Experimental Wireless

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Experimental Topics.

An Amateurs' Radio Research Fund.

IT is a pleasing thing to find the attention of a wireless club being occasionally devoted to the general advancement of radio science as a change from the individual problems and requirements of their own members. The Derby Wireless Club, at their annual general meeting—their thirteenth A.G.M. by the way—discussed the possibility of forming an Amateurs' Radio Research Fund. The proposal made was that all holders of wireless licences should be invited to contribute to such a fund, a minimum subscription of one shilling being suggested, and that the revenue be devoted to research. Radio television was advocated as being a suitable line of investigation, but it was thought that the nomination of the precise subject and of an expert investigator might be left in the hands of the President and Vice-Presidents of the Radio Society of Great Britain. Here is the germ of a good idea. It is very appropriate that those who benefit by the wireless facilities now available should do something practical to advance further discovery. Donors to the fund would get a direct return in the greater service which improved wireless could render them, and incidentally they would have the satisfaction of knowing that they were contributing to the advancement of a branch of science in which they were personally interested. The precise method by which such a fund might be most usefully employed needs, we think, fuller consideration and discussion. A great deal of research work is already being conducted in university and college laboratories, as well as by private workers, and possibly some portion of the amount subscribed might be employed with advantage in founding research scholarships, or in some other way subsidising the work of qualified student or staff workers in those institutions. The founding of an annual prize for the best piece of private research work might be another useful means of encouragement of effort. It is not always the professional investigator who makes the most important discoveries in science, and the possibility of securing some adequate recognition of their work might encourage amateur experimenters not only to greater effort, but to conduct and record their experiments in a more systematic way. In any case, the Derby proposal is an interesting one, and we shall be glad to open our columns to any of our readers who would like to express their views.

The Transatlantic Tests.

The annual Transatlantic tests have always been regarded as one of the most important events in the life of the amateur transmitting enthusiast, or "ham," as he is familiarly termed in the States. Perhaps it is safe to suggest that in the light of the success of this year's performance, low-power Transatlantic communication will be so commonplace that in the very near future any organised tests will cease to exist.

There is even now very good evidence that this is likely to be the case, for although the official tests have been concluded, almost regular Transatlantic communication is still continuing. Future development is likely to occur in two directions. Up to the present time Transatlantic work has been confined to the winter months, roughly from November to April. This year, however, the first results were obtained as early as August, and there is every indication that experimenters will be carrying on well into the late spring. The next step will be two-way telephony. Already speech has been received from America and British 2KF is reported as having been heard, but not confirmed. The reason for the increasing success of each year's performance is not very obscure. It is obviously due to the greater experience and knowledge of the experimenter, to whom we offer our heartiest congratulations, and we hope that he will achieve even greater things during the present year. In the later pages of this issue will be found very full details of some of the apparatus and circuits which were specially designed by some of the most successful experimenters for this season's tests.

Dealer and Experimenter.

Does the dealer stock components which the experimenter really requires? Recently we had need to purchase rather hurriedly so simple an item as a single-pole three-point switch, and were forced to visit no fewer than seven dealers before the desired switch could be obtained. In addition, only one shop was capable of delivering from stock three non-inductive resistance, and of these only two were of the same value. Such an experience as this prompts us to criticise the average dealer's selection of components and apparatus. True, there seems to be an everlasting demand for crystal detectors, variometers, inter-valve transformers, and other joys for the home constructor, and it is only natural that these should predominate on the shelves and in the show-cases of the "wireless shops." On the other hand, there is a very considerable number of experimenters who demand an entirely different class of goods. The genuine experimenter is at heart a scientist and conducts his investigations in a true scientific manner. Accordingly he requires a high-class instrument of guaranteed accuracy on which he knows he can depend. Losses must be reduced to a minimum, insulation must be perfect, operation must be constant, and efficiency a maximum. Condensers, inductances, resistances, meters, and switching devices which conform to these requirements should find a ready market. We know that they exist, but if some of our enterprising dealers could give a little more prominence to them and study a little more carefully the tastes of the experimenter, we feel sure that it would be to their advantage. The experimenter is usually a good customer, and is prepared to pay a reasonable price for really good apparatus.

An Institution of Wireless Engineers.

One of our contemporaries, in an editorial comment, asks how long will it be before this country rises to the dignity of having an Institution of Wireless Engineers, and points out how divided and scattered are those connected with radio engineering. Of course, we have the wireless section of the Institution of Electrical Engineers, but such a body is obviously not in a position to devote sufficient time which the subject really demands. Admittedly the formation of an Institution and the definition of the qualifications for membership at once presents considerable difficulties, but all these would ultimately find some solution, and it is to be hoped that some very definite steps will be taken before very long to bring together our leading radio engineers and scientists.

"E.W.'s" Progress.

We desire to thank many correspondents for the complimentary references to EXPERIMENTAL WIRELESS in their letters. In our first number we pointed out that the scope of our activities would become more manifest issue by issue, and a glance over the 300 or more pages of matter which we have given during the past five months will show that our promise to give the experimenter some matter of first-class technical interets has not been unfulfilled. Every day brings further evidence of the importance of experimental work in the wireless field. We shall continue to keep our readers fully abreast of all new developments, both at home and abroad, and shall hope to deserve in the future as many kind messages of encouragement and appreciation as we have received in the past.

Post Office Radio Station, Devizes.

By J. H. REYNER, B.Sc., A.C.G.I.

DEVIZES is the Post Office station which deals with long-distance ship traffic. The ordinary stations are equipped with 1½ to 5-kw. spark transmitters operating on 600 metres, and are capable of working ships at ranges of from 150-300 miles, depending on conditions.

In August, 1920, however, a service was inaugurated, working on 2,100 metres C.W.,

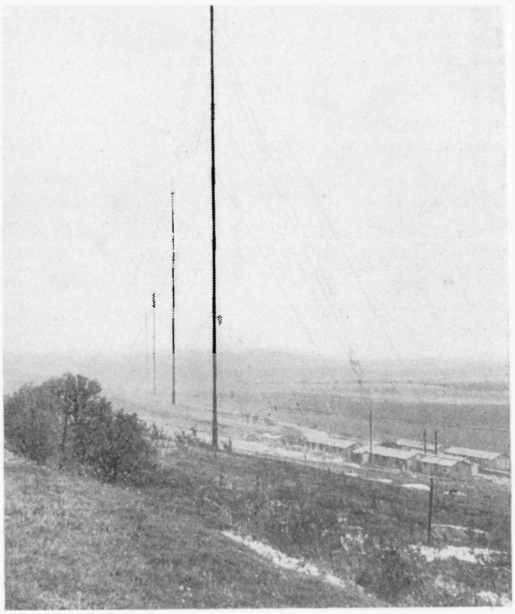


Fig. 1.—A general view of GKU.

for the purpose of maintaining communication with the large Transatlantic and south-bound liners, at considerably greater distances. The chief ships operating on these long-distance routes were accordingly fitted with 1½-kw. valve transmitters and the necessary C.W. receiving gear, while Devizes, which was chosen for the shore station, was equipped with a 6-kw. valve set. Since that time the number of ships fitted with C.W. apparatus has increased enormously, and there are several 3-kw. valve and 5-kw. arc sets in operation.

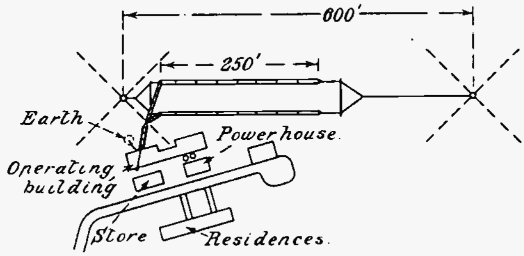


Fig. 2.—Layout of aerial system and buildings.

The Devizes station (GKU) is situated in the middle of the Wiltshire downs, about four miles from Devizes itself, on the Marlborough Road. Fig. 1 shows a view of the station looking east.

The first two masts only are in use at the present time. These two masts are each 300 ft. tubular steel masts of the Marconi pattern and are 600 ft. apart

The aerial is a double cage, 250 ft. long, each cage consisting of three wires spaced equally round a hoop 3 ft. in diameter. The lead-in is a 6-wire cage, 4 ft. 6 ins. diameter.

Fig. 2 gives a plan of the aerial system and the station buildings.

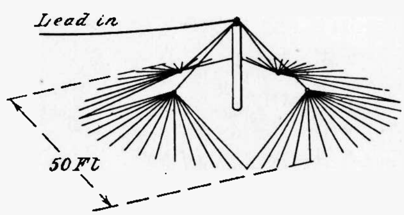


Fig. 3.—The earth system.

