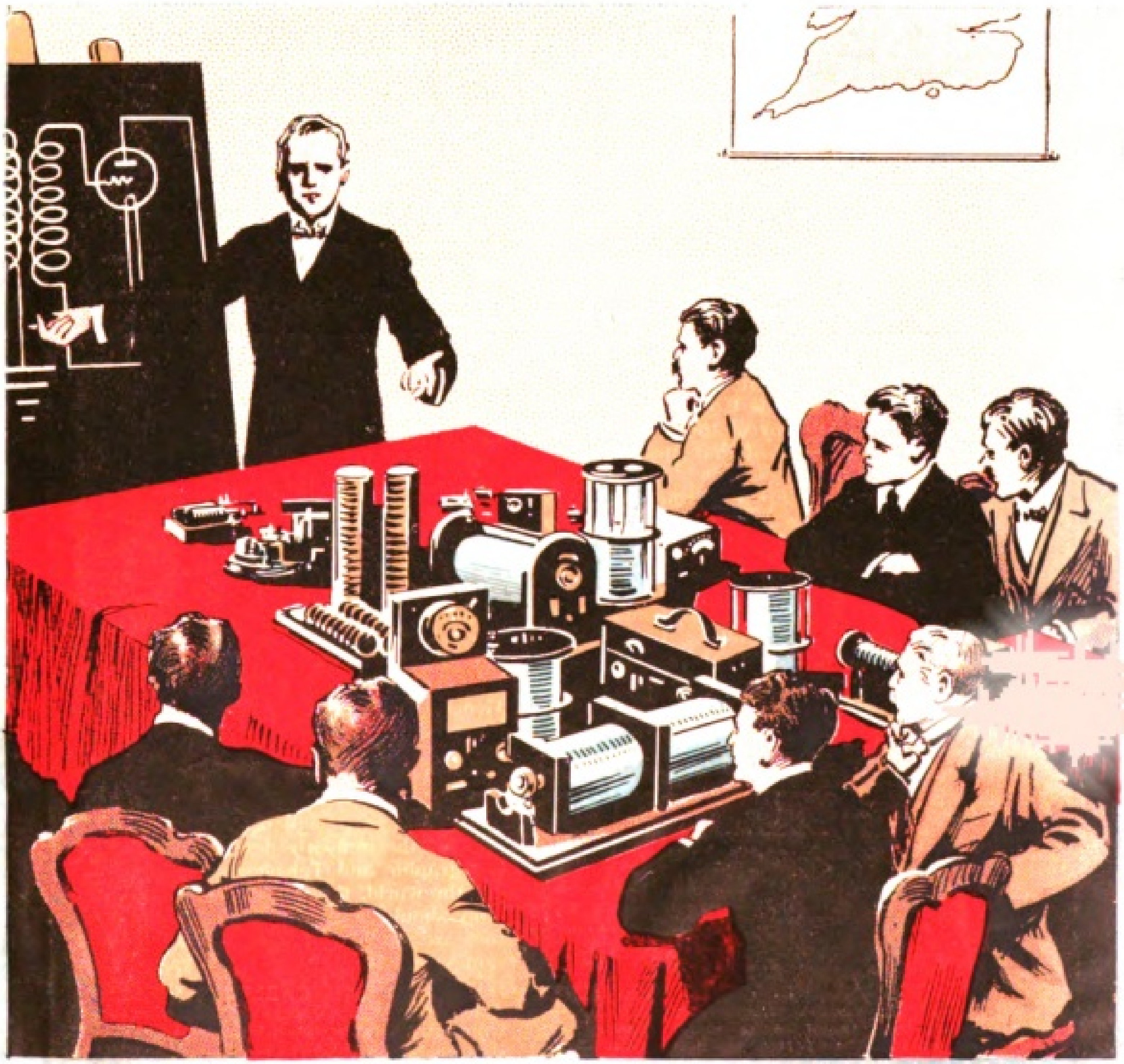
The WIRELESS WORLD



THE
WIRELESS WORLD

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The Training of a R.A.F. Wireless Operator.

BY MICHAEL B. EGAN.

ALTHOUGH most of us might agree that the narrow limits of our native tongue render it unsuited to the task of expressing our private opinions about war in general and the Great War in particular, few of us will deny that four years of Zepp raids and ration cards made us the recipients of a liberal education in our own shortcomings, both as an Empire and as individuals. It might truly be said that each day of the war brought its own particular lesson, but, as often as not, the supreme exigencies of the moment prevented the immediate application of newly-revealed methods owing to the impracticability of upsetting existing organisations, or the necessity for compromising between output and efficiency—between quantity and quality.

The signing of the Armistice, however, gave the signal for the embodiment of those principles and ideas which the war so clearly emphasized as vital to our national success in the great work of reconstruction, and in this respect the post-bellum syllabus for the training of wireless personnel in the Royal Air Force indicates a commendable determination on the part of our youngest service to avail itself fully of the knowledge acquired under the tutorship of war.

Everyone is aware that no other individual branch of science played so important a part in the conduct of the war as the ever-expanding science of wireless telegraphy and telephony. It was wireless that rendered it possible for our generals in the field to discuss strategy with the War Staff at Whitehall whilst preliminary operations were actually in progress. It was wireless that enabled our Admiralty Staff to pin-point the exact position of every British ship on the ocean charts of the world at any moment of the day or night; and it was wireless that enabled our wonder-

Flowerdown Wireless Training Camp, Winchester.

ful Aerial Squadrons to flash back swift tidings of their progress as they hummed their lonely way above the clouds on their perilous midnight excursions over enemy territory. Wireless was a subtle sixth sense that negatived space and established human intercourse between the Mother Country and the smallest and most remote and isolated contingent of British forces in foreign climes.

The Wireless Operator was ubiquitous.

From the outset of the war the demand for trained wireless personnel was always in excess of the possibilities of supply. Wireless operators could not be made in a day, nor yet in a month, nor, indeed, could they be *made to order* in any length of time.

There is something peculiarly distinctive about the personality of a *real* wireless operator that raises him considerably above the ordinary level and relegates him to a class by himself. Good brains and a capacity for steady application represent two very important characteristics in the composition of an efficient wireless operator, but, although these are two essential factors, they do not in themselves constitute the *ideal* wireless operator. The mentality of the ideal wireless operator must include a natural and instinctive alertness of mind balanced by a capacity for the exercise of sustained self-control during periods of unwonted activity in the world of ether waves.

This pronounced individuality of the *pukka* wireless personality gained daily confirmation during the progress of the war, and by instituting a method of selection which was based on the accumulated data of war-time experiences, the Royal Air Force has aimed at securing the cream of that veritable army of young wireless enthusiasts whose ambition urges them to share the limitless regions of the blue with the happy feathered things of nature.

Enlistment in the Wireless ranks of the R.A.F. is in active progress at the moment. Trained wireless operators and mechanics are being engaged for immediate service and a large number of vacancies exists for boys of about 16 years of age who will undergo a three years' course in wireless telegraphy and telephony before being graded as Leading Aircraftsmen in the capacity of wireless Mechanic-Operators. Successful candidature for these vacancies involves a good standard of health, a willingness to engage for 8 years' active service and four years on the Reserve, and a certificate of nomination from the local Educational Authorities. This Educational body will hold periodical examinations at the chief centres, and successful candidates will be granted a nomination certificate for the R.A.F. The examination is not a difficult one; it comprises a number of elementary questions in mathematics and science which are calculated to test the candidate's general intelligence and estimate his suitability for the work to which he proposes to devote his future.

The successful candidate, after satisfying the Medical Officer with regard to his physical fitness will then proceed to the Air Force Training Camp at Halton Park in the rank of Boy Mechanic. Here the first six months of his training will be devoted to general workshop practice, physical training, sport, and general education. It will also include the inculcation of that very important and beneficial thing which is the foster-mother of *esprit de corps* and healthy comradeship in every service—the true spirit of discipline.

Photo by Bassano

Wing Commander J. B. Bowen, O.B.E., Commandant of Flowerdown Wireless Training Camp, Winchester.

On the completion of this preliminary stage the future airman will embark upon two and a half years of specialised training at the Wireless Training School at Flowerdown Camp, Winchester. The Flowerdown Wireless course is divided into five different stages, each of which lasts a little over five months, the balance of the time being absorbed by liberal holidays during the summer and at Christmas. At the end of Stage I a terminal examination is held and a survey of the results enables the Chief Instructor to classify all students as (a) satisfactory and ready for further training, (b) in need of a repetition course, (c) unsuited for further training in this sphere of work.

In addition to these terminal examinations, which are held at the close of each stage, all Boy Mechanics are obliged to enter for the City and Guilds Elementary and Ordinary Examinations at the termination of Stages I and II respectively, and, at the end of the whole course—when the successful Boy Mechanic is *immediately* promoted to the distinctive rank of Leading Aircraftsman—examinations are held for the City and Guilds Advanced Certificate and also the Post-Master-General's certificate for Sea *and* Air.

This is certainly an excellent scheme

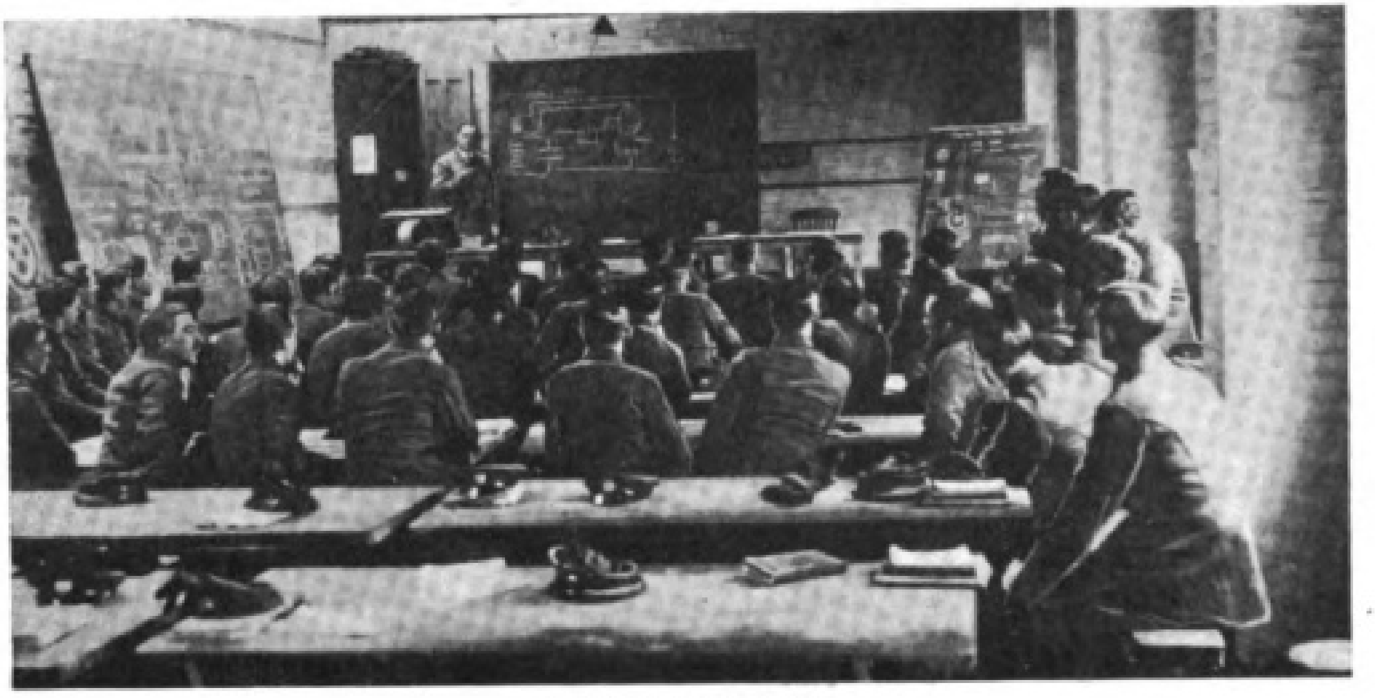
which cannot be praised too highly. Its inauguration marks the rapid destruction of that almost insuperable barrier which in the past too frequently separated the "time served" soldier or sailor from his rightful place in the commercial world. Truly it was a valuable war lesson which can claim responsibility for the fact that the time-served airman of the future will step back into civil life with *certificated* qualifications *at least* as good as those possessed by the men amongst whom he is going to compete in the nation's industry!

As it is outside the scope of this article to enter into a detailed account of the complete Wireless course, a brief consideration of the manner in which the subject matter of Stage I is treated must suffice to indicate the very high standard of efficiency which characterizes the whole programme. Stage I is arranged in a very delightful and ideal manner. The technical training commences with a series of introductory lectures which are delivered each day on such subjects as "The Physical Properties of Ether," "The Constitution of Matter," "What are Molecules, Atoms and Electrons," etc., etc. In conjunction with these lectures simple experiments are chosen and demonstrated with a view to emphasizing the fundamental ideas set forth in the lectures. For example, in the early part of the course, detailed experiments are arranged whereby the students can with *their own* senses *observe* the various phenomena associated with positive and negative charges, static and current electricity, magnetic and electric fields, the relationship between the pressure, current, and resistance in a simple electric circuit, etc. All these fundamental phenomena are demonstrated during the preliminary lectures and each pupil is afforded ample opportunity for repeated investigation under his own management. In this way, in the light of his own individual discoveries, the student is encouraged *to deduce from personal observation*, the most important elementary principles —such as are embodied in Faraday's, Lenz's, and Ohm's laws.

Great and justifiable attention is given to this aspect of the preliminary training. There is no attempt to cram or to insist on the memorisation of cumbersome formulæ by rule of thumb. From the outset, no effort is spared which is likely to assist the development of that attitude of interested curiosity than which no other attribute is so essential to the mental equipment of the student of science. As the course continues, the future wireless operator is introduced to those electrical properties associated with the terms "Capacity," and "Inductance," and exhaustive experiments are conducted with a view to establishing an accurate and indelible conception of these important principles.

After this the student is familiarised with simple electrical measurements and the next portion of Stage I deals with the commoner types of secondary batteries, their installation, and the necessary precautions for their charging and discharging, etc. Simple circuits in connection with electric lighting are then dealt with and the concluding lectures are devoted to the less complex types of continuous current dynamos and motors.

The whole course is hall-marked by a sound appreciation of the necessity of combining theory with practice. Each day's programme includes the allocation of a suitable period for practical work in the Instrument Laboratory and the Electrical Workshops. In the Instrument Laboratory are carried out those



A lecture in progress.

elementary electrical experiments to which reference has already been made. In addition, the incipient wireless operator is here instructed in the use of various instruments employed in connection with electrolysis, general galvanometry, and calibration, special attention being given to the measurement of resistances by the Wheatstone Bridge, The Post Office Box, Meggers, etc. Here also dynamos and motors are subjected to practical tests from the results of which students are enabled to evolve and compare the " efficiency curves " of individual machines.

In the Electrical Workshops is to be found a variety of lathes and tools, and well-stocked benches such as only exist elsewhere in the wildest dreams of the ambitious wireless amateur. Here the young enthusiast is taught to attack a real practical job of work. Under the heading " Fitting and Turning," the practical work of Stage I includes instruction in the use of ordinary workshop tools, bench-work, forge-work, the use of treadle and power lathes, drilling and boring, screw-cutting, etc., and due attention is also given to the necessity for clear and systematic diagrams and the cultivation of an ability to work direct therefrom.

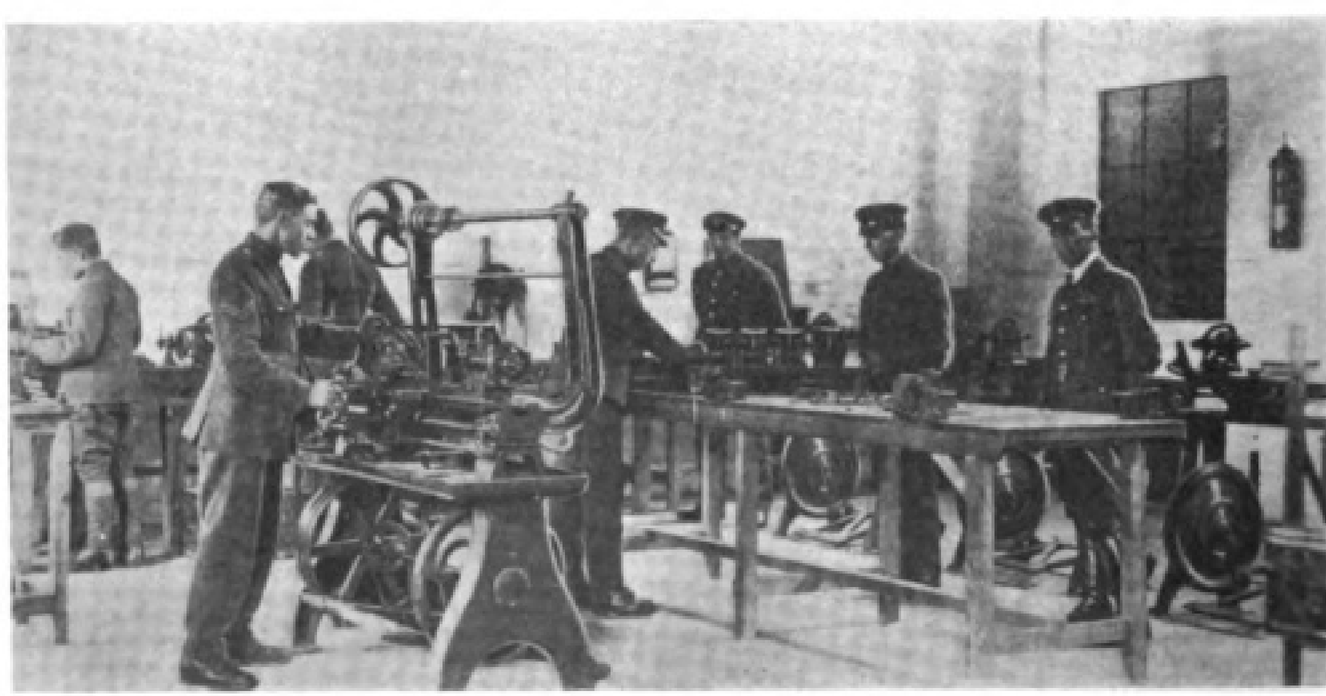
In addition to the technical instruction, an appropriate period is set aside in each day's programme for (a) General Education, (b) Buzzer and Visual Signalling, and (c) Physical Training and Drill. The syllabus for general education includes Practical Mathematics, English, Mechanical and Practical Drawing, Elementary Physics and Mechanics. In the Signal School, where Morse buzzer practice is in constant progress, the embryonic airman is also trained as an efficient exponent of the various methods of visual signalling which are employed by his brothers-in-arms, the soldier and sailor.

After an interval of five weeks Stage II begins, and this is really an advanced continuation and amplification of Stage I. Stage II is also succeeded by a test examination from which the industrious and successful worker emerges with the key that opens the door to further scientific training. Another important process of selection is applied at this period. All satisfactory students are now re-classified and each one is "labelled" as having shown an individual aptitude for such particular portions of his previous work as indicate his suitability for specialized training as (a) an Electrician, (b) a Mechanic-Operator.

The remaining three stages are now devoted exclusively to either of these two branches of study. Those who pursue the career of an Electrician will conclude their course with the City and Guilds Advanced Examination, and Mechanic-Operators will sit for the P.M.G.'s Certificate for Sea and Air. One of the most important developments in the economics of wireless is expressed in the term Mechanic-Operator. During the war we trained great numbers of mechanics and great numbers of operators and thus practised a system of wasteful duplication that was only justified by the abnormal conditions and necessities of the moment. The straining demands of the war have now ceased however, and their withdrawal has rung up the curtain on a new and more economical organisation. The R.A.F. Mechanic-Operator of the future will be, as his name suggests, an efficient "self-contained" unit. In the many strange circumstances and climates through which his adventurous career must inevitably lead him, the nature and quality of his specialized training will always signalize him as an important and independent link in the chain of aeronautical development.

Capt. H. Leedham, Chief of the Staff of Wireless Instructors at Flowerdown Camp.

The last three stages of the Mechanic-Operators' Course are devoted to all types of Aerial Wireless Telegraphy Instruments (spark and continuous wave), Corps Squadron Work, Wireless Telephony, and Wireless Direction Finding. They also include a lengthy programme of Aerodrome Practice which assures that every qualified Mechanic-Operator will have had considerable practical experience of working



A Corner of one of the Workshops.

under difficult conditions during flight. Having successfully completed his course the now full-fledged Leading Aircraftsman is available for dispersal to any of the various fields of wireless activity associated with the work of the Royal Air Force.

His first "job" may drop him neatly into the wireless cockpit of an aeroplane or seaplane, or the more luxurious surroundings of the Wireless Cabin on a giant airship. On the other hand he may kick off with a warmer billet in an Aerodrome W/T Station, a Direction Finding Station, or a motor launch used in co-operation with seaplane work. Whatever be the conditions under which he makes his *début* in the world of aeronautical wireless he will find himself standing beneath one of the many signposts that point the way to an industrious and successful career in the R.A.F.

It would not be fair to the originators and executors of this comprehensive syllabus to omit reference to the important and intelligent schemes which are in operation in connection with the provision of suitable opportunities for physical and intellectual recreation during leisure hours. Every form of outdoor sport is encouraged. Cricket and football, inter-School teams and leagues are in full swing at all times, and long lists of fixtures are arranged with outside schools and clubs and other branches of the service. A well stocked gymnasium will provide the means for passing many enjoyable and profitable hours. For those who feel themselves unduly burdened with a multitude of new and original ideas (and who does not pass through this stage at some period or other?) a debating society affords ideal opportunity for conducting misguided fellow students into the shining realms of truth. An enterprising dramatic society is ever on the look-out for fresh histrionic talent, and a well filled library strives to cater for the most fastidious literary tastes and provides a haven of peaceful solitude for the thoughtful soul.

To crown all, if one is addicted to the musical vice, no time need be lost in making arrangements to contribute one's just share to the unearthly din which is responsible for the desolate and uninhabited aspect of the Camp on Band Practice evenings!

Operators in the Station at the Air Ministry.

DOCTOR CORNELIS JOHANNES DE GROOT.

Personalities in the Wireless World

DOCTOR ENGINEER CORNELIS JOHANNES DE GROOT was born at den Helder on the 27th of January, 1883, graduated at the Technical High School at Delft as Mechanical Engineer, and afterwards obtained the diploma of Electrical Engineer at Karlsruhe.

After spending eighteen months in the service of the General Electric Co. at Berlin he passed over to the Dutch East Indian Government and superintended the erection of various wireless telegraph stations in the Indian Archipelago.

During his furlough in Europe in 1915-1916 he took his degree as Doctor in Technical Science at the Delft University on the dissertation "Radio-Telegraphy in the Tropics," which work was afterwards published. The Doctorate was conferred upon him "cum laude" after his defence of the thesis :—" A Radio-Telegraphic Communication between Holland and its Colonies without the use of relay stations is politically a necessity and technically possible."

Immediately upon his return to the Indies in 1916 he set to work to prove the practical feasibility of his scheme. Being promoted to Chief of the Radio-Telegraphic Service in the Indies, he took up quarters at Bandoeng, and after many trials with an installation partly of his own construction and by means of his receiver placed purposely on board of H.M.S. de Zeven Provincien, he succeeded in keeping radio-telegraphically in touch with this war vessel all over the Pacific Ocean up to Panama, which was a record in wireless transmission from shore to ship.

This special receiver was installed later on at the experimental station near Blaricum in Holland, and took the first wireless message ever received in Holland direct from Bandoeng. For this feat he was lionized and fêted by the citizens of Bandoeng.

As soon as the transmitting station now being built in Holland is completed, a direct Radio-Telegraphic Service between Holland and its Colonies will be established.

One of Dr. de Groot's best known works is his paper entitled "The Nature and Elimination of Strays," which was read before the Institute of Radio Engineers, New York.

An Efficient Variable Condenser

By G. W. Hale.

NOW that the restrictions on Private Wireless are somewhat relaxed and wireless enthusiasts all over the country are contemplating the construction of their apparatus, a description of an easily constructed variable condenser which possesses several advantages over the ordinary semi-circular vane type will no doubt be appreciated.

The component parts of the condenser are shown in the accompanying sketches.

