THE

RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. II OCTOBER, 1921 NO. 10

Editor :
PROFESSOR G. W. O. HOWE, D.Sc., M.I.E.E.
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PHILIP R. COURSEY, B.Sc., F.Inst.P., A.M.I.E.E.

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Abstracts of Articles and Patents
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THE RADIO REVIEW

INFORMATION FOR CONTRIBUTORS

All correspondence relating to contributions should be addressed to The Editor, The "Radio Review," 12 & 13, Henrietta St., Strand, London, W.C. 2.

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Editorial.

The Effect of Atmospherics on the Choice of Wavelength.—It was discovered very early in the development of radiotelegraphy that as the receiving aerial was tuned to longer and longer wavelengths, the disturbances due to atmospherics steadily increased, indicating that if they possessed any frequency it was relatively low. No indication of any definite frequency has been found, however, and it is now generally assumed that atmospheric disturbances are due to heavily damped non-oscillatory electromagnetic pulses. This was the assumption made by Abraham in his paper in the *Jahrbuch* in 1919 in which he discussed the reason for the frame or coil aerial being less susceptible to atmospheric disturbances than the open antenna. In the present issue we publish a paper by Mr. L. B. Turner, in which he applies Abraham's formulæ to the calculation of the optimum wavelength to employ over any given range so as to obtain not the maximum received power, but the maximum ratio of signal to atmospheric. This leads to much shorter wavelengths than are obtained from consideration of the power only.

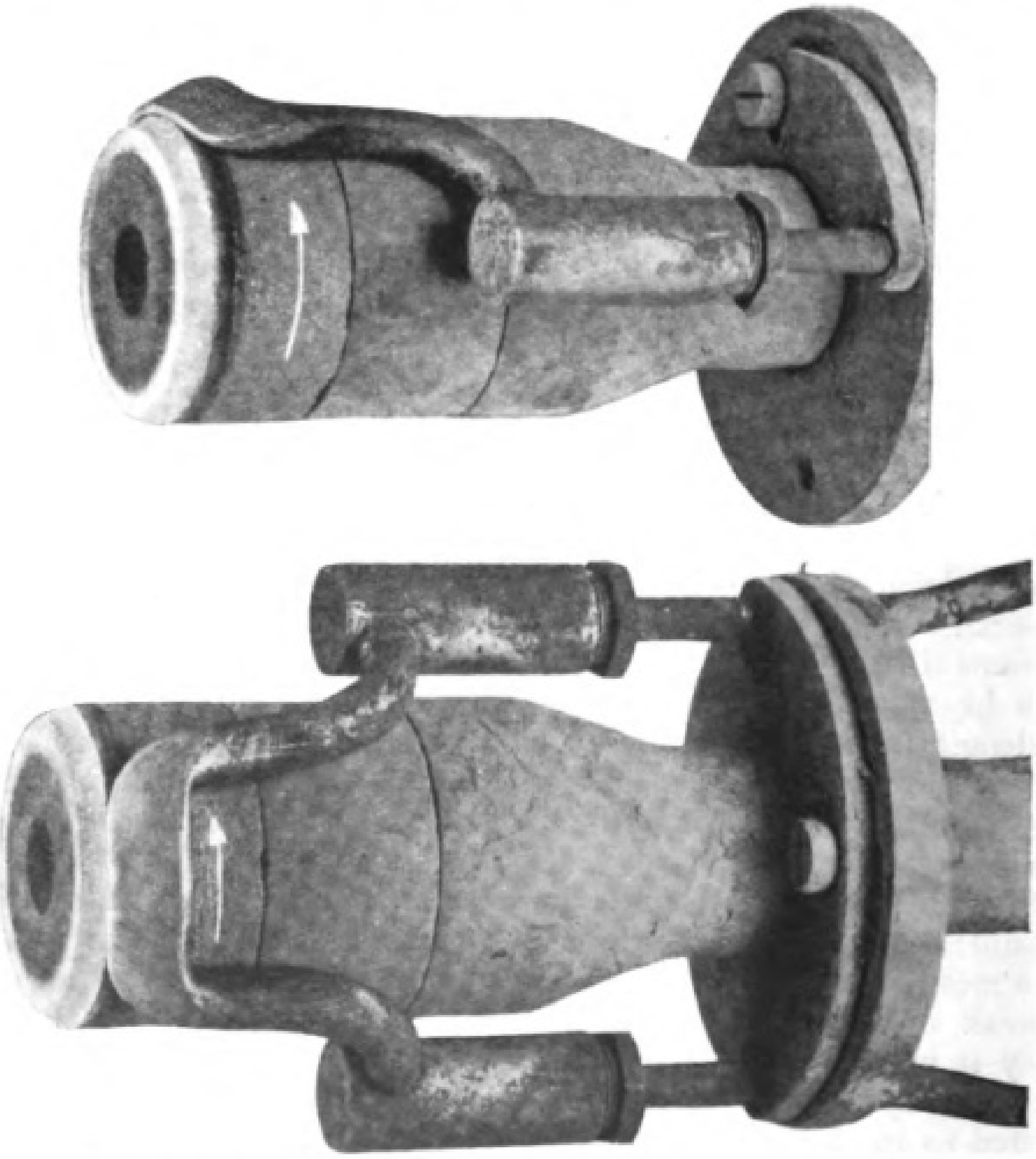
That this is a matter of the greatest importance is evident to any one acquainted with the operation of long-distance stations at the present day. When messages cannot be received it is not as a rule due to the signals being too weak, but to the atmospherics being too strong.

May it not be that the makers of high-frequency alternators and arcs, with the help of the promise held out by the Austin-Cohen formula, have tempted us too far in the direction of long wavelengths? It would appear so, unless some really effective anti-atmospheric device can be devised and thus remove what is undoubtedly the most serious limitation to long-distance radiotelegraphy. **[3593]**

Recent Improvements in the Poulsen Arc.—Professor P. O. Pedersen, who has done so much to throw light on the operation of the Poulsen arc under practical conditions, has recently published * an interesting account of an improvement which he has introduced. This consists of a water-cooled copper saddle resting on the carbon cathode a short distance from the striking edge. In each cycle the arc strikes between the nearest points of

* *Electrician*, 86, pp. 684—686, June 3rd, and pp. 714—716, June 10th, 1921.

the electrodes, is driven upwards and outwards by the magnetic field until it is extinguished. If working normally it should then restrike at the original points, but if the field be too weak it will restrike as a long arc where it has just been extinguished and continue to be blown still further during the succeeding cycle, which is thus not an exact repetition of the first cycle.



Two views of Professor Pedersen's Water-cooled Arc Saddle.

With still weaker fields three or four cycles may elapse before the arc ceases its outward travel and restrikes at the nearest points of the electrodes. This irregularity of successive cycles can be prevented by suitably increasing the field, which must not be made too strong, however, since this would lead to reduced efficiency.

The addition of the water-cooled saddle causes the arc to extinguish on reaching it and to restrike at the nearest points of the electrodes even with a magnetic field too weak to give this ideal operation when the water-cooled saddle is not fitted. Professor Pedersen has given oscillograms and photographs proving conclusively that the arc does work in this way. He states, however, that no great increase in the efficiency was obtained directly by the use of the cooling saddle. The photographs give a clear idea of the construction of the saddle which is held stationary whilst the carbon electrode is rotated.

The British Association.—Elsewhere in this issue will be found an account of some experiments carried out by Mr. A. A. Campbell Swinton on Shielded Frame Aerials. These were described in a paper read before Section A of the British Association for the Advancement of Science, which met this year at Edinburgh, between September 7th and 14th, under the Presidency of Sir T. Edward Thorpe, C.B., D.Sc., F.R.S. Other papers of wireless interest read before the Association will be dealt with in our next issue.

Wireless Telegraphy in Western Australia.

By R. C. GRAY, M.A., D.Sc.

Western Australia is a land of large spaces, and seems to the writer to have an enormous opportunity for both amateur and professional wireless telegraphy and telephony. Unfortunately the isolated position of the State, away from the markets of the world, prevents those interested here from realising the strides the science has made in recent years, and business firms at home from appreciating the scope there is for the development of their business in the State.

The amateurs are mostly settled round Perth, the capital city, built on a soil consisting chiefly of yellow sand. This sand stretches inland to the Darling Range, beyond which is the great tableland of the interior, from 1,000 to 2,000 feet above sea level, and the difficulty of getting a proper earth in the sandy soil, which in summer dries to several inches below the surface, is considerable. The old "stand by," the water pipe, when used as an earth, introduces nightmares, of considerable intensity when the receiving gear is at all sensitive. The city has a widespread tramway system; this forms the second trouble. The local lighting system is by 250 volts A.C. electricity, borne far into the bush in every direction on wooden poles about 25 to 30 feet high. Owing to the rapid growth of the city in late years and the consequent overloading of the electrical generators, the voltage of the lighting supply is continually varying with the load, and the enthusiastic amateur hears most of these variations, in spite of all known precautions. In addition to these disturbances, we have atmospherics, especially in summer, of a strength seldom experienced in Great Britain. On the other hand, the only disturbing station is the Perth W.T. station (**VIP**), situated at Applecross, about five miles away, and working generally with ships on 600 metres spark; and an efficient receiving set tuned for long waves eliminates such signals completely. Amateurs listening on 600 metres have plenty of scope; a detecting valve with a leaky grid handles signals from **VIP** effectively, and is always ready for weak signals from distant ships. The promise of good research work by amateurs lies, however, in the use of long waves. There are no disturbing stations working on long waves, within hundreds of miles. The result is that, provided the night is quiet, European stations (8,000 miles away) on 10,000 metres and upwards are easily picked up. In March these signals begin to increase *slowly* in strength at about one hour after sunset here (seven hours before sunset at home), and reach a maximum about 1 a.m. (one hour before sunset at home); this maximum is retained until an hour after sunrise, after which the signals fade *very rapidly* to the day strength, although at this time the waves are travelling through seven hours (105°) of darkness and only one hour (15°) of light. Nauen (**POZ**) on 12,600 metres and Lyons (**YN**) on 15,500 metres are heard most easily, though the new station of Lafayette (**LAF**) has been heard more loudly at times. Eilvese (**OUI**) and Rome (**IDO**) are easily picked out; but on these long waves (12,000 to 20,000 metres) the overlapping becomes considerable, and the trouble of identifying the other weaker signals is very great. Probably the most interesting signals heard at night are from Annapolis (**NSS**) on about 17,000 metres. This station is about 11,600 miles from Perth, almost on the other side of the earth, the angle through which the direction of the waves changes being 167° 50′. Signals from **NSS** are most easily heard at night, but this may be due mainly to the stoppage of the local tramcars at midnight. During a tramway strike, the writer heard the time signals from **NSS** at 11 a.m. local time (0300 G.M.T.), easily readable, on an aerial of three parallel wires 30 feet high and 50 feet long, the receiving gear being two single layer inductances, loosely coupled, condensers about one jar, and a three-valve (two V24, one Q) radiofrequency amplifier. These signals are heard about the same strength with *one* valve on a neighbouring aerial 40 feet high and 160 feet long. It is worthy of note that low-frequency amplifiers are absolutely useless in low latitudes such as ours.

From the business point of view, the extensive spaces to the north and east badly need wireless telegraphy, or preferably telephony. The cost of running a telegraph line a few hundred miles for only one or two subscribers is prohibitive. Information published recently shows that the Australian Postmaster General's Department, in response to a request for telegraphic communication, proposes erecting wireless telegraph stations at Powell's Creek and Camooweal, these stations to be provided solely for the purpose of collecting traffic from private wireless stations in the scattered outlying districts. The estimated cost of erection of a telegraph line to serve these districts is £60,000, whereas the wireless stations will cost about £5,000. A similar scheme of private stations working with Government stations would be more easily developed in Western Australia, on account of the large number of Government stations already in existence here. There are apparently, however, no firms in Western Australia in a position to demonstrate the working of a wireless telegraph or telephone transmitting set, or to quote for such, and there seems to be an excellent opportunity in this connection, waiting for British firms. A set shown working at the Royal Agricultural Show, held annually in October and attended by pastoralists and agriculturists from all over the State, would open the market, and incidentally help in the development of Western Australia. **[4091]**

The Opening of the Leafield Wireless Station.

Leafield, the first station of the British Imperial Wireless Chain, was formally opened for service on Thursday, August 18th, 1921. The long-drawn-out history of the British Imperial Wireless Scheme is too well known to need detailed repetition here, but it may be recollected that the plans for the erection of the station on this site date back to 1913 when a contract (subsequently cancelled) was made between the Post Office and Marconi's Wireless Telegraph Co., Ltd., for its erection as a 300 kW spark installation, together with other stations of the chain. The site chosen, Fig. 1, is high up

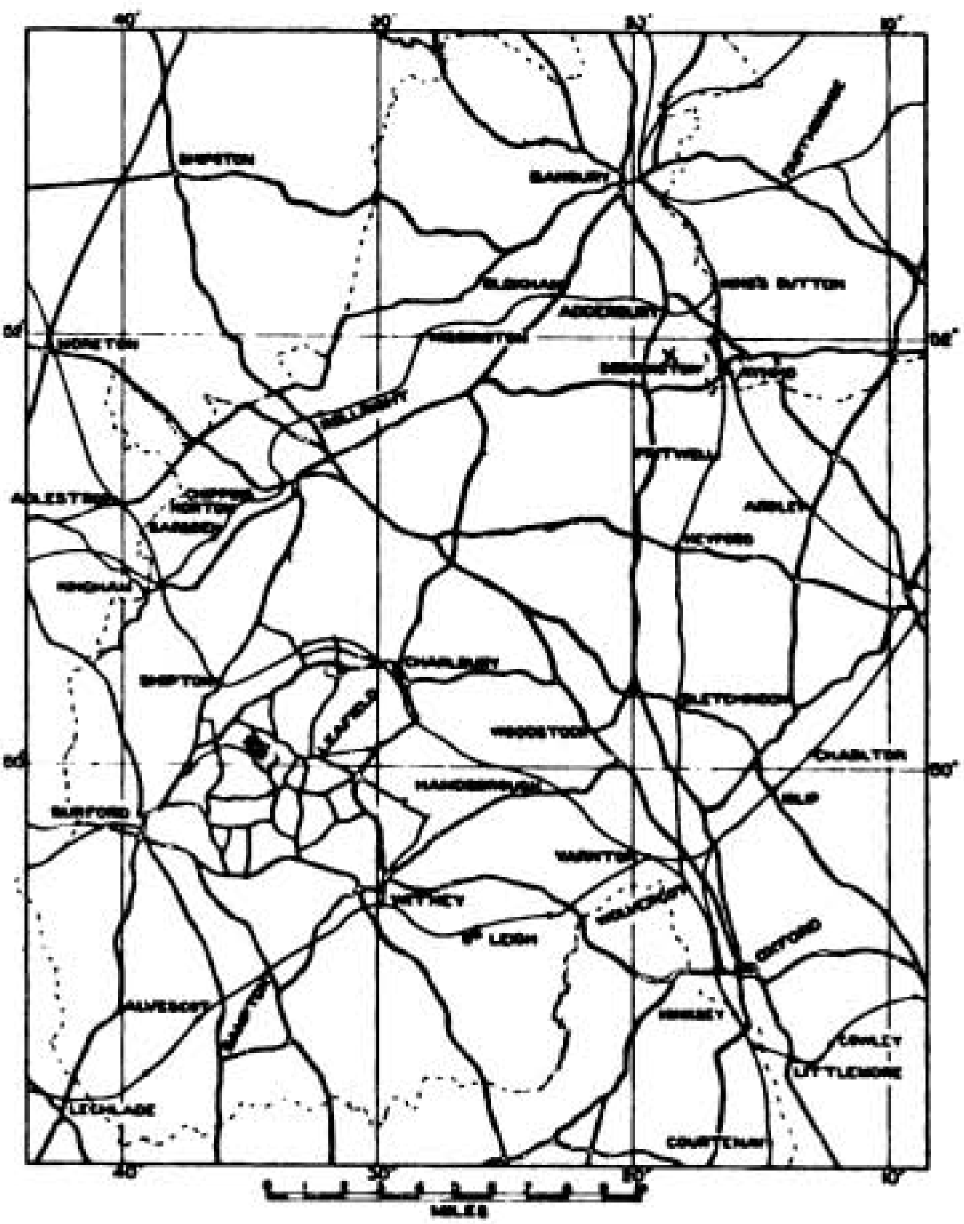
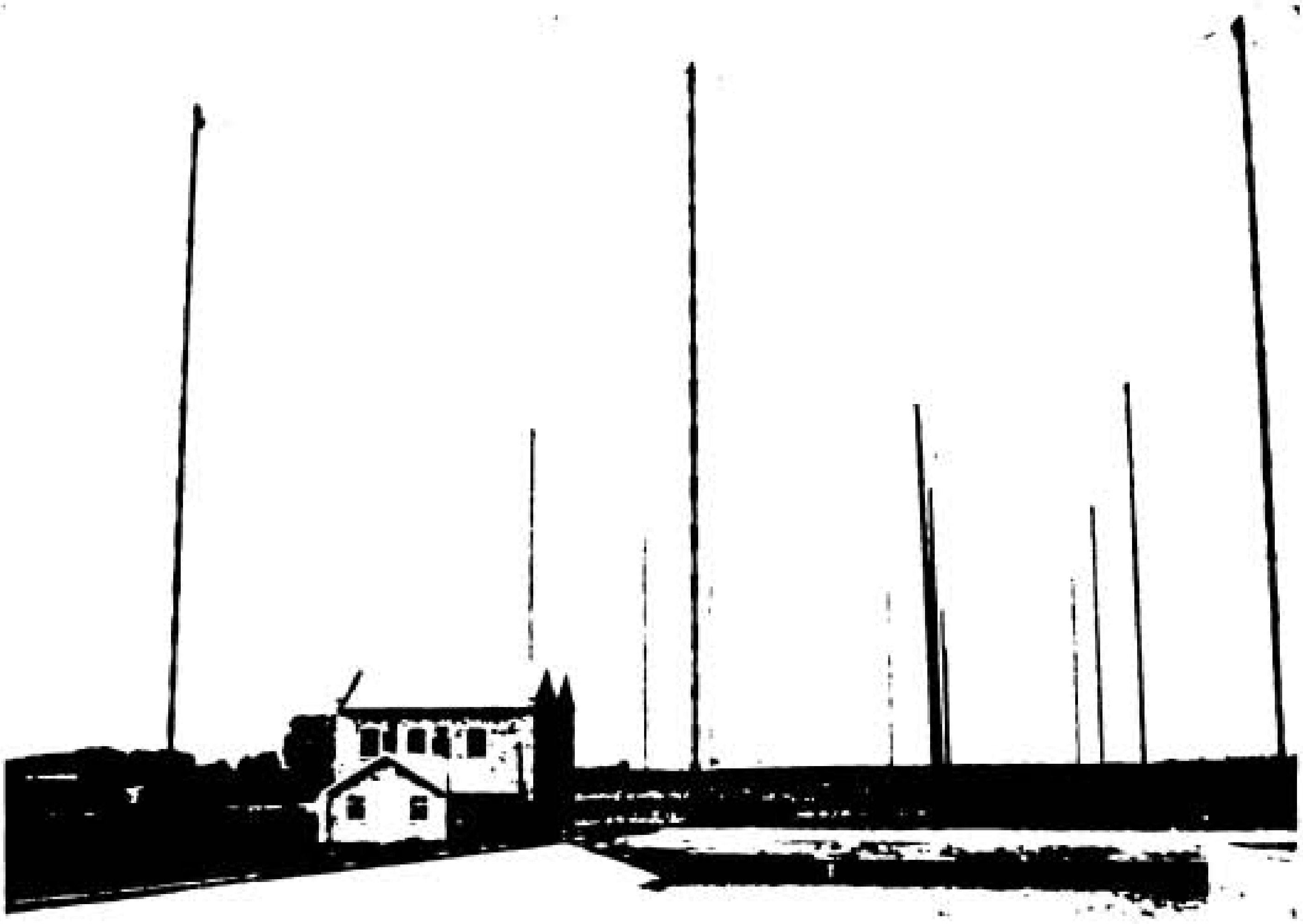


Fig. 1.—Map showing Site of Leafield Station and approximate position of proposed station near Banbury.

on the Cotswold Hills in Oxfordshire about 600 feet above sea level and the tubular steel masts form a landmark for many miles around. These masts, of which there are ten (Fig. 2), are each 300 feet high and were erected by the Marconi Company before the cancellation by the Post Office of the above-mentioned contract.

All the work on this station as regards its development for Imperial communications was suspended during the war, the masts, up till 1918, being merely utilised to support aerials for experimental reception. In the spring of 1919 the question of completing the English and Egyptian stations and of utilising the sites originally chosen for them came under review by the Imperial Communications Committee which had recently been instituted. In view of the very heavy pressure of traffic on the cables between England and Egypt it was decided to complete the stations, and Parliament sanctioned the estimated expenditure of £170,000 for this purpose in August, 1919. The scheme has been delayed by the numerous difficulties in the industrial world, with the result that the Leafield Station has only just been opened, while the Cairo station will not be ready until November.



[Photo: *Sport and General.*

FIG. 2.—General view of Leafield Station, showing Wireless Building.

The great development of continuous wave generators which has taken place in the period covered by the war made it clear that high power spark installations are now obsolete, so that the methods of generating high frequency continuous waves—the alternator, the timed spark and the Poulsen arc—which were then available were investigated by the Post Office. After a careful watch on the performance of various transatlantic services it was decided that the most suitable generator to use for these stations was the arc, and rough plans and estimates for the completion of the stations were prepared by the Post Office Engineering Department.

To mark the historic occasion of the opening of the first station of the British Imperial Chain the ceremony was performed by the Postmaster-General, Mr. F. G. Kellaway, who was accompanied by a number of Post Office engineers and members of the Advisory Committee. Among the visitors were :—

Sir Thomas Williams, of the London and North-Western Railway, and Mr. Blakemore (members of the Post Office Advisory Committee) ; Admiral of the Fleet Sir Henry Jackson (Chairman of the Radio Research Board); Colonel Cusins (War Office Signals Experimental Establishment, Woolwich) ; Mr. O. F. Brown (Technical Officer of the Radio Research Board) ; Mr. S. C. Clements (representing Sir R. Jones, of Reuter's, a member of the Cable Users' Committee) ; Colonel Crawley (Deputy Inspector of Wireless Telegraphs, G.P.O.) ; Major Purves (Assistant Engineer-in-Chief, G.P.O.) ; Mr. E. H. Shaughnessy (Head of the Wireless Section, G.P.O.) ; and Mr. F. J. Brown (Assistant Secretary in Charge of Telegraphy, G.P.O.).

[Photo: *Sport and General.*

Fig. 3.—The Postmaster-General receiving the replies to the first messages sent out from Leafield Station.

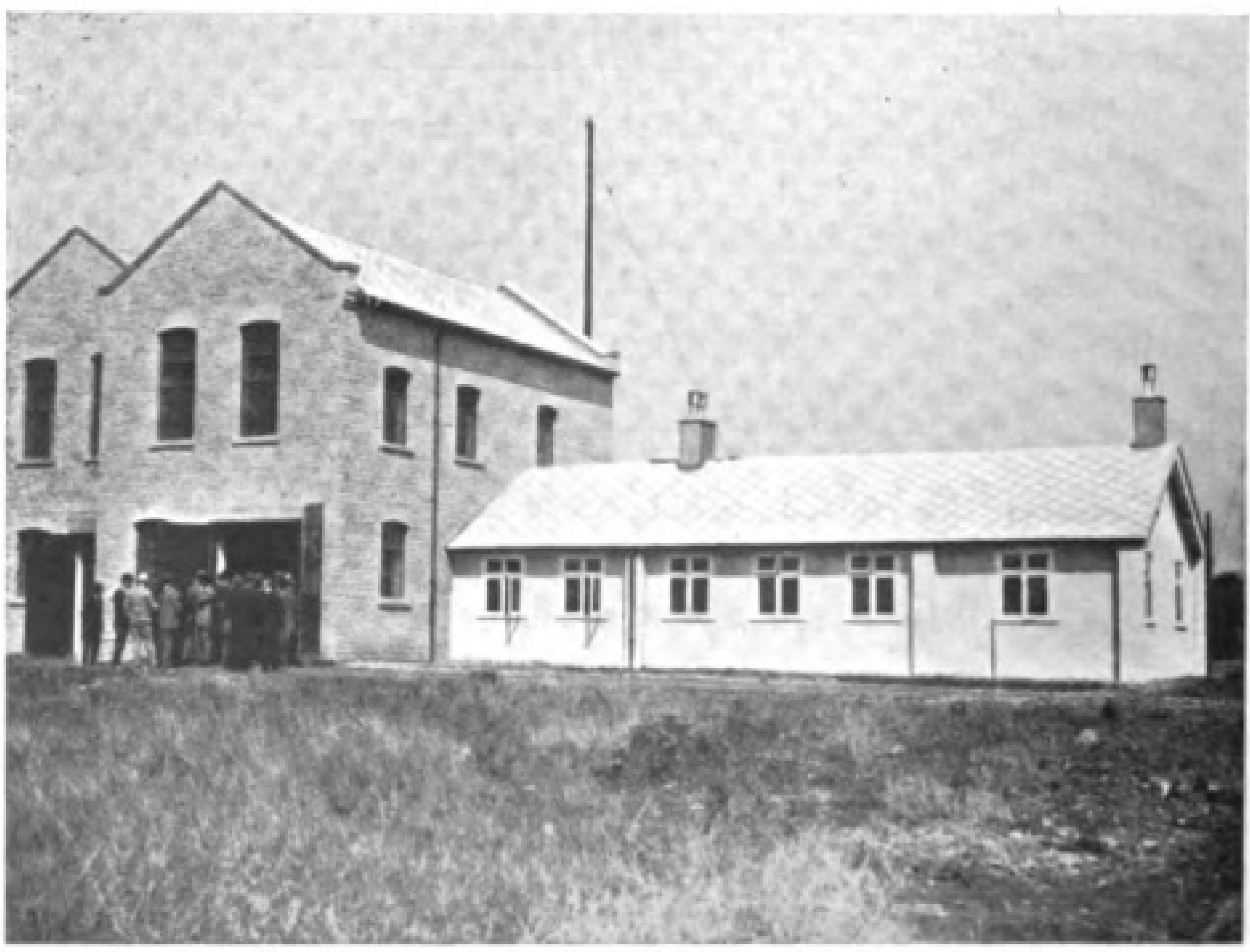
After a tour of inspection of the buildings two messages were sent out, the first to all British stations in range, and the second to all European and other foreign stations in range. These messages ran as follows :—

(1) The Postmaster-General sends greetings to all British stations within range on the occasion of the completion of this, the first station of the Imperial wireless chain, and trusts that the station will help to knit still closer the bonds which bind together the different parts of the Empire.

(2) The Postmaster-General sends greetings to all European stations and to other foreign stations in range on the occasion of the completion of this, the first high-power station owned by the British Post Office, and trusts that the development of wireless communication will help to knit still closer the bonds of amity which bind the British Empire to all other States.

A few minutes after the second message had been despatched replies and acknowledgments were received from various European stations, including Rome, Budapest, Posen, Nauen, Malta and stations in France, Norway and Sweden (Fig. 3), the signals being reported as being clear and having a good note. Test signals have also been acknowledged from Gibraltar, Aden, St. John's, Newfoundland, Bermuda, and Jamaica.

FIG. 4.—View of Power House with Wireless Building in background.



[Photo: *Sport and General.*

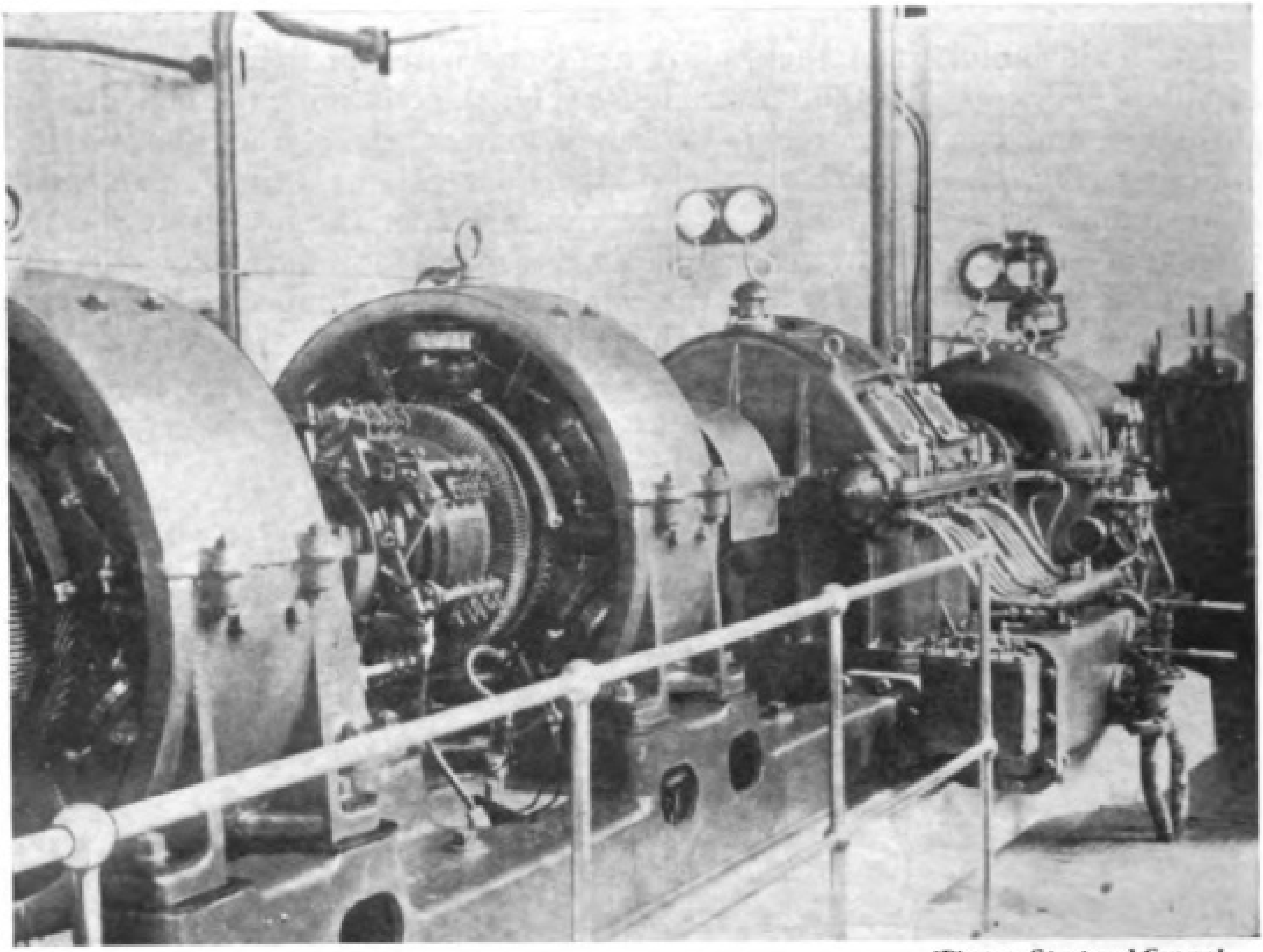
FIG. 5.—The Wireless Building at Leafield.