The earth system consists of 56 plates, 6 ft. by 2 ft. 6 ins. by 24 S.W.G. copper, buried in the earth on the circumference of a circle 50 ft. in diameter. The connections from these plates are collected in four groups and led to a common terminal at the top of a

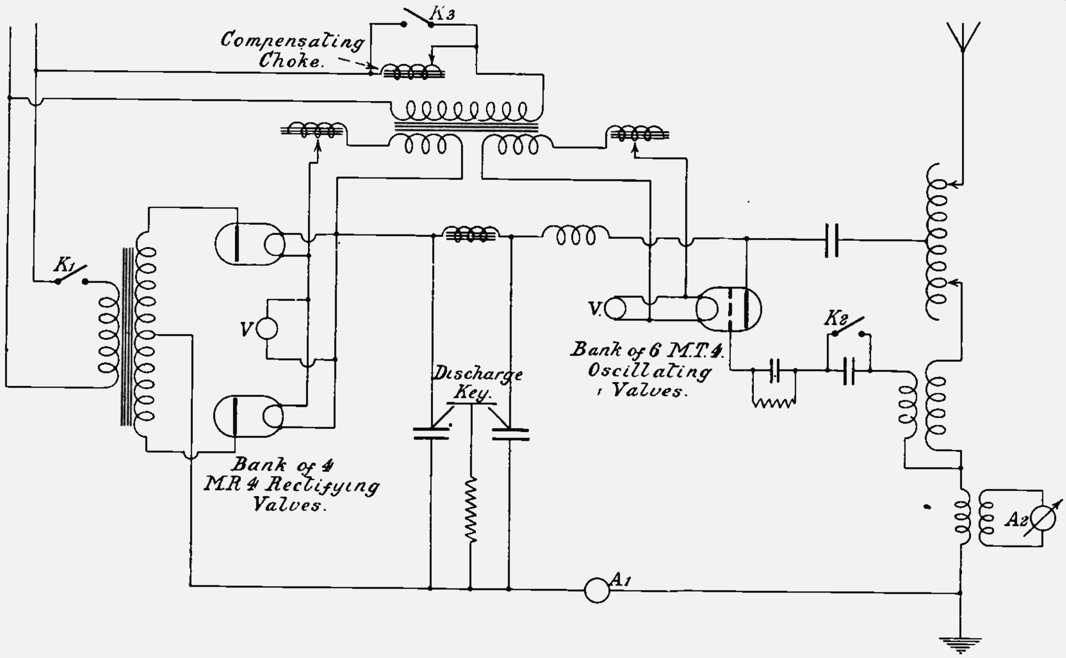


Fig. 4.—A simplified circuit diagram. The three keys are operated simultaneously.

10-ft. pole, whence a lead is taken into the operating building.

Fig. 3 gives a diagram of the earth system.

Transmitter.

The transmitter is a Marconi 6-kw. valve set employing six M.T.4 oscillating valves and four M.R.4 rectifying valves. A simplified circuit diagram is given in Fig. 4. Power is supplied to the set at 500 volts 300 cycles, and is stepped up to 15,000 volts before being applied to the rectifying valves, which thus supply H.T. to the oscillating valves at about 10,000 volts D.C. The ripple on the rectified H.T. supply is smoothed by two condensers of ·25 μF operating in conjunction with a choke coil, as indicated.

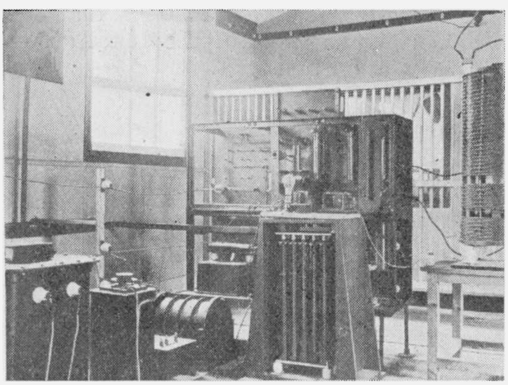


Fig. 5.—Back view of the panel.

The valve filaments are supplied from a stepdown transformer having two secondaries one supplying the rectifiers and the other the oscillators. By this means independent control is obtained, variable choke coils being inserted in each circuit to control the voltage applied to the valves. It should be noted that the valves are run at constant voltage as this is found to give a considerably longer life than with constant current working.

The oscillating circuit is of the direct-coupled type, the aerial constituting the tuned circuit, and an untuned reaction coil being connected in the grid circuit. A_1 is the feed ammeter, and A2 is the aerial ammeter operated through an air core transformer.

The parallel H.T. connection is employed as is usually the case for medium and high power sets, a high-frequency choke coil being inserted in the H.T. supply lead to keep the high-frequency currents from flowing back through the transformer. A condenser is also placed in the anode tap lead, as otherwise the H.T. would have a direct short circuit path through the A.T.I. to earth.

Keying is effected by several electromagnetic keys, marked K_1, K_2 and K_3 in Fig. 4. These keys are normally open and are closed simultaneously by the depression of the operating key.

K_1 makes or breaks the primary circuit of the main transformer. K_2 controls the grid circuit, simply serving to disconnect the grid reaction coil when the key is up. As the H.T. supply is disconnected simultaneously there is no possibility of "grid tick." K_3 controls the compensating choke. When the load comes on the set the voltage drops slightly. To compensate for this a choke is inserted in the primary of the filament transformer which is short-circuited by the depression of the key, so increasing the voltage on the filaments sufficiently to make up for the drop in alternator voltage.

Fig. 5 gives a view of the back of the panel. The main and filament transformers can be seen on the left, while the A.T.I. is on the extreme right.

The aerial current is 20 amperes, the aerial resistance being of the order of 4 ohms, so that the actual high-frequency energy is about 1½ kw.

Power Plant.

All the necessary power is generated on the station itself. There are two 16-kw. direct-coupled generating sets supplying D.C. at 110 volts. The engines are Robey semi-diesel type, running off crude oil. The sets are run on alternate days and normally charge a 450-amp.-hour battery, which supplies the station for the remainder of the day, although arrangements can be made in case of emergency to eliminate the battery. Figs. 6 and 7 give views of the generating plant and switchboard.

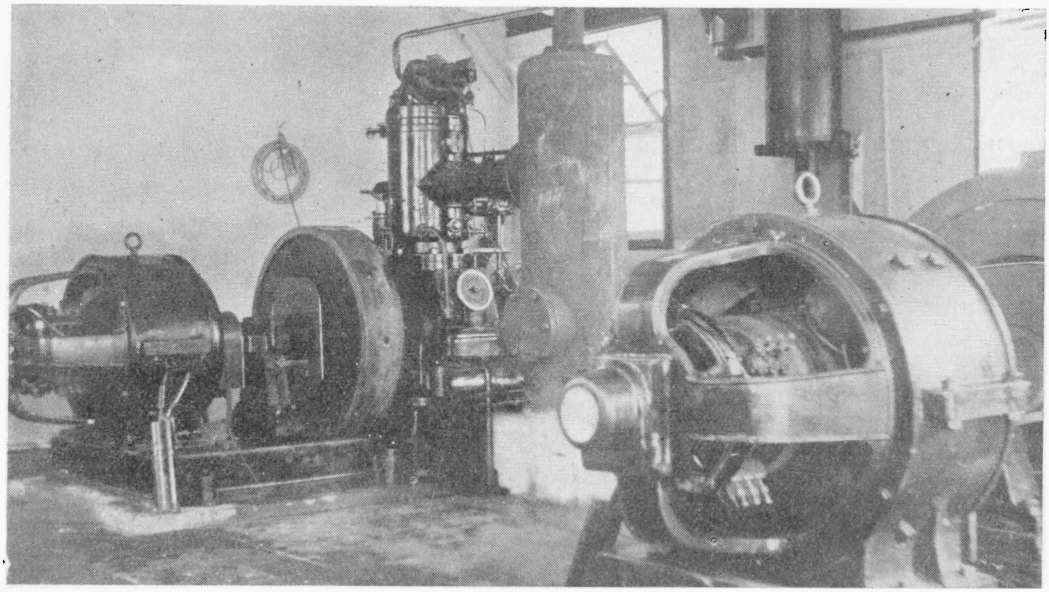


Fig. 6.—A general view of the generator plant.

Lighting for the station is run direct off the battery. The power for the set, however, is supplied through a motor alternator converting to A.C. at 500 volts 300 cycles. There are two such machines (one standby) housed in the apparatus room with the valve panel; this room also contains a motor generator set and distribution board for charging the filament batteries for the receiver.