The rotor, Fig. 1, consists of a disc of ebonite or similar insulating material, the under surface of which should be as flat as possible. The two semi-circular tin—or preferably copper—foil plates B and C are attached to the under surface of the rotor by means of shellac varnish, which should first be allowed to harden, the plates being held in position and then pressed with a hot flat-iron. This method precludes the possibility of moisture causing defective insulation. Contact is made to the right-hand plate C by means of a round nut on the spindle as

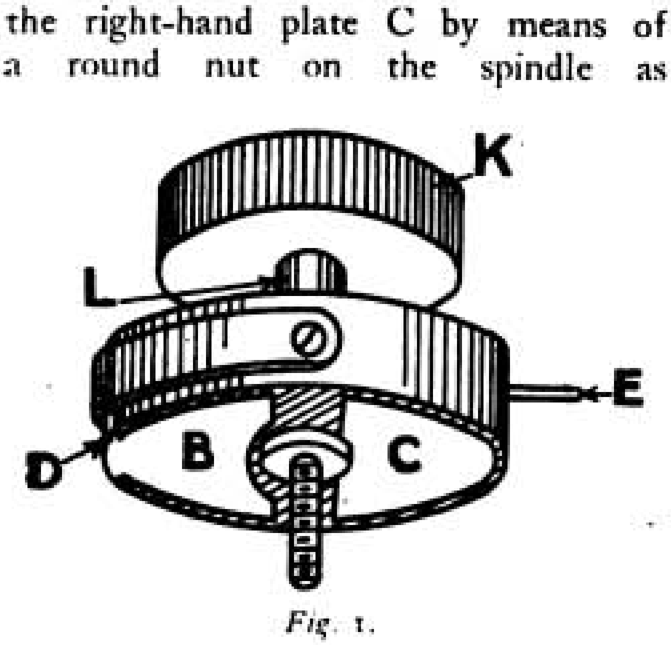


Fig. 1.

shown, while the left-hand plate B is connected through the lug D to a brass or copper strip which is bent around the circumference of the rotor as shown, and screwed at each end with 6 BA countersunk brass screws. The Stop Pin E is a piece of brass wire screwed into the side of the rotor, and by working between the stops E_1 and E_2 on the base (see Fig. 2), prevents the rotor from being turned through more than 180°. The fixed conductors F and G (Fig. 2) are attached in a similar manner to those of the rotor and are connected to their respective terminals. The pillar at the back of the base supports a brush of springy brass which should be set to bear evenly on the contact strip on the rotor. The brush should be cut in two or three places so as to give the smallest possible contact resistance. The wire J from the left-hand terminal, as shown by the dotted line, is soldered to a brass washer K, and thus makes a connection to the rotor spindle. Between the upper and lower plates is placed a disc of thin sheet-ebonite $\frac{1}{64}$th or $\frac{1}{100}$th of an inch in thickness. Photographic celluloid film may also be used. The gelatine must be removed from both sides of the film, which may easily be done by soaking it in warm water for about five minutes, and scraping with a blunt knife. The rotor spindle is placed through a recessed hole in the base and secured underneath with a couple of nuts bearing on a spring washer and the washer K. The spring washer should be compressed just sufficiently to permit easy movement of the rotor. The adjusting

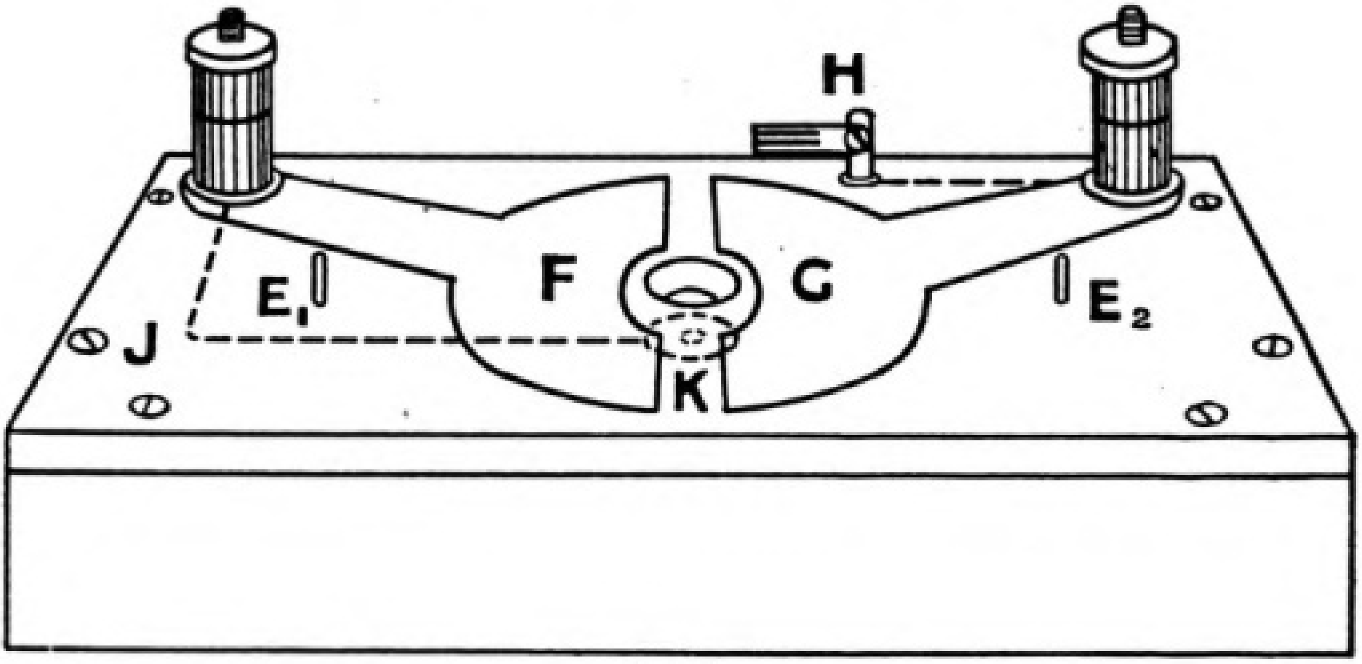


Fig. 2.

knob and distance piece are drilled and tapped (2BA) and screwed on the spindle which should not project above the upper surface of the knob. The completed instrument is depicted in Fig. 3.

For tuning a short wave receiver secondary the condenser described is just right as its minimum capacity is practically zero, a feature which is not frequently met with in the ordinary multi-vane type of condenser where the edge-to-edge capacity of the two sets of zinc plates is quite considerable, making it often necessary to disconnect it from the circuit altogether. This results in a sudden reduction of wave-length, requiring a readjustment of inductance. When using a valve receiver

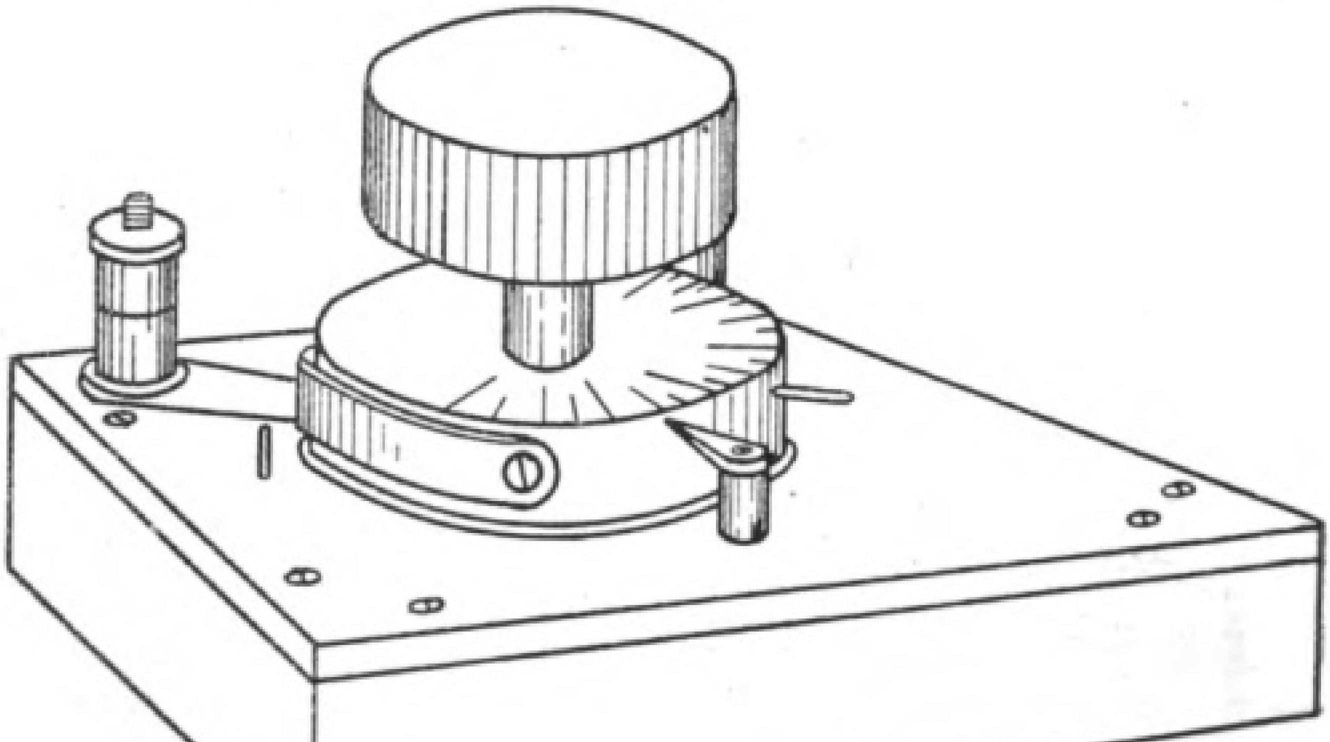


Fig. 3.

it is usually preferable to tune the circuits with as little additional capacity as possible, relying on the inductance of the coils in conjunction with their own capacities and that of the connecting leads to give the desired wavelength. As a guide to those readers who may wish to construct a condenser of this type the following dimensions may be of use (see Fig. 4).

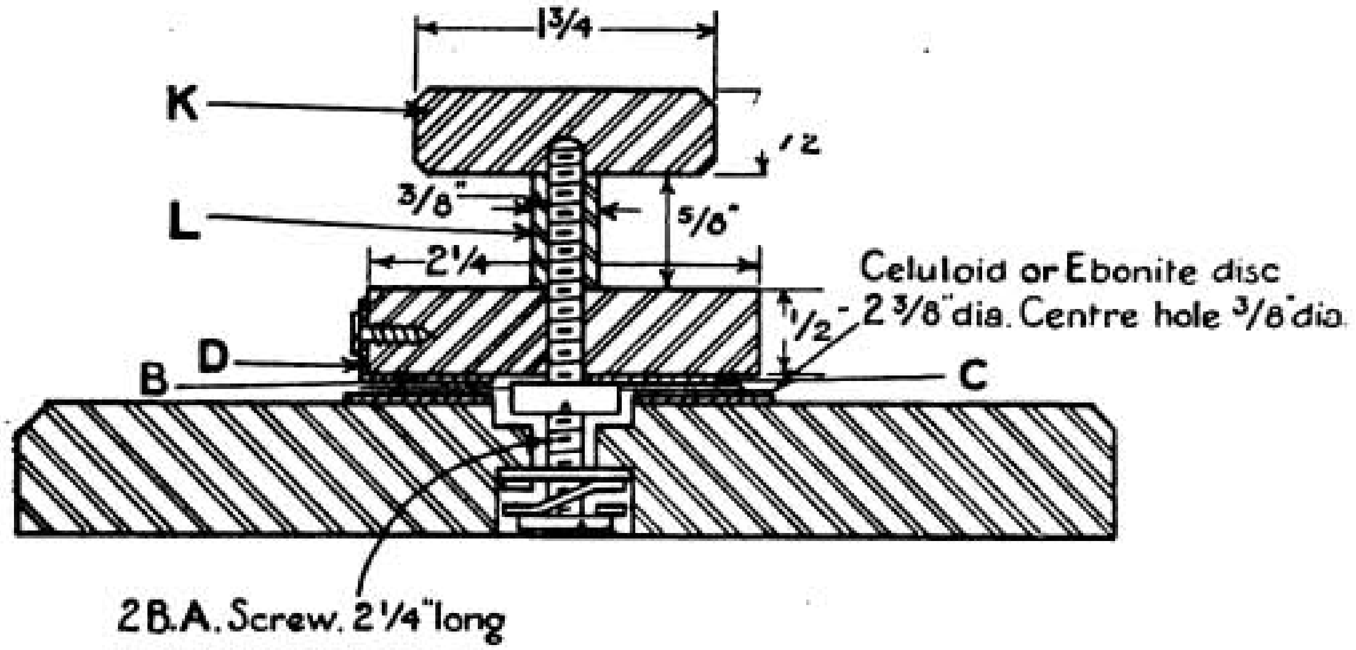


Fig. 4.

Rotor (ebonite), diam. $2\frac{1}{4}$ inches, thickness $\frac{1}{2}$ inch.

Adjusting Knob (ebonite), diam. $1\frac{3}{4}$ inches, thickness, $\frac{1}{2}$ inch.

Distance Piece (ebonite), length $\frac{3}{8}$ inch diam. $\frac{3}{8}$ inch.

Celluloid or Ebonite Disc, diam. $2\frac{3}{8}$ inches, Centre Hole, $\frac{3}{8}$ inch.

Spindle, 2BA Screwed Brass Wire $2\frac{1}{4}$ inches long.

The base may be made from $\frac{1}{4}$ inch sheet ebonite and should be about 4 inches long and $3\frac{1}{2}$ inches wide. If desired it could be made part of the panel of a complete cabinet receiver, according to the individual needs of the experimenter.

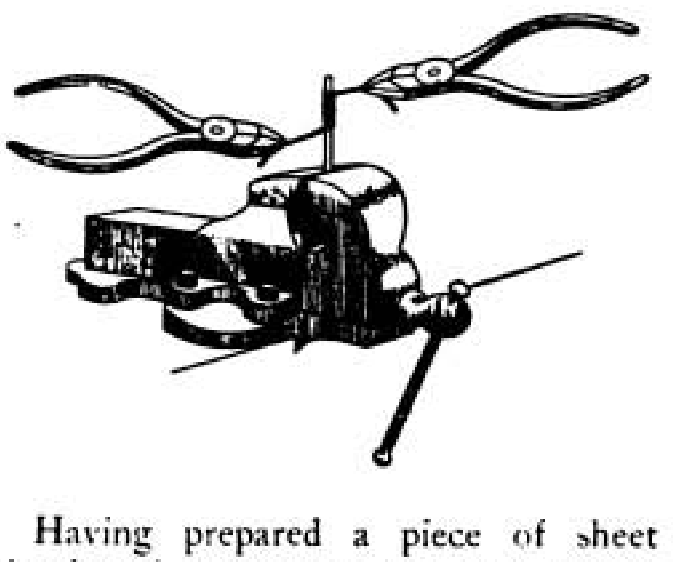
A Condenser made as described was found on test to have a maximum capacity of 0·00017 mfd. using $\frac{1}{64}$th inch thick ebonite dielectric. The capacity if celluloid film is used is somewhat higher as it is only about a fourth the thickness.

A FLEXIBLE SOCKET FOR WIRELESS RECEIVING VALVES.

By E. W. Kitchin, A.M.I.C.E.

THE usual rigid socket for a three-electrode valve has the disadvantage of being unable to adapt itself to slight manufacturing variations in the " set " of the plugs which form the electrode terminals. One or more of the plugs may be slightly out of the straight, involving the risk of strain if the valve is forced into a perfectly rigid socket. The following method of constructing sockets, recently devised and used with great success by the writer, produces a valve socket with sufficient flexibility to enable a valve to be inserted easily and make good contact without risk of straining the plugs. It has the further advantages of cheapness and ease of construction, which will recommend it specially to the amateur.

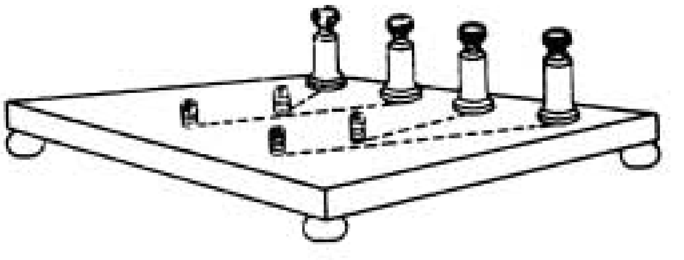
Procure some brass or copper wire of No. 18 S.W.G., the correct gauge being important. Clean the wire well, and if of brass, soften it. Fix a "former" made of a short length of No. 10 S.W.G. wire in a vice, and wind the wire round it closely for nine or ten turns. Adjacent turns should touch, and the coil will be about half an inch in length. Care must be taken to wind the wire in such a direction that the coil forms, as it were, a right-handed screw thread. Tighten the coil on the former by using two pairs of pliers in opposition, and make the end of the wire quite smooth. Leave on the other end a few inches of straight wire, and finally slide the coil bodily off the "former." One of these coils will be required for every plug of the valve.



Having prepared a piece of sheet ebonite of convenient size, and preferably not less than $\frac{1}{4}$ inch thick, press the plugs of a valve on a piece of paper with sufficient force to leave a mark from each. Transfer this template to the ebonite and mark through the paper, with a sharp point, the positions of the centres. Drill holes at these points, and tap each with $\frac{1}{4}$ inch Whitworth thread.

Now carefully screw one of the wire coils into each hole, starting from the under side of the ebonite, until each coil projects about $\frac{1}{4}$ inch above the ebonite; the bottom end with the piece of straight wire will then be about flush with the under side.

Fix four terminals in convenient positions on the ebonite, and connect each of the straight ends of wire to one of these, cutting off any surplus.



Attach four small feet to the under side of the ebonite base so that the wires and terminal bottoms will not touch anything when in use, and the apparatus is complete.

If thicker ebonite than $\frac{1}{4}$ inch is used the coils should be proportionately longer, the idea being to have them flush with the under side and projecting $\frac{1}{4}$ inch above.

If carefully made, the coils will fit tightly in the holes, but it is perhaps as well to spread them from the under side by forcing a tapering instrument in, and giving it a few twists. This will press the lower turns of the coil well home into the screw thread cut in the ebonite.

The split plugs of the valve should be carefully opened out somewhat if necessary.

The sockets may, if desired, be made still more flexible by making the coils longer and increasing the portion which projects above the ebonite base. This is, however, not recommended in view of the possibility of two adjacent coils being accidentally caused to touch each other.

Stray Waves

THE AMATEUR POSITION.

ON the surface the situation has undergone no change since we last went to press; the Government has made no further move and there is no news of the promised Wireless Telegraphy Bill. Yet the amateurs themselves are steadily altering the state of affairs, witness the persistent increase in the membership of the existing clubs, the rapid recrudescence of clubs whose activities ceased when the war broke out, and the numerous new clubs which spring into being every month.

We are glad to note that several clubs have decided to affiliate with the Wireless Society of London. Such a course, we feel sure, will benefit the whole amateur community without robbing the individual clubs of their freedom to work along their own lines.

We are still under the impression that there are a number of clubs existing with whom we are not yet in touch. Will their Secretaries be good enough to communicate with us, thus aiding us to complete our list. We constantly receive enquiries for details of the clubs nearest to certain towns.

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POWER FROM THE SUN.

Commenting on Sir Oliver Lodge's recent Truman Wood lecture at the Royal Society of Arts, Mr. A. A. Campbell Swinton, in a letter to *Nature* (Dec. 18, 1919), points out that in referring to the probable high efficiency of vegetation as a utilizer of solar energy, the lecturer appeared to be unaware of the fact that Dr. Horace Brown has shown that the actual amount of energy stored is less than 2 per cent of that reaching the vegetation. This amount is, during daylight, more than 1,000 H.P. per acre. The main object of Mr. Campbell Swinton's letter is to suggest that there is probably a better way of utilizing solar energy than by converting the radiation first into heat and he asks whether it is not worth while to consider the possibility of employing some method involving an action analogous to that of the thermionic valve, in order to produce electric currents without an intermediate step.

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RADIOGONIOMETER AND TRIANGULAR DIRECTIVE AERIAL PATENTS.

We are requested by Mr. E. Bellini to give publicity to the following, in view of the item which we published under this heading in our Dec. (1919) issue:

"In the Numbers of October 24 and 31, November 7, 14, 21, &c., of *The Electrician*, page xxx of the announcements under the heading 'Patent Rights for Sale, &c.,' Mr. Artom published under the above title a short and confused note, from which readers could believe that the Italian Courts had judged that the Radiogoniometer, the Direction Finder and the Triangular Directive Aerial were invented by Mr. Artom.

"This affirmation is incorect. In 1915 and 1917 in this same Journal Mr. Artom had advanced the same pretension, which was the origin of a public correspondence with Mr. Bellini.

"It is necessary to repeat here, in the name of truth and justice, that the

Italian Courts not only did not judge this question, but, on the contrary, they explicitly declared that they had not to decide it. The translation of the part of the judgment containing the said limitation is as follows:—

'It is not decided here whether the inventions, the subject of the Italian Patents, No. 88,765 and No. 88,766, were made by the scientists Brown and Blondel, or by Mr. Artom, or by MM. Bellini and Tosi. . .' "

* * *

WIRELESS POLICY IN AMERICA.

A new policy for the control and development of wireless communications in the United States was placed before Congress by Mr. Secretary Daniels on October 15th. It provides for maintenance of Naval and Private Stations, with the latter under the control of a National Wireless Commission. It deals with the licensing of Private Wireless Stations in the matter of assistance to Americans in establishing wireless facilities with foreign countries. The National Wireless Commission would attend Board Meetings of Private Companies. Aliens or alien interest could not obtain licences from the Commission and all Officers and Directors of Private Wireless Companies would have to be American citizens and the majority of the stock of such companies would have to be held by Americans. Private Wireless Companies would not be permitted to affiliate with Submarine, Cable, or Land Telegraph or Telephony Systems without consent of the National Commission, and would not be permitted to operate in the Philippines or Panama Canal Zone.

THE NEW PATENTS ACT.

For the benefit of those of our readers who have to do with the patenting of inventions or who intend to devote themselves to investigations which may result in discoveries worth patenting, we briefly describe hereunder the alterations in the law which are embodied in the new Act. Firstly, the period between the filing of the provisional and the complete specifications has been increased to nine months,—a very beneficial measure, as will be fully appreciated by all who have taken out patents. Next, the Patent, under the new Act, will be allowed to run for sixteen years, an increase of two years, the advantages of which are obvious.

A number of rules are laid down to provide against abuses of the Patent Law by foreign inventors, who were formerly able to dodge the law to the disadvantage of British patentees. Under special clauses the British inventor is protected much more than formerly. All patents must be worked within four years.

In respect to claims an amendment is enacted whereby the inventor who finds it necessary to prosecute for infringement, need only prove the validity of his principal claims. Under the old law, if he failed to support an unimportant subsidiary claim he lost his action and the infringer reaped the benefit of his malpractice until the inventor amended his specification.

The extensions of the terms of patents has been altered from seven and fourteen years to five and ten years respectively, and the Act has been made retrospective, thus prolonging for two more years patents which otherwise would expire this year.

Digest of Wireless Literature

THE SELF-OSCILLATIONS OF A THERMIONIC VALVE.

By R. Whiddington, M.A., D.Sc.

Cambridge University Reporter, May 27th, 1919, also *Radio Review*, November, 1919.

IT has been found possible to produce oscillations of almost any frequency by means of a three-electrode valve without employing the usual capacity-inductance circuits. A soft valve is used which contains sufficient quantities of gas or vapour to permit of collisional ionisation taking place. Fig. 1 shows the circuit normally employed for the production of these oscillations. It will be seen that there are here no capacity-inductance circuits whatever as the resistance R is non-inductve, consisting normally of a soft lead pencil split lengthways and fitted with a small metal sliding contact. With batteries of suitable magnitude strong oscillations may be set up in this circuit the frequency of which is determined almost entirely by the value of the grid potential and the geometry of the valve electrodes. These oscillations can be detected, and their wavelength measured by means of an ordinary heterodyne wavemeter placed near the circuit.

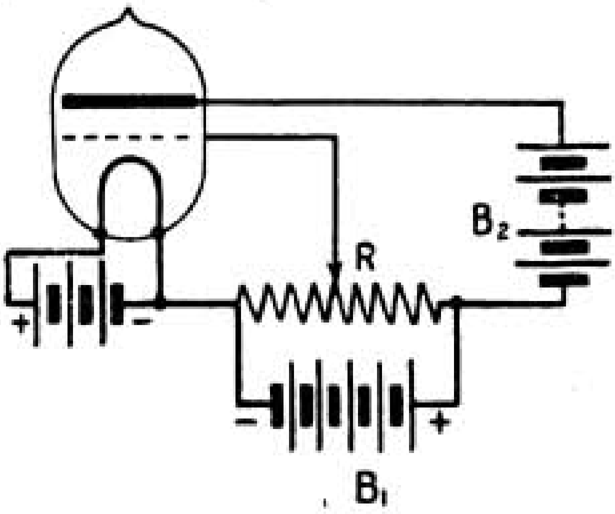

Fig. 1.

To account for these oscillations which, broadly speaking, are to be regarded as being due to periodic surges of mercury ions closing in on the filament, one must assume that although the filament as a whole is emitting electrons continuously according to Richardson's law, yet there are often isolated spots which emit with exceptional power. If this is granted it also seems reasonable to assume that the bombardment of the filament by rapidly moving positive ions in the neighbourhood of such an emitting spot would greatly increase the local emission.

A burst of electrons starting from such a spot on the filament would travel from filament to grid under the influence of the small grid potential normally used. On passing through the grid interstices the electrons travel into the strong electric field of the anode and attain sufficient velocity to produce collisional ionisation among the residual mercury atoms in the tube. The positive mercury ions so formed now travel back to the filament and bombard the original emitting spot, causing another burst of electrons to travel towards the grid and cause the whole process to be repeated in a regular manner. On account of the repetition of this cycle of operations the anode current is of a pulsating nature and thus may be regarded as possessing both a steady and an oscillatory component. On this theory it may be shown that the frequency n of the oscillation set up is given by the formula

$$n^2 = 2 \cdot \frac{e}{m} \cdot \frac{V}{d^2} \quad \ldots\ldots(1)$$

where $\frac{e}{m}$ is the charge to mass ratio of the positive ion concerned, d is the radial distance of filament to grid, and

V is the positive grid voltage. This method of producing oscillations suggests a wireless method of determining the value of $\frac{e}{m}$ as the other quantities of equation (1) can be measured. It also suggests the possibility of producing extremely short wireless waves by a method entirely different from the ones normally employed.

MESURE EN VALEUR ABSOLUE DES PERIODES DES OSCILLATIONS ELECTRIQUES DE HAUTE FREQUENCE.

By MM. Henri Abraham and Eugène Bloch.

Annales de Physiques, Oct. 1919.

The exact determination of the wavelength of electrical oscillations is the basis of all high frequency measurement. Its importance is particularly evident in the calibration of wavemeters for practical work in radiotelegraphic transmission. However, nowadays things are quite different. The development of Wireless Telegraphy in all directions has caused the multiplication of sending stations. Also the use of continuous waves, introducing the possibility of exceedingly fine tuning, requires that our wavemeters should be much more accurate than they were formerly.

