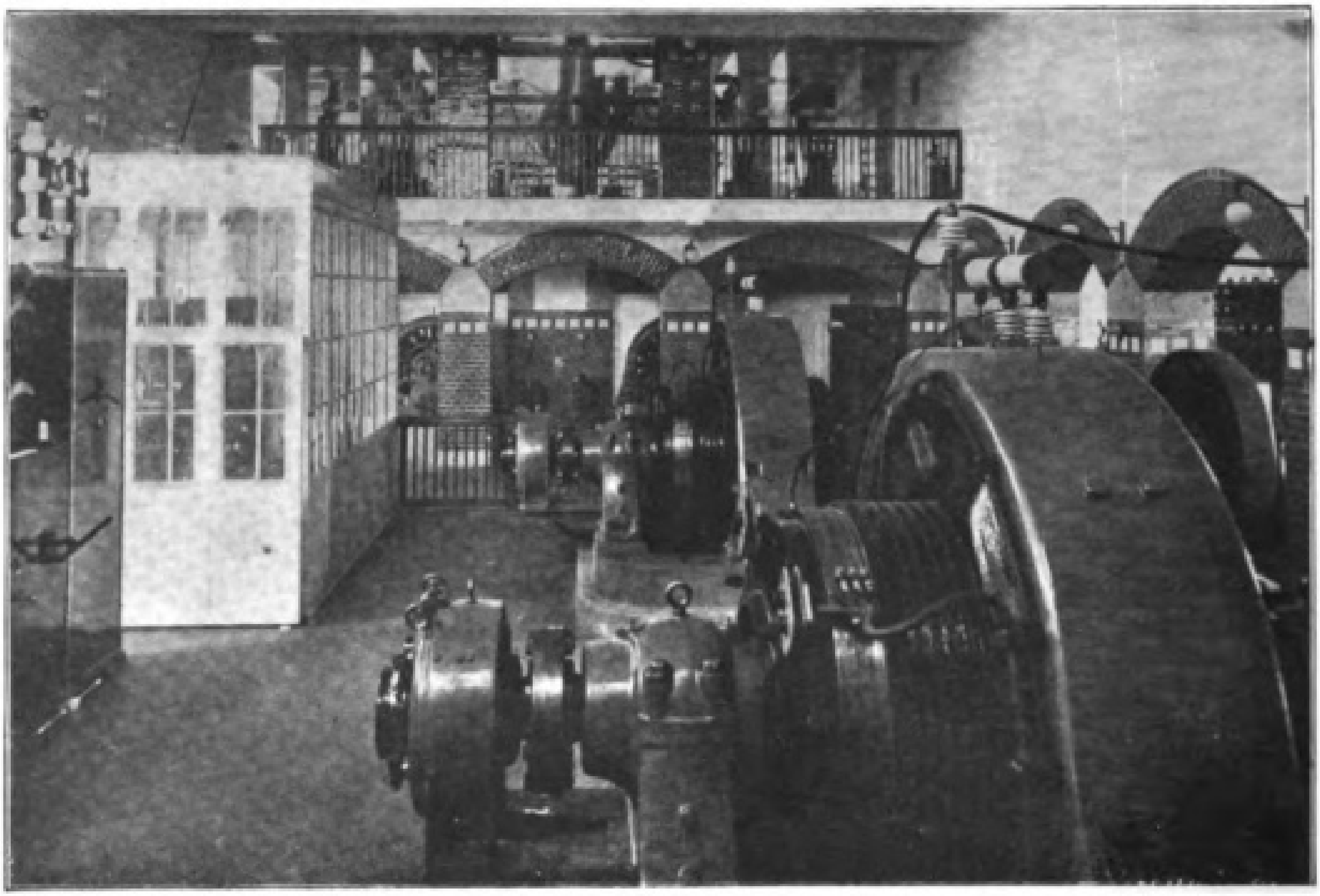
I. Stavanger Radio

By JULIUS GALSTER, Engineer-in-Charge

In Norway the importance of wireless telegraphy was grasped at an early date. The long and dangerous coast line frequented by numerous vessels, the important shipping centres which here find a home, and the hundred and one fishing stations dotted all along the seaboard would otherwise have to rely upon extensive cable connections constantly liable to fracture. As early as 1900 the Norwegian authorities despatched an engineer to London to study the Marconi system, and in 1901 the Norwegian navy made their first experiments. After the first connection had been established between the fishing stations at Sörvaagen and Röst a number of other installations were erected at various points south of the North Cape. The next step was to erect a long-distance station. Matters were arranged between the Marconi Company and the Norwegian authorities in August, 1912, the scheme being ratified in June, 1913.

The Transmitting Station.

The "Timed Spark System" is employed, and the station constitutes one of the most powerful yet erected by the Marconi Company. A 500 h.p. motor drives two 150 k.w. 5,000-volt continuous-current machines, which charge a condenser battery of about two microfarads. This is discharged across the disc. The spark gap is, however, so long that the main spark does not form until a smaller control



A VIEW IN THE MACHINERY HALL. ABOVE, IN THE GALLERY, PORTIONS OF THE TRANSMITTER CAN BE SEEN.

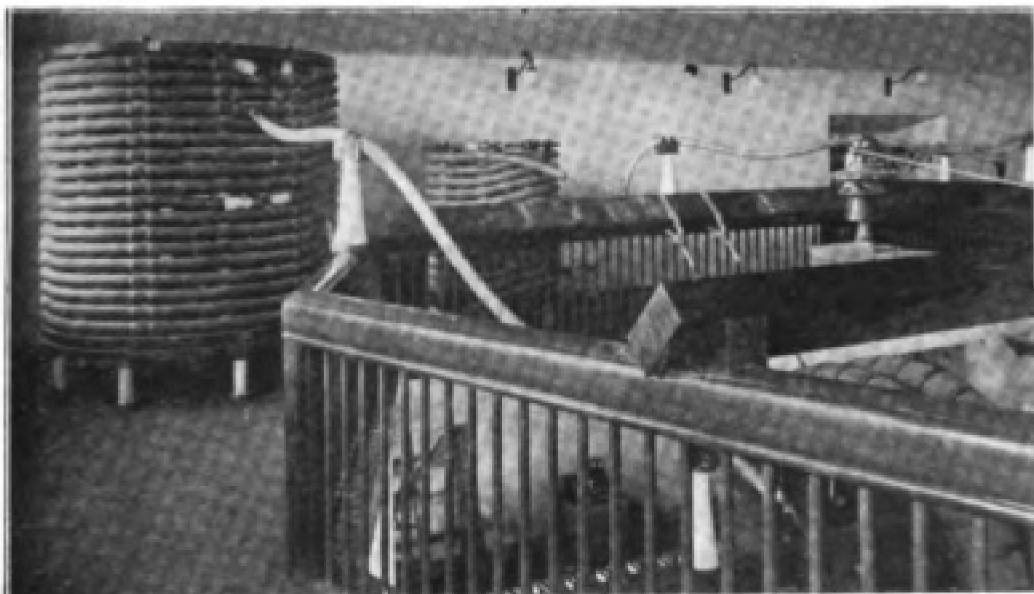
spark has crossed the gap and ionised the air. The oscillations thus induced pass through the jigger primary, from which they are transferred by induction to the jigger secondary, one end of which is connected with the earth, whilst the other passes through the aerial inductance coils to the aerial. The latter is of the inverted L-type and directional, radiating the energy most strongly in the direction of the angular point of the L.

The discharger consists of three large steel discs with copper teeth. One of these discs—known as the trigger disc—does the work of ionising the air in the main spark gap. The other two discs each contain 24 teeth, and are so placed in relation to one another that impulses arise from the oscillations of one before those in the other have died away. These machines rotate with a speed of rather more than 2,000 revolutions per minute.

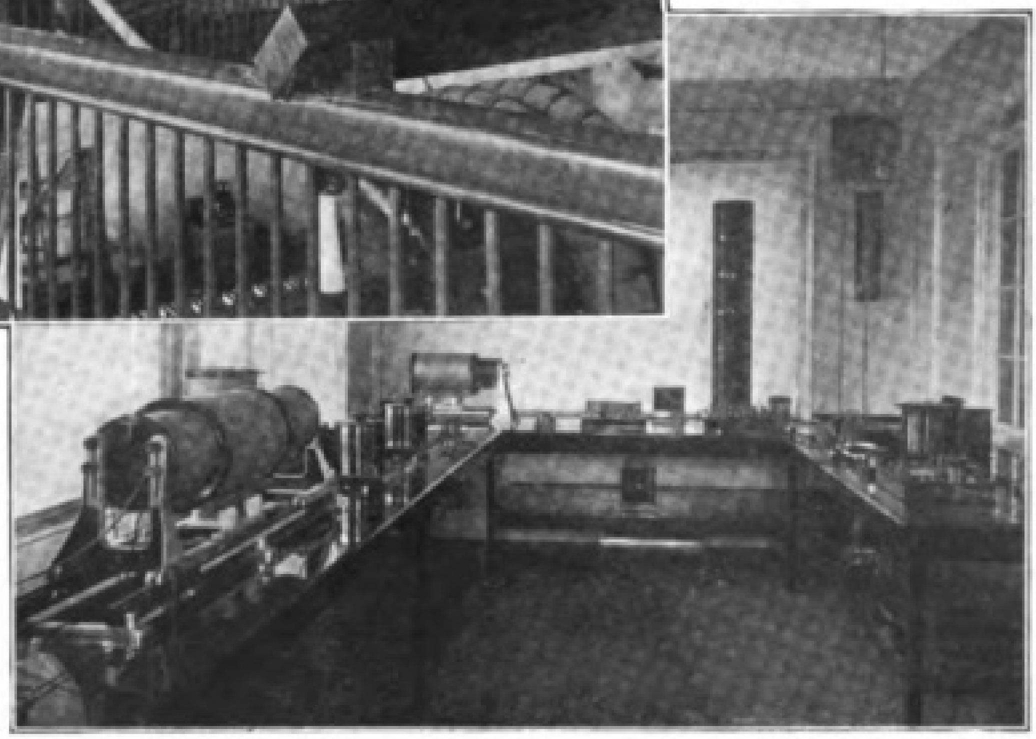
The station is arranged for duplex work—*i.e.*, it can send and receive telegrams simultaneously to and from its linked American station, which is located in the neighbourhood of Boston. This result is attained by the interposition of a considerable distance between the receiving and transmitting aerials combined with a differentiation in wave-length. The receiving station has been placed at Naerland, about 16 miles south of the transmitting apparatus, which is located just outside Stavanger. The wave-length on which messages are received from Boston is 50,000 ft., whilst that employed for radiation by Stavanger is 30,000 ft.

The transmitting station lies on a heathery moor that slopes towards the historic Hafrsfjord. The area covered is approximately 1,320 yards long by 330 yards wide; so that it can easily be understood that the task of erection presented a formidable problem. Before being able to make any headway it was found necessary to lay down roads and erect a small quay on the margin of the fjord. By August, 1913, work had progressed far enough to allow of the transport of sand and shingle to the destined site of the masts, and the foundations were duly laid. By the new year the operation of erecting the ten 400-ft. masts was proceeded with. They were arranged in two rows of four. At the further extremities, where these masts are exposed to increased strain on account of the aerial's downward slope, a middle mast was intercalated. The aerial supports are of tubular construction, built in sections of semicircular rolled plates $\frac{3}{8}$ in. thick, bolted together. They are calculated to be able to stand a top strain of 2 tons and a wind pressure of 30 lb. per square foot. The masts, which are of the well-known Marconi tubular steel variety, were erected on their bases, thus obviating the difficulties of hauling into place so tall a structure.

The masts are stayed to four large bases with six sets of stays composed of 3-in. wire. Each stay is divided into several sections by insulators. These came from England already fastened together, so that it was only necessary to insert the last splice on the spot. These insulated stays are tested for a pull of 13 tons. Large 2-in. rigging screws secure them to the foundation irons. Between each pair



ABOVE.—THE AERIAL TUNING INDUCTANCE AND AERIAL LEAD-IN.



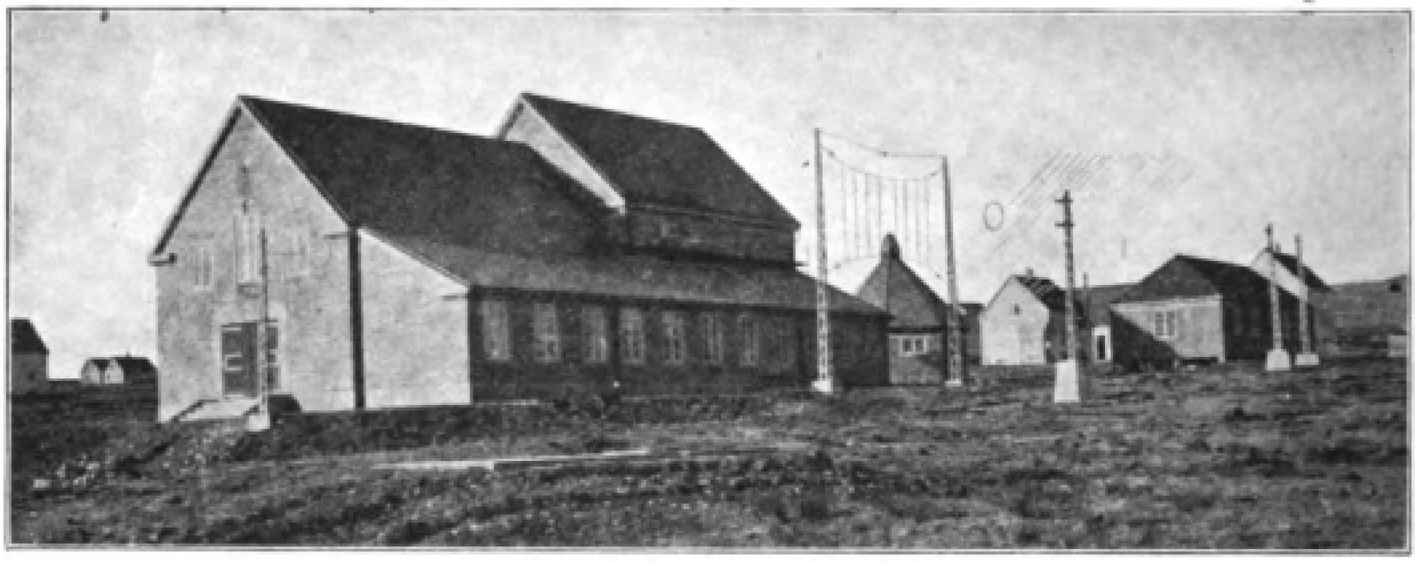
BELOW.—THE RECEIVING ROOM. THE TALL OBJECT IN THE BACKGROUND IS A LARGE INDUCTANCE FOR RECEIVING LONG WAVES.

of masts stretches a $1\frac{1}{2}$-in. steel wire supporting the aerial. Each aerial wire is 400 ft. long, and is made of silicon-bronze. The aerial is separated from the supporting wires by insulators a yard in length.

Earth connection plays an important part in the effectiveness of every station, and the earth-net therefore received careful attention. It consists of an outer and an inner ring of galvanised iron plates, well buried in the earth and connected together with copper wire. From the outer ring of these plates a number of copper wires are led under the mast for the whole length of the site.

The station building, 30 yards by 16, is constructed of granite blocks. This was already completed before the outbreak of war.

For the transmitting work of the station a power of 400 k.w. is required. This is derived from the Stavanger Electric Station, which delivers a current of 5,200 volts through a direct line carried overhead for the first part of its journey and

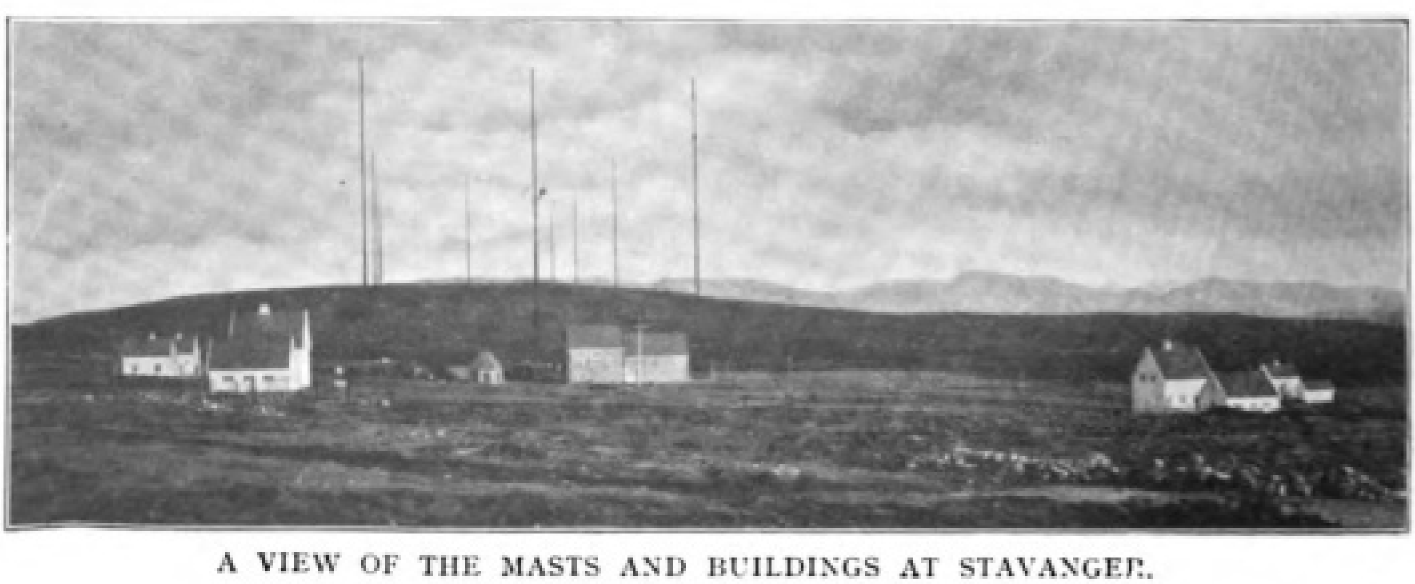


THE TRANSMITTER HOUSE AT STAVANGER, SHOWING THE AERIAL LEAD-IN.

during the last mile by underground cable. In the transformer house of the radio station this voltage is converted to 440, and the current is then transferred to the low-tension switchboard in the station building. A 500 h.p. synchronous motor drives two 150 k.w. high-tension continuous-current dynamos. The high-tension machines are placed on insulated foundations, the dynamos being furnished with separate exciter machines.

The discharger, to which we have referred already, is driven by a continuous-current motor, supplied by a special motor generator. On the second storey stands the condenser battery, which consists of about 200 condensers connected partly in parallel and partly in series, each condenser being made up of square zinc sheets separated by glass plates, all of which are contained in porcelain tanks filled with oil.

The jigger primary is built up of stranded wires, which are wound in spirals over a cylindrical wooden former. Into this former the jigger secondary can be shifted so that the coupling between the closed and open circuits can be changed. Between the aerial lead-in and the jigger secondary are located different coils utilised for varying the wave-lengths. To prevent the formation of an arc air is blown into the spark gap. This air is introduced at a pressure of 40lb. As the disc room becomes heated it is necessary to use fans for the renewal of the air. The high-tension key is placed in the trigger circuit and is manipulated from the receiving station, which is connected through a double line with a relay at the transmitting station. The high-tension key itself breaks a current of 5,000 volts, at the approximate rate of 2,000 times per minute when automatic transmission is being



A VIEW OF THE MASTS AND BUILDINGS AT STAVANGER.

used at the speed of 100 words per minute. Compressed air has also to be used here in order to prevent the formation of an arc.

THE RECEIVING STATION.

Here the masts are placed in one row and only 300 ft. high. The aerial consists of two wires 8,500 ft. long. The earth-net is also smaller than that of the receiving station. The receiving apparatus constitutes an excellent specimen of the latest type of Marconi instruments for long-distance reception. Hand-sending is dealt with in the ordinary auricular fashion; but when automatic sending is being dealt with the speed becomes too much for ear and hand, and phonograph records are here utilised. These are subsequently taken over and set on machines running at a slow speed, so as to enable the operator to interpret the signals. A detailed description of the receiving apparatus is impossible here. It is only necessary to remark that the work is carried on with the highest efficiency, and that signals from America are, by the utilisation of the latest magnifier, brought to such a degree of strength that it is almost impossible to keep the telephone to one's ear.

Though there is a great difference between the length of receiving and transmitting waves, it was found advisable to make special provision against possible interference by the neighbouring transmitting station. This is effected by the balancing aerial, which consists of wire carried by seventeen 100-ft. wooden masts. By a simple coupling between coils, combining signals from both aerials, it is possible to cut out any interference.

In view of the permanent character of this station the Norwegian authorities have taken care to provide for the comfort of their operators. The buildings have been specially designed for this purpose, and the staff owe much to the care with which the Telegraph Director, Mr. Heftye, has bestowed upon this side of the matter.

The provisional tests were made in March and April of this year, but in view of the taking over by the Federal authorities of all wireless in the U.S.A., the Boston station has not been able to start its commercial intercourse with Norway, and we are still awaiting the time when we may expect a vast influx of traffic, so desirable from the point of view of international commercial intercourse.

SOLIDITY OF CONSTRUCTION AND ÆSTHETIC CONSIDERATIONS HAVE NOT BEEN OVERLOOKED IN THE PLANNING OF THE STATION.

PERSONALITIES IN THE WIRELESS WORLD

COMMANDER B. L. GOTTWALDT

THE modern capital of Norway, Christiania, was the place of birth of Commander B. L. Gottwaldt, who first saw the light there in 1880. At the age of eighteen he entered the Naval Academy of his native country and, after passing through a brilliant career at that establishment, graduated as Sub-Lieutenant three year later. Between the years 1901 and 1904 he attended the Military Academy of the Royal Navy, and subsequently went through courses at the well-known Technical College in Charlottenburg, Berlin. At the latter institution he devoted his activities to specialising in the study of electrical engineering, telephony, and telegraphy (both wired and wireless). An intense interest in radiotelegraphy had been excited in his mind during the course of his service as a Naval Officer aboard Norwegian warships, whereon wireless had been installed for experimental purposes during the early years of the present century. It was in consequence of the enthusiasm thus awakened that he devoted much attention to the science of ether waves. In the course of 1906 Lieut. Gottwaldt was despatched to England on behalf of the Norwegian Admiralty, in order to co-operate in some special work with Messrs. Armstrong, Whitworth & Co., Newcastle-on-Tyne. Upon his return to his native land he was allotted the task of controlling wireless telegraphy in the Royal Norwegian Navy, a position which he has filled with much distinction ever since. Gazetted as Commander in 1912, he has on a number of occasions been entrusted with the control and testing of wireless apparatus ordered in England and in Germany by the Norwegian Navy. He represented his motherland as one of her delegates at the International Radio Conference held in London in July, 1912.

Towards the close of 1918 Commander Gottwaldt received permission from his official chiefs to take part in the newly instituted Norwegian Wireless Company, " The Norsk Marconi Kompani," of Christiania. He is acting as the Technical Manager of this firm, which is destined to play a most important part in the development of wireless in Norway, especially in the direction of manufacturing wireless apparatus, based upon the Marconi system. He has been a considerable contributor to technical journals on his special subject, more particularly favouring the *Naval Gazette* in this respect. He is, moreover, the author of three separate volumes treating of wireless.