The main buildings of the station are constructed of limestone quarried locally. They comprise the Power House (Fig. 4), containing the boiler room, turbine room, condenser room, workshop, offices, etc.; and the Wireless Building (Fig. 5), in which on the ground floor are the switch room, main store room and general offices, and on the first floor the arc room and the inductance room. The Wireless Building is separated from the Power House by a distance of 150 feet. On the site are also a number of bungalows (Fig. 6), for the accommodation of the station staff.

[Photo: *Sport and General.*

Fig. 6.—One of the Bungalows for the Station Staff.

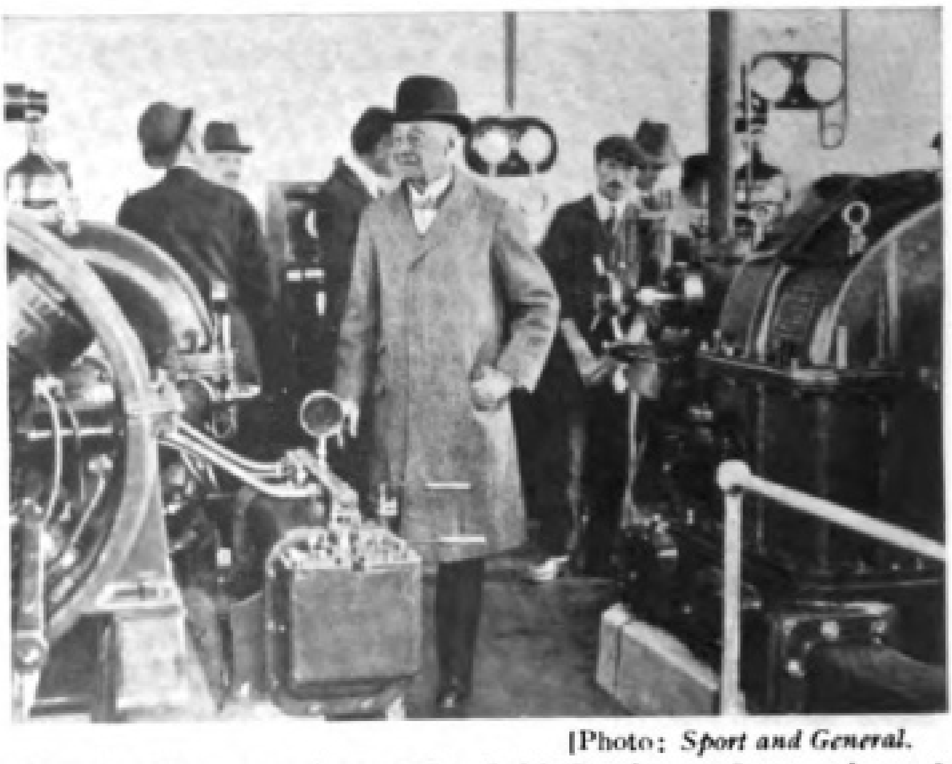
In the boiler house two hand-fired Babcock and Wilcox boilers are installed, each unit being capable of meeting the demands of all the turbines. The working steam pressure is 200 lbs. per square inch with a superheat of 200° F. A brick shaft 60 feet high, and 4 feet internal diameter at the top, provides natural draught for the boilers, but a motor-driven Sirocco fan is also installed so that induced draught can be used if desired. The turbo-generators with their controlling switchboard, condensers, air pumps and other auxiliaries were installed by Messrs. W. H. Allen, Son & Co., Ltd. One of the units is shown in Fig. 7. Four turbo units are provided arranged in two sets for the generation of continuous current at 220 volts, and at 750 to 1,000 volts. These supplies are used for the auxiliary motors and lighting, and for the arcs respectively. The switching arrangements provide for the use of the duplicate sets (Fig. 8) for each voltage either singly or in parallel. The turbines are of the Curtis type and run at 6,000 r.p.m. They are geared down to 650 r.p.m. for the 1,000 volt generators, and to 1,000 r.p.m. for the 220



[Photo: *Sport and General.*

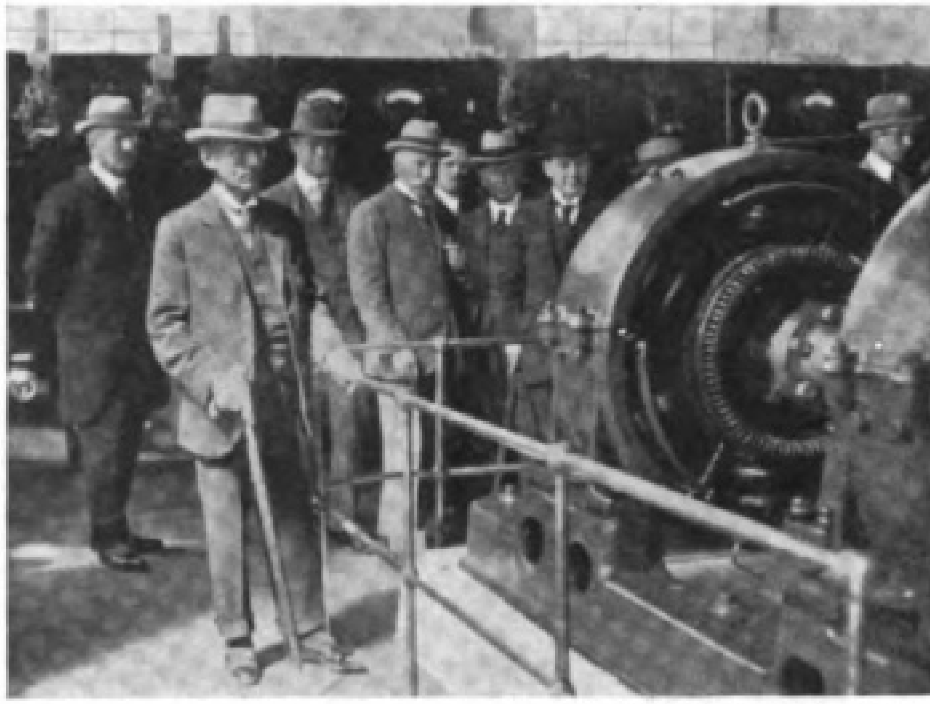
FIG. 7.—One of the 1,000-volt Turbo-generator Units.

volt machines. Each of the 1,000 volt 250 kW sets consists of two 500 volt machines mounted on the same shaft as may be seen from Fig. 7, and connected in series. These machines are each insulated from the bedplate and are connected by insulating couplings. The 220 volt units are of 60 kW capacity each and are compound wound. Cooling water for the condensers is obtained from a spring in a valley about one and a quarter miles distant from the wireless station. Motor driven pumps are used for pumping water up to the cooling pond near the Power House.



[Photo: *Sport and General.*

FIG. 8.—The Opening of Leafield Station. Inspection of turbo-generators, and showing relative position of the duplicate sets.

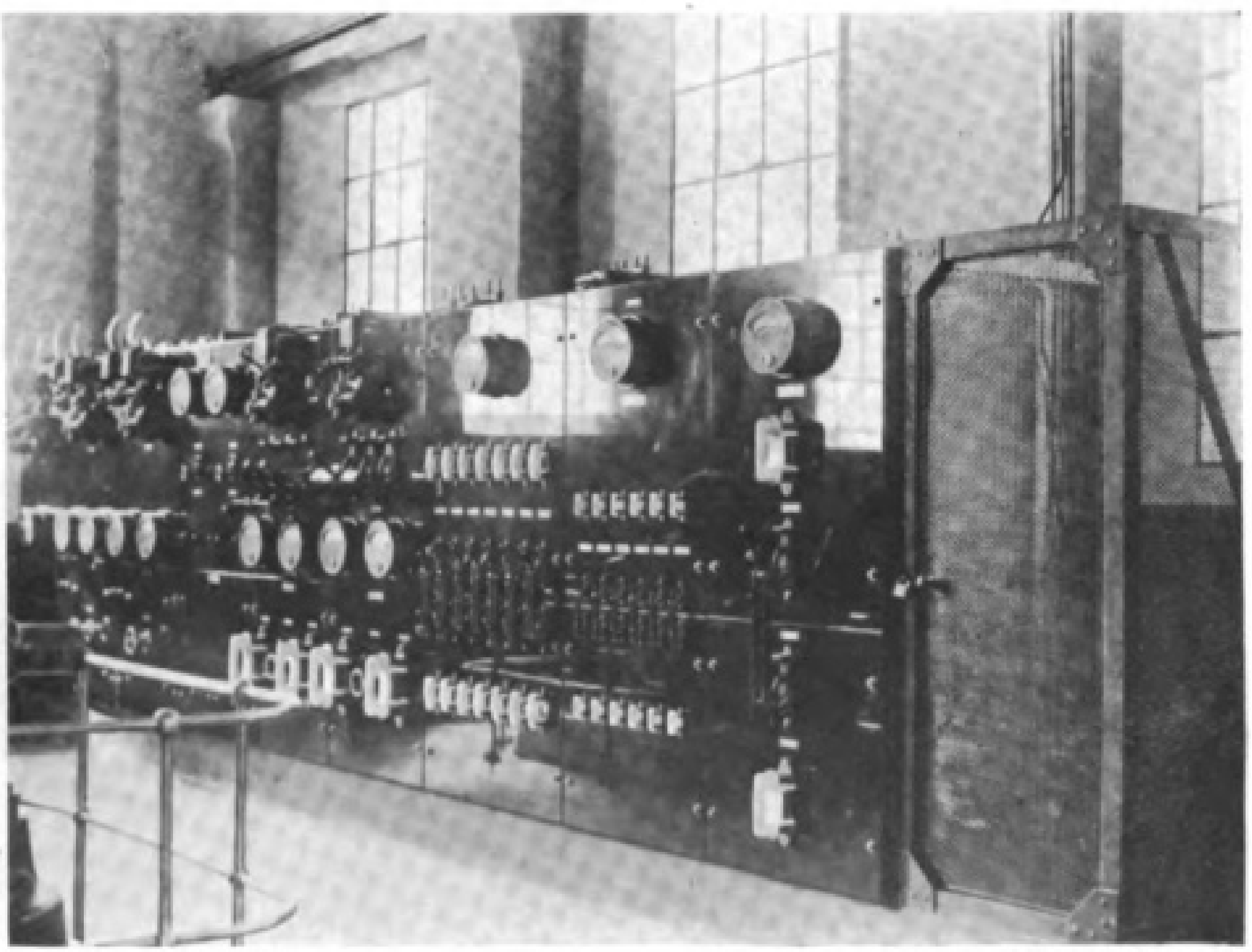


[Photo: *Sport and General.*

FIG. 9.—Turbo-generator, dynamo end, showing Switchboard in background.

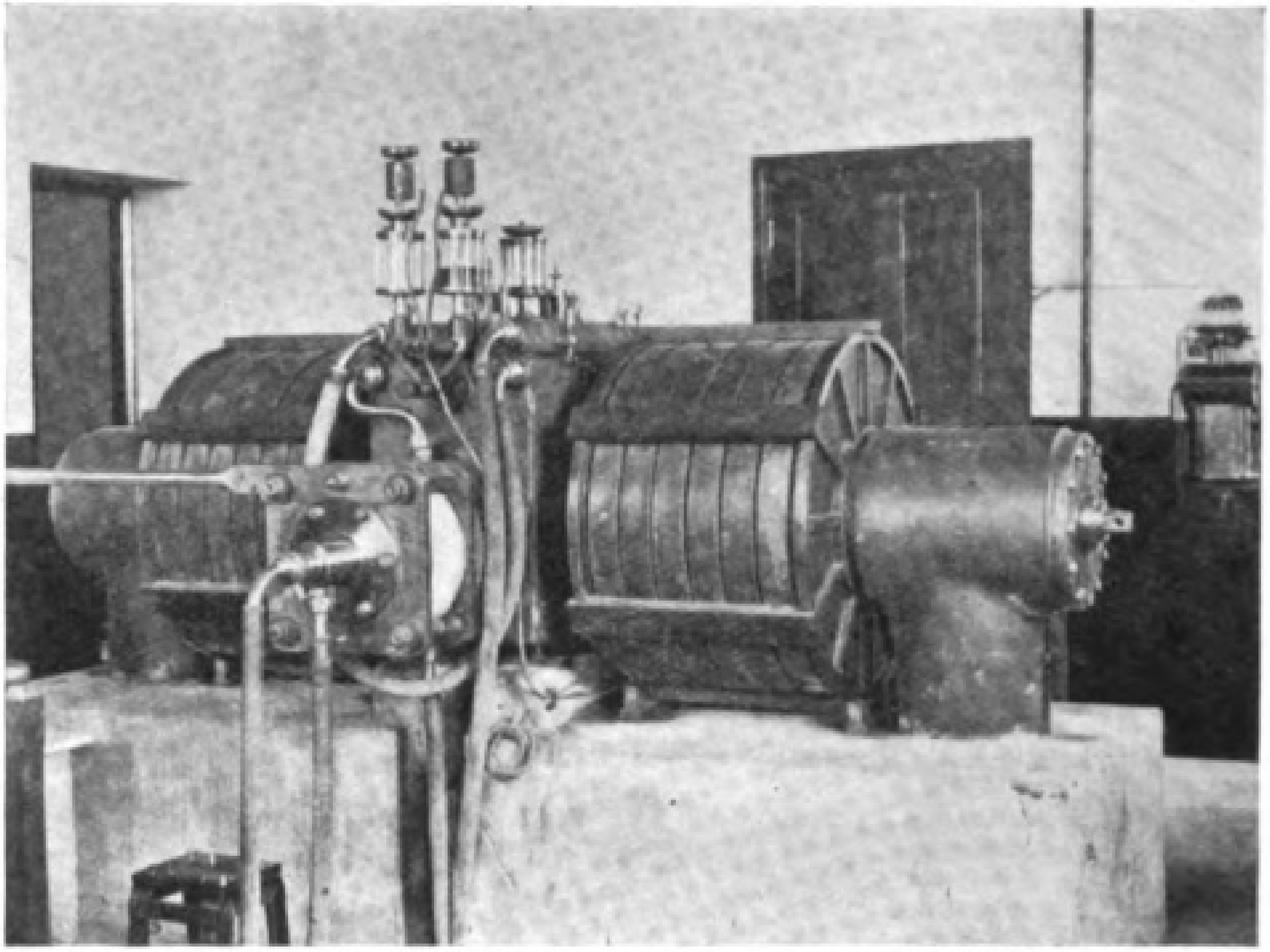
This pond has a capacity of about 1,000,000 gallons. A general view of the main switchboard which controls the whole of the energy generated in the station is shown in Fig. 10. Armoured cables are used to convey the current from it to the switchroom of the Wireless Building.

In the Wireless Building itself the high frequency energy is generated by arc apparatus which is installed in duplicate. Each of the arc units is of 250 kW capacity and was manufactured by Messrs. C. F. Elwell, Ltd., who also supplied the necessary auxiliary equipment. One of the units may be seen in Fig. 11 and some of its component parts in course of construction at the works of that company in Fig. 12. In this illustration a few magnet coils can be seen on the right-hand side, a part of one of the arc chambers with cathode on the left of



[Photo: *Sport and General.*

FIG. 10.—The Main Switchboard at Leafield Station.



[Photo: *Sport and General.*

FIG. 11.—One of the 250 kW Elwell-Poulsen Arc Generators.

FIG. 12.—Component Parts of one of the 250 kW Arcs during manufacture at works of Messrs. C. F. Elwell, Ltd.

[Photo: *Sport and General.*

Fig. 13.—Inspection of one of the Arc Anodes.

the picture and the iron magnetic circuit in the centre background. The yoke of the magnetic circuit of the arc is mounted in a concrete base as may be seen in Fig. 10. Both the magnet windings of each arc can be excited by the arc supply current, and this is the arrangement used for signalling at the normal wavelength.

Suitable switchgear is, however, provided to enable one of the windings to be excited from a separate 16 volt generator (which can supply currents up to 500 amps) when special wavelengths are required. The hydrogenous atmosphere for the arc is produced by dropping alcohol into the arc chamber from sight feed lubricators mounted on the top. These and the pipes leading cooling water to the cathode and to the arc chamber can also be seen in Fig. 10. The size of the arc electrodes can be judged from Figs. 13 and 14 which were taken after the opening ceremony. The cathode holder for one of the arcs is shown in Fig. 15.

[Photo: *Sport and General.*

Fig. 14.—Inspection of one of the Arc Cathodes.

The supply circuit to the arcs is taken through large choke coils which serve to maintain the arc current steady. These choke coils are shown in Fig. 16 and their position when installed in the basement of the station in Fig. 17. The striking of the arc and the necessary adjustments of the apparatus are carried out by an arc attendant, who has on a control desk in front of him (Fig. 18) instruments indicating the conditions of the arc and auxiliary apparatus. This control desk serves to operate contactors fitted in the room below the arcs which perform all the switching operations in the 1,000 volt circuits. These contactors are operated from the 220 volt circuits.

Signalling is effected by means of a special key, shown in Fig. 19, which has been developed after extended experiments on high power. It is operated by a Creed pneumatic engine, controlled by a Carpenter relay. It is arranged to short circuit coils coupled to the keying inductance joined in the aerial circuit. The spirals of copper strip which are short-circuited by the key are arranged on either side of the keying inductance circuit as shown in Fig. 20. The arrangement of this part of the circuit is indicated in Fig. 21. A compressed air supply is fed to the contacts of the signalling key for extinguishing the arcs when the circuit is interrupted. The air compressors and the water circulation pumps are automatically started by contacts on the arc controller. The adjustment of the wavelength radiated by the aerial is made by a separate aerial tuning inductance (Fig. 22), which is constructed of stranded cable each wire of which is insulated to reduce the eddy current losses. A portion of this coil is constructed of bare copper tube for fine adjustment of the wavelength.

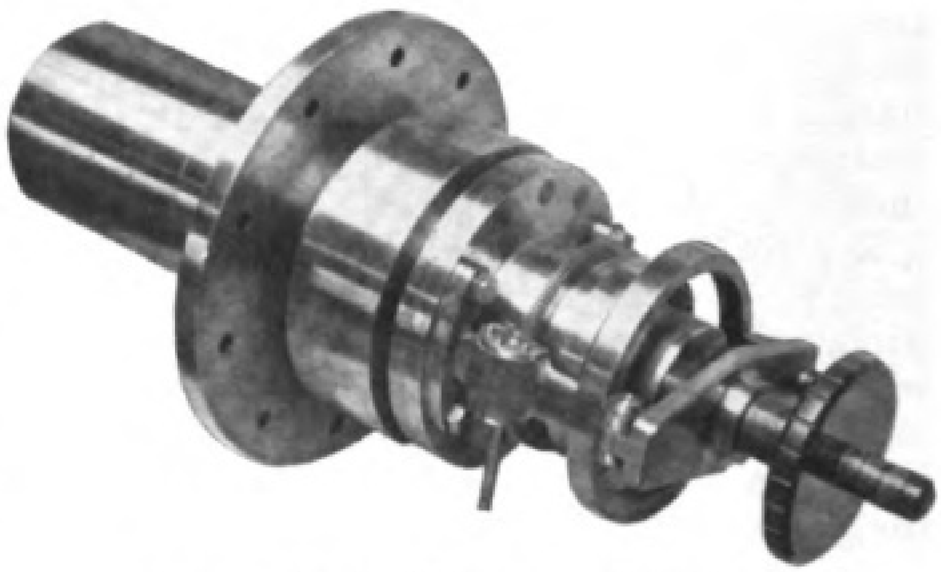


Fig. 15.—Cathode Holder for 250 kW Arc.

The aerial insulators are of the porcelain rod type (Fig. 23) to which reference has already been made in these columns * and the lead-in insulator is arranged in the centre of a glass panel (Fig. 24). The earth system is buried at a depth of about 9 inches below the surface of the ground and the connections from the arc cathodes

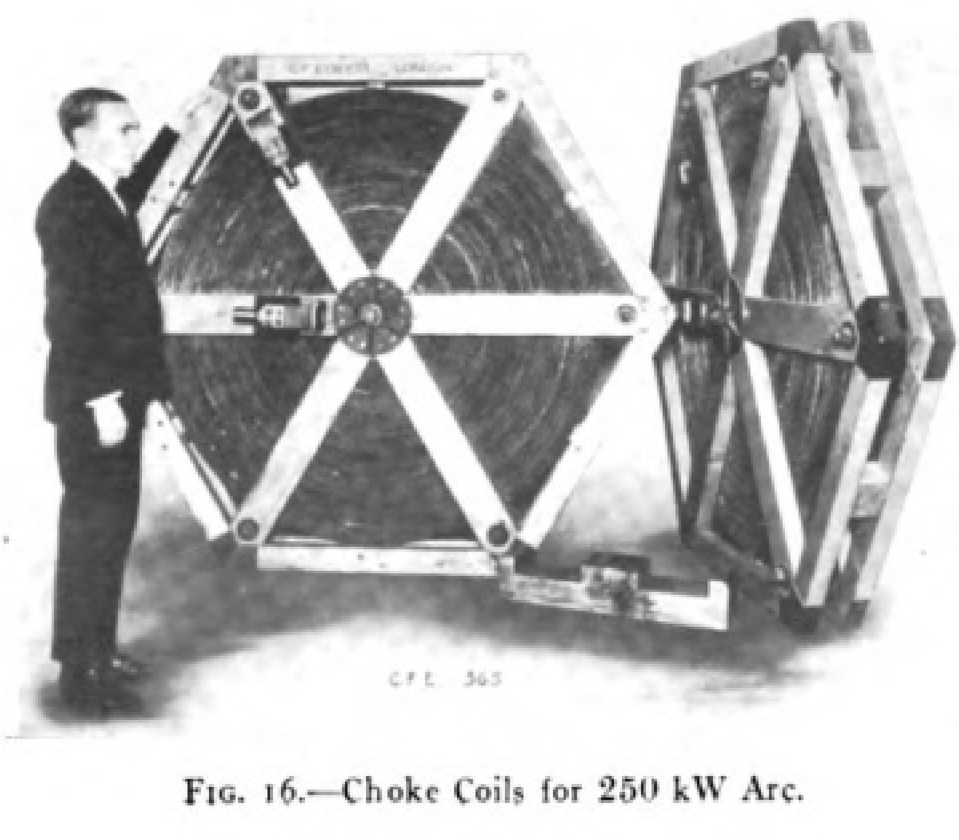


Fig. 16.—Choke Coils for 250 kW Arc.

* Radio Review, 2, pp. 197—199, April, 1921.

to these earth wires are made by broad copper strips which pass down the outside wall of the buildings to just below the ground level where they join a similar strip running right round the building close to the walls. The radiating earth wires are soldered to this latter strip. The arc and inductance rooms are screened by means of a zinc plate which completely covers the floor area and is joined to the main earth system to prevent the induc-

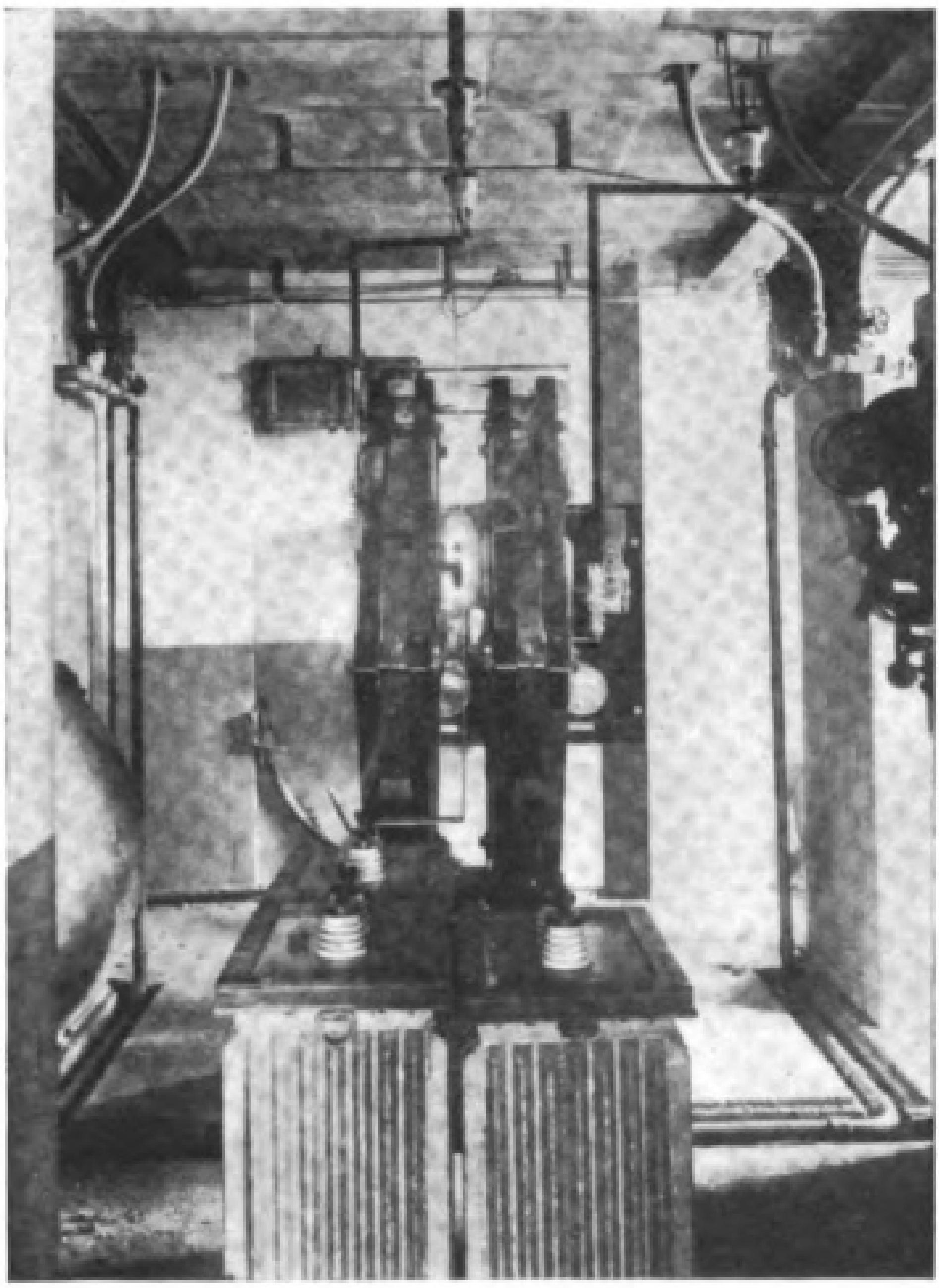


FIG. 17.—View in Basement of Leafield Station Wireless Building, showing Choke Coils in position.

tion of high frequency currents in the apparatus in the ground floor rooms below.

A separate aerial supported on 75 foot poles is temporarily used for reception at Leafield but it is proposed at a later date to build a separate receiving station near Banbury (see Fig. 1) so as to enable duplex working to be carried on.

At the conclusion of the tour of inspection of the buildings and equipment

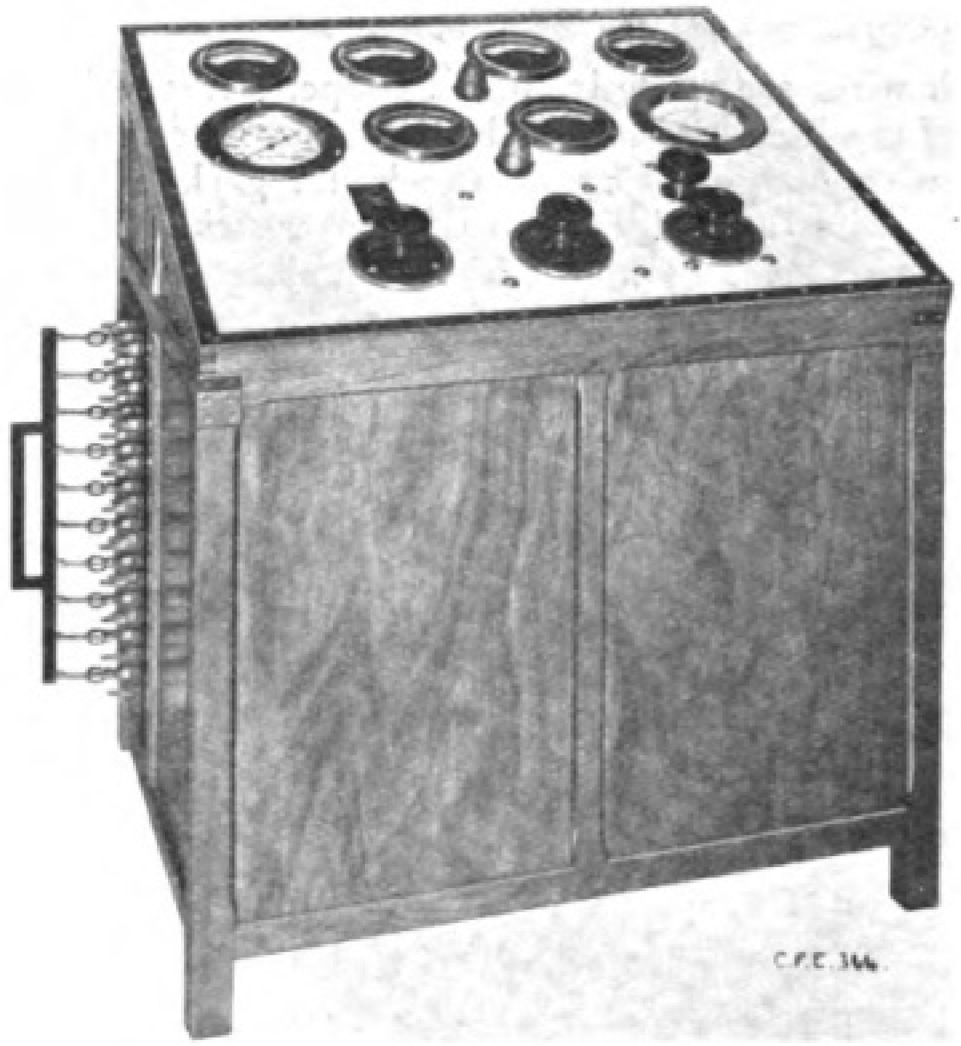


FIG. 18.—The Control Desk for one of the Arcs.