The new method proposed for the calibration of wavemeters consists in determining not the wavelength of the oscillation but the period. This period is determined by making it identical with that of a harmonic of a low frequency valve oscillator, the frequency of which can be made identical with that of a standard tuning fork. For example, if a tuning fork of a frequency of 1000 is used a wavemeter can be tested at a frequency of 150,000 ($\lambda=2000$ metres approximately) provided the valve oscillator emits harmonics up to the 150th. An ordinary heterodyne wavemeter emits harmonics say up to the 12th but by using a special circuit (known as a "multivibrateur") it has been found possible to obtain harmonics with a frequency 300 times that of the fundamental.

The full set of operations may thus be briefly summarized as follows:—

(a) The frequency of the standard tuning fork is determined exactly by comparison with a standard clock.

(b) The fundamental frequency of the multi-vibrateur is made equal to that of the standard tuning fork.

(c) The wavemeter is now calibrated by comparison with a harmonic of known order. Electrical resonance is utilised for this adjustment. The wavemeter circuit is coupled very loosely both with the multivibrateur circuit and also with a detector-amplifier. A heterodyne circuit is loosely coupled to the latter to enable the adjustment to be made by means of an audible beat note. The arrangement used is shown in Fig. 2.

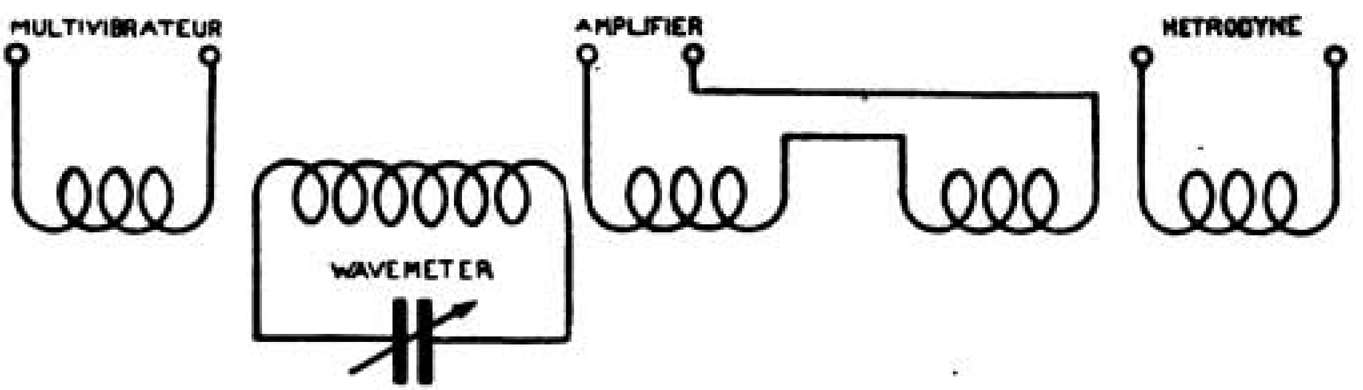

Fig. 2.

Notes on the Physics of the Thermionic Valve

By T. G. Petersen.

(Continued from January Number.)

Alteration of Anode Diameter, or Distance from Filament.

It is not proposed to deal at any length with the alteration of anode diameter, since the idea of the stray field and the counter field (or assisting field, as the case may be) will now have been thoroughly grasped, but a passing reference should be made to Fig. 11. It will therein be noted that when the plate is in position P_1, E_s will have a certain value, but when at P_2 this value becomes less, until in position P_3, it becomes zero.

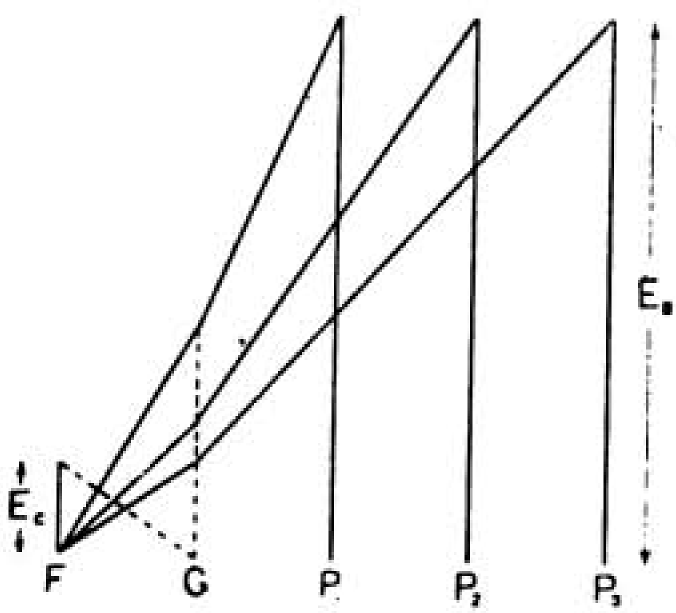

Fig. 11.

Hence, the general statement may be made, that the combined effect of the grid and a negative potential impressed on it tending to diminish the valve current, is increased when the plate is moved away from the grid.

Effect of Space Charge on Slope between G and F.

It will have been noticed that the existence of a space charge between grid and filament has, up to the present, been ignored. When it is remembered that this is a negative charge situated between grid and filament it will be readily understood that it will have some effect upon the slope along this portion of the field E_S. Now the space charge only exists when electrons are emitted from the filament at a faster rate than they can be carried away by attraction of the field E_S. Thus any excess of electrons will set up an electric field counter to E_S. If then we regard the conditions in this manner, it is seen that the result upon the slope of E_S will be analogous to that obtained by decreasing the mesh of the grid or increasing a negative potential on the grid, as already outlined.

A conception of the effect upon the slope between G and F is shewn in Fig. 12, in which the plate has been left out. The height HG represents the value γE_B, but this is reduced, by reason of the counter field of FJ to KG, which is equivalent to $\gamma E_B - E_C$. SC_1, SC_2, and SC_3 represent the loca-

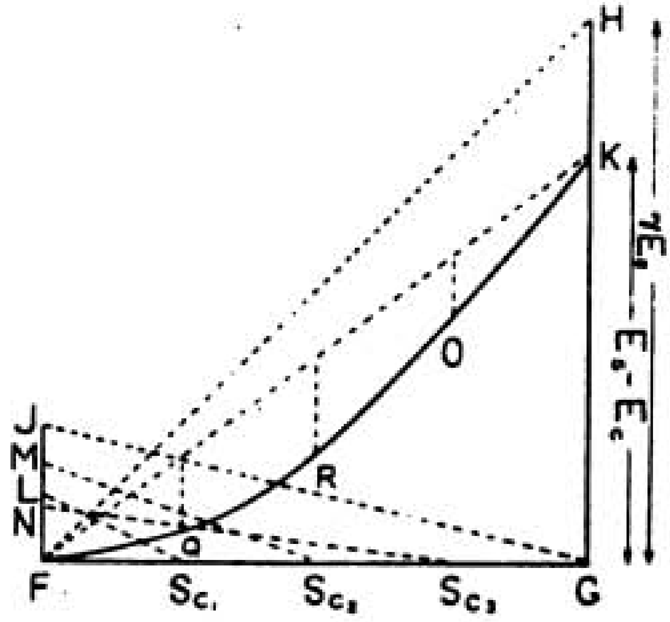

Fig. 12.

tion of the space charge and FL, FM, and FN are proportional to the intensity at the respective points. Deducting FN brings the slope down to O, similarly deducting FM and FL lowers the corresponding points of the slope to R and Q respectively. The slope therefore becomes curved similar to the line F, Q. R, O, K, which shows clearly how the velocity of electrons leaving the filament may be seriously decreased when the space charge is present.

Operating Constants.

Owing to the vast amount of research work which has been carried out by many prominent wireless and other experts, a number of the constants of the three-electrode valve, which were not long ago more or less unknown quantities, may now be deduced from its structural dimensions and the applied potentials. Therefore in addition to the store of information regarding valves thus provided, their design is greatly facilitated. Amongst the constants which are most important are those contained in the appended list. There are others, but they are hardly within the scope of these elementary notes. We will therefore limit our considerations to the four factors enumerated:

Factor	*Sign*
Plate Current	I
Voltage Amplification Factor	μ
Maximum Voltage Amplification Factor	μ_o
Plate Resistance	R_o

Plate Current.

Various formulæ have been given for the calculation of the plate current I; for instance, Langmuir gave

$$I = a\,(E + KE_g)^{\frac{3}{2}} \quad \text{.........(1)}$$

in which E is the plate voltage, E_g the grid voltage, K the maximum voltage amplification factor, and a is a factor dependent upon the valve dimensions.

Van der Bijl has shown that I can be calculated from the equation:

$$I = a\,(\gamma E_B + E_C + \epsilon)^2 \quad \text{.........(2)}$$

in which a and ϵ are constants depending on the dimensions of the valve (see preceding remarks). E_B and E_C correspond to E and E_g of Langmuir's formula (1) and γ (gamma) is the reciprocal of the maximum voltage amplification factor.

But for practical purposes the plate current can be calculated from Langmuir's original emission current equation, in a revised form, which considers the action of the grid by the inclusion of the function μ_o, thus:

$$I = 14{\cdot}65 \times 10^{-6}\,\frac{l}{r}\left(\frac{E}{\mu_o} + E_g\right)^{\frac{3}{2}} \quad \text{....(3)}$$

That this satisfies the case for practical purposes will be seen by reference to Fig. 13, which shows the plate current—grid volts characteristic of a typical V24 valve, for seven different plate voltages.

Taking the values as follows: l = 2 cms., r = 0·686 cms., E = 35 volts, E_g = 4 volts, and μ_o = 7, we obtain the following result:

$$I = 14{\cdot}65 \times 10^{-6} \times \frac{2}{0{\cdot}686}\left(\frac{35}{7} + 4\right)^{\frac{3}{2}}$$

$$= 1{\cdot}15 \text{ milliampères.}$$

It should be noted, in passing, that

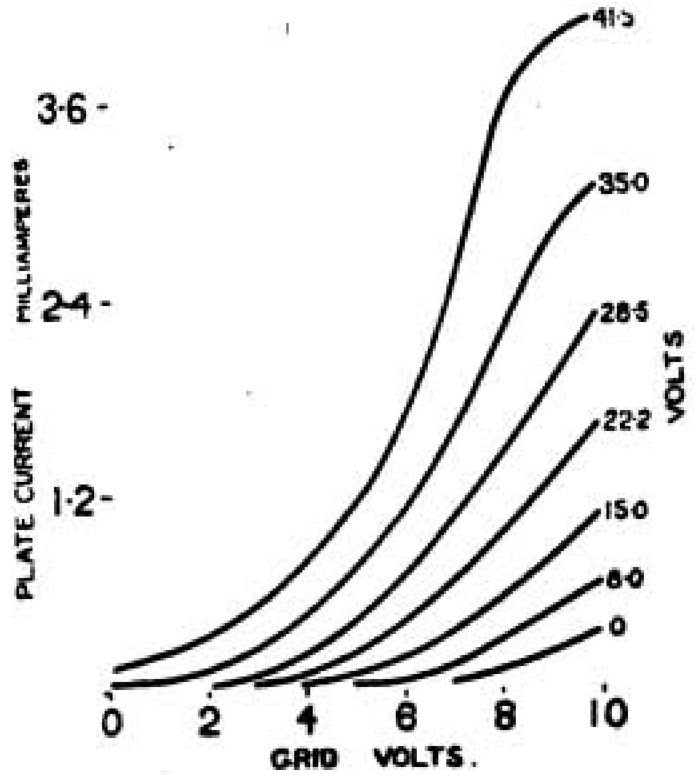

Fig. 13.

in plotting the values in Fig. 13 a series resistance was used in the negative end of the filament, across which there was a voltage drop of approximately 1·5 volts, so that E_g corresponds to the position 5·5 volts (positive), along the x axis.

The method (3) replaces the constant a in (1) and (2) by $14{\cdot}65 \times 10^{-3} \frac{l}{r}$ and, since the computation of these constants is rather a complicated process, offers a ready means of ascertaining mathematically the approximate value of the plate current obtainable, given certain constants.

It is interesting to note that the value of plate current obtainable in modern transmitting valves exceeds 350 milliampères, even when the grid is maintained at a high negative potential. In Fig. 14 are depicted three curves showing the plate current values, at 4,000, 6,000, and 8,000 volts, of a medium power transmitting valve.

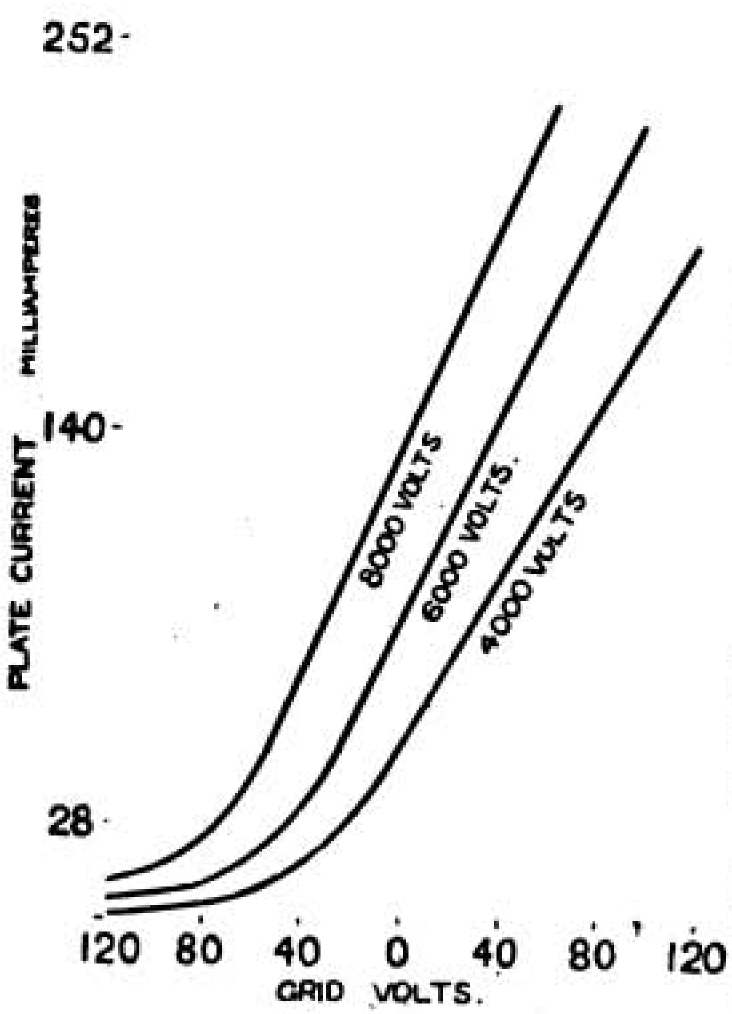

Fig. 14.

VOLTAGE AMPLIFICATION FACTOR.

In the case of a valve to be used as an amplifier, one of the chief of its constants is that which denotes its value of magnification. Such factor may be termed its voltage amplification factor, and is expressed as a ratio of change in voltage on the plate, for a constant plate current.

For instance, let us suppose that with the grid of a valve 5 volts positive, and its plate 50 volts positive, a current of 2 milliampères flows in the plate circuit. Let the plate voltage be lowered to 41 volts (*i.e.*, a decrease of 9 volts); then if by increasing the grid voltage to 6·5 volts (*i.e.*, an increase of 1·5 volts) the plate current remains the same, the voltage amplification factor at this point is $\frac{9}{1{\cdot}5} = 6$.

It will thus be seen that μ can be found practically by plotting the characteristic plate current—grid volts curves for various plate voltages, and it is now proposed to show the method of operation. It is not possible to read the value of μ directly from the curves, but it is necessary to construct two curves from these, plotting plate current against plate volts. Call the first of these derived curves A, and let it be relative to a constant grid potential of 5 volts positive; then the following set of values will be obtained from the curves of Fig. 13.

Anode volts.	Plate current.
8	0·25
15	0·5
12·2	1·75
28·5	3·5
35	6·5
41·5	9·5

and plotting these we obtain curve A. Similarly, plot curve B corresponding to a positive grid voltage of 6 volts. Both of these curves are shown in Fig. 15.

We have thus made a change of one volt on the grid (*i.e.*, from 5 to 6 volts positive) and can see at a glance the value of the decrease in plate volts necessary to obtain the same plate current at the higher grid voltage.

It will be noticed that the value μ varies when the operating position on the slope of the curve is altered; in a well-designed valve, however, the maximum value μ_o is where the grid is at zero potential with reference to the filament.

The μ_o of several modern valves is given in the appended list.

μ_o	Receiving	Transmitting
6	MARCONI V24	—
50	MARCONI Q	—
200	—	MARCONI MT 1

PLATE RESISTANCE.

For low-frequency currents the impedance of the plate circuit—internal to the valve—is in the nature of a pure resistance, and it is only when high-frequency currents are present that the inter-electrode capacity of the valve tends to lower this value. Since we are here not concerned with high-frequency currents, the consideration of R_o will be limited to that of true ohmic resistance. That this resistance of the plate (sometimes called the internal impedance) is a variable quantity will be seen by reference to Fig. 15. For instance, when working with 26 volts on the plate, and with the grid between 5 volts and 6 volts positive, the resistance R_o is

$$\frac{E_p}{I_g} = \frac{5{\cdot}875}{0{\cdot}00033} = 17{,}800\ \omega.$$

but with 37·5 volts on the plate R_o becomes $\frac{6{\cdot}375}{0{\cdot}00039} = 16170\ \omega$. Hence, as the plate voltage is increased, the value of R_o decreases for a given grid voltage.

The necessity of first evaluating μ before R_o can be determined, makes the process a rather lengthy and complicated one, since this involves the plotting of two sets of curves similar to those of Figs. 13 and 14. In order, therefore, to obviate this tedious operation, Stewart Ballantyne (Proc. I.R.E., April, 1919) has evolved a dynamic method for finding R_o directly, based on the bridge principle.

The circuital arrangement is depicted in Fig. 16.

This method has the advantage of simplicity, and a series of curves may quickly and accurately be obtained by its aid. R_1R_2 is a slide wire, and R is a known non-inductive resistance of approximately the same value as the

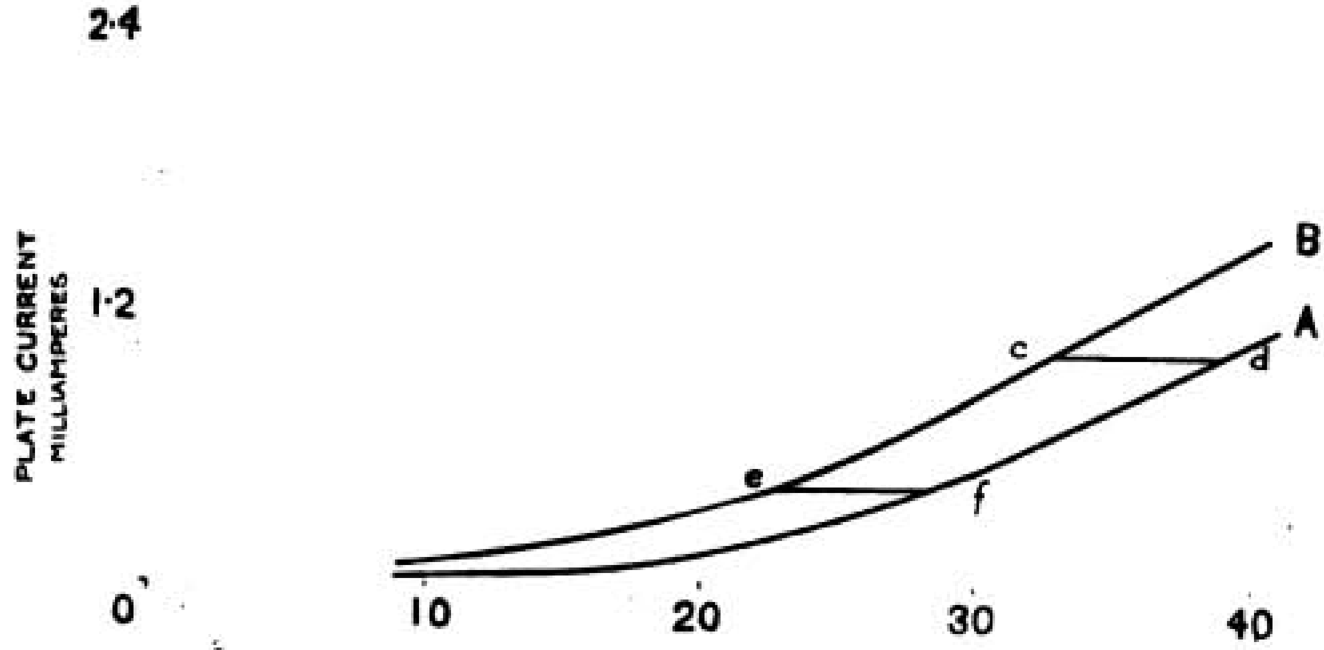

Fig. 15.

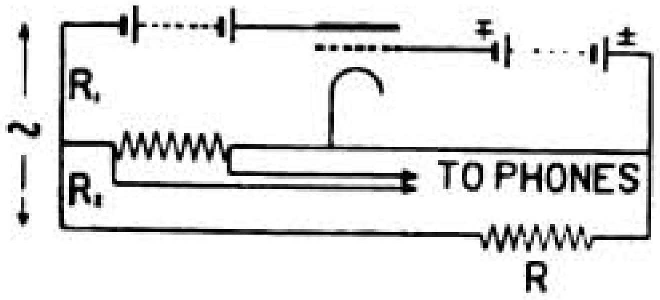

Fig. 16.

plate resistance. The method of operation is as follows: An intermittent d.c. or an a.c. is sent through R_1R_2, and the pointer is then moved along it until the current through the balance lead falls to zero, namely when signals vanish. R_o is then obtained by multiplying R by the ratio $\frac{R_1}{R_2}$. In the compilation of the curves in the concluding figure (17), the source of the current pulses was a high-note shunted buzzer; $R_1 R_2$ consisted of a yard length of number 36 Eureka wire and R of a Remco resistance rod of 19,700ω resistance.

The curve which is of most interest is that corresponding to 50 volts on the plate, since it is almost symmetrically placed with reference to the detecting point. It may appear a little curious that R_o should go up after a certain positive value of grid volts is increased, but this is due to the fact that grid current is flowing, to the right of minimum resistance.

This value of anode volts change, divided by the grid volts change (in this case, one volt), denotes the value of μ at that particular value of plate voltage. In the two cases shown, *i.e.*, $c-d$, $e-f$, the values are 6·3 and 5·9 respectively.

From the case above mentioned it will be seen that letting

V_1 = higher plate voltage.

V_2 = lower plate voltage.

V_g = the change in grid volts for constant plate current, then

$$\mu = \frac{V_1 - V_2}{V_g} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

and substituting in the case $e-f$ (Fig. 15),

$$\mu = \frac{V_1 - V_2}{V_g} = \frac{28 \cdot 5 - 22 \cdot 6}{1} = 5 \cdot 9$$

The method outlined above entails the construction of curves, which occupy a good deal of time in operation and plotting; it may be, therefore, an inconvenient process if an approximate value is all that is desired, and a quicker method may be more suitable. Such a method should already have become obvious to the reader from what has been said. Having ascertained experimentally the point at which grid current starts, note the plate voltage and current. Now decrease the plate volts and increase the grid volts till the plate current has reached its former value. It will be seen that in this operation one is, in reality, selecting the desired points on the characteristic curves, and that values may be substituted in equation (4) and μ be obtained in this manner.

Calculation of μ_o from Valve Dimensions.

The factor μ_o of a valve with cylindrical electrodes may be calculated with accuracy by the formula below, due to Sir J. J. Thomson, to whom thanks are due for permission to publish.

$$\mu_o = \frac{\pi d' N \log\left(\frac{du}{d'}\right)}{\log\left(\frac{1}{\pi dg N}\right)} \quad \ldots\ldots\ldots (5)$$

where

d' = diameter of grid in centimetres.

du = diameter of anode in centimetres.

N = number of turns per cm. length of grid.

dg = diameter of grid wire in cms.

It will be noted that this formula does not include any electrical units, but shows the factor μ_o directly from the dimensions and disposition of the electrodes. It will perhaps be of interest to see how the calculation compares with the actual case of the receiving valve mentioned above. The values are:

d' = 0·32 cms.

dg = 0·023 cms.