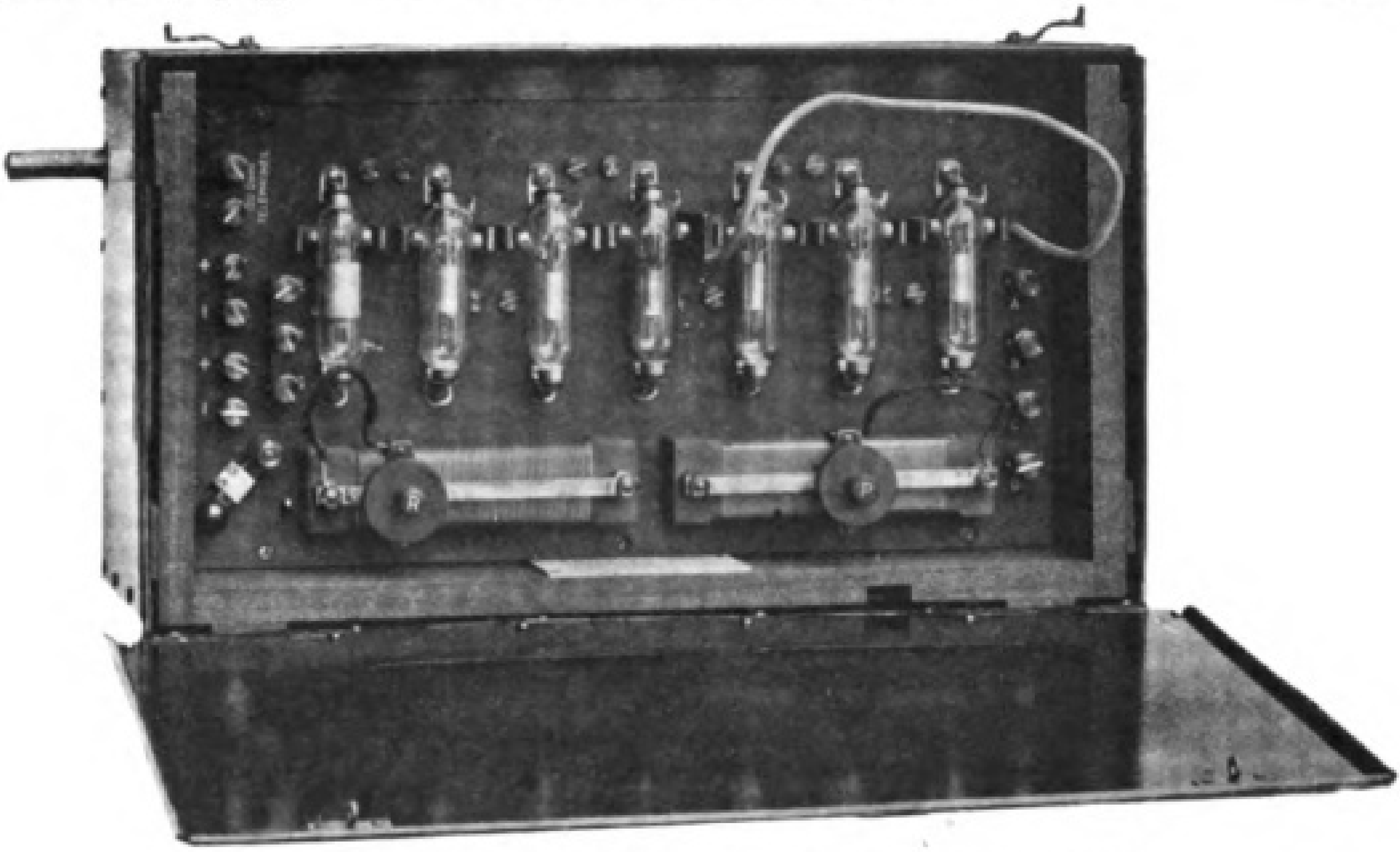
Super-Sensitive Receivers

Some War-Time Developments Revealed

THE series of articles on valves and valve circuits which has been running practically continuously in this magazine for many months has enabled our readers to realise to some extent the enormous developments which have lately taken place in the art of receiving wireless signals. Until now the heavy hand of censorship has been laid upon our magazine to an extent which only those in intimate contact with the subject can realise, and as a consequence, while we have been able to publish much useful information of a theoretical nature, the actual instruments which have been evolved have remained hidden from the public view.

This month we are able to publish the first photographs of two receivers evolved by the Marconi Company during the war and used extensively in practically every phase of wireless working. They are known respectively as Types 50 and 55. Type 50 is a four-valve fixed-wavelength amplifier and detector. It is used in conjunction with the usual tuners and may be substituted for the crystal detector. It consists, as will be seen from the photograph, of a teak box containing an ebonite panel on which are mounted four small valves, a series resistance and a potentiometer. The valves are of two types, the first three (from the left) being used for high-frequency amplification and the fourth (on the right) as a detector and rectifier. The valves for high-frequency amplification are of a type known as

MARCONI VALVE AMPLIFIER AND DETECTOR, TYPE 50.



MARCONI VALVE AMPLIFIER AND DETECTOR, TYPE 55.

" V.24 " and differ somewhat in construction from the " Q " type valve used as the detector. In a future article we shall deal in detail with these two types of valve, but for the moment we may say that the plates and grids are differently constructed.

The series resistance inside the box controls the brilliancy of the filaments in the amplifying valves, while the potentiometer is connected to the three grid circuits. On top of the box are mounted a series resistance and potentiometer for controlling the " Q " type or rectifying valve.

It will come as news to many of our readers who are under the impression that highly sensitive valve receivers use very high voltage batteries to learn that in these modern receivers the high tension battery in the plate circuit is of only 24 volts. This battery is connected to the positive and negative terminals on the right hand side of the detecting valve. 60 ohm telephones are connected to the pair of terminals just below. On the left hand side of the box four other terminals will be seen, the upper two being connected to the tuner and the lower to the six-volt battery for lighting the filament. The switch seen on the outside of the case serves to switch the batteries on and off.

The particular receiver illustrated in our photograph is wound for a wavelength of 600 metres, this being the wavelength on which it is most sensitive. It may, however, be wound for other wavelengths. Whilst its construction is such that a 600 metre wave gives the best results, wavelengths not greatly differing from this figure may be received almost equally well, but too great a deviation from this figure brings about a considerable reduction in sensitiveness. The reasons for this, together with many other interesting facts on this and similar receivers, will be dealt with in a further article at a later date.

The practical wireless man will immediately be struck by the extreme simplicity of this piece of apparatus, which is designed to contain a minimum of adjustments. Beyond an occasional adjustment of the series resistance and potentiometers so as to obtain the maximum sensitiveness, this device requires no attention whatever. In this it is in marked contrast with earlier amplifying receivers containing several adjustments for different magnifications and delicately tuned resonant connections between each circuit.

Another amplifying and detecting device designed particularly to fill the need for a robust and highly sensitive amplifier and detector adaptable without change to a wide range of wavelengths is that depicted in our second photograph. This instrument, which, as will be seen, contains seven valves, is of different construction internally, but is marked by the same main characteristics and ease of adjustment. In this case the first six valves from the right are of the "V.24" type mentioned above, the seventh being a "Q" type valve used for rectifying and detecting. The series resistance and potentiometer shown below the valves are used as before. The two upper terminals on the right hand side of the panel are connected to the tuner, while the three pairs of terminals on the right hand side are connected to the telephones (120 ohm), a 50-volt high tension battery and a six-volt filament battery respectively. It should be mentioned here that although a 50-volt battery is used the voltage impressed upon the plate circuit is no higher than that used in the type 50 receiver already described, the reason for the higher voltage being the higher resistance of certain windings used.

This seven-valve type is shown mounted in a black enamelled box which acts as a screening device. The two slits in the lid of the box enable the resistance and potentiometer to be altered while the box is closed.

Some idea of the super-sensitive character of these receivers may be judged from the fact that connected to a coil of a few turns of insulated wire wound on a former a couple of feet square and without any aerial or earth connection they are able to yield loud signals from ordinary ship installations 200 or 300 miles away. In addition, the signals yielded by the last valve may be magnified still further on a note-magnifying device similar to that referred to in THE WIRELESS WORLD for July, page 224; or, again, two of these amplifiers may be used in series by disconnecting the first detecting "Q" valve and thus placing six or twelve high-frequency amplifying valves in series with a detecting valve.

To Our Readers

Editorial Announcement concerning the New Volume

OUR April issue will start the seventh annual volume of THE WIRELESS WORLD, and the new conditions brought about by the cessation of hostilities will enable us to make a number of important improvements.

Amongst other innovations will be found a series of articles dealing with wireless in its connection with aviation, while a new series of instructional articles will make their first appearance.

Simultaneously we shall *reduce the price of our magazine to NINEPENCE*, thus redeeming our promise to withdraw the higher price at the earliest possible moment. In this reduction we believe we may claim priority over all other magazines. We shall make further reductions just as soon as opportunity offers, and it is perfectly obvious that readers can be of material assistance in hastening this much desired consummation by continuing their support and assisting us to extend the circulation of the magazine.

Digest of Wireless Literature

"EFFECTS OF DIELECTRIC ON THE SPARKING VOLTAGE."*

IT is a well-known fact that the usual arrangement employed for the precipitation of fumes or gases consists of a comparatively thin wire placed inside a large pipe along its axis. The wire is maintained at a high negative potential, while the pipe is grounded. When the gases are passed through the pipe the dust contained in them gets repelled from the wire and covers the inner walls of the pipe.

It has been noticed that, in the case of non-conducting fumes, the efficiency of the plant fell off as soon as a sufficient layer of dust was deposited on the collecting electrode. The initial efficiency could be restored by moistening the deposit.

In order to ascertain the nature of the above phenomena, the author carried out a series of experiments, a short account of which is given below.

Instead of a wire and a pipe, a point and a grounded plate, of dimensions sufficiently large to prevent arcing to its edge, were employed. The potential was in each case raised gradually until a discharge occurred. The corresponding voltage was measured by a sphere-gap meter, introduced in parallel to point and plate.

First of all, the influence of the polarity of the point was studied. It was found that with the point negative the arcing voltage was about 2½ times larger than the one observed when the point was made positive. This property was utilised by the author for constructing a H.T. A.C. rectifier.

In the next place, various dielectrics were placed on the grounded plate. When the point was maintained at a negative potential the following arcing voltages were observed :—

No dielectric on the plate	120	K.V.
Mica on the plate	50	,,
Sulphur on the plate	50	,,
Glass wool on the plate	50	,,
Filter paper on the plate	90	,,
Varnished cambric on the plate	70	,,
Asbestos on the plate	100	,,
Edge of glass plate underneath the point	65	,,
Writing paper on the plate	118	,,
Writing paper crumpled	90	,,

It will be seen that the voltage depends not only on the substance of the dielectric, but also on the state of its surface. This is brought out very clearly in the last two cases.

The same effect could be obtained by providing the sheet of paper with a hole, instead of crumpling it.

Another series of experiments have shown that when means were provided for conducting away the charge of the dielectric (by moistening in the case of sulphur, or by covering with a grounded metallic screen in the case of mica), no lowering of

---

* By E. R. Wolcott, *Physical Review*, Second Series, Vol. xii., p. 284 (October, 1918).

the arcing voltage could be observed. This seems to indicate that the effect is due to a charge accumulated in the dielectric. The existence of such a charge could be demonstrated by long sparks obtained from the mica, after removing it from the plate or while on it.

From the experiments described above, the author arrives at the following explanation, which we can do no better than quote in his own words: "From these data it appears that a dielectric placed on the grounded plate of a point-to-plate unidirectional discharger, the point being negative, accumulates a charge, the potential of which may be sufficient to ionise the surrounding gas, producing a glow typical of the positive discharge. This glow, being a much better conductor of electricity than other portions of the gas, decreases the total resistance between the two electrodes and lowers the voltage necessary to produce a disruptive discharge."

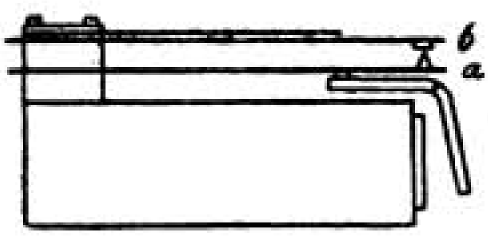
In conclusion, the author draws attention again to the importance of the dielectric having a more or less discontinuous surface. This discontinuity can be effected by roughening the surface, provided the sheet of dielectric is thin enough to be punctured by the discharge.

On Contacts.*

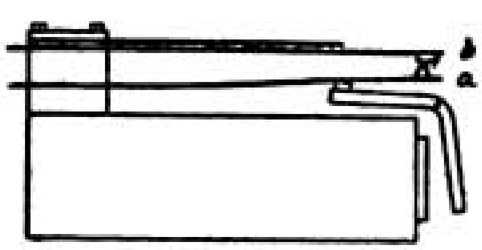
The troubles one experiences in employing relays arise mainly in connection with the contacts. The causes of bad contacts can be divided into three classes:

1. Dirt or dust accumulating on the contacts.
2. The burning away of the contacts.
3. The sticking together of the contacts.

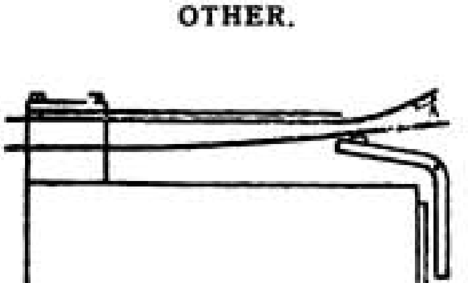
As to the first cause, it can be removed by frequent cleaning and also by making the lower contact in the form of a sharp cone (see Fig.). The second cause involves the elimination of sparking. This can be done, if all conditions (*i.e.*, current, voltage and number of breaks) remain constant, by introducing in shunt to the spark gap, judiciously chosen capacities and resistances. Under variable conditions, however, the contacts will gradually burn away and one must carefully watch them.



A. RELAY AT REST.



B. CONTACTS TOUCH EACH OTHER.



C. ARMATURE FULLY ATTRACTED.

As to the sticking of the contacts, this arises in the following manner: Owing to the spark, which occurs at the moment of breaking, a very fine point is formed on one of the contacts. When the contacts next come together again, a great quantity of heat is developed at the sharp point, and welding takes place. There is not any certain method for removing radically this source of trouble. It can, however, be considerably reduced by arranging the contacts in such a way that one of them should scrape the surface of the other during the period of closure. Such an arrangement is shown on the figure, which does not want any further explanations.

The author gives next an account of his attempts to substitute the generally employed platinum by some other material. Extensive experiments with tungsten gave very satisfactory results. The author introduced tungsten contacts

* "Neurungen an Kontakten und Kontaktmaterial." By H. Fleischbein, *Elektrotechnische Zeitschrift*, No. 45, p. 415 (November 7th, 1918).

on relays which had to work all day, and where a high degree of reliability was required. The current flowing through the contacts varied from ·5 to 10 amps. The number of interruptions was up to 20 per second. After six months' working no traces of oxydising could be detected.

At first some difficulties were experienced in the welding on of the tungsten. Later on, however, a method was devised (point-to-point welding by means of an arc in an atmosphere of hydrogen) which set the manufacture on a quite commercial basis. The author thinks that, even after the war, when there will be no special difficulty in getting platinum, tungsten will yet be retained as a material for contacts, owing to its advantages in many respects.

"A New Standard of Current and Potential."*

The author describes a new and simple apparatus, which is intended to replace the standard cells in certain classes of measurements.

The idea of the new standard can be seen from Fig. 1, in which the resistances A, C and D form three arms of an ordinary Wheatstone bridge. The fourth arm, B, is formed by a platinum wire (about ·005 mm. in diameter and from 1 to 3 cms. in length) placed in an evacuated vessel (the pressure being from 10^{-4} to 10^{-5} mm. of mercury). Now, the resistance of our wire will depend on its temperature, or, in other words, on the current passing through it. It follows, therefore, that the galvanometer will give a zero reading only for a quite definite value of the current flowing through the filament. Assuming, for instance, that resistances C and D are equal, we must also have resistances of B and A equal, and this will occur only for one single value of the current passing through B, as can be seen from Fig. 2, where the relations involved are represented graphically.

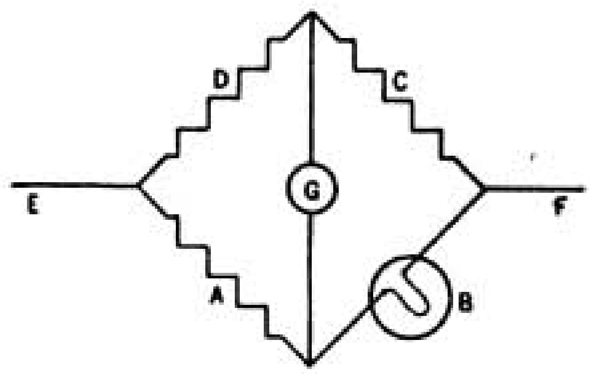


FIG. 1.

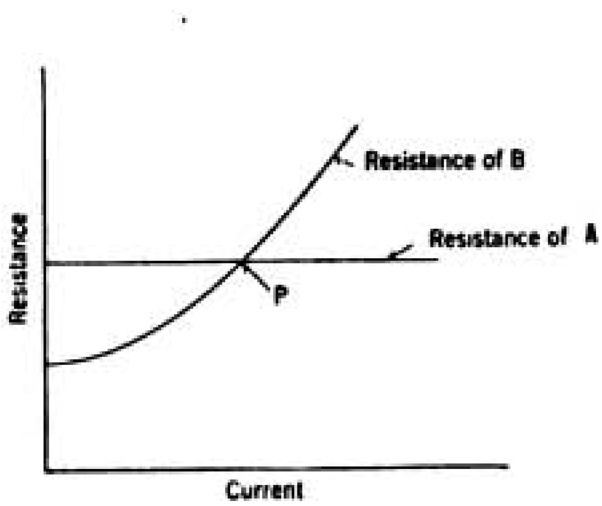


FIG. 2.

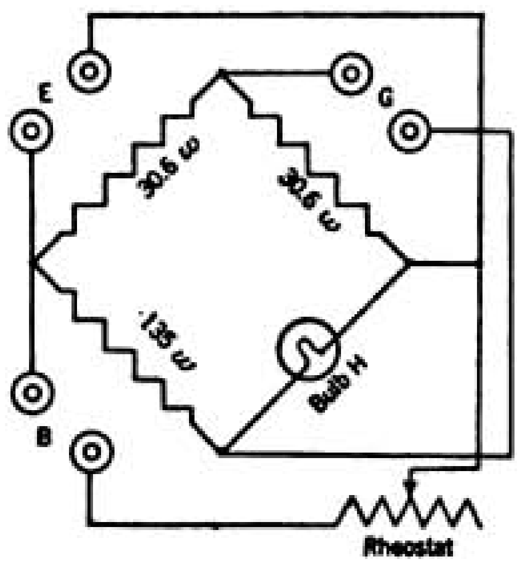


FIG. 3.

It is evident that with a resistance of this type the question of constancy over a long period is of very great importance. This was successfully attained by subjecting the filament to an "ageing process," which consisted in passing through the filament a current sufficient to heat it to a bright red glow, for 24 hours.

* By C. T. Allcutt, *Proceedings of the Institution of Electrical Engineers*, Vol. xxxvii., p. 83.

Tests made with an "aged" filament have shown that the functional relation between its resistance and the current remains constant. The change in resistance due to evaporation is perfectly negligible if the filament is operated below red heat.

As to the influence of external temperature, it has been found that variations, which may be expected under ordinary circumstances, affect the resistance of the filament in a very small degree indeed.

Fig. 3 gives the diagram of connections taken from an actually built device, a view of which is shown in Fig. 4. The terminals *B* are connected to a dry cell, while the galvo is introduced between the terminals *G*. When the rheostat has been adjusted until the galvanometer gives no deflection there will be one volt between the terminals *E*.

The author states in conclusion that the standard "may be relied upon to maintain an accuracy of ·1 per cent."

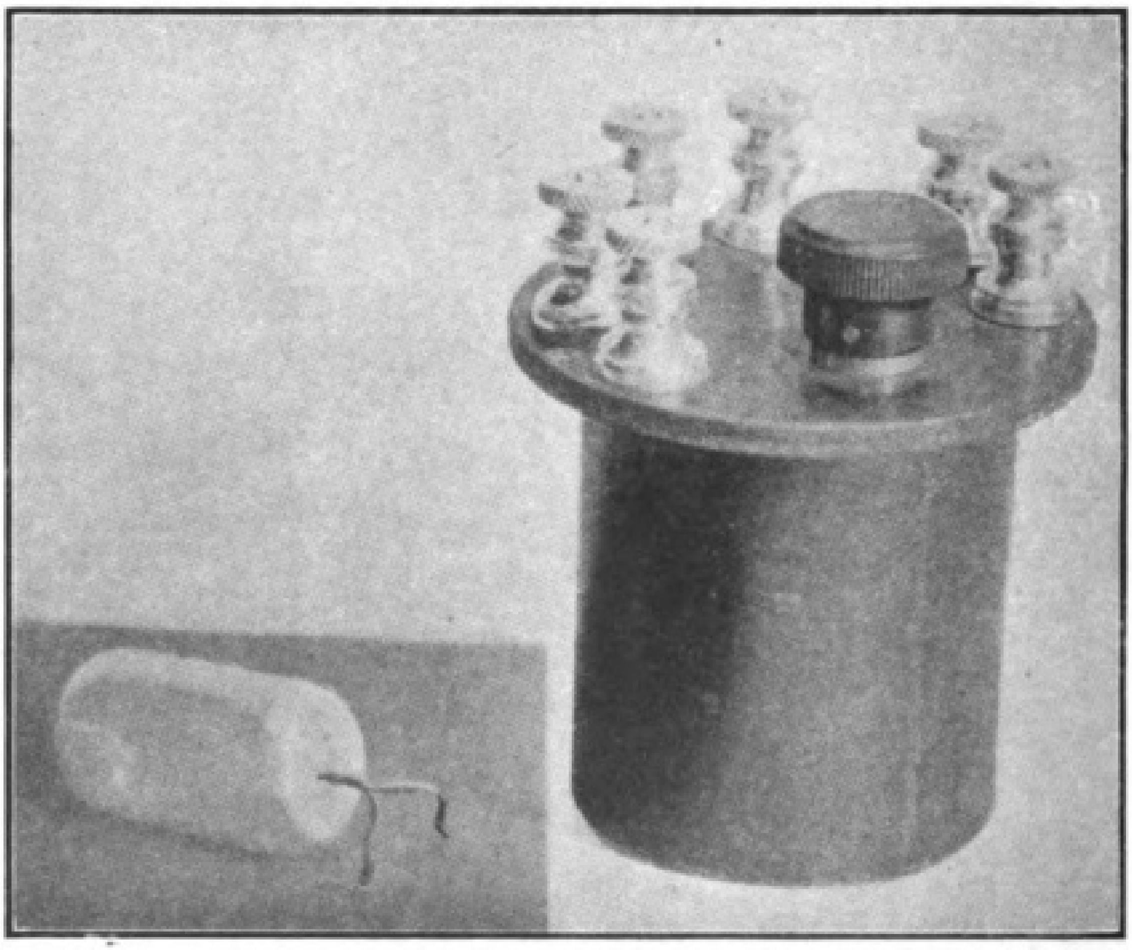


FIG. 4.

FREQUENCY CONTROL

IN an article published in the November issue of *The General Electric Review*, entitled "Better Frequency Control," Mr. Henry E. Warren discusses the Warren method, for which he claims many advantages.

In cases where it is necessary to maintain the frequency of an alternating current system at a definite value, the method hitherto adopted has been that of employing a frequency meter, the readings of which must be constantly noted by an attendant, who makes the necessary adjustment as the frequency due to changes of load deviates from the normal.

Frequency meters indicate instantaneous values, and hence it often happens that before the operator has time to readjust the machine to changed conditions, which incidentally may be momentary, another adjustment becomes necessary.

With the new method frequent and often unnecessary adjustments are avoided, the device described indicating the average value of the frequency. In this way it is only necessary for the operator to make adjustments at such times as the average value alters.

A short survey is made of the disadvantages and errors introduced by the use of indicating frequency meters, amongst which are enumerated: (1) the errors introduced by adjustments made from momentary observations and the necessity for frequent attention on the part of the operator in order to ensure tolerably accurate results from this method; (2) errors of significant value introduced through the calibration, the effect of time, depreciation and changes of temperature; the departures from the average frequency are estimated by Mr. Warren to be as high as one and two per cent. at large power stations using the frequency meter method of control; (3) errors due to the difficulty experienced in taking precise readings and the limited size of the scale graduations.

In general the new method conveniently and accurately compares the number of completed alternations with elapsed time, being practically insensitive to the instantaneous value.

The instrument itself consists of a complete pendulum clock with two dials, the lower dial serving the usual purpose of recording the time of day, whilst the upper dial, which is of larger diameter, has two hands, one black and the other gold-coloured. The black hand is revolved once in five minutes by the clock mechanism, whilst the gold-coloured hand is independently revolved through gearing by a small self-starting synchronous motor supplied by a transformer from the alternating current system. The gearing between the gold hand and its motor must be such that at the normal frequency of the A.C. system, on which it is operated, the gold hand is revolved at the same speed as the black hand. Special features of the clock mechanism are novel regulating arrangements and absence of error due to changes of temperature.

In order to operate this instrument the black and gold hands are set over one another, and the operator is instructed to correct the speed of the turbines if the gold hand gains or loses with respect to the black hand.

Inasmuch as this system only responds to sustained changes in frequency, adjustments are made by the operator, only at such times as a change in the average value is indicated by the device. Thus much labour is saved, and by its simplicity of construction instrumental errors are reduced.

Sketching past performances of this instrument, the author states that it has been in constant operation for 24 hours per day at the works of the Boston Edison Company without repairs of any kind since October, 1916, and he calculates that the improvement in their frequency regulation is such that no change in frequency can be shown when readings taken with the Warren method are plotted on the same scale as readings taken with the frequency meter method.

Mercantile Marine Uniforms

THE Board of Trade have made arrangements with the Admiralty for the inclusion of uniforms for officers of the Mercantile Marine in the Admiralty scheme of control for the provision of naval officers' uniforms. Tailors and outfitters on the Admiralty list will be notified by the Admiralty that Mercantile Marine officers' uniforms may be made from the P.N. cloths at the prices already arranged for naval officers' uniforms which are made from P.N. cloths. Tailors and outfitters who have regularly made Mercantile Marine officers' uniforms in the past, but who are not already on the Admiralty list and who desire to be included, should make application to the Director of Contracts, Admiralty, London, S.W.1, direct.

Submarines and their Wireless

Some Personal Experiences of a Radio Engineer

By S. C. ANSELMI

(Continued from page 553 of our January issue.)