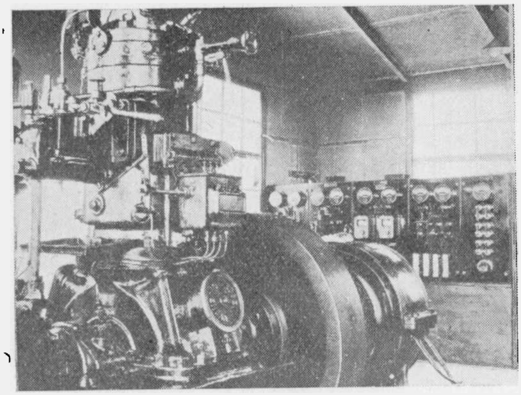


Fig. 7.—Generator with switchboard in rear.

Receiving Gear.

The receiving apparatus is shown in Fig. 8. It consists of a Bellini Tosi radio-goniometer, the signals from which are passed through a two-stage H.F. filter, amplified and rectified on a Marconi type 55 amplifier, and finally passed, if conditions permit, through a two-stage note filter. One or two extra stages of (low-frequency) magnification are available if required.

The note filter can only be employed on steady notes. In a heavy sea the ships are inclined to roll, and this, by altering the aerial capacity, causes considerable variations in wave-length. Modern transmitters, however, are fitted with coupled circuits or master oscillators, so rendering the wave-length independent of the aerial capacity.

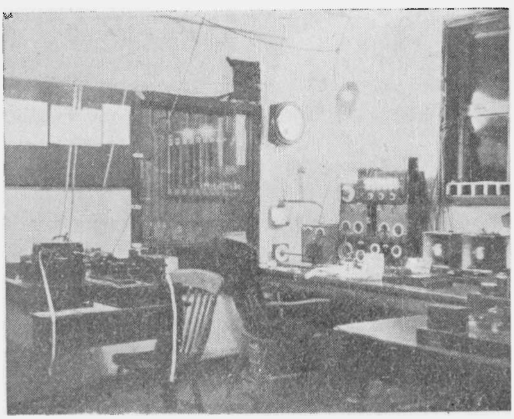


Fig. 8.—The receiver and operating room.

Since most of the reception is from the west and south-west, the radio-goniometer is extremely useful, enabling "barrage" reception to be employed. For this arrangement a combination of frame and aerial reception is employed, the frame assisting the aerial in one direction but opposing it in the other. Hence, by suitable adjustment, reception from one direction can be suppressed over an arc of about 120 degs., which, of course, considerably minimises jamming, which very largely comes from the east.

The two aerials for the radio-goniometer are erected from the main mast, and are in the form of double triangular loops of 150 ft. side, as indicated in Fig. 9.

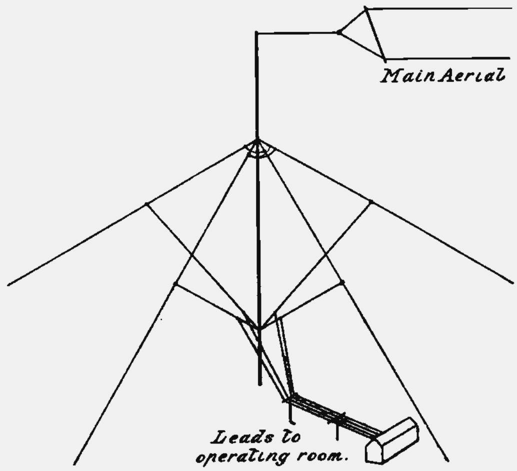


Fig. 9.—Arrangement of Bellini Tosi aerial.

All operating is done from the room shown in Fig. 8. The necessary switches and key are arranged close at hand and operate the transmitter by remote control. The valve panel itself is in the next room and can be seen through the glass panel on the left of the operator. The land line instruments are not visible in Fig. 8, but are situated in a separate compartment on the right. The table on the left of the figure contains recording gear for use when conditions permit of high-speed reception.

Since its inception the traffic handled by the station has increased enormously, and it is proposed to instal a second transmitter at Devizes and to remove the reception point elsewhere, so enabling duplex working to be carried out with both transmitters by remote control from the receiving station.

Directive Radio Telegraphy and Telephony.

By R. L. SMITH-ROSE, Ph.D., M.Sc., D.I.C., A.M.I.E.E.

II.—DIRECTIONAL WIRELESS ON WAVE-LENGTHS ABOVE 100 METERS.

(*Continued from page* 198.)

During the last few years there has been considerable development in directional work, particularly with the use of extra short waves. There are obviously many applications of directional transmission, and we are giving below a general summary of modern methods and practice.

(g) Permanent Errors and their Causes.

If the conditions of the arriving wave are suitable for correct indication of direction by the rotating frame any local cause tending to distort the wave will result in an error in the observed direction. For example, if another receiver, whether of the closed coil or open aerial type, is in the neighbourhood of the direction-finder and tuned to the same incoming wave the direction-finder will be subject to both the original field due to the wave and a second field arising either by induction or re-radiation from the currents in the second receiver also due to the incoming wave. The effect of the superposition of this second field is easily observed in the form of an error in the reading of the direction-finder, except in the particular case when the two fields are coincident in direction.

For example, when a direction-finder is used within a distance of about 100 yards from a medium-size aerial and tuned to the same wave-length an error of 4° to 5° has been observed, and this would, undoubtedly, be greatly exceeded for a much larger aerial. A second frame coil brought within 30 ft. of the direction-finder introduces an error of the same order of magnitude. It is usually found that the detuning of the second aerial or coil circuit results in a large reduction of the error, which is then only appreciable at comparatively short distances. In many respects a tall tree is similar to an untuned vertical aerial, and, as would be expected, the effects on a direction-finder in the two cases are very similar. When, however, large numbers of trees are massed together in clumps their combined effects may be much larger, and it is found necessary to be at least one or two hundred yards from such clumps of trees in order to be free from directional errors, which at shorter distances may rise to 10°.

In the neighbourhood of a long run of a number of overhead wires, such as are frequently met with on a trunk telephone route, the errors are even more serious, and may amount to as much as 90°. The error in this case, however, decreases very rapidly with distance, and a movement of the direction-finder to about 100 yards from the wires is found to practically clear this error. In some cases the errors encountered in the neighbourhood of trunk telephone lines are observed to be subject to large variations of the order of 50°, due, possibly, to an alteration in the telephone circuit conditions.

Large masses of sheet or solid metal work in the neighbourhood of a direction-finder will have currents set up in them by the incoming waves, and the secondary field from these currents may cause an error in apparent direction of the waves, the error varying with the magnitude and distance of the metal work. Small tinned-iron boxes about 2 feet cube, for instance, produce errors of a degree or two when within 5 ft. of a frame coil direction-finder, whereas a large mass of ironwork, like an airship shed, produces errors ranging up to about 30° at points both inside and outside the shed. From the latter examples it would be expected the metal hull of a ship would produce errors in the reading of a direction-finding installation erected on board. This is found to be the case, the error in the observed bearing varying with the direction of the incoming waves relative to the ship's axis, giving a quadrantal error curve of the form shown in Fig. 9, which is a curve plotted from some of the writer's observations. Unfortunately it is not possible to get far away from the disturbing metal work when using a direction-finder on board a ship, and some means must, therefore, be found of compensating for or correcting the error introduced. In many instances the stays, funnels, etc., contribute largely to this error on board ship, and where the wires form closed loops, with loose shackle joints, the conductivity of these may vary with the state of the weather from day to day, and the resulting error, therefore, becomes very variable. By taking suitable precautions, however, the error may be made fairly constant, and then the curve such as in Fig. 9, determined by tests made on stations in known distances, may be used as a means of applying corrections. Alternatively, means have been devised by which the constants of the circuits are adjusted so that practically complete compensation for the error can be obtained. Similar quadrantal error curves are obtained for direction-finders used on aircraft, although these are usually somewhat less in magnitude than a ship's curve. Here, again, difficulty is frequently experienced from the variability of the error due to variations in resistance of loops formed by wire stays, etc., and all

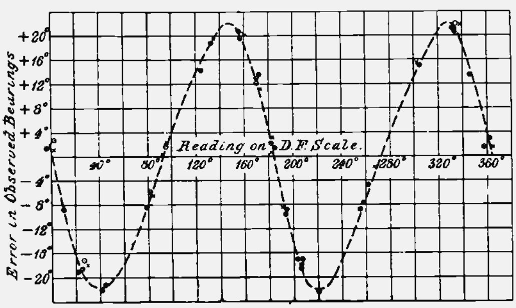


Fig. 9—Typical calibration of a wireless D.F. on board ship.

metal joints are preferably to be well bonded to maintain permanence of the error. Auxiliary coils may be mounted in the machine to introduce a third component into the field linking the direction-finder, which is adjusted to compensate, as far as possible, the second field due to the machine itself. Capacity effects between the machine and ground also frequently preclude the possibility of plotting an error curve obtained on the ground for use when the machine is in flight.