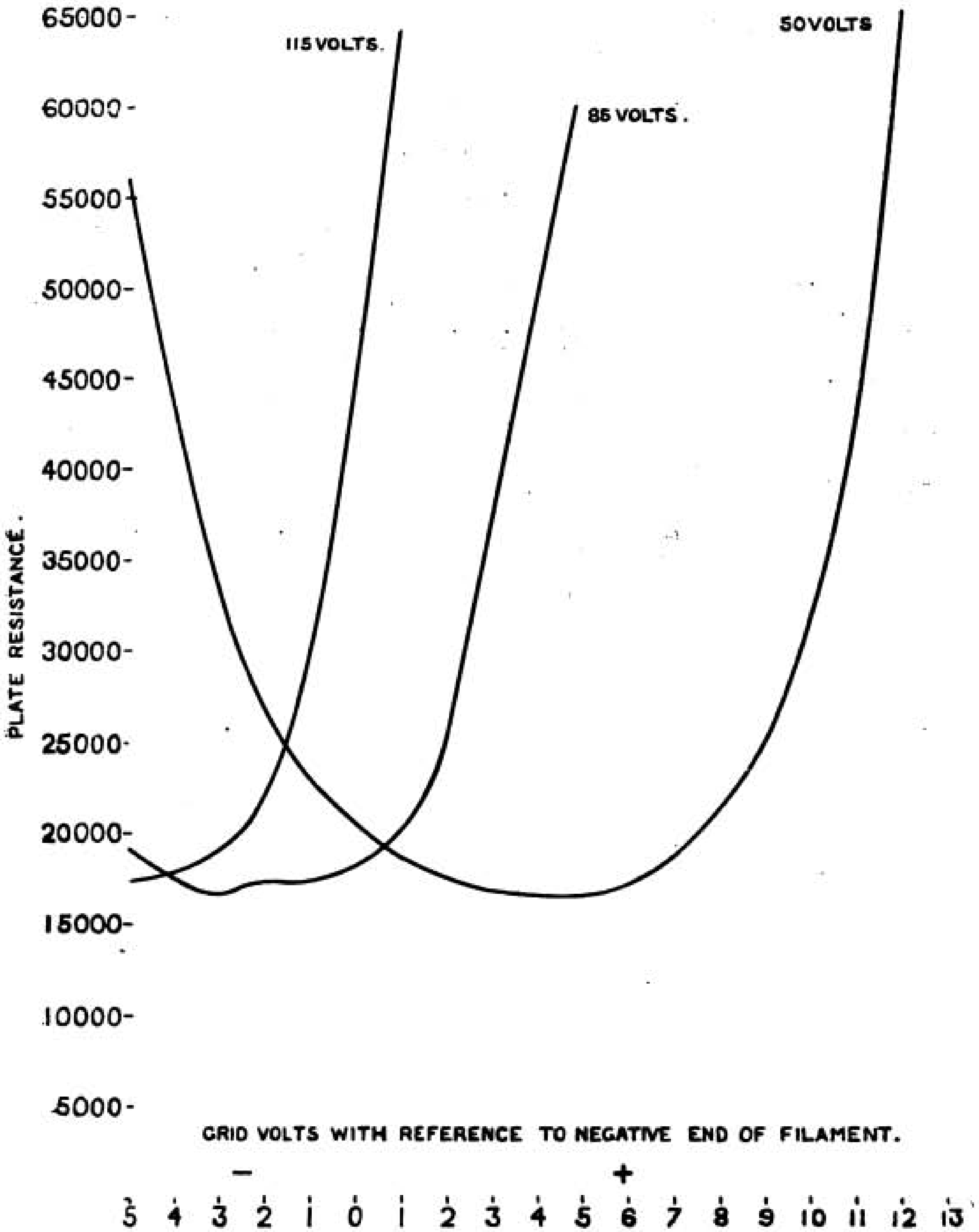
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
PLATE RESISTANCE.
115 VOLTS.
85 VOLTS.
50 VOLTS
GRID VOLTS WITH REFERENCE TO NEGATIVE END OF FILAMENT.
−
+
5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13

Fig. 17.

$du = 0{\cdot}685$
$N = 6$

and substituting in formula (5) and working the numerator first, for the sake of clearness, we obtain

$$3{\cdot}1416 \times 0{\cdot}32 \times 6 \times \log\left(\frac{0{\cdot}685}{0{\cdot}32}\right) = 1{\cdot}99$$

and for denominator we have

$$\log\left(\frac{1}{3{\cdot}1416 \times 0{\cdot}023 \times 6}\right) = 0{\cdot}345$$

$$\therefore \mu_0 = \frac{1{\cdot}99}{0{\cdot}345} = 5{\cdot}8 \text{ nearly.}$$

It will be noticed that the anode diameter, and the thickness of the grid wire, are considered in the equation (5), as indeed they should be; but provided the valve is designed correctly these two values may be disregarded, and the expression

$$\mu_0 = 2\pi r N \qquad (6)$$

will be found to be sufficiently true for practical purposes. The symbols r and N refer to the radius of the grid, and the number of turns on the grid respectively. When the grid is composed of a mesh, the value of μ_0 will be roughly $4\pi r N$, in which case N represents the number of meshes per centimetre.

Other direct methods of obtaining the voltage amplification factor have been devised, such as Miller's (Proc. I.R.E., vol. vi., 1918) and Allen's (WIRELESS WORLD, November, 1918), but reference should be made to the descriptions of these methods as given by the originators. —(*To be continued.*)

The Library Table

THE WIRELESS AMATEUR'S DIARY AND NOTEBOOK.

The Wireless Press, Ltd. 4/6 net.

THIS is an attractive looking production consisting of two separately bound parts inserted in a stout pig-skin folder which has special accomodation for stamps, visiting-cards, treasury notes, and private papers. The first part should go straight to the amateur's heart for it contains just the kind of information he is always asking for, such as a list of the world's chief high-power stations with details of the systems and wavelengths used, much useful data which has been compiled with an eye to what the amateur really needs, and a series of well-drawn typical valve circuits. Space is provided for a directory of amateur wireless stations and for " Receiver Notes " wherein the amateur can jot down the various adjustments of his instruments for certain wavelengths. There is also a 1920 Calendar and a large quantity of directly useful miscellaneous data, followed by a diary and notebook. The second part consists entirely of the ever-useful squared paper. The case measures $3'' \times 5\frac{3}{4}''$ and fits into the average top vest pocket quite comfortably.

THE WIRELESS OPERATOR'S DIARY AND NOTEBOOK.

The Wireless Press, Ltd. 4/6 net.

With the exception of some items which have been specially prepared for the benefit of professional wireless operators, this notebook is identical with the one described above. It contains a list of the principal stations on the ocean routes, a table for calculating tolls on messages, notes on freaks and long-distance communications, and on the best adjustments of the receiver for various wavelengths. It also includes the valve circuit diagrams.

Notes of the Month

THE STEADY MARCH OF WIRELESS.

The Amalgamated Wireless (Australasia) Ltd. have received an order for a complete wireless installation for direct communication between Nukualofa and Suva.

* * *

The Council of Ministers, Colombia, has approved the terms of a contract for installing a wireless station in Puerto Velillo or some other point on the coast. The plant is to be powerful enough to maintain day and night communication with the station which the Marconi Company is to erect at Bogota.

A station is also to be constructed in one of the islands of the St. Andres and Providencia Archipelago.

* * *

A wireless station has been installed at Cobija, Bolivia, for communication with other parts of the Republic and with Brazil.

* * *

The Venezuelan government has invited tenders for the construction of a wireless station to be situated in the neighbourhood of Caracas, which must be able to communicate with the U.S.A. and Europe. The specification provides for both C.W. and spark systems.

* * *

CANADA—BERMUDA WIRELESS SERVICE.

The Department of the Canadian Naval Service at Ottawa announces the inauguration of a commercial wireless service between Canada and Bermuda. The service will be established by the Canadian wireless station at Barrington Passage, Nova Scotia, and the British Government station at Bermuda.

The Stavanger wireless station in Norway has now been opened. Communication will be held with the Annapolis station at Washington and the Tuckerton station near Philadelphia.

* * *

Restrictions in force during the war with regard to the use of wireless by merchant vessels in Argentine waters have now been removed.

* * *

NEW CALL SIGNALS.

The following alterations and additions are notified by the Berne Bureau:—

FFA	Algiers.
FFC	Bonifacio.
FFH	Le Havre.
FFM	Marseilles.
FFN	Nice.
FFU	Ushant.
FFX	Bordeaux.
FUC	Cherbourg—Rouges—Terres.
FUD	Dunkirk—Castelnau.
FUE	Mengam.
FUI	Ajaccio—Aspretto.
FUK	Aran Ain el Turck.
FUN	Lorient—Pen—Mané.
FUQ	Porquerolles.
FUR	Rochefort-sur-Mer.
FUX	Toulon—Croix des Signaux.

* * *

PUBLICATION OF TECHNICAL W/T ARTICLES.

The War Office states that it has been decided to allow experts (either military or civil) employed on wireless duties in the Army, to write scientific papers for publication in this country. The form of publication may be either by journal or by lecture, provided that no detailed reference is made to Service Sets and that the paper is forwarded through the usual channels to the War Office, whence it will be passed for censoring to the Wireless Telegraphy

Board. Papers for censorship should be submitted at least a month before it is desired to publish them.

• • •

NEW APPOINTMENT.

Acting Captain J. A. Slee, C.B.E., R.N., has been appointed Technical Superintendent and Adviser on the staff of the Marconi International Marine Communication Co., Ltd.

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I.E.E. AWARD.

The Council of the I.E.E. has awarded the David Hughes Scholarship of £50 to Mr. Bernard Cronin, of the University College of South Wales and Monmouthshire.

• • •

THE HIGH-FREQUENCY RESISTANCE OF WIRES AND COILS.

An interesting paper on the above subject was read by Professor G. W. O. Howe, D.Sc., at the ordinary general meeting of the Institution of Electrical Engineers, held at the Institution of Civil Engineers on Wed., Dec. 17th last, followed by a discussion in which Professor C. L. Fortescue, Dr. W. H. Eccles, Messrs. P. R. Coursey, H. W. Taylor, F. Murphy, and R. C. Clinker took part.

• • •

SUCCESSOR TO SIR OLIVER LODGE.

Mr. Chas. G. Robertson, C.V.O., has been appointed Principal of Birmingham University. He has been Tutor in Modern History at Magdalen College, Oxford, since 1905.

• • •

AWARD FOR PHYSICS.

It has been decided to award the Kastner-Boursault prize for Physics to M. Marius Latour. This gentleman, who is a certificated engineer of l'Ecole supérieure d'Electricité, is well-known in wireless circles for his work on H.F. alternators in connection with wireless telegraphy, and on the thermionic valve.

• • •

WIRELESS TO ROME.

A special wireless service between England and Italy for the use of the newspaper Press was opened on 6th January last by the Marconi Company. This service, authorised by the Italian Government and the British Post Office, was instituted particularly to assist the Italian Press in obtaining prompt reports of the Italian Prime Minister's visit to London. The Marconi high-power station at Carnarvon is being used for the purpose and three hours daily have been allotted for this particular traffic.

• • •

AWARD TO DR. WIEN.

The *Technische Hochschule* of Danzig has conferred upon Privy Councillor Dr. M. Wien, Professor in ordinary of Physics at the University of Jena, the rank of "Honorary Doctor Engineer" in recognition of his achievements in the domain of oscillation phenomena and especially for his discoveries relating to the effect of the quenched spark.

• • •

THE PHYSICAL SOCIETY OF LONDON.

At the tenth annual Exhibition held by the Physical Society of London and the Optical Society at the Imperial College of Science, South Kensington, on January 7th and 8th last, there was a fine display of Wireless Apparatus. The Exhibits included: Thermionic Valves, shown by the Marconi-Osram Valve Co., demonstrating the evolution of the valve.—Direction Finders (Marine Pattern), Measuring Instruments, Various types of Valves, etc., shown by Marconi's Wireless Telegraph Co., Ltd.—Various types of Condensers, shown by the Dubilier Co., Ltd.—Induction Coils and Transformers, shown by the High Tension Co.—Three-Valve Amplifying Receiver and a series of Condensers, shown by Messrs. H. W. Sullivan.—A new Wireless Condenser of extra fine adjustment, named the "Phantom," shown by Messrs. Isenthal & Co., Ltd.—A Series of Thermionic Valves, shown by the Edison Swan Electric Co., Ltd.

* * *

CATALOGUE OF WIRELESS APPARATUS.

It may interest amateurs to know that Messrs. H. W. Sullivan's new catalogue is now in the press and will be ready for issue during the early part of February.

WIRELESS CLUB NOTES.

THE WIRELESS SOCIETY OF LONDON

The Wireless Society of London will hold its next meeting at the Institution of Civil Engineers, Gt. George Street, Westminster, on January 29th, at 6 p.m., when Mr. R. C. Clinker will deliver a lecture on "A Portable Valve Set and some Properties of C.W. Circuits," which will be illustrated by experiments and lantern slides.

The Presidential Address will take place towards the end of February at the Institution of Civil Engineers. Notice of the exact date will appear in the next issue. Those who were privileged to attend the last Presidential Address given by Mr. A. A. Campbell-Swinton, F.R.S., in 1914, will look forward with pleasure to some novel experiments, with which the President's address will no doubt be illustrated.

* * *

THE BURTON-ON-TRENT WIRELESS CLUB.

(Affiliated with the Wireless Society of of London.)

On December 17th, 1919, a well-attended meeting was held. Mr. A. Chapman, presiding, stated that a number of books were now available and could be borrowed by members. He also stated that the wireless room was not up to then equipped with a valve, but that excellent reception was, however, being obtained. Four new members were elected. The Secretary announced the affiliation of the Club with the Wireless Society of London.

Mr. A. J. Selby then gave a demonstration of electricity and magnetism with home-made instruments, and Mr. R. Chapman (late R.A.F.), replied to several questions on the higher principles of wireless.

Hon. Sec., Mr. R. Rose, 214, Belvedere Rd., Burton-on-Trent.

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THE NORTH MIDDLESEX WIRELESS CLUB.

(Affiliated with the Wireless Society of London.)

A meeting of this Club was held on December 31st, 1919, at Shaftesbury Hall, Bowes Park, the President, Mr. A. J. Arthur, being in the Chair. Addressing the meeting, Mr. Arthur announced that it was hoped that the aerial pole would be delivered in the course of a few days, and asked that some members would form a working Committee to look after the erection of the pole and install the instruments. Several names were at once handed in. He then called on Mr. Geo. W. Evans to give his address on the construction of Variable Condensers.

Mr. Evans then gave a most instructive talk, and he having brought a number of variable condensers of different types, members were able to gain a lot of useful information.

The chief difficulties likely to be met with were explained, and the salient points of each type of instrument were pointed out. A short discussion then followed, at the close of which Mr. Savage moved a vote of thanks to Mr. Evans, and at the same time drew the attention of those present to the necessity of more lectures of that nature, and asked members to come forward with suggestions.

For particulars of the Club apply to the Hon. Secretary, Mr. E. M. Savage, Nithsdale, Eversley Park Road, N. 21.

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THE DERBY WIRELESS CLUB.

(Affiliated with the Wireless Society of London.)

The Annual General Meeting was held on Jan. 2nd, when the Secretary, speaking on behalf of the Chairman, Mr. S. G. Taylor, who was unable to be present, dealt with the amateur situation and recent developments of wireless. Reviewing the present position of the Club, he stated that the membership is now 58 as compared with the pre-war total of 120; this he attributed to the fact that many of the Corresponding Members had now joined clubs in their home towns.

Regret was expressed that Sir Henry Norman, M.P., was unable to continue as President, and it was announced that Mr. F. W. Shurlock, B.A., B.Sc., has consented to be President for the year. Mr. S. G. Taylor was re-elected Chairman, Capt. W. Bemrose, O.B.E., Hon. Sec. and Treasurer, and Mr. J. Lowe, Librarian. The Committee were also elected, a draft of new Club Rules was submitted and approved, and it was resolved to affiliate the Club with the Wireless Society of London.

The meeting was followed by an exhibition of apparatus. Mr. S. G

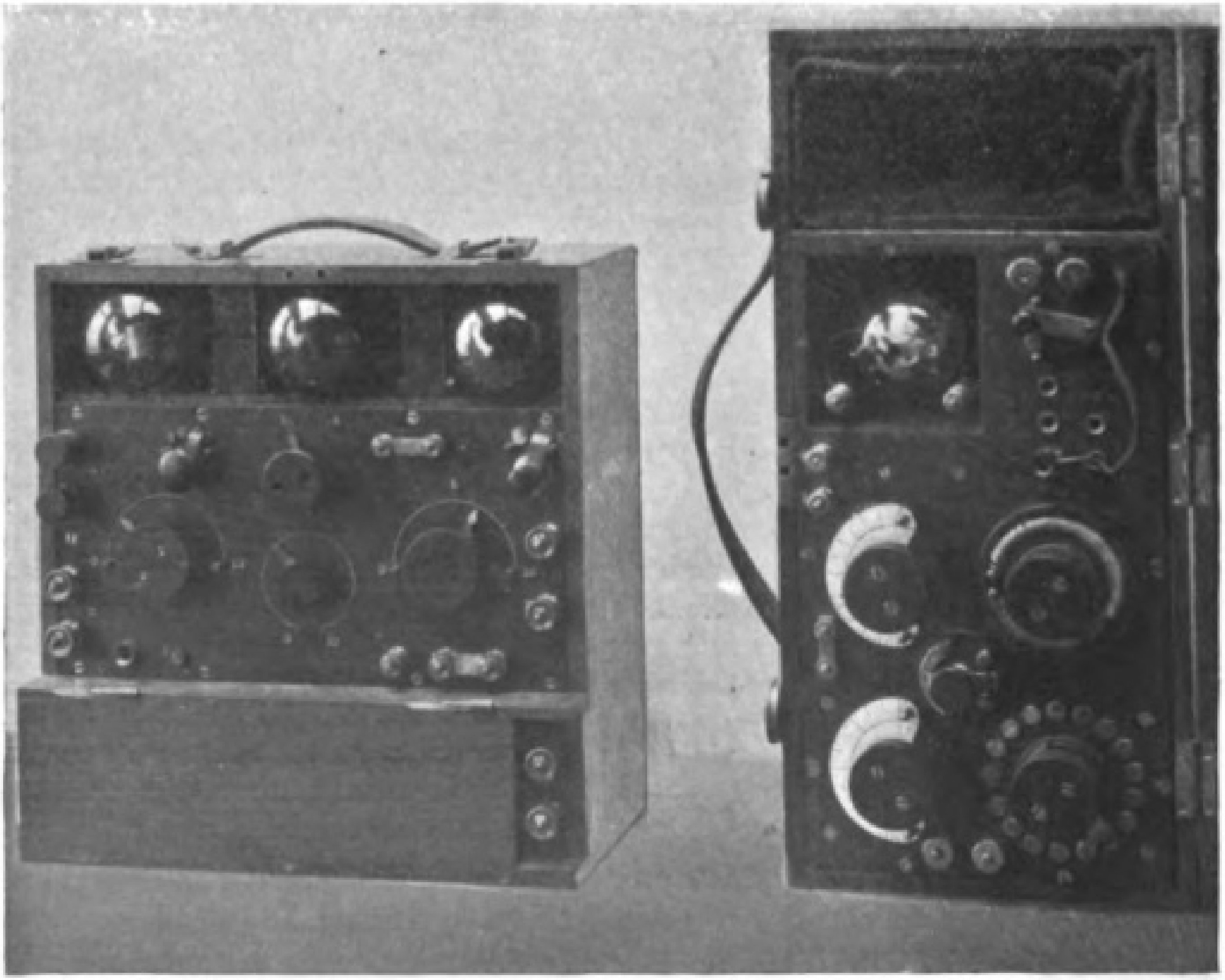

Fig. 1. Portable Receivers exhibited by Mr. A. T. Lee at the Derby Wireless Club.

Taylor showed, amongst other things, a compact single-valve receiver, the whole of which was contained in a cigar-box measuring about $7'' \times 4\frac{1}{2}'' \times 2''$. Mr. A. T. Lee showed two portable receivers, specially built by himself for use on aircraft (Fig. 1). Capt. Bemrose exhibited a five-valve amplifier of his own construction (Fig. 2), and Mr. J. Huson showed some German vari-

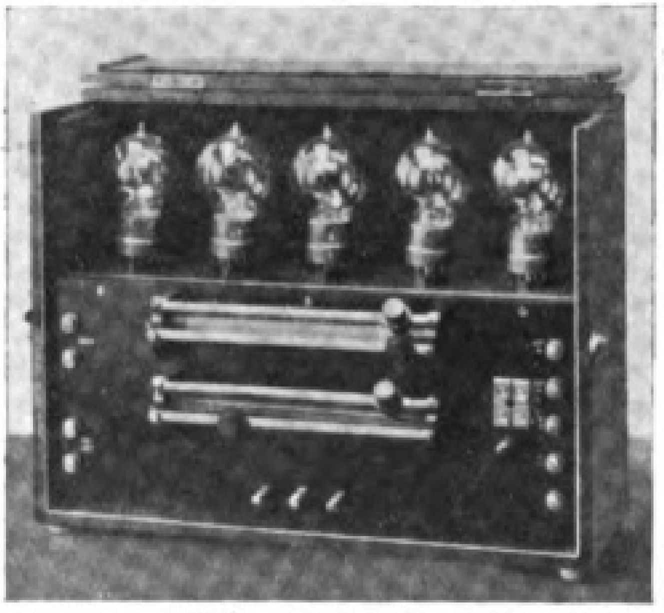

Fig. 2. Amplifier Exhibited by Capt. Bemrose at the Derby Wireless Club.

able condensers and other parts of radio apparatus. Messrs. Newton Bros. kindly lent three W/T. generators as used on aircraft.

The Secretary (Little-over-Hill, Derby) will be pleased to hear from old or intending new members.

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THE MANCHESTER WIRELESS CLUB.

(Affiliated with the Wireless Society of London.)

The first General Meeting took place on December 17th, 1919, at the Club Rooms, 335, Oxford Street, Manchester. A large and representative gathering of members was present, most of whom had seen service of an important nature as wireless operators in H.M. Forces.

The Committee has lost no time in getting to work, and already a splendid series of lectures has been arranged for the session.

Through the kindness of the Principal of the Universal School of Telegraphy, the members have been allowed the use of practice rooms and instruments, and also the use of a workshop, which is a great boon to the amateur.

The Club is now open to receive applications for membership, and every help is given to the new *bona fide* wireless experimenter in designing and constructing his instruments.

Morse Code practice takes place every Wednesday at 7 p.m.

Full particulars may be obtained from the Hon. Sec., 16, Hawthorne Avenue, Monton, Eccles, Lancs.

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THE THREE TOWNS WIRELESS CLUB (PLYMOUTH).

December 3rd, 1919—The Chair was taken by Mr. J. Jerritt, and a lecture on "Condensers and their Uses" was delivered by Mr. Voss (late R.F.C.), at the conclusion of which the Hon. Sec. (Mr. W. Rose), drew a number of diagrams illustrating how an ordinary vane type condenser may be specially adapted for valve work.

December 10th, 1919—Mr. J. Jerritt in the Chair. The evening was devoted to Morse practice and a discussion on a variometer brought by the Hon. Sec. and kindly lent by Messrs. Antennæ Instruments, 50, The Promenade, Palmer's Green. Although guaranteed to be efficient only up to 8,000 metres, this instrument worked well up to 10,000 metres.

The club is still waiting for its P.M.G. "permission," as also are some of the members.

The Hon. Sec., Mr. W. Rose, 7, Brandreth Rd., Compton, Plymouth, will be pleased to see visitors or intending members.

The Wireless and Experimental Association.

A lecture on internal combustion engines was delivered on Jan. 7th by Mr. J. F. Sutton, illustrated with diagrams and dealing chiefly with the smaller types. Reports of the other January meetings will be given in our next issue, as they will not occur until after this number has gone to press.

Intending members please address the Secretary, Mr. F. H. Gribble, 48, Surrey Square, S.E. 17.

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The Sheffield and District Wireless Society.

No reports of recent meetings have come to hand (will the Hon. Sec. kindly note?) but we must mention that we have received a copy of the Presidential Address which was delivered on Oct. 2nd, 1919, by Mr. H. E. Yerbury, M.I.C.E., M.I.E.E., M.I.Mech. E., at Sheffield University. It is a most interesting pronouncement, upon which we congratulate the Society, and we venture to suggest that some of the other Societies would be repaid by devoting an evening to a discussion of the paper. We shall be delighted to lend our copy if others are unobtainable.

Hon. Sec., L. H. Crowther, 156, Meadow Head, Norton Woodseats.

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The Southport Wireless Experimental Society.

Hon. Treasurer and Sec., Mr. Philip H. Christian, 9, Russell Road, Southport. This is a newly formed club, further particulars of which will be published later.

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The Bristol and District Wireless Association.

Will intending members please note that the address of the Hon. Sec., Mr. Alan W. Fawcett, is 11, Leigh Rd., Clilfton.

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Wanted.

Wireless Clubs for Chelmsford, Brighton, Croydon, Birmingham, and Edinburgh. Those interested should communicate with the following gentlemen. Mr. C. E. Jackson, 3, Seymour Street, Chelmsford; Mr. M. G. Foster, Sillwood House, Sillwood Street, Brighton; Mr. A. F. Lake, 318, Brighton Road, South Croydon; Mr. A. H. Staples, Y.M.C.A., Dale End, Birmingham, and Mr. W. Winkler, 9, Ettrick Road, Edinburgh.

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The Liverpool Wireless Association.

Hon. Sec., Mr. S. Frith, 6, Cambridge Road, Crosby, Liverpool.

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Newcastle and District Amateur Wireless Association

Sec., Mr. A. W. Bridges, 53, Greystoke Avenue, Jesmond, Newcastle-on-Tyne.

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Barnsley Amateur Wireless Society.

Sec., Mr. G. W. Wigglesworth, 13, King Edward's Gardens, Barnsley.

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Overseas Radio Clubs.

Holland: The Nederlandsche Vereeniging voor Radio - Telegrafie. Official organ: *Radio-Nieuws,* van Aerssenstraat 162, den Haag, Holland. Membership: *circa* 1500.

United States: The Milwaukee Amateurs' Radio Club. Secretary: Mr. Rudolf A. Teschan, 2319-2329, Wells Street, Milwaukee, Wis., U.S.A.

The Proceedings of the Wireless Society of London

Ordinary General Meeting held in the Lecture Hall of the Institution of Civil Engineers, on Friday, December 19th, 1919. The President, Mr. A. A. Campbell Swinton, in the Chair.

The Secretary read the Minutes of the last meeting which were duly confirmed.

THE PRESIDENT then referred to the list of members recommended by the Committee for election and now put up for ballot by the meeting. He also announced that three members of the Society had been transferred from the grade of Associate to that of Member. Dr. J. Erskine-Murray then delivered a lecture entitled "The Transmission of Electro-Magnetic Waves about the Earth," which was followed by a discussion. The meeting adjourned at 7.30 p.m. after passing a vote of thanks to the Lecturer.

THE TRANSMISSION OF ELECTRO-MAGNETIC WAVES ABOUT THE EARTH.

BY J. ERSKINE-MURRAY, D.SC., F.R.S.E., SQUADRON LEADER R.A.F.

IN this paper I want to give you a *résumé* of the state of our knowledge of the conditions in the atmosphere as regards the transmission of electrical waves. Most of our work in wireless is, as a rule, on the actual instruments themselves; but this takes us outside, into meteorology and the physics of the atmosphere. The atmosphere is not very thoroughly understood, though great advances have been made recently; but our knowledge is increasing, and, though it seems rather strange, we certainly have in the past few years learned quite a lot about it from wireless observations.