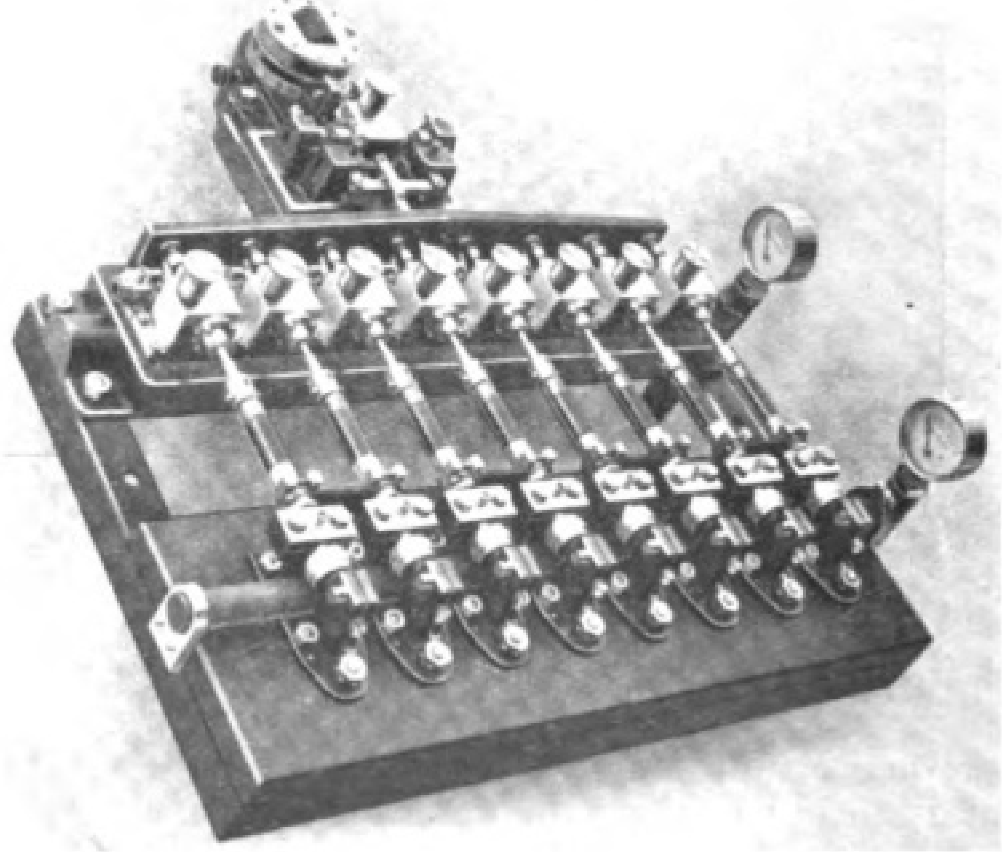


FIG. 19.—Signalling Key.

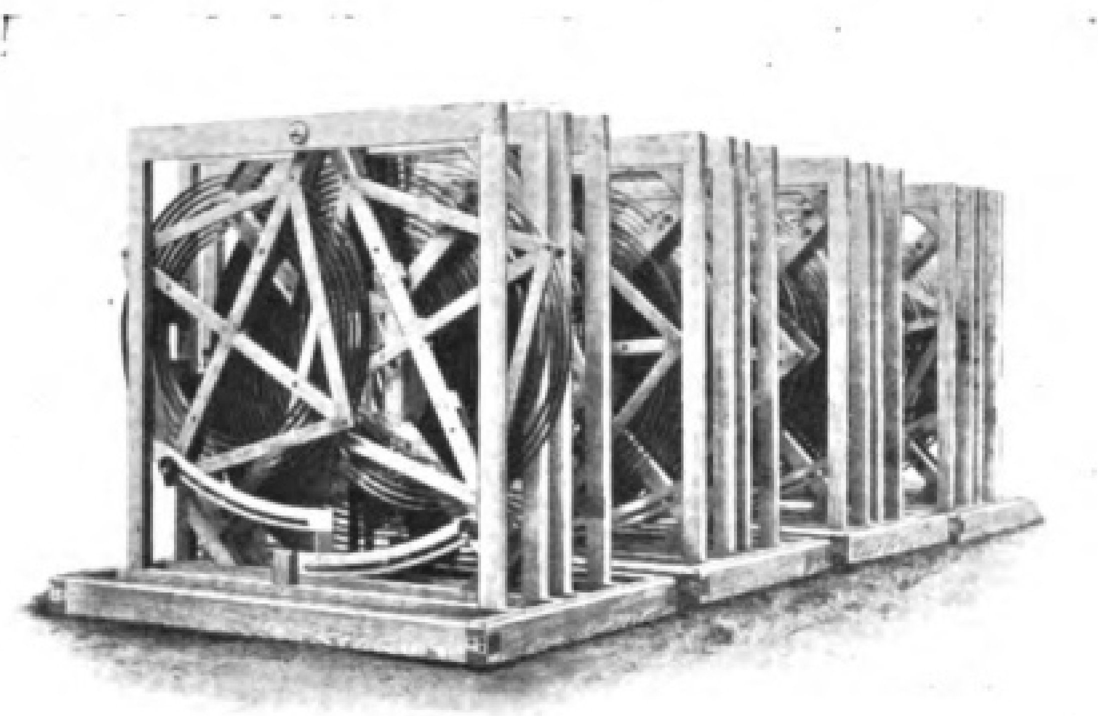


FIG. 20.—Keying Inductances in Aerial Circuit.

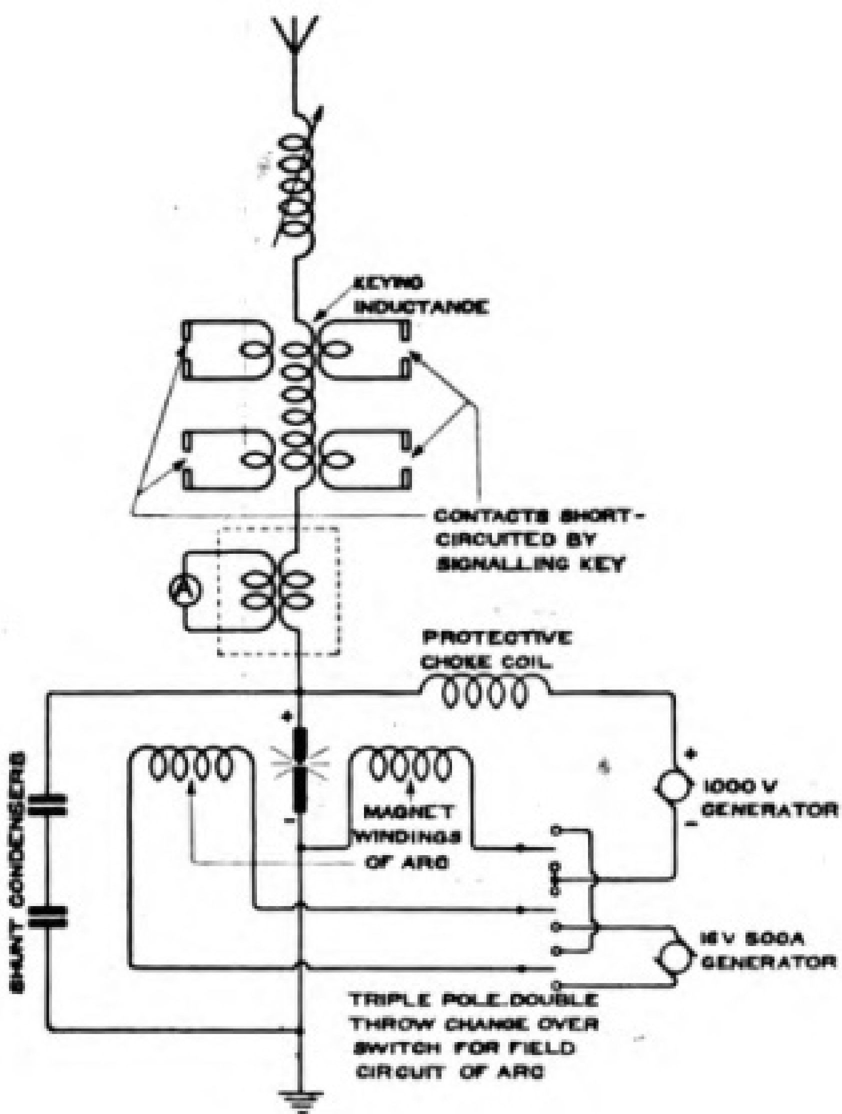


FIG. 21.

the Postmaster-General addressed a short speech to the company present in which he stated that—

it was felt that such an historic occasion should be marked by some public ceremony. He thought the Post Office suffered from too much modesty, and unless attention was occasionally called to some of its developments the public were apt to regard it as a slow and dead-alive body. Those who had visited that undertaking had had a real tonic experience, and what particularly appealed to him was the fact that nearly all the principal work was the result of British production and inventiveness. That surely should act as a tonic in these times, when they were so much given to self-depreciation. The Elwell arc transmitting equipment, which was assembled at the firm's works at Peckham, was one of the most important inventions in connection with wireless telegraphy or telephony that the world had seen, and it ought to put to shame the Jeremiahs who seemed to take a pride in deprecating British inventiveness. It was a source of gratification to him to see present on that occasion Admiral Sir Henry Jackson, who was associated with Mr. Marconi in his early experiments. He was then a captain in the Navy, and it was primarily due to Sir Henry's enthusiasm that the Navy was predominant in the matter of wireless equipment at the outbreak of war. It was difficult to believe that wireless telegraphy was only invented in 1896, when Mr. Marconi, then a young man of twenty-two, visited England and took out the first wireless patent. Mr. Marconi's first experiments were carried out in conjunction with the Post Office engineering staff under the direction of Sir William Preece, who was then engineer-in-chief, and

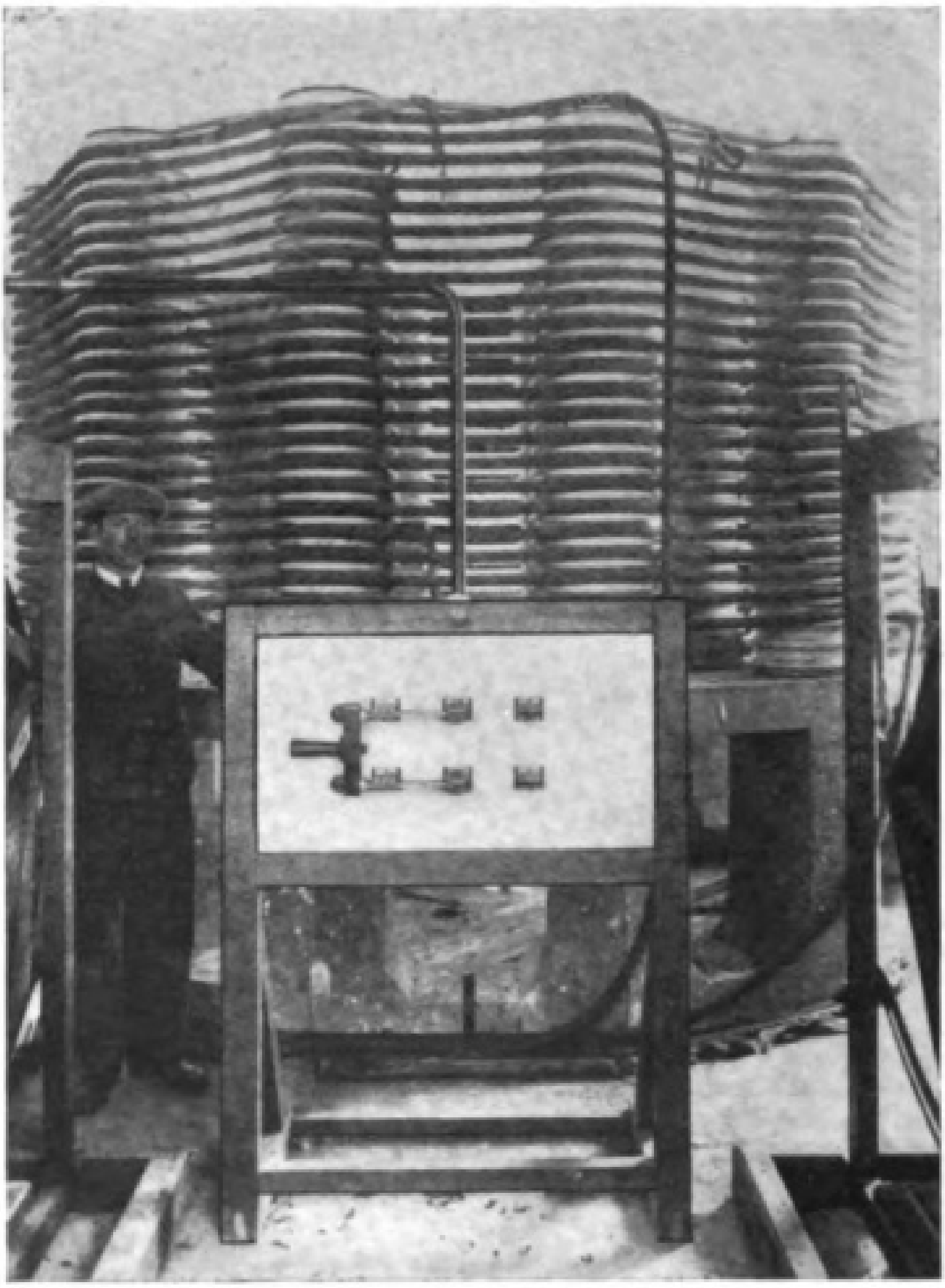


FIG. 22.—The Aerial Tuning Inductance.

Mr. Marconi has always frankly recognised the assistance he received from the department in those early days.

Having passed under review the various developments that had been made in the wireless service under the Post Office Department, Mr. Kellaway said that as regards wireless telephony the work was at present only in an experimental stage, but special attention was being paid to the development of this art, and especially to the efficient combination of wireless with wire telephony, so as to admit of speech between ordinary exchange subscribers, over the exchange and trunk lines, with ships at sea, with aircraft in flight, or with any overseas places with which wireless telephony may ultimately be possible. "I was present," he added, "at some of the Imperial Conferences, at which great interest was taken in wireless communication. It is a very fascinating prospect, and when our ambitions are realised we shall practically have destroyed space. If Mr. Hughes in Melbourne can take off his receiver and talk to Mr. Lloyd George in Downing Street, the amount of gratification it will give to those two statesmen is, I am sure, practically unlimited." (Laughter.) Leafield is the first station of the Imperial wireless chain, and is designed to communicate with the corresponding station at Abu Zabal, near Cairo. These two stations will form the first pair of a series of four stations. The third station will be in East Africa, and the fourth in South Africa. In accordance with the proposals of the Imperial Wireless Telegraphy Committee, which sat last year under the chairmanship of Sir Henry Norman, another pair of stations will be erected in England and Egypt, and these will be continued to India, Singapore, Australia, and Hong Kong. They are being planned by a commission of experts, consisting of Professor Eccles, Mr. L. B. Turner, of Cambridge, and Mr. E. H. Shaughnessy, of the Post Office, who is mainly responsible for the design of the present station.

"I am impressed with the fact that in many ways this is an historic occasion. This undertaking is going to do a great deal to bind closer together the various parts of the Empire and to break down barriers which distance and time would otherwise create. This is the first and to some extent a modest effort, but although modest it is going to justify the work the Post Office engineers have put into it." (Cheers.)

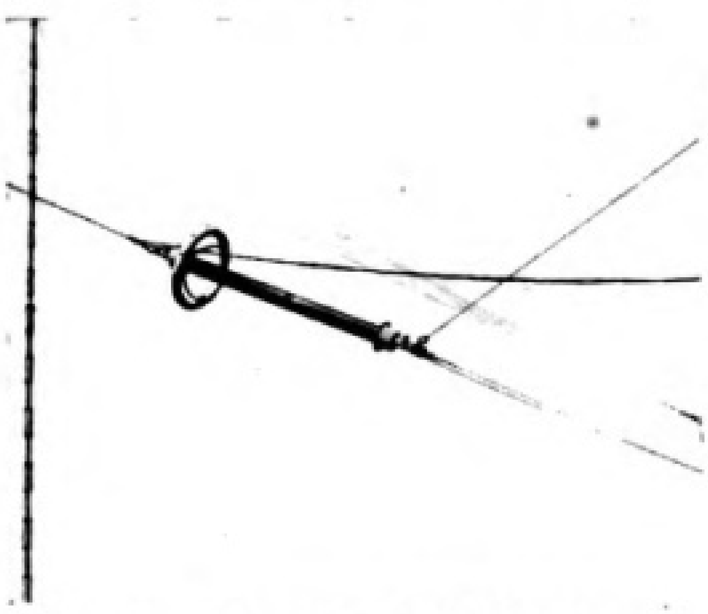


Fig. 23.—One of the Aerial Insulators.

Fig. 24.—Aerial Lead-in.

The corresponding station at Abu Zabal was being proceeded with rapidly, and it was expected to be ready in three months' time. That station and the Abu Zabal station would then carry on a service between England and Egypt, and the Abu Zabal station would also be used for communication with Mesopotamia, and perhaps for broadcasting news to India; it would also, pending the completion of the rest of the stations of the system, exchange traffic with the Eastern Telegraph Company's cables beyond Egypt. In view of the pressure on the cables between this country and Egypt, the service to be provided by this pair of stations could not but be useful from a commercial point of view. The rate by wireless between this country and Egypt would be 9*d*., as compared with the present charge of 1*s*., and there would be corresponding reductions for deferred and other telegrams, but, of course, the main importance of the stations would consist in their being the first links in the chain to South Africa. The Government had been criticised by persons who spoke with limited knowledge—that most dangerous equipment for controversy—for going on with a 2,000-mile link scheme instead of proceeding to set up stations of tremendously wider power. Those grandiose people always broke down immediately they came to questions of expense. In increasing power in wireless they increased the expense altogether out of proportion to the increase in power. Those people were not satisfied with a practical system which obtained the results that were desired. It seemed to him that three things were necessary in any system of communications—reliability was the first essential, the second was cheapness, and the third was speed. By adopting the system of links of 2,000 miles they hoped to provide the most reliable, the most economical, and taking the whole year through the speediest system. It was an achievement of which the British Post Office had a right to be proud. (Cheers.) **[4090]**

Optimum Wavelength and Atmospherics.*

By L. B. TURNER, M.A., M.I.E.E.

1. Symbols Employed.

λ = Wavelength, km.

n = Frequency, periods per sec.

$p = 2\pi n$.

x = Distance between transmitter and receiver, km.

h_s = Height of transmitting aerial, km.

I_s = Current in transmitting aerial (peak value), A.

F, H = Electric and magnetic field strengths, E-M. C.G.S. units.

ρ = Damping index $\frac{R}{2L}$ of receiving antenna, Ω/H.

δ = Decrement $\frac{R}{2nL}$ of receiving antenna.

$F_a . \epsilon^{-rt}$ = Electric field at receiver due to an atmospheric.

P = Power in receiving antenna derived from signal, W.

q = M. Abraham's " Störungsfreiheit " ratio

= (Energy from signal) $\div$ (energy from atmospheric).

f = " Immunity fraction "

$= \frac{q}{q_{max.}}$

c = Velocity of propagation = 3×10^{10} cm/sec.

Where a dashed symbol, *e.g.* q', is also used, it refers to aerial reception, the undashed symbol referring to loop reception.

2. Introductory.

Since Hertz first demonstrated the transference of power from one electrical circuit to another by radiation across the intervening medium, engineers, in applying the phenomenon to telegraphic purposes, have proceeded steadily from short to longer wavelengths. Hertz produced waves of some 2 metres; in Marconi's early experiments the wavelength was of the order of 20 metres, which had grown to some 200 metres when the first practically useful wireless telegraphy had been achieved; by the early days of transatlantic signalling the advance had been carried to 2,000 metres; and to-day the Croix d'Hins station is transmitting regularly at over 20,000 metres; from 1887 to 1921 an increase in wavelength of 10,000 times. Whereas Hertz's achievement was the production of electric waves of frequencies invisibly low, difficulties are

* Received June 30th, 1921.

experienced to-day because the frequencies employed tend to be—are—no longer even inaudibly high.

There are, of course, many factors which together control the choice of wavelength, and amongst them three have been very prominent in requiring increased length—(*a*) With rising antenna power, larger antennæ have been required to restrict corona loss; (*b*) more powerful high-frequency generators, particularly of the arc and alternator types, have necessitated lower frequencies of oscillation; and (*c*) the spatial attenuation of field intensity over the surface of the earth has called for greater wavelengths over greater ranges. It is the last consideration which has been generally associated with the term "optimum wavelength."

If the earth were flat and well conducting, and the atmosphere an unlimited perfect dielectric, the field at a distance x from a non-directive transmitting aerial would be

$$F = c\,.\,H = c\,.\,\frac{2\pi}{10^6}\,.\,h_s I_s\,.\,\frac{1}{\lambda x}\,. \qquad (1)$$

and as long as we could take $h_s I_s$ as sensibly independent of the choice of λ, the received intensity at any distance would increase indefinitely as the wavelength were reduced. Over earth's surface, however, the intensity is found to fall off more rapidly than this; and a truer formula is

$$F = c\,.\,H = c\,.\,\frac{2\pi}{10^6}\,.\,h_s I_s\,.\,\frac{1}{\lambda x}\,.\,\epsilon^{-\beta} \qquad (2)$$

where β is a function of λ and x.

With the same assumption that $h_s I_s$ is unaffected by choice of λ, there is now for each value of x a value λ_o of the wavelength which makes the field strength a maximum:

$$\lambda = \lambda_o, \text{ when } \frac{d}{d\lambda}\left[\frac{\epsilon^{-\beta}}{\lambda}\right] = 0 \qquad (3)$$

According to L. W. Austin's and other measurements

$$\beta = \frac{0{\cdot}0015x}{\lambda^{\frac{1}{2}}} \qquad (4)$$

which leads to the well known optimum wavelength formula

$$\lambda_o = 5{\cdot}6 \times 10^{-7}x^2 = (0{\cdot}00075x)^2 \qquad (5)$$

According to L. F. Fuller's suggestion, recently supported by G. Vallauri's measurements of Annapolis' signals at Leghorn,

$$\beta = \frac{0{\cdot}0045x}{\lambda^{1\cdot4}} \qquad (6)$$

which leads to the formula

$$\lambda_o = 0{\cdot}027x^{0\cdot71} = (0{\cdot}0063x)^{0\cdot71} \qquad (7)$$

These "optimum wavelengths" λ_o are calculated for four ranges in Table I.

It is generally taken that the choice of wavelength for any given service should be made in this way, subject, of course, to the wavelength so selected not proving impracticable from some other consideration such as those named at (*a*) and (*b*) above. Of the two attenuations mentioned, the Austin-Cohen factor is the more firmly established, at least for moderate wavelengths and ranges; for it has been widely checked as roughly true for normal daylight signalling with wavelengths up to 4 km and ranges up to 4,000 km. On this basis we should arrive, for example, at a wavelength of about 5½ km for a Clifden—Glace Bay Service. This is not very far from the wavelength actually used. Others of the transatlantic transmitters, *e.g.* Croix d'Hins and New Brunswick, employ much longer waves than the above calculations would indicate, and may serve to illustrate the operation of the other factors, such as the difficulty of working a very large arc or alternator except at very great wavelengths.

TABLE I.

Range x km	λ_0 k n	
	Austin	Fuller
3,000	5·1	8·0
4,000	9·1	9·9
5,000	14·1	11·7
10,000	56	19

The assumption,* explicit or implicit, that wavelength should be chosen to give maximum received field or antenna current can not, however, be accepted. The absolute strength of received field is nowadays of secondary importance, for amplifiers enable us to deal with almost any strength, however small. The problem of problems in wireless telegraphy to-day is not how to make the signal perceptible, but how to make the signal more perceptible than the atmospherics. It is the ratio (signal strength) ÷ (atmospherics strength) which is of primary importance.

Since the fields are not perceived directly, but by the currents they cause in the antenna, the relevant ratio is not that between field strengths of signal and atmospheric, but between signal and atmospheric effects within the receiving circuits. This ratio is, indeed, proportional to the field strength ratio; but it is also a function of wavelength and form of antenna—and, of course, of arrival forms of signal and atmospheric. The purpose of the present paper is to draw attention to the very important bearing of this conception on the determination of optimum wavelength. The calculations are based upon a recent theoretical investigation by M. Abraham † of the

* Examples of this assumption are found in Professor Howe's article "The Power required for Long-Distance Transmission," RADIO REVIEW, 2, pp. 598—608, September, 1920; and in the opening paragraph of Mr. C. F. Elwell's Introductory Notes to the Discussion on "Long-Distance Wireless Transmission" at the Institution of Electrical Engineers, May 25th, 1921. (See RADIO REVIEW, 2, p. 373, July, 1921, for abstract.)

† "Die Spule im Strahlungsfelde, verglichen mit der Antenne." (*Jahrbuch der drahtlosen Telegraphie*, 14, pp. 259—269, August, 1919—RADIO REVIEW Abstract No. 72, December, 1919.)

relative immunity from atmospheric disturbance in closed loop and open aerial forms of receiving antennæ. In the earlier part of the present paper both loops and aerials, and both Austin-Cohen and Fuller attenuations, are considered; and the bearing of wavelength upon speed of signalling is also touched upon. Subsequently the investigation is restricted to the open aerial and the Austin-Cohen attenuation.

3. Signal versus Atmospheric.

Abraham has calculated (*loc. cit.*) for a C.W. signal sustained during long time T the ratio—which he calls the "Störungsfreiheit," *i.e.* immunity from disturbance—

$$q = \frac{\text{energy from signal}}{\text{energy from an atmospheric}}$$

absorbed by loop and aerial forms of receiving antenna, on the following assumptions:—

Arrival form of field due to atmospheric is a suddenly rising aperiodic pulse $F_a\epsilon^{-rt}$;

Low antenna decrement, *i.e.* $\rho << p$;

Atmospheric damping is much greater than antenna damping, *i.e.* $r >> \rho$. These Störungsfreiheit ratios, for loop and aerial respectively, are:—

$$q = \left(\frac{F}{F_a}\right)^2 \cdot \frac{1}{2\rho} \cdot \frac{p^4(p^2 + r^2)}{r^4} \cdot T \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$q' = \left(\frac{F}{F_a}\right)^2 \cdot \frac{1}{2\rho'} \cdot \frac{p^2(p^2 + r^2)}{r^2} \cdot T \quad . \quad . \quad . \quad . \quad . \quad (8a)$$

The quality of the receiving antenna with respect to disturbance is thus a known function of ρ, p and r.

It is to be noted in passing that these expressions indicate that disturbance from atmospherics is indefinitely reduced in either form of antenna, and whatever the value of r, by reducing the decrement of the antenna or/and reducing the wavelength.

When, as Abraham considers is usually the case,*

$$r^2 << p^2$$

we have

$$q = \left(\frac{F}{F_a}\right)^2 \cdot \frac{1}{2\rho} \cdot \frac{p^6}{r^4} \cdot T \quad \propto \frac{F^2}{\delta} \cdot \frac{1}{\lambda^5} \quad . \quad . \quad . \quad . \quad (9)$$

$$q' = \left(\frac{F}{F_a}\right)^2 \cdot \frac{1}{2\rho'} \cdot \frac{p^4}{r^2} \cdot T \quad \propto \frac{F^2}{\delta'} \cdot \frac{1}{\lambda^3} \quad . \quad . \quad . \quad . \quad (9a)$$

4. Optimum Condition.

Provided that the signal power received does not turn out to be too extremely small to be conveniently dealt with by modern amplifiers, the best wavelength is that which makes the "Störungsfreiheit" ratio q a maximum. We will investigate this condition for the above form of atmospheric, viz.

* Lightning fields are known to die away in $\frac{1}{1000}$ to $\frac{1}{10000}$ sec, corresponding to (say) $r = 5{,}000$ to $50{,}000$, and are almost certainly non-oscillatory.

$r^2 << p^2$, on the assumption that δ does not depend on λ. (Actually δ is completely under control by retroactive triode devices.) Putting for F the function of λ and x of equation (2), the above expressions (9) and (9a) become

$$\begin{cases} q \propto \frac{1}{\delta} \cdot \frac{\epsilon^{-2\beta}}{\lambda^7 x^2} & \qquad (10) \\ q' \propto \frac{1}{\delta'} \cdot \frac{\epsilon^{-2\beta}}{\lambda^5 x^2} & \qquad (10a) \end{cases}$$

We have to find the values of λ which make these expressions a maximum.

Whether for β we take expression (4) or (6), both of the expressions (10) and (10a) are of the form—

$$q \text{ or } q' \propto \frac{\epsilon^{-2ux\lambda^{-v}}}{\lambda^w x^2} \qquad (11)$$

where u, v are numbers depending on whether the Austin-Cohen (4) or Fuller (6) attenuation is taken, and w is a number depending on whether the antenna is a loop or aerial ((10) or (10a)). Differentiating (11) with respect to λ, and equating to zero, we find that the maximum occurs when

$$\lambda = \left(\frac{w}{2uvx}\right)^{-\frac{1}{v}} \qquad (12)$$

This is the optimum wavelength we seek.

Putting in the appropriate values of u, v and w we find from (12)

$$\text{Austin-Cohen} \begin{cases} \lambda_{\text{opt.}} = (0{\cdot}00021x)^2 & \qquad (13) \\ \lambda'_{\text{opt.}} = (0{\cdot}00030x)^2 & \qquad (13a) \end{cases}$$

$$\text{Fuller} \begin{cases} \lambda_{\text{opt.}} = (0{\cdot}0018x)^{0{\cdot}71} & \qquad (14) \\ \lambda'_{\text{opt.}} = (0{\cdot}0025x)^{0{\cdot}71} & \qquad (14a) \end{cases}$$

These optimum wavelengths are calculated in Table II. for the four ranges 3,000, 4,000, 5,000 and 10,000 km.

TABLE II.

$r^2 << p^2$.

Range x in km	Optimum wavelength in km			
	Austin-Cohen		Fuller	
	Loop	Aerial	Loop	Aerial
3,000	0·40	0·81	3·3	4·2
4,000	0·71	1·44	4·05	5·1
5,000	1·10	2·25	4·8	6·0
10,000	4·4	9·0	7·8	9·8

As the form of the atmospheric field is a matter of some uncertainty, in Table III. the optimum wavelengths are recalculated for the (less probable) case of very rapidly damped atmospheric, viz. for $r^2 >> p^2$.

Table III.

$r^2 >> p^2$.