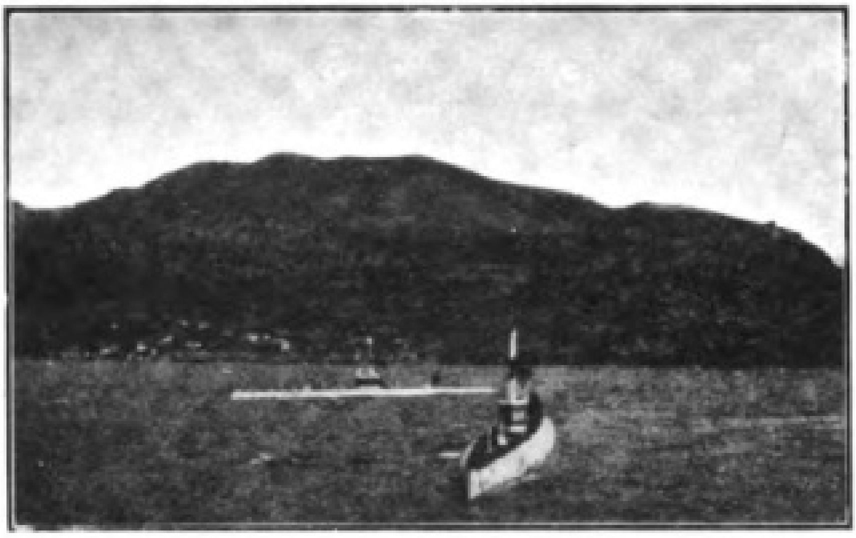
During hostilities, in order to avoid the danger of being attacked by Allied vessels, the Spanish Government painted their submarines a bright white colour, encircling the conning towers with bands of red and yellow, the national colours of Spain. This precaution deprived their vessels of much of their warlike appearance. When the submarines went out for a short cruise or diving practice, they were escorted by a surface vessel. The wisdom of this precaution will be seen from the following incident. One day the crew of A2 returned to Cartagena in a state of high excitement, and the town was speedily filled with wild rumours of an attack having been made on this Spanish submarine by a cargo boat. What actually occurred I learned from one of the officers. It appears that on the way back from a bay frequently used for diving practice, just as they doubled one of the small promontories which abound on this coast, they came within the close proximity of an 8,000-ton Italian steamer seeking the protection afforded by Spanish territorial waters. The Italian, believing the Spanish craft to be a Hun in disguise, and knowing the little regard these pirates pay to International Law, immediately trained their big gun upon the vessel, and would have opened fire had not the escorting torpedo-boat come in sight with the Spanish flag waving from its after-mast.

VIEW OF DECK AND CONNING TOWER LOOKING FORWARD. THE TELEPHONIC BUOY APPEARS IN THE FOREGROUND.

An interesting life-saving appliance is carried on each of the craft. This consists of a buoy placed on deck, the interior of which is fitted with a telephone transmitter and receiver. The position in which the buoy is fixed will be seen, from the accompanying illustration, to be close at the foot of the conning tower. Should any accident happen, so that the submarine could not rise from the watery depths, this buoy can be released, and any ship that came along could read the following appeal imprinted on a large brass plate carried on the cover of the float :

ATTENTION—TELEPHONIC BUOY—SUBMARINE . . . —DO NOT FIRE AT BUOY: OPEN THE LID—FOLLOW INSTRUCTIONS ENCLOSED.

Two additional buoys are placed at each extremity of the vessel. These, which are capable of being released from the inside, carry a hemp rope, many fathoms long, reeved through two large lifting-eyes fixed on the boat's deck. They are intended for the use (in case of disaster) of a submarine salvage ship, which would reeve a strong steel chain through the lifting-eye of the submarine by means of these two hemp ropes. In addition to these devices the keel of the submarine, which weighs about nine tons, may be released, in order to assist the vessel to rise.



A2 AND A3 AT ANCHOR IN THE BAY OF MAZARRON.

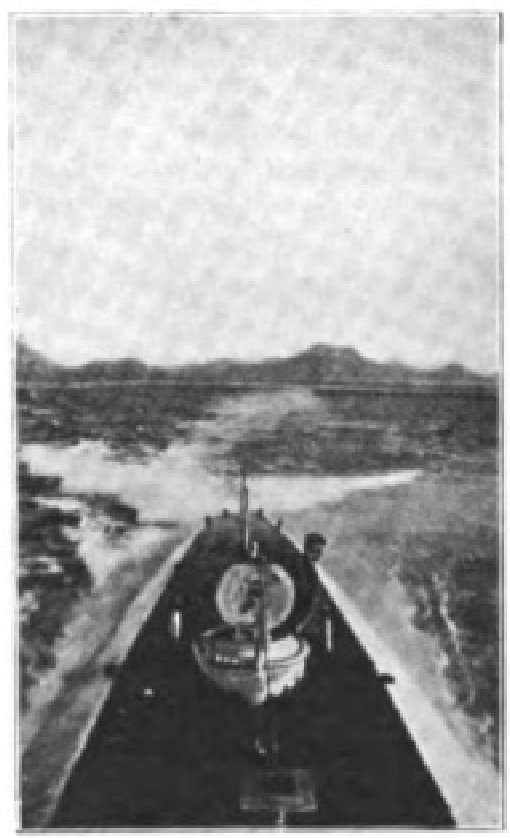
Perhaps the readiest way of giving readers an idea of what conditions on submarines are like would be by asking them to accompany me on a short cruise in one of them. . . .

We reach their mooring place in the Cartagena arsenal (see illustration on page 609) at 7 o'clock in the morning; and an hour later the A2 and A3 lift their anchors and glide majestically out to sea. Our first impression is that we are being carried, like Sindbad the Sailor of "Arabian Nights" fame, upon the back of a vast fish. 'Tis a brisk, sunny November day, such as one meets only in the Mediterranean Sea. It does not take us very long to glide past our escort, the gunboat *Bonifaz*, and we notice that she seems to labour in the choppy sea, through which we are gliding with ease.

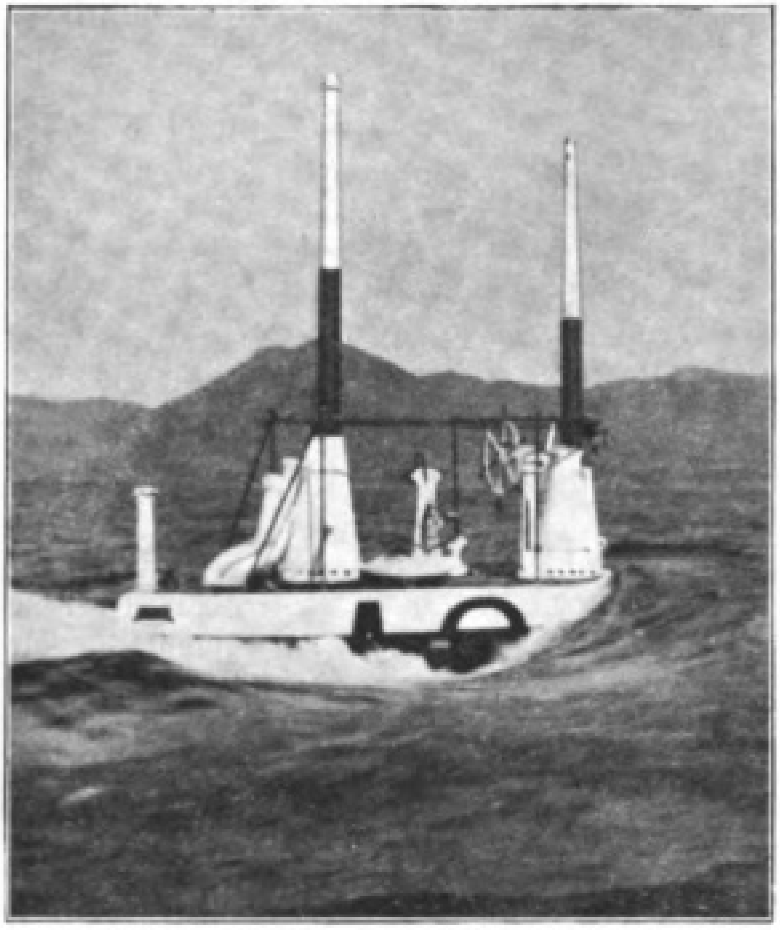
The wash of the water churned by the propellers heightens the fish-like aspect of the vessel as we gaze aft from the windows of the conning tower. Our picture (see below) gives a very fair idea of the view obtained, and the officer who steps on deck from the half-open hatchway smiles with subconscious appreciation of the conditions in which we find ourselves.

After three hours of delightful voyaging, at the rate of twelve knots, we reach the Bay of Mazarron, where we stop and prepare to submerge. We watch our crews as they trim the decks of movable gear and disappear with them down the hatchways. As soon as the latter are screwed up, so as to be watertight, our engineers start the electric motors and the boat slips quietly along with its human load inside it. The temperature within our steel envelope is fairly high, and we are glad to dispense with as many garments as decency will permit. Portholes in the conning tower afford an opportunity of witnessing the actual diving operation, and it is there accordingly that we take our stand. An order comes that the water-tanks are to be filled. Little by little the hull disappears below the surface, and waves start breaking against the glass windows of the conning tower right in our faces. What are our sensations under such circumstances? For my own part, I feel no tremor; the outstanding impression is a sense of awe in face of the immensity of the watery waste surrounding the boat. The last words I utter as we disappear beneath the surface are "Great Scott! What a lot of water!"

Now we are fairly underneath, and become immediately struck by the cessation of perceptible motion and by the deadening of sound. A quiet hush reigns throughout the vessel, broken only by the hum of the big motors and by the spoken orders of our chief. Nothing meets our view, as we peer out of the conning-tower portholes, save a luminous film of green water. The popular belief that fishes can



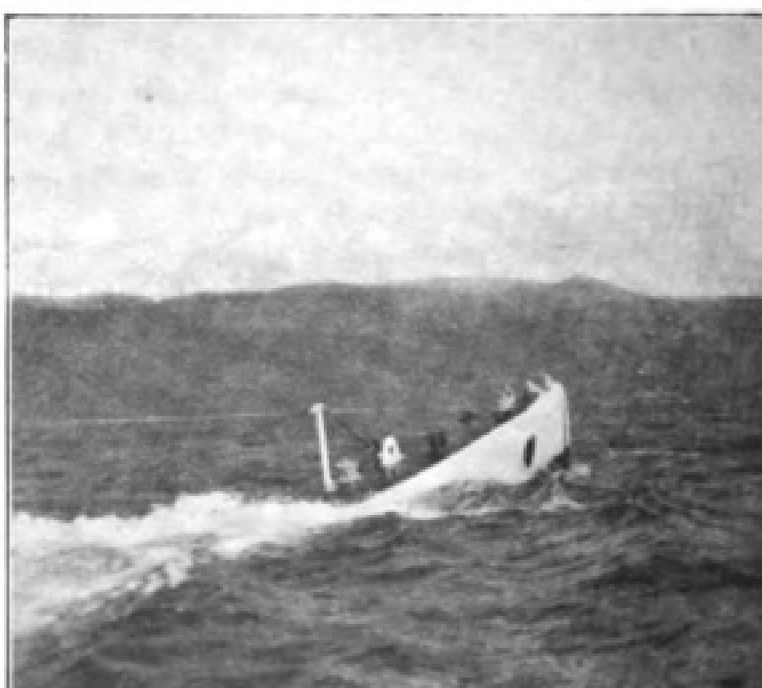
VIEW OF SUBMARINE ON THE SURFACE LOOKING AFT FROM THE CONNING TOWER.



THE A3 RUNNING AWASH. THE DARK PART OF THE PERISCOPE IS TELESCOPIC.

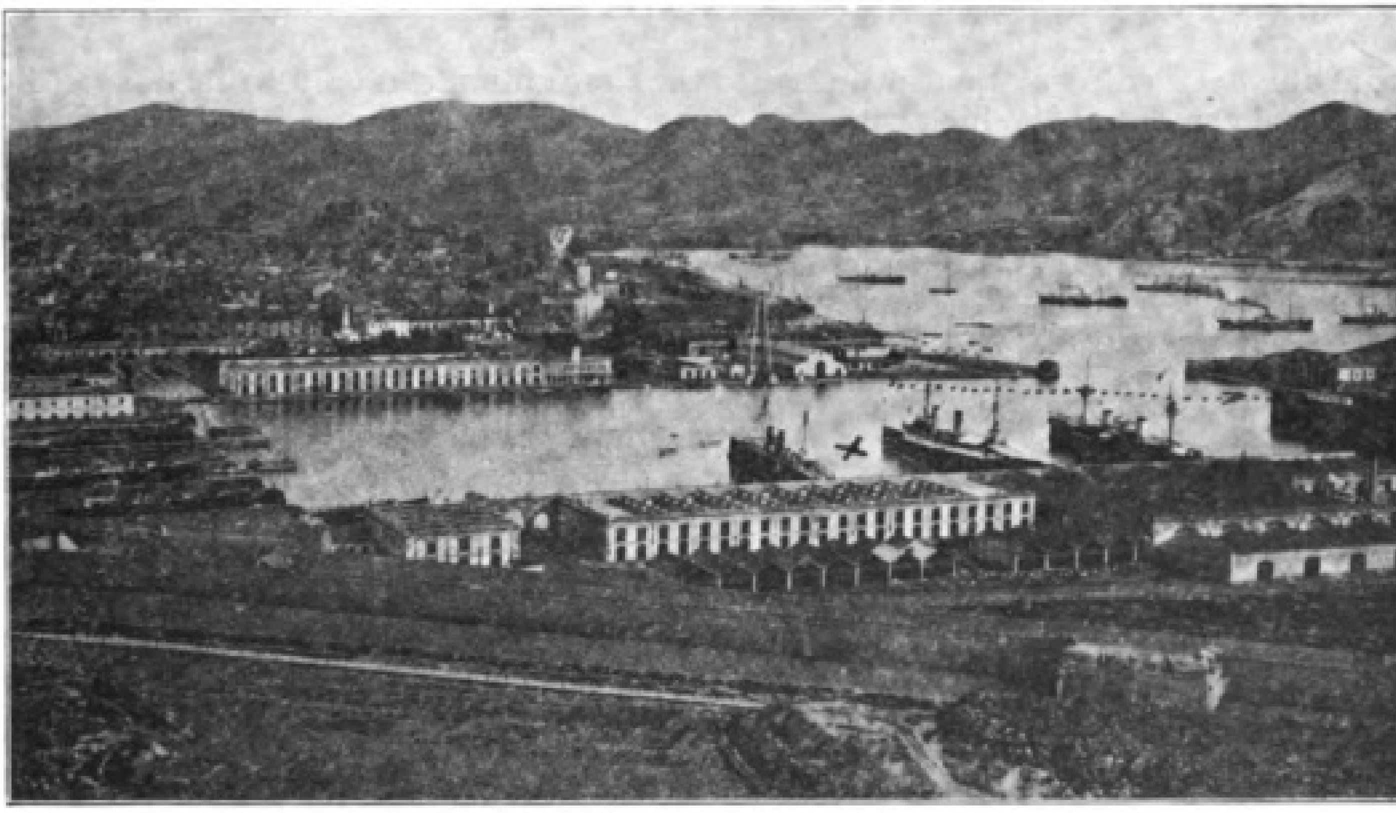
be seen gliding past the windows under such circumstances is erroneous, and probably arises from the widespread perusal of that fascinating scientific prophecy of Jules Verne's *Twenty Thousand Leagues Under the Sea*. As a matter of fact, all denizens of the deep are frightened away from the vessel's neighbourhood by the motion of the propellers.

Have you had enough of the conning tower? Well, let us go down to the navigating room. Here we find everybody at his post. One of the periscopes is in charge of the commander, whilst a subordinate is scanning the neighbourhood through the submarine's second "eye." Let us ask leave to take a peep ourselves. The moment I get the opportunity and apply my eye to the instrument, I am struck by the great range of vision obtainable. Every object seems perfectly clear; the only drawback is that one is apt to gain a false impression as to the distances separating us from objects on the surface. Yonder, about 200 yards away on the port side, I can just discern the periscopes of our sister craft. As I peep the vision disappears, and I notice that the poise of our ship has altered. We are descending at an angle. We plunge down to a depth of 18 to 35 feet, and I begin to feel some slight anxiety as to the possibility of a collision of the two submarines operating so close to each other. Both are by this time "in the dark." Suddenly we hear the strong, beautiful note of the Fessenden oscillator as it sends a call to the A2. This seems to have the same calming influence upon our nerves as the wireless spark must have upon passengers on a liner when they believe themselves in peril. The two boats now maintain a continuous subaqueous communication. The messages sent from our sister ship can be clearly heard by all on board as the sound-waves strike our hull. All the time the operator is receiving I notice that he keeps changing



RISING TO THE SURFACE ON A SLOPING KEEL. A RATHER DARING FEAT.

his telephones from one side to the other. This enables him to advise the commander whether the A2 is on the port or starboard side. Despite the fact that we have been under water for nearly two hours, I do not notice any sense of stuffiness and no trace of buzzing in the ears. The atmosphere appears quite normal, and I observe a point of difference between the British and Spanish submarines in the matter of testing the salubrity of the air. The former carry canaries; the latter pin their faith upon white mice! Canaries are supposed to be specially sensitive to any vitiation of the atmosphere. Soon after 2 p.m. we rise to the surface again and anchor the boat. Now all on board the *Bonifaz* for a frugal and well-earned meal! This afternoon we spend in evolutions awash, and start for home at 5 o'clock in the evening. (*Concluded.*)



THE NAVAL DOCKYARD AT CARTAGENA. THE POINT AT WHICH THE SUBMARINES USUALLY LIE IS MARKED BY A CROSS.

International Wireless Administration

Some Suggestions asked for by the Berne Bureau

In the issue of THE WIRELESS WORLD for August last, under the heading of "A Striking Sign of Rapid Expansion," we detailed the suggestions made by various nationalities, in response to a request of the Berne Bureau, with the view of meeting certain difficulties which are likely to arise ere long in the allocation of station call letters. The rival suggestions were three in number.

We have received circular No. 101, issued by the International Radiotelegraphic Bureau at Berne on November 30th, which sums up the situation as it stands at present. The preceding circular No. 98 had set forth the rival solutions proposed:—

(*a*) That of the British, which suggested that after the combinations on the present three-letter system are exhausted, each administration shall be able to use signs of four letters formed by the letter T followed by one of the three-letter combinations at present reserved for its use.

(*b*) The German proposal, which is based on the same principle, but advocating the insertion of the letter T at the end, instead of at the beginning, of the four-letter groups.

(c) The Dutch suggestion, which followed on the lines of the British, but substituted the letter P instead of the letter T as the initial sign of the four-letter combination.

In the second Berne circular above referred to (No. 98 of June 18th last) the administrators asked that the nations who are members of the Convention should reply before November 20th, 1918, stating which proposal met with their approval. The circular which we are at present considering (No. 101 of November 30th) states that out of the 71 nationalities who adhere to the Convention, only 15 replied before the expiration of the time limit. Out of these, nine voted for the British proposal and four for the German; whilst the Netherlands remained in their minority of one. The fifteenth reply came from Mexico, which sided in principle with the Netherlands suggestion, varying it, however, by desiring that the letter P should be placed at the end.

Article 11 of the International Radiotelegraphic Convention of London provides that the detailed regulations attached to the Convention can only be modified "by "mutual consent of the high contracting parties." Under the present circumstances, "mutual consent" has not been arrived at, and all the proposals are, therefore, taken as rejected in accordance with the provisions of paragraph 9 of Article LXXXIV of the Telegraph Regulations.

The German Administration gave as its reason for adherence to its own counter proposal that "with regard to the four-letter combination with either P or T, one "must always reckon on the possibility of error in reception, if the signals be not "transmitted in accordance with strict telegraphic rule. There is the special "objection to the use of P that the telegraphic transmission would be thereby "unnecessarily prolonged."

The Belgian Administration, in supporting the British proposal, considered that the objection raised on the score of faulty signals would speedily cease to apply in practice, especially in view of the fact that calls are always repeated three times.

A reply from British India was received after the time limit, but the Berne authorities think it worth while to quote their views. Briefly, they amount to agreement with the Netherlands suggestion of P instead of T; but propose that it should be placed as the third or fourth letter of the combination.

A still more recent circular, No. 102 of December 5th, 1918, states that the U.S.A. have submitted a fresh proposal, on which the International Radiotelegraphic Bureau at Berne ask for the votes of the parties to the Convention. This proposal is that, after the three-letter combinations have been exhausted, a four-letter series shall be used as supplementary thereto; and that these four-letter combinations shall be arrived at by doubling the first letter of those three-letter combinations of the original system which have been allotted to the various countries. Thus, the whole of the triple combinations beginning with N, from NAA to NZZ (which are allotted to the U.S.A.), might be supplemented by a series of four-letter combinations beginning with a second N, from NNAA to NNZZ.

French Somaliland

WE are informed, through the medium of a Berne circular, that the necessary overtures have been made by the Minister for the French Colonies for the adhesion of the French Coast of Somaliland to the International Radiotelegraphic Convention. The new station at Djibouti on this coast was recently notified as ready for service.

A Tribute to Wireless and Wireless Men

Some Gratifying Words of Praise for Radiotelegraphy and Telegraphists from our Leaders in the War

In the summer of 1914 Senatore Marconi uttered the prophetic words: "The "value of wireless telegraphy may one day be put to a great practical and critical "test; then perhaps there will be a true appreciation of the magnitude of our work." Within a very brief space after his utterance the test arrived. After a period of trial extending over four years and three months, the results attained have more than justified the most sanguine expectations. The tests have been searching in the extreme, and have affected every branch of the active services—at sea, ashore, and in the air. We are able here to reproduce, from the chiefs of the various branches of His Majesty's Service affected, their autographed verdicts on the result of the practical and critical test to which Senatore Marconi referred. These form at the same time eloquent testimonials to the gallantry and devotion of the men who have carried them through. The period of trial started on July 30th, 1914, when the First Fleet, which had just left Portland after the great Naval Review at Spithead, was recalled by wireless telegraphy, and instructed not to disperse for manœuvre leave, as had been previously arranged. Ever since that date the aerials over the roofs of the Admiralty, which Horatio Nelson's statue overlooks from its lofty perch in Trafalgar Square, have been busy night and day picking up messages from the Grand Fleet, and from all quarters of the globe; transmitting information and issuing orders. There has never been a moment when the ether was free from messages transmitted by the ships themselves. The science fulfilled its destiny in completely revolutionising naval warfare; whilst radiotelegraphists have played as important a part in the maintenance and accentuation of British sea supremacy as their gallant confrères aloft, at the guns, or in the engine room.

It may be not inapposite to recall the impressionist sketch of an American correspondent who visited the Grand Fleet during the autumn of 1915. Our friend from overseas was conducted through the flagship and finally into the little cabin which forms the "hub" of the mighty organisation:

"Stepping into a small room where telegraph keys clicked and a compact wireless "apparatus was hidden behind armour, we saw one focus of communication which "brings the Admiral word of any submarine sighted, or of any movement in all the "seas around the British Isles, and carries the Commander-in-Chief's orders far and "near. The complicated manœuvres of a modern fleet are only possible under such "conditions. The 'traffic,' as it is technically called at headquarters, is enormous. "The lieutenant-commander in charge of signals has information poured over him "without cessation; sheaves of white forms intrude upon his plate as he sits at "table, are thrust into his hand as he goes on deck, follow him wherever he is in the "ship, and fill his cabin. Only the Admiral and the paymaster who acts as the "Admiral's secretary can guess the vast mass of detailed information, instructions "and routine, connected with the squadron wherewith they daily wrestle, even when "the enemy makes no attempt to bring them to action. 'Stupendous' is the only "word which can adequately describe the paper work alone. This goes on without "cessation; the British Fleet is on active service all the time."

Such is the test through which wireless telegraphy and its exponents have issued triumphant. Comment is needless—Admiral Sir David Beatty's letter, written with his own hand, and here reproduced in facsimile, tells its own tale.

15 . 12 . 18

Sir

Your original letter certainly failed to reach me or I should have answered it before this.

I am very glad to be able to testify to the very excellent and efficient service performed by the Wireless Ratings of His Majesty's Navy.

On the efficient working of the W/T installations, and the accuracy of the operators, depends largely, the control of the large force of vessels which constitute the Grand Fleet: they have maintained W/T touch at all times, whether shot away in action, when blown away in gales. and have overcome all

attempts by the Enemy to interfere
and jam the Communications
They indeed deserve well of their
Country

Yours Truly
David Beatty

Can any service receive words of higher commendation from its chief? Sir David Beatty informs us that naval operators have "maintained W/T touch at all "times, when shot away in action, and blown away in gales." He summarises the situation by stating that "they indeed deserve well of their country."