Now the first—for I am going to inflict upon you more or less the story of the thing from the beginning—the first serious experiments on transmission were made by the late Mr. Duddell and Mr. Taylor, who was at that time a wireless officer in the Post Office. I do not know that they were the first actual measurements but they were certainly the first serious measurements; they consisted of observations of received current by means of the Duddell thermo-ammeter at a station near the pier of Howth, in Ireland, near Dublin. The telegraph ship belonging to the Post Office was fitted with a spark transmitting set, and she sailed in various directions from Howth, including a trip across to Holyhead. Fig. 1 shows by the full lines the actual currents received at Howth when the ship was at certain definite distances, as she was crossing from Howth to Holyhead. There are two lines in the Fig., one showing the received currents for 60 sparks per second, and the other for 40 sparks per second. They are both the same type of curve. The dotted line shows the product of the received current and

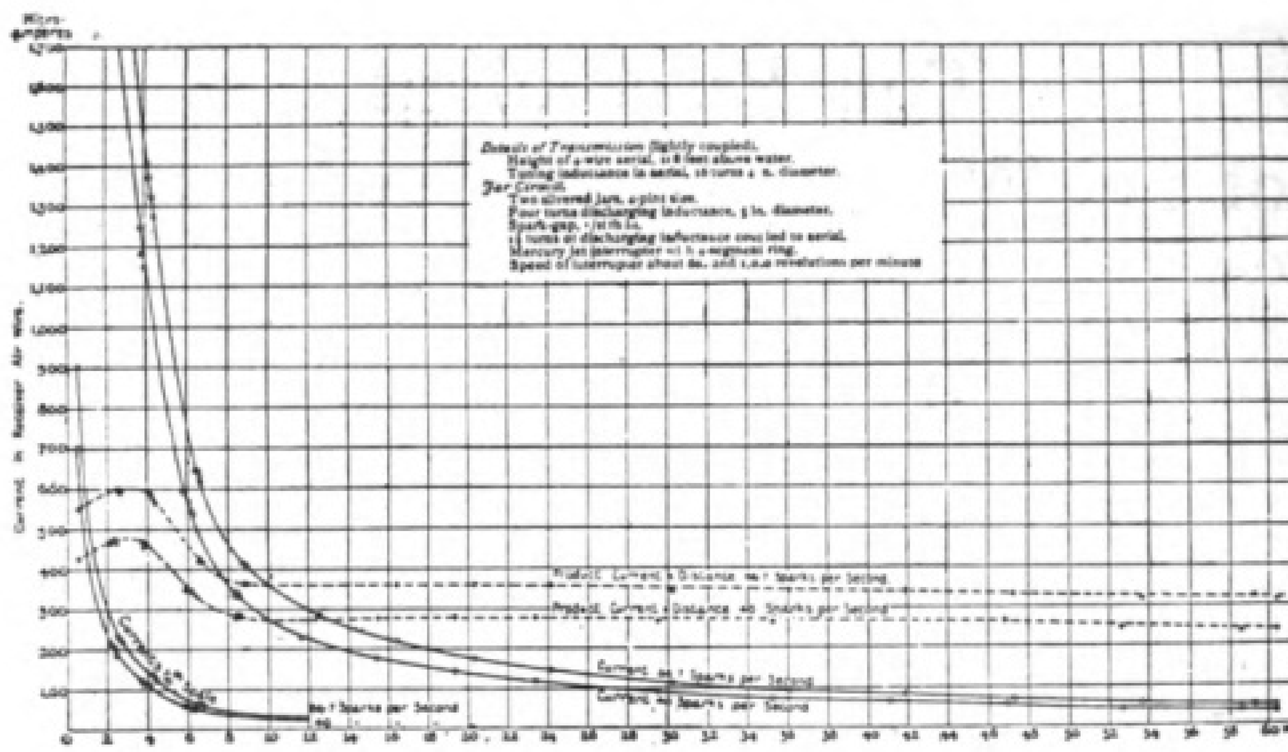

Fig. 1. Received Currents at Howth. Ship crossing from Hcwth to Holyhead.

the distances between the receiving and transmitting stations. You will notice that for a large part of the course it is nearly a straight horizontal line, that is to say, that the received current was very nearly inversely proportional to the distance. There is a slight drop as you get further away, indicating some kind of absorption. There is a very curious hump between zero and eight miles, which shows something quite different—that is, there is some difference in the conditions for that portion of the course.

Fig. 2 is another diagram relating to the same set of experiments, in which the trip was in a slightly different direction. It shows the same

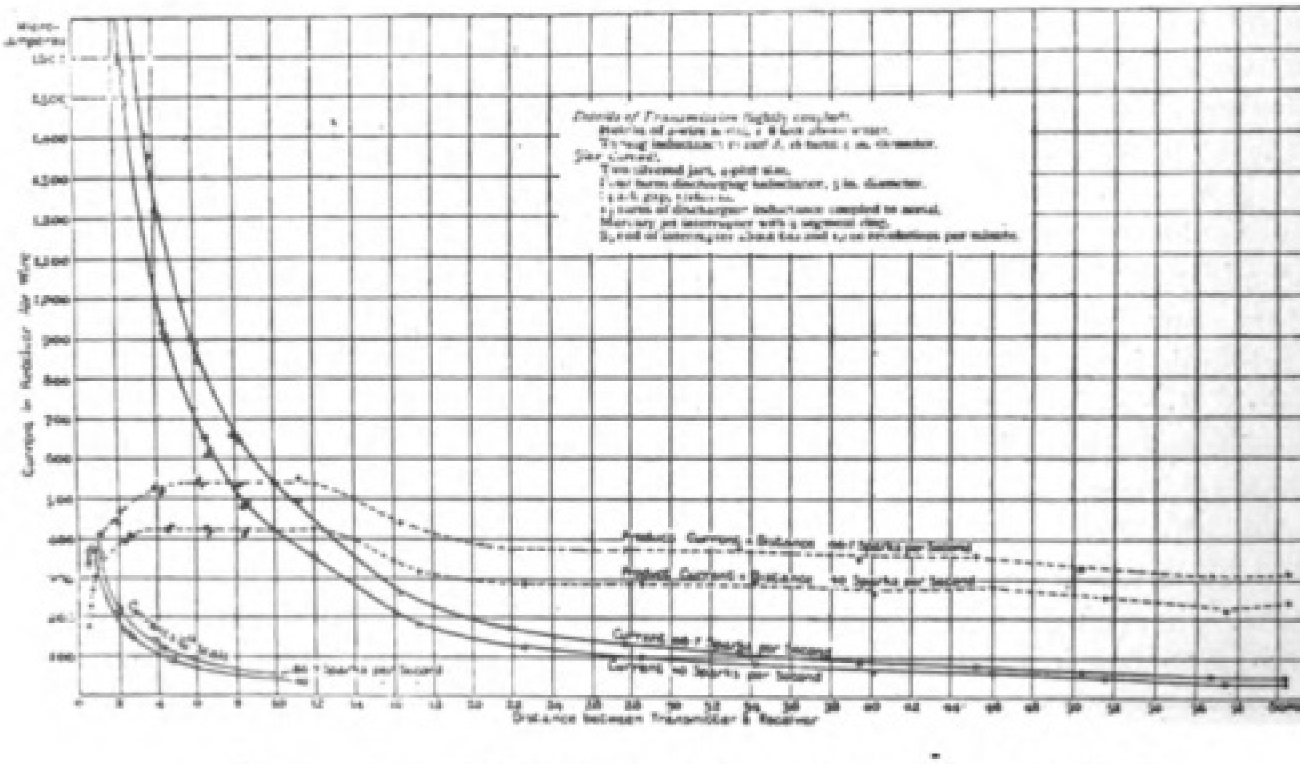

Fig. 2. Received Currents at Howth. Ship returning to Holyhead.

features: the product of current into distance is nearly constant from about twenty miles to about sixty miles, which was right across the channel, but the hump is very much larger. That is to say, between sixteen miles and the start, there was a very much larger current than would be expected if it were proportional to the distance. That is for the ship returning.

Now I would like to show you what I take to be the meaning of these curves. Fig. 3 shows the tracks of the vessel near Howth. For the first three miles or so on the outward track the signals were very much stronger

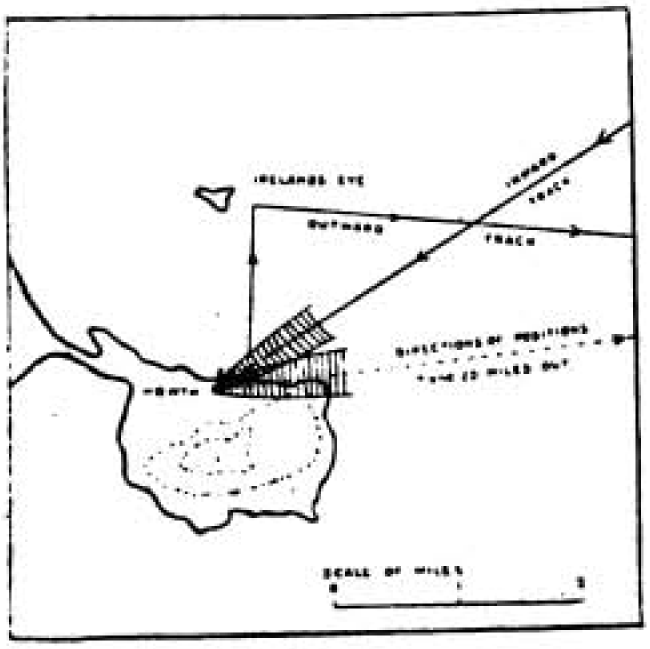

Fig. 3. Useful portions of wave trains arriving at Howth from various directions.

in proportion to those received during the remainder of the outward trip (Fig. 1). The outward track went straight out from Howth pier, turned eastwards, and went on with a slight trend southwards. The dotted line in Fig. 3 shows the direction of the vessel when she was twenty miles out on the outward track, and seven miles out on the inward track. Those were the positions where the sudden transitions took place—the product of received current and distance, from being constant at one value, rose suddenly to a higher value as Howth was approached. For the first portion of the track the signals had to cross practically no land; after the vessel was about seven miles out the signals had to traverse a considerable portion of the land between the station and the eastward coast. The lower shaded area on the Fig. is supposed to represent the waves which really got to the aerial. They scattered a bit because the aerial has a certain height, absorbs a certain amount, and there is a certain concentration. The parabolas bounding the shaded areas—they are approximately parabolas—represent the last parts of the series of waves arriving at the receiving station, and it may be noted that in the case of the inward track, very little of that area is on land (upper shaded area); in the outer track, about half of it is on land (lower shaded area). This makes a difference. All the outer part of the journey of the waves was over sea; but the tail-end receptional part had to pass over about a mile and a half of land before it got to the station. In the other positions, to the northward, there was no such absorption; in the positions southward, there was much more absorption, the product of current into distances being still smaller. This is a practical proof that the ground resistance, especially near the receiver, is of much importance.

Other deductions which I made from those experiments, showed that the actual loss by absorption and the dissipation during the day was equivalent to about 0·24 micro-amperes per mile on a total of 126 micro-amperes at 60 miles. That is hardly a strict mathematical way of stating it but it gives a reasonable idea. During the night the drop was only 0·025 micro-amperes per mile, just about a tenth. Obviously, therefore, there was more dissipation during the day than during the night.

The form in which the waves arrive at the receiving station is very important. The effect of the ground or sea is to bend back the wave-front by reason of the waste of energy due to ground resistance. The result of this is that the energy reaches the receiving station not horizontally, but in a downward sloping direction. Hence it follows that this energy must have been transmitted in a direction sloping upwards. The energy which leaves the transmitting aerial in a *horizontal* direction is bent downwards and dissipated in the ground immediately Thus the energy arriving at the receiving aerial is transmitted mainly through the upper parts of the atmosphere. A series of diagrams has been given by Dr. Zenneck* showing not exactly the form of the waves but how the received voltage varies at a point as a wave passes it. These diagrams, by showing the inclination of the maximum received voltage under different ground conditions, indicate the direction in which the receiving aerial should be inclined in order to obtain the best signals.

Fig. 4 indicates roughly the properties of the atmosphere. The left-hand scale gives kilometres of height. The lower layers of the atmosphere are oxygen and nitrogen; higher up the percentage of nitrogen increases; at about 75 kilometres there is no more nitrogen but there is a little hydrogen. A paper has appeared this month in the *Philosophical Magazine*, in which Professor Lindemann discusses this question of atmospheric composition in connection with magnetic storms and disturbances. He rather doubts whether there is much hydrogen there, partly from the fact that there is not

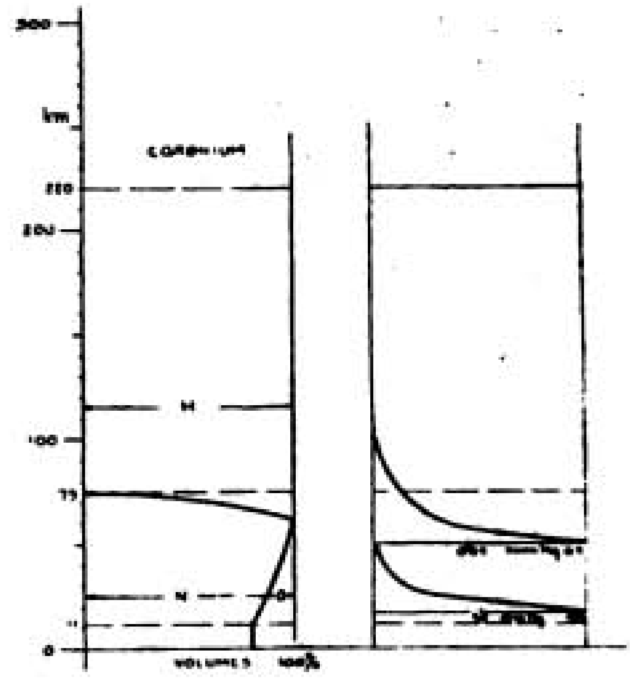

Fig. 4. Diagram showing composition and pressure of the atmosphere at various heights.

much to be seen of the hydrogen spectroscopic line. The right-hand side of this diagram indicates the atmospheric pressure, but this does not affect us much at the moment, except to show that at the fifty kilometre line you have got a very low barometric pressure and therefore a place where there may be considerable conductivity. Fig. 5 shows to scale the curve of the earth, marked E, and above it the part of the atmosphere which is conductive—not very conductive, but about as conductive as very good clean water. This conductivity is confirmed from the known facts about vacuum tubes. At a pressure such as we get at 75 kilometres up there must be a fair conductivity, especially if there is ionisation, and, in the day-time, ionisa-

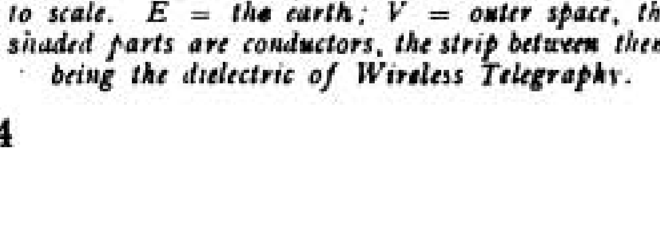

Fig. 5. A portion of the earth and atmosphere to scale. E = the earth; V = outer space, the shaded parts are conductors, the strip between them being the dielectric of Wireless Telegraphy.

* Dr. Zenneck: "Handbook of Wireless Telegraphy."

tion must be always present owng to the ultra-violet light from the sun, if for no other reason.

The first suggestion of a conducting surface in the upper atmosphere was due to G. F. Fitzgerald, a well-known Irish physicist who made the suggestion in 1893. Sir Oliver Lodge made some experiments to ascertain whether any oscillations could be detected, that might be produced by the concentric condenser formed by the earth and this layer. He could not find any such oscillations. Heaviside introduced the same idea into his article on "Telegraphy" in the *Encyclopædia Britannica*—the latest edition—and Professor Kennelly of America elaborated the idea somewhat later.

Now the next point that we come to is the question of the variation between day and night. This was first noticed by Marconi in 1902. He had an installation on a ship, I think the *Philadelphia*, going across to America, and by day he got good signals up to about 700 miles. By night he got them up to about 1,500 miles, or some such figure about twice as far at night as it was during the day. That was very interesting, and naturally it was put down at first to a possibly less electrically perturbed atmosphere during the night. This was therefore naturally connected with the ionisation of the air by daylight. Much experimental data began to accumulate shortly after that; in particular, observations made by Mr. Edwards, head of the Canadian Government wireless service. A great many observations were published of long distance transmission during the night, or "freaks," as they were called. I put those all together some time ago, and found that it did not matter in which direction you went, or what wavelength was used, these unusually long transmissions could be effected on many nights in the year.

The particular case which seemed to make it perfectly clear that this was due to reflection from the upper layer was one in which there were three stations—Victoria in British Columbia, on Vancouver Island, Pachena Head, on Vancouver Island, about 75 miles away, and a place on another island, called Ikeda Head, four hundred miles away. (Fig. 6.) Victoria transmits to Pachena Head during the day and during the night equally well, but always with some difficulty (there is some local difficulty). Victoria can be heard at Ikeda Head almost every night, but never during the day. If you assume your upper conducting layer as at AB, to act as a reflector during the night, the above is easily explained. Signals from Victoria to reach Pachena Head by reflection from the layer AB, would strike it at the large angle θ. This is not favourable for reflection, especially as the layer is by no means a perfect reflector, but is like the reflection from water or glass. A great deal of the energy will go through. In order to reach Ikeda Head, the waves

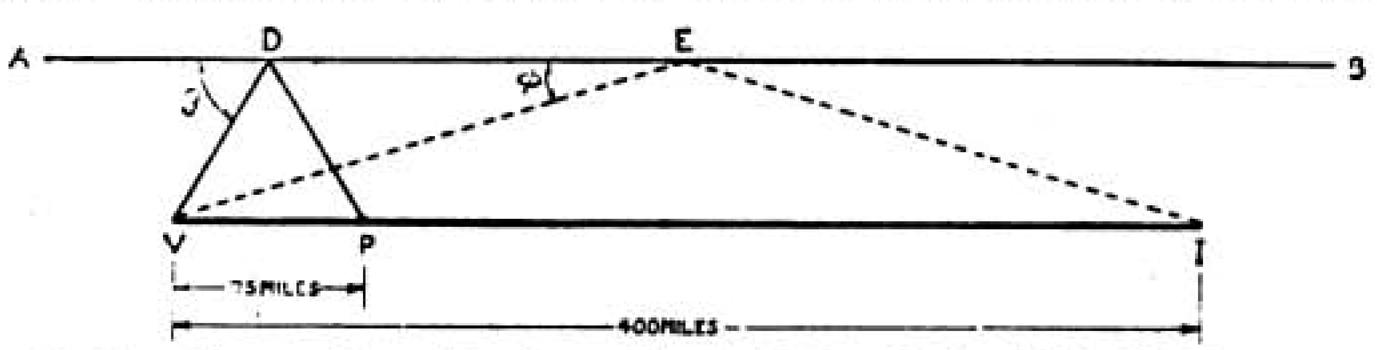

Fig. 6. Diagram of transmission between Victoria, Pachena Head and Ikeda Head Stations.

will have to strike a point E about 200 miles away. They will graze the surface at the small angle ϕ and the reflection will be good. This explains the fact that signals are received at Ikeda Head during the night, and not during the day—whereas the night makes very little difference to the communications between Victoria and Pachena Head. Many other instances could be given but this is a particularly good one.

Now I would like to mention Dr. Austin's measurements of the energy received at considerable distances over sea by day. He carried out a great many experiments, from the results of which he deduced the following well-known formula:—

$$I_r = 4{\cdot}25\ I_s \frac{h_1 h_2}{\lambda d}\ \epsilon^{-0{\cdot}0015 d/\sqrt{\lambda}}.$$

where I_r = Received current (amperes)
I_s = Sending current (amperes)
h_1 = Height of sending aerial (kilometres)
h_2 = Height of receiving aerial
λ = Wavelength (kilometres)
d = Distance between stations (kilometres)

It shows the relation between the received aerial current and the transmitting aerial current, the distance and the wavelength. It includes a factor for dissipation, that is to say the loss of energy *en route*. It is interesting to note that Dr. G. N. Watson published only a few months ago a mathematical paper in which he shows that a layer of ionised air having a resistance of $6{\cdot}95 \times 10^5$ ohms per centimetre cube, and a height of about 100 kilometres, will give just the same results as Austin's formula. We have now, therefore, a theory for the Austin formula. This all goes to show with almost mathematical certainty the existence of this ionised layer.

Of course it is not actually a case of reflection in the day-time; it is not a purely reflecting layer. In the daytime it is rather a case of refraction and appears to conform to the explanation which Dr. W. H. Eccles has given of the bending of electromagnetic waves in their passage from a layer of less to a layer of greater ionisation. Fig. 7 gives an idea of what happens when the sunlight strikes the earth. On the left hand is the dark side. The arrows represent the sun's rays. The irregular part of the lower boundary on the right of the layer OPQR is meant to indicate that the ionisation is coming

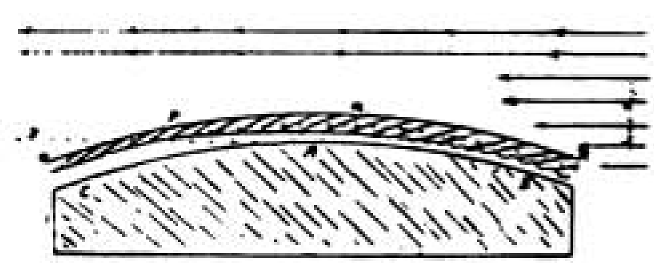

Fig. 7. Effect of daylight on transmission. CAB = earth; OPQR = conducting layer; AD = line dividing sunshine above from darkness below

down nearer to the earth's surface. Towards the left, that is, round to the night, where there is no sunshine, the ionisation dies out and the layer rises, and a clean, sharp reflecting layer is formed at that part.

Many interesting observations were collected together in a paper in the Proceedings of the Institute of Radio Engineers, and show the variations experienced at sunrise and sunset. Dr. Kennelly and others have pointed out that these variations may be due to the approach of that irregular part indicated on the right-hand side of Fig. 7, where the transition from darkness to sunlight takes place. Here there is, as it were, a reflecting wall of ionised gas, which will throw back the signals and disturb them in some way or other. The sudden dips at sunrise and sunset hold practically uniformly for stations in temperate climates.

Now I come to the work of Dr. De Groot. He has been acting for the last nine or ten years as chief wireless telegraph engineer to the Netherlands Government in the East Indies, and he has had there an opportunity of studying many things which we do not get a chance of studying so well in this country.

Fig. 8 provides a definite proof that the reflecting layer actually exists, and that its height in the tropics is about 180 km. The proofs I have shown so far are satisfactory to most people, but this proof cannot be got round in any way. S represents Sabang on the north-west point of Sumatra. O is Osaka, in Japan. There is about 6,000 kilometres between the two. Sabang is only a five kilowatt station and, in ordinary circumstances during the day, could not be heard above 150 miles. But at the place marked J, which is near Java, S can be heard quite nicely at night. It cannot be heard again at greater distances until Osaka is reached, where it is frequently received at night. That is a clear proof; there is no other way by which the waves could get from S to O without touching P and Q, except by reflection; and, since they were very short waves, and since length of waves—as he afterwards proved—made no difference, it clearly must be a matter of practically pure reflection—reflection from a surface that is a pretty good reflector. Later experiments show that these maxima occur every 3,000 km. right round the dark side of the globe, if the transmitting station be a large one, six maxima occurring between the station and its antipodes.

Fig. 9 is simply a theoretical diagram showing roughly how energy waves from a source S would be reflected from a semi-transparent surface AB. It will be seen that if the waves strike the surface AB at a large angle θ, as at SCD, that most of the energy goes through; if they strike at a smaller angle φ, as at SEF, some of the energy is reflected down, as at EG; if they strike at a still smaller angle all the energy is reflected. SHK is the angle of total reflection.

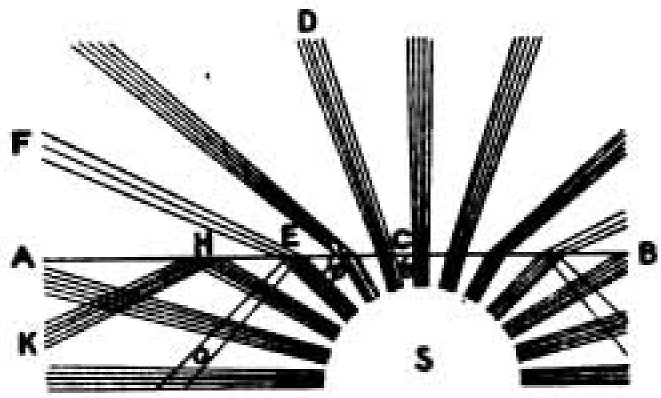

Fig. 9. Reflection of energy at a semi-transparent surface.

We now come to the most interesting part of De Groot's work, which really does throw a good deal of light, when properly understood, on the actual atmospheric conditions. Fig. 10 shows a series of measurements of strengths of signals. The ordinate scale is not actual signal strength, but the values of the shunt resistance connected across telephones—the greater

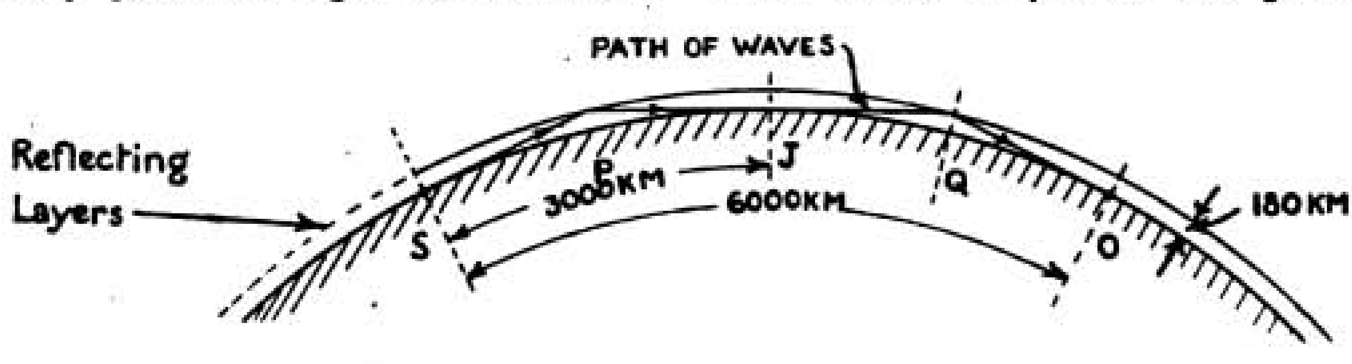

Fig. 8. Diagram of transmission from Sabang.