Range x in km	Optimum wavelength in km			
	Austin-Cohen		Fuller	
	Loop	Aerial	Loop	Aerial
3,000	0·81	2·25	4·2	6·0
4,000	1·44	4·0	5·1	7·4
5,000	2·25	6·25	6·0	8·7
10,000	9·0	25	9·8	14·1

5. High-Speed Signalling.

In the foregoing sections it has been assumed that the transient epoch, during which the current amplitude in the receiving antenna gradually grows under the action of the E.M.F. impressed by the signal, is so short as to be a negligible portion of the whole signal epoch, the Morse dot. In high-speed, long-wave telegraphy this assumption may not be permissible. The true

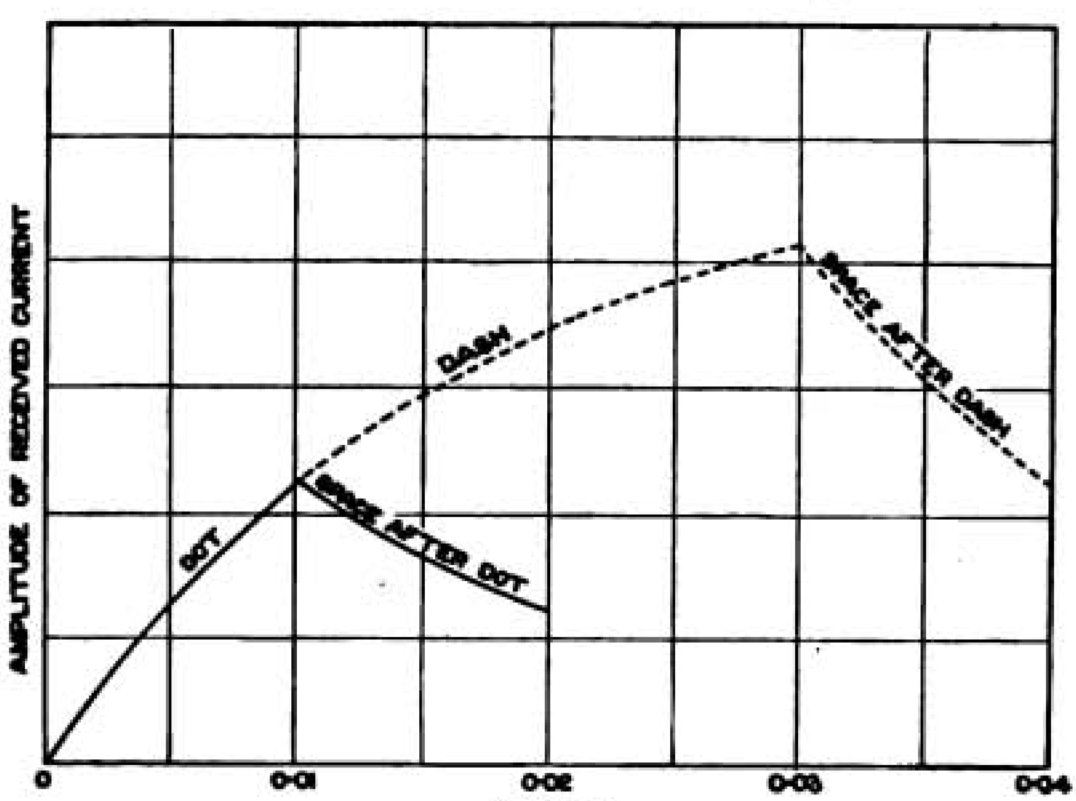


Fig. 1.—Signalling at 125 words per minute.
$\lambda = 10{,}000$ m. $\delta = 0\ 002$

expression for the current amplitude at any time t after the beginning of the signal is

$$I\,(1 - \epsilon^{-n\delta t}).$$

We have hitherto taken $(1 - \epsilon^{-n\delta t})$ as sensibly unity throughout the Morse dot.

Writing θ for the duration of the dot, it is clear that this approximation is not permissible unless $n.\delta.\theta$ is sufficiently large—say over 3 or 4. This is illustrated in Fig. 1 for the numerical case:

$$n = 30{,}000\ p.p.s. \qquad i.e.,\ \lambda = 10\ \text{km}.$$
$$\theta = 0{\cdot}01\ \text{sec}. \qquad i.e.,\ 125\ \text{words/min}.$$
$$\delta = 0{\cdot}002. \qquad n\delta\theta = 0{\cdot}6.$$

It is manifest that ordinary methods of Morse signalling would be impossible here.

A rather elaborate examination of various numerical cases has shown that for "well-shaped" Morse signals to be given by the indicator actuated by the received antenna current, $n\delta\theta$ must not be allowed to fall below about 1·8. This limits us, in reducing δ for purposes of gaining sensitivity and freedom from atmospheric disturbance, to the value giving

$$\rho = n\delta = \frac{1{\cdot}8}{\theta}$$

In cases (high speed, long wave, low decrement) where $n\delta\theta$ would, if not prevented on this account, approach such low values as 2 and less, this has the effect of lowering somewhat further the optimum wavelength. The high-speed consideration in its bearing on optimum wavelength is not further analysed here; but it should be borne in mind that its effect, however large or small, is necessarily towards the choice of waves still shorter than the low-speed optima of Tables II. or III.

6. Limitation of the Investigation.

Henceforth in these notes the investigation is narrowed to ranges not exceeding 5,000 km, and to the Austin-Cohen attenuation factor. Whether or not the latter is generally applicable, it is known to be a fair approximation to the observed average daylight attenuations for such ranges and wavelengths as are hereafter contemplated. Further, we adhere—with ever

TABLE IV.

Range	Best wavelength	
	Loop	Aerial
3,000 km	0·40 km	0·8 km
4,000 km	0·71 km	1·4 km
5,000 km	1·10 km	2·2 km

greater confidence as the wavelength is diminished—to our assumption that $r^2 << p^2$.

For slow speed and with Austin-Cohen attenuation, then, we extract from Table II. the values set out in Table IV. The issue is hereafter further confined to *aerial* reception. We proceed to compare conditions at the receiver when the wavelength is increased from the optimum values above calculated.

7. Received Power, and Immunity Fraction.

The maximum power receivable from the field F at wavelength λ—viz. when total antenna resistance equals twice the radiation resistance—is *

$$P'_{\text{max.}} = \frac{2{\cdot}37 \times 10^7}{c} E^2\lambda^2 \quad \text{E-m units}$$

$$= 2{\cdot}80 h_s{}^2 I_s{}^2 \frac{\epsilon^{-0{\cdot}0030x/\sqrt{\lambda}}}{x^2} \text{ watt} \quad . \quad . \quad . \quad . \quad . \quad (15)$$

From (10a) and (4), $q' = k\dfrac{\epsilon^{-0{\cdot}0030x/\sqrt{\lambda}}}{\lambda^5 x^2}$ where k is not a function of λ or x.

Further, we have found (13a) that $q' = \text{max.}$ when $\lambda = (0{\cdot}0030x)^2$.

Hence

$$f = \frac{q'}{q'_{\text{max.}}} = 1{\cdot}1\left(\frac{0{\cdot}3x}{1{,}000}\right)^{10}\frac{\epsilon^{-0{\cdot}0030x/\sqrt{\lambda}}}{\lambda^5}$$

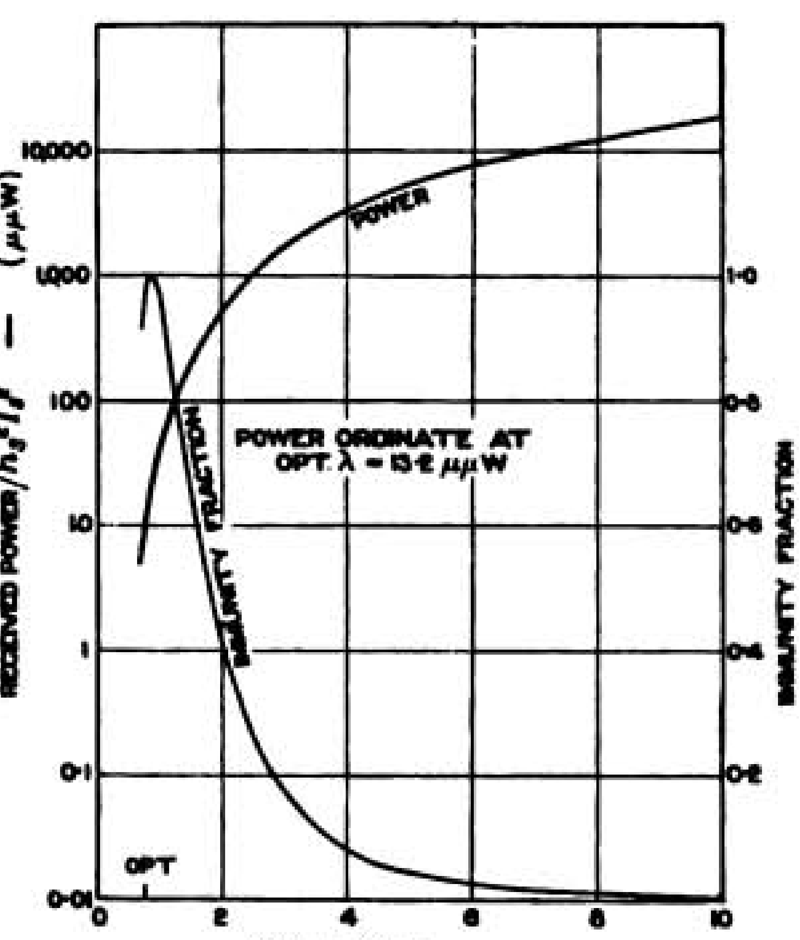


FIG. 2.—Received Power and Immunity Fraction as functions of wavelength for range 3,000 km.

The ratio f may be termed the "immunity fraction"; it measures the immunity from disturbance experienced at wavelength λ as a fraction of the immunity which would be experienced at the optimum wavelength.

The power $P'_{\text{max.}}$ and the immunity fraction $f = \dfrac{q'}{q'_{\text{max.}}}$ are plotted as functions of λ for the three ranges in the graphs, Figs. 2, 3, 4.

8. Meaning of the Graphs.

In examining the graphs the following points should be noticed :—

(*a*) The peak of the immunity fraction curve gives the optimum wavelength for

* Abraham, *loc. cit.*, p. 265.

the range, in the sense that at that wavelength atmospheric disturbance is a minimum.

(*b*) The ordinate of the power curve is the received power in micromicrowatts for 1 square kilometre-ampere in the sending aerial. The power does not reach a maximum as wavelength is increased, because we have not chosen a fixed antenna resistance independent of the wavelength as is often done (*e.g.* Austin's 25 ohms). Our assumption of optimum antenna resistance (viz. twice the radiation resistance) seems a more practical basis when dealing with open aerials and short waves; for then, if we are concerned to increase the received power, it is feasible to obtain high radiation resistance.

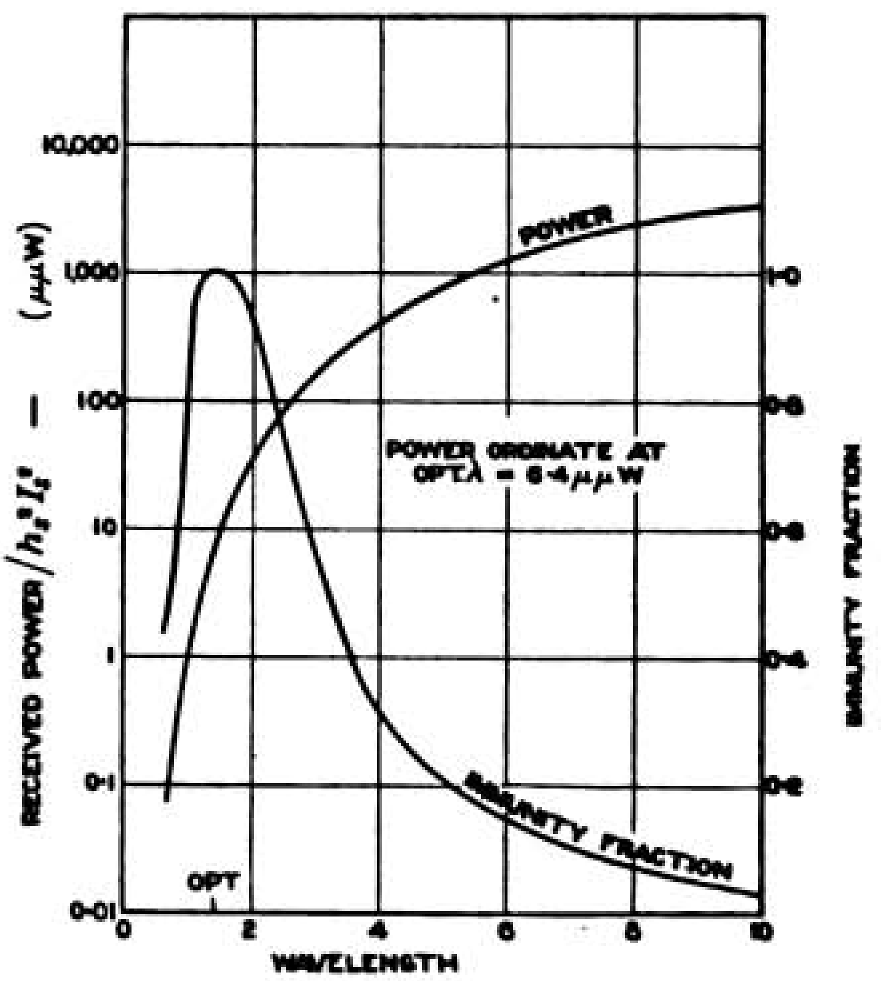


FIG. 3.—Received Power and Immunity Fraction as function of wavelength for range 4,000 km.

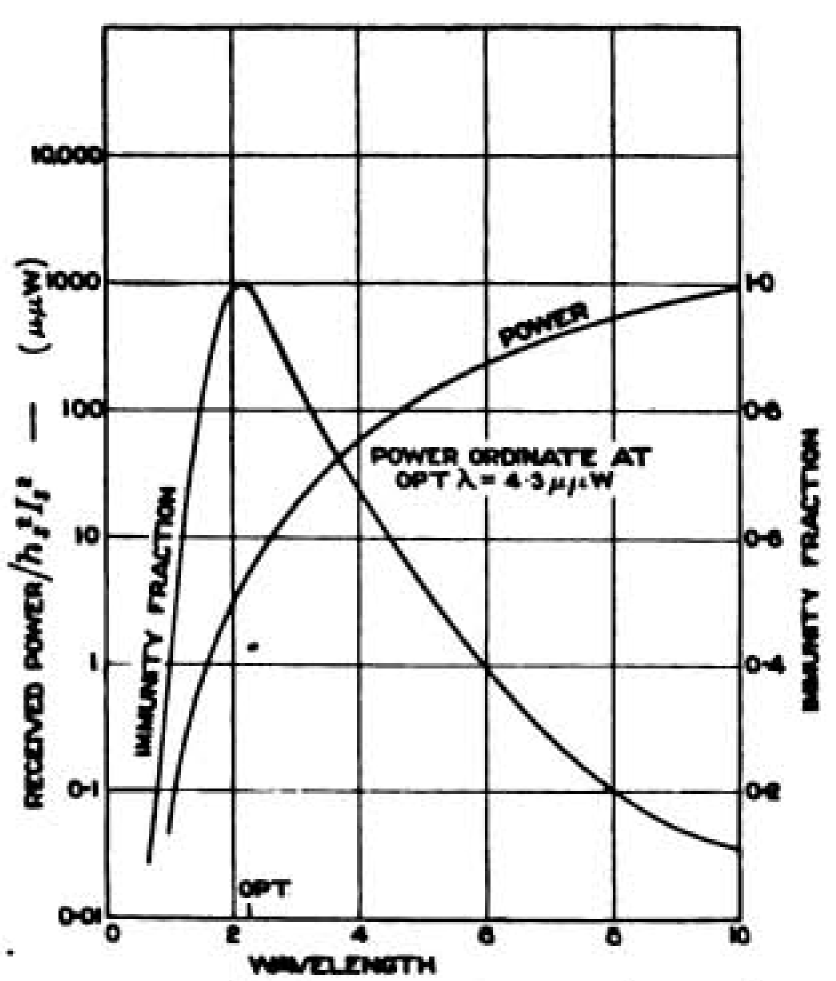


FIG. 4.—Received Power and Immunity Fraction as function of wavelength for range 5,000 km.

(*c*) In each of the three ranges, doubling the wavelength from the optimum value nearly doubles the atmospheric interference. The power received from the signal is increased about 20 times, but the power from atmospherics is increased nearly 40 times.

(*d*) The graphs do not show how the value of the "Störungsfreiheit" ratio q' decreases as range is increased. This is given, however, for assumed constant decrement, by the formula (10a).

$$q' \propto \frac{\epsilon^{-2\beta}}{\lambda^5 x^2}$$

With the Austin-Cohen attenuation and the optimum wavelength, this becomes

$$q'_{\text{max.}} \propto \frac{1}{x^{12}}.$$

Hence if minimum disturbance is taken as unity at 3,000 km

at 4,000 km it is 31,

at 5,000 km it is 460.

It is to be remembered that throughout we are comparing powers, not currents or E.M.F's.

9. Numerical Case.

As a numerical example of choice of wavelength, let us consider a 4,000 km range, with sending aerial 0·08 km high, 141 amps (R.M.S.) in the aerial, and alternative wavelengths of 8·2 km and the optimum, 1·4 km, shown in Fig. 3. Here $h_s I_s = 16$ km-A.

From (2) and (4) the received fields are:

$$\text{at } \lambda = 8{\cdot}2. \qquad H = 3{\cdot}7 \times 10^{10}$$

$$\text{at } \lambda = 1{\cdot}4. \qquad H = 1{\cdot}1 \times 10^{10}.$$

From graphs in Fig. 3,

$$\text{at } \lambda = 8{\cdot}2 \begin{cases} \text{Power} = 2{,}600 \times 256\ \mu\mu\text{W} = 0{\cdot}67\ \mu\text{W}. \\ \text{Immunity fraction} = 0{\cdot}07. \end{cases}$$

$$\text{at } \lambda = 1{\cdot}4 \begin{cases} \text{Power} = 6{\cdot}4 \times 256\ \mu\mu\text{W} = 0{\cdot}016\ \mu\text{W}. \\ \text{Immunity fraction} = 1. \end{cases}$$

Without retroactive triode devices, the received power of 0·67 μW at $\lambda = 8{\cdot}2$ km could not in practice be obtained; for masts of colossal height would be necessary to give a radiation resistance approaching half the total resistance. Taking the height of receiving aerial as 0·08 km, its radiation resistance would be 0·15 ohm. If it were impossible to reduce the total resistance below (say) 1·3 ohms, the received power would be $0{\cdot}67 \times \frac{0{\cdot}30}{1{\cdot}3} = 0{\cdot}16\,\mu$W (and most of this would not reach the detector). On the short wave, however, the radiation resistance would be 5 ohms, and the calculated power could be easily obtained (and most of it be delivered to the detector).

Thus the reduction of wavelength from 8·2 to 1·4 km may be taken as dividing the received power by (say) about 10, while reducing atmospheric interference some $\frac{1}{0{\cdot}07} = 14$ times.

It appears, therefore, that the shorter wavelength would give much better service, as far as atmospheric troubles are concerned. Before such a wavelength could be adopted, it would be necessary to consider the other factors referred to in section **2**. Continuing with our numerical example, assuming that we have a triode or other oscillator competent to produce the assumed antenna current of 141 amperes at the frequency corresponding with 1·4 km wavelength, would the received power be not impracticably small ? and could the antenna voltage at the transmitter be kept sufficiently low ?

It is not easy to quote a figure for the smallest practicable received power. G. W. O. Howe,* for the purpose of his transmission calculations, takes $H = 1{\cdot}7 \times 10^{-9}$ as adequate for good signals, apparently without regard to wavelength. It is doubtful whether the disregard of wavelength is justifiable ; and in any case this figure is apparently based on Austin's experiments in 1910 using a crystal detector. G. Vallauri † found $H = 2{\cdot}6 \times 10^{-9}$ adequate even when receiving a wave of 17,300 m on a loop (without retroactive reduction of its resistance) of area only about $(0{\cdot}037 \text{ km})^2$. J. H. Dellinger ‡ reports cases of loud signals, without heterodyne, with received antenna powers down to 25 $\mu\mu$W. With heterodyne it would doubtless be feasible to work with much less than 1 $\mu\mu$W. Hence it appears that in our numerical example, the received power is quite adequate, and need not impose restriction on choice of wavelength.

We may then consider corona loss at the transmitter. To limit aerial potential to (say) 50 kV, the capacity must be not less than 0·0031 μF. This capacity (roughly) would be given by a cage aerial 200 m long and 6 m in diam.—a not unpractical form of aerial. The aerial would radiate 100 kW.

10. Conclusion.

Theoretical considerations, based on such experimental facts as are available, indicate that for ranges such as 4,000 km much shorter waves should be adopted than are usually contemplated, provided the requisite power can be developed at such wavelengths. The calculations are based on assumptions as to the arrival form of the more troublesome atmospherics and as to the relation between attenuation and wavelength, which assumptions are open to a good deal of doubt. The theoretical conclusions arrived at are therefore much in need of direct experimental support. As far as they go, the recently published § German experiences at Togoland just before and after the outbreak of war are an interesting confirmation of the general contention that relative freedom from atmospherics, and not strength of desired signals, must be the criterion in choosing wavelengths. The distance between Nauen and Togo is over 5,000 km, so that according to Table I. the wavelength for strongest signals would be over 12 or 14 km. Many trials with different wavelengths were made, and led to the selection of 4·5 km, on which wave considerable traffic was carried out. " No text could be received with the wavelength of 9,400 m, although the sound intensities were good, because the disturbances were far greater than with smaller wavelengths." **[3593]**

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* RADIO REVIEW, 1, p. 599, September, 1920.

† *Proceedings of the Institute of Radio Engineers*, 8, p. 294, August, 1920.

‡ *Scientific Papers of the Bureau of Standards*, No. 354, p. 479, 1919.

§ See R. Roscher. " Nauen and Togoland : A Tragedy of Radio-Telegraphic Development." RADIO REVIEW, 2, pp. 68—75, February, and pp. 250—261, May, 1921. (Abstracted from *Archiv für Post und Telegraphie*.)

The Wireless Service for Press Messages from Geneva.

In order to facilitate the transmission of press despatches from Geneva during the second assembly of the League of Nations a special wireless service has been installed by Marconi's Wireless Telegraph Co., Ltd., to give direct communication from Geneva to London and to Denmark, Norway, Sweden and Spain. A standard 6 kW Marconi valve transmitter has been installed at Berne (Mönchenbuchsee) and is controlled and automatically operated at high speed from Geneva. The controls and transmitting key are fitted in a room at the Hotel Victoria adjoining the Reformation Hall, in which the meetings of the League are held. The equipment is of a somewhat temporary nature and use has been made of the two steel lattice towers in course of erection by the Marconi Company for the Swiss Government.

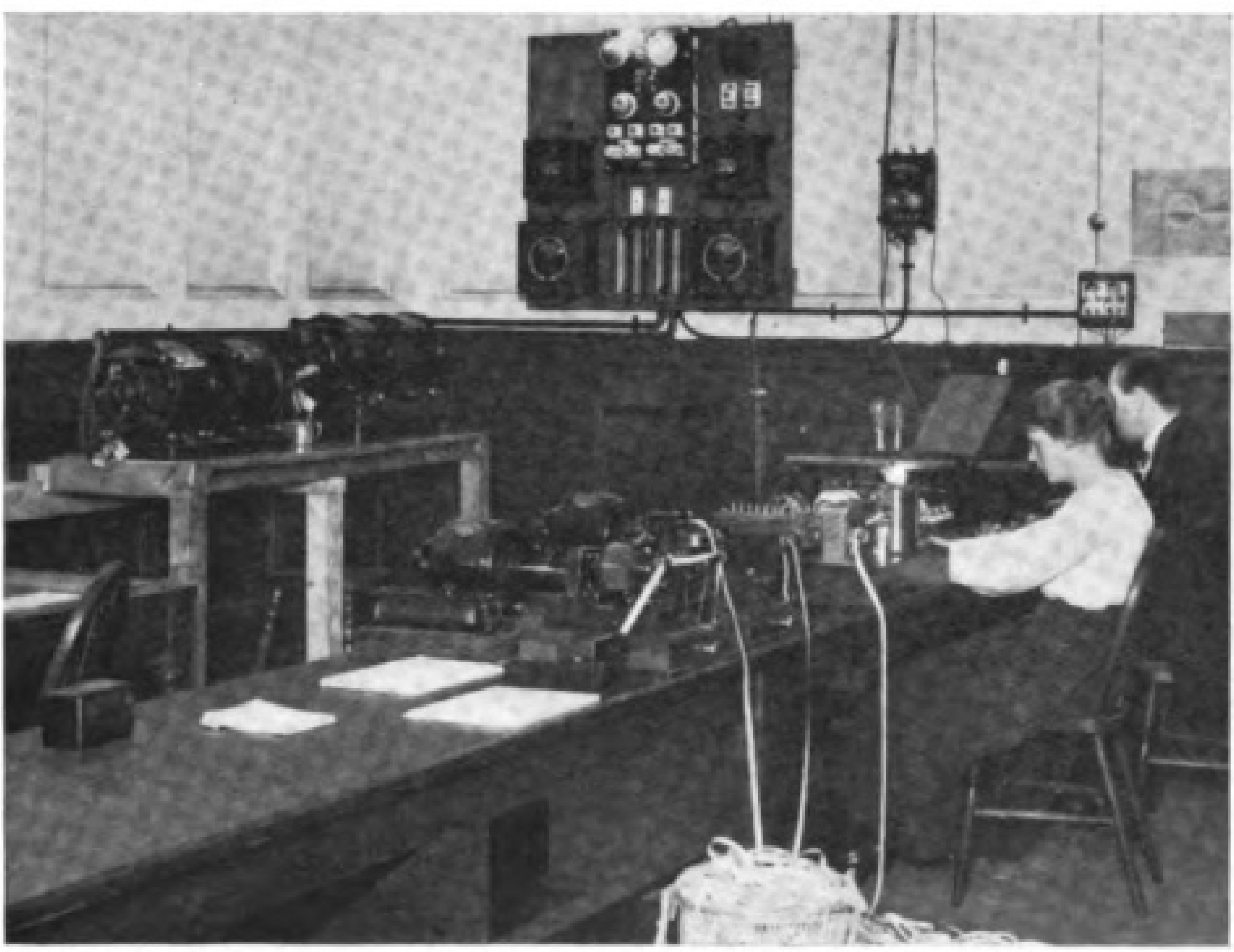

FIG. 1.—The Creed Printing and Recording Apparatus.

These towers when completed will be 300 feet high but at the present time only 200 feet is being used for supporting the transmitting aerial. Power is obtained from a 13 kW Austin petrol-driven generating set. The transmitting wavelength is 3,400 metres.

Since the bulk of the traffic is outgoing from Geneva high speed transmitting equipment has been installed but only an ordinary pattern of receiving apparatus. The receiver, using a D.F. aerial, has been set up at Arare about five miles outside Geneva. This receiving station is in telephonic communication with Geneva.

FIG. 2.—Another view of the Recording Apparatus.

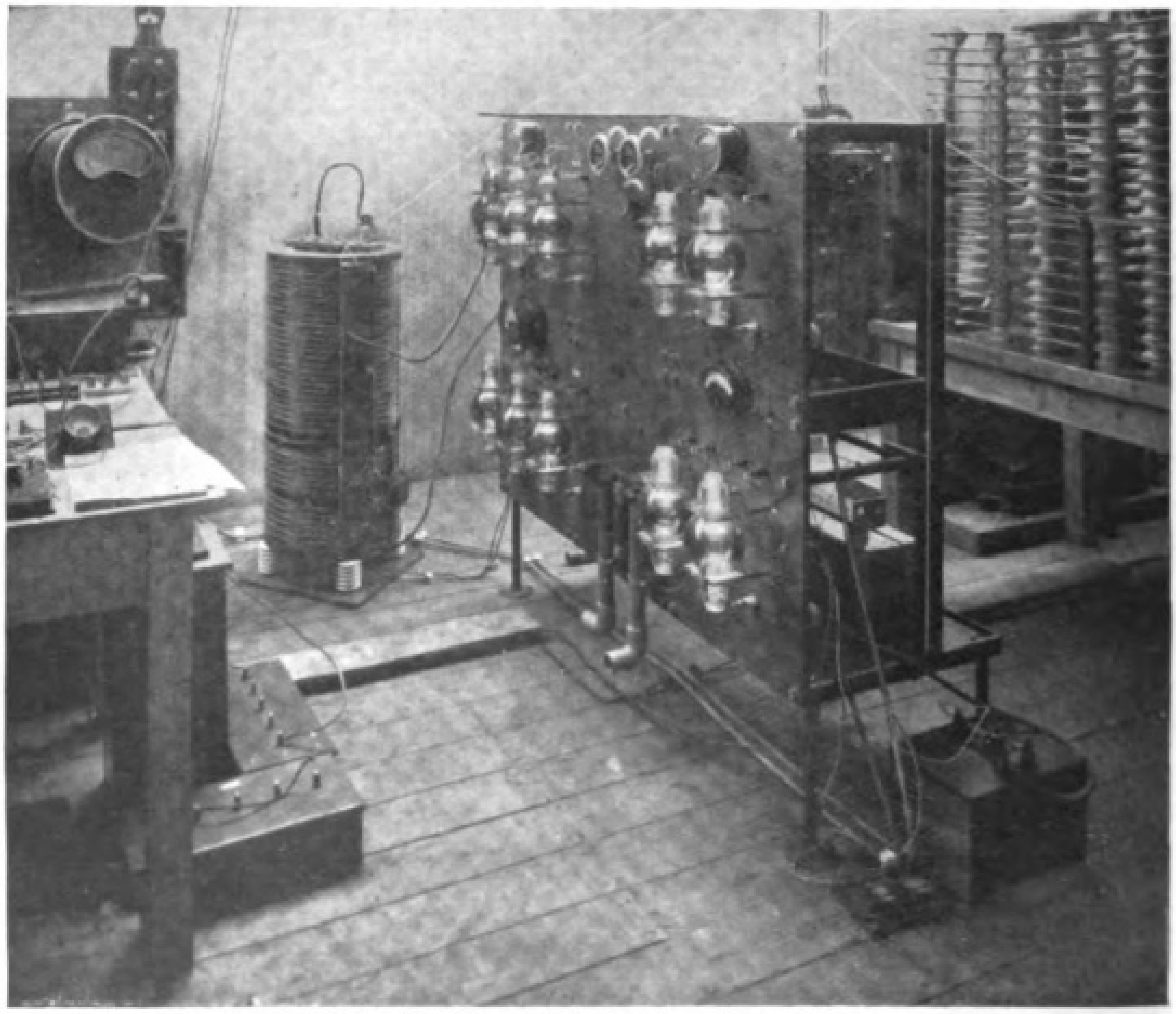

FIG. 3.—The 6 kW Transmitter at Chelmsford

The reception of the signals in England takes place at Witham in Essex, the receiving station normally employed for the wireless service to Paris being utilised. A D.F. aerial 100 feet high with a span of 200 feet is employed for reception. A 7-valve amplifying receiver is employed in conjunction with note magnifying valves and special circuits for relaying the incoming signals on to the landlines whence they are relayed directly through to Marconi House, London. The latter place is thus in direct communication with Geneva. The final reception of the messages takes place on an "undulator" and a Creed receiver and printer. Two views of the receiving and printing apparatus as installed in Marconi House are given in Figs. 1 and 2. A key has also been installed in Marconi House which operates, *via* the landlines, a 6 kW valve transmitter at Chelmsford (Fig. 3). This is used for sending acknowledgments and service instructions back to the Geneva receiving station. The aerial at Chelmsford consists of two wires 500 feet in length suspended from a 210 feet tubular steel mast of the "Gray" type. These wires are carried out to two 50-foot poles and thence back to the transmitting house. A wavelength of 3,000 metres is employed for this purpose. **[4026]**

Modern Methods of Valve Manufacture.