We feel certain that every individual in the wireless ratings of His Majesty's Navy will treasure such praise to his life's end. The gallant Admiral's additional remark that they have "overcome all attempts by the enemy to interfere and jam "communications" constitutes an interesting authoritative announcement on the question of interference which attracted so much attention in pre-war days. WIRELESS WORLD readers will doubtless find thereby recalled to their recollection the abortive efforts of the enemy to jam during the fight between Admiral Sturdee and Von Spee on December 8th, 1914, when "pandemonium reigned in the ether." *

* * * * * *

Ashore, wireless telegraphy introduced almost as complete a revolution into military communications as it did afloat. The area over which guns range is now calculated in miles, and the whole field of operations has been immensely magnified. The lay reader may perhaps not realise what it means to depend for inter-communication upon miles of wire which may be severed at any point and at any moment; but any military leader would understand in a moment what his indebtedness is to a system which eliminates these risks. The important part played in the Great War has been shared by wireless installations of every description, from the quasi-permanent equipment of Headquarters to the motor-van and pack sets which accompany the front lines when they move. As for military aircraft, it is impossible to overestimate their services, not only in "spotting" for the artillery and in actual fighting work, but in that most important work of observation which more than anything else earned for them the title of "the cavalry of the air." The recently issued despatch of General Allenby attributed his success in Palestine largely to the fact that the Royal Air Force achieved supremacy over the enemy, preventing him from receiving intelligence and keeping up a continual stream of information to British Headquarters. Such communication work is, under modern conditions, almost entirely carried out by wireless.

The letter from Field-Marshal Sir Douglas Haig, which we reproduce here, sums up in a few terse words his appreciation of the valuable services which have

* See "The Falkland Islands Naval Engagement," which appeared on pages 766–8 of our issue for March, 1915.

GENERAL HEADQUARTERS,

BRITISH ARMIES IN FRANCE.

1st December, 1918.

The Wireless Press, Limited,
Marconi House,
Strand, LONDON, W.C.2.

I am glad to take the opportunity you offer me to express my very real appreciation of the good services performed by the wireless telegraphists throughout the war. Their work has been one of great and increasing importance, and the zeal and efficiency with which it has been carried out has been of great value to their country.

D. Haig. F.M.

Commander-in-Chief,
British Armies in France.

been rendered by radiotelegraphists under his command, and his message will be valued as highly by military wireless men as that of Sir David Beatty by those who have served at sea.

* * * * * *

One of the outstanding lessons which we British have learned during the recent conflict consists of the supreme national importance to these islands and to the Empire of all shipping, not only naval but mercantile. Modern warfare has indeed done away with the old division in wartime between civilians and belligerents. Nations threw the whole force of their being into the struggle; and those energies which in peacetime were devoted to carrying the flag of commerce to every sea, focused themselves on beating the arrogant enemy, who not only challenged, but affected to despise them. The struggle has brought out in a dramatic fashion the greatness of Britain's shipping organisations and the gallantry of the men engaged therein. Common danger and common effort have drawn the two great sea services more closely together, and have proved to "landlubbers" that courage and devotion are the characteristics of both.

During the past four years the pages of THE WIRELESS WORLD have chronicled such of the more prominent instances of heroism as the Censor allowed to appear. The duties of a wireless operator on a merchant ship in times of peril are of paramount importance to all on board. It is no small matter of pride to reflect that in no single instance which has reached us have ships' telegraphists failed to rise to the occasion. The submarine menace did but intensify their courage and devotion, as it intensified their danger. Many of them were lads under military age, and it may be not inopportune to record the fact that during the last year of warfare no fewer than seventy wireless operators under the age of eighteen have made the Supreme Sacrifice in the discharge of their duty. Sir Joseph Maclay, the Shipping Controller, has sent to us an autographed message of praise for the way in which they discharged their duty. This message constitutes an official acknowledgment of the work they have done for England, and will be prized as such not only by the living, but by those who mourn their dead.

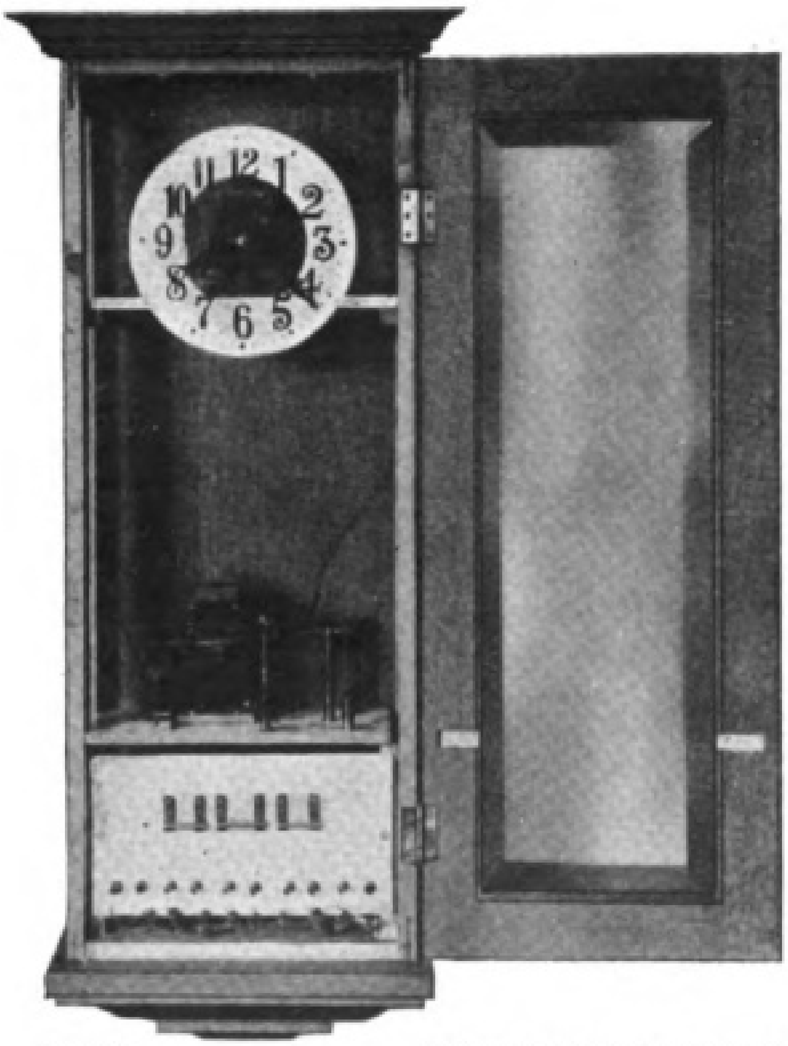
The wireless telegraph has played a crucial part in the conduct of the war on sea as on land and in the air, and I am glad to have the opportunity of expressing my warmest admiration for the manner in which the wireless operators on board our merchant ships have throughout discharged their very trying and often most dangerous duties. The safety of officers and passengers and crews has time and again been in their hands and they have ever maintained the highest traditions of our sea service.

J. P. Maclay.

Wireless Horology

The Possible Application of Wireless to the Regulation of Clocks

THE fact that ether waves travel with the speed of light, and are consequently practically instantaneous, as far as distances on our globe are concerned, places wireless telegraphy in a peculiarly favourable position for dealing with time. The principal use up to the present to which this function of wireless has been applied consists of the issue of time signals, which form such familiar features to wireless men all over the world. By these signals thousands of navigators regulate their chronometers in all quarters of the globe, and on their accuracy depends the correct reckoning of many a ship's longitude.



Phot.] [Underwood & Underwood.

WIRELESS TIME CLOCK OF GERMAN MANUFACTURE.

The wireless amateurs of our own country, in times when they can be allowed to conduct actual experiments, soon become well acquainted with the time signals radiated daily from the Eiffel Tower, and those of other countries are doubtless on equally "good terms" with the signals sent out from Washington, Melbourne, Chosi, Darien and other radiotelegraphic centres.

In pre-war days the well-known chronological expert, Mr. Alfred E. Ball, conducted a series of experiments to test the possibility of actually regulating clocks automatically by wireless waves. The results were so successful that, in a detailed article from his pen, published in THE WIRELESS WORLD, Vol. III., pages 15–20, Mr. Ball deliberately gave it as his opinion that in the future "one of the most "useful forms in which radiotele- "graphic waves will be pressed into "the service of the horologist will "be the wireless regulation, or rather "supervision, of public clocks." Mr. Ball's experiments, in common with so many others, had to be given up on the outbreak of hostilities; but they are doubtless only in the state of "suspended "animation."

Undoubtedly the possibility of such instantaneous regulation opens out a tempting prospect of doing away with the annoyance of the variation in the times announced by our public instruments, and Mr. Ball's experiments are probably far from being the only ones carried out having for their aim the realisation of this desirable project. The illustration which we print on this page shows a time regulator for wireless telegraphy set up at Fulda, in Germany, and would appear to illustrate an attempt to construct an instrument based on Ferdinand Schneider's system, whereby clock mechanism may be set in motion through the medium of wireless telegraphy.

Endeavour and Achievement

The Story of a Successful Effort to Cope with National Needs

THE full story of the magnificent work performed by wireless operators in the Mercantile Marine during the Great War still awaits the telling, although numerous individual instances have come to light in this magazine and in the general Press. Nothing, however, has yet appeared recording the really remarkable feat performed by the Marconi organisation in obtaining at short notice, training and sending to sea the young men who have done such good service *pro patria*. It was extremely fortunate from a national point of view that the Company had in peace time carried out the practice of maintaining direct control over their large body of employés on various steamship routes. Their policy has fully justified itself in the light of experience, demonstrating at a time of national crisis that it conduces to the interests of the Empire. It was owing to this policy, and this alone, that it was possible to carry out the stupendous task recorded below.

THE INITIAL EFFORT.

On the outbreak of hostilities in August, 1914, the Marconi Company were maintaining upon their books a regular operating staff of just over 1,000 men, together with but a relatively small number of men in training to fill the gaps caused by normal requirements. This staff was steadily, but gradually, increasing day by day, to meet the needs automatically created by the fitment of additional ships with wireless telegraphy. The declaration of war, however, brought to this Company, as to many others, a number of extremely difficult problems calling for immediate solution.

The Navy forthwith summoned all those men who had previously indicated their willingness to serve in the Royal Naval Reserve should a war break out. The number, however, of those thus available speedily showed itself far from sufficient, and the Company—laying aside its own interests—made an immediate call for volunteers. Seeing that necessarily, under the conditions of their service, board-ship operators are dispersed in all parts of the world, comparatively few are on shore at any one time, but determined efforts, combined with a number of personal appeals, achieved the result of obtaining immediate offers of service from the great majority of the men. Thus the wireless operating staff voluntarily deprived itself *ab initio* of a large proportion of the very best operators in the service.

As men came in from their voyaging abroad still more were withdrawn, and ere long several hundred men had proceeded under naval orders to Chatham, Portsmouth, and other centres. These were distributed amongst the various classes of His Majesty's Navy: battleships, dreadnoughts, cruisers, destroyers, armed trawlers, submarines, etc. One of the first naval tragedies of the war—the sinking of the *Hogue*, *Cressy* and *Aboukir*—involved the sacrifice, in each instance, of expert telegraphists thus early supplied by the Marconi organisation.

Meanwhile, with their personnel depleted to a dangerous limit, the Marconi Headquarters Staff in London, setting to work at high pressure, had managed to call up a number of additional men from the waiting list. During every hour of the day and night new applicants were being interviewed, medically examined, tested, and passed to sea. Fortunately, there were a number of young men under tuition as wireless operators in the various schools whose training could be speeded up. By bringing in such students and by drastic reforms in procedure, the main difficulties were tided over for the moment, and the work of supplying operators to merchant ships continued.

Had matters stopped at this point the war records of the Company would have constituted a worthy subject of pride. But they were continued long past it.

At the end of May, 1917, the Operating Staff had been increased from the 1,000 men in hand three years before to 2,900, whilst some 325 students were attending day and evening classes at Marconi House.

THE CRISIS.

Then, just at a time when the ordinary source of supply of wireless man-power was showing itself scarcely sufficient to meet the requirements of newly fitted ships, when the loan of picked men to the Navy and other specialised services had sorely thinned the ranks of the best men, at a time, moreover, when the pressure of general recruiting was sweeping into the fighting services numbers of youths who might have been suitable for training as wireless operators, and when the Royal Flying Corps, the Royal Naval Volunteer Reserve and the Royal Naval Air Services had added to the difficulties by their own training schemes for wireless men, THE NATION AT LARGE WAS CONFRONTED WITH THE SINISTER MENACE OF THE SUBMARINE, AND THE AID OF WIRELESS WAS INVOKED.

At such a crisis as this, it was realised what radiotelegraphy means to ships under stress of peril at sea. Unfitted vessels were falling like ripe plums into the U-boat basket.

A conference was held at the Admiralty for the purpose of considering the practicability of fitting with wireless telegraphy all ships of 1,600 tons and over. The desirability of carrying two operators for maintaining continuous watch was also emphasised. The authorities thereupon approached the Marconi Company with the view of ascertaining whether they could possibly cope with so huge a task. Few ships under 3,000 tons had up to that date been fitted, and it was quite evident that not only would a tremendously increased volume of wireless apparatus have to be made and supplied, but that the Operating Staff would need to be practically trebled. It was estimated, in other words, that the trained personnel, already increased in three years from 1,000 to nearly 3,000 men, would have to be swelled to a total of about 4,000 to 4,500 *in a few months*. With full knowledge of his gigantic task, Mr. Godfrey Isaacs, on behalf of the Company, undertook definitely to provide both apparatus and men.

As soon as the Marconi Company got to work, a review of the situation made it clear to the management that (1) very special inducements would have to be held out if young men were to be attracted in sufficient numbers for this career, and (2) that the previous age limit would need to be lowered so as to prevent mutual interference between their scheme and the requirements of the military. Up to this time any young man who desired to become a wireless operator had been obliged to pay a fee for his training at one or other of the private wireless schools distributed throughout the country. It is true that some men were receiving gratuitous training at Marconi House, but this number was small compared with the total number of men in the various outside establishments. As part of the new scheme, a course of free tuition was offered, and—the school accommodation at Marconi House itself being insufficient for accommodating the number required—arrangements were made with King's College and with the Birkbeck. Further, in concert with the educational authorities in Birmingham, Leeds, Newcastle and Glasgow, similar schemes were established in those cities.

The wide publicity campaign so well known to most of our readers was then instituted, and ere long suitable candidates presented themselves for a course of intensive training.

GOVERNMENT ACTION.

The Government authorities, seeing that the Marconi Company had their undertaking well in hand, issued on October 23rd, 1917, an Order in Council making wireless compulsory on 1,600-ton vessels and upward. The publicity campaign already in full swing was extended by the conclusion of arrangements with the Royal College of Surgeons and St. Bride Foundation. These London institutions undertook the accommodation of additional students to be trained under the direct control of the Company. Furthermore, in order to tap provincial centres to a still larger extent, and to assist those young men who were unable to leave their homes to take up residence in London during tuition in wireless training, additional centres were established in the provinces, the scheme now extending to ten municipal colleges and six private wireless schools. Suitable apparatus of a modern type, together with keys, buzzers, telephones and other accessories, were lent to such institutions as were not already provided therewith. The number of students grew rapidly, until, by the end of April, 1918, no fewer than 2,660 pupils were in training, under 51 instructors provided by the Company and 62 furnished by the schools themselves. An ample supply of students having been thus secured through these special advertising schemes, which included posters, announcements in cinema theatres, newspaper write-ups, and display advertisements, the free training scheme was closed on April 1st, 1918.

The record of the year following September 1st, 1917, constitutes a very remarkable achievement. Nearly 1,000 ships were equipped by the Company with wireless apparatus, whilst between 2,000 and 2,500 operators were trained and supplied to the Mercantile Marine—that is to say, that over this period *every day in the week saw three ships fitted with wireless apparatus and six operators supplied.* The number of vessels carrying only a single operator was reduced by one-third; whilst, at the end of that period, over 1,000 students were still in training under the Marconi's Company's scheme to provide the necessary reserve supply for the newly equipped vessels and for those whose operating staff was increased. The beneficial result of this wonderful piece of work was speedily manifested in the improved position with regard to the safety of the Mercantile Marine; and there can be little doubt that this "Wireless to the Rescue" programme played an important part amongst the British counter-strokes which defeated the enemy's submarine efforts.

The Material Problem.

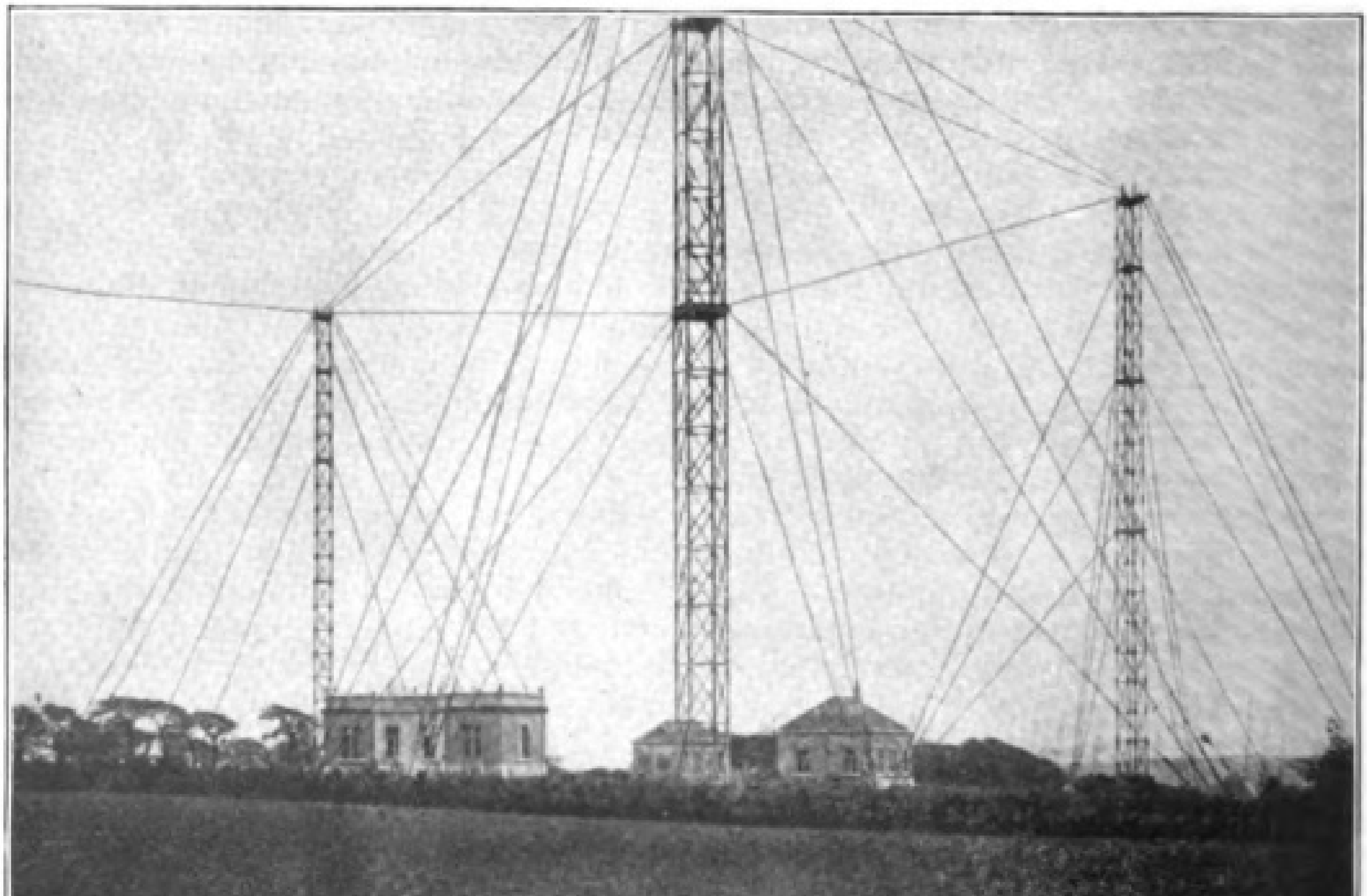
We have dwelt mainly upon the work accomplished in the enlistment of recruits and their instructional training, because the human element constituted the more difficult of the two problems. But the material side was only second thereto in its formidable character. Every possible means had to be resorted to for increasing the supply of new apparatus. Additional plant was laid down at the Marconi Works in Chelmsford, and the workers engaged there were called upon for intensified effort. Right well did they respond to the appeal; but at the height of the pressure it was found necessary to obtain a certain number of sets from America and Canada, and to impress every available man upon the Engineering Staff for the fitting on shipboard of the new equipment. Valuable assistance in this direction was also rendered by a number of the "old hands" amongst the operating staff.

It will be easily understood that, in the midst of this whirlwind of demands for fresh apparatus and operating staff, the skill of those who had already had the benefit of previous experience was invaluable. Yet, simultaneously with so vastly enhanced a need for their services, the Marconi Company was obliged to part with a large proportion of them. Right from the start of the war heavy drafts of experienced men were detailed for Admiralty service, and even up to the last few days before the signing of the armistice, the Marconi Company was responding to the call for practised experts to take up duty, both in the military and naval branches of His Majesty's Forces. The results of the activities of these men remain, up to the present, practically unknown to the general public. Silence had perforce to be maintained concerning the large staff of skilled wireless operators engaged in expert work at direction-finding stations distributed all around the coast. It was by their aid that enemy submarines, surface ships, Zeppelins and other aircraft were accurately located. Then, too, a number of men were called upon to proceed to distant quarters of the globe for service in specially erected wireless stations, which have proved of the utmost strategic importance.

We are only able here to refer to these matters in outline; the full story of this and other special branches of wireless work must be reserved for subsequent issues. What we have set before ourselves is the task of throwing some light upon the great achievement involved in thus providing wireless operators and apparatus to safeguard the National Mercantile Marine. Now that hostilities have ceased this feat can be viewed in its true perspective. The wireless service has every reason to be proud of its endeavour and its achievement, although its justifiable pride is sobered by regret for the large number of lives which have been lost in the attainment of this splendid record. On another page we publish a tribute to wireless from the chiefs of the various branches of His Majesty's Service. Such wholehearted encomium may be looked upon as a fitting close to a most dramatic chapter in wireless history.

Lying Aerials

The Nerve Centre of Germany's Wireless Propaganda



THE GREAT WIRELESS STATION OF NAUEN (NEAR BERLIN), FROM WHICH INSTRUCTIONS WERE SO FREELY RADIATED TO THE PREDATORY SUBMARINES.

Notes of the Month

A Belgian Farewell Dinner.

After the capture of Brussels by the Germans the Société Anonyme Internationale de Telegraphie Sans Fil "carried on" in London during the four years of world-wide struggle, and from welcome guests became everyday working comrades of the staff of the British Marconi Company. When Belgium was cleared under the terms of the armistice, they announced their intention of returning to their own home at 13 Rue Brédérode, Brussels, and gave a farewell dinner at the Savoy Hotel on December 23rd last. It was a most agreeable function, and the notable feature thereof consisted of genuine cordiality. Mr. Isaacs took the chair, supported by four directors of the British Marconi Company, Mr. Alfonso Marconi, Captain Sankey, Mr. Bradfield and Mr. Bramston.

The two principal speeches of the evening were contributed by the Chairman, and by M. Hubert, who had conducted the S.A.I.T.'s operations in England during the war with marked success. Mr. Isaacs, after adequately voicing the feelings of the British Marconi Company, made the interesting suggestion that an excellent way towards carrying out the principle of making Germany pay would be to force them to contribute a sur-tax upon every letter and every telegram which left the confines of their territory. M. Hubert's reply was delivered partly in French and partly in English, and expressed in terms wherein emotion was masked under the cloak of dignified diction, the feelings inspired in himself and his companions by the trials to which they had been subjected and by the spirit of cameraderie displayed on this side of the Channel.

World-Wide Mourning.

Although his intimate friends knew that ex-President Roosevelt's health had been indifferent for some time, to people in general his death came like a thunderbolt from a clear sky.

It is hardly too much to say that it constitutes a subject of world-wide mourning, and no tribute more fitly represents the feelings of us all, put in a few words, than does that paid by Senatore Marconi, which runs as follows :—

"In Theodore Roosevelt the United States has lost one of the most forceful "and magnetic personalities of our time—a man whose broad views and liberal-"mindedness were fully appreciated, not only in his own country, but all the world "over. Personally, I grieve deeply at the loss of a valued friend."

A New Publication.

The International Radiotelegraphic Bureau at Berne published in April, 1918, the fifth edition of their list of radiotelegraph stations of the world, and to date eight monthly supplements have been issued. The net price is 5 fr. 50 c. per copy.

Cuban Wireless Station Rebuilt.

In September, 1917, a hurricane devastated the Island of Pinos, which lies just south of Cuba, and totally destroyed the radiotelegraph station erected at Nueva Gerona. A new station has now been installed, and was put into operation on August 24th last. It possesses a range of 5-600 miles by day and 1,000 miles by night. The tower, 250 feet high, was supplied by the Marconi Wireless Telegraph Company. It would appear that the new station possesses a marked superiority over the old. We understand that messages can be transmitted direct to the United States *via* Washington (N.A.A.) during the night, but that they should be forwarded *via* Havana in daylight hours.

French Coast Stations.

We learn from Circular Letters Nos. 72 and 73 of the Berne Bureau that the French Administration have advised that French coast stations are now open for the exchange of radiotelegrams in plain language—either French, English or Italian—concerning the movement and safety of steamships, as well as for wireless messages of a similar character between captains of ships and their owners or agents.

A Suggestion from Washington.