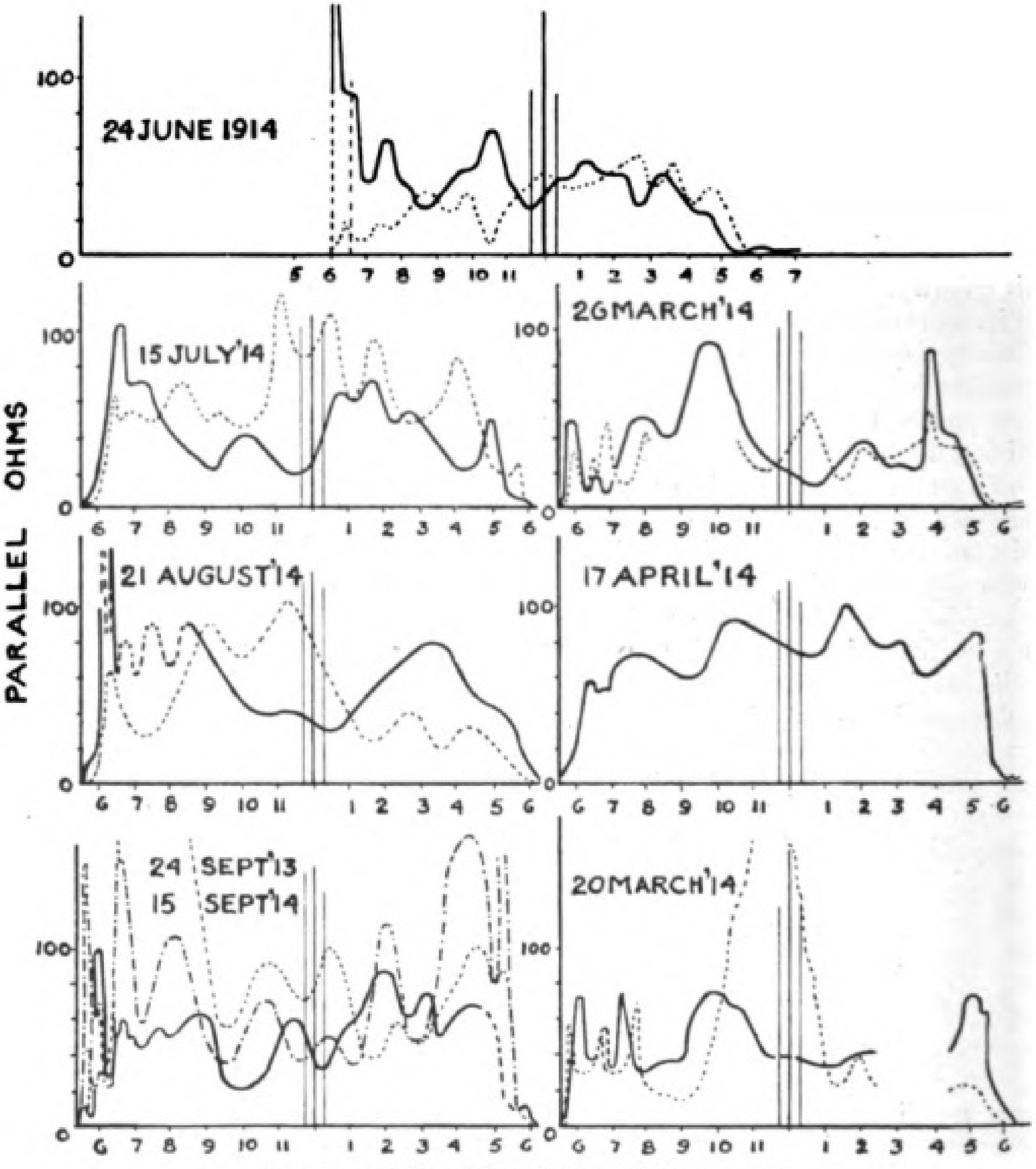

Fig. 10. Series of Signal Strength Measurements.

this resistance, the weaker the signal. Thus the peaks of the curves represent absorption. Generally speaking, it will be seen that in June, during which month the sun is lowest in these regions, there are four comparatively small absorption maxima. As the height of the sun increases from month to month these peaks increase also as the diagram shows. The full line relates to transmission in one direction between two islands about 1,000 kilometres apart. The transmission in the other direction is shown by the dotted line; it is of a similar character but not quite the same. The most interesting part of the picture is for those months in which the sun is nearly vertical. There is enormous absorption at two peaks, one on each side of mid-day, and two other peaks about eight in the morning and half past four in the afternoon. The little sunset and sunrise effects which figure so much in this country practically disappear altogether. There is a big variation at 4.30 a.m., which is an hour and a half before sunrise. The minimum of absorption about the middle of the day does not always come at noon exactly. Sometimes it is a little bit on the afternoon side; at other times of the year it comes a little on the morning side. Evidently the whole thing has some perfectly definite relation to the position of the sun, and that is the important point about it.

De Groot has actually worked out the principles of these relations. Fig. 11 is his diagram illustrating what he thinks happens. I may put it this way: during the day the way in which the energy gets from Sitoebondo to Koepang and Amboina—two places, one 1,100 and the other 1,700 kilometres away—is clearly through some upper part of the atmosphere. This is for two reasons, firstly, as we have seen above, the energy that leaves the transmitter horizontally is always absorbed by the earth's resistance, and therefore the energy that actually gets to the receiver must have left the transmitter in an upward direction; secondly, these daily variations, since the sun cannot be imagined as producing large variations in the resistance of the earth's surface. I do not say that the energy is reflected because during the day the quantity of energy which gets from the one place to the other depends on the wave length. This points to ionised layers refracting the waves as they pass from one layer to another. The diagram does not show all the waves that are leaving this sending station; it is simply drawn in order to show that for waves to arrive at the distant receiver they must have started at the angles indicated, because if they did not do so they would be deflected down to the earth again as at T and A′. It should be remembered that the peaks in Fig. 10 were perfectly definite and fairly sharp; they started up in half an hour and went off again in half an hour, which shows that there is not just one layer of ionised air, but layers. This coincides with our knowledge of vacua; the vacuum tube as it is exhausted does not slowly increase in conductivity, it goes in jumps depending on the sudden formation of ions at certain definite pressures.

De Groot found that there were certain definite relations between the sun's position and the formation of these maxima of absorption. He found that whenever the sun was vertical over one or other of four great circles on the earth, the absorption was greatest. Fig. 12 is a somewhat complex looking diagram, but it is a wild attempt to draw planes through great circles and small circles. E is the globe, SP is the south pole, and PP is the path of the sun through W′X′Y′Z′. Over that small circle of the earth the sun is vertical on some particular day—remember those stations—marked S and K—are between the tropics. The great circle through the stations is marked on the diagram. Whenever the sun is nearly vertical over the points

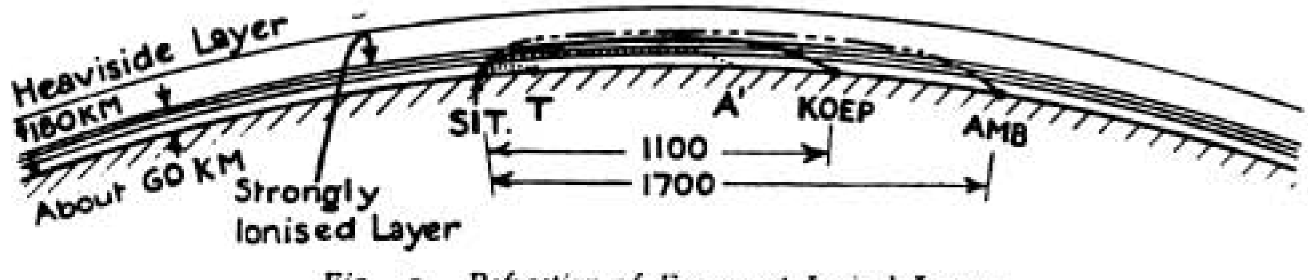

Fig. 11. Refraction of Energy at Ionised Layers.

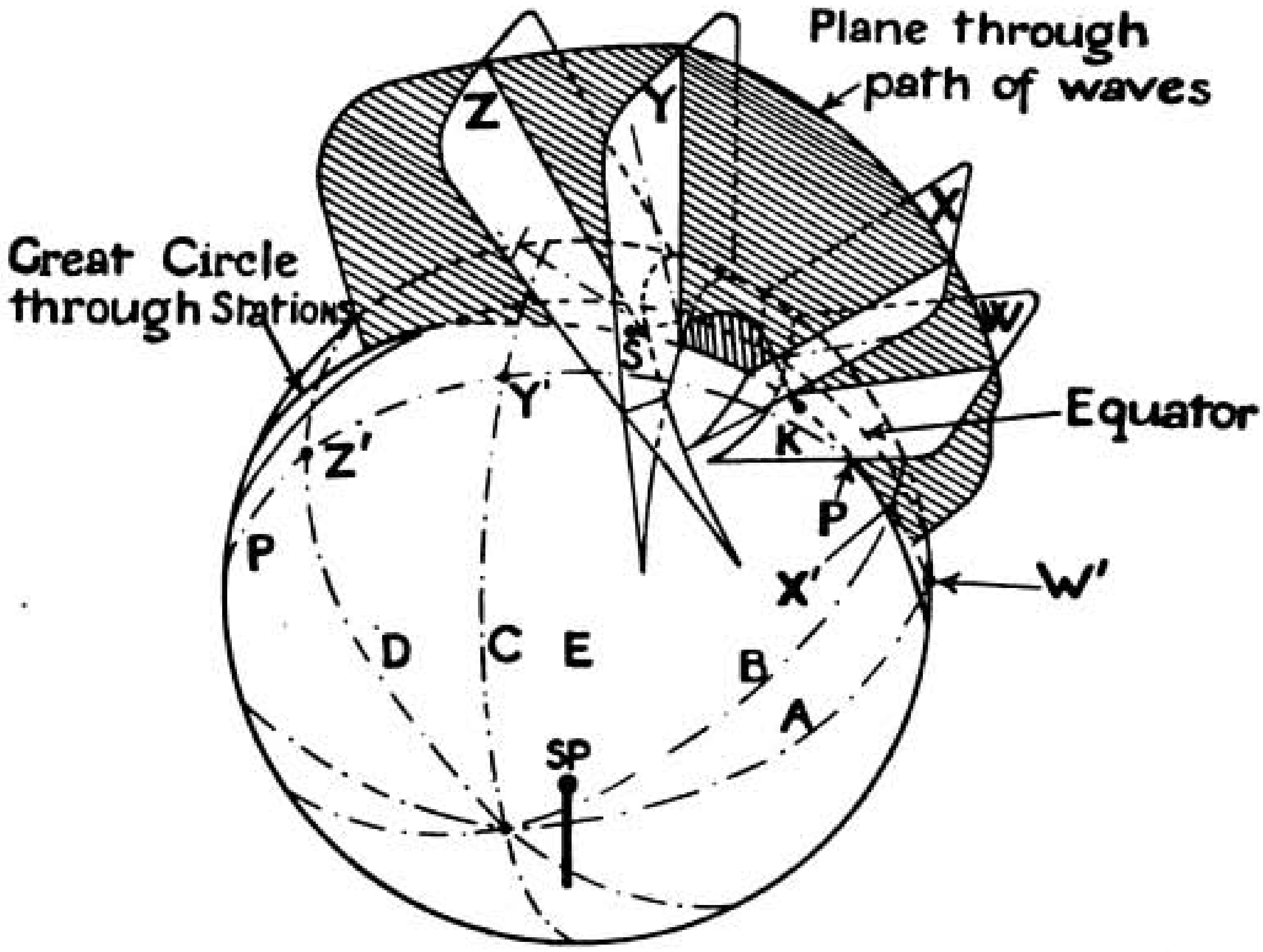

Fig. 12. De Groots's diagram to illustrate his Theory.

W′, X′, Y′, or Z′, there is a maximum absorption. For another day in the year these points might be further up on the four fixed great circles—A, B, C, and D. They are at right angles to the line of transmission (great circle) between the stations and a definite number of degrees away from it—B is twenty degrees east, C twenty degrees west, D forty degrees west, and A forty degrees east. This shows that there is a definite relation between the height of the sun and the absorption of the energy of the waves in passing from one of these stations to the other. The plane through the path of the waves is shown shaded, and the darker shaded portion is the path of the waves from station to station. De Groot raises the question: What can the relation be between the verticality of the sun on this spot of earth and the amount of absorption of energy from a wireless signal passing from S to K? There is this fact; those great circles on which the sun is vertical at moments of maximum absorption are perpendicular to the path of the waves. He asks further: What is the only thing that can be affected? It must be the path of the waves itself.

Let us draw a plane W, parallel to the great circle A which passes through W′. The light of the sun is coming down in that plane, and it cuts the path of the waves as indicated. For one or two days in the year the sunlight will actually come down the centre line of the plane and be in the plane of the wave path itself; at other times it will not come down the centre line but will still be at right angles to some other line which starts from Koepang and rises in the upper atmosphere, and De

Groot says that this line is probably the path of the actual waves, and that the fact that the sunlight is coming down at right angles to the path of the waves is in some way or other a cause of the absorption. Similarly for the other planes X′Y′Z′ later in the day. The plane X corresponding to the position of the sun over X′ should be at right angles to another part of the wave path. The sun's rays come down at right angles or some definite angle—he says a right angle—thus there is a definite relation between the direction of the sunlight and the absorption, which probably arises from a definite relation between the sunlight and the path of the waves rising from the one station and descending to the other.

I will conclude with one or two sketches showing what sort of relation De Groot thinks may actually exist. He suggests, of course, that it is probably a variation in ionisation; that is undoubtedly the only thing which we have got in the conditions which *can* vary. Taking mid-day as being the simplest to begin with (Fig. 13); suppose we consider AB to be the surface of the earth, while S is the station Sitoebondo and K is Koepang. The sun is vertical There is no want of symmetry, so that there should be horizontal layers of ionised air, the upper ones no doubt being more ionised than the lower ones. Of course, further up there will not be enough air to ionise, but immediately above the earth, up to, say, sixty kilometres or so, there will be progressively increasing ionisations with, as far as we know, comparatively sharp boundaries between the layers. In order that the waves may get from S to K they must have travelled somewhat as indicated. At mid-day there is not any particular absorption; the waves make a symmetrical course, do not go very high and come down to the station in about as short a way as they could reasonably do.

Take another case, for about nine o'clock in the morning. (Fig. 14.) AB is the surface of the earth; S is Sitoebondo, K, Koepang. The arrows indicate the direction of the sunshine. The ionised layers will be bent down somewhat as shown. The cause of this bending may be seen by reference to Fig. 15 which diagramatically illustrates the shape of the conducting shell round the earth as modified by the effect of the sunlight. The question arises: How are the waves going to get from one place to the other? Re-

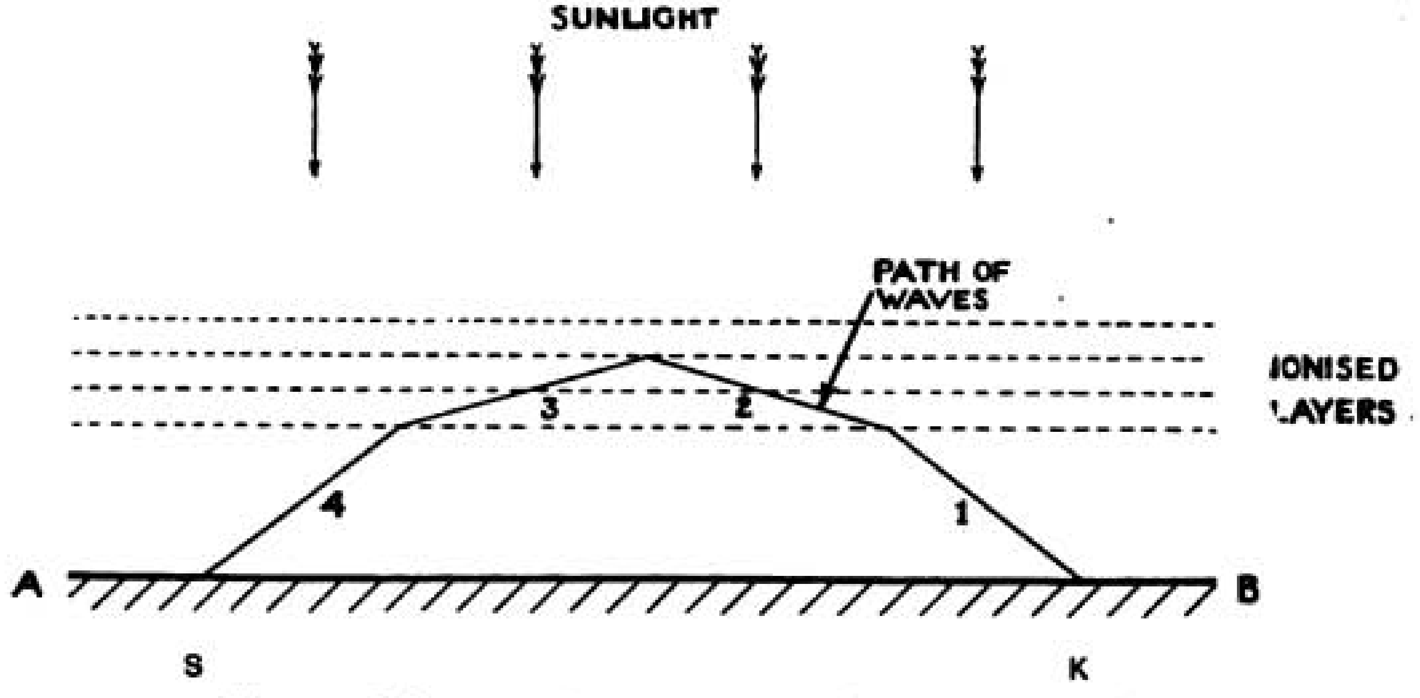

Fig. 13. Refraction of Energy between Sitoebondo and Koepang (noon).

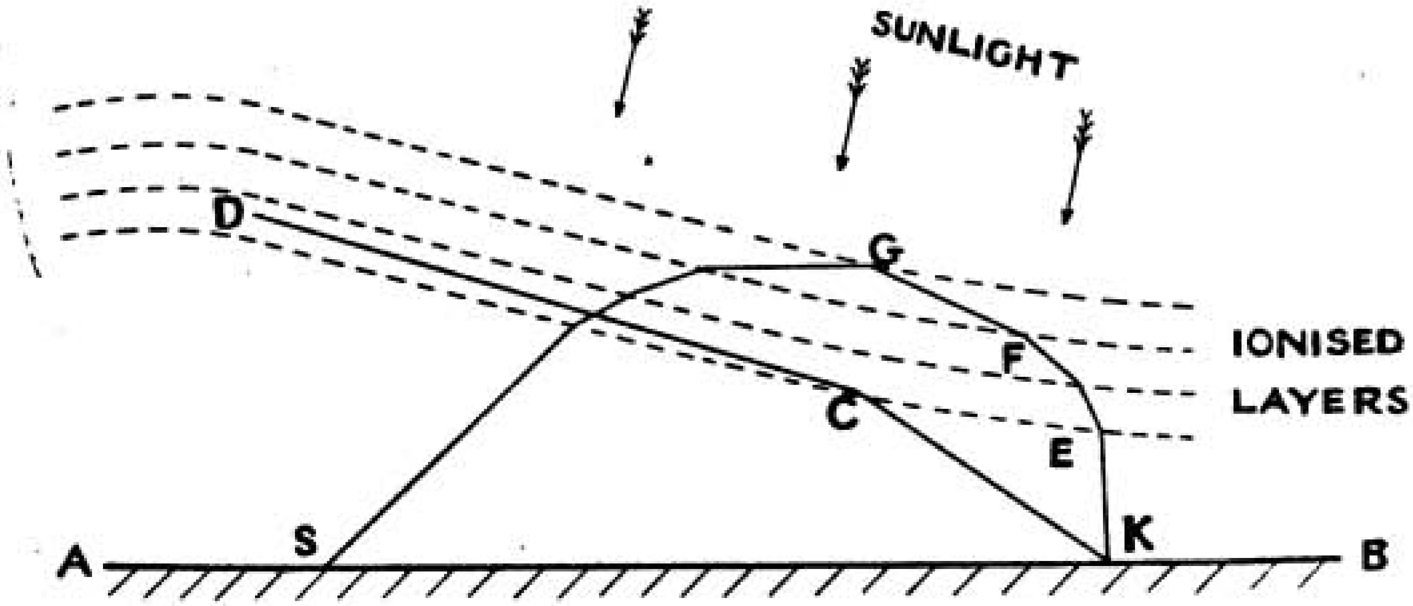

Fig. 14. Refraction of Energy between Sitoebondo and Koepang (10 a.m.) looking North.

ferring again to Fig. 14, let us consider a wave at an angle of about forty-five degrees (as in the case of Fig. 13) to begin with and see where it goes. It goes from K, probably reaches C, gets refracted from there, and goes away between the layers towards D, and is lost. That is the direction of the radiation from the aerial which reached the receiver at mid-day (Fig. 13) but now it no longer gets there. The wave that is going to get to S, starts up at a much bigger angle, something like KE—that is a much weaker wave than the first one, because there is very little energy radiated vertically from an ordinary aerial. KEFG is then the wave that is going to reach S when the layers of ionisation are as shown. If the diagrams for other times in the day were drawn we should find possibly a real explanation of these extraordinary daily variations. I may point out one fact, that during the time when the sun is comparatively low at mid-day, in the cooler season in fact, De Groot obtained sunrise and sunset effects comparable to those of Europe. During the time when the sun is nearly overhead—from November to January—sunset and sunrise effects disappear almost completely, and these hourly variations become very marked.

Most of the foregoing account of De Groot's experiments I have taken from Dutch publications, and in particular from De Groot's "Radiotelegrafie in de Tropen." I hope I have been able to throw some light on the

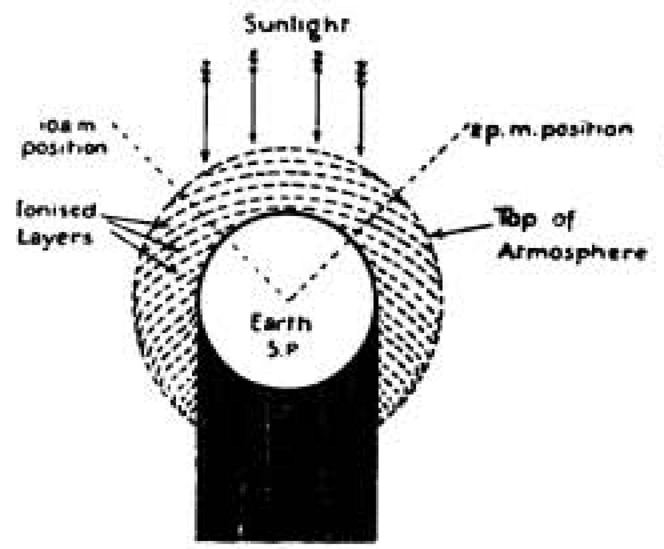

Fig. 15. Distribution of Ionised Layers round the Earth, looking Northwards.

subject, and that you will now be able to follow what is going on in this particular branch of radio work.

DISCUSSION.

The President said he had intended to call upon Professor Howe to open the discussion, but as the latter had left the meeting he would call on Admiral Sir Henry Jackson.

Admiral Sir HENRY JACKSON: Mr. Chairman, and gentlemen, I do not feel qualified to discuss the paper, but I should like to congratulate Major Erskine-Murray on it. He has put a very difficult question extremely clearly, and I think that anybody who has followed his explanations will now go away with some good clear idea of how it all happens. It has puzzled many of us, I expect, at various times. I have never studied these effects to the extent that he has done, and I go away very much happier than I came in. I must congratulate him on the paper and the way he has put it; evidently there has been a very great deal of work involved in getting the results out from Dr. de Groot's theory. I leave it to more technical people to discuss some of these matters as regards the ionisation of the atmosphere, and the distance the ions can penetrate. I do not profess to know myself, but somebody else can perhaps enlighten us. I think we can all agree that we owe a very hearty vote of thanks to Major Erskine-Murray for his lecture.

Mr. PHILIP COURSEY: I do not think I can add much useful discussion to the very lucid description that Major Erskine-Murray has given us this evening. It is very useful for everyone to have such descriptions of experiments that are going on at the present time, especially when they are published in foreign languages, and in publications such as Government ones, which are not accessible to everybody. I think we must all thank Major Erskine-Murray very much for giving us this excellent description.

Mr. MAURICE CHILD: I noticed that Dr. Erskine-Murray mentioned the fact, on the question of absorption, that freak communications took place in all parts of the world and at all sorts of times. From enquiries that I have frequently made from various operators on ships at sea, I have generally had the information given to me that in Europe the longest distances in which one might say that freak communications took place were generally in the direction of north and south; that no great distance in Europe seems to take place when the signalling is east and west. I do not know whether Dr. Erskine-Murray can give us any information about that?