The needs of the Services during the war have led not only to important developments in the design of thermionic valves, but to equally important improvements in the methods used for their manufacture and testing. The manufacture of valves in large quantities, on a "mass production" basis, necessitates the use of different methods than are required for the construction of small quantities of experimental tubes. The most important requirement necessarily is standardisation of all the component parts so that the finished products will be interchangeable both electrically and mechanically and will conform to a given specification.

An inspection of the works of the Mullard Radio Valve Co., Ltd., at Hammersmith reveals some of the methods that may be employed in the manufacture of valves for modern requirements. Each valve passes through a series of separate processes, the operatives at each stage performing in the main one operation only. The various separate parts of the valve are thus built up from the raw materials, and finally assembled to make the finished product.

Following the manufacture of a small valve right through the works we may note the following details:

Firstly, the preparation of the leading-in wires.

Pieces of copper and nickel wire are cut off to the correct length using a suitable gauge, and are then welded to a platinum connecting wire in a small blowpipe flame, so that the nickel wire serves for supporting the electrodes inside the glass stem, while the copper is used for the external connections to the valve cap.

The valve electrodes are prepared from sheet nickel and nickel wire respectively, the former being stamped out to the correct size and welded to one of the above-mentioned nickel supporting wires by means of a small electric welder. It is then shaped round an appropriate gauge to give it the desired cylindrical shape. The latter, the grid, is built up of molybdenum wire coiled up into a spiral and similarly attached to its supporting wires.

A special machine is employed for cutting off uniform lengths of glass tubing to form sealing stems for the valves. These lengths of glass are then fed by hand into a flanging machine consisting of two chucks driven round by an electric motor and provided with a foot pedal release so that a piece of glass tube can be gripped in one of the chucks without stopping its rotation. Meanwhile the second or upper chuck is rotating another piece of tubing in the blowpipe flame, so that by the time a finished flanged tube has been ejected from the lower chuck and a new piece of tubing inserted in its place, the tubing in the upper chuck is hot enough for flanging. The four supporting wires for the electrodes are sealed into one end of this flanged tube so as to form the stem of the valve.

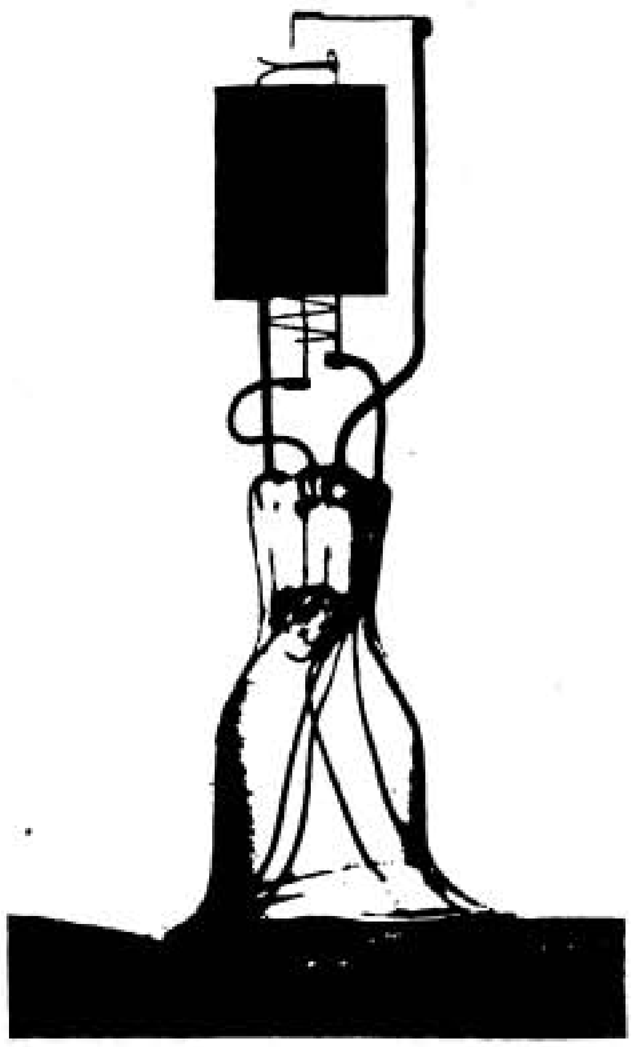

FIG. 1.—Electrodes mounted on Stem.

After the mounting of the grid and anode of the valve on to their supporting wires the filament is threaded down the centre of the grid and secured to the terminal wires by pinching. The finished glass stem with the electrodes and filament mounted in place is shown in Fig. 1. Tension on the filament is maintained by means of a small flat spring to which its

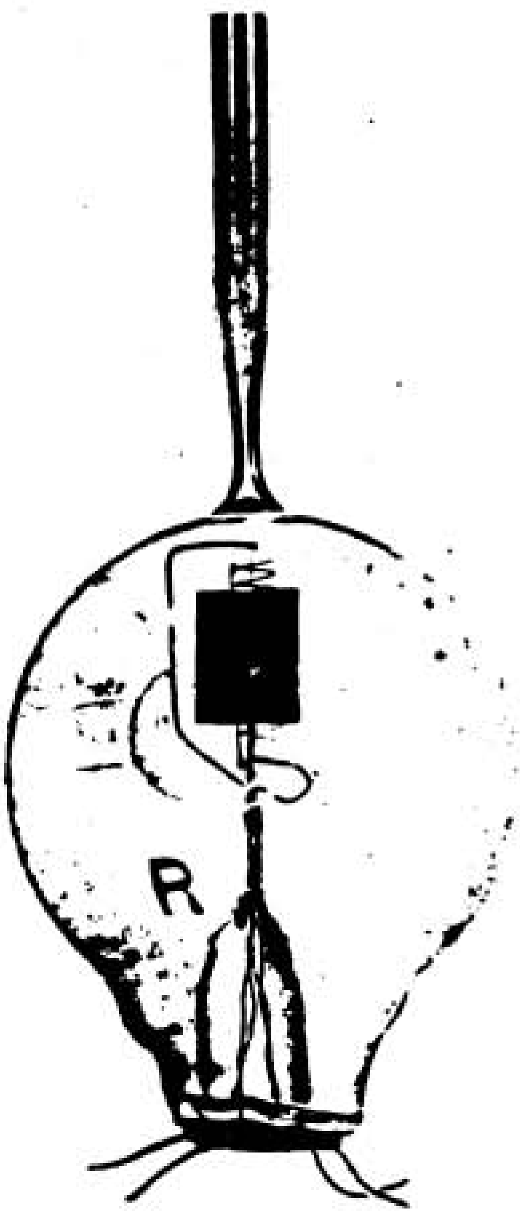

FIG. 2.—Electrodes mounted in Bulb before Exhaustion and Finishing.

upper end is attached as may be seen in the illustration. The next process consists in the preparation of the bulb in which the component parts of the valve are to be inserted. In valves of the R type this is usually nearly spherical in shape but for the K and D type valves a more elongated cylindrical bulb is used. A spherical type of bulb with stem and electrodes sealed into place is shown in Fig. 2 and the completed bulb after sealing off but before capping, in Fig. 3. During the exhaustion of the valve and before its sealing off it is subjected to electrical tests both to drive out occluded gases from the metal electrodes and to indicate the state of the vacuum. For this purpose high voltages are applied to the valves so as to heat up the electrodes by electronic bombardment and thus to drive out the gases. When the blue glow has disappeared a satisfactory state of vacuum is indicated and the valve may be sealed off from the pumps.

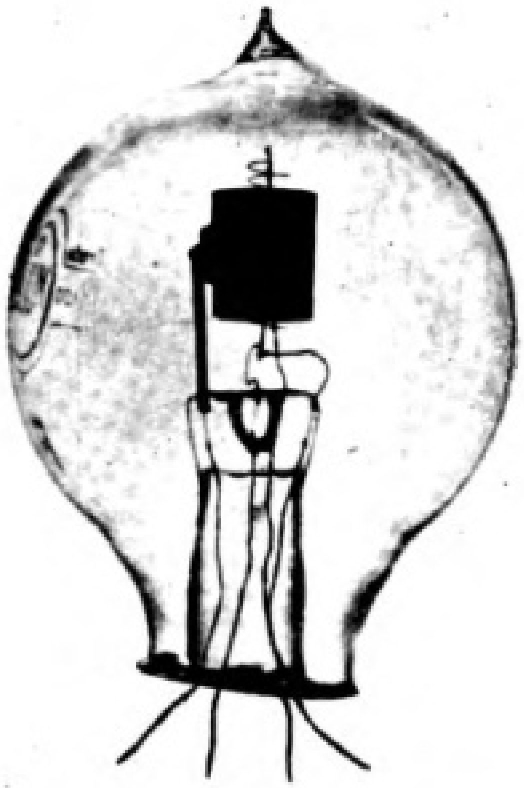

FIG. 3.—The Bulb Sealed Off.

After sealing off a terminal cap is attached to the valve with cement. This cap is usually of one or other of two patterns—the four-pin type cap, originally standardised on the "French" valves—or the spring contact type of cap which originated in the Naval and Air Force laboratories. These two types of cap are shown in Figs. 4 and 5 respectively which illustrate the KA and KB valves. The special type of cap shown on the KB type valve is particularly suited for short wave work as the complete valve and holder of this type gives a smaller effective valve capacity. Apart from this difference in mechanical construction the KA and KB types of valve are practically identical and are designed particularly for amplification, being especially suitable for use with high frequency amplifiers. They require about $3\frac{1}{2}$ volts on the filament and

FIG. 4.
The KA Valve.

FIG. 5.
The KB Valve.

only 20–30 volts between the anode and filament for normal working. Characteristic curves taken on a valve of this type are shown in Fig. 6.

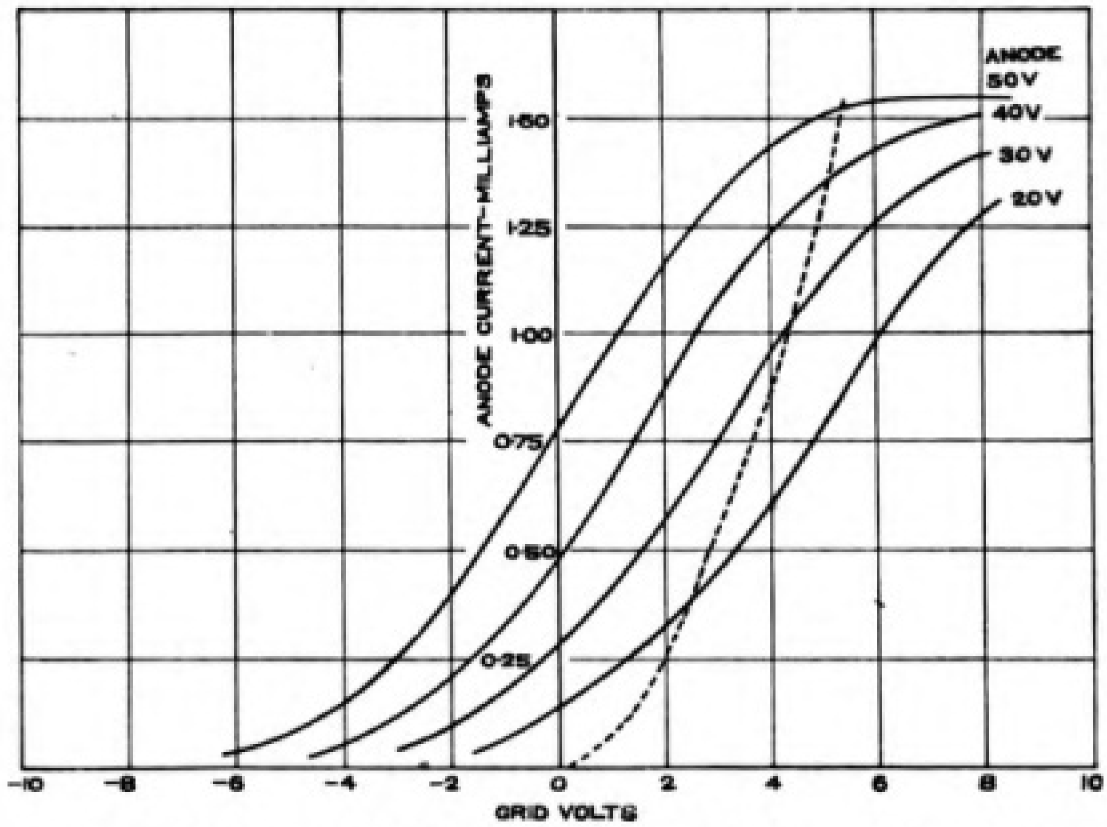

FIG. 6.—Characteristic Curves of the K Type Valve, with filament current = 0·6 A, and filament voltage = 3·3 V. The broken line = grid current × 100.

Before the caps are mounted the valves are subjected to a short "ageing" run, and afterwards to a careful testing process. In carrying out these tests the filament current is adjusted until an electronic emission of 2 milliamps, as indicated by the milliammeter in the plate circuit, is obtained using a given anode voltage. The filament voltage and current are then read off on appropriate instruments, and these must fall within certain predetermined limits or the valve is rejected. The high tension voltage applied to the anode is then reversed and a "backlash" test is made by observing the current flowing through the valve on a sensitive microammeter. This backlash current must not exceed 0·3 microampere. These tests are also repeated with various high tension voltages applied to the anode so as to obtain some indication of the slope of the anode-voltage anode-current curve.

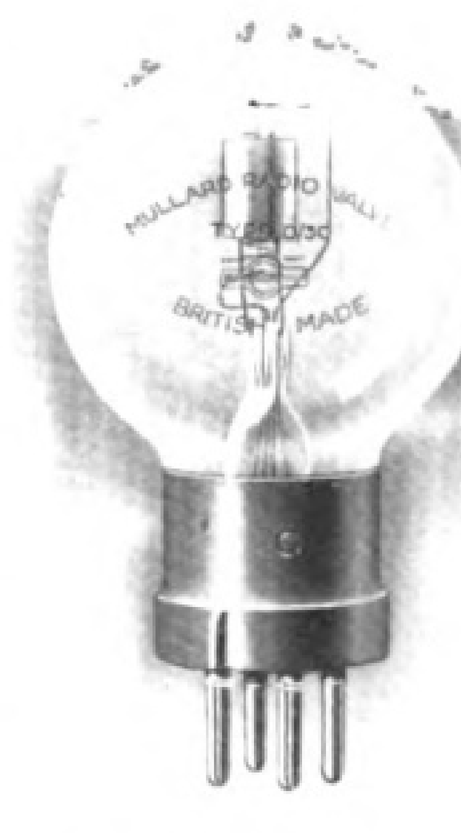

FIG. 7.—The O/30 Transmitting Valve.

In the construction of larger valves for transmission purposes slight modifications are introduced into the above scheme, except in the case of the smallest transmitting valves made by this firm, viz., the O/20 and O/30

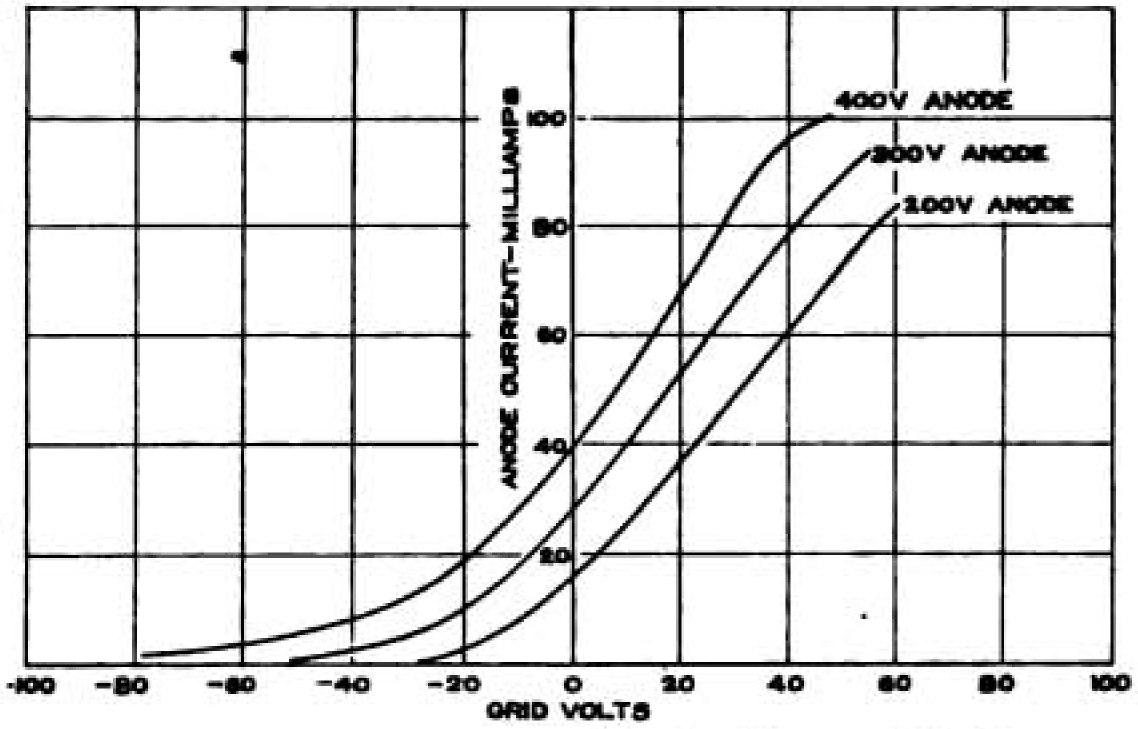

FIG. 8.—Characteristic Curves of O/20 valve, with filament current = 1·7 A, and filament voltage = 6·0 V.

types. These are of similar design to the R and K types of receiving valves with the exception of a slightly more robust design. A valve of the O/30 type is illustrated in Fig. 7. This valve is designed to operate on an anode voltage of between 600 and 1,200 volts with a filament current of 1·2 amperes at 6 volts. The anode of this valve will safely dissipate 30 watts under these conditions which means that an output of high frequency energy of at least this amount is obtainable in the circuit connected to the valve. Particular mention may also be made of the O/20 type of valve which is of similar design but will operate satisfactorily on an anode voltage of between 200 and 400 volts, the safe anode dissipation

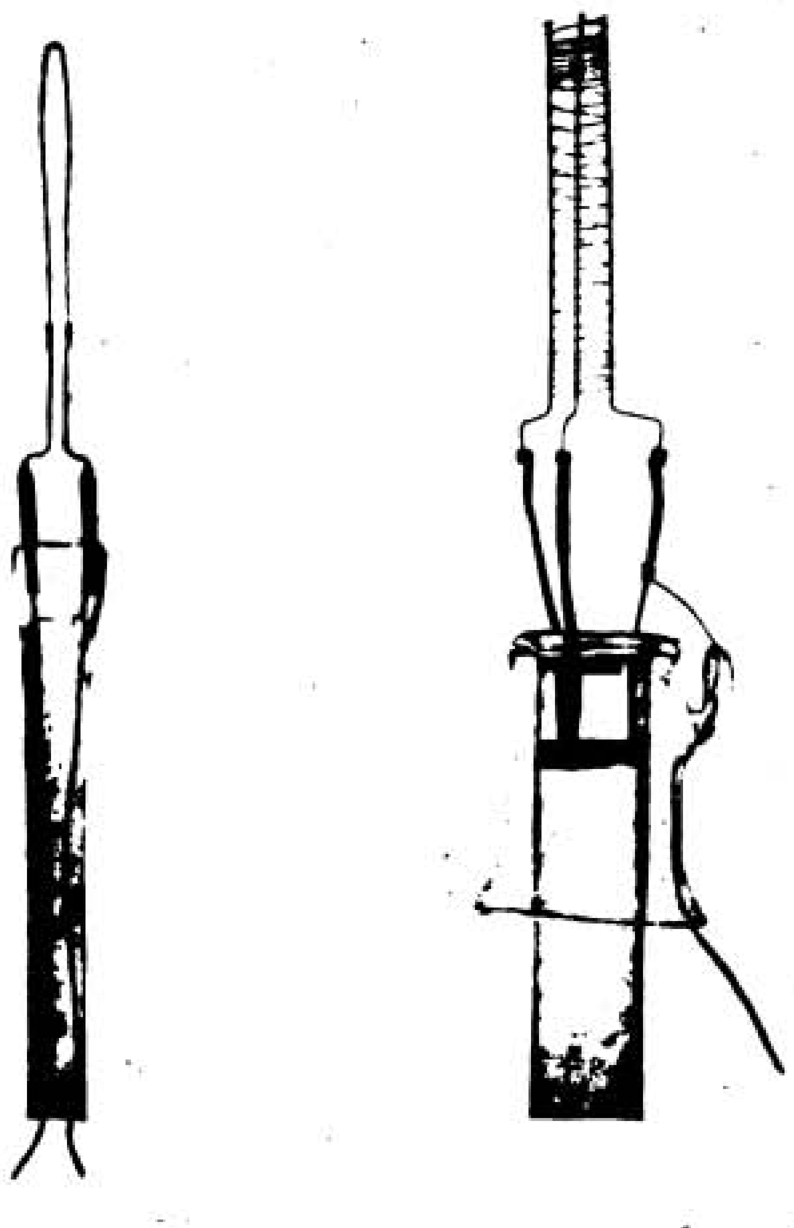

FIG. 9.—Grid and Filament of O/250 Valve, separately mounted ready for Sealing into Bulb.

being 20 watts. Characteristic curves for one of these valves are given in Fig. 8.

Larger transmitting valves designed for safe energy dissipation of 100–150 watts (Type O/150), of 200 watts (Types O/250A and O/250B) and of 500 watts (Type O/500), are also manufactured by this firm. In these valves a different construction is adopted and use is made of the specially designed features claimed in British Patent 158720. This special construction provides exceptionally long insulating paths between both anode and grid and the filament. It also has the additional advantage of rendering possible the renewal of the valve filament by the makers, if the valve is returned with the bulb intact. The maintenance cost of valve installations may thus be very considerably reduced.

The manner in which the electrodes of a power valve are built up to obtain these results may be seen from Figs. 9 and 10, which show the four component parts of such a valve mounted on their respective glass stems. Taking the filament first; this is of loop form and is mounted on two nickel strips on its own glass stem which is of such a diameter that it will pass freely up the centre of the inner glass tube of the stem on which the grid is mounted without coming into contact with any of the grid supports or connections. The grid is formed of a spiral of nickel wire laced on to straight nickel supporting wires which themselves are carried by channel-shaped nickel strips held in place by friction on the inside of the glass tube of the grid stem. The flanged end of the glass stem carrying the filament is ultimately sealed on to the outer end of the inner glass tube of the grid supporting stem and this part is finally completely exterior to the valve bulb itself, which is sealed on to the flanged outer part of the grid stem. Similarly the tension spring which supports the loop of the filament from the other end of the bulb is attached to a narrow glass tube which passes centrally up, but separated from the inner glass tube which supports the anode of the valve from the opposite end of the bulb. There is thus

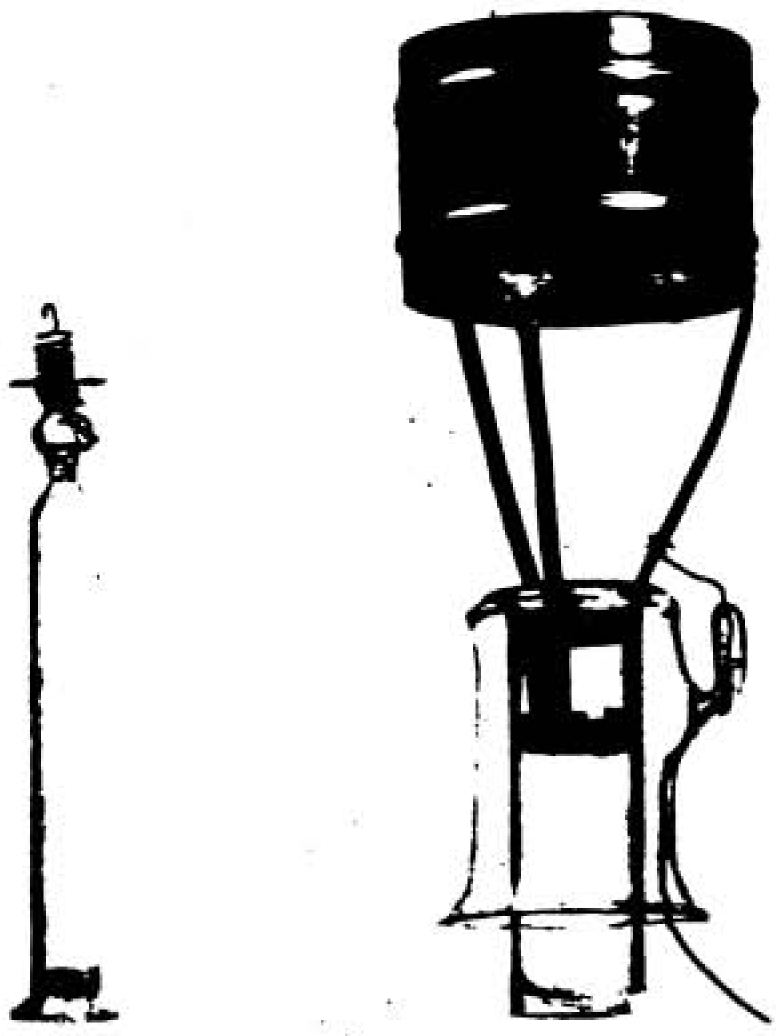

FIG. 10.—Anode and Filament Tension Spring, separately mounted before Sealing into Bulb.

in each case a double glass wall and a vacuous space between the anode and the grid terminal wires and the filament leads. The final appearance of one of these valves may be seen from Fig. 11 which illustrates a valve of the O/500 type designed for an anode voltage of 2,000, and requiring a filament circuit of 5·25 amperes at 17·5 volts. The overall length of such a valve is about 16 inches and the diameter of the bulb about 7 inches. With the exception of a greater length of anode grid and filament this valve is of the same type as the O/250, the parts of which have been illustrated in Figs. 9 and 10. By cutting through the tubes which project at opposite ends of the valve, the two small stems supporting the loop filament and its tensioning spring may be withdrawn from the valve and a new filament inserted in place, sealed into position and the valve re-exhausted. Some characteristic curves taken on a power valve of the O/500 type are shown in Fig. 12.

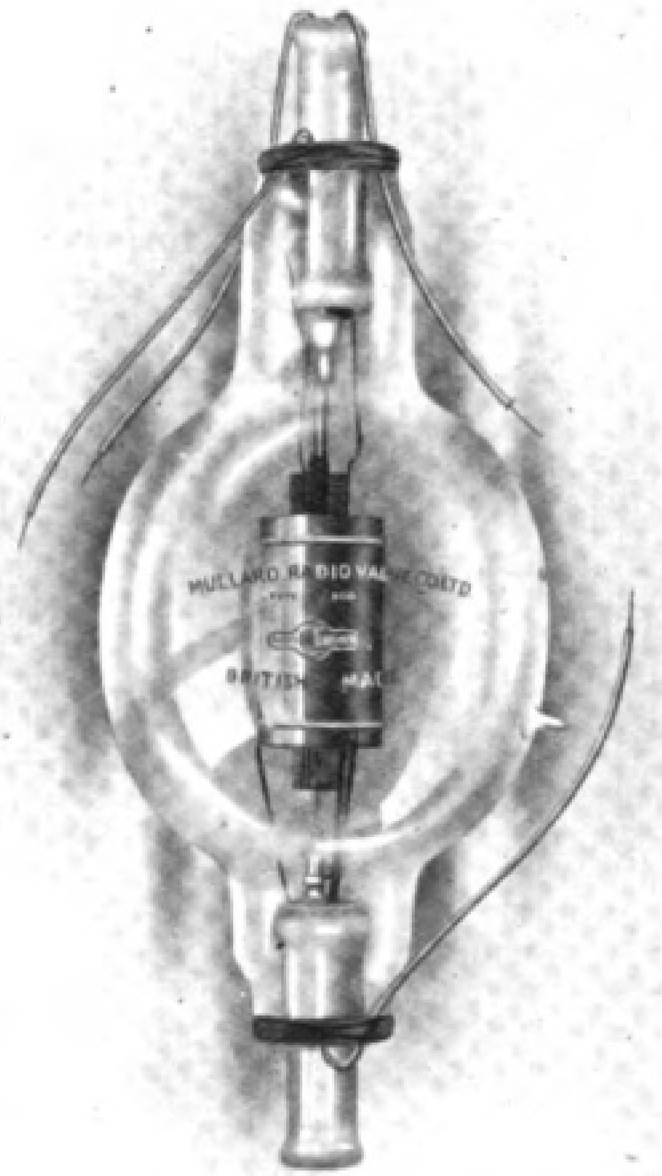

Fig. 11.—Transmitting Valve, Type O/500.

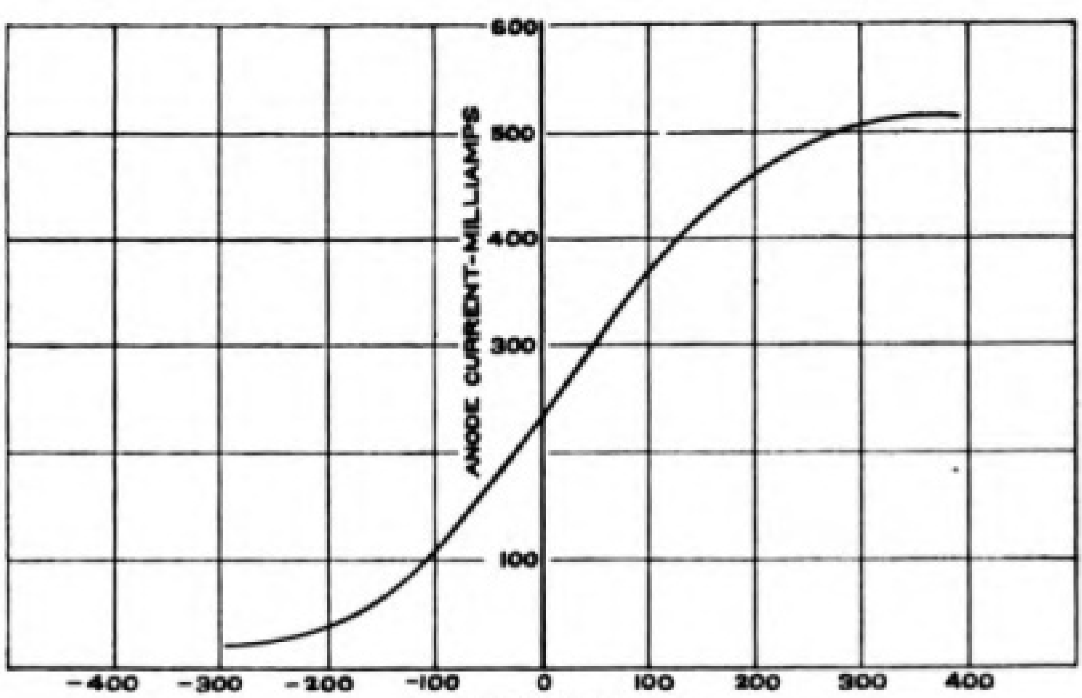

Fig. 12.—Characteristic Curve of O/500 Valve.
Anode voltage = 1,600 V.