The characteristic shape of the quadrantal error curve produced by a long mass of metal work, like a ship, has led to at least one instance of the location of underground metal work by wireless direction-finding. A direction-finding set was erected for experimental purposes on a site which appeared to be perfectly satisfactory from the point of view of buildings, trees, telephone wires or other disturbing features above the surface. The bearings observed on the set, however, were found to be seriously in error in many cases, the error varying with the direction of the station observed. After many confirmatory observations, the error curve shown in Fig. 10 was plotted, and was found to be independent of any daily or seasonal variations. Now, in the case of Fig. 9, showing the error curve for a ship, the readings 0° and 180° on the direction-finder coincide with the fore and aft line of the ship. From the similarity of the two curves in Figs. 9 and 10 it seemed logical to conclude that the latter was produced by a large mass of metal work extending in a direction about 165° from true north. Examination of the site of the D.F. installation showed that this direction coincided with that of a large sewer, located by a line of manholes in the vicinity. Detailed exploration of the site with a portable D.F. set also showed the error to be definitely associated with the line of the sewer, correct readings being obtained at a distance of 100 yards from it. Reference to the surveyor's plans of the neighbourhood showed these deductions to be correct, for although the sewer itself was of non-metallic construction, a special length of it in the neighbourhood of these experiments was supported on a plate of steel, 300 ft. long by 6 ft. wide, this plate being about 8 ft. below the ground surface. In a similar manner it would be expected that gas and water mains or streaks of metal ore in the ground would produce errors on a direction-finder in the neighbourhood.

Owing to the varying conductivity of different portions of the earth's surface, it would be expected that waves might be subjected to a refraction effect. For ordinary cases of conductivity of dry land and sea-water this refraction is found to be only appreciable when using waves shorter than 1,000 metres. The effect is such that in crossing the boundary from a material of high to one of lower conductivity the waves are bent towards the normal to the surface. As in the case of light, the deviation increases with the angle of incidence, and is greatest for grazing incidence at the boundary. The error experienced on a direction-finder from this cause is usually only a few degrees, although cases are quoted where it may reach 10°. Fortunately, the error is reasonably constant, and, when known, may be included in the corrections to be made to the readings of the instruments.

(h) Variable Errors.

From the preceding section it will be gathered that it is by no means an easy matter to find a site for a direction-finding installation which approaches at all closely to the ideal. In the light of experience gained in the investigation of errors it is, however, possible in many cases to select a fairly satisfactory site, usually in a very desolate part of the country at which the local errors encountered are reasonably small, *e.g.*, not greater than 2° or 3°. Having selected such a position, a calibration may be carried out, using either various permanent transmitting stations if these are well distributed around the points of the compass, or preferably a portable transmitter from which signals can be sent in various directions to the D.F. receiver. From this calibration a table or curve of corrections is made from which bearings taken in practical working may be corrected, depending upon the cause of these local errors, they may be quite permanent or slightly variable, and in any case it is advisable to repeat the calibration at moderately frequent intervals to ascertain any alterations that may be required in the applied corrections.

When a direction-finder is set up and calibrated in this manner, and used for observation on transmitting stations at reasonably short distances, it is found that the bearings obtained are extremely good on the whole, but are occasionally subject to slight variations which cannot always be attributed to an error of observation of the instrument. These variations, however, have an extreme amplitude of only 2° or 3°, and with highly skilled observers they rarely, if ever, give rise to an error in bearing exceeding 2°. Such a limit of accuracy is usually sufficient for most practical applications of direction-finding.

When the distance between the transmitter and receiver is increased, however, another and much more serious class of variable error enters the field, chiefly during the hours of darkness, and presents many more difficulties in the way of its compensation or elimination. The minimum distance at which this error is encountered in practice

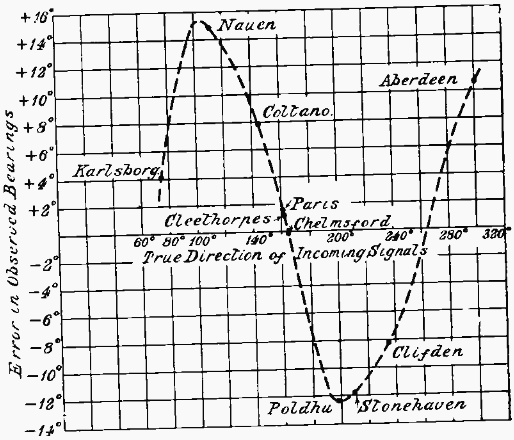


Fig. 10—Curve showing permanent deviations in bearings at Aberdeen University D.F. Station.

is found to be much greater over sea than over land, being roughly 90 miles in the former and 15 miles in the latter case. If the distance of transmission be gradually increased during observation the first sign that these variable errors are about to be encountered is given by a change in character of the signal minimum by the location of which the direction is determined. In place of the sharp, well-defined minimum or zero which is observed at short distances, a distinctly flattened or blurred minimum is obtained which often makes it extremely difficult to locate the true minimum point with any accuracy. As the distance is still further increased this blurring not only becomes a much more frequent occurrence, but the position of the minimum is also found to be very different from its true bearing position. The variable errors arising in this way do not usually occur when daylight prevails over the whole path of the transmission. In the neighbourhood of sunset at either the transmitter or receiver these variations are liable to commence, and they continue throughout the night until a short time after sunrise in an extremely erratic manner in regard to their direction, rate and magnitude.

As a result of several years' concentrated observation of these variations under all possible conditions their chief characteristics are now fairly well defined and understood. Apart from their use in showing the limitations of direction-finding in its practical application, the results will be extremely useful in studying the problem of the propagation of electro-magnetic waves in both its theoretical and practical aspects. As giving some idea of the manner of these variations some of the observed results obtained with direction-finders taking apparent bearings upon fixed land transmitting stations are shown graphically in Figs. 11–13; and the following brief resumé of the general impressions gathered from such observations may be given.

While during the day periods the variations are limited to an extreme amplitude of approximately 7°, during the night both the frequency and amplitude of the variations are considerably increased. On some occasions the rate of variation is moderately great, amounting to several degrees per minute, while at other times the variation is in the form of a slow drift of the apparent bearing. The mean of large numbers of readings taken at night is very closely the same as the mean of similar readings taken during the day periods, this resulting in an approximately equal distribution of the variations on either side of the true bearing (*i.e.*, assuming no permanent local error exists).

This point is somewhat difficult to establish definitely, as the change in wave-length usually takes a few minutes to carry out,

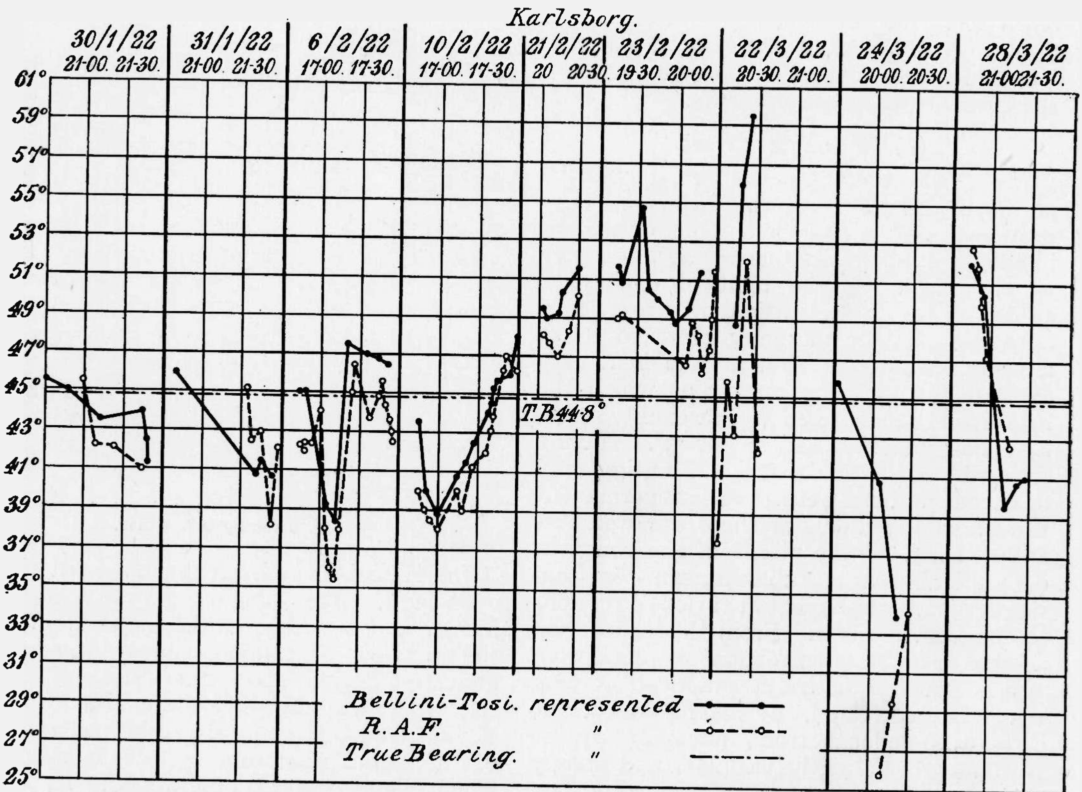


Fig. 11—Observations of bearings made at Slough, weeks ending 4th, 11th and 25th February, 25th March and 1st April.