Mr. J. SCOTT-TAGGART: I would merely like to add a word of appreciation to the excellent paper we have heard to-night, and, perhaps, to ask Dr. Erskine-Murray to let us have some of the practical details of the methods by which these observations were taken. It would be interesting to know, furthermore, what form of detector was used. I understand that the parallel resistance method was employed, and so it was essential that some form of constant method of detection should be used. It would be interesting to know exactly what type of detector was used, and what means were taken to maintain its constant action. I think the subject is of considerable importance to us at present, since most of us are now able to receive messages from America, and these problems of ionisation effects concern us all and not merely those in charge of the higher power stations. Consequently we all look forward to seeing this paper in print, when we shall have a better opportunity of studying it in detail.

A MEMBER: I should like to ask Dr. Erskine-Murray one thing with regard to directional wireless at night; surely there is a certain amount of electrical turbulence? If you have got a station whose direction you think you know in the day time, at night it may appear to move in a clockwise direction or counter clockwise direction. You get extraordinary variations in a very short time indeed; I should say that is possibly due to clouds of ionised gas, or something like that.

Lieutenant HALL: I should like to ask Dr. Erskine-Murray to explain if possible the extraordinary freak transmission in the presence of the northern lights. I have noticed most clear examples in Canada; coming down the River St. Lawrence on one occasion stations with only half a kilowatt communicated with places as far distant as San Francisco. When the northern lights disappeared the stations resumed their normal range.

Mr. W. H. SHORT: Dr. Erskine-Murray has shown us the diagrams of the variations of the signal-strengths for certain months. I take it those diagrams are compiled from a whole series of diagrams taken on consecutive days. There is a gradual change in the position of the peak from the start of the month to the end of the month; I should like Dr. Erskine-Murray to make that clear.

The PRESIDENT: If no one else wishes to speak I would like to add the thanks of the meeting to Dr. Erskine-Murray for his address. I came into the room knowing nothing about the subject at all, but I certainly feel that I know a little more than when I came here. I take it that is the *raison d'être* of this Society. We are all anxious to learn. We are in a rather different position from what we were before the war, because we have now got a certain number of members who know a great deal, whereas others of us know a very little. We are hoping we shall gradually get those who know to impart their information to those who do not.

Dr. J. ERSKINE-MURRAY: In regard to the point that Sir Henry Jackson raised as regards ionisation, I do not think there are any real figures in respect to the upper atmosphere. A great deal of theoretical work has been done, and the latest I have seen is the paper of Dr. Lindemann in the *Philosophical Magazine*, which gives most of the available facts—or approximate facts, may I say—about the upper atmosphere.

As regards north and south freaks, I do not think that there is really very much in this, except perhaps near sunrise and sunset. Near sunrise and sunset when the shadow wall is coming along, in all probability there is better transmission north and south than across the shadow wall; but if you were to take the middle of the night, or the middle of the day, you would find freaks going pretty well in all directions. In America the commonest freaks, I believe, are across the continent—that is, east and west. The common direction of freaks is very often simply the common direction of a particular station. A man thinks, for example, that he usually hears freaks in a particular direction because he usually hears Aden; but if there was another station in the middle of the Indian Ocean he might get the freaks from there just as well. Except for the shadow wall, I do not think the north and south direction has any serious relation to the direction of freaks.

The detector which Dr. de Groot used was, I believe, a very carefully constructed crystal detector. He had several, graduated them, kept them in very good order, and used the shunted telephone method for the measurement of signals. Measurements were made day after day, but the actual curves which you see were for particular days—since the curves varied from day to day. One curve was given which was an average for the month. The height of the sun varies from day to day, so it was more scientific to retain the observations of particular days instead of averaging them. Most of the curves were for a definite day, but observations were taken daily, and confirmed that from day to day there was a slight difference in the magnitude and position of this maximum of absorption.

As regards "D.F." at night, I did not mean to give the impression that the upper reflecting layer is a beautiful smooth sphere. A very slight difference in the direction in which the under surface of the upper layer is reflecting would make a very great difference in the way in which the waves would strike any receiving aerial. The explanation of those variations of apparent direction at night may very likely depend upon the fact that the upper layer is not a perfect sphere. I think it is also most probable that some of them may be due to refraction. I pointed out earlier in the paper that Dr. Zenneck showed the energy of the wave was first in one direction, then up to a maximum nearly vertical, and then down in the other direction, so that you had always a turning field at every station, and more at some than at others, depending upon the nature of the ground.

I think there is no doubt about what Mr. Hall said about the aurora giving freak distances. The aurora is certainly an electrical discharge in the upper atmosphere, which is extremely well ionised and acts as a very fine reflector. I think there is no doubt about that, because of the work that has been done alike on the aurora and on wireless. Those are all the points that have been brought up, and I thank you for your appreciative attention. I know the subject is more or less a special one, and I hope in future you will be inclined in this Society to make something of it, because it is the kind of thing that private observers on wireless can do. You can perfectly well go on observing all night if you like. With telephone and ordinary shunt resistances you can observe from day to day. But I do not raise your hopes that you will find these wonderful regular peaks; they are difficult to find because you are not in the tropics.

Aircraft Wireless Section

Edited by J. J. Honan (late Lieutenant and Instructor, R.A.F.).

These articles are intended primarily to offer, as simply as possible, some useful information to those to whom wireless sets are but auxiliary "gadgets" in a wider sphere of activity. It is hoped, however, that they may also prove of interest to the wireless worker generally, as illustrating types of instruments that have been specially evolved to meet the specific needs of the Aviator.

SHORT-WAVE TUNER, MARK III. *(Continued).*

THE AERIAL CIRCUIT.

As shown in the schematic diagram, given in Fig. 26, this circuit comprises the aerial variable tuning condenser, variable tuning-inductance, and earth.

The condenser is of the movable-vane type with aluminium plates and air dielectric. It is graduated in degrees from 0-180° and has a maximum capacity of 0.0015 mfds.

The inductance consists of seven-stranded wire wound upon an horizontally-mounted drum from which non-inductive leads are taken to 19 studs, giving the following values:—

Stud	1 = 6	mhys.
„	2 = 12·2	„
„	3 = 20·5	„
„	4 = 30·6	„
„	5 = 40·6	„
„	6 = 53·2	„
„	7 = 67·4	„
„	8 = 83·5	„
„	9 = 97·5	„
„	10 = 112·3	„
„	11 = 126·3	„
„	12 = 143·8	„
„	13 = 158·2	„
„	14 = 177·6	„
„	15 = 195·0	„
Stud	16 = 213·4	mhys.
„	17 = 230·8	„
„	18 = 250·0	„
„	19 = 280·0	„

The earth is preferably of the capacity type consisting of one or more copper-gauze mats spread out on the surface of the ground. Both the aerial lead-in and the earth lead should be as short as possible, the former being well insulated and the latter of stranded low-resistance wire.

THE CLOSED CIRCUIT.

The variable condenser is of similar design to that contained in the open circuit, but has a maximum capacity of 0·0005 mfds.

The stranded-wire inductance is wound on a drum of the same size as that used for the aerial inductance, and has five tappings, giving the following values:—

Stud	1 = 13.5	mhys.
„	2 = 23·5	„
„	3 = 40	„
„	4 = 115	„
„	5 = 280	„

This drum is also mounted horizontally, but is rotatable about a perpendicu-

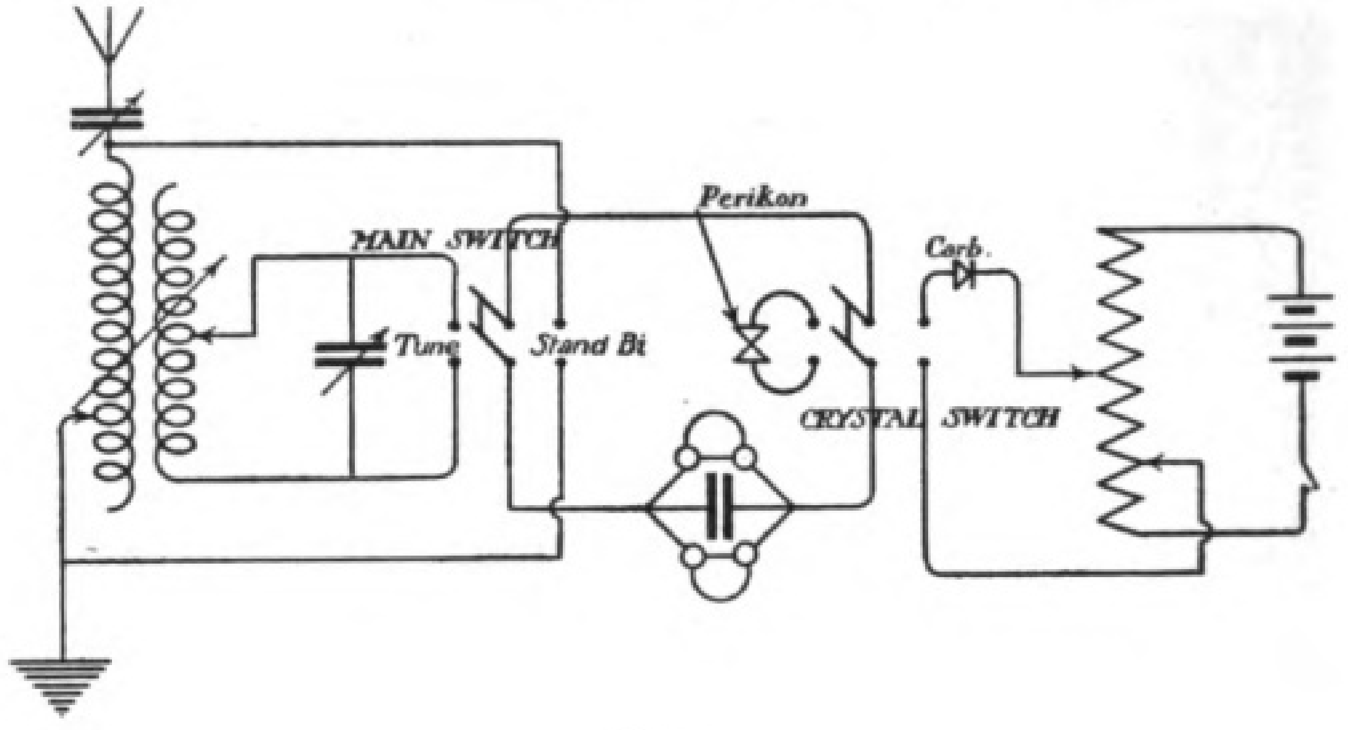

Fig. 26.

lar axis so as to increase or diminish its magnetic linkage with the open-circuit coil, and thereby vary the inductive coupling between the two circuits. This is controlled by means of a handle mounted on the axis of the drum and brought out to the ebonite face-plate of the set.

THE DETECTOR CIRCUIT.

As shown in Fig. 26, either the Perikon or carborundum can be placed in series with the phones at will by means of the "crystal" switch. As a general rule the carborundum crystal is more stable than the Perikon, though the latter is more popular in use as no potentiometer adjustment is necessary.

It is advisable to test the Perikon from time to time with the buzzer, readjusting the contact point between the two crystals when necessary. Sometimes it is impossible to get satisfactory results with any contact point, in which case the crystals are probably "fatigued" and should be replaced by fresh ones. In all cases a light contact-pressure should be used. A forced pressure gives poor results, and, moreover, shortens the effective life of the crystal.

The potentiometer circuit used with the carborundum is fed from a battery of four dry cells giving a potentiometer difference variation of $+3$ to -3 across the crystal. The potential applied is adjusted by means of a handle which controls the position of the variable point along the rheostat. A switch is provided to open the circuit and save the cells from running down when the potentiometer is not in use.

The two pairs of high-resistance phones (4,000 ohms. per earpiece) are used in parallel and are shunted by a small condenser which is inserted in order to compensate for the lag in the passage of the signal current caused by the high inductance of the telephone windings.

The detector circuit as a whole is thrown on "stand by" or "tune" position by means of the main change-over switch.

CALIBRATING THE CIRCUITS.

The buzzer is also used to calibrate the open against the closed circuit with the object of securing rapidity and accuracy in tuning-in.

The closed circuit is first tested against a wavemeter for varying wavelengths, the results being recorded, so that a definite series of wavelengths corresponds to ascertained values of closed-circuit inductance and capacity.

Corresponding values of open-circuit inductance and capacity are then obtained by tuning the open circuit against the known wavelengths now emitted by the closed circuit, when set at the previously recorded values of inductance and capacity and excited by means of the buzzer.

This series of results is tabulated on a calibration card so that when a signal is first received on "stand by" the operator will be able by rapidly noting the open-circuit condenser and inductance readings for maximum sound and comparing them with his calibration card, not only to ascertain the signal wavelength, but also to set the closed-circuit condenser and inductance to the correct value before switching-over to the "tune" side, thereby obviating the risk of losing weak signals when changing-over.

Though involving a certain amount of intial trouble, the calibration card was found in practice to be most useful, particularly in the case of operators who were "learning the ropes."

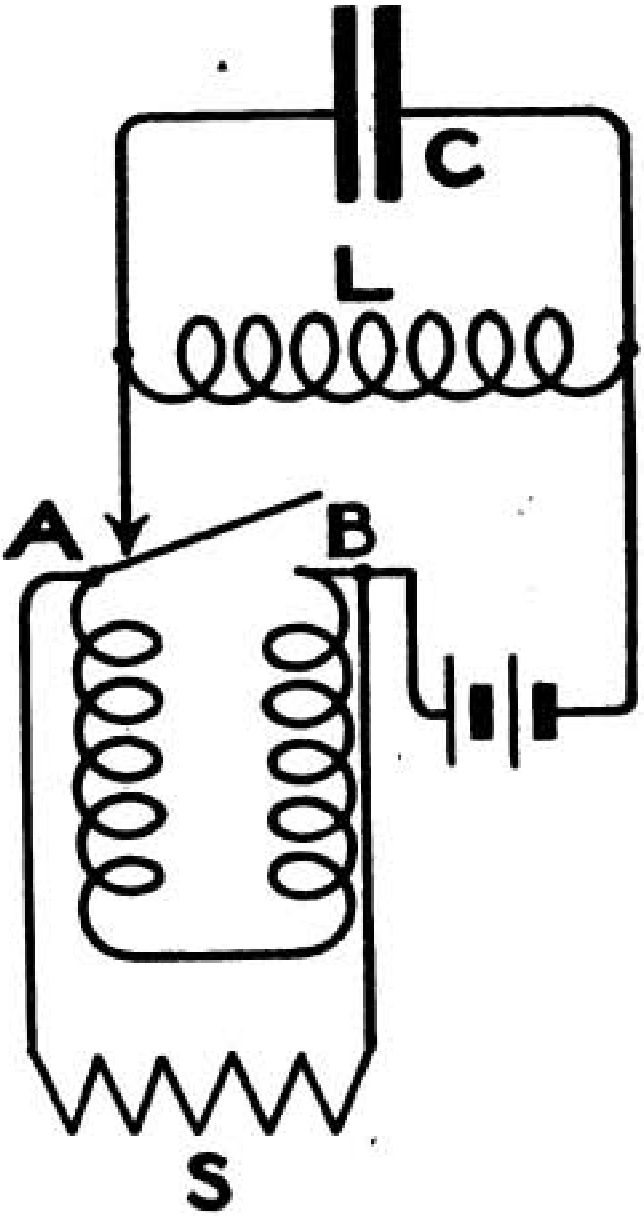

Fig. 27.

THE SHUNTED BUZZER.

The buzzer itself, as shown in Fig. 27, is shunted across the poles by a non-inductive resistance S. This affords a discharge path for the high e.m.f. induced across the armature winding when each "break" occurs, and prevents a spark discharge between the points, which would in effect prolong the current and so lessen the inductive impulse applied to the oscillatory circuit L.C.

In addition, whilst the contact points are closed, the shunt is in parallel with the high-resistance of the solenoid and thereby allows a higher value of current to pass through the points. As the magnetic field created about the inductance L increases as the square of the current, the extra current passed by the shunt considerably increases the vigour with which the buzzer energises the oscillatory circuit L/C.

Though forming but a comparatively unimportant detail of the tuner, it is as well, perhaps, to have a clear conception of the exact significance of the "shunted buzzer," as owing no doubt to the appealing qualities of the name itself it is frequently and widely applied by experts and others in a sense which, to put it mildly, indicates a regrettable lack of technical precision.

Aviation Notes

PIONEERS OF THE AUSTRALIAN AIR-WAY.

THOUGH lacking the dramatic elements associated with the transatlantic flight, the achievement of the brothers Ross in linking Australia to the Mother Country by way of the air will probably take equal rank in the annals of Aviation with the exploit of the late Sir John Alcock, of heroic memory, and his gallant comrade.

The outstanding merits of the Australian flight are to be found as much in the intrepidity and endurance of the airmen, as in the triumph of constructive design and workmanship represented by the machine and its engines.

It may, of course, be argued that the flight, which was largely an overland route, became theoretically possible years ago—in fact, directly machines had been designed capable of spanning the relatively short water distances involved. This is true, but it implies the existence of the necessary ground organization, and also of an unlimited number of relay machines and flying personnel.

The great difference, however, that exists between these assumptions and the actual accomplishment of a flight

Photo: Photo Press

The Vickers-Vimy Machine.

Photo: Photo Press
Captain Sir Ross Smith, K.B.E., M.C., D.F.C., A.F.C.

of 11,300 miles within a period of 28 consecutive days by a single machine driven throughout the journey by the same pair of engines and carrying a crew of four, is just the measure of the solid progress that has been made, and equally constitutes a criterion of the credit that is due to the performance.

The King has conferred the honour of Knighthood of the British Empire upon both the pilot and his gallant brother in recognition of the valuable services rendered to aviation by their achievement. His Majesty has also approved of the award of a bar to the Air Force medal in the case of Sergt. Shiers and Sergt. Bennett.

As regards the craft, the laurel leaves again go to the Vickers-Vimy machine and the Rolls-Royce engine. The machine, of which a photograph is given, carried two 350 H.P. Eagle Mark VIII engines, giving a maximum speed of 100 miles per hour. It weighed 3 tons when empty.

The route from Hounslow touched Lyons, Pisa, Cairo, Damascus, Busra, Karachi, Delhi, Calcutta, Rangoon, Bangkok, Singapore, Bima, and thence to Port Darwin. It is unnecessary to chronicle the misfortunes that attended the attempt to continue the journey across Australia, and its subsequent abandonment, since the object of the trip had been accomplished and the prize of £10,000 won when Port Darwin was reached on December 10th.

PAYING THE TOLL.

Unhappily a heavy tribute was exacted before the new air-way had been traversed. It is said that the old

Photo: Photo Prsse.
Lieut. Sir Keith Macpherson Smith, K.B.E., late R.A.F.

caravan routes across the Sahara are brazed with the bones of those who have fallen by the way. Similarly a grievous toll of life has been levied by that Arbiter of the Air who guards its ways and appears to view each fresh encroachment of his kingdom with a jealous eye.

We have to deplore the loss to the world of Aviation caused by the crashing of the Alliance "Endeavour" but a few minutes after starting out on the same journey, resulting in the deaths of Lieut. Roger Douglas, M.C., the pilot, and of Lieut. J. S. L. Ross, his navigator.

Another tragedy to be recorded is that of the Martynside Rolls machine which was wrecked off the Island of Cyprus whilst *en route* to Australia. No trace remains of Captain C. E. Howell, D.S.O., M.C., D.F.C., and Air Mechanic Frazer, who formed its crew. Apparently the machine was forced down whilst over the sea by shortage of petrol, and became a total wreck.

Photo: Photo Press.
Sergeant W. H. Shiers, A.F.M.

Photo: Photo Press.
Sergeant J. M. Bennett, A.F.M.

CORRECTION.

In Aviation Notes for December it was stated that the R38 was under completion by Messrs. Vickers. This of course should have read Messrs. Short Bros., who are the builders not only of the R38, but also of her sister airships.

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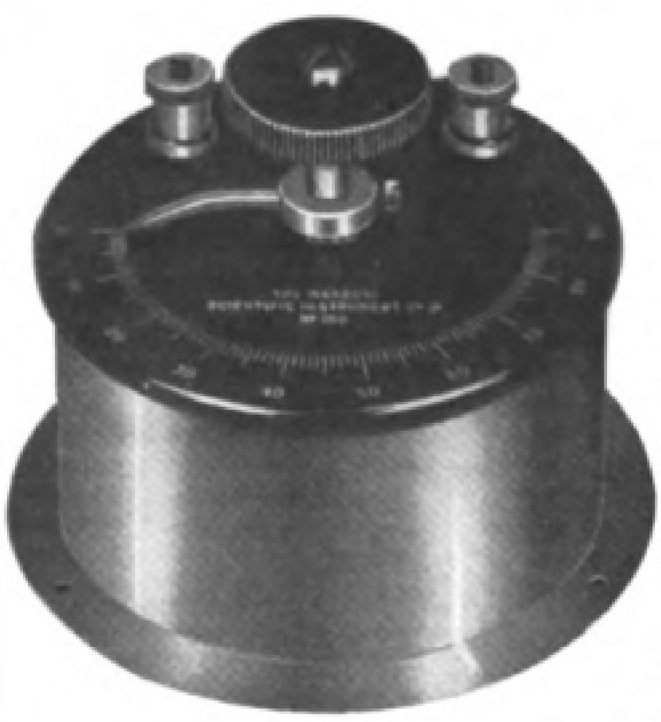

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Notes on the Design and Construction of Valve Amplifiers

BY JOHN SCOTT-TAGGART, M.S., Belge E., A.M.I.Radio E.

III.—DETECTOR-AMPLIFIERS (*Continued from December*).

MARCONI'S Wireless Telegraph Co., Ltd., have evolved a number of interesting amplifier-detectors, and as they are of the class immediately under consideration a short description of their types will not be out of place.

Fig. 12 shows type 55A. It employs seven valves in cascade, the first six of which are high-frequency amplifiers and the last one a rectifying valve. The amplifying vacuum tubes are of the V24 type, whereas the last valve is of the "Q" type. The "Q" valve differs chiefly from the V24 in that its grid is of metal gauze, whereas the grid of the V24 takes the form of a spiral wire.

In order to obtain efficient reception over a wide range of wave-lengths, the aperiodic inductance coils are wound with resistance wire to increase the damping effect. In the case of type 55A, the resistance of each coil is 24,000 ohms.

The output circuit of one valve is coupled to the input circuit of the next in two ways. There is the ordinary magnetic inductive coupling, and also a form of resistance coupling. There is in series with the anode of each valve a high resistance, and when the anode

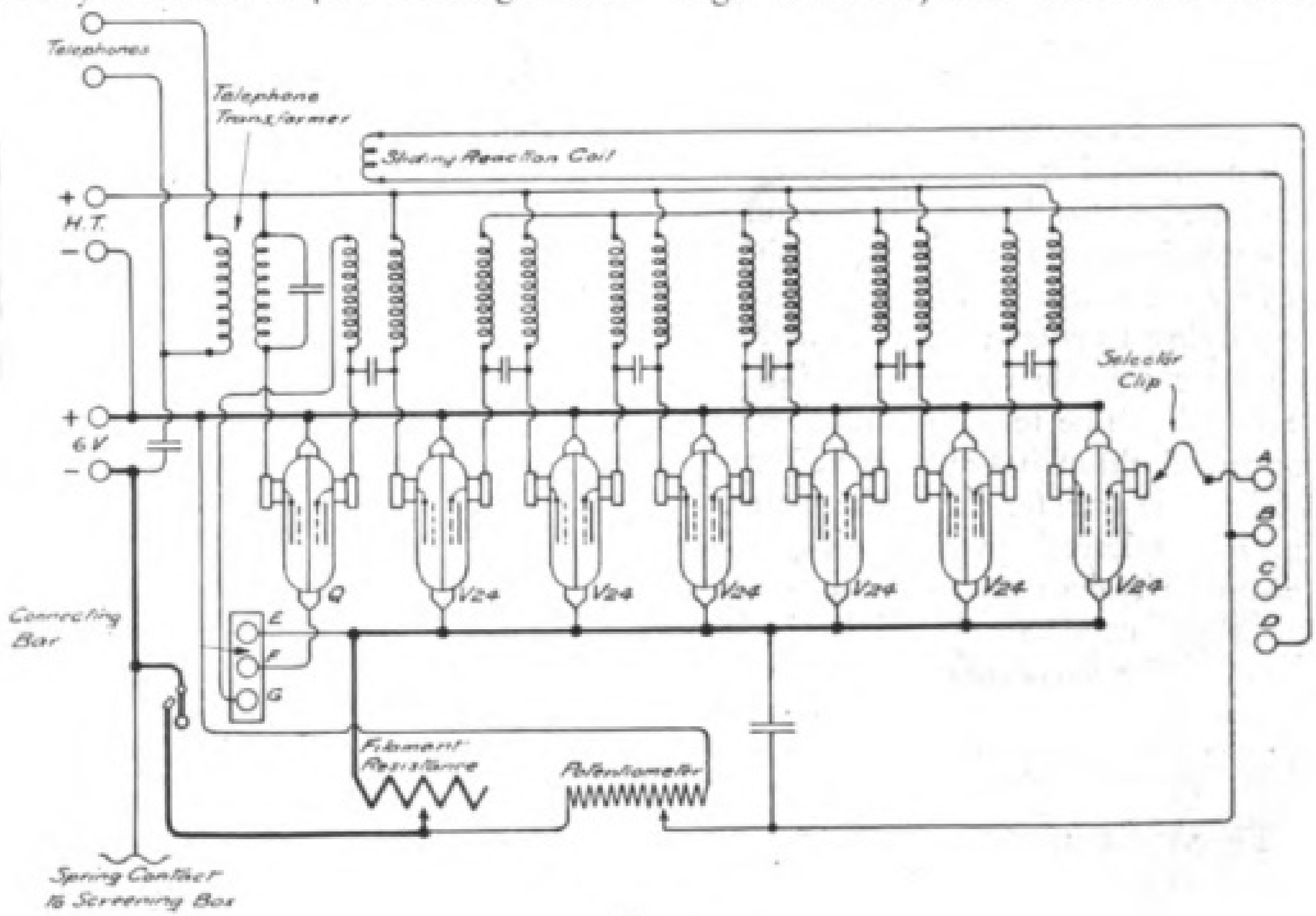

Fig. 12.