Two-electrode valves for rectifying high tension alternating currents are also manufactured to similar designs. A small and a large pattern rectifying valve are illustrated in Figs. 13 and 14, which show valves designed for anode dissipations of 30 and 250 watts respectively. The U/500 type of rectifying valve built on these lines will pass an anode current of 0·55 ampere.

Quite recently further developments have been made in the manufacture of power valves capable of dealing with still larger amounts of energy without overheating the anode. These valves are enclosed in a silica bulb and have anodes designed on a much larger scale than those here illustrated. They are built up of narrow molybdenum strip plaited into a hollow cylindrical form. The general design of filaments and grids for these valves does not differ materially, except in dimensions, from that used for smaller valves. The most striking feature of these valves is their small size for the power they are capable of handling, since the silica bulb is made cylindrical in form and very little larger than the anode. This construction is possible on account of the high melting point of silica, but this high melting point naturally renders their manufacture much more difficult since the material can only be worked in an oxyhydrogen flame. The exhaustion of these high power valves also introduces special problems, and extensive research work is in progress as a result of which valves capable of handling very large outputs will be available.

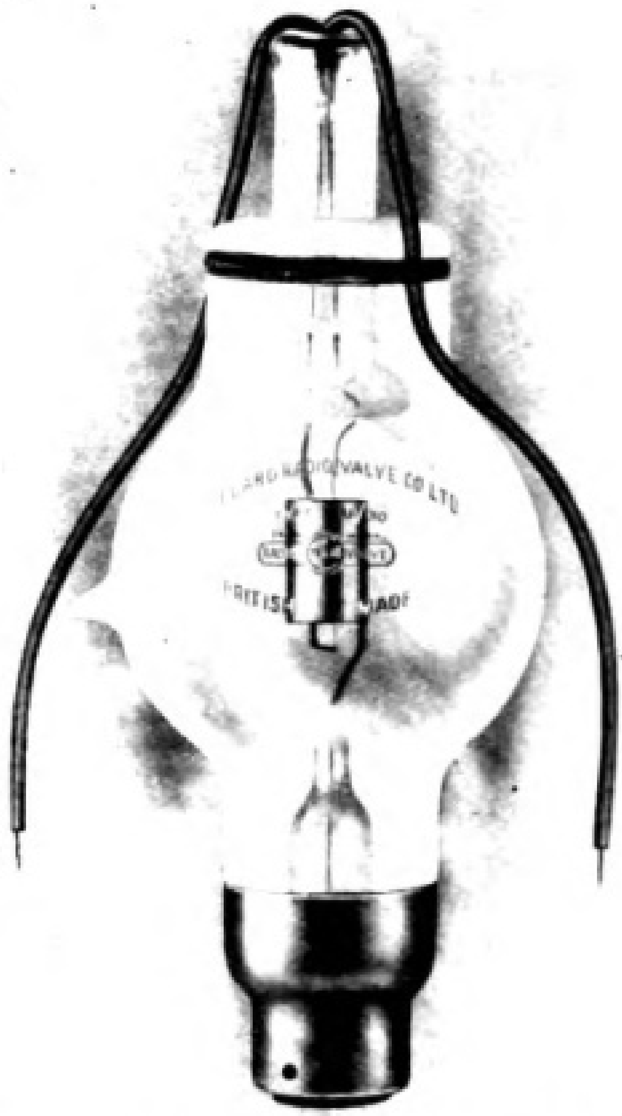

Fig. 13.—Rectifying Valve, Type U/30.

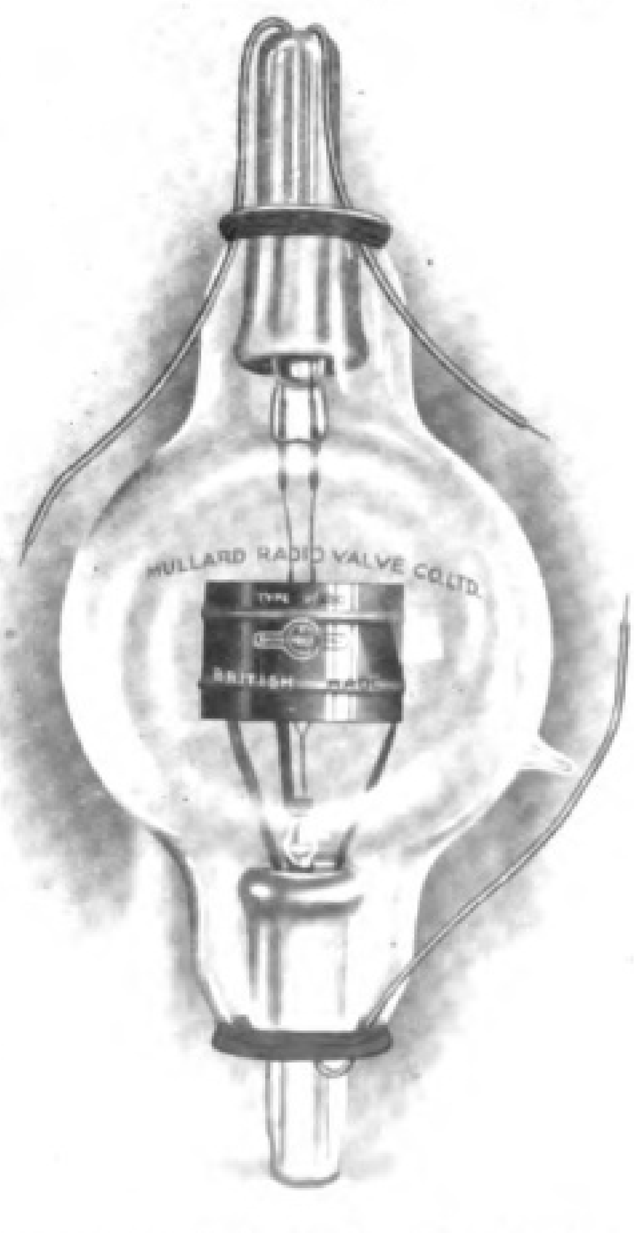

Fig. 14.—Rectifying Valve, Type U/250.

The Reception of Wireless Waves on a Shielded Frame Aerial.*

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

The following experiments were recently carried out by the writer in his laboratory in London, in order to test a suggestion made by Mr. N. P. Hinton, a member of the Sub-Committee on Directional Wireless of the Radio Research Board, that something of the nature of a wireless telescope with improved direction finding properties, might be made by placing a frame aerial in a large metal tube or wire spiral, open at the ends.

Particulars are published with the permission of the Radio Research Board.

The frame employed was a circular one, 1 foot in diameter, with 100 total turns of No. 20 S.W.G. cotton-covered copper wire all the turns bunched together, with a four-way switch so arranged that the number of turns in use could be diminished to twenty, forty or eighty turns, as desired.

With eighty turns in use, and with an adjustable condenser connected across its ends, this frame records, in London, the spark emission from the Eiffel Tower in Paris loudly when coupled to a five-valve resistance amplifier connected to a three-valve transformer-coupled note magnifier, and has fairly good directional properties. All the experiments were made with spark emission from Paris, which has a wavelength of 2,600 metres.

The shielding tube first employed consisted of an oblong wooden frame of square section, 18 inches wide, 18 inches deep, and 4 feet long, wound round with No. 18 S.W.G. bare copper wire spaced 1 inch apart, and connected to earth. With the ends of the tube open, and with the extremities of the square copper spiral unconnected, the frame, when placed within the tube, gave signals from Paris of approximately the same strength as outside of the tube. When, however, the ends of the spiral were connected together, so as to form a closed circuit, the signals received on the frame were considerably weakened, say by about 50 per cent., and this weakening was accentuated so that the signals only retained about 25 per cent. of their original strength, by short circuiting the individual spirals with four longitudinal copper wires along the corners of the tube. It was found, however, that the tube itself possessed no appreciable directional screening effect upon the frame, it making no detectable difference in what direction the tube was pointed provided the frame itself was in the plane pointing to Paris. This continued to be the case even when the open ends of the tube were closed by grids of copper wire connected at numerous points to the spiral, the putting on or removal of these grids making no detectable difference in the strength of the signals.

Finally the whole tube, including its ends, was completely covered in with iron wire netting of about $\frac{1}{2}$ inch mesh, in contact with the copper spiral and end grids, when it was found that though the signals were slightly further diminished in intensity, say to about 20 per cent. of their original strength, Paris could still be easily heard on the frame, which continued to have directional properties quite irrespective of the position of the wire netting covered tube.

It would appear from the experiments that while completely enclosing the frame in a conducting network considerably damps the currents in the frame, and thus diminishes the strength of the signals, such conducting network by no means entirely screens the frame from incoming waves of the 2,600 metre length sent out on the spark emissions of the Eiffel Tower. This result would appear to be dependent on the considerable wavelength tested, as copper wire grids such as are mentioned above, with the wires parallel to the plane of polarisation of the waves, pretty well completely screen off the very short waves of a few centimetres length, such as were used in the original lecture room experiments with Hertzian waves as shown many years ago by Sir Oliver Lodge.

Further experiments were made with the frame placed within a copper box in the form of a cube of 2 feet dimensions in each direction, made of sheet copper about $\frac{1}{32}$ of an inch in thickness. This box was completely closed in with soldered joints excepting on one side, which was open, but could be closed by means of a close-fitting lid also made of similar sheet copper.

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* Paper read before Section A of the British Association at Edinburgh on Thursday, September 8th, 1921.

In all the experiments the copper box was connected to earth. The same circular frame aerial, 1 foot in diameter, used in the previous trials, was employed, but a more compact transformer-coupled six-valve amplifier was used in place of the five-valve resistance amplifier and the separate three-valve note magnifier.

Preliminary experiments, in which only the frame aerial was enclosed in the copper box, the amplifier, tuning condenser, telephone receiver and batteries being outside, having proved unreliable owing apparently to the outside apparatus picking up the waves irrespective of the frame, it was decided to put the whole of the apparatus and connections, as well as the frame, inside the box, and to listen to the telephone receiver through a ½ inch rubber tube passed into the box through a round hole in the latter. Considerable trouble was experienced in getting the apparatus to work properly under these conditions, the close proximity of the frame and the amplifier causing reactions, that were apt to lead to automatic howling, but with care clear signals were again obtained.

Experiments were again repeated with the 2,600 metre spark emission from the Eiffel Tower.

Though putting the frame and other apparatus into the box greatly reduced the strength of the received signals, still, when the frame was pointed in the right direction, with the open side of the copper box turned towards Paris, the signals could be heard quite easily. They were probably only about 5 per cent. of the strength obtained with the frame completely unshielded.

On closing up the open side of the box with the copper lid, it was found that as the lid was put on, the signals further gradually diminished in strength. They were, however, still distinctly audible so long as the narrowest possible slit or opening was left. Indeed, they only disappeared, and did so quite suddenly, when the edges of the lid came into actual contact with the box so as to form a closed continuous electrical conductor round the frame. With the lid quite closed, and making good electrical contact all round, no trace of the signals could be heard.

Experiments were also tried with a lid consisting of thin tin-foil pasted on wood, in place of the copper lid. This lid was just as effective as the copper one in stopping the signals. When the tin-foil lid completely closed the aperture and made good contact all round with the copper box, no trace of any signals could be obtained.

As mentioned, all these results were obtained with the open side of the box facing Paris, but exactly similar results, with no distinguishable difference as regards the strength of the received signals, were obtained when the box was turned round so that its open side was pointing in the exactly opposite direction from Paris. By such means it is therefore not possible to ascertain the absolute direction of the waves, any better than with an unshielded frame.

With the box turned so that its open side pointed in a direction at right angles to the direction of Paris, either to the right or to the left, but with the frame pointing in the direction of Paris, no signals at all could be heard, though the side of the box was completely open; but with the box so placed that its open side pointed in a direction making an angle of 45° with the direction of Paris, with the frame pointing in the same direction or more towards Paris, the signals could be heard, though faintly, being reduced to some 1 per cent. of their value with the frame completely unshielded.

For any signals to be heard it was, however, essential that the relative positions of the box and frame were such that a prolongation of the plane of the frame towards or away from Paris, no matter which, came out of the open side of the box clear of the copper sides.

With box turned up so that its open side pointed to the sky, with the vertical frame pointing to Paris, the signals could be heard at about 1 per cent. of their full unshielded value and disappeared when the lid was put on, in exactly the same way as when the open side of the box was pointing to, or directly away from Paris.

From these experiments it would appear that waves of the length and strength of those experimented with do not penetrate into a completely closed metallic box to a sufficient extent to give audible signals with a frame aerial and amplifier of the description used, even if the side of the box facing the source of the waves is only closed with tin-foil. Further, it would seem that the screening effect is largely a matter of a closed electrical conducting circuit in that portion of the box that surrounds the periphery of the frame, the smallest break in the electrical conducting continuity interfering largely with the screening effect.

That this is so, is shown by further experiments made with a flat sheet of tin plate, 5 feet in length and 8 inches wide, bent so as to form a cylinder. This was placed over the frame so that the axis of the cylinder coincided with that of the frame. With the ends of the tin-plate sheet overlapping, but not in electrical contact, the effect in reducing the strength of the signals was small, but immediately increased considerably, so that the signals were reduced to about 20 per cent. of their original strength, when the ends of the sheet were allowed to touch so as to form a continuous conducting ring round the periphery of the frame. Contracting the diameter of the ring by sliding the overlapping ends of the plate so that the ring was closer to the frame all round still further reduced the strength of the signals, till when the ring was touching the insulated wires of the frame all round, the signals very nearly disappeared. This indicates that the effect is not merely a question of screening, but also of eddy current damping which was further shown by contracting the tin-plate cylinder still further, and placing it inside the frame, where it again had the effect of largely reducing the strength of the signals. That damping enters largely into the matter was also proved by placing a large flat copper plate close up to one side of the frame, where it could have no screening but only a damping effect, which also greatly diminished the strength of the signals.

The result obtained with the frame inside the copper box in getting signals of equal strength with the open side of the box facing away from the source of the waves, as when the open side faced towards such source, may perhaps be of some interest from the point of view of theory in throwing some light upon the mechanism of electro-magnetic wave phenomena, inasmuch as it gives evidence that in addition to what is analogous to a "push" upon an aerial in front of the wavefront, there is also something of the nature of a "pull" upon an aerial behind the wavefront.

Otherwise, the experiments go to show that, at any rate upon the small scale employed, the use of a shielding tube or box does not assist in improving directional reception. It is possible, however, that if tried on a larger scale, with much more space between the frame and the shield, so as to avoid damping, the results might be different.

Notes.

Personal.

Mr. H. G. Thomson, who resigned from the Edison Storage Battery Company in 1919 to form the Transportation Engineering Corporation of which he was elected President, has been appointed Sales Manager of the American Radio and Research Corporation, Medford Hills, Mass. **[3798]**

Paulino Solorvano has been appointed Director-General of Communications of Nicaragua with headquarters at Managua, *vice* T. Tijerino, appointed Consul-General of the Nicaraguan Government at New York. **[4011]**

Mr. Joseph D. R. Freed who, during the war, was Radio Engineer at the Radio Test Shop, U.S. Navy Yard, Washington, D.C., and subsequently for over two years Designing Engineer and then Assistant Chief Engineer of the Wireless Improvement Company, has organised the Radio Manufacturing Company, Executive Office, 156, Fifth Avenue, New York, N.Y., which company will manufacture radio apparatus of all kinds. Mr. Freed will further act in the capacity of Consulting Radio Engineer. **[4013]**

A. Stachel has been nominated Chief of the Telegraph, Telephone and Wireless Section of the Federal Ministry of Communications for Austria. **[4024]**

Mr. Peter Cooper Hewitt, the distinguished American scientist and inventor, died on Thursday, August 25th, at the American Hospital, Neuilly. He was in his 61st year, having been born at New York on March 5th, 1861. **[4030]**

Mr. Thomas Thomassen Heftye, Director-General of the Norwegian Telegraph Administration, died on September 18th, as the result of a railway accident. **[4121]**

Legislation.

COMMERCIAL SERVICES FROM NAVY STATIONS.—The House of Representatives (U.S.A.) has passed a bill authorising the Secretary of the Navy to use all the radio stations of that department for the transmission of press messages and private commercial messages. **[3797]**

ADHESION TO THE RADIOTELEGRAPHIC CONVENTION.—The Polish Republic and the Danzig Free State have both signified their adherence to the Radiotelegraphic Convention and to the service regulations attached thereto. Certain reservations have been made in connection with Poland. **[4023]**

NEW RADIO LAWS FOR SWEDEN.—Under date of May 13th, 1921, a Royal Order has been made concerning the use of radiotelegraphic or telephonic installations on board foreign vessels in Swedish waters. It provides :—

(1) "That radio installations on board foreign vessels may only be used in the neighbourhood of Swedish ports with the special authorisation of the Director-General of Telegraphs in concert with the Chief Naval Officer and under strict observation of the detailed regulations prescribed by the Director-General of Telegraphs.

(2) "That radio installations on foreign vessels within 10 miles of a Swedish coastal radio station may only be used in cases of distress or for communication with the nearest coast station.

(3) "The Director-General of Telegraphs in consultation with the Chief Naval Officer may forbid or restrict, except in cases of distress, the use of wireless installations on board foreign vessels in other areas of Swedish territorial waters than are covered under Section 2 above." **[4025]**

THE NEW AUSTRALIAN NAVIGATION ACT, which comes into operation on October 1st, requires that every foreign-going or Australian trade ship, and every ship engaged in the coasting trade, which carries more than twelve passengers, or which, in the case of other ships, is of 1,000 tons gross tonnage or upwards, shall carry wireless apparatus as well as operators and watchers, unless specially exempted from doing so. **[3698]**

Every private wireless station in France is to be taxed 10 francs (4*s.* 5*d.*). **[1657]**

MARCONI WIRELESS PATENTS.—A verdict in favour of Marconi's Wireless Telegraph Co., Ltd., and the Compania Nacional de Telegrafia Sin Hilos has been given in the Spanish Courts as the result of a joint action brought by these companies against the Compania Ibericia de Telecommunicacion for infringement of patents relating to thermionic valves. **[3810]**

New Wireless Stations and Services.

NEW CANADIAN RADIO STATIONS.—The Alaska Wireless Telegraph Company is considering the possibility of introducing a wireless service between Edmonton, Alberta, Can., and Fort Norman. The Canadian Government is installing four wireless receiving stations between Peace River Crossing and the Arctic Ocean. **[3826]**

The radio station maintained at the offices of the *New York Times* has now been equipped with dictaphone receiving apparatus for the reception of press news direct from Bordeaux and Nauen at speeds up to 100 words per minute. A balanced loop aerial system is employed which considerably reduces interference from atmospherics. **[3832]**

THE FEDERAL TELEGRAPH COMPANY, U.S.A., state that their wireless stations at San Francisco and Portland are now ready for service. An additional station is also to be erected at Los Angeles. **[3833]**

NEW VENEZUELAN WIRELESS STATION.—It is reported that the erection of the towers for the new wireless station at Maracaibo (Venezuela) has been completed and that the station is nearly ready for commercial operation. The towers are 164 feet high and the normal sending radius will be about 800 miles by day and 1,600 miles by night. **[3866]**

THE RADIO CORPORATION OF AMERICA has announced that its new Radio Central station at New York is nearly ready for opening. Two of the arms of the antenna have been completed using twelve steel towers 400 feet high. Two Alexanderson H.F. alternators have been installed. **[3867]**

The S.S. *Majestic*, which is being built for the White Star Line and is now nearing completion, will carry three wireless installations the largest of which will be capable of maintaining permanent communication with both America and England during the entire voyage across the Atlantic. The lifeboats include two motor boats equipped with wireless. Elaborate submarine signalling gear has also been installed. **[4029]**

WIRELESS SERVICE FOR LEAGUE OF NATIONS.—A special wireless telegraph service has been instituted by Marconi's Wireless Telegraph Company, Ltd., for the second assembly of the League of Nations at Geneva. The opening of this service, which was originally fixed for September 5th, has been pushed forward and actually took place on August 30th so as to render it available for the meeting of the Council of the League which is considering the Upper Silesian problem. Some further particulars may be found on p. 535 of this issue. **[4026]**

CHICAGO WIRELESS TELEPHONE SYSTEM OPENED.—The Chicago Municipal Wireless Telephone System, constructed under the supervision of W. G. Keith, City Commissioner of Electricity, to connect all police and fire stations, has been put in operation, and initial tests have proved satisfactory. The main sending and receiving station is on the roof of the City Hall. Commissioner Keith stated that ultimately there would be receiving stations on all beats to enable policemen to receive messages from stations or from headquarters. **[4040]**

Commercial and General.

A close working agreement between the Swedish and English interests has been established in the field of wireless telegraphy. The Swedish Radio Company and Marconi's Wireless Telegraph Company have been amalgamated into a new company which will still be called the Swedish Radio Company. **[4032]**

From the *Telefunken Zeitung* we learn that in April the speed of transmission from Nauen to Marion (U.S.A.) was increased from 50 to 80 words per minute. Nauen used the 400 kW set with a wavelength of 12,600 metres and operated the signalling choke coil from a Wheatstone transmitter through a special relay. In America a photographic recorder was employed. **[3749]**

THE INSTITUTION OF ELECTRICAL ENGINEERS.—At a meeting of the Privy Council, held at Buckingham Palace on Wednesday, August 10th, 1921, the petition of the Institution for a Royal Charter of Incorporation was approved and a Royal Charter has now been granted. His Majesty the King has also been graciously pleased to intimate his willingness to become a Patron of the Institution. **[3876]**

WIRELESS TRANSMISSION OF PHOTOGRAPHS.—According to *Telegraph and Telephone Age* some tests have recently been made of the transmission of photographs and written messages between the United States and France. The transmission was effected from the Naval Radio Station at Annapolis. The results are stated to have been successful. **[4012]**

A NEW PORTABLE WIRELESS RECEIVER.—The latest development in portable wireless receivers has just been placed upon the market by the Westinghouse Electric and Manufacturing Company, of East Pittsburgh, Pa., U.S.A., under the trade name of "Aeriola Jr." The complete outfit weighs but five pounds, and merely requires to be connected to a single wire aerial and to an earth wire, the remainder of the auxiliary apparatus being contained in the one case. All tuning operations are effected by means of a single movable arm. **[4045]**

WIRELESS TELEPHONY IN SOUTH AFRICA.—The Union Government is experimenting with wireless telephony with the view of linking the chief centres. Communication has been successfully established between Johannesburg and Bloemfontein. It is hoped to extend the system gradually, thus lessening the cost of ordinary telegraphic and telephonic working, which is unusually high owing to maintenance charges over immense distances. **[4031]**

LYONS WIRELESS STATION.—As a result of a violent storm recently the wireless station at Lyons has been considerably damaged. Two of the steel towers, which are over 600 feet in height, crashed to the ground. **[3879]**

Review of Radio Literature.

1. Abstracts of Articles and Patents.

(A.) General Articles descriptive of Installations, etc.

2430. **Gesellschaft für drahtlose Telegraphie.** Sending Arrangement for Wireless Telegraphy. (*German Patent* 317541, October 25th, 1918, relating to *German Patent* 304361. Patent granted December 24th, 1919; *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 60, January, 1921.)

One or more oscillating circuits tuned to the fundamental frequency are connected to intermediate points of the loading inductance of an antenna circuit (see Fig. 1).

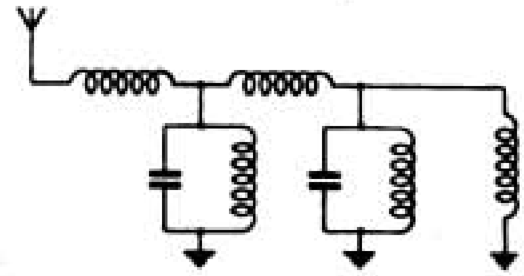
FIG. 1.

2431. **H. Thurn.** Nauen. (*Archiv für Post und Telegraphie*, 7, pp. 253—279, July, 1921.)

A semi-popular but very complete and well illustrated account of the development and present equipment of the station at Nauen.

2432. The new Dutch Station at Kootwijk. (*Radio Nieuws*, 4, pp. 196—198, July, 1921.)
A few details of the high-power station in course of erection between Assel and Kootwijk.

2433. The Present State of Large Telefunken Stations being built in Holland, Java and Argentine. (*Telefunken Zeitung*, 4, pp. 17—21, May—June, 1921.)
A descriptive illustrated article giving a few details of the erection of these stations.

2434. The Telefunken 10 kW Triode Transmitter in Prague. (*Telefunken Zeitung*, 4, pp. 27—29, May—June, 1921.)
An illustrated description.

2435. Foreign Radiotelegraph Progress. (*Electrician*, 87, pp. 185, 190, August 5th, 1921.)
Notes of the statements made by **Mr. Pike Pease** in the House of Commons relative to the high-power stations of the United States, Germany and France, and the equipment of the Leafield station.

2436. The Clifden Station. (*Engineer*, 132, p. 193, August 19th, 1921.)
A short note dealing with the fuel consumption at the Clifden radio station.

2437. The Lyons Radio Station. (*Radio News*, 3, pp. 6—8, July, 1921.)
An illustrated description of the station and its equipment.

2438. **R. R. Smith.** The Clark Radiophone. (*Radio News*, 3, pp. 108—109, August, 1921.)
An illustrated description of the installation at Clark University (U.S.A.) with details of the results obtained on various aerials.

2439. **P. Boucherot.** Radio Central. (*World Wide Wireless*, 2, pp. 3—5, August, 1921.)
A short description of the progress in the building of the high-power radio station near New York.

2440. The Paris Radio Centre—June, 1921. (*Radioélectricité*, 2, pp. 14—24, July, 1921.)
An account of the progress of the work in the building of the high-power radio central station at Sainte Assise near Paris. Charts are given of the progress in the building of the towers and of the installation of other parts of the apparatus with photographs of the buildings in course of erection and of the machinery and apparatus already installed.

2441. **L. V. Bournat.** The Most Powerful Station in the World. (*Technique Moderne*, 13, pp. 49—54, February, 1921. *Radioélectricité*, 1, p. 145D, June, 1921—Abstract.)
General descriptive article on Sainte Assise station with a comparison with Nauen.

2442. The Largest Radio Station in the World. (*Technique Moderne*, 13, p. 32, February, 1921. *Radioélectricité*, 1, p. 145D, June, 1921—Abstract.)
A description of the Lafayette Station.

2443. **M. B. Sleeper.** Commercial Practice applied to Experimental Radio Stations. (*Radio and Model Engineering*, 1, pp. 11—12, June, 1921.)

2444. **G. Viard.** The High-power Radio Station at Nauen, near Berlin. (*Genie Civil*, 78, pp. 405—409, May 14th, 1921.)
Gives a summary of the history of the station followed by a description of the installation—alternators, frequency doublers, etc., with illustrations of some of the apparatus.

2445. **F. Linke.** The Alexanderson High-frequency Machine and the High-power Station at New Brunswick. (*Zeitschrift des Vereines deutscher Ingenieure*, 65, pp. 467—469, July 30th, 1921.)
A general descriptive article on the lines of Abstracts Nos. 2084, July, 1921; 1333, January, 1921; and 2492 in this issue.

2446. The Opening of the Leafield Wireless Station. See pp. 509—523 in this issue.

2447. **D. Sinclair.** The Wireless Stations of the British Commercial Airways. (*Wireless World*, 8, pp. 798—810, February 19th; p. 830, March 5th, 1921. *Radioélectricité*, 1, p. 147D, June, 1921—Abstract.)
An illustrated description of the stations and plant.

2448. Austrian Portable Radio Sets. (*Scientific American*, 122, p. 697, June 26th, 1920—Abstracted from *Elektrotechnik und Machinenbau.*)

2449. **H. P. Davis.** Radio—Its Future. (*Electric Journal*, 28, p. 109, April, 1921.)

2450. **W. S. Rugg.** Radio—Its Relation to the Electrical Industry. (*Electric Journal*, 28, pp. 109—110, April, 1921.)

2451. **E. W. Stone.** Radio Telephony. (*Radio News*, 3, p. 24, July, 1921.)
A general article.

2452. **E. Reinhard.** The Building of Large Radio Stations. (*Telefunken Zeitung*, 4, pp. 8—14, March, 1921.)
A discussion of the conditions for the successful erection of a large station, the area required, the nature of the foundations, water supply, necessary surveying, buildings, cooling pond, road-making, etc.

2453. **W. Bragg.** Electrons and Ether Waves. (*Discovery*, 2, pp. 224—228, September, 1921.)

2454. **H. Zickendraht.** Wireless Telephony. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 369—372, May, 1921.)
A report of reception tests made at Bâle University on various telephonic transmissions. The antenna was a 2-wire **T** 18 metres high and 80 metres long, using a crystal detector and a 2-stage low-frequency amplifier. The Königswusterhausen valve transmitter gave very clear speech and music, but the Poulsen arc at the same station was not good in spite of its loudness. After preliminary improvements the high-frequency alternator tests from Nauen gave good results. The causes of defective reproduction are discussed and also the interference due to other stations heterodyning with the desired transmission, *e.g.*, Nauen $\lambda = 4{,}700$, and Coltano $\lambda = 4{,}450$ metres.

2455. **Lorenz Company.** Wireless Telephony with the Poulsen Generator. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 373—375, May, 1921.)
Gives a few details of the apparatus employed in the Easter Concert transmitted from Königswusterhausen. The arc was of the 4 kW type giving 30 amperes into the antenna at a wavelength of 3,700 metres. The microphone current passes round the iron core of an inductance in the antenna circuit; the voice causes variations of the microphone current which alters the permeability of the iron core and thus detunes the aerial. Further details are promised.

2456. A New Wireless Station for China. (*Electrical Review*, 88, p. 554, April 29th, 1921.)
Refers to the construction of a high-power wireless station east of Pekin and also to other contemplated radio stations in Shantung.

2457. The New Paris Radio Station. (*Radio News*, 2, p. 606, March, 1921.)
A summary of the chief features of the proposed radio station to be built at Sainte-Assise.

2458. A New Use for Radio. (*Radio News*, 2, p. 856, June, 1921.)
Relates to the broadcasting of radio telephone music from the Union College Radio Club Station.

2459. Golden Gate Pilots Use Radiophones. (*World Wide Wireless*, 2, p. 17, July, 1921.)
The port pilot ships for guiding vessels through the Golden Gate have now been equipped with wireless telephones to expedite communication.

(B.) Spark Gaps and Spark Transmitting Apparatus.

2460. **M. Woltke.** Reversal of Rectification in Spark Gaps with Air Blast. (*Physikalische Zeitschrift*, 22, pp. 123—125, February 15th, 1921.)
In a point and plate gap the rectification is very small and uncertain in direction unless the gap is submitted to a powerful air blast. With gradually increasing blast the direction may reverse once or twice, but with a strong blast the rectification is very good and is always in the direction from point to plate.