and in this time the bearing may vary considerably even on the same wave-length. In the case of one transmitting station, however, it was consistently noticed that when the wave-length in use was changed from 4·2 to 2·5 km. the apparent bearing also changed by a much greater amount than would have been expected from the variations occurring either immediately before or immediately after the change in wave-length. In the case of double-wave transmissions, as from Leafield, it is frequently to be observed that the readings on the marking and spacing waves are drifting in opposite directions, and are often on opposite sides of the true bearings (Fig. 12). Since the mean bearings on either wave are practically identical the variations are again approximately equally distributed about the true bearings.

Fig. 13 shows some observations taken on the marking wave of Leafield on board a ship located at 40–50 miles from the nearest land, which was practically in the direction of the transmitting station. This indicates that for waves emanating from an inland transmitter the variations are in no way decreased by propagation over the sea for the above distance before arriving at the receiver. Similar observations made at a coast direction-finding station show that, where the waves arrive over a direct sea path of over 400 miles there is no apparent decrease in the frequency and amplitude of the variations. When both the transmitter and receiver are situated on the coast, and there is a direct sea path between them, the variations experienced are usually negligible for distances up to the order of 80–90 miles, but at greater distances the same phenomena are experienced, as in the case of transmission entirely or partially overland.

These must be taken as some of the general conclusions arrived at from the observations so far made. They are in many cases somewhat difficult to confirm, as it is not practicable always to obtain the transmitter and receiver in the positions required, and also to satisfy all the conditions as to length of land and sea path in all directions around the receiver. For the tests of the different conditions involved it is necessary to employ several direction-finders located at different places, and there is always a slight element of uncertainty in assuming identity of other factors for purposes of comparison.

(j) A Possible Explanation of Variable Errors.

The theory which is usually put forward to explain these somewhat abnormal variations in observed bearings at night is an extension of that adopted to account for the great increase in range and the increase and variability in the strength of signals commonly experienced in night working as compared with day conditions. On this theory, which was elaborated by Eccles in 1912, the effect of sunlight operates on the propagation of the waves by reason of the ionisation of the earth's atmosphere In daylight the atmosphere is ionised practically down to the earth's surface, and the only waves arriving at the receiving station are those which are propagated directly along the surface of the earth. The increased resistance of dry earth as compared with sea water accounts for the more rapid attenuation, and hence the decreased range of transmission overland as compared with over sea. When, however, darkness sets in re-combination of the ions takes place in the lower regions of the atmosphere, and only at the top and rarer portions is there assumed to be a permanently ionised layer due to the influx of either electrons or dust particles projected from outside. Hence, for increasing altitude in the earth's atmosphere at night there is encountered a large increase in the ionisation gradient, and this supplies a comparatively well-defined surface which may act as a reflector of the long waves employed in radio communication. We thus see the possibility of waves arriving at the receiver at night after reflection from the upper layers of the atmosphere, which will add their effects to those of the direct waves in producing an increase in received signal strength. Also due to the fact that these waves travel through a clear un-ionised atmosphere they will suffer much less attenuation than the direct waves travelling along the earth's surface, and will thus produce detectable signals at night at places beyond the effective range of the direct waves in the daytime.

The theory of which the above is an extremely brief outline was extended by Eckersley and by Bellini to provide an explanation of night errors in D.F. bearings. Due to the conductivity of the earth the magnetic field of the direct wave is assumed to be horizontal, since any vertical component would be quickly absorbed by the eddy currents in the earth. Except for irregularities in the earth's surface and any other causes, as mentioned above, of real or apparent deviations of the wave, this magnetic field is also perpendicular to the line of propagation. This assumption is justified very largely by the fact that in the daytime bearings observed upon a vertical frame coil or system of such coils are reasonably accurate.

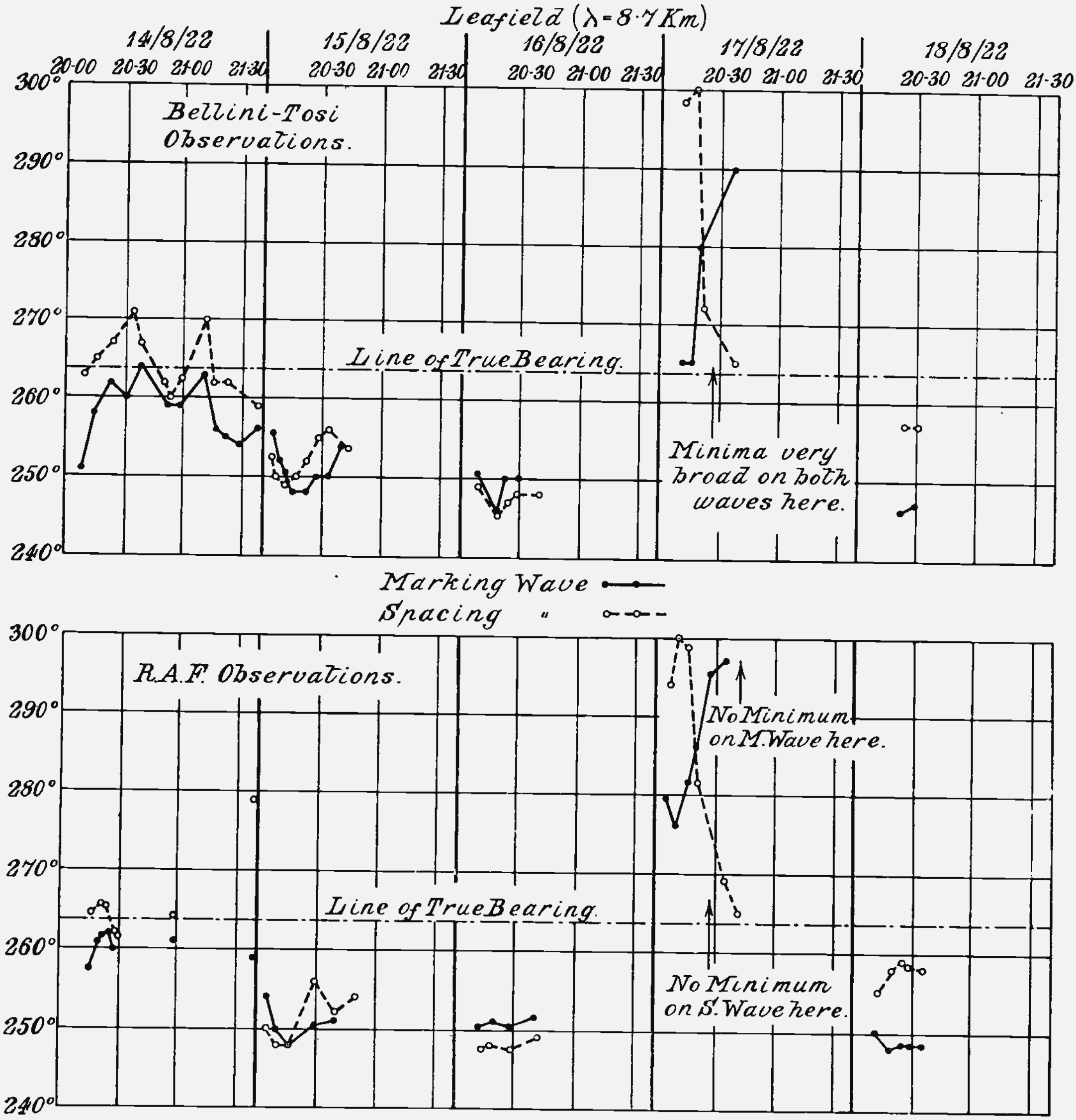


Fig. 12.—Observation of bearings made at Oxford, week ending August 19, 1922.