The Department of Commerce at Washington have placed before the International Radiotelegraphic Bureau at Berne a proposal to add to the list of abbreviations annexed to Article XXII. of the International Radiotelegraph Regulations call letters to represent the following abbreviations :—

1. What is my true bearing ?
   Your true bearing is........degrees.
2. What is my position ?
   Your position is........latitude........longitude.

These would, of course, be added to the Q.T. series for abbreviated service working.

The American Administration, in support of these proposals, point out that abbreviations of this character will become necessary, owing to the fitting at coast stations of instruments permitting determination of the bearing or position of ships at sea. These suggestions are to be open for the observations, amendments or counter-proposals of Signatories to the Convention until May 1st, 1919.

"The Problems of Agility."

We have received from the publishers, the Anglo-French Music Company, an interesting publication (1s. 3d. net) under the above title which is well worthy of the attention of our readers.

This little pamphlet is a summary of the laws governing the speed in reiteration and succession for wireless operators, telegraphists and others. It should appeal particularly to teachers of telegraphy and wireless, dealing as it does with the proper and accurate timing and cessation of the muscular actions, the use of the correct muscles concerned, ease and freedom in the action of those muscles and other similar matters. Obviously the laws which govern rapidity of the reiterated actions called for in wireless and ordinary telegraphy are identical with those governing speed in the utterance of successive notes and repetitions in pianoforte playing, and the author has brought to bear upon the subject his wide experience in musical matters.

A Specialist in Narrow Escapes.

The P.S.N.C. liner *Orduna*—in pre-war days one of the pet boats of this famous steamship company—has during the war established a high repute for hairbreadth escapes, and it seems the irony of fate that she should have become involved in a collision during her first " peace trip " from New York.

On one occasion Captain Taylor, who commands her, was steaming, with 600 French reservists and a large number of British Volunteers on board, through the tracks of the *Dresden* and *Karlsruhe*, what time those predatory vessels were still on the prowl. Of course she travelled through the night with all her lights switched off, and at a critical point of the journey—in order to keep the enemy more completely " in the dark "—the ingenious commander called up an imaginary ship by wireless, and informed a non-existent brother-captain that the *Orduna* was leaving important letters for him at Las Palmas. Of course the Germans intercepted the message, and—as it may be supposed—made the necessary arrangements to catch the *Orduna* off the Canary Islands. In the meantime the wily Britisher shaped his course 30 miles westward of the group, and reached Lisbon in perfect safety.

Wireless in Air Navigation

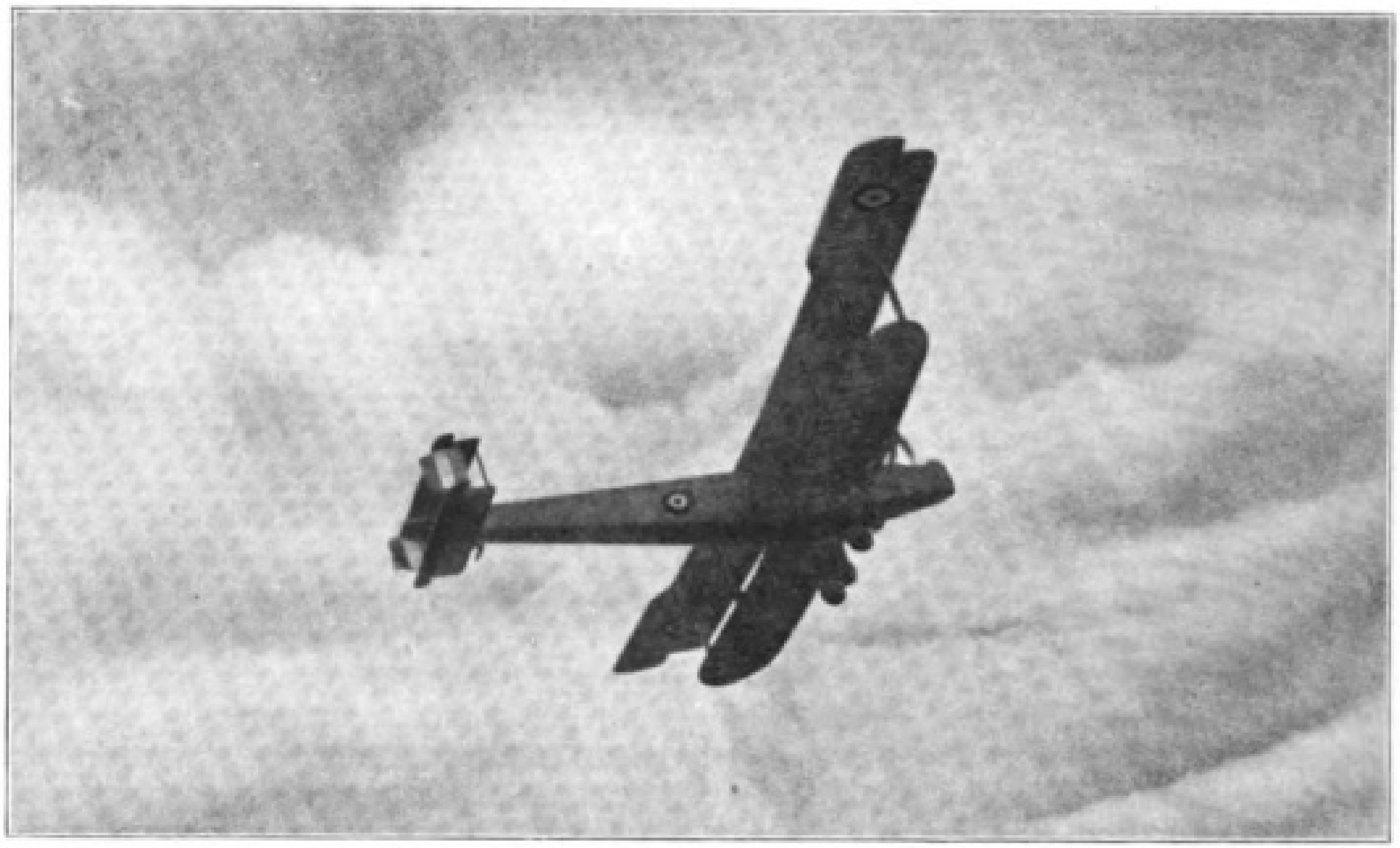
The Important Part to be Played by Radiotelegraphy in the Aerial Ocean

The writer of this article desires to express his obligations to MR. HANDLEY PAGE, not only for the loan of photographs, but for many valuable and instructive remarks and hints, some of which are embodied in the text.

THE modern division of matter—leaving on one side the unique and all pervading ether—is dichotomous. That is to say, it assumes two forms: (*a*) solid, and (*b*) fluid, sharply divided from one another by their elastic properties. Air and water fall under the same division, and that is the reason why we find the practical problems affecting both to be similar. We are, from the point of view of everyday problems, as well as that of scientific theory, absolutely accurate in speaking of the " Ocean of Air."

It is curious to observe how the advent of radiotelegraphy has affected human endeavour in its relationship to the various forms assumed by matter. Land transport was able to attain a high degree of excellence and development long before the possibilities latent in ether waves were realised, although radiotelegraphy is increasingly being used in conjunction therewith. Much also was effected in the world of water-borne traffic; although the systematised organisation thereof suffered very serious disabilities owing to the lack of inter-communication, and ran the gauntlet of a number of risks due to the same cause. Wireless has performed wonders with regard to the Sea Services already, and is certain to do much more later on. But it put in an appearance at a comparatively late stage. With regard to air, however, it would almost appear as though men, before they undertook to wrestle seriously with the immense difficulties which confronted them, had been waiting for Marconi! The sea, at all events, has its islands, its capes, its

MARCONI CONTINUOUS WAVE AIRCRAFT TRANSMITTING SET.



A HANDLEY-PAGE MACHINE IN FLIGHT.

THESE MACHINES WILL BE ABLE TO CARRY ABOUT A COUPLE OF TONS OF MATERIAL ON EACH TRIP. THE LARGER 4-ENGINE HANDLEY-PAGE CAN, OF COURSE, CARRY MORE THAN TWICE THIS LOAD.

mountain heights, and similar *points d'appui* for communication with vessels engaged in voyaging. The air possesses none of these.

We would recall to the recollection of our readers Lord Montagu of Beaulieu's lecture on the future of air navigation, delivered at the Central Hall, Westminster, on June 21st, 1917, in which he emphasised the convenient situation of British possessions for an organised Air Service; touched upon the necessity of the establishment of fixed "lanes" or zones of flight, with specific altitudes allotted to certain types of traffic; and dwelt upon the fact that meteorology and the study of wind-currents will be of supreme importance. He adverted also to the many organic arrangements involved in such systematised flying—instancing the establishment of air police, a system of lighthouses for air pilots, traffic-control centres, etc. The whole plexus of such an organisation hangs upon radiotelegraphy.

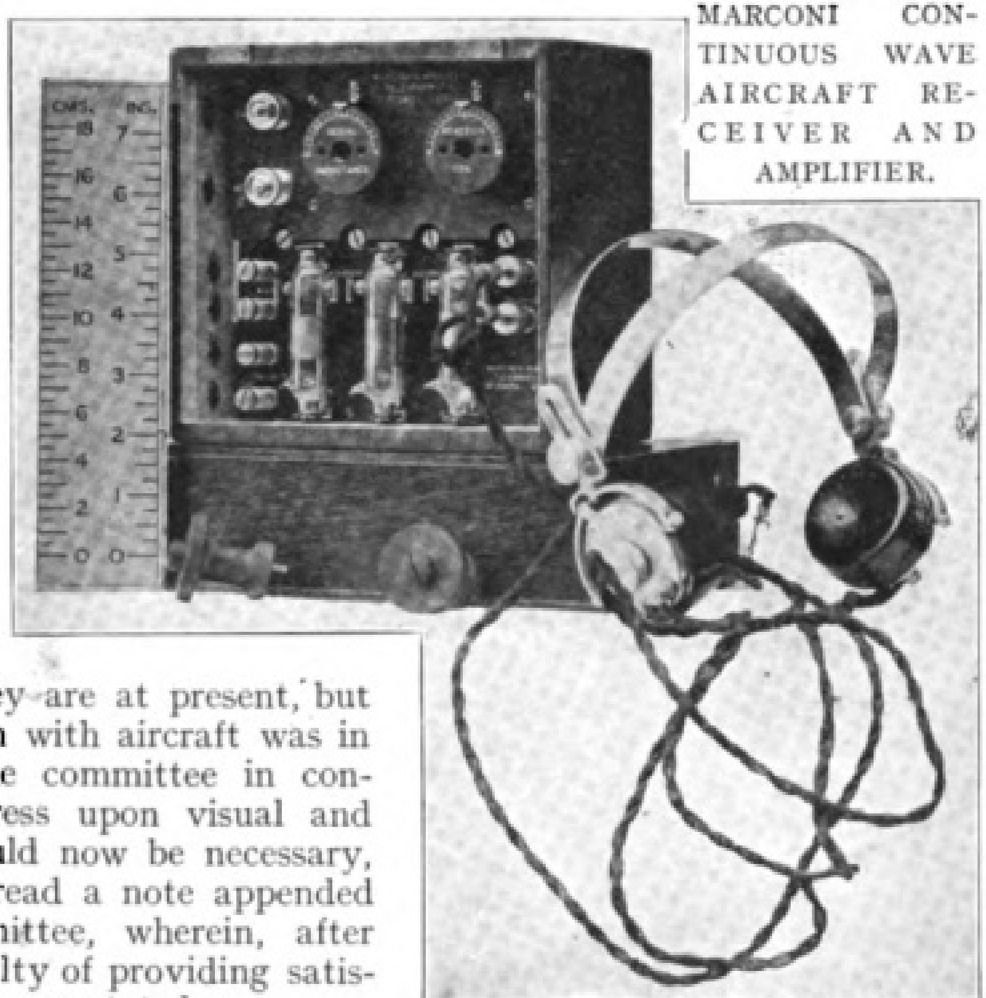
Major-General Sir F. H. Sykes, speaking on January 8th last, dwelt with especial insistence upon the influence of the weather upon aviation, and pointed out that, for this reason, a night service was often less liable to interruption than day service. "Flying through clouds," said the Chief of the Air Staff, "still "remained a matter of much difficulty, owing to the entire loss of all sense of "direction, until the introduction of the *turn indicator*."

Scientific instruments of a similar nature for the facilitation of flying are constantly being evolved from the brains of our ingenious experimenters; but, after all is said and done, the factor upon which most reliance must be made is wireless. Sir F. H. Sykes went on to give an excellent example of the use of directional wireless telegraphy in the recent test flight of a large aeroplane from London to Paris; wherein "an aerial navigator gave all directions as to steering, and "stated periodically where the machine was, *without ever looking out*. Paris was "reached in a fog within five minutes of the time calculated by the navigator.

"On the return journey the officer, when he stated that the machine should be over "Brighton at that moment, was found to be less than a mile out in his calculation."

The gallant Major-General, like Lord Montagu of Beaulieu, dwelt upon the necessity for aerial lighthouses or "wireless beacons, unaffected by fog, and with a "range of visibility of six or seven hundred miles. Their cost would be high; perhaps "in the neighbourhood of £60,000 or £70,000 per station; but for aircraft they were "primary requirements."

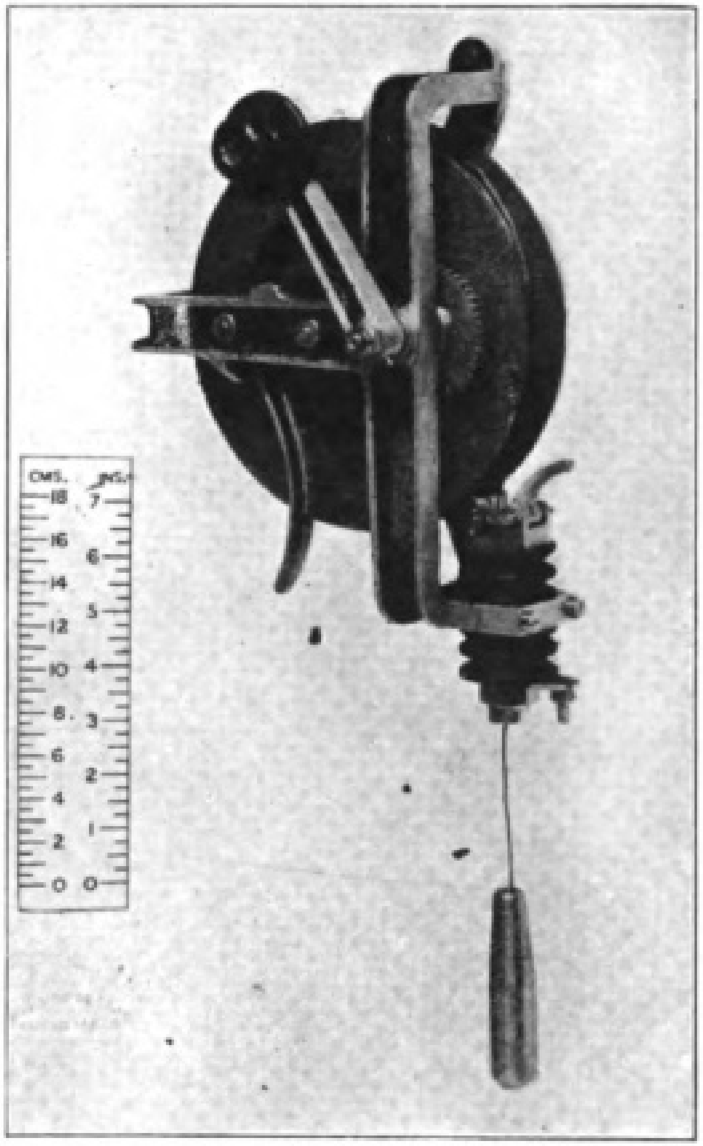
It has possibly escaped the recollection of some of us that an International Convention, in regard to aerial navigation, was held in Paris in 1910, and that a report was issued by the Civil Aerial Transport Committee appointed by that Convention. This report was printed *in extenso* by *Flight* in their issue of December 26th last. The subjects therein dealt with, indicate the complex nature of the problems involved. They may be summarised as: (1) nationality and registration; (2) certificates of navigability and licences; (3) territorial boundaries and rights; (4) flight laws and regulations, rules of the road, landing and distress signals, etc.; (5) customs and tariff restrictions; (6) national air services; (7) punishment for offences. At the time when this report was issued, not only were aeroplanes in a much more primitive stage of development than they are at present, but wireless in its connection with aircraft was in a similar situation. The committee in consequence laid more stress upon visual and audible signals than would now be necessary, and it is instructive to read a note appended by the Special Committee, wherein, after dwelling upon the difficulty of providing satisfactory audible signals, it was stated:



MARCONI CONTINUOUS WAVE AIRCRAFT RECEIVER AND AMPLIFIER.

It is understood, however, that the possibility of providing aeroplanes with magnetic or wireless signalling apparatus is now being investigated, and should any simple system be successfully devised, the Special Committee think that an International Regulation enforcing its use would be desirable.

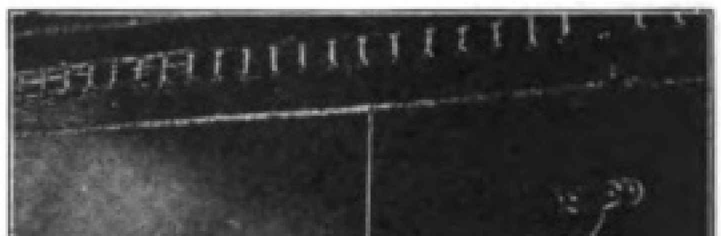
Now that the new organisation for developing an air service for passengers, mails, parcel-post and parcels delivery appears upon the point of being consummated, such a pronouncement as that recently made to a representative of the Press Association by Mr. Godfrey Isaacs possesses peculiar interest. This eminent *entrepreneur* announces that the Marconi organisations under his control are in a position to supply every aeroplane with a combined wireless telegraph and telephone installation, as well as an efficient and thoroughly qualified operator. They are prepared to do this on the same basis as has been for years past in operation with regard to ships at sea—that is to say, that the Wireless Company will install apparatus suitable for the purpose, will keep it abreast of the most modern develop-



AERIAL WINDING REEL.

ments, maintain it in perfect working condition, and supply an expert telegraphist, all at an inclusive charge.

Charts giving the exact position of a number of wireless stations in all parts of the world will be issued, and the land stations will be furnished with direction finders, so as to be able to give the operator the exact position of the aeroplane, wherever it may be. Air-maps will be provided, wherein space is marked off in zones, each bearing its special number. The aerial operators in the Marconi Service will at given periods send out air reports, and will, in their turn, receive communications of a like nature. From time to time record charts will be issued, embodying the information extracted from these reports, so that in course of time the air will become as systematically charted with regard to currents and disturbances as the sea with regard to ocean streams, tides and depths. There can be little doubt that such air charts will (as has been repeatedly emphasised by first-class authorities like those quoted above) not only prove of supreme importance for aerial operations, but also will assist navigators at sea. Moreover, the general meteorological information thus made for the first time available, cannot but render incalculable assistance to agriculturists and other members of the community ashore. The latter object will be furthered by the issue of general weather reports from the different wireless stations, both at home and abroad, towards which the Marconi Associated Companies in foreign lands will systematically contribute. The numerous ships at sea fitted with Marconi installations will contribute



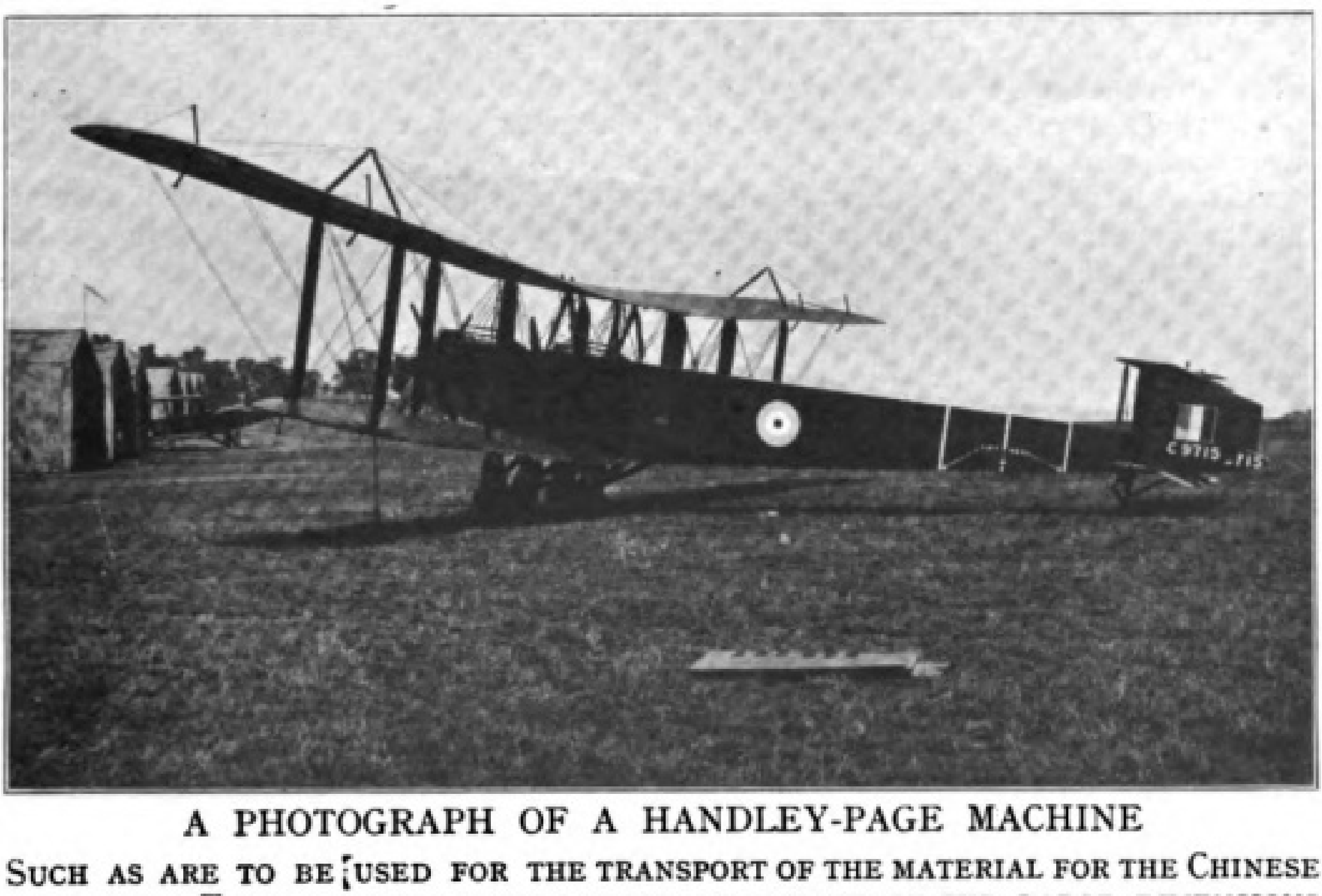
SMALL AIR-DRIVEN DYNAMO ON THE SIDE OF THE FUSELAGE.

TWO GENERATORS OF THIS DESCRIPTION SUPPLY THE CURRENT NEEDED FOR THE WIRELESS AND LIGHTING. THE DUPLICATION OF THESE SETS ENSURE CONTINUANCE OF OPERATION.

their quota of assistance and play a definite part in the general organisation. Thus do additions to one branch of knowledge benefit all that are inter-related with it.

Even from the point of view of the stay-at-home public, no inconsiderable boon will be conferred by the possibility of thus extending radiotelegraphic communication. They are already able to keep in touch with their private and business friends through the medium of ships' aerials, and the same facilities will be available on aeroplanes as at present on vessels at sea. The former will, like the latter, have accounts current with the Marconi Companies for the transmission of telegrams from the air to any part of the world

We have just witnessed a significant instance of the fashion after which these aerial possibilities will assist in the development of the world. Arrangements were recently made for the erection of wireless stations in the "far-away" parts of China, and a contract for wireless installations has (as already announced in our pages) been concluded with the Chinese Government. These stations are destined to initiate that rapid inter-communication between the various parts of those vast territories which must constitute an essential preliminary to emergence from their present inchoate condition. So great are the difficulties of transport to points at vast distances from the coast and over tracts of land totally unprovided with railways or roads, that Mr. Godfrey Isaacs recently stated he should have hesitated to undertake such a task had not the Air Service come to his rescue. Arrangements made with Mr. Handley Page for the transport of the necessary material by one or more of the big machines which are now being built have put the Marconi Company in the position of conveying their material in two or three days, instead of having to expend the same number of months over the process. We may add the further consideration that by this means alone can be assured the safe crossing of a dangerous tract of country. But for such facilities this promising enterprise would have run the serious danger of being "nipped in the bud."



A PHOTOGRAPH OF A HANDLEY-PAGE MACHINE

SUCH AS ARE TO BE USED FOR THE TRANSPORT OF THE MATERIAL FOR THE CHINESE STATIONS. THE VIEW ILLUSTRATED SHOWS TO ADVANTAGE THE LARGE DIMENSIONS OF THE FUSELAGE (OR BODY) IN WHICH THE APPARATUS AND PLANT ARE TO BE PACKED. THE WINDOW IN THE AFT CABIN IS JUST VISIBLE IN THIS PHOTOGRAPH.