2461. **F. Trey.** The Effect of Electric Wind on Spark Gaps. (*Physikalische Zeitschrift*, 22, pp. 406—409, July 15th, 1921.)
In some cases radium or ultraviolet light not only causes the spark to occur but if brought nearer or strengthened acts in the opposite sense and inhibits the spark. This is shown experimentally to be due to the production of an electric wind.

2462. **E. Meyer.** On the Influence of Impurities on Sparking Voltages in Air. (*Annalen der Physik*, 65, pp. 335—368, June 28th, 1921.)

2463. **H. Stücklen.** On the Influence of Water-vapour on Spark Voltage. (*Annalen der Physik*, 65, pp. 369—377, June 28th, 1921.)

2464. **R. Bosch Aktien-Gesellschaft.** Quenched Gap Generator. (*German Patent* 317921, May 19th, 1917. Patent granted January 7th, 1920. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, p. 380, November, 1920—Abstract.)
An arrangement for quenching a spark gap magnetically, the electromagnet being automatically energised at each spark.

2465. **J. Marsten.** Some Notes on Quenched Gap Transmitters. (*Radio News*, 2, p. 689, April, 1921.)

2466. **F. Lowenstein.** Spark Gap. (*British Patent* 157258, January 10th, 1921. Convention date August 25th, 1914. Patent not yet accepted.)
A multiple spark gap in which the number of effective elements can be varied with a switch. The gaps have cylindrical, conical or spherical fluted surfaces.

2467. **A. J. Klonck.** A Synchronous Rotary Spark Gap. (*Wireless Age*, 8, p. 23, August, 1921.)

2468. **Gesellschaft für drahtlose Telegraphie.** Wireless Transmitters. (*British Patent* 147436, July 7th, 1920. Convention date December 6th, 1913. Patent not yet accepted.)
In order that spark transmitters may be used with heterodyne receivers successive sparks are timed so that the resulting wave-groups occur in correct phase-relation.

2469. **R. B. Goldschmidt.** Continuous Wave Transmitter. (*French Patent* 508122, January 3rd, 1920. Published October 2nd, 1920.)
The specification describes a method of exciting a high-frequency oscillating circuit by a primary circuit by means of a direct or inductive coupling. The damping of a condenser discharge is obtained by employing a resistance which varies with the time, for example, a self-inductance instead of relying on the resistance of the spark path.

2470. **E. von Lepel.** Apparatus for the Generation of Electrical Oscillations. (*German Patent* 302502, April 7th 1914.)

A method of generating electrical oscillations by means of a direct voltage source and condensers with rotating or vibrating plates. A system of choking coils prevents the discharges from passing through the source. Modulation voltages may be introduced in the circuit *via* coil M (Fig. 2).

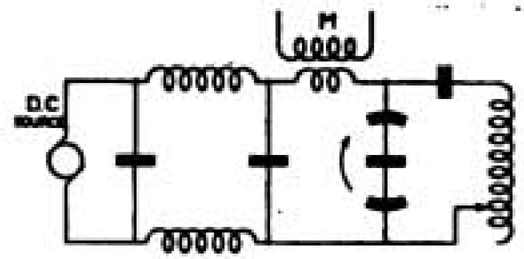

FIG. 2.

2471. **W. S. Lemmon.** The Resonant Converter. (*Q.S.T.*, 4, pp. 17—21, May, 1921.)

An illustrated description is given of a commutator set for converting from D.C. to A.C. The application of the arrangement to spark and valve transmission is dealt with.

2472. **F. H. Newman.** A New Form of Wehnelt Interrupter. (*Proceedings of the Royal Society*, 99A, pp. 324—330, July 1st, 1921.)

The interrupter consists of a platinum wire immersed in a saturated solution of ammonium phosphate. The whole is contained in an aluminium vessel which acts as the cathode. Less heating is claimed. Some oscillograms are included with the paper.

2473. **G. Holst** and **E. Oosterhuis.** The Influence of the Gas on the Operation of a Mercury Break. (*Physica*, 1, pp. 56—57, May, 1921.)

An experimental investigation of the effect of different gases on the spark-length of an induction coil. The differences are very great, *e.g.*, 1·7 cm with 85 per cent. argon and 15 per cent. nitrogen, 11·5 cm with coal-gas or hydrogen. The authors explain this by the difference in the ability of the gases to form clusters or heavy ions of small mobility.

(C.) Arc Apparatus.

2474. **H. Marchand.** The Poulsen System used at the Radio Station at Bordeaux. (*La Nature*, 49(1), pp. 293—296, May 7th, 1921.)

An illustrated article dealing with various types of Elwell Poulsen arc equipment.

2475. **J. Cohen.** Wireless Telegraphy. (*British Patent* 157782, January 10th, 1921. Convention date, November 13th, 1915. Patent not yet accepted.)

In an arc generator system two oscillatory circuits are shunted across the arc, and the time constants L/R of the two circuits are so adjusted in relation to one another, that when both circuits are closed oscillatory current will flow in one circuit but not in the other.

2476. **Gesellschaft für drahtlose Telegraphie.** Wireless Signalling. (*British Patent* 147428, July 7th, 1920. Convention date, July 3rd, 1914. Patent not yet accepted.)

Oscillations generated by an arc are transmitted to an aerial through a static frequency raiser and may be modulated at the same time by currents in additional windings.

2477. **W. A. Eaton.** Description of a Uni-wave Signalling System for Arc Transmitters. (*Electric Journal*, 18, pp. 114—115, April, 1921. *Electrical World*, 77, p. 1175, May 21st, 1921. *Science Abstracts*, 24B, pp. 362—363, Abstract No. 747, July 30th, 1921—Abstract.)

The necessity for the development of a uni-wave signalling system is detailed and the essential equipment is discussed.

2478. Improvements in Arc Generators. (*L'Elettrotecnica*, 8, pp. 252—253, April 15th, 1921.)

Describes arrangements of condensers and resistances and choking coils devised by **L. F. Fuller** for the protection of the dynamo supplying the arc.

2479. **C. Lorenz Akt.-Gesellschaft.** A Small Poulsen Arc Wireless Telephone Set. (*Elektrotechnische Zeitschrift*, 42, p. 550, May 26th, 1921.)

A brief description with photograph of a set exhibited by the Lorenz Company at the Essen exhibition. The whole is contained in a small box with the exception of the arc which stands on the box and takes 2 amperes at 220 volts. Range 15 km without amplifier, using aerials 20 metres high and 300 cms capacity. A somewhat similar set using a triode oscillator is also described.

2480. **T. D. Haig.** The Arc or Continuous Wave Transmitter. (*Radio News*, 2, pp. 520—521, February, 1921.)

A general account of the mode of operation of an arc transmitter.

2481. **A. de la Bruère.** Continuous Wave Transmitter. (*French Patent* 509966, May 30th, 1919. Published November 24th, 1920.)

The specification relates to luminous arc apparatus employed in the emission of electromagnetic waves. The chamber in which the arc is formed is connected by a tube with a reservoir containing a liquid which will not dissolve the gas which constitutes the special atmosphere within which the arc is formed, or which will only dissolve the said gas in a very small proportion. The reservoir is connected at its lower end by a tube with a second reservoir to receive the liquid which is forced out of the first reservoir by the gas, so that the said gas can be maintained under a predetermined pressure.

2482. **D. G. Little.** Continuous Wave Radio Communication. (*Electric Journal*, 28, pp. 124—129, April, 1921. *Electrical World*, 77, p. 1383, June 11th, 1921—Abstract.)

Illustrated descriptions are given of small and large arc apparatus, H.F. alternators and various patterns of valve transmitters.

2483. **Q. A. Bracket.** Radio Arc Transmitters. (*Electric Journal*, 28, pp. 142—146, April, 1921.)

Various patterns of arc apparatus are briefly described and illustrated.

2484. **C. R. Leutz.** A New Arc Transmitter. (*Radio News*, 3, p. 99, August, 1921.)

An illustrated description of a 5 kW panel type installation designed for ship use.

2485. **D. R. Clemons.** Construction of a 1 kW Arc Converter. (*Radio News*, 3, pp. 103, 162, August, 1921.)

An illustrated description.

2486. **Compagnie Générale de Radiotélégraphie.** Continuous Wave Transmitter. (*French Patent* 504135, February 9th, 1918. Published June 25th, 1920.)

The invention consists in employing as the atmosphere surrounding the arc of an arc generator, hydrogen charged with petrol ether vapour. An apparatus is also described for causing the hydrogen to be charged with the said vapour in which the hydrogen is directed on to the surface of liquid petrol ether.

2487. **E. Mayer.** The Theory of the Poulsen Arc. (*Zeitschrift für technische Physik*, 2, pp. 18—28, January; pp. 40—49, February; pp. 73—81, March; pp. 94—105, April, 1921.)

A very long and detailed theoretical investigation of the effective value of the current, the power, efficiency, stability, etc., in an arc for oscillations of the first and second kind all based on the assumption of sine wave current and simple forms of characteristic. The paper was written in an internment camp in the United States.

2488. **J. F. Bront.** The Arc and Radio Telephone Transmitters. (*Radio News*, 2, pp. 868—869, June, 1921.)

Constructional details are given of low-power arc installations for experimental work.

2489. **P. O. Pedersen.** Some Improvements in the Poulsen Arc. (*Electrician*, 86, pp. 684—686, June 3rd, and pp. 714—716, June 10th, 1921. *Electrical World*, 78, p. 81, July 9th, 1921—Abstract.)

A series of investigations made by the author from 1914 to 1918 in an endeavour to elucidate the operation of the Poulsen Arc has resulted in certain improvements in the arc. The author deals with the investigation and the main results obtained as an explanation of the improvements which are described in the latter part of the article. Oscillograms of the arc are given, in verification of the theory proposed, and a description of a special water-cooled cooling shoe fitted to the cathode of the arc, to enable weaker magnetic fields to be used. (See also pp. 505—507 in this issue.)

2490. The Arc System in Radio. (*Scientific American*, 124, p. 343, April 30th, 1921.)

A short note setting out the advantages claimed for arc apparatus.

2491. **G. von Arco.** A Comparison of High-frequency Alternators, Arcs and Valve Transmitters. (*Telefunken Zeitung*, 4, pp. 5—8, March, 1921.)

A popular article in which it is claimed that the arc cannot maintain the constancy of frequency called for by the latest developments in receiving apparatus, involving multiple heterodyne methods. The increased selectivity and diminished damping of the receiving apparatus necessitates a greater constancy of frequency. It is claimed that to obtain equal loudness of signals and freedom from interference, the radiated power with an arc must be three times that from an alternator and ten times that from a valve transmitter.

(D.) High-frequency Alternators.

2492. **E. E. Bucher.** The Alexanderson System for Radio Communication. (*General Electric Review*, 23, pp. 813—839, October, 1920. *Electrical World*, 76, p. 1225, December 18th, 1920—Abstract. *Scientific American Monthly*, 2, pp. 161—166, October, 1920—Abstract.)

This paper has already been abstracted from the *Wireless Age*. (See Radio Review Abstract No. 1333, January, 1921, and 1809, May, 1921.)

2493. **Société Française Radioélectrique.** Wireless Signalling. (*British Patent* 147465, July 7th, 1920. Convention date July 9th, 1919. Patent not yet accepted.)

Relates to the use of several H.F. alternators in parallel with condensers in series with each machine to maintain the correct phase relations.

2494. **Société Française Radioélectrique.** Wireless Transmitting Apparatus. (*British Patent* 165037, July 7th, 1920. Convention date October 16th, 1919. Patent not yet accepted.)

Relates to an arrangement of high-frequency alternators connected in parallel, each alternator being connected to the busbars through a condenser. The signalling key may be connected across the inductance coupling the busbars to the transmitting aerial system.

2495. **Ateliers de Constructions Électriques du Nord et de l'Est.** High-frequency Alternator. (*French Patent* 502925, June 27th, 1916. Published May 29th, 1920. *Radioélectricité*, 1, p. 85D, January, 1921—Abstract.)

The specification describes forms of windings for high-frequency alternators.

2496. **Compagnie Française pour l'Exploitation des procédés Thomson-Houston.** High-frequency Alternator. (*French Patent* 507092, December 5th, 1919. Published September 4th, 1920.)

This specification describes a high-frequency inductor alternator. The field magnet is provided with a number of independent exciting windings, each of which is capable of furnishing the field excitation for full load. The windings are arranged so that they can be easily repaired or renewed. Further particulars may be obtained from the corresponding *British Patent* No. 136147, in the names of **E. F. W. Alexanderson** and **S. P. Nixdorff** (see Radio Review Abstract No. 485, July, 1920).

2497. **Gesellschaft für drahtlose Telegraphie.** High-frequency Alternators. (*British Patent* 148446, July 10th, 1920. Convention date January 19th, 1915. Patent not yet accepted.)

Relates to the subdivision of the stator windings into a number of groups connected in parallel.

2498. **Société Française pour l'Exploitation des procédés Thomson-Houston.** High-frequency Alternator. (*French Patent* 506859, December 2nd, 1919. Published August 31st, 1920.)

A high-frequency alternator for radio communication has a circular stator core from which is supported a pair of laminated rings, each carrying an armature winding arranged in slots. Stationary field magnet coils are also carried on the stator. A rotating inductor which is slotted to form a plurality of magnetic poles, the slots being filled with blocks of non-magnetic material such as copper, moves between the laminated rings carrying the armature winding. See also *British Patent* 13904/1915.

2499. **Compagnie Française pour l'Exploitation des procédés Thomson-Houston.** High-frequency Alternator. (*French Patent* 506981, April 10th, 1919. Published September 2nd, 1920.) Also **General Electric Co. (U.S.A.)** (*British Patent* 155061, September 26th, 1919. Patent accepted December 16th, 1920.)

The alternator is of the inductor type in which the inductor is constructed as a rotating disc, the edge of which carries magnetic members serving as bridge pieces. The disc is of non-magnetic material and carries radially disposed magnetic members around its outer periphery adjacent to the stator slots. The magnetic members are arranged to fill slots in the non-magnetic disc and are maintained in position by a metal band.

2500. **Gesellschaft für drahtlose Telegraphie.** High-frequency Alternators. (*British Patent* 147847, July 9th, 1920. Convention date January 19th, 1915. Patent not yet accepted.)

Relates to a H.F. alternator with sections of the armature winding connected in parallel so as to enable the insulation thickness to be reduced.

2501. **B. G. Lamme.** Data and Tests on 10,000 Cycles per Second Alternator. (*Electric Journal*, 28, pp. 110 and 132—136, April, 1921.)

An abridged reprint of a paper read before the American Institute of Electrical Engineers in 1904, describing one of the earliest practical H.F. alternators built by the Westinghouse Electric and Manufacturing Company for M. Leblanc. The design method used is closely similar to methods used to-day.

(E.) Static Frequency Raisers.

2502. **T. Minnohara.** The Use of the Impulsion Wave Method—Frequency Doublers. (*Revue Générale de l'Électricité*, 8, pp. 859—862, December 18th, 1920.)

A continuation of an earlier article by the same author in which mention was made of a special method of operating frequency doublers—there termed the impulsion wave method—in which the effective primary ampere turns are equal to the ampere turns of the direct current winding. The present contribution gives the full development of the saturation curve of the iron cores and a vectorial representation of the conditions of operation. The final section discusses the relation between output and volume of iron core.

2503. **J. F. Peters.** Static Frequency Doublers. (*Electric Journal*, 28, pp. 122—123, April, 1921. *Electrical World*, 77, p. 1382, June 11th, 1921—Abstract.)

An analysis of the mode of operation of transformer frequency doublers.

2504. **R. Swyngedauw.** Resonance of Third Harmonics in Transformers caused by Hysteresis and Saturation of the Iron. (*Revue Générale de l'Électricité*, 8, pp. 299—312, September 4th; pp. 363—373, September 18th, 1920.)

2505. **P. Trichard.** Continuous Wave Transmitter. (*French Patent* 506937, September 13th, 1918. Published September 1st, 1920. *British Patent* 154720, September 5th, 1919. Patent accepted December 6th, 1920.)

The specification describes a frequency multiplier in which two sets of three-electrode valves in parallel are employed. In each valve the grid is connected to the filament through a resistance. In order to multiply the frequency n times, $2n$ valves are used, the grids of which are excited by $2n$ potentials obtained by adding constant potentials furnished by accumulators to $2n$ alternating potentials forming two n-phase systems, the valves being assembled in parallel in two groups fed by two equal batteries of accumulators.

2506. **P. Mauv** and **V. Bontron.** On a Static Frequency Multiplier. (*Revue Générale de l'Électricité*, 9, pp. 523—527, April 16th; p. 204D, June 25th, 1921.)

Use is made of a three-electrode valve having a steady negative voltage upon its grid as well as the impressed A.C. voltage. The normal negative voltage of the grid is sufficient to reduce the plate current to zero, and the amplitude of the alternating current is adjusted so that the plate current flows for any desired fraction of the alternation. By combining together n such similar arrangements fed from an n phase supply, the initial frequency can be multiplied n times.

2507. **Gesellschaft für drahtlose Telegraphie.** Frequency Multiplying Apparatus. (*British Patent* 147444, July 7th, 1920. Convention date October 26th, 1918. Patent not yet accepted.)

Relates to transformer frequency raising apparatus having the primary and secondary circuits tuned to more than one multiple of the fundamental so that further frequency raising is accomplished by successive reflections between primary and secondary circuits on the lines of the Goldschmidt H.F. machine.

2508. **P. Trichard.** Frequency Changers. (*British Patent* 160179, March 16th, 1921. Convention date March 16th, 1920. Patent not yet accepted.)

An arrangement for doubling the frequency of a single phase supply by the use of two thermionic valves in parallel, as indicated in Fig. 3, in which the input transformer-fed single phase supply is shown at T_1 and the output transformer at T_2. This may be connected to a second similar frequency doubling stage.

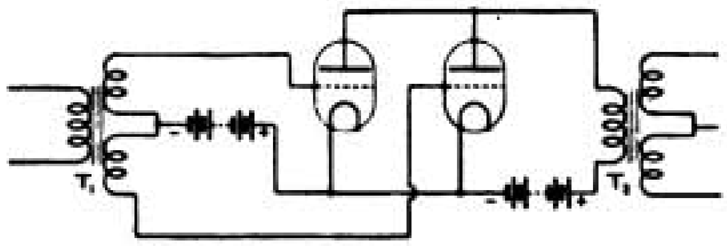

FIG. 3.

2509. **Gesellschaft für drahtlose Telegraphie.** Wireless Transmitting Apparatus. (*British Patent* 147702, July 8th, 1920. Convention date February 26th, 1914. Patent not yet accepted.)

Relates to choking apparatus inserted in the D.C. magnetisation circuit of static frequency multipliers.

2510. **Gesellschaft für drahtlose Telegraphie.** Static Frequency Transformers. (*British Patent*, 154885, October 26th, 1920. Convention date December 2nd, 1919. Patent not yet accepted.)

Relates to means for stabilising the static frequency raiser during keying.

2511. **P. Trichard.** Continuous Wave Transmitter. (*French Patent* 506295, September 9th, 1918. Published August 18th, 1920.)

The invention consists in a static frequency multiplier wherein to increase the frequency *n* times *n* thermionic three-electrode valves are employed. (See also RADIO REVIEW Abstract No. 2505 above.)

(F.) Thermionic Valves, and Valve Apparatus.

(2) GENERAL DESCRIPTIVE ARTICLES.

2512. **W. C. White.** The Vacuum Tube as an Engineering Problem. (*Scientific American*, 124, pp. 125, 138, February 12th, 1921.)

Discusses the need for more careful observation of the rating of a tube in connection with the work it is to perform—more on the lines of ordinary electrical machinery.

2513. **W. D. Owen.** Thermionic Amplifiers. (*Electrical Review*, 88, pp. 528—529, April 22nd, 1921.)

An abstract of lecture delivered before the North-Eastern Centre of the Institution of Electrical Engineers at Newcastle-on-Tyne on February 28th and giving a general description of the mode of operation of thermionic valves as amplifiers and oscillation generators.

2514. **E. F. Huth** and **S. Loewe.** Vacuum Tube Generator. (*German Patent* 310793, November 14th, 1917.)

A circuit in which the filament heating current is derived from the oscillatory current generated. An anode voltage source (V) only is used. (See Fig. 4.)

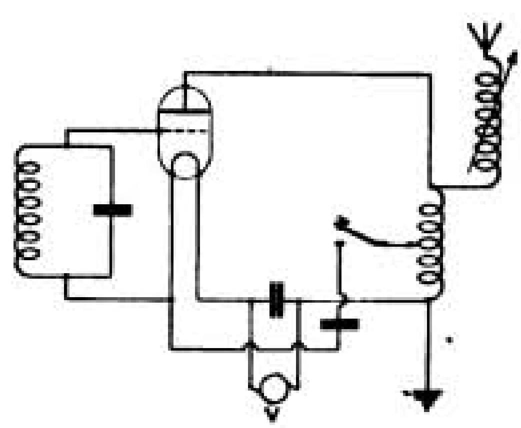

FIG. 4.

2515. **R. L. Smith-Rose.** The Evolution of the Thermionic Valve. (*Journal Télégraphique*, 45, pp. 41—46, March 25th; pp. 61—66, April 25th; pp. 81—86, May 25th, 1921.)

A translation of an article published in the *Journal of the Institution of Electrical Engineers*, April, 1918.

2516. **J. O. G. Cann.** The V24 Triode Valve. (*Q.S.T.*, 3, pp. 19—20, July, 1920.)

A short account of the chief properties of this valve.

2517. Thermionic Valves. (*Engineer*, 131, p. 610, June 10th, 1921.)

A summary of the chief points in the development of three-electrode valves.

2518. **R. A. Heising** [Western Electric Company]. Thermionic Valve Apparatus. (*British Patent* 146519, July 5th, 1920. Convention date October 2nd, 1916. Patent not yet accepted.)

The negative potential for the grid of a valve is derived from a resistance in the grid circuit of another oscillating valve to avoid the use of a separate battery.

2519. **Compagnie Française pour l'Exploitation des procédés Thomson-Houston.** Valve Multiplier. (*French Patent* 508169, January 6th, 1920. Published October 4th, 1920.) Also **J. H. Payne** [British Thomson-Houston Co.]. (*British Patent* 148128, July 9th, 1920. Convention date January 3rd, 1919. Patent not yet accepted.)

A negative potential is maintained on the grid of a low-frequency thermionic amplifier or modulator by impressing on the grid circuit currents of radio-frequency derived from the grid leak of an oscillating valve.

2520. **W. C. White.** Some Operating Characteristics of Electron Tubes. (*Journal of the Franklin Institute*, 191, pp. 473—492, April, 1921. *Wireless Age*, 8, pp. 11—17, July, 1921. *Radio News*, 2, pp. 776—777 and 800—806, May, 1921. *Revue Générale de l'Électricité*, 9, p. 207D, June 25th, 1921—Abstract. *Science Abstracts*, 24B, p. 366, Abstract No. 758, July 30th, 1921—Abstract.)

The paper aims at furnishing practical information with regard to the use of vacuum tubes both for experimental and practical radio work and follows similar lines to that referred to in Abstract No. 1930, June, 1921. He discusses in somewhat greater detail the points there discussed. Aluminium lightning arresters for the protection of the H.T. machines supplying oscillating valves are described and illustrated. It is suggested that the operation of a radio telephone transmitter may very conveniently be watched by inserting a small tungsten filament lamp in the plate circuit of the modulator tube, the lamp being so chosen that normally it burns at a dull red. When the microphone is spoken to the lamp flashes up and thus indicates whether the modulation tube is operating correctly.

2521. **H. Gernsbach.** A Cold Cathode Vacuum Tube. (*Radio News*, 3, p. 93, August, 1921.)

A short note giving preliminary details about a new vacuum tube developed by **Dr. J. E. Lilienfeld** using a cold cathode which is stated to be suitable for use as detector, amplifier or oscillation generator.

2522. **J. Marsten.** Operation of Vacuum Tubes in Parallel. (*Radio News*, 3, p. 106, August, 1921.)

2523. **H. B. Sherman** and **S. R. Parker.** The Development of the Thermionic Valve and its Application to Telephony. (*Journal of the Engineering Institute of Canada*, 4, pp. 456—459, August, 1921.)

A general description of the valve and its use as a repeater.

(3) Theory and Physics of Thermionic Valves.

2524. **P. Heegner.** Theory of the Triode Oscillator with Intermediate Circuit. (*Archiv für Electrotechnik*, 9, pp. 127—152, August, 1920. *Electrical World*, 76, p. 937, November 6th, 1920—Abstract. *Science Abstracts*, 24B, p. 55, Abstract No. 112, January 31st, 1921—Abstract.)

A very thorough analytical investigation of the phenomena in a triode oscillator in which the oscillatory anode circuit is coupled with another oscillatory circuit. The effects of variations of capacity and inductance with different degrees of coupling are investigated and the technical application of the results obtained is discussed with the aid of numerical examples.

2525. **G. Stead.** Effect of Electron Emission on the Temperature of the Filament and Anode of a Thermionic Valve. (*Journal of the Institution of Electrical Engineers*, 59, pp. 427—432, April, 1921. *Electrical Review*, 88, p. 354, March 18th, 1921. *Nature*, 107, p. 216, April 14th, 1921—Abstract. *Technical Review*, 9, p. 128, May 24th, 1921—Abstract.)

Paper read before the Wireless Section of the Institution of Electrical Engineers; also discussion. See RADIO REVIEW, 2, pp. 170—171, April, 1921, for abstract of paper.

2526. **H. Busch.** The Electric Heating of Wires in a Partial Vacuum. (*Annalen der Physik*, 64, pp. 401—450, March 10th, 1921. *Science Abstracts*, 24A, p. 356, Abstract No. 885, May 31st, 1921—Abstract.)

A very comprehensive experimental and theoretical investigation of the properties of wires heated electrically in hydrogen at various pressures. Iron and nickel wires were used as in the well-known ballast resistances.

2527. **B. van der Pol.** Amplitude of Free and Forced Triode Vibrations. (*Technical Review*, 9, p. 79, May 3rd, 1921—Abstract. *Radioélectricité*, 1, p. 115D, April, 1921—Abstract.)

See Radio Review, 1, pp. 701—710, November, 1920; and pp. 754—762, December, 1920.

2528. **B. S. Gossling** and **J. W. Hyde.** The Ionisation Potential of Helium. (*Radio Review*, 2, pp. 75—77, February, 1921. *Radioélectricité*, 1, p. 141D, June, 1921—Abstract.)

2529. **L. S. Palmer.** The Effect of Impurities on the Ionisation Potentials measured in Thermionic Valves. (*Radio Review*, 2, pp. 113—125, March, 1921. *Science Abstracts*, 24B, pp. 315—316, June 30th, 1921—Abstract.)

2530. **J. A. Fleming.** A Note on the Theory of the Thermionic Tube. (*Radio Review*, 2, pp. 133—136, March, 1921. *Science Abstracts*, 24B, p. 368, Abstract No. 762, July 30th, 1921—Abstract.)

2531. **M. v. Laue.** Equilibrium Conditions for Electron Emission from Glowing Bodies. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 199—218, September, 1920. *Science Abstracts*, 24A, p. 291, Abstract, No. 700, April 30th, 1921—Abstract. *Radioélectricité*, 1, p. 97D—99D, March, 1921—Abstract.)

A theoretical investigation of the conditions in the space charge both for parallel plates, one of which is the emitting body, and for the cylindrical case with an axial heated wire. The results show good agreement with Langmuir's measurements. On some points the article is a reply to criticisms made by **Schottky** on a previous paper by the author.

2532. **A. C. Bartlett.** Triode Valve Designs. (*Science Abstracts*, 24B, pp. 215—216, Abstract No. 439, April 30th, 1921—Abstract.)

See Radio Review, 1, p. 744, November, 1920.

2533. **T. C. Fry.** The Thermionic Current between Parallel Plane Electrodes; Velocities of Emission distributed according to Maxwell's Law. (*Physical Review*, 17, pp. 441—452, April, 1921. *Science Abstracts*, 24A, p. 445, Abstract No. 1145, June 30th, 1921—Abstract.)

The electrical equations applying to this problem are developed without neglecting the distribution of initial velocities. Maxwell's distribution of velocities is then considered in detail and the complete solution obtained. Curves from which to compute the space current are given for the cases when Maxwell's distribution applies; and curves are also included showing the deviation of the characteristic curves from the $\frac{3}{2}$-power law.

2534. **E. M. Sargent.** Conduction of Electricity through Vacuum and Gases with Applications to Design of Radio Apparatus. (*Radio News*, 2, pp. 694, 746 and 748, April; pp. 782 and 816, May, 1921.)

A general article on the theory of electronic conduction in valves.

2535. **K. Mühlbrett.** The Grid Current in Amplifier Valves. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, pp. 288—294, April, 1921. *Science Abstracts*, 24B, p. 367, Abstract No. 760, July 30th, 1921—Abstract. *Radioélectricité*, 2, p. 5D, July, 1921—Abstract.)

In valves containing an appreciable amount of gas, the grid current reverses for negative grid voltages due to ions passing to the grid. Between — 1 and — 4 volts the slope of the grid current curve may be negative, corresponding to a negative resistance to oscillations. This was confirmed by inserting an oscillatory circuit in the grid current; oscillations could be detected in a telephone receiver connected to the secondary of the transformer, the primary of which constituted the inductance of the oscillatory circuit.

2536. **G. Jaffé.** The Theory of the Vacuum Discharge. (*Annalen der Physik*, 64, pp. 733—744, April 29th, 1921.)

A theoretical discussion of the characteristics when the effect of remanent gas is taken into account.

2537. **J. E. Lilienfeld.** The Theory of the Vacuum Discharge. (*Annalen der Physik*, 64, pp. 745—749, April 29th, 1921.)
A criticism of some of the conclusions drawn by **Jaffé**. See preceding Abstract.

2538. **F. Horton** and **Miss A. C. Davies.** Critical Electron Velocities for the Production of Luminosity in Atmospheric Neon. (*Philosophical Magazine*, 41, pp. 921—940, June, 1921.)

2539. **J. R. Carson.** The Equivalent Circuit of the Vacuum Tube Modulator. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 243—249, June, 1921.)
If a voltage E_g is impressed between the grid and filament of a triode in the anode circuit of which is a load impedance z the operation of the device as a modulator may be correctly described by postulating an E.M.F. of value $M\left(\frac{\mu R_0}{R_0 + z} E_g\right)^2$ impressed on the load impedance z through a resistance R_0 (internal resistance of tube). The modulator factor M is equal to $\frac{1}{2R_0}\frac{\partial R_0}{\partial E_a}$ where E_a is the anode voltage. μ is the voltage factor of the triode.

2540. **G. Holst** and **E. Oosterhuis.** The Electrical Conduction in Gases. (*Physica*, 1, pp. 78—87, June, 1921.)
Experiments on the conduction in argon and neon both with cold and with hot cathodes.