The wave which travels up into the atmosphere, however, need not be polarised with its magnetic field horizontal, since there will be no absorption of the vertical component. When this wave is reflected also at the upper hypothetical ionised layer, a rotation of the plane of polarisation of the wave may take place, whether the previous polarisation was such that the magnetic field was horizontal or vertical. The possibility is thus seen of the reflected wave arriving at the receiver with its magnetic field in directions other than the horizontal. In the general case it will be inclined, and taking the projection of it on a horizontal plane which gives the on the direction-finder will be ill-defined and the direction will be given by the major axis, resulting in an error of bearing which may vary within wide limits. In the case of a circular resultant field no change in signal intensity will be experienced as the coil or loop is rotated, and no bearing at all can be determined. When the phases of the two waves differ by an integral number of half cycles a linear resultant will be obtained giving a sharp bearing, which may be considerably in error, depending on the

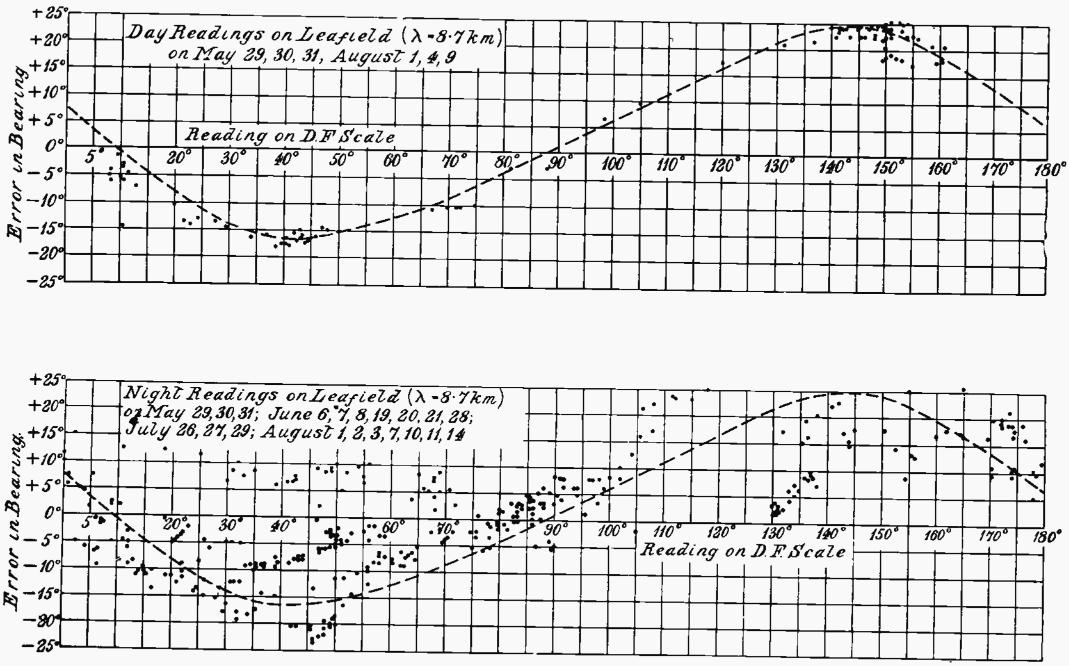


Fig. 13.—D.F. Observations made on a ship at about 50 miles from land.

only component which will affect a vertical coil, it will be appreciated that this horizontal component will not necessarily be perpendicular to the path of travel of the waves. The effect on the D.F. coil will be that due to the resultant of the horizontal components of the magnetic fields of both the direct and reflected waves. Now, since the reflected wave has arrived by a longer path than the direct wave, the two may or may not be in phase at the receiver. The resultant horizontal magnetic field, therefore, will not necessarily be linear, but either elliptical or circular. In the former case the minimum relative magnitudes of the two components.

Qualitatively, therefore, it is seen that most of the phenomena encountered in connection with wireless bearings can be accounted for on the supposition of this Heaviside layer. Previously, observations on this matter have not been available in sufficient numbers to make various quantitative checks on the theory. With the results now being collated it is hoped that sufficient data will soon be available for this purpose, and criticism of the theory must consequently be postponed for the present.

The D.C. Voltage Raiser.

By MARCUS G. SCROGGIE, B.Sc.

Since the voltage raiser was first described certain modifications have been made, and details of these, together with the theory of operation, should be of very great value to many readers..

ONE of the advantages of alternating current which has led to its almost universal use for large power schemes is the ease and economy with which it may be transformed to any desired voltage. This property is utilised to a large extent in providing the anode current (H.T.) supply for valve transmitters, both large and small. It is used by the B.B.C. for their stations, and also by very many low-power experimental stations. It is true that a good deal of complication is introduced in the form of rectifiers, smoothers, etc., but it is usually more economical than the use of D.C., where an expensive motor-generator is required.

In *The Wireless World and Radio Review* for August 15, 1923, and *Radio News*, November, 1923, a new device was described which steps up D.C. from the voltage usually supplied by town mains to a value suitable for valve transmitters, and which is both efficient and cheap in first cost as compared with the machines usually used for this purpose.

A considerable number of experimenters have now adopted this method, and satisfactory reports have been received as to its

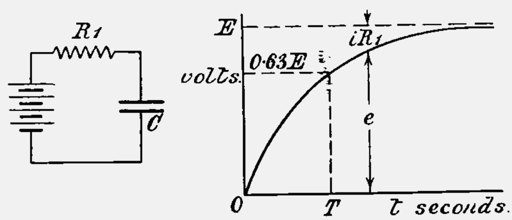


Fig. 1.—Illustrating the charging of a condenser through a resistance.

effectiveness. It is proposed now to give some further details with regard to it, but it is assumed that the reader is familiar with the original description referred to. It may, however, be mentioned briefly that the method consists in continually charging from the D.C. supply a number of condensers in series, the output being taken from the ends of the group of condensers. This process may be effected by a pair of brushes connected to the input and rotated by a small motor against a fixed radial commutator, certain sectors of which are connected to the condensers.

In order to design such a machine to fulfil certain conditions, it is necessary to have some knowledge of the theory underlying

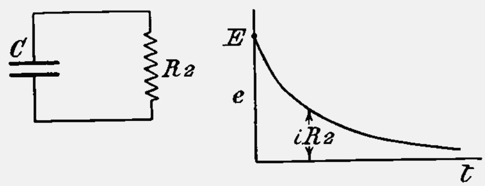


Fig. 2.—Showing the discharge of a condenser through a resistance.

it. For example, it is possible to design a much more economical machine for telegraphy than for telephony, and as many inquiries have been received on this point it will be as well to go into it more fully.

If a condenser is connected to a fixed supply voltage, current is forced into it until the back e.m.f. of the condenser due to this charge is equal to that of the supply. The difference at any given moment is that due to resistance, and where the resistance is small the time taken for a complete charge (theoretically a condenser never *quite* attains its complete charge !) is extremely small.

In Fig. 1 a battery of e.m.f. E volts charges a condenser of C farads in series with resistance R_1 ohms. The back e.m.f. of the condenser $e=\frac{Q}{C}$, where Q is the charge in coulombs (or ampère-seconds). The ordinates under the curve give e at any moment, while those between it and the ultimate value E give the drop in volts across the resistance $=iR_1$. The charging current i is therefore greatest at the moment of con-

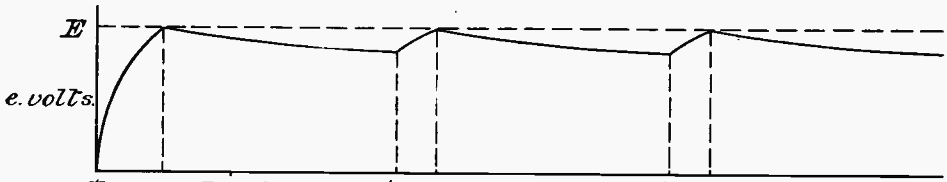


Fig. 3.—Curve showing voltage across any of the condensers.

nection and gradually falls off. The time taken for the condenser to receive 0·63···· of its final charge (the "time-constant" T) is R_1C seconds. To take practical values, if C is 1 μF and R 10 ohms, T is 0·00001 sec., and in 0·0001 sec. the condenser has received 0·999952 of its ultimate charge.

If the condenser is now removed and allowed to discharge through R_2 (Fig. 2), a similar but inverted curve tells the story.