The Use of Impedance, Capacity, and Resistance Couplings in High-Frequency Amplifiers

By J. SCOTT-TAGGART

Membre de la Société Belge des Electriciens, R.E.

VALVE amplification may be of two kinds: magnification of high-frequency oscillations, and also that of low-frequency current variations. Each form of amplification has its own peculiarities and circuits, although both depend on the fundamental principles of a local circuit current being varied by a separate controlling circuit.

The writer has already described types of circuits used for low and high-frequency amplification (WIRELESS WORLD, January, February, March, 1918). Those used for the amplification of the low-frequency unidirectional pulses produced by the rectification of beats or wave-trains consisted of several valves connected in series or cascade. The plate circuit of one valve was coupled to the grid circuit of the next by means of a step-up transformer. Although this arrangement of intermediary transformers is probably best for low-frequency amplification, it is proposed to show how we may dispense with them in circuits which will be found of very high efficiency as receivers of wireless signals.

The term "high-frequency amplifier," although strictly an arrangement merely for the reproduction of oscillations on a larger scale, very frequently also implies the rectification of these magnified oscillations. The circuits which follow are complete wireless receiving circuits and possess the advantage of not employing either intermediary transformers or oscillatory circuits between the valves.

In the plate circuit of a valve which is being used as a rectifier there is practically always an oscillating variation of plate current as well as an average decrease—or sometimes increase—for each wave-train. Fig. 1 shows a number of wave trains and their effect on the plate current of a valve having a "leaky condenser" in its grid circuit. The oscillations in the plate circuit are shown superimposed on the drop in plate current produced by each wave-train.

In the case of a circuit where the first valve is used as a detector, and subsequent valves, interconnected by step-up transformers, are used as low-frequency amplifiers of the rectified current, very little use is made of the oscillations in the plate circuit

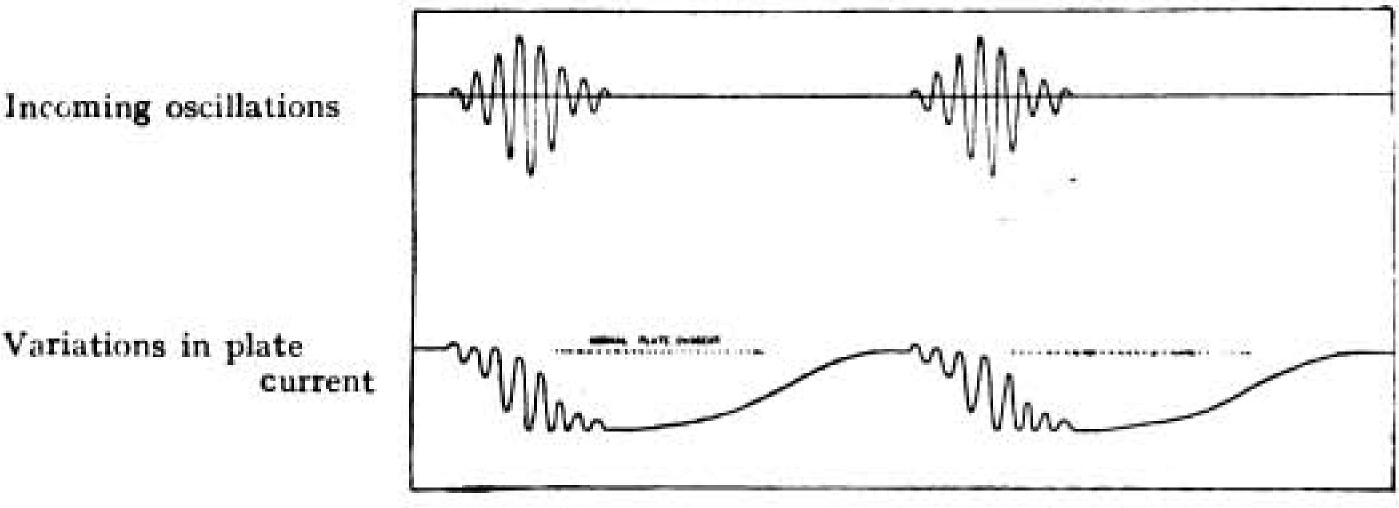


FIG. 1.

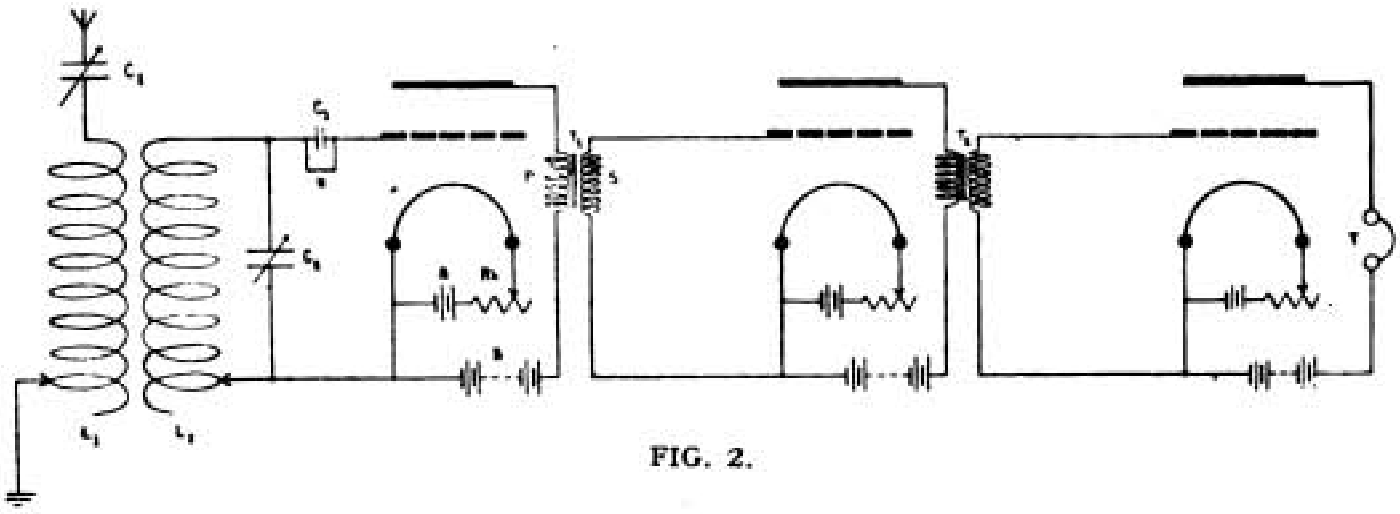


FIG. 2.

of the first valve. Fig. 2 is an example of such a circuit. Another disadvantage of this arrangement is that the rectification of the signals is left chiefly to the first valve which has to deal, when signals are weak, with very small variations of grid voltage. It may be taken as a general rule that the weaker the signals the less efficient is the valve as a detector, since the bends of both grid and plate characteristic curves are comparatively blunt. Signals which are inaudible in the plate circuit of the first valve are not likely to be reproduced efficiently in the plate circuit of the last valve. Rather is it a better principle to strengthen the incoming oscillations to at least the value necessary before the valve detector can be used with any degree of efficiency. Having done this we can *then* apply our oscillating voltages across the grid and filament of a rectifying valve. A common method of augmenting the amplitude and time of duration of wave-trains is that introduced by Franklin, whereby the oscillations in the tuned plate oscillatory circuit are made to react on the original incoming oscillations. Another method of strengthening incoming oscillations is to use a system of amplifying valves with tuned grid and plate oscillatory circuits coupled to each other in the ordinary way. This last method is very selective and requires considerable skill on the part of the operator. In most of the methods described below low and high-frequency amplification takes place at the same time. The circuits of consecutive valves are coupled together, not by the ordinary radio-frequency coupling of tuned circuits or by intermediate transformers, but by means of impedance coils, resistances, and capacity effects. Somewhat obscure reaction effects, which have generally been discovered by accident, such as by the touching of certain parts of the circuit, are also given. These reaction effects,

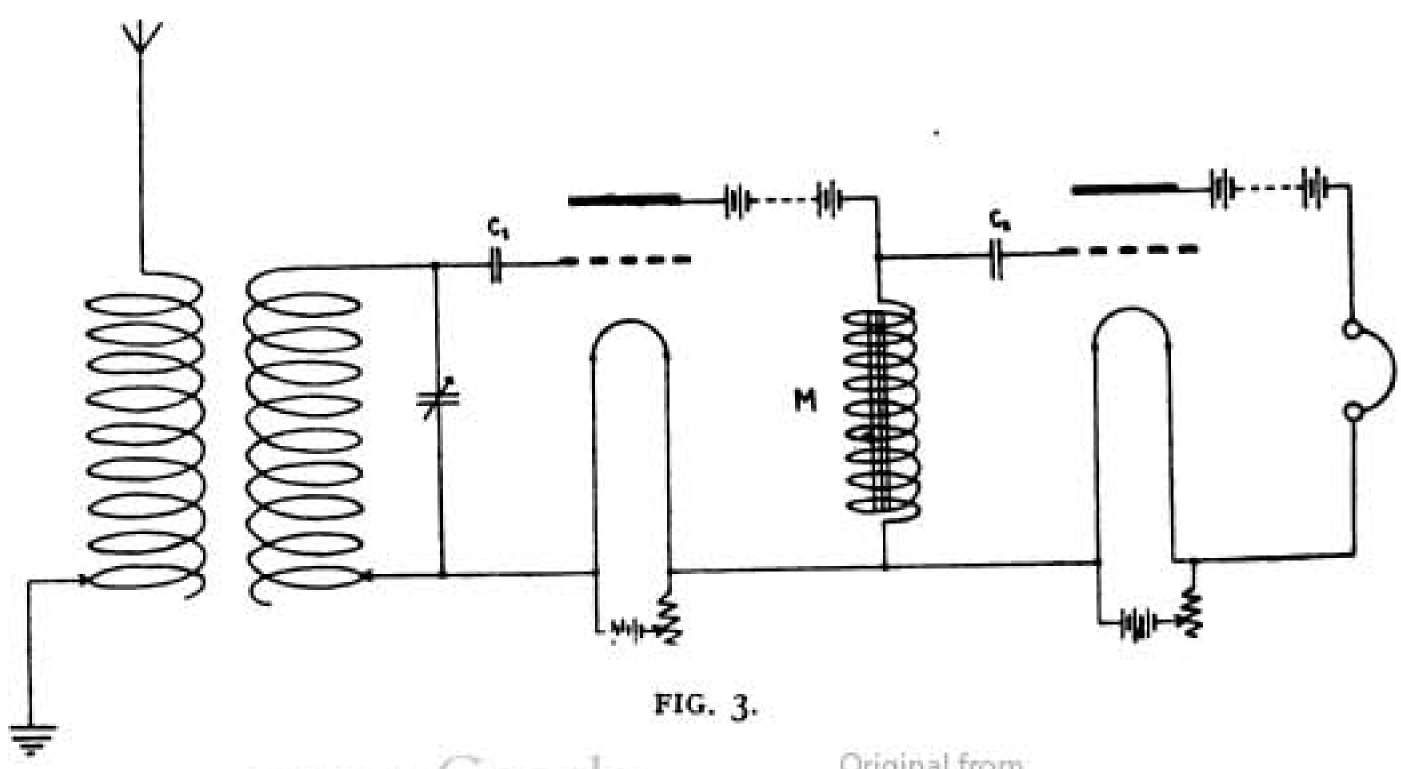


FIG. 3.

if made sufficiently large, will frequently cause sustained oscillations to take place in the circuits, and, if the frequency of the latter be suitably varied, continuous-wave signals may be heard.

Fig. 3 shows an arrangement, described by A. Hoyt Taylor, in which two audions are coupled together by means of a choking coil *M*. A very small blocking-condenser is used in the grid circuit of each valve. The variable condenser *C* should be of as small capacity as possible. With specially chosen valves the system is capable of oscillating of its own accord and continuous-wave signals may be received. The principle of the choking coil is that it allows the passage of the steady direct current of the plate circuit of the first valve, but tends to stop high-frequency or pulsatory current. The result is that oscillating and pulsating voltages are impressed on the grid of the second valve, producing loud signals in the telephone receivers included in the plate circuit of the second valve. With such a circuit continuous wave signals from Nauen were received at North Dakota, a distance of 10,000 miles, on an aerial 75 feet high.

In place of the choking coil *M* plain resistances have been found effective.

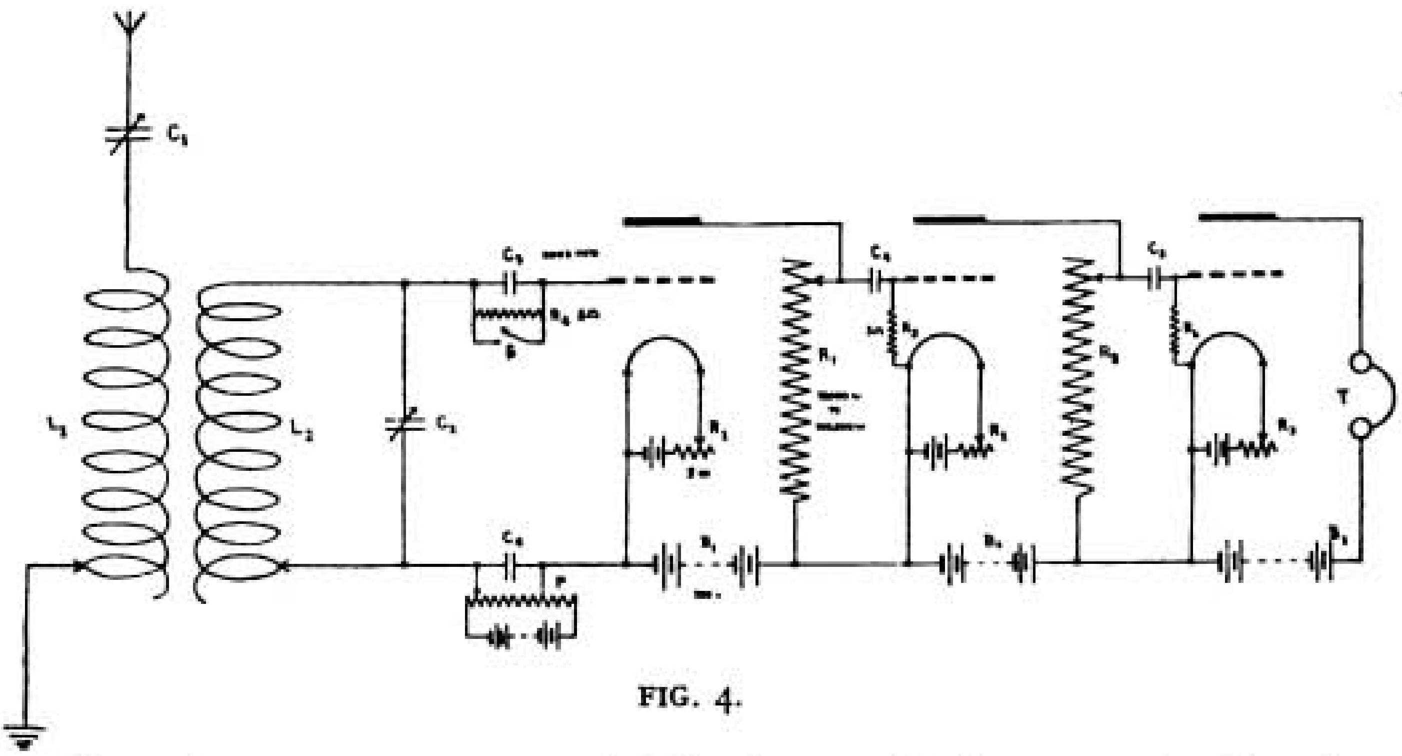


FIG. 4.

Fig. 4 shows an arrangement which has been used with success by the writer. In the grid circuit of each valve is a small condenser *C*, having a capacity of about ·0003 mfd., with a pencil-line resistance of about 5 megohms across the grid and filament. The filament current of each valve is smoothly variable by means of a rheostat of about 5 ohms resistance. In the plate circuit of each valve is a resistance variable by means of studs between the limits 10,000 ohms and 100,000 ohms. This resistance is composed of ten studs mounted radially on ebonite.

Between each pair of studs is connected a pencil-line resistance of 10,000 ohms resistance. These resistances may be constructed by making grooves about 1 in. long on a piece of ebonite with the sharp point of a knife. These grooves are then filled with graphite by simply rubbing an ordinary pencil across them. Terminals are fitted at each end so that good contact with the graphite is made. The terminals are connected to an insulation tester, and the grooved lines rubbed with pencil until the required resistance is obtained.

The function of these plate-circuit resistances is very similar to that of the choking coil in Fig. 3. The oscillations of potential and the slow telephonic current variations are, by their means, communicated to the grid of the next valve.

Instead of using the first valve as a rectifier it may be used almost solely as an amplifier of the original high-frequency currents. A switch *S*, shown in Fig. 4

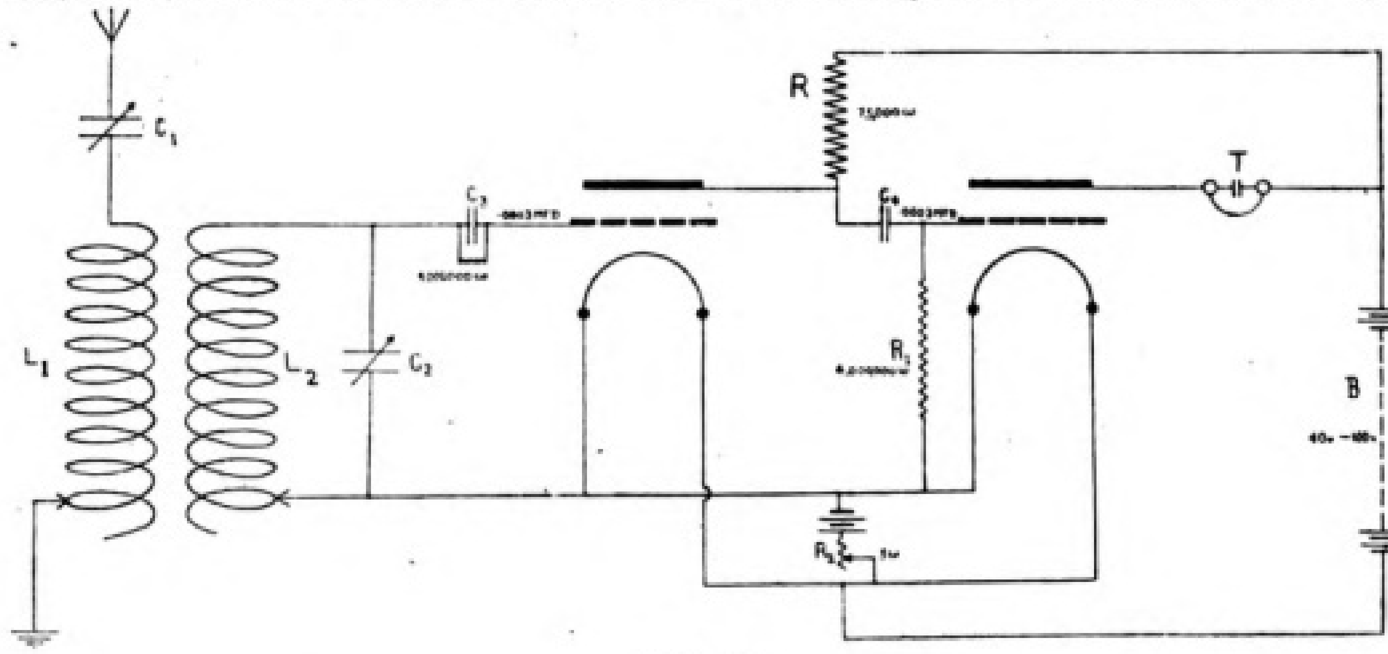


FIG. 5.

enables us to short the leaky grid condenser of the first valve, and the potentiometer P enables us to adjust the normal grid potential to a suitable value for pure amplification. In order to allow a free passage for high-frequency currents, a small condenser is shunted across the potentiometer P. The values of the plate voltage and filament current of the first valve will probably be different from the values in the case of the other two valves, since the latter are required as rectifiers.

In the plate current of the last valve is connected a pair of high-resistance telephone receivers. It is, however, preferable, as in all valve circuits, to use a step-down telephone transformer in conjunction with low-resistance 'phones.

Fig. 5 shows another receiving circuit capable of good amplification and utilising a pencil-line resistance to couple the two valves together. Both valves are used as rectifiers and have leaky condensers in their grid circuits. In the case of the second valve, the "leak," which is of about 4 megohms resistance, is of necessity connected directly across grid and filament instead of across the grid condenser. The resistance R is fixed, and has a value of 75,000 ohms, which has been found to give good results. If convenient, however, it should preferably be variable about that value. It will be seen that only one high-tension battery of 100 volts and one lighting accumulator is used for both valves. The telephone receivers are connected in the plate circuit of the second valve. With this arrangement oscillating potentials are set up across the resistance R having a frequency equal to the frequency of the incoming signals. At the same time there are comparatively slow

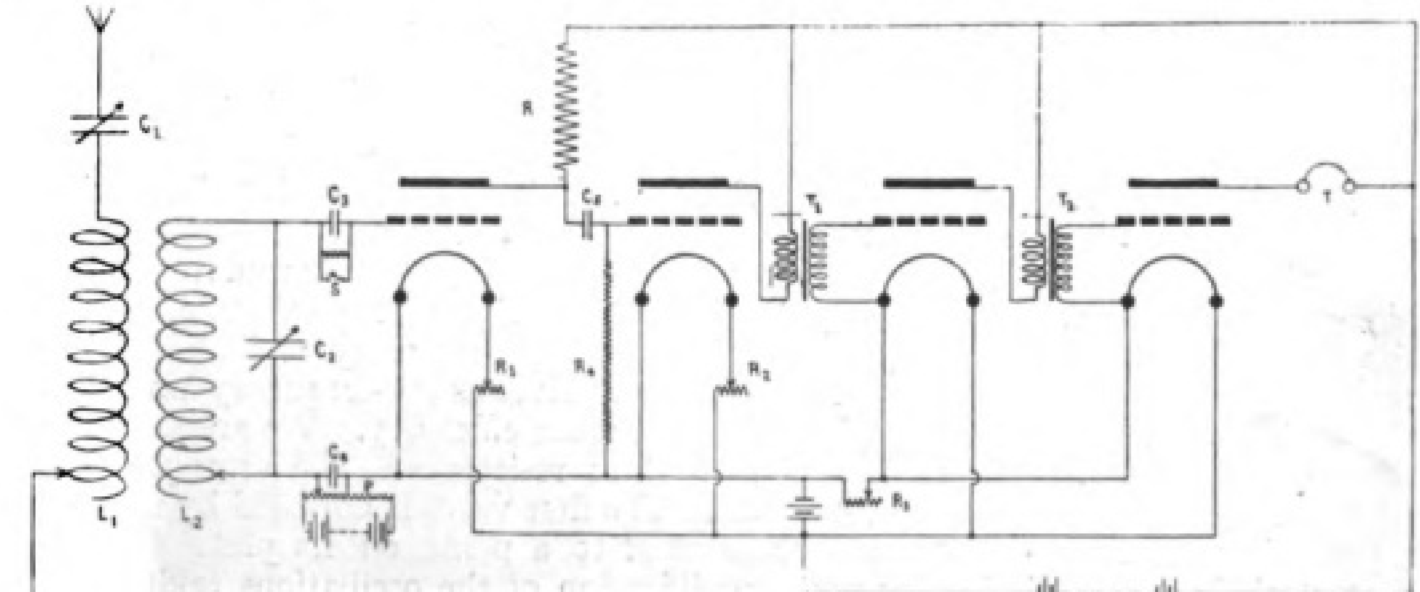


FIG. 6.

pulsating voltages, due to the rectifying action of the first valve. The frequency of these pulses is equal to the spark-frequency of the transmitting station or the beat-frequency of heterodyned continuous-wave signals, as the case may be. The magnitude of this pulsating voltage across R is proportional to the square of the voltage on the grid of the valve due to incoming signals.

At the foot of R we have, therefore, voltage impulses of both high and low frequency, and these are communicated to the grid of the second valve, in the plate circuit of which the amplified low-frequency pulses are detected by the telephones T.

It is found that such a circuit is more efficient for the reception of long waves than short waves. This is probably due to the impedance being insufficiently great for high frequencies. The capacity in the valve itself acts in parallel with the resistance R and lessens its effective impedance for oscillations of high frequency. By shortening and separating all connecting leads and using valves which have small capacity effects between different parts less inefficiency is experienced on short wave-lengths.