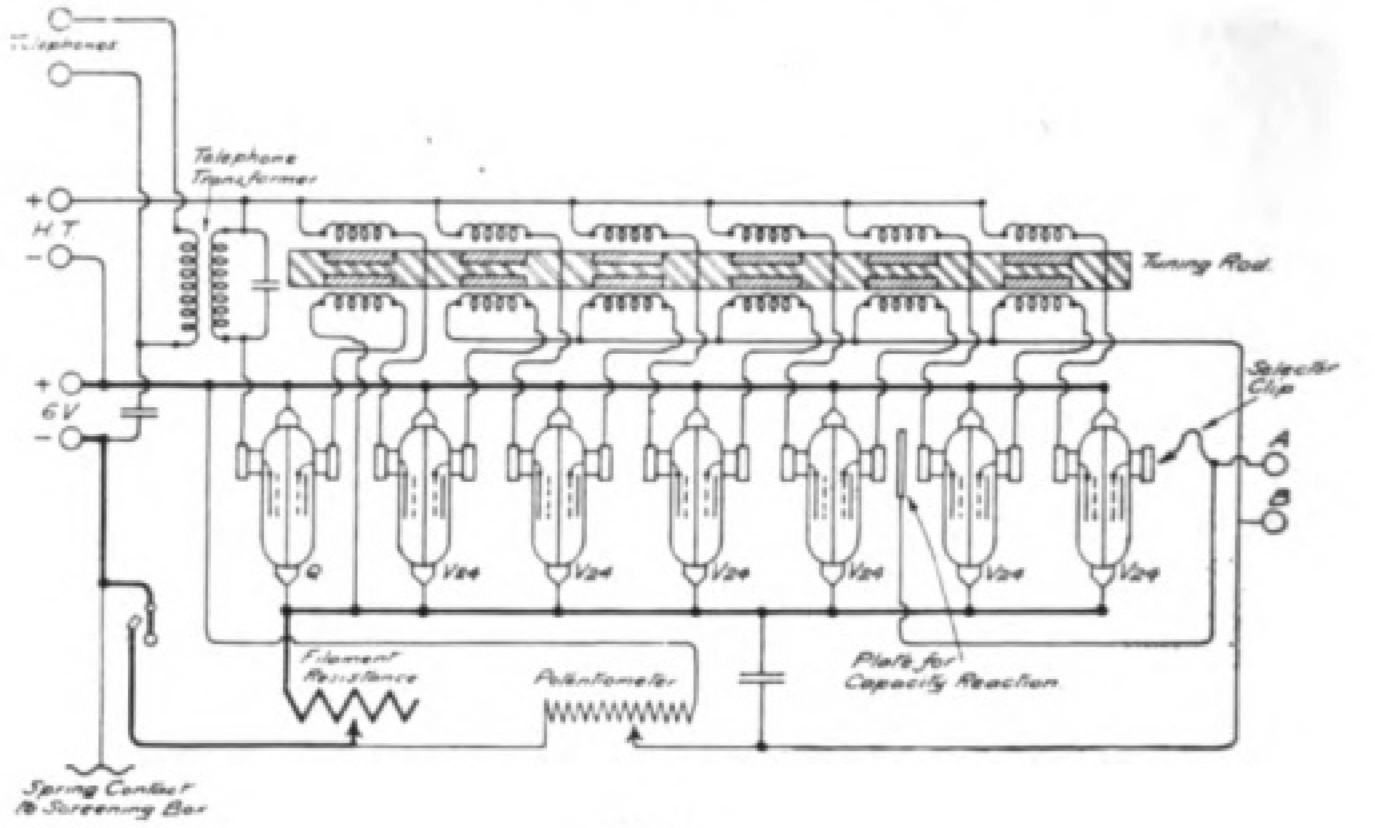

Fig. 13.

current is flowing there is an appreciable potential drop along this resistance. By means of the condenser connected between the transformer windings and the capacity between the windings themselves, variations of this voltage drop caused by incoming signals, are communicated to the grid of the next valve.

The receiving oscillatory circuit is connected across the terminals A and B. A potentiometer is arranged, as shown, to vary the potentials of the grids of the amplifying vacuum tubes, in order that the most suitable operating point may be found. The telephone receivers are connected through the intermediary of a telephone transformer to the plate circuit of the detecting valve which, it will be noticed, does not operate on the leaky grid condenser principle, but because of the asymmetry of one of the characteristic curves of the valve. A selector clip enables any number of valves up to six to be used.

Type 55A works best on a wave-length of 1,000 metres, but will receive signals efficiently on wave-lengths between 500 metres and 3,000 metres. It is interesting to note that the sensitivity of these amplifiers falls off rapidly for wave-lengths below the optimum value, but only slowly in the case of longer waves. As will be seen from Fig. 12, a retroactor coil (or "reaction" coil) may be coupled to any of the transformers to produce retroactive amplification or self-oscillation when continuous waves are to be received. This may be done by removing the connecting bar from terminals E, F and G, connecting E and F together, and connecting the retroactor coil terminals C and D to F and G. The coil is now in series with the grid winding of the last high-frequency transformer. In the case of short waves, retroaction is usually obtainable by adjusting the potentiometer.

Fig. 13 shows Type 55B. The use of a condenser between the transformer windings has now been abandoned, chiefly because capacity effects lessen the efficiency of high-frequency amplifiers, especially when short waves are being received. Type 55B is intended to receive waves having a length of from 100-130 metres. Capacitative retroaction is obtained by means of a small copper plate inserted between the anode clip of the second valve and the grid clip of the third valve. This plate is connected to the first grid and is suitably insulated.

A special feature is the use of an ebonite rod in which are mounted iron-cores of a peculiar type consisting of cylinders of paraffin wax impregnated with finely-divided iron. By sliding the cores in or out of the transformers close tuning may be accomplished. It would appear that on later amplifiers these special cores are omitted.

A type of high selectivity used by the author during some experiments is shown in Fig. 14. It will be seen that the intermediary transformers are of the loosely-coupled type which eliminate interference to a very marked degree. Consequently, the circuit is really only suitable for reception on a given wave-length, owing to the difficulty of rapid tuning. The circuits should first be tightly coupled and tuned to give the best results. The coupling should then be gradually loosened, the operator retuning, as may be necessary. The grids of the amplifying vacuum tubes have their potential varied by the potentiometer P. Cumulative rectification is used, although the leaky condenser can be dispensed with and rectification obtained by taking advantage of the non-linear characteristics of the grid or anode current curve. Retroactive amplification may be obtained by coupling the retroactor coil L to a suitable preceding inductance. A modification of this circuit consists in making the anode circuits aperiodic and the grid circuits tuned.

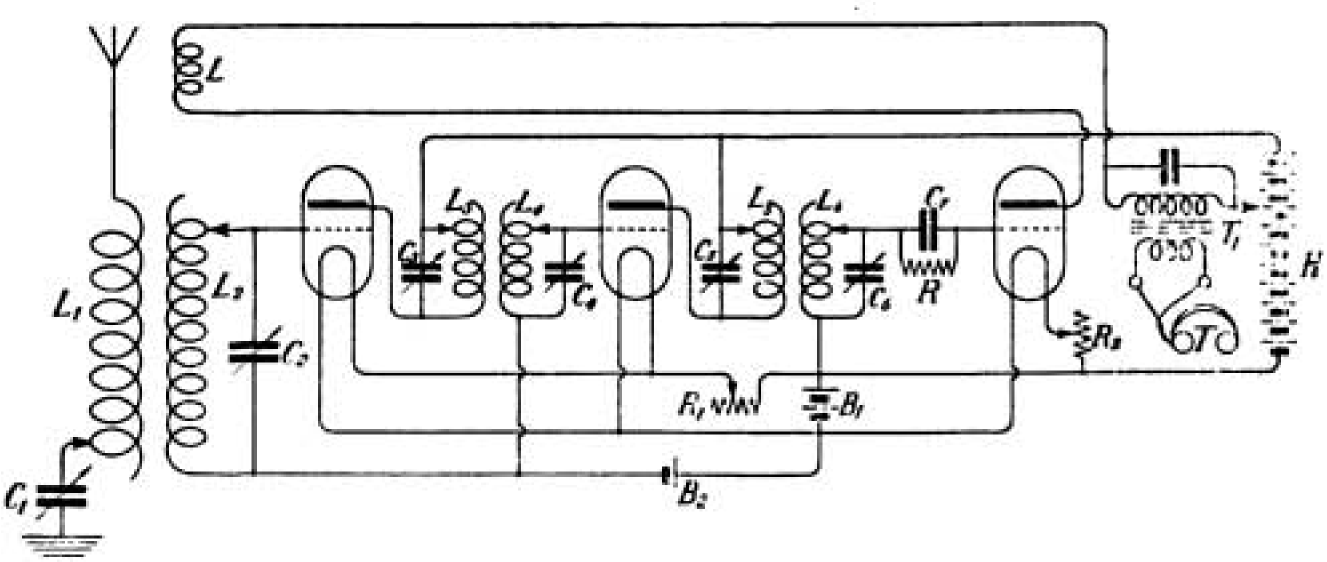

Fig. 14.

(*To be continued.*)

CORRECTIONS.

In our report of Mr. Scott-Taggart's Paper on a "Syst m for the Reception of Continuous Waves" (January issue), the word "unless" in the second column of page 597 should read "when." In Fig. 1 (page 594), the transformer T_1 T_2 should be shown as a step-up transformer, while in Fig. 8 (page 600) the transformers T_3 T_4 and T_1 T_2 should be of the step-down type.

The Construction of Amateur Wireless Apparatus

This series of articles, the first of which was published in our April number, was originally designed to give practical instruction in the manufacture of amateur installations and apparatus, and arrangements had been made with Marconi's Wireless Telegraph Co., Ltd., to supply complete apparatus to the designs it was intended to detail. The restrictions on amateur work, however, remained in force, and the author was compelled to proceed on general lines only. A further series will be published giving the class of information originally intended.

Article Eleven.—HIGH-TENSION SUPPLY (*continued*).

THE arrangement shown in Fig. 1 of our last article can be still further simplified by the choice of a valve of suitable design. The working voltage of any practical design of valve is mainly governed by the mesh of the grid. The reader will understand that by " mesh " we mean the spacing of the wires forming the grid; the latter may, of course, not actually be a mesh in the ordinary sense of the word, but may consist of a spiral of wire enclosing the filament. In general, the more open the mesh of the grid the lower the working voltage of the valve. This fact may be utilised in the design of a very simple heterodyne receiver. By opening the mesh sufficiently a valve can be produced which will oscillate satisfactorily with a pressure of only two or three volts applied to the plate. An example of such a valve is the " V24 " pattern manufactured by the Marconi Company. In Fig. 1 we illustrate a separate oscillator working on this principle.

In this Fig. A represents the usual oscillatory circuit consisting of an inductance shunted by a variable condenser, the proportions of the circuit being suitably adjusted for the wave-length it is desired to receive. This circuit should have a fairly large L/C ratio. A safe value to take for the maximum capacity of the condenser is ·001 mfd. Of course a smaller condenser will be quite all right, but the capacity should never exceed the before-mentioned value or difficulty will be experienced in making the set oscillate. Assuming that the voltage across the filament of the valve, when burning at the correct brilliancy, is about four volts, the accumulator should have an E.M.F. of six or eight volts, the series resistance R being used to adjust the filament current to its correct value. C is the reaction coil connected in the

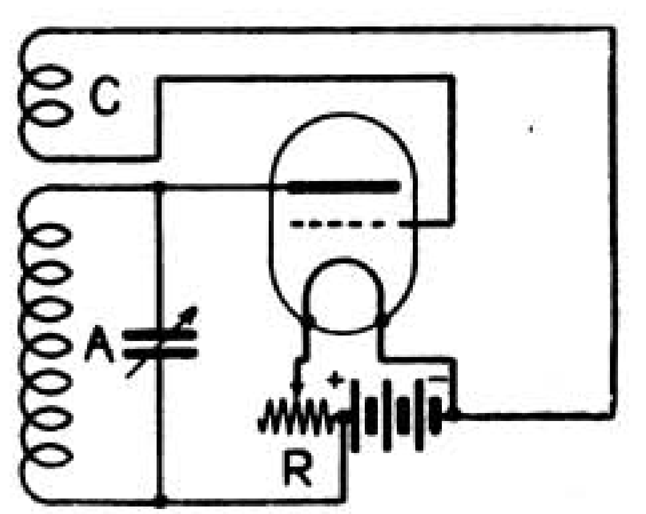

Fig. 1.

grid circuit of the valve; it operates in exactly the same manner as described in previous articles.

Referring to the diagram it will be noticed that we have connected the series resistance in the positive lead from the battery and that the plate oscillatory circuit is connected directly to the positive terminal of the battery itself. It is therefore clear that the plate will be at a potential of six or eight volts positive to the negative leg of the filament, depending on the voltage of the battery employed for lighting the filament. This voltage is quite sufficient to cause the valve to maintain continuous oscillations in the circuit A when the reaction coil is suitably adjusted. The oscillations produced will not be of large amplitude, but will be quite strong enough to give interference tones with continuous wave signals when the circuit is coupled magnetically with any spark receiver. As a matter of fact a weak heterodyne is an advantage for receiving work. If the local oscillations are too strong the detector may become saturated, with the result that signals will be weakened and may disappear altogether. Also there is less likelihood of interference with other stations owing to the induction of appreciable currents in the receiving aerial (we shall return to this point later).

The same principle can be equally well applied to a self-heterodyne valve circuit. Such an arrangement is illustrated in Fig. 2. This circuit will be seen to be similar to the coupled continuous wave receiver described in a previous article, with the exception that the high voltage battery has now disappeared. It will be observed that we have shown the telephone transformer shunted by a condenser. This condenser is very important. It provides an easy path for the high frequency oscillations past the telephone transformer. Owing to the high impedance of the high resistance winding of this transformer, it is very difficult to make the circuit oscillate unless the winding is shunted by this condenser. A suitable value is about ·003 mfd. This small capacity will not act as a shunt to the low frequency rectified beat current, and consequently the strength of signals will not be affected by its presence.

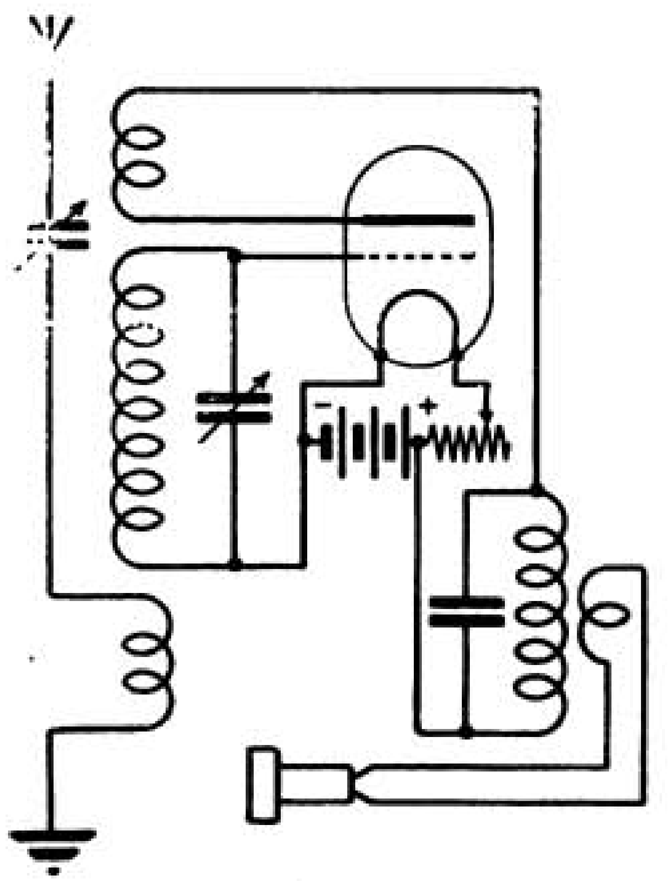

Fig. 2.

Should any difficulty be experienced in getting either of the above simple circuits to oscillate the postive potential applied to the plate should be increased a little. This can be easily done by connecting a four-volt flash lamp battery in series with the plate winding. This battery should be connected at the *bottom* end of the winding, *i.e.*, the negative end of the flash lamp battery should go straight to the positive end of the filament lighting battery. Difficulty will also occur if the insulation of the condenser is not good or the coils are damp. It is preferable, if possible, to use an air condenser; and the coils should be wound on highly insulating formers, thoroughly dried out and then given a coat of shellac varnish.

We have referred to the question of interference caused to other stations by a continuous wave heterodyne receiver. This question is very important and we propose to make a few remarks on the subject.

The cause of the trouble will be perfectly clear by a reference to Fig. 5 of Article Eight (November 1919 issue). This Fig. illustrates a direct coupled self-heterodyne receiver, the aerial being directly connected to the grid oscillatory circuit. Now it is perfectly clear that, when the valve is oscillating, an undamped oscillatory current will flow in the aerial during the whole time that reception is taking place. The aerial will therefore be radiating a continuous wave whose wavelength corresponds to the tune of the receiving circuit. This wave will be very weak, because the currents flowing in the receiving circuit are very small; but the sensitivity of a heterodyne receiver is so great that it may be clearly audible at another station several miles distant, and may cause interference if the second station happens to be receiving a weak signal. Also as the receiver condenser is turned round annoying "swoops" will be heard at the second station. It may be that regulations will be introduced forbidding the use of direct coupled self-heterodyne circuits for continuous wave reception.

The trouble can be minimised by the use of the coupled circuit receiver shown in Fig. 6 of Article Eight. When using this arrangement the aerial is tuned to the wavelength of the incoming signal, whereas the grid circuit is tuned to a slightly longer or shorter wave in order to get a beat note. And since the coupling between the aërial coil and the grid coil will be very weak, on account of this mistuning only a very small current will be induced in the aerial itself. Or at any rate, the current in the aerial will be very much smaller than that in the grid circuit of the valve. Consequently the intensity of the radiated wave will be very much less in this case than in that of the direct coupled circuit. The chief trouble experienced with this inductively coupled arrangement is the difficulty of "finding" any station. Owing to the extreme sharpness of tuning of the circuits the condensers have to be very accurately adjusted to get the signals. This is, however, a matter of practice, and the amateur will soon get expert in the manipulation of the circuit when once he has grown accustomed to the circuit. It is very useful when first setting up the receiver to make out a table of condenser adjustments found for different stations. This table can be placed in a convenient position and referred to when it is desired to pick up any station.

Questions and Answers

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) Readers desirous of knowing the conditions of service, etc., for wireless operators will save time by writing direct to the various firms employing operators.**

A. E. P. (Manchester) (1).—The reactance of a condenser is defined as the negative quantity $-1/2\pi nK$. The Hawkhead and Dowsett formula $2\pi nL - 1/2\pi nK$ which is equivalent to $2\pi nL + (-1/2\pi nK)$, is therefore the sum of the reactance of the inductance and the negative quantity which is the reactance of the capacity. (2) The units in the above formula are Henries and Farads.

S. J. (Solihull) (1).—The capacity of the cylindrical condenser you mention will be about 43 micro- microfarads. (2) A coating of varnish will theoretically slightly increase the capacity, but unless the coating is very thick the increase will be quite negligible.

T.H. (Liverpool) (1).—When an ionic tube is used with a condenser in the grid circuit, the unidirectional current flowing in the grid circuit tends to charge this condenser. If this charge is allowed to build up, the resultant potential across the condenser alters the potential which the grid initially has, and which corresponds to a sensitive point on the grid potential-plate current curve, to a new value which corresponds to a flat and therefore insensitive part of this curve. The tube therefore loses its sensitivity very quickly unless some means of preventing this potential from building up in the condenser is supplied. The most convenient way of doing this is to put a resistance across the condenser by which the charge may slowly leak away as it accumulates.

WABTEE (H. M. T. Aro.) (1).—We think the performance you record probably does approach a record for short power range, although we cannot, of course, say for certain. With amplifying receivers freedom from jamming at the receiving end is one of the most important factors in working long distances, and you were probably exceptionally favoured in this respect. (2) Excluding the watts lost in your 16 c.p. lamp, we do not think that your primary power can have approached as much as 50 watts,—it was probably nearer 20. Your effective aerial watts would not have been more than 10 at most. (3) This connection probably introduces a self-capacity on its side of the buzzer break. This tends to charge up at the instant of break, thus helping to prevent the stored energy of the circuit from discharging as a bad spark across the gap. (4) Dispense with the condenser, and use a telephone transformer. The circuit would tune so very flat that it is not worth while attempting it.

H.V.G. (S. S. Sheafdart).—The station does use a C.W. arc for most of its traffic. The tearing tone at short distances is common, and is due to variations in arc discharge. The higher pitched note is not so common. As you apparently only hear it at short distances from the connections you mention it may be due to forced oscillations in the receiver setting up beats with the incoming radiation. As you do not say whether the pitch varied with the tuning, we cannot say for certain, and this may also have been due to irregularities at the transmitting station.

SPARKS (Plymouth) (1).—220 volts A.C. is quite unsuitable for grid potential of a valve, even with a lamp of any size in series. (2) The design of a wireless telephone set for a given range and a given aerial is rather outside the scope of these columns. The loop aerial you suggest is quite unsuitable. If you must use a loop, use a former several feet in diameter. The T aerial would be fairly suitable. For details of suitable circuits see Goldsmith's Radio Telephony, or Bucher's Vacuum Tubes.

A. E. B. (Welling) (1).—The aerial would be suitable for short wave stations at not too great distances. It would be very little use for large stations on long waves without complicated and expensive apparatus, and a great deal of skill in manipulation. (2) No 24 wire would be quite suitable for the inductance, but you would probably not want as much as you suggest for the wavelengths for which your aerial would be suitable. (3) The sketch you give is fairly suitable for an elementary receiver. (4) Ordinary phones are suitable for wireless work *if* they are of suitable resistance,—*i.e.*, about the same as the detector in use. Most crystals have high-resistance and therefore need high-resistance phones. Unfortunately most ordinary phones are low resistance. (You should consult a book such as Bangay's "Elementary Principles," in which you will find the answers to most difficulties such as these which bother beginners.)

GADGET (Bournemouth).—The condition for the oscillatory discharge of a condenser is arrived at mathematically, roughly, as follows. The differential equation for the variation of the charge can be written down from first principles, and is :—

$$\frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{LC} = 0$$

Solving this by methods given in any book on differential equations, we get

$$q = Ae^{\left(-\frac{R}{2L} \pm \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}\right)t}$$

Now this is the equation to an oscillatory quantity if, and only if, the expression in the bracket is imaginary; and from fairly elementary algebra, this is the case if

$$\frac{R^2}{4L^2} - \frac{1}{LC} \text{ is negative, } i.e., \text{ if}$$

$$\frac{R^2}{4} < \frac{L}{C} \text{ or, if } R < \sqrt{\frac{4L}{C}} \text{ which is the}$$

required condition.

M. D. M. (Cricklewood) (1).—An inductive reaction coupling, though very convenient in practice, is not essential for producing oscillations. Oscillations can be sustained by any means by which the change of the plate current can be made to affect the potential of the grids provided that the sense in which the potential is changed is such as to assist the changes in the plate current and not to damp them out. Thus in your first example the grid potential will vary with the charge on the A.T. condenser, which in turn will vary with the plate current. The circuit will therefore be capable of oscillating. It can then be tuned for the local oscillations to beat with the oscillations induced by the incoming waves. Your circuit 2 probably oscillates owing to the connection between the plate and the grid circuit condenser when the ultra-audion switch is closed. We do not think it likely that it would oscillate with this connection broken, at any rate with hard valves. (2) We believe so. (3) This article duly appeared in the WIRELESS WORLD, Vol. V., p. 280. (4) The scheme for charging cells from a vacuum tube rectifier is practicable, if a suitable valve is used, as for instance the Tungar bulb of the B.T.H. An ordinary valve as used in receiving circuits would not pass enough current.

J.S.F. (Herne Hill).—We do not think the scheme of connections you suggest would give good results, and it differs so much from usual practice that we could not give the best values for the inductances and capacities—particularly as you do not give the dimensions of the aerial you propose to use, or the wavelengths you wish to receive. We recommend you to try one of the more usual circuits to begin with.

NEMO (Aberdeen) (1).—Auto transformers would not be suitable, as their use would put comparatively low-resistance paths between the positive end of the H.T. battery and the filaments. (2) The exact value for the condenser is not important—try 0.25 mfds., variable in a few large steps. The circuit could be adapted for note magnification by substituting an iron core transformer for the second H.F. transformer shown. A telephone transformer would also be necessary in the plate circuit of the third valve with low resistance phones.

J. W. (S. S. Mahsud) (1).—In view of the very high resistance of the grid leaks, we do not think that the introduction of a battery in the manner you suggest would be of any use. It would certainly not increase the ease of control. (2) About 10,000 to 20,000 ohms. Such crystals can be used as grid condenser leaks, but would not have high enough resistance for the circuits in the diagram you mention. (3) The circuits of the amplifier are quite different, (vide Fleming's new book). The amplifier should, of course, be used with suitable receiving circuits, and is then quite reliable.

TRAMP (Birmingham (1).—The poles you describe would serve very well for masts for an aerial. Sink them in concrete sockets to a depth of about 3 feet below the level of the ground, tar or otherwise protect the earthed ends, and stay the poles securely from about 35 feet up. Use four stays with their anchors at the corners of a square with 25ft. sides. (2) We can give you no idea of the cost of the apparatus you mention and advise you to apply direct to the makers.

G. W. (Preston).—Your question is so very comprehensive that it is difficult to answer briefly. We think, however, that you would have little difficulty in obtaining a position as a sea-going operator. Posts ashore are not so easily secured, as there are fewer available. It will save time if you write direct to the wireless companies.