In the voltage raiser each one of the group of condensers is periodically placed in contact with the supply for a short time, and throughout the whole time is discharging through the valve. If the condenser were very small and the load very big the former might be completely discharged before another charge was given, but in practice this is avoided. The voltage across any condenser is as indicated (Fig. 3).

The periods of charge for the other condensers in the series fall at intervals in between those for any one, so that the total e.m.f. across all the N condensers in series= NE volts, less a certain fluctuating amount due to the discharge. In order to simplify matters it may be assumed :—

(1) That each condenser is fully charged every time it is connected to the supply. How far this assumption is justified may be calculated as previously explained. Practically the only resistance in the charging circuit is an optional one of 10-20 ohms to limit the current in the event of a short circuit.

(2) That the average output voltage is equal to the maximum less half the fluctuating voltage due to charging and discharging.

(3) That the output current is constant at the average output voltage. This is very nearly so provided the voltage fluctuation is small, as should be the case where a smooth carrier wave is desired.

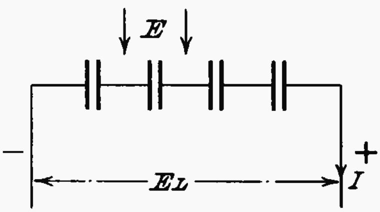


Fig. 4.—The voltage E is applied to each of the condensers.

The following symbols will be used throughout :—

E = supply voltage from mains.
E_0 = maximum (no load) output voltage = NE.
E_L = actual output voltage on load (average).
δE = amplitude of fluctuation on output voltage.
I = average output current (amperes) to valve.
W = average output power (watts) to valve = E_L I.
W max. = maximum output power (watts) obtainable from the machine.
N = number of condensers in series.
C = capacity of each condenser (farads). (Always remember to multiply by a million to give the more familiar microfarads (μF).)
n = number of times any condenser is charged per second $= \frac{RS}{60}$

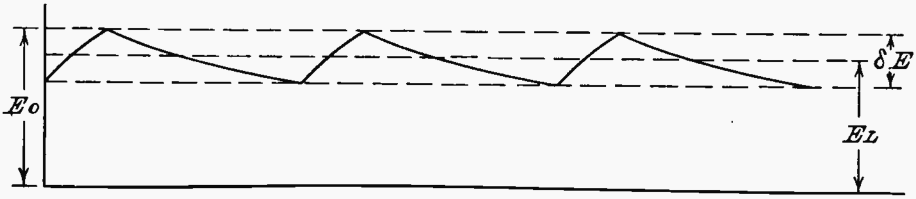


Fig. 5.—Diagramatic representation of the conditions obtaining when the voltage is applied to the condensers.

R = revolutions per minute of brushes.
S = number of charges on any condenser per revolution.

Whenever the voltage across a condenser alters by an amount e, the quantity of electricity passing in or out (according as e increases or decreases) is $Q = Ce$.

In our case, with the foregoing assumptions—

$$Q = It = I \times \frac{1}{n}$$

$$\text{and } e = \frac{\delta E}{Cn}$$

$$\text{so } \delta E = \frac{NI}{Cn}$$

$$\text{Now } E_L = E_0 - \frac{\delta E}{2} = E_0 - \frac{NI}{2Cn} \text{ (Fig. 5)}$$

$$W = E_L I = E_0 I - \frac{NI^2}{2Cn}$$

$$= NI\left(E - \frac{I}{2Cn}\right)$$

It will be seen that if $\frac{I}{2Cn}$ is greater than E—in other words, if the condensers are completely discharged in less time than is allowed between charges—the equation ceases to have any practical meaning in this connection, so that it must be assumed that $\frac{I}{nC} \ngtr E$.

It is interesting to find the maximum power ($W_{max.}$) that can be obtained from a machine. It may be shown* that $W_{max.} = \frac{NE^2nC}{2}$, and that $\delta E = E_0$, so that each condenser is just completely discharged before being re-charged, the output voltage being half the maximum.

If the maximum power is used, then, besides the voltage being low, the transmitted wave is a completely modulated tonic train unless smoothing circuits are used, and is useless for telephony, besides causing interference. It is advisable, therefore, to make the voltage fluctuation as small as possible. The percentage fluctuation is $\frac{\delta E}{E_0}$, and can be shown to be approximately $\frac{W}{NE^2nC}$ *for small values.* For a given power and fixed supply voltage and charging speed this is inversely proportional to NC or the total capacity of condensers used. So that other things being equal, the larger the capacity the smoother the output, or, on the other hand, if the percentage fluctuation is kept the same, the output is proportional to the condenser capacity.

It will also be quite evident that it is an advantage to have n and E as large as possible, but the latter is not usually under control (or there would be no need for the machine at all), while mechanical considerations limit n to somewhere of the order of 100. If the machine charges each condenser twice per revolution and runs at 2,000 r.p.m., then $n = 67$.

In the original design brushes were moved round against a fixed radial commutator, but, of course, an obvious alternative method of construction is to have a fixed cylindrical commutator made from a copper tube, and mounted on an insulating tube of ebonite or other suitable material, being spaced from it by small condenser spacing washers, in order to prevent metallic dust between segments causing a flash-over due to the high voltage (Fig. 6). The copper tube is first screwed down with countersunk screws and then sawn across at various places as indicated. To avoid short-circuits between the brushes a dead segment is placed between each live one, while the two between the end terminals are each 50 per cent. larger than their fellows.

The diagram shows a four-stage raiser, but any number of stages may be used by arranging a suitable number of segments. Also by having double or three times the number each condenser may be charged twice or three times per revolution, leading to a smoother or larger output. Connections for a half-revolution three-stage machine are given in Fig. 7.

Carbon brushes are not suitable owing to the small gaps between segments causing

---

$$* \quad W = NI\left(E - \frac{I}{2Cn}\right)$$

$$\frac{dW}{dI} = NE - \frac{NI}{nC}$$

$$= N\left(E - \frac{I}{nC}\right)$$

for max. $I = EnC$

$$\text{but } \delta E = \frac{NI}{nC}$$

so $\delta E = NE = E_0$, *i.e.*, each condenser is just completely discharged, and

$$E_L = \frac{E_0}{2}$$

$$W_{max.} = E_L I$$

$$= \frac{NE^2nC}{2}$$

them to wear rapidly, and the best type used so far is made of a number of phosphor-bronze laminations inclined at about 30 degs. to the surface.

These are carried on arms, with a piece of coiled spring wire pressing them on the commutator in the case of the cylindrical type, or the arms themselves may be springy in the radial type, the pressure being adjusted by screwing the plate on which the commutator is mounted back and forth along the axis of the motor shaft. The current is led to the brushes by rubbing contacts on two insulated parts of the rotating member.

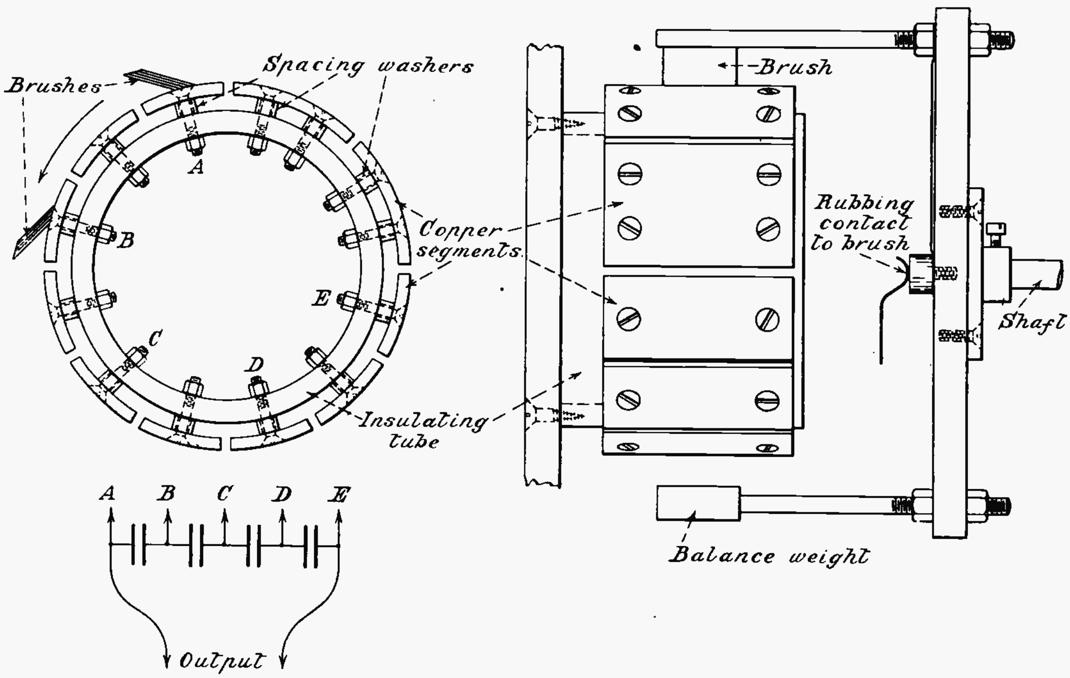


Fig. 6.—Illustrating the special construction of the commutator to prevent a flash over on high voltages.