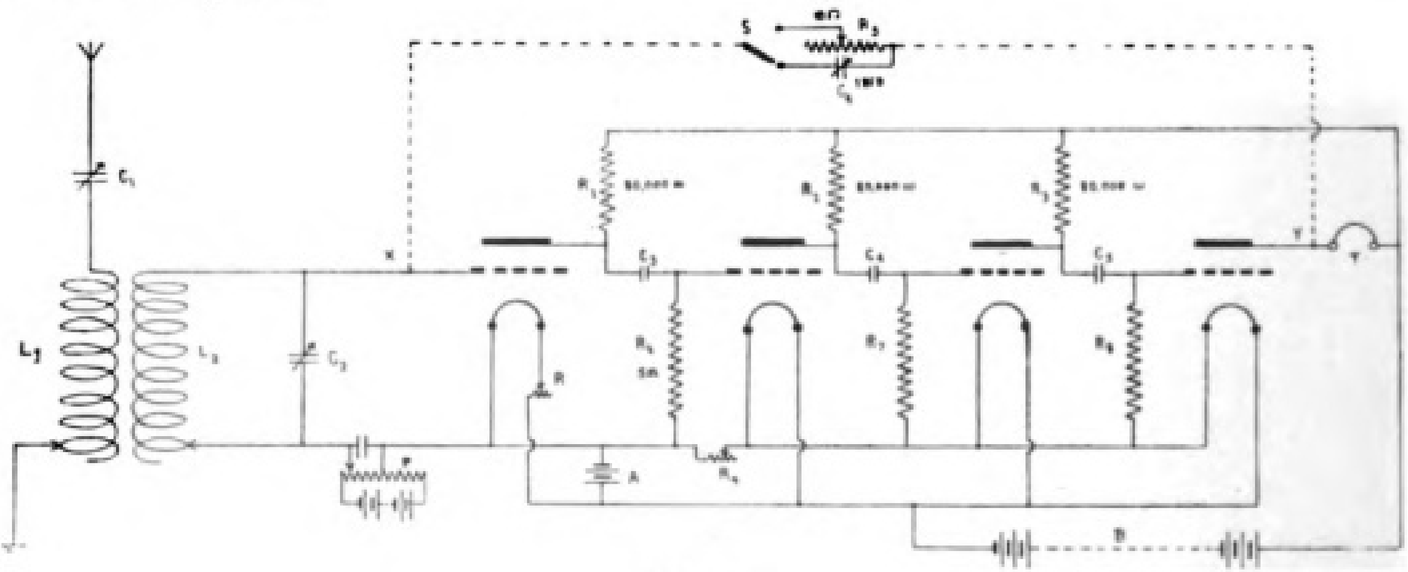


FIG. 7.

It may be as well to emphasise once again the need to cut down as much as possible the capacity of the closed circuit to which the first valve is connected. The condenser which is used to tune the circuit should only be large enough to give sharp tuning, most of the adjustment being done on the variable inductance.

Fig. 6 is a modification of Fig. 5. Two more valves are connected for the purpose of amplifying the low-frequency rectified pulses taking place in the plate circuit of the second valve. Instead of the telephones of Fig. 5, we have a step-up transformer, having a primary resistance of about 2,000 ohms, and a secondary of about ten times that resistance. This secondary winding is connected across the grid and filament of the first low-frequency amplifying valve, the plate circuit of which is likewise coupled by means of a step-up transformer to a second valve.

Another feature of the circuit is the grid condenser shorting switch S and the potentiometer P. The arrangement of Fig. 6 is not shown as a circuit to be specially recommended, but rather as an example of how different forms of amplification may be obtained and utilised in the same receiving circuit, using one accumulator and one high-tension battery. When the potentiometer of Fig. 6, for example, is used, the first valve is almost purely an amplifier of high frequency oscillations. The second valve is used as a rectifier and the last two valves as low-frequency amplifiers.

Fig. 7 is a four-valve amplifying circuit of great efficiency. We are now using three coupling resistances, each of 80,000 ohms resistance. The arrangement is simply a development of the Fig. 5 circuit. The first valve is adjusted by means of a potentiometer P and a separate rheostat R to a point on its plate and grid characteristic curve suitable for pure amplification of the oscillations taking place in the closed receiving circuit.

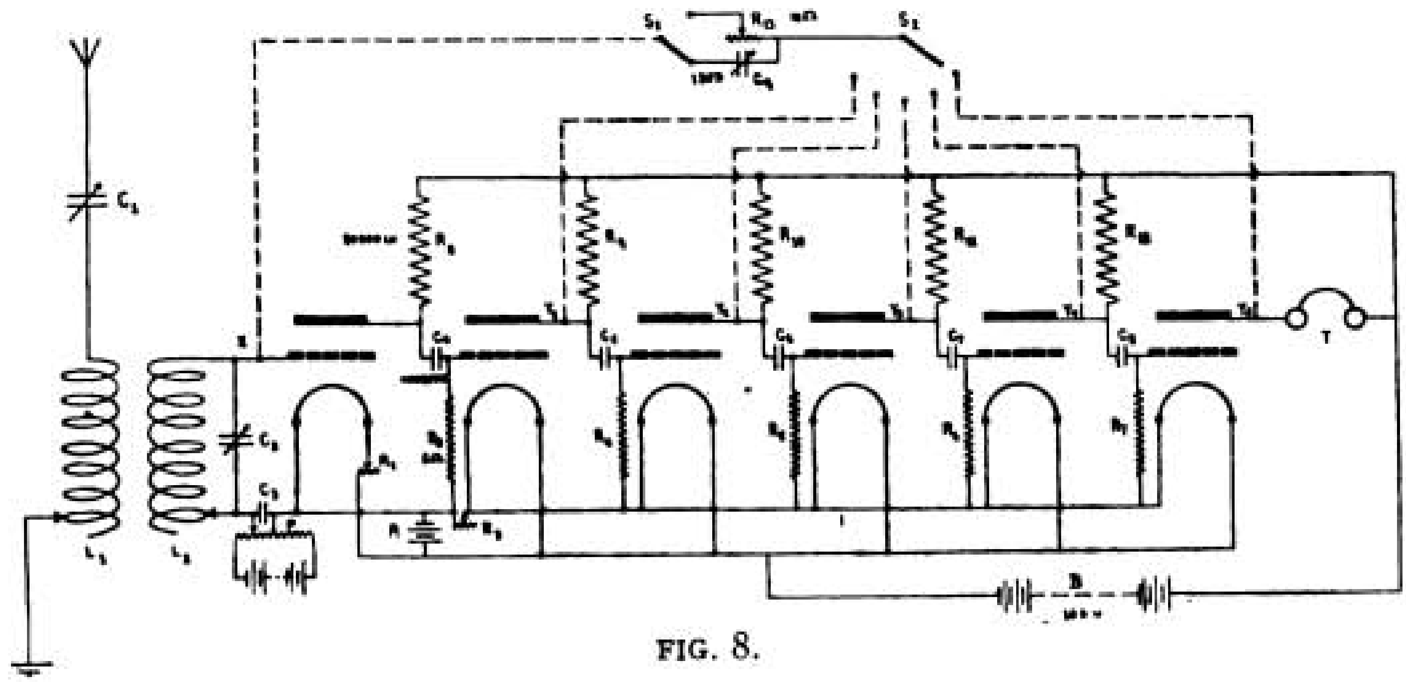


FIG. 8.

High-frequency pulses are produced at the foot of R_1, and are impressed on the grid of the second valve. This valve and the two remaining ones act as high and low-frequency amplifiers and have leaky condensers in their grid circuits for rectification purposes. Since their functions are alike, their filament currents are controlled by a rheostat R_4, common to all; the telephones are connected in the usual way in the plate circuit of the last valve.

A very interesting and valuable effect may be obtained in circuits of this type. The strength of signals is appreciably increased by producing a reaction effect from the plate of the last valve to the grid of the first one of the series. This may be accomplished by means of a very small variable condenser, or by a very high resistance. The former method is an example of capacity reaction coupling which is frequently met with in circuits which tend to oscillate of their own accord. By increasing the value of the small variable condenser the system can usually be made to pass through the regenerative stages prior to the point of instability at which maintained oscillations establish themselves. The dotted line in Fig. 7 shows the connections. A two-way switch allows for either the use of a very small reaction condenser or a resistance variable about a mean value of 10 megohms.

In Fig. 8 we have a six-valve circuit which is designed on the same lines as the one in Fig. 7, except that still further amplification is obtained. The first valve is used purely as an amplifier, and has a separate rheostat. The remaining valves act as rectifiers and high and low-frequency amplifiers. A five-way switch is provided which allows, for experimental purposes, the reaction resistance or condenser to be used from the grid of the first valve to the plate of the second, third, fourth, fifth, or sixth valve. By adjusting this reactance the circuits can usually be made to oscillate of their own accord. To tell when this is occurring it is only necessary to bring near the circuits an oscillating wave-meter, the design of which was first described by the writer in THE WIRELESS WORLD of October, 1917. On turning the wave-meter condenser round to "cut through" the wave-length of the oscillating circuit, a "chirp" should be heard. Even if the circuits are not oscillating, continuous-wave signals may be received by using the wave-meter for heterodyning the incoming oscillations; this will probably give even better results.

It will frequently be found, when dealing with circuits of this type, that various obscure reaction effects are produced by touching some part of the circuit. Signals are strengthened, but revert to their normal strength on taking the hand away. Such effects can generally be replaced and made permanent by connecting either a high resistance or small capacity across the part touched, and, say, the earth, the metal part of the head-gear or other point of the circuit found by trial.

Among the Operators

Although, happily, the loss of life at sea by enemy action has ceased, it is still our melancholy duty to record the names of operators who have lost their lives by accident and natural causes. The recent epidemic has taken heavy toll of Marconi men both at sea and on land. Mr. L. S. Craig was drowned at Gibraltar whilst bathing, on October 20th, 1918, and the remainder whose names are mentioned this month have died from natural causes. Both for our own part and that of our numerous readers we extend to the parents and relatives of these young men the deepest sympathy in their sad bereavement.

Born at Lewisham on August 7th, 1888, WARRANT TELEGRAPHIST ARTHUR JOHN REYNOLDS, R.N.R., was educated at St. Mary's School, Lewisham. He entered the service of the South-Eastern and Chatham Railway Company, Limited, after leaving school, and served with them for six years, joining the Marconi School at Seaforth for training in wireless telegraphy in September, 1909. Mr. Reynolds served on many ships and was well thought of by his commanders. He had also a period of duty at the Clifden high-power station. On August 4th, 1914, he joined up for naval duty, and reported to the Commodore, Naval Barracks, Devonport, for instructions. During the war he performed his duty with distinction, but unfortunately died on October 28th, 1918, of pneumonia.

MR. CLIFFORD WILLIAM PERKIN was born at Buxton on November 3rd, 1880, and educated at Buxton College. He was appointed telegraphist in the Buxton Post Office, transferring thence to Manchester. He served in the Boer War as Telegraphist R.E., from June, 1900, to May, 1902, after which he entered the Civil Telegraph Service of the Transvaal, and ultimately that of the British East Africa Protectorate. Indifferent health compelled him to return to his native land, and after a period of recuperation he joined the Marconi Seaforth School, being appointed to the staff as a seagoing operator on October 19th, 1910. Mr. Perkin was an expert telegraphist, widely known among the older men for his skill and personality. He held the Queen's and King's South African medals, and twice suffered torpedoing during the period of the war, dying in harness, at sea, of influenza, on October 11th, 1918.

MR. LESLIE SCOTT CRAIG was born at Inverallochy, Aberdeenshire, on December 8th, 1898, and went to the Public School, New Pitsligo, Aberdeen, for his education. His training in wireless telegraphy was received at the North British Wireless Schools, Limited, Glasgow, and after obtaining the P.M.G. Certificate Mr. Craig commenced his services with the Marconi Company in January, 1917.

In his eighteenth year, MR. ALEC CHARLES GILLIES was born at St. Giles-in-the-Wood, Leigh, North Devon, and received his education there and at Wallingbrook Secondary School. In order to relieve his brother for service with the army, he filled his place as gardener, subsequently attending the Marconi House School for training in wireless telegraphy, where he gained the P.M.G. Certificate and was appointed to the seagoing staff of the Marconi Company last May. Mr. Gillies succumbed to pneumonia on October 14th, 1918.

MR. HERBERT SAMUEL WALL was born at Ledbury on March 12th, 1901. He was educated at West Malvern School and trained under Marconi instructors at the Municipal Technical School Extension, Birmingham, in wireless telegraphy, where he qualified for the P.M.G. Certificate. On gaining the latter he was placed

ROLL OF HONOUR.

on the operating staff of the Marconi Company in June, 1918. Mr. Wall died of dysentery at Calcutta on October 21st, 1918.

Coatbridge, N.B., was the birthplace of MR. JAMES BROWNLIE on July 27th, 1895. After receiving his education at Bellshill Academy, he became a steel worker at the Mossend Steel Works. His wireless training was received at the North British Wireless Schools, Limited, Glasgow, and after passing the P.M.G. examination for his certificate, he joined the operating staff of the Marconi Company in March, 1917. Mr. Brownlie died at sea of influenza on October 18th, 1918.

MR. ARTHUR ERIC ARRAN, born at East Macclesfield on August 27th, 1899, was educated at Burnley, and commenced his career with the Whittlefield Mill Company, Limited, in that town. His wireless training was received at the City School of Wireless Telegraphy, Manchester, and on receipt of the P.M.G. Certificate he proceeded to sea as a Marconi operator in December, 1917. Mr. Arran's demise was from pneumonia following influenza.

MR. FRANK GULLEN was born on August 2nd, 1890, at Limerick, and was a pupil at the Limerick Model National School, and Closes's Intermediate School. After completing the curriculum of the latter, he took up a position as a commercial clerk, leaving it to embrace wireless as a career, and was trained in radiotelegraphy at the Atlantic Wireless Telegraph College, Cahirciveen. Mr. Gullen was given the P.M.G. Certificate in November, 1913, and then entered the service of the Marconi Company. His death, which took place on October 30th, 1918, was also due to pneumonia following influenza.

Born at Finniterstown, co. Limerick, on June 23rd, 1900, MR. JOHN JOSEPH JONES was educated at the National School, Skeheenarinky, co. Tipperary. He attended the Irish School of Telegraphy, Cork, and there qualified for the P.M.G. Certificate. After its award Mr. Jones joined the Marconi Company's service in March, 1918. His death on October 26th, 1918, was from pneumonia following influenza.

Formerly a boy telegraphist in the Royal Navy and serving on board H.M.S. *Impregnable*, H.M.S. *Vernon*, and at the Royal Naval Barracks, Chatham, from whence he was invalided out of the service, MR. FRANK LESLIE DELLAR was born at Kensington on January 21st, 1899, and educated at the Royal Hospital School, Greenwich. His service with the Marconi Company dated from November 21st, 1915, and continued until the time of his death on October 25th, 1918, which took place from heart failure following influenza, on board the s.s. *Sagama River*, at Greenock.

Born at Llandudno on September 13th, 1898, MR. JOHN STANLEY LEVIS was educated at the Duffryn Road Council School, and "The John Bright" County Secondary School in the same town. He was employed for a time as salesman with Messrs. Hogg and Mitchell, of Manchester, after which he became a student at the City School of Wireless Telegraphy, Manchester. When possessed of the P.M.G. Certificate, Mr. Levis was placed on the seagoing staff of the Marconi Company in June, 1907. The cause of death, at sea, was fever.

MR. TIMOTHY REGAN was born at Glandore, co. Cork, on September 9th, 1891, and attended Glandore Boys' School and Skibbereen Collegiate School for his education. He was a competent yachtsman, and sailed on several well-known private yachts before attending the Liverpool Wireless Telegraph Training College, where he gained the P.M.G. Certificate. Mr. Regan was placed on the operating staff of the Marconi Company in February, 1916. He died of pneumonia on October 31st. 1918.

Instructional Article

NEW SERIES (No. 11)

EDITORIAL NOTE.—Below we give the eleventh of a new series of twelve Instructional Articles devoted to PHYSICS FOR WIRELESS STUDENTS. *Although at first sight the subject of physics would not seem to have a very intimate connection with wireless telegraphy, yet a sound knowledge of this subject will be found of the greatest use in understanding many of the phenomena met with in everyday radiotelegraphy. As in previous series, the articles are being prepared by a wireless man for wireless men, and will therefore be found of the greatest practical value.*

THE QUANTITATIVE MEANING OF SYMBOLS AND FORMULÆ.

The Relative Combining Weights of Elements.—It has been explained that chemical formulæ show the proportions in which the atoms in compound molecules have combined, because of the fact that they are written according to an agreed method, each symbol representing a certain number of atoms and each formula a certain number of molecules. Thus, taking the case of manganese dioxide, the formula for which is MnO_2, the student is now able to see at once that a molecule of this material is composed of manganese and oxygen in the proportion of 1 atom of Mn to 2 atoms of O.

This kind of information is, however, insufficient to give us a practical working idea of the proportion of each element in a compound. Suppose we wish to prepare a *certain quantity* of a compound, say of copper sulphate ($CuSO_4$) for use in a Daniell's cell; if we know nothing more about the amount of each ingredient required than that we must bring them together in the proportions of 1 atom of copper, 1 atom of sulphate and 4 atoms of oxygen, we shall find ourselves faced with an impossible task and shall be forced to work in the dark. Even if we know that a practical method of making copper sulphate is to dissolve copper in sulphuric acid, how are we to decide how much of these materials to use in order to produce the quantity of sulphate needed? The equation representing the action is

$$Cu + 2H_2SO_4 = CuSO_4 + SO_2 + 2H_2O$$

and, as will be shown presently, this and a knowledge of the atomic weights of the four elements concerned will enable us to overcome the difficulty.

We know that the atomic weights of elements are *relative* weights; therefore, as the symbol of an element means 1 atom of that element we can consider it to mean also *a number of relative parts by weight*, the number being the same as that representing its atomic weight. For example, as the atomic weight of hydrogen is 1·008, its symbol, H, means "1·008 relative parts by weight of hydrogen"; and H_2 means "2·016 relative parts by weight of hydrogen." Taking the case of a formula, say $ZnSO_4$, we understand this to mean that zinc sulphate is composed of 65·4 parts by weight of zinc, 32 parts by weight of sulphur and 64 parts by weight of oxygen. Thus, if zinc sulphate could be made by merely bringing these three elements directly together we should know that to produce $(65{\cdot}4 + 32 + 64) = 161{\cdot}4$ parts by weight —tons or ounces or grammes—of this compound, we should need 65·4 tons, ounces or grammes of zinc, 32 tons, ounces or grammes of sulphur and 64 tons, ounces or grammes of oxygen. It does not matter what weight we make the "parts" so long as all the "parts" are of equal weight.

Emergency Preparation of $CuSO_4$ for Daniell's Cell.—Returning now to this question, by simple calculation from the atomic weights we find from the equation $Cu+2H_2SO_4=CuSO_4+SO_2+2H_2O$ that

63 parts Cu + 196 parts H_2SO_4 = 159 parts $CuSO_4$ + 64 parts SO_2 + 36 parts H_2O.

Hence it is evident that to prepare 159 ounces of copper sulphate we must treat 63 ounces of copper with 196 ounces (by *weight*—not *fluid* ounces) of sulphuric acid. Once these proportions are known it is a simple matter to decide how much copper and acid is required to make a given amount of this salt.

Thus it is seen that a chemical equation is also a mathematical equation, both sides being, in the sense just explained, numerically equal. Bringing down the figures of the above equation we get $63+196=159+64+36$, which is correct.

It may be useful to point out that the copper and acid (concentrated) should be very gently and carefully heated together in a chemical glass or porcelain vessel until the action commences; the heat should then be adjusted so that the action continues without undue violence. Clean copper filings, turnings or thin wire should be used, and when it has been dissolved the solution should be filtered if necessary, and evaporated almost to dryness; the residue is then ready for use. If required urgently the copper sulphate need not be brought to the solid state; in this case the solution which remains after the action should be evaporated to saturation point and put straight into the cells.

(1) Use distilled water if possible.

(2) Use slightly more acid than the amount required theoretically.

(3) Avoid the fumes of SO_2 which are evolved; they are extremely pungent. In this connection it is worth mentioning that if an emergency fumigator is required, no sulphur being obtainable, these fumes will serve the purpose efficiently.

Molecular Weights.—Chemical symbols and formulæ serve also as the means of determining the relative *molecular* weights of substances. The symbol O represents an atom of oxygen of relative weight 16; hence O_2, the symbol for a molecule of oxygen, at once gives us 32 as the relative molecular weight. A few more examples follow:—

Water (H_2O)	Relative molecular weight $=(1\times2)+16$	$=18$
Sulphuric acid (H_2SO_4) .	Relative molecular weight $=(1\times2)+32+(16\times4)$	$=98$
Sodium chloride ($NaCl$) .	Relative molecular weight $=23+35$	$=58$
Carbon dioxide (CO_2) .	Relative molecular weight $=12+(16\times2)$	$=44$

These weights in grammes are the gramme-molecules of the substances.

It is sometimes necessary to know the *percentage* of a certain element in a compound and this is easily found if the formula of the latter is known. For example, the percentage of lead in litharge may be calculated as follows. The formula is PbO, which means that $(207+16)=223$ parts by weight of litharge contain 207 parts by weight of lead; hence the percentage is $\frac{207\times100}{223}=92{\cdot}82$ per cent.

The Volume of Gases.—In addition to indicating the relative weights of reacting substances chemical formulæ furnish us with data to determine the relative *volumes* of gaseous substances, but before explaining this we must state the **Law of Avogadro,** which is as follows: **Equal volumes of all gases at the same temperature and pressure contain an equal number of molecules.** We cannot here consider the reasons which led to the enunciation of this law; for our present purpose the reader may accept it as true. The formula for 1 *molecule* of ammonia is NH_3 and from this we know that the relative molecular weight is $(14+3)=17$. The formula for 1 *molecule* of carbon dioxide is CO_2, hence the molecular weight is 44. The formula for 1 *molecule* of hydrogen is H_2, giving us the molecular weight as 2. Here we have the relative weights of three different molecules,

NH_3 . . . . 17 $\qquad$ CO_2 . . . . 44 $\qquad$ H_2 2

and assuming that they are under similar conditions of temperature and pressure, *by Avogadro's Law* the volumes occupied by these molecules are equal. Hence their relative *densities* must be

$NH_3 \ldots . 8{\cdot}5 \qquad CO_2 \ldots . 22 \qquad H \ldots . 1$

We may say, therefore, that the relative densities of gases as compared with hydrogen, which is taken as unity, are found by halving their molecular weights.

Now it was shown above how the weight of gas produced by chemical action can be calculated if the weight of the original substances is known, but it is also possible to find the *volume* of gas evolved at standard temperature and pressure if we know its relative density. Measured at 0° C. and 760 mm. pressure a gramme of hydrogen has a volume of 11·165 litres,* and as the density of carbon dioxide is 22 it is obvious that 22 grammes of that gas measured under the same conditions will occupy the same volume as one gramme of hydrogen. This may be further explained as follows: Suppose we pour a liquid into a vessel until a certain mark is reached and then ascertain that that amount of liquid weighs 1 lb.; obviously, if we fill the vessel up to the same mark with another kind of liquid which is 22 times heavier than the first, or, in other words, whose density relative to the first is 22, the weight of the measured quantity of the second liquid will be 22 lbs. Hence *the relative density of any gas, expressed in grammes, gives us that weight of the gas which will occupy a volume of* 11·165 *litres.*

Examples:—

Relative density of a gas $= \frac{\text{Its molecular weight}}{2}$

At 0° C. and 760 mm., $\frac{\text{molecular wt.}}{2}$ grammes of any gas occupy 11·165 litres.

At 0° C. and 760 mm., $\frac{71}{2} = 35{\cdot}5$ grammes of Chlorine occupy 11·165 litres.

At 0° C. and 760 mm., $\frac{17}{2} = 8{\cdot}5$ grammes of Ammonia occupy 11·165 litres.

At 0° C. and 760 mm., $\frac{32}{2} = 16$ grammes of Oxygen occupy 11·165 litres.

From the above it follows at once that *the gramme-molecule of any gas, measured at 0° C. and 760 mm. pressure, will occupy* $(11{\cdot}165 \times 2) = 22{\cdot}33$ *litres.*

We are now in possession of sufficient data to calculate the volume of a gas evolved as a result of chemical action, provided the equation representing the action is known.

Example.—Suppose we wish to fill a vessel of capacity roughly 50,000 cubic centimetres with hydrogen which is to be prepared by the action of sulphuric acid on zinc. How much zinc must be used?

(*a*) The equation being $Zn + H_2SO_4 = ZnSO_4 + H_2$ we know at once that 65 grammes of zinc will give us two grammes of hydrogen, or, in other words, a gramme-molecule of hydrogen.

(*b*) A gramme-molecule of hydrogen measured at 0° C. and 760 mm. has a volume of 22·33 litres, and as this is produced by the solution of 65 grammes of zinc it is easy to calculate that to obtain the required volume—*i.e.*, 50 litres—we must use about 150 grammes of zinc. From our figures we actually get $\frac{50 \times 65}{22{\cdot}33} = 145{\cdot}5$ grammes of Zn; in practice this amount would be increased in order to compensate for that volume of gas which would remain in the apparatus after the action had ceased.

The volume we have just found, however, is that of the gas at 0° C., a temperature which is not always readily reached; what we really need to know is the volume when the gas is measured at the temperature and pressure at which it is made.

* 1 litre = 1,000 cubic centimetres.