2541. **F. Trautwein.** The Thermionic Valve as a Measuring Instrument. (*Telegraphen- und Fernsprech-Technik*, 10, pp. 69—74, June, 1921.)
A continuation of a previous paper on the same subject. The present paper deals in the first place with the rectifying amplifier, in which the grid is made so negative that only the positive half waves produce the anode current, which is used to measure the P.D. applied to the grid. This is then extended to the use of multi-stage amplifiers for the measurement of small alternating voltages. The final section of the paper deals with the measurement of small alternating currents by superposing them upon the steady filament heating current of a diode or triode and measuring the charge produced in the saturation current. The galvanometer in the anode circuit is compensated for the steady anode current; several ways of doing this are described and test results are given showing the time required for the reading to get steady after altering the heating current. Various methods are discussed whereby the alternating current can be superposed upon the heating current and specially constructed two-electrode valves are recommended with high resistance filaments to increase the sensitiveness of the method.

2542. **E. Dubois.** On the Minimum Electric Discharge Potential in Hydrogen at Low Pressures. (*Comptes Rendus*, 173, pp. 224—225, July 25th, 1921; pp. 293—294, August 1st, 1921.)
Deals with some experimental investigations on discharge voltages and on the absorption of gas in the discharge tubes.

2543. **J. Marsten.** Characteristic Curves. (*Wireless Age*, 8, pp. 33—35, August, 1921.)
Discusses the various types of valve characteristics.

2544. **L. C. Pocock.** The Thermionic Tube—A Return to Simplicity. (*Electrician*, 87, pp. 232—234, August 19th, 1921.)
The writer points out that in most articles dealing with the theory of the thermionic valve complicated differential equations are evolved, the results of which are subsequently rendered useless by simplifying assumptions. Making the assumptions that (1) the grid current is zero; (2) the capacity currents are negligible, and (3) the grid voltage—plate current curve is linear, the author discusses in a simple way the following points: Amplification factor, effective amplification, the proportions of the circuit, dynamic characteristics, and the oscillating tube with vector diagrams.

2545. **E. V. Appleton** and **B. van der Pol.** On the Form of Free Triode Vibrations. (*Philosophical Magazine*, 52, pp. 201—220, August, 1921.)
An oscillographic investigation of the variations of the anode current in a self-excited triode valve. A method of estimating the amplitude of the anode current variations is given in terms of the oscillation characteristic and the circuit constants. The cooling of the

valve due to the electronic emission is considered and its effect shown to be only marked at very low frequency of oscillations. For very high frequencies the emission is sensibly constant, so that the dynamic characteristic is generally but slightly different from the one deduced from a knowledge of the static characteristic and the circuit constants. The possibility is also considered of omitting the filament heating battery, the filament being maintained at the necessary working temperature by the effect of the emission current itself when once started.

2546. **Research Staff of the General Electric Company (London).** The Disappearance of Gas in the Electric Discharge—III. (*Philosophical Magazine*, 42, pp. 227—246, August, 1921.)

A continuation of previous work with the object of clearing up certain difficulties.* It is shown that the absorption of the gas is proportional to the ionisation.

2547. **A. W. Hull.** The Effect of a Uniform Magnetic Co-axial Cylinders. (*Physical Review*, 18, pp. 31—57, July, 1921.)

Equations of motion are developed for electrons starting from a cylindrical cathode and moving towards a co-axial cylindrical anode in a uniform magnetic field parallel to the common axis. The electrons will reach the anode if the ratio of potential difference to magnetic field is greater than the critical value and will fail to reach it if this ratio is less than this value. Formulæ are given expressing this critical value under different simplifying conditions as to the relative size of the two cylinders, and it is shown that when both cylinders are at the solution reduced to the familiar one of plain parallel plates the equation of the path of the electrons is deduced from the assumption that the space charge distribution is the same as without the magnetic field. Experimental curves taken under different conditions are in agreement with the theory within the limits of experimental error.

2548. **L. Page.** Theory of the Motion of Electrons between Co-axial Cylinders taking into account the Variation of Mass with Velocity. (*Physical Review*, 18, pp. 58—61, July, 1921.)

A continuation of theoretical work by A. W. Hull (see previous Abstract), and indicating an experimental method for verifying the theoretical formulæ.

(4) Design and Construction of Valves.

2549. **Société Gallot et Cie.** Valve Construction. (*French Patent* 498178, April 24th, 1918. Published December 31st, 1919.)

The invention has for its object an arrangement permitting the feeding of the incandescent cathode when the apparatus is in use by a two-core flexible cable in such a manner as to keep the cable away from other objects in the vicinity of the valve. The cable is put under tension by the means of a spring which is fixed at one end and at the other is attached to the shackle of a pulley over which the cable passes.

2550. **H. J. Round.** Thermionic Valves. (*British Patent* 154982, September 3rd, 1919. Patent accepted December 3rd, 1920. *Engineer*, 131, p. 85, January 21st, 1921—Abstract.)

To reduce the unevenness of the heating of the filament in a valve in which the emission current is of the same order as the filament current, a number of tappings are made to the filament and connected together through resistances to form the anode circuit connection.

2551. **B. S. Gossling** and **A. C. Bartlett** [General Electric Company, London]. Thermionic Valves. (*British Patent* 164175, March 19th, 1920. Patent accepted June 9th, 1921.)

A thermionic valve having cylindrical control electrodes situated at either extremity of the filament for the purpose of controlling saturation.

2552. **Le Matériel Téléphonique.** Valve Construction. (*French Patent* 504569, March 8th, 1918. Published July 8th, 1920.)

The specification describes more particularly a cathode for emitting electrons, the said cathode comprising a filament of platinum or similar metal coated with a coating formed of one part of a thermionically active substance, and one part of a noble metal such as platinum,

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* Radio Review Abstract No. 1438, February, 1921.

gold or silver. The coating can be formed of oxide of barium or oxide of strontium or of these two oxides mixed with oxide of calcium.

2553. **Société Française pour l'Exploitation des procédés Thomson Houston.** Valve Construction. (*French Patent* 504591, October 6th, 1919. Published July 8th, 1920.)

The invention relates to vacuum discharge devices and particularly to the construction of the electrodes. The cathode is in the form of a helical filament and the grid consists of a filament wound round the cathode. The anode is a cylinder surrounding the cathode and is supported by two arms, one on each side.

2554. **E. F. Huth.** Hot Cathode Tube. (*German Patent* 310132, April 18th, 1918. Patent granted November 14th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 224, March, 1921—Abstract.)

A thermionic valve with grid and anode plates on opposite sides of the filament. The centre of the grid surface is made concave with respect to the filament.

2555. **E. H. F. Müller.** Vacuum Tube Relay. (*German Patent* 316363, July 27th, 1917.)

A valve of cylindrical design, the spiral grid of which may be rendered incandescent.

2556. **E. F. Huth** and **S. Loewe.** Vacuum Tubes for Relays, Amplifiers, etc. (*German Patent* 305665, March 21st, 1917. Patent granted October 4th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 17, p. 224, March, 1921—Abstract.)

A vacuum tube with a grid and an anode on opposite sides of a single filament. The grids and anodes are so arranged that if one anode current is increased the other is reduced in magnitude.

2557. **L. Guinet.** Vacuum Tube Construction. (*French Patent* 506944, December 26th, 1918. Published September 1st, 1920. *British Patent* 144305, June 3rd, 1920, Convention date December 26th, 1918. Patent not yet accepted.)

The grid and anode of a vacuum tube are in the form of plates of flat or curved shape, one on each side of the cathode. The plates may be corrugated or of "U" shape or the anode may be concave with respect to the grid.

2558. Modern Methods of Valve Manufacture. (See pp. 537—544 in this issue.)

2559. Vacuum Tube Construction. (*Wireless Age*, 7, p. 23, March, 1920.)

An illustrated abstract of a patent by **F. P. Driver** dealing with the means of supporting the electrodes of thermionic valves.

2560. **Société Anonyme pour l'Exploitation des procédés M. Leblanc-Vickers.** Electric Discharge Devices. (*British Patent* 161587, April 14th, 1921. Convention date April 15th, 1920. Patent not yet accepted.)

The grid of a thermionic valve containing mercury vapour or an inert gas such as argon consists of two or more parallel elements the openings in which are staggered relative to one another. The grids may all be maintained at the same potential or the ones nearer the anode may be at a lower potential than those nearer the cathode.

2561. **Western Electric Company, U.S.A.** Electric Discharge Apparatus. (*British Patent* 161619, November 28th, 1919. Patent accepted March 29th, 1921.)

Relates to a means for constructing the grid electrodes of thermionic valves.

2. Books.

MODERN HIGH SPEED INFLUENCE MACHINES: Their Principles, Construction and Applications to Radiography, Radiotelegraphy, Spark Photography, Electro-culture, Electro-therapeutics, High-tension Gas Ignition, The Testing of Materials, etc. By V. E. Johnson, M.A. (London: *E. and F. N. Spon, Ltd.* 1921. $8\frac{1}{2}'' \times 5\frac{1}{2}''$. Pp. viii + 278, with 93 illustrations. Price 14*s*. net.)

The subject with which this book deals is, as the author points out, one which has been almost completely neglected, and a treatise dealing with it is to be welcomed as a step towards the opening out of very great possibilities in machines for the direct generation of high pressure continuous current. We must confess however that the book leaves us with a sense of disappointment. It gives the result of many experiments which the author has carried out and describes many machines which he has constructed, but it gives little sign of any attempt to develop the machine along sound engineering lines or in accordance with the fundamental principles which underlie their design and operation. It is particularly to be regretted that no application has been made of the theory of the machines as given by Gray in his book on influence machines, which is referred to by the author and is obviously well known to him. Gray's book indicates very clearly certain sources of inefficiency which are necessarily present in the ordinary influence machine and which must be avoided if a really satisfactory one of high power is to be evolved, but the author has apparently made no attempt to apply these in practice. We would suggest also that before the design of these machines can be regarded as upon a footing in any way approaching that of a dynamo it will be necessary to discard the theory well-beloved by antiquated text-books and still adhered to by the author, in which unlike charges attract and like ones repel. It would, we fear, be very difficult to base the calculation of the magnetic circuit of a dynamo on the forces existing between imaginary north and south poles, and in the same way to really understand the action of an influence machine it is necessary to think of the electrostatic field between the various parts. The "like and unlike charge" theory is in fact quite capable of leading one astray, and in particular we would mention the theory of the action of the Wimshurst machine as given on page 41, which if examined quantitatively would show that the excitation of the machine would diminish instead of increasing. The true reason for increase of charge, viz. the edge effect between the earthed section and neighbouring ones has apparently been omitted.

The developments made by the author appear to be chiefly in the direction of increase of speed, a movement which is certainly along the right lines, as machines in the past have owing to their faulty mechanical construction been run at speeds much lower than the strength of the materials employed would allow. Further developments appear in the use of a triplex system of plates, in which one moving plate is influenced on both sides although this had been adopted by other workers previously. The use of grooved plates in order to increase the surface is a little difficult to follow and we certainly are surprised that the author has accepted without comment Wehrsen's claim to increase the capacity of a condenser by corrugating one of the coatings which is in effect what his corrugated sectors amount to. Apparently the reason for the increase in output with grooved plates is the difficulty in properly collecting the charge off a sectorless disc, and it is fairly clear that the material which is the ideal for an influence machine disc would be one having very good insulation along its surface in one direction while it would be conducting in a direction at right angles to it. The ordinary sectored disc is at best a poor substitute for this.

We believe that the suggested use of what may be termed "multipolar" designs of influence machine which is to be found in the book is novel and is one which will bear fruit particularly in machines of large size and comparatively low voltage such as might be used for wireless purposes, but we can scarcely agree with the development of machines with 10-foot discs which the author repeatedly advises. A little consideration of the centrifugal force acting on the discs and of the factors governing the output will show that if the machine is made two-polar the current output for a range of machines in which the centrifugal force at the edge of the discs is constant will be proportional to the 1·5th power of the radius of the disc while if the machine is made multipolar and all the machines are designed for the same voltage, the output will be proportional to the 2·5th power. It is rather unlikely that the weight and cost of the machine for really large sizes will vary at a rate less than the cube of the disc diameter, so that apparently an excessively large disc is not as the author suggests an economical use of material.

The weakest portion of the book is undoubtedly that dealing with numerical results, and here we must confess to a certain amount of scepticism. For example, the author claims to have produced a machine giving from 60 to 120 times the current of an equivalent Wimshurst with an increase in spark length, *i.e.* in voltage. The Wimshurst machine would, we believe, give a current of 15 to 20 microamperes at 100,000 to 120,000 volts, *i.e.* from 1·5 to 2·4 watts. Taking 2 watts as an average figure and taking a ratio of 100 to 1 as representing the author's claim to improvement, this gives an output of 200 watts from his machine. We note that he does not claim an efficiency of more than 45 per cent. nor do we think it possible with his arrangement so that the power input would be 445 watts or 0·605 h.p.

In view of the fact that the machine in question is manually driven the improvement effected can hardly be as great as claimed unless the comparison has been made with a machine which is much below the ordinary standard. There are several other discrepancies which will be found if the figures are looked into closely. For example on page 188 we see that the current which should have been 1·5 to 2 milliamps would not move the needle of the milliammeter, and is estimated by the author as less than 0·1 milliamps.

Again an illustration is given of a ¼ h.p. electrostatic motor, but we are unable to trace any evidence that it ever gave this power, nor do we think it at all possible, as it clearly states that the generator gave more current than the motor could absorb. Allowing 50 per cent. for motor efficiency and 45 per cent. for the generator we obtain the same impossible figure for the author's output of horse power.

We note again on page 269, that *Q* the quantity of electricity is given in Joules, which of course is incorrect, but sufficient has been said of the book's deficiencies. On its behalf we would say that it is suggestive and that the author has clearly made a very careful study of all that has been done on the subject, and on this account alone it deserves the attention of any one interested in this important but hitherto neglected branch of applied electricity.

E. A. WATSON.

THE ELECTRICAL TRANSMISSION OF PHOTOGRAPHS. By Marcus J. Martin. (London : *Sir Isaac Pitman & Sons, Ltd.* 1921. Pp. xi + 136. 7″ × 4½″. Price 6s. net.)

This book has been written as an attempt to condense into a useful and concise tome a description of the methods of transmission of photographs by electricity, their progress and application. A portion of the subject-matter appeared in series form in the *Model Engineer and Electrician* and these enlarged and with an historical introduction form the basis of the work.

Starting with an interesting description of the early history and experiments, the author describes the various known methods which have been employed culminating in the invention and development by Professor Kom of the selenium operated machine, followed by the later-known developments of the telautograph, telestereograph, telectrograph, etc. The difficulties and shortcomings as well as the accomplishments of these methods of transmission are well and ably dealt with.

Television has a chapter to itself, several methods of presenting an actual instantaneous visual impression of the distant object are described, the greatest obstacle and defect of all known methods being the human visual defect of persistence of vision.

Wireless transmission has only five pages allotted to it, the author having dealt fully with this portion of the subject in his book on "The Wireless Transmission of Photographs." *

The author has had a considerable experimental and practical experience on his subject and in order to assist those who desire to experiment themselves, a chapter has been included containing full working drawings and descriptions of apparatus similar to that used by the author himself in his investigations.

There might have been included a few modern examples of telegraphed photographs, but apart from this the book is well and fully illustrated.

E. A. GORDON.

ELECTRICITY AT HIGH PRESSURES AND FREQUENCIES. By H. L. Transtrom. (Chicago: *The Joseph G. Branch Publishing Co.* Second Edition. 1921. Pp. xi + 247. 7½″ × 5″. With 141 Illustrations. Price $2.50.)

The book is ostensibly written to bring to the notice of practical electrical workers the wonders of high frequency high voltage electrical phenomena in a not too technical manner. Actually it would seem to be a book best suited for the experimenter, in spite of the author's brief discourse (in the preface) on the trend of modern practice in high voltage power transmission lines.

The first 164 pages in the book are devoted to general electrical principles and to explanations of the mode of operation of dynamos, transformers, etc., while the remainder treats purely of the effects and phenomena exhibited by high frequency currents obtained from the so-called "Tesla" coils. Many spectacular experiments with these currents are described and

* "The Wireless Transmission of Photographs." (The Wireless Press, Ltd.)

illustrated, and what is more important for the experimenter, data is given in most cases of the actual construction of the coils, condensers, etc., that may be employed. The reader is thus enabled (if he so desires) to reconstruct the apparatus and to repeat the experiments.

P. R. C.

The Year Book of Wireless Telegraphy and Telephony, 1921. (London: *The Wireless Press, Ltd.* 1921. Pp. lxxxiv + 1355. 8″ × 5″. Price 21s. net.)

The 1921 issue of the Year Book maintains the level of interest and usefulness, to the wireless man, reached by preceding editions.

The volume begins with a calendar section containing, on the pages devoted to 1921, many date references to outstanding scientific discoveries—most interesting reminders of the pioneer work done by the early enthusiasts. A few lines of postal information added to this section would prove useful (although possibly it is considered that the changes of rates are too frequent nowadays to justify it !). Four pages of "Official Holidays" serve to remind the wireless man that if he is not on holiday, others are, and yet others recovering therefrom.

An interesting section of twenty pages is that devoted to a "Record of the Development of Wireless." One looks in vain, however, for the name of Lodge in these pages. Surely Lodge's early recognition of, and insistence on, the necessity for tuning should appear here under date. The reader must turn to p. 1149 where, in Professor Howe's article, he will find full justice done to the work of this pioneer. Under 1879 we find Hughes' discovery of coherer action mentioned, but it is of interest to remember also that Hughes, by his experiments over 500 yards' distance, really demonstrated the existence of electric waves, although the meaning of his results was not at that time appreciated. Should not the date of the discovery of the "Edison effect" find a place ? Also the date of the addition of the "grid" by De Forest, as fixing the genesis of the triode ?

A large section of the book is that devoted to International Laws and Regulations. The texts of the International Radiotelegraphic Convention, and of the Convention on Safety of Life at Sea are followed by the wireless laws and regulations of all countries of the world, arranged in alphabetical order, from Abyssinia to Zanzibar. Not the least useful feature of this section is the inclusion of maps showing the location of wireless stations, and brief descriptions of the country concerned.

The Directory of the World's Wireless Stations, which forms the next section, and one of the most useful, has been enlarged by the addition of about 30 per cent. to the list of call letters of land and ship stations.

The article on "Radio Communication and Meteorology," by Lieut.-Colonel E. Gold, is repeated from the previous edition, with slight additions, as also is the article on "Wireless and Time," by the Secretary of the Royal Geographical Society, Mr. A. R. Hinks.

The section on "International Time and Weather Signals" has been extended. One notes that the circular clock diagrams of the Paris signals have been replaced by clearer straight-line diagrams, but errors have crept in here. The number of dashes between 1044 and 1045 should be nineteen, not eighteen. Similarly there are fourteen "d's," not thirteen, between 1046 and 1047.

The section entitled "National Résumés," being a series of short articles by well-known writers on the progress of wireless in various countries, contains much of interest.

A series of four special articles follows. Mr. P. R. Coursey writes on the Interference Problem, Mr. Stuart Ballantine on the Radio Compass, Professor Howe on "Historical Landmarks in Wireless Invention," and Mr. F. P. Swann on "Valve Amplifiers for Shipboard Use," the last article describing the use of a four-electrode valve. All these articles are worth study. Reference to Professor Howe's article, in which justice is done to Lodge's early work, has already been made.

The Patent Section by Mr. J. Shoenberg is a very useful section for reference, and is complete with name and subject indexes of 1920 patents, both British and American.

The Aviation Section by Lieut.-Colonel H. B. T. Childs has been enlarged, further data on aviation stations, marking of aircraft, etc., having been added.

The "Useful Data" Section comes next, and has been slightly enlarged. Regarding the list of definitions, although it is true that there may be (as found by Kipling's Neolithic Poet, in the case of tribal lays) "nine-and-sixty ways" of constructing a definition, yet one feels that some of those given here could hardly be included. For instance, "Ampere turn" is defined as the unit of mmf without any reference to 4π. (Not that any one wants 4π in it, but things go wrong if you calculate without !) Then again, " Self-inductance of a circuit " is defined as " *that portion* of the inductance . . ." But why " that portion " ? Surely " inductance " and " self-inductance " are always regarded as synonymous terms. Further the definition of " inductance " clearly refers to self-linkage only. " Natural frequency " is defined as that " with which a circuit will oscillate when supplied with energy and left to itself." While this is true for " lumped " inductance and capacity, it should be made clear that it does not apply to such a circuit as an open solenoid, which has many natural frequencies at which it will oscillate if supplied with a suitable distribution of energy, and left to itself. The definition of " Mutual inductance " as energy seems hardly to convey as clear an idea—especially to the beginner—as by employing the conception of linkage of magnetic lines with the electric circuit.

On p. 1250 are given data on " Distance of Horizon at Sea." Although the figures at the bottom of the page are approximate, one notes that they are given to an accuracy of one part in thousands and, curiously enough, nearly all differ by about 8 per cent. from the theoretical figure given by the formula above. Possibly atmospheric refraction (in reading the slide rule) accounts for the discrepancy.

In the list of " Conventional Signs used in Wireless Diagrams," the battery polarity shown is unconventional. See correct polarity in diagrams (1) and (2) on preceding page. In circuit (2) should not " r " instead of " R " appear in the final formula ?

A few pages are devoted to a list of companies engaged in the commercial development of wireless, and are followed by a Biographical and Obituary Notice Section which affords personal touches which are invariably of interest.

There is a very useful list of Wireless Literature, including books and articles on the subject arranged in alphabetical order. Under " Periodicals " on p. 1327 one misses the *Proceedings of the I.E.E.* which contains accounts of the activities of the Wireless Section. The corresponding American journal is mentioned.

The Amateur Section consists of a short article by Mr. E. Blake giving an account of amateur activity during 1920, and a directory of wireless societies. Considering the importance of the amateur to the progress of wireless (as well expressed on p. 1129 of the 1920 Year Book), the size of the section devoted to his activities seems rather small, although it must be recollected that other sections of the book appeal to the amateur, as well as to those engaged professionally. It is of great importance that the amateur movement should not be hampered by restrictive legislation, and it is to be hoped that the present law requiring every receiving apparatus to be licensed will be abolished, if only for the reason that illicit receiving with modern apparatus cannot be detected when no external aerial is used.

Regarding the word " amateurism," one rather wishes for a more pleasing word to express the same idea.

The volume concludes with a list of Wireless Telegraphy Courses in Colleges and Schools, and a Code Section giving the Morse signs.

There is a good alphabetical index at the beginning of the book.

R. C. CLINKER.

LONGUEURS D'ONDE ET PROPAGATION. By P. Viellard, with a Preface by General Ferrié. (Paris : *Gauthier-Villars et Cie.* 1921. 10" × 6½". Pp. xii + 416. Price 55 frs.)

The scope of this book is indicated by the sub-title " Étude théorique de la T.S.F. extérieure," that is to say, it deals with the mathematical theory of that part of the subject which is external to the four walls of the station. General Ferrié has written a brief preface outlining the need for and the scope of the work. The book is divided into two parts of which the first deals with the oscillations produced in the aerial and the length of the wave produced, whilst the second deals with the propagation of the waves over the earth's surface, their attenuation due to various causes and their effect on the receiving aerial. A chapter is devoted to aeroplane aerials and another to the losses occurring in the masts and the reradiation of energy from the masts.

The author assumes a considerable knowledge of mathematics and of electromagnetic theory. The subject is approached from the point of view of the mathematical physicist rather than that of the electrical engineer, but it is that of a mathematical physicist who is thoroughly conversant with the practical details of radiotelegraphy. At many points throughout the book one is given actual measured results to compare with the values obtained by theory and at the end of Part II. is a chapter giving a *résumé* of the principal results arrived at and their application to the calculations necessary in planning and designing a radiotelegraphio station.

Although the names of previous workers in the subject are sometimes mentioned, there is hardly a reference to enable one to look up any previous publication. This is undoubtedly a serious defect in a book of this advanced specialist type. The volume forms, however, a useful addition to the literature of the subject and will be specially welcomed by those who, already having some knowledge of the subject, wish to make a special study of the theory of the aerial.

G. W. O. H.

Die neuere Entwicklung der Funkentelegraphie; ein Siegeszug der Vakuumröhre. By H. Wigge. (*Cöthen. Anhalt*, "*Ingenieur Zeitung*." Second Edition. 9" × 6". Pp. 71. Price not stated.)

This is a semi-popular description of the action of the thermionic valve and its manifold applications. It contains hardly a single mathematical symbol, but diagrams of connections are given of almost every known way of using the valve for detecting amplifying and generating oscillations. A section is devoted to the practical application of the triode to various branches of radiotelegraphy and a section to radiotelephony. The book concludes with a useful classified bibliography of the subject. The descriptions are simple and clear, the diagrams are fairly good, but the photographic reproductions are as poor as any we have ever seen.

G. W. O. H.

Einfuhrung in die Elektrotechnik. By Otto Nairz. (Leipzig: *J. A. Battle.* 10" × 6¼". Pp. viii + 415, with 351 figures. Price unbound 18M., bound 25.20M.)

This introduction to electrotechnics is based upon lectures delivered at Charlottenburg by Professor Slaby, one of the founders of the Telefunken Company. It assumes no previous knowledge of the subject and is a very suitable text-book for those beginning the study of electrical engineering. It covers the underlying principles of the whole subject both continuous and alternating. The last of the sixteen chapters is dovoted to high-frequency currents and wireless telegraphy. In view of the origin of the book it is not surprising that this chapter occupies more than a sixth of the whole volume. It is largely obsolete, however, the detectors described being the coherer, the magnetic, electrolytic, etc., no mention being made of the thermionic valve. This is partly explained by the fact that the preface is dated 1913; no attempt has been made to bring the book up to date.

G. W. O. H.

Books Received.

Les Tubes a Vide. By P. Dapsence. (Paris: *G. Pericaud.* Second Edition, 1921. Pp. 49. 8¼" × 5½". Price frs. 2.50.)

Radiotelefonia. By D. Ravalico. (Torino-Genova: *S. Lattes & C.* 1920. Pp. vii. + 219. 6¼" × 4¼". Price L.14.)

La T.S.F. par les Tubes a Vide. By P. Louis. (Paris: *Librairie Vuibert.* 1920. Pp. 142. 9" × 5¾". Price frs. 6.)

Le Livre de l'Amateur de T.S.F. By J. Roussel. (Paris: *Librairie Vuibert.* 1921. Pp. vi + 304. 10" × 6½". Price not stated.)

Correspondence.

WIRELESS APPARATUS.

To the Editor of the "Radio Review."

Sir,—With reference to the restrictions hitherto in force on the manufacture, purchase, sale and possession of wireless apparatus, I am directed by the Postmaster-General to say that, in consequence of the lapse of Regulation 22 of the Defence of the Realm Regulations so far as Great Britain is concerned, such apparatus may now be made (or bought, sold or held) in Great Britain (but not in Ireland) without permit or restriction.

The supervision by the Post Office of dealings in such apparatus has accordingly ceased so far as Great Britain is concerned. As indicated above, Regulation 22 is still in force as regards Ireland.

I am to add that the Postmaster-General's licence under the Wireless Telegraphy Act, 1904, is still necessary before any apparatus for wireless telegraphy may be installed or worked. An arrangement has, however, been adopted for allowing "toy" sets of wireless apparatus to be used (in Great Britain only for the present) without formal licence provided that the designs of the sets have been approved by the Postmaster-General and that the sets have been stamped or marked to that effect before sale. Firms or persons who desire to sell "toy" sets of apparatus for use under this arrangement should furnish full particulars (including illustrations or diagrams) of the apparatus, in order that the question of approving the designs of the sets may be considered. Where the designs appear suitable, it will be necessary to require that specimen sets shall be submitted for inspection before definite approval is given. Generally speaking, a "toy" set will be regarded as apparatus arranged for transmission and reception as a Hertzian oscillator, and not intended for connection to earth or to any aerial other than small rods with or without vanes. The range of such sets should not exceed 50 yards.

J. I. DEWARDT,
for the Secretary.

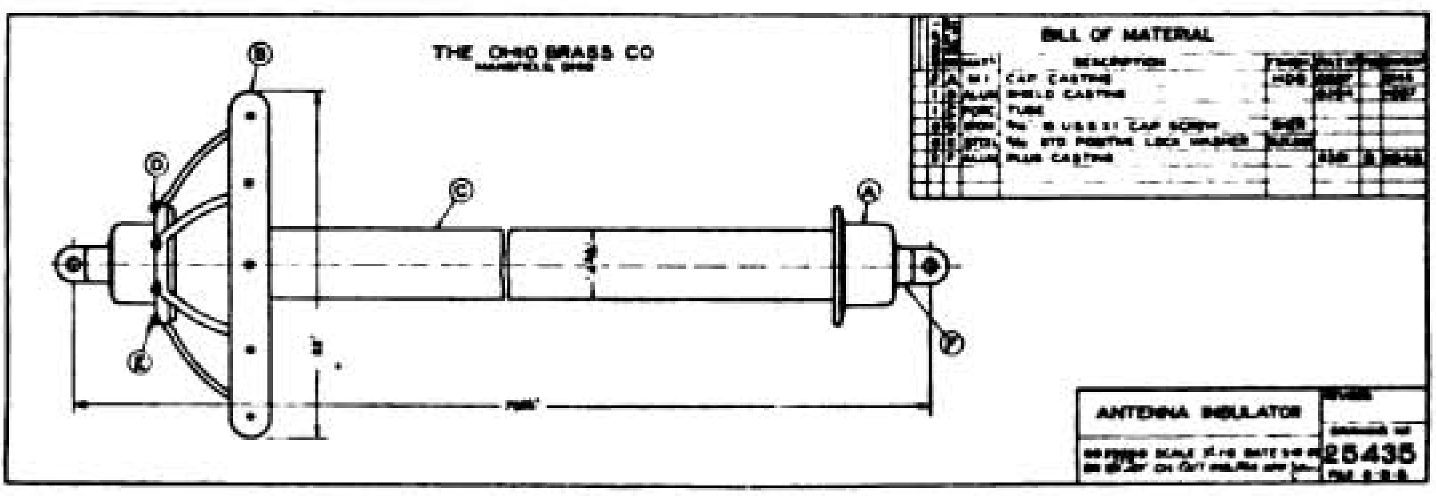
General Post Office,
London.
September 1st, 1921.

A NEW DESIGN OF AERIAL INSULATOR.

To the Editor of the "Radio Review."

SIR,—I notice in the RADIO REVIEW for April an article on a new design for aerial insulators. I am surprised that the original investigators of this type of insulator were not mentioned by Messrs. Elwell and Bullers.

I am enclosing herewith blueprint No. 25435 of the Ohio Brass Company, Mansfield, Ohio. This is the insulator shown on your page 198, and is the exact insulator produced by Mr. Elwell



Reproduction of the blueprint referred to in Mr. Sawyer's letter.

for the British Post Office stations at Oxford and Cairo. The gentleman who did most of the original research work on these insulators either is now or has been connected with the Ohio Brass Co., and Mr. Edward Austin, Mr. Leonard Fuller and Mr. W. A. Hildebrand did most of the research work which was carried on at Barberton, Ohio, at the expense of the U.S. Navy Department.

E. W. SAWYER.

New York,
June, 1921.