Ordinary atmospheric pressure at sea-level is 760 mm., and we will assume that the temperature under normal working conditions would be about 18° C. Our problem is to find out how much zinc must be dissolved in H_2SO_4 in order to produce 50 litres of hydrogen at *normal* temperature and pressure.

Charles' (or Gay-Lussac's) Law.—*If the pressure is kept constant the volume of a gas is directly proportional to the absolute temperature.*

Absolute Temperature.—This is the temperature in Centigrade degrees, plus 273°, or, the number of Centigrade degrees above −273° C.—a temperature which has never been attained. *E.g.*, if Centigrade temperature=60°, the absolute temperature=60°+273°=333°.

From a consideration of Charles' Law it may be seen that the same volume of all gases should increase by the same amount when the temperature is raised 1°; indeed, experiment has shown that this is very nearly true. The constant increase in volume for every degree increase in temperature, the pressure remaining constant, is called the **Coefficient of expansion of a gas**, and is $\frac{1}{273}$ (0·00366) of the volume.

As the volumes are directly proportional to the absolute temperature we can say that,

$$\frac{\text{1st Vol.}}{\text{2nd Vol.}}=\frac{\text{1st Temp. (Abs.)}}{\text{2nd Temp. (Abs.)}}$$

Let 1st Vol. be 1, and 1st Temp. 273° Abs. (0° C.). Then if the temperature be raised 1°, *i.e.*, to 274° Abs., the 1st Vol. will increase to $1+\frac{1}{273}$. Putting these figures into the foregoing equation, we get

$$\frac{1}{1+\frac{1}{273}}=\frac{273}{274},$$

which is obviously a true equation, the general form of which may be written

$$\frac{v_1}{v_2}=\frac{t_1}{t_2}$$

Now our task is to find the increase in volume of 22·33 litres of hydrogen (measured at 0° C. and 760 mm. pressure) if the temperature is raised to 18° C. (or 291° Abs.) while the pressure remains the same; that is, we have to find the value of v_2 in the last equation.

$$\frac{v_1}{v_2}=\frac{t_1}{t_2}, \text{ hence}$$

$$v_2=\frac{v_1 t_2}{t_1},$$

so that by using our figures we get

$$v_2 \text{ (or the vol. at 291° Abs.)}=\frac{22{\cdot}33\times 291}{273}=23{\cdot}8$$

This is the number of litres of hydrogen which the solution of 65 grammes of zinc in sulphuric acid will produce at atmospheric temperature and pressure; therefore to obtain 50 litres of gas we must dissolve

$$\frac{65\times 50}{23{\cdot}8}=136{\cdot}5 \text{ grammes of zinc,}$$

although, as was previously mentioned, this quantity would be slightly increased in practice, to allow for the capacity of the vessel in which the gas is made.

NOTE 1.—**Standard Pressure.**—This is a pressure of **one atmosphere**, and will support a column of mercury 76 centimetres high at 0° C. Taking the weight of a cubic centimetre of mercury as nearly 13·6 grammes the standard column of mercury will correspond to a pressure of about 13·6 × 76 = 1033·6 grammes per square centimetre, roughly 14·7 lb. per square inch.

NOTE 2.—**Density and Specific Gravity.**—Having referred in this article to the *density* of gases it may be useful to point out that this quantity is **mass per unit volume,** whereas *specific gravity* is the **weight of a given body compared with that of an equal volume of water at 15° C.** Supposing we wish to know the specific gravity of some engine oil, we can estimate as follows :—

$$\text{Sp. Gr.} = \frac{\text{Wt. of given vol. of oil}}{\text{Wt. of same vol. of water}}$$

A useful practical standard is, 1 gallon of water weighs 10 lb. Weighing 1 gallon of the oil we find it to be, say, 9 lb.

Hence its Sp. Gr. $= \frac{9}{10} = 0{\cdot}9$ (a ratio only) and a value which corresponds to a light motor oil, too heavy for sewing-machines or spindles but too light for cylinders and heavy shafting. This method is "rough and ready"; in the laboratory about 50 cc. of water and of oil would be weighed on a fine chemical balance, and the calculation carried to three figures.

If instead of using lbs. and gallons we conduct the experiment in cubic centimetres and grammes we shall arrive at 0·9 just the same, and in this system (C.G.S.) the figure for the Sp. Gr. is also that for the density. Hence the ***density*** of our oil is 0·9 grammes per c.c. Under the British system density is (Sp. Gr. ×62·3) lb. per cubic foot; therefore the density of our oil may be said to be (62·3 ×0·9)=56 lb. per cubic foot.

CONSTRUCTION OF EQUATIONS.

Before leaving the subject of formulæ it is desirable to go briefly into the method of writing equations, the object being to assist the student to construct them for himself and to appreciate fully those which he may encounter in his reading. In order to give the correct equation to a chemical action we must know the composition of the substance or substances taking part in the action and the composition of the final products of the action.

Example 1.—Quicklime is made on a commercial scale by burning chalk in kilns. What equation represents the chemical action involved? Qualitative analysis shows that chalk is calcium carbonate, and quantitative analysis has determined the composition of this substance to be represented by the formula $CaCO_3$. Then, experiment proves that if $CaCO_3$ is strongly heated it breaks up into carbon dioxide and calcium monoxide (quicklime). Putting these facts down in the form of an equation, we get

Calcium carbonate = Calcium monoxide + carbon dioxide

or

$$\begin{array}{ccccc} CaCO_3 & = & CaO & + & CO_2 \\ \text{(5 atoms)} & = & \text{(2 atoms)} & + & \text{(3 atoms)} \end{array}$$

Example 2.—Now certain oxides of metallic elements form hydroxides when combined with water, and lime is one of these; when it is exposed to a moist atmosphere it combines with water to form calcium hydroxide (slaked lime). The equation to this action can be written down at once as

$$CaO + H_2O = Ca(HO)_2$$

The primary thing to be careful of in making equations is the conservation law; if we have x atoms to begin with—*i.e.*, on the left-hand side—we must have x atoms remaining—*i.e.*, on the right-hand side.

Example 3.—When a hydroxide combines with an acid a salt is formed; therefore, if we treat calcium hydroxide with hydrochloric acid the products are calcium chloride and water. Writing down

$$Ca(HO)_2 + HCl = CaCl + H_2O$$

we find that we cannot make a correct equation in this case by simply putting the formulæ of the reacting substances on one side and those of the products on the other.

In fact, what we have just written is not an equation at all, because on the left-hand side we have 7 atoms and on the other side only 5 atoms. Besides this, $CaCl$ is not the true formula for calcium chloride; it should be written $CaCl_2$. The way out of the difficulty is to put $2HCl$ instead of HCl. This gives us the extra atom of chlorine required and also enables us to make a true equation as regards the number of atoms shown on each side. The correct statement is

$$Ca(HO)_2+2HCl=CaCl_2+2H_2O$$

After writing $CaCl_2$ we find we have to account for 4 atoms of H and 2 atoms of O, and these obviously make up 2 molecules of H_2O. The student may ask how he could be expected to know the true formula for calcium chloride to be $CaCl_2$ and not $CaCl$. A knowledge of the formulæ of compounds is largely a matter of experience and memory; one has to acquire them in much the same way as one acquires a vocabulary. In the case of calcium chloride a knowledge of the **valency** of calcium would enable the student to realise at once that its atom combines with *two* atoms of chlorine. Valency will be dealt with in the next article.

Example 4.—If calcium carbonate (chalk, marble, egg-shell, etc.) is treated with hydrochloric acid the products of the action are calcium chloride, carbon dioxide and water, and if we write this in the simplest way we again find that we get a wrong statement.

$$CaCO_3+HCl=CaCl_2+CO_2+H_2O.$$

Here all the formulæ are correct but the *quantities* are not, there being (*a*) 1 *atom of H in excess on the right-hand and* (*b*) 1 *atom of Cl in excess on the right-hand.* Therefore we write

$$CaCO_3+\mathbf{2HCl}=CaCl_2+CO_2+H_2O.$$

If the action were to be carried out in practice according to the incorrect equation we wrote first, the result would be that the HCl would be insufficient and only half the quantity of $CaCO_3$ present would be decomposed.

Example 5.—When mercuric oxide is strongly heated it decomposes into mercury and oxygen, and the most direct way of writing the equation is

$$HgO=Hg+O$$

But this is wrong, for it shows a *free atom* of oxygen, and we know that a molecule of oxygen—a structure made up of *two* atoms—is the smallest particle of that gas which can exist in a free state. The oxygen molecule being di-atomic the equation must be

$$2HgO=2Hg+O_2$$

Note that we write $2Hg$ and not Hg_2 because Hg_2 would represent "a molecule of mercury composed of two atoms," whereas the Hg molecule is **mon**-atomic; hence as we have 2 atoms of Hg we also have 2 *molecules* of Hg, and they are represented according to the rule, with the figure 2 preceding the symbol.

Share Market Report

BUSINESS has been extremely quiet during the past month and there is little change to record. Prices as we go to press are:—Marconi Ordinary, £4 11s. 3d.; Marconi Preference, £3 15s.; American Marconi, £1 9s.; Canadian Marconi, 12s. 9d.; Spanish and General, 14s.; Marconi International Marine, £3 10s.

Personal Notes

Decorated.

We are pleased to learn that Warrant Telegraphist Allan Anderson, D.S.O., D.S.M., has received two decorations and has been twice mentioned in dispatches for service whilst engaged in wireless duties.

Whilst still a Chief Petty Officer at the Scarborough Wireless Station he was commended by Admiral Sir A. M. Farquhar, K.C.B., C.V.O., for ingenuity displayed in devising a "quick method" of working certain codes.

Presentation.

On December 30th last the managing director of the Marconi International Marine Communication Company, Limited, presented on behalf of Lloyd's a bronze medal and certificate to Operator W. C. Bowey for meritorious conduct in rendering valuable assistance to the captain of the s.s. *Beaumaris* at the time when she was torpedoed by an enemy submarine. A full description of this incident was published in the Personal Notes of the August number of The Wireless World for 1918.

After personally congratulating Mr. Bowey, Mr. Isaacs said that the presentation ceremony had been delayed owing to his (Mr. Bowey's) absence, but he now had great pleasure in presenting the medal and certificate. Mr. Bowey had worthily upheld the best traditions of the service. After dwelling on the pluck displayed by the brave operator, Mr. Isaacs said that it had been decided by the directors to award Mr. Bowey, as a mark of appreciation, the sum of £50, in addition to the monetary grant already given by the Merchant Ships Gratuity Committee. The ceremony concluded by individual congratulations from all the officials who were present.

Wireless Telegraphists Celebrate the Armistice.

A correspondent from the Admiralty Wireless Station at Murcar, Aberdeen, sends us an interesting account of a dinner given to celebrate the defeat of the Hun. The chair was taken by Senior Petty Officer W. Pettengill, in the absence of the Commanding Officer, Lieut. W. J. Picken, R.N.V.R., and a number of operators were present.

The usual toasts and speeches were followed by a musical programme. Among the performers were P.O.'s Davis, Baker, Condon, Maltby, Barrow, Wellington and White Taylor, the last named being responsible for the arrangements.

Institute of Electrical Engineers.

Mr. J. C. Hawkhead, joint author with Mr. H. M. Dowsett of the well-known *Handbook of Technical Instruction for Wireless Telegraphists*, has recently been elected an Associate Member of the Institute of Electrical Engineers.

Scandinavian Associations of Wireless Telegraphists.

We learn from Copenhagen that the Skandinavisk Radiotelegrafist Forening of 1917, Copenhagen, has now succeeded in establishing close relationship with the two already existing Norwegian Associations of Wireless Telegraphists. All these Associations work in conjunction with one another, and on formation of the contemplated Swedish operators' union it is hoped that a "Skandinavisk Radiotelegrafist Union" may be created.

LIEUT. BASIL COOK, R.E.

OBITUARY.

We regret to learn of the death of LIEUTENANT BASIL EGERTON COOK, R.E., who fell a victim to pneumonia following an attack of influenza. Lieutenant Cook joined the Royal Engineers as a sapper in 1916, and proceeded to France, where he obtained his commission as a Wireless Officer, and went through the Battle of the Somme. He was invalided with shell shock and, until the time of his death, employed on home service.

FLIGHT CADET JOHN MASHEDER, of St. Annes-on-Sea, Lancashire, was killed in an aeroplane accident in Egypt on September 19th, 1918. He was accepted in the Wireless Branch of the R.F.C. in February, 1917.

Much sympathy is felt with Mr. and Mrs. W. C. Coleman, of 58, Elers Road, West Ealing, whose eldest son, CHARLES JAMES BRUCE COLEMAN, 66th Wing, R.A.F., died on October 27th, 1918, whilst on active service in Italy, and was buried with full military honours at Taranto. He joined the R.N.A.S. in January, 1917, and proceeded to Italy on November 4th of that year, on special service.

The accompanying illustration shows the last resting place, at Bagdad, of the late CAPTAIN W. H. PAYNE, Deputy Manager of Amalgamated Wireless (Australasia), Ltd., whose death occurred on active service in December, 1917, and whose obituary notice we published in the May, 1918, issue.

CAPT. PAYNE'S GRAVE.

AWARD.

The Distinguished Conduct Medal has been awarded MECH. ELECT. STAFF-SERGEANT J. SMITH, R.E., of Pelaw, who, through his bravery and energies as a wireless fitter, although under great mental and physical stress at the time, kept his station in working order throughout a long siege, daily transmitting a large volume of traffic. His splendid determination and heroic endurance were beyond praise.

RESCUE.

MR. WALTER CONDON, wireless officer, Bridge of Don, Aberdeen, was fortunate in being able to save a man who had fallen into the river there. Mr. Condon did not find the work of rescue an easy one, as he had to make fast a rope round his body before going down the steep bank into the river to pull the man out. This constitutes Mr. Condon's second successful life saving and his third attempt.

MR. E. T. S. DE LACEREA.

SANK WITH HIS SHIP.

MR. E. T. S. DE LACEREA, of Société Anonyme Internationale Télégraphie sans fil, who was junior operator on board the Portuguese steamer *Brava*, lost his life when that vessel was torpedoed by the enemy. Mr. de Lacerea was born at Ponta Delgada, Azores, on January 9th, 1899, and entered the wireless service a little over a year ago. As the ship sank in four minutes Mr. de Lacerea had no chance of escape, being imprisoned in his berth by the collapse of the cabin.

Questions & Answers

ANNOUNCEMENT

We have received a large number of inquiries this month regarding pay and prospects in the Wireless Service. As the space required to publish this information in full would cover several pages applications should be made for Conditions of Service to The Traffic Manager, The Marconi International Marine Communication Company, Ltd., Marconi House, Strand, London, W.C.2.

NOTE.—*This section of the magazine is placed at the disposal of all readers who wish to receive advice and information on matters pertaining to both the technical and non-technical sides of wireless telegraphy. Readers should comply with the following rules :* (1) *Questions should be numbered and written on one side of the paper only, and should not exceed four in number.* (2) *Queries should be clear and concise.* (3) *Before sending in their questions readers are advised to search recent numbers to see whether the same queries have not been dealt with before.* (4) *The Editor cannot undertake to reply to queries by post.* (5) *All queries must be accompanied by the full name and address of the sender, which is for reference, not for publication. Queries will be answered under the initials and town of the correspondent, or, if so desired, under a "nom-de-plume."* (6) *During the present restrictions the Editor is unable to answer queries dealing with many constructional matters, and such subjects as call letters, names and positions of stations.*

A. F. (Invergold).—With the receiver adjusted above the normal range it is sometimes possible to hear signals from stations working on very long waves, even though it is impossible to reach a state of resonance. This, however, in no wise affects the validity of the general statement made by the author of the article you mention.

D. S. (Rhyl).—We are not yet in possession of any information as regards the official attitude towards amateur wireless telegraphy. On receiving such information we shall immediately make it public in the columns of THE WIRELESS WORLD.

M. M. H. (Salisbury).—(1) As regards the actual telegraphy, technology and knowledge of regulations, it is possible to prepare for the Postmaster-General's Examination by home study. In order to obtain the certificate a candidate must pass in actual fault tracing on apparatus on which practice is necessary. (2) There are no women employed as wireless operators on British ships at the present time.

G. H. W. (Grimsby).—See announcement at the head of these columns.

CPL. S. O. B. (Basra).—(1) For particulars regarding examinations for the P.M.-G. Certificate you should apply to the Inspector of Radiotelegraphy G.P.O., London. (2) We believe that the Technical School at Plymouth has instituted a course in wireless telegraphy. (3) It would appear that you have already reached the required standard for telegraphy, and the time required for coaching in technical work would depend upon your previous knowledge. (4) Application to the above address would bring you information regarding fees. (5) See announcement at the head of these columns.

RADIO (Aberdeenshire).—(1) Refer to page 491 of the December issue of THE WIRELESS WORLD. (2) See pp. 495 same issue. (3) See announcement at the head of these columns.

N. W. C. (Harwich).—The interference which you mention may perhaps be caused by induction from nearby current-carrying cables, and in such cases is probably caused by small fluctuations of the current due to commutation. This may sometimes be eliminated by earthing one of the brushes of the machine in the case of a non-earth return. Sometimes it is necessary to re-arrange entirely the wiring of the mains, but in other cases the trouble can be eliminated by a re-arrangement of the external wiring of the receiving circuits.

G. G. B. (Liverpool).—You will find *The Handbook of Technical Instruction for Wireless Telegraphists*, by J. C. Hawkhead and H. M. Dowsett, a suitable work. If you require a more advanced text book, *The Principles of Electric Wave Telegraphy and Telephony*, by J. A. Fleming, will meet your requirements.

C. A. S. (France).—There is at present no postal course run by the Wireless Press, Ltd. If you refer to the advertising pages you will no doubt be able to make a suitable selection.

F. H. B. (Holyhead).—(1) No. The minimum length of service is twelve months. (2) You should apply to the Traffic Manager, the Marconi International Marine Communication Co., Ltd., Marconi House, Strand, London, W.C.2, for conditions of service. (3) It is impossible to make any definite statement. It depends entirely upon circumstances.

R. J. M. (Mildenhall).—See announcement at the head of these columns.

W. J. K. (Urmston).—Your actions in this matter should be governed entirely by the kind of life you prefer—*i.e.*, on sea or shore.

J. W. (Shildon).—We understand that one or two steamship lines employ their own operators, but operators in the Marconi Company's service must be prepared to take up duty on board any ship to which they may be appointed.

W. J. C. (Troon).—You will find the answers to your queries (1), (2) and (3) in the appendices of the Postmaster-General's *Handbook for Wireless Telegraphists*, obtainable from our publishers, price 4½d., post free.

C. G. S. (Winchester).—(1) It is almost impossible to forecast post-war conditions. (2) No general statement with regard to this question is possible, as it is necessary to know the age, qualifications and health of the candidate. (3) Some form of wireless for inter-communication between airships and between airships and earth will be essential if only from the point of view of navigation. There will therefore be a demand for it, the extent of which will depend upon the magnitude of aerial navigation undertakings.

J. O. (H.M.S. *Curacoa*).—(1) The prospects in both services are good. It depends largely upon your natural bent as to which you think is the better of the two. (2) To enter the service of the Marconi Company it is necessary that you should hold the P.M.G. first-class certificate in wireless telegraphy. Applications for conditions of service and appointment should be addressed to the Traffic Manager, the Marconi International Marine Communication Co., Ltd., Marconi House, Strand, London, W.C.2. You might make similar application to cable companies. (3) See conditions of service.

S. L. C. (Wellington).—When the height of an aerial is varied both its inductance and capacity are altered. The resultant change in wave-length is dependent upon the rate at which the capacity and inductance change as the height is increased. Since these two quantities are not directly proportional to the height, and because the rate at which the capacity is reduced may not be as great as the rate at which the inductance increases, it is impossible to solve the problem by your methods. For instance, you have not taken into consideration the fact that increasing the length of the down lead causes a slight increase in capacity. It must be borne in mind that the capacity and inductance are distributed over the whole of the aerial system, and the general form of the aerial and disposition of the down leads introduce other complications. See the *Calculation and Measurement of Inductance and Capacity*, by W. H. Nottage, B.Sc., advertised in this issue.

A. P. (Tours).—(1) and (2) See announcement at the head of these columns. (3) See Appendix V. of the Postmaster-General's *Handbook for Wireless Telegraphists*, published by H.M. Stationery Office, London, and obtainable from our publishers, price 5½d., post free.

H. J. R. (H.M.S. ——).—(1) and (2) See announcement at the head of these columns. (3) There is an extensive wireless service in Australia. The land stations are controlled by the Government, and the Mercantile Marine is equipped and operated by Amalgamated Wireless (Australasia), Ltd., 97 Clarence Street, Sydney. Similar conditions also pertain in New Zealand. The publication dealing with wireless in these colonies is *Sea, Land and Air*, published by the Wireless Press, 97 Clarence Street, Sydney. In Canada there is also an extensive wireless service, and inquiries might be addressed to the Marconi Wireless Telegraphy Company of Canada, 173 William Street, Montreal. There are also Government wireless services in the Colonies with which you might get in touch by addressing your inquiry to the respective inspectors of radiotelegraphy.

W. B. (Thetford).—(1) See announcement at the head of these columns. (2) Students accepted for the Marconi Company's school are guaranteed appointments on qualifying for the necessary certificate. This scheme, however, is at present closed down. The period of waiting after your name has been placed on the waiting list is dependent entirely upon the demand. (3) See "Operators' Notes," December issue of THE WIRELESS WORLD. (4) See Appendix V. of Postmaster-General's *Handbook for Wireless Telegraphists*.

"SAFE SIDE" (Beeston).—If you refer to the list of advertisers you will no doubt be able to make a suitable selection.

G. S. (H.M.S. ——).—See answer to R. J. M. (Mildenhall).

S. D. B. (H.M.S. ——).—See announcement at the head of these columns. (2) The activities of a number of companies have been curtailed during the war. The majority of British ships equipped with wireless are operated by the Marconi Company. (3) The cost of a kit is dependent upon the amount of underclothing, etc., already possessed and the tastes of the individual as regards quality. An inquiry from your tailor might bring you the required information. Prior to the issue of the Mercantile Marine Uniform Order the average cost of uniform was from £10 to £12.

G K. (Johnstone).—The friend in whom you are interested certainly took a great risk in purchasing his uniform before he was accepted. The medical requirements of a private company are not necessarily the same as those required for the Army; for instance, particular stress must be laid upon any affection of the ear likely to develop through the constant wearing of telephones.

M. R. (B.E.F., France).—(1) Refer to Appendix V. of the Postmaster-General's *Handbook for Wireless Telegraph Operators.* (2) You should communicate with the Inspector of Radiotelegraphy, G.P.O., London. (3) *The Elementary Principles of Wireless Telegraphy*, by R. D. Bangay, and the *Handbook of Technical Instruction for Wireless Telegraphists*, by J. C. Hawkhead and H. M. Dowsett. (4), (5) and (6) See announcement at the head of these columns.

J. M. M. (Glasgow).—(1) See answer to M. M. H. (Salisbury). (2) See answer to J. W. (Shildon). (3a) See pp. 492 December issue of THE WIRELESS WORLD. (3b) See announcement at the head of these columns.

"AURORA."—You should refer to page 495 of the December issue of THE WIRELESS WORLD. (2) The qualifications necessary for appointment to a shore station differ from those required for an operator in the Mercantile Marine. Whether or not a man has a first-class P.M.G. certificate is not the main point in selection. This particularly applies in the case of high-power stations. (4) See announcement at the head of these columns.

RADIO (Rotherhithe) wishes to know why, on page 268 of the *Handbook of Technical Instruction*, in an illustration showing the type No. 16 crystal receiver, a multipoint switch is used for varying the inductance, and a large condenser placed in circuit, while in the secondary circuit there are only three possible variations of inductance and a very small condenser, seeing that both of the circuits have to be tuned to the same wave-length?

Answer.—When a very large inductance is placed in series with a very small condenser so as to make a periodic circuit, a very slight alteration in the value of the capacity will make a very large difference in the time period of the circuit. In the case of the receiver in question, the maximum capacity of the "billi" condenser in series with the smallest amount of inductance gives a wave-length which is slightly above that of the smallest practical amount of capacity in series with the second degree of inductance. The relation of capacity and inductance in the third degree is similar, so that one can get a continuous range of wave-lengths, from the shortest to the longest, by using the first, second or third adjustment of the inductance. In the case of the aerial circuit, however, it must be remembered that the large condenser is not in parallel with the aerial tuning inductance, but in series with it, and seeing that the total inductance of the aerial without the aerial tuning inductance is small, a large amount of inductance, graduated in steps, has to be used for tuning purposes, the aerial tuning condenser serving the purpose of making the circuit resonant to wave-lengths shorter than that of the natural frequency of the aerial.

E. T. (Bradford).—Quite impossible to answer this question. See other replies to queries on the subject of training and appointment to the Marconi service.

P. W. (Birmingham).—For full particulars, apply to the Traffic Manager, The Marconi International Marine Communication Company, Ltd., Marconi House, London, W.C.2.

SPECIAL NOTE.

THE MARCONI FREE TRAINING SCHEME IS NOW CLOSED.

Correspondents who wish to train as Wireless Operators should apply to the nearest Wireless Training School or College.