To prevent vibration, a balance weight must be mounted on the rotating disc so as to oppose the force due to the brushes.

Yet another type of machine that has been proposed is worked by a cam carried on the motor shaft, which actuates a number of vibrating contactors. The general arrangement is as Fig. 8.

As many pairs of vibrating contacts are mounted round a fixed insulating piece as there are stages of raising (N), and corresponding fixed contacts are mounted on a piece fixed round the motor shaft. Each pair of contacts is connected to the supply and is vibrated by the cam, which raises and depresses the small insulating block between them. The fixed contacts are connected to the condensers in such a manner that connection is made from the mains to each condenser in turn, thus charging them. This method allows of much experiment as regards adjustment of duration of contact, phase angle, etc.

In order to make the procedure clear, two designs will be worked out, using the principles already given.

The first is for a 10-watt telephony transmitter to operate from a 200-volt source, delivering at about 500 volts and the ripple not to exceed 6 per cent. of the maximum voltage.

Three stages of raising will be suitable, and the condensers may be charged twice per revolution, *i.e.*, N=3 and S=2. The brushes may be run at 3,000 r.p.m., either by direct coupling to a motor at that speed or by belt drive, in which case the motor may be slower, but must be more powerful as the belt loss would be a large part of the total resistance. A small fan motor is quite

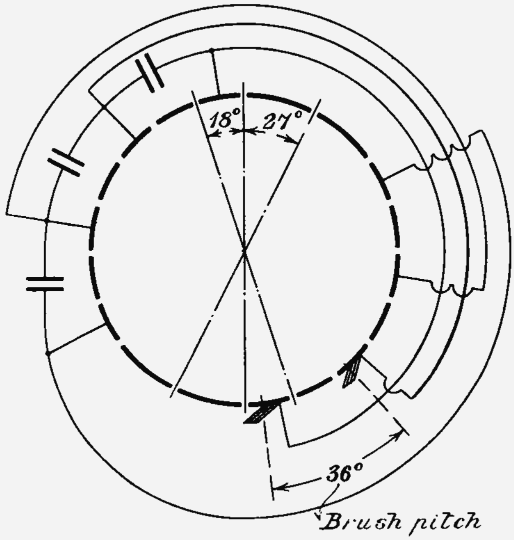


Fig. 7.—Connections for a half revolution, three-stage machine.

satisfactory, and may even require resistance to cut down the current to it, as the power required to work the brushes is extremely

so that three condensers of this capacity are joined up in series.

E_L = approximately 580 volts
and I = 17 milliamps.

The maximum power obtainable from this machine is 84 watts at 300 volts.

The second example is for a tonic train transmitter, where the maximum power is made use of. Supply voltage, 250; output, 30 watts at 750 volts; brush speed, 2,000 r.p.m.

E_0 must be equal to $2E_L$, or 1,500 volts, so six stages must be used, and as this is fairly large only one charge per revolution will be arranged for.

I = 40 milliamps.

$$C = \frac{I}{En} = \frac{0{\cdot}04 \times 10^6}{250 \times \frac{2,000}{60}} = 4{\cdot}8, \text{ say, } 5\mu F$$

so that six condensers of 5μF each are used.

An actual machine which is giving good results has four 18μF Mansbridge condensers, and works off 200 volts, giving 50 watts

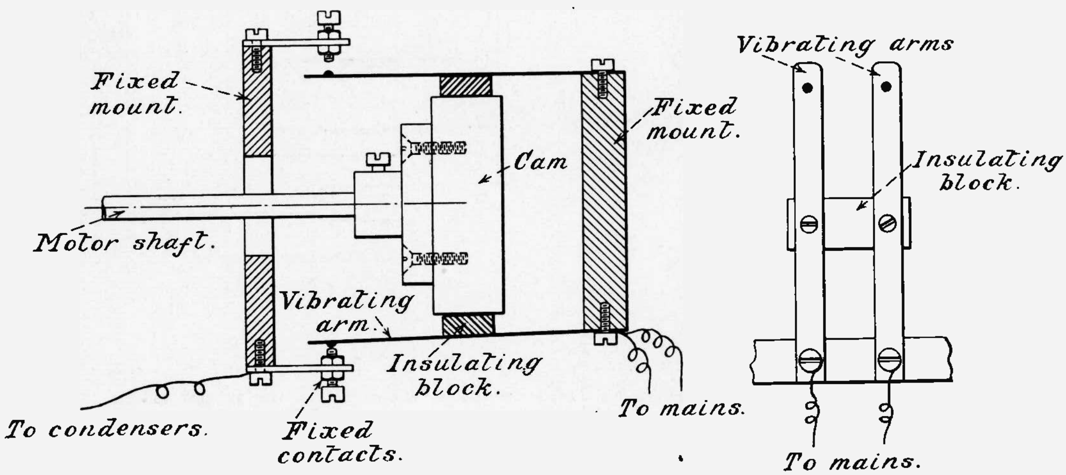


Fig. 8.—Illustrating another form of machine in which a cam operates a number of contactors.

small, or a battery motor may be used run off the filament accumulator.

$$\text{We have } \frac{\delta E}{E_0} = \frac{W}{NE^2nC}$$

Filling in the appropriate values—

$$0{\cdot}06 = \frac{10}{3 \times 200^2 \times \frac{3,000 \times 2}{60} \times C}$$

$$\therefore C = 14\mu F$$

at 650 volts. The percentage fluctuation is 36 per cent., which is smoothed with chokes (Fig. 9).

A device may be mentioned for obtaining voltage variation and yet utilising all the condensers. The connections are as in Fig. 10.

A plug with three or more points fixed to an insulating holder is arranged to be pushed into any three adjacent sockets as shown, and if the voltage across each condenser is, for example, 200, outputs of 400, 600 or 800 may be obtained by putting the plug into the appropriate sockets. The condensers are at the same time connected in the most advantageous manner. Instead of a plug a special switch can be used, and is more easy to manipulate but more difficult to make.

It might be asked if the principle could be adapted to A.C. working. Owing to the lack of A.C. supply the writer has not been able to test his theory in this respect; the following is offered as a suggestion to any who may have the facilities for trying such a device. The one machine takes the place of transformer, rectifier, and, to some extent, smoother. The chief difficulty that arises

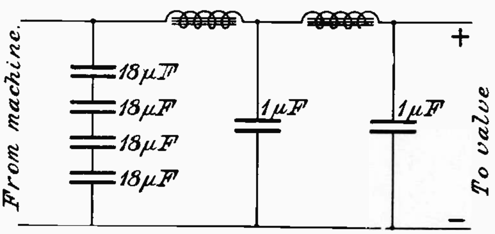


Fig. 9.—A suitable form of smoothing circuit.

is that a synchronous motor is necessary, and such is not to be obtained as readily as a D.C. motor. To those who like experimenting with A.C. the problem is an extremely interesting one to solve. A synchronous motor could be made from a small

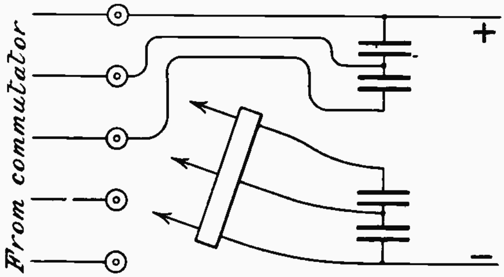


Fig. 10.—A system for obtaining voltage variation.

Assuming, then, that the brushes can be rotated at a fixed speed depending on the frequency of supply, the condensers can be charged in a similar manner to that already described, provided that the right moments are selected for contact.

Fig. 11 shows the sine wave voltage curve of the supply, which, for the sake of convenience, is assumed to be 200 volts 50 cycles. The maximum voltage is therefore 283, and if a condenser is in contact at the moment marked A it will be charged to that amount. The dotted curve indicates its gradual discharge after being disconnected at A, and at time B it is again at the same voltage as the supply, so this is the most opportune time for connecting it again as far as C; after which the process is repeated. It is assumed that the resistance in the charging circuit is negligible, and so the condenser voltage follows that of the supply exactly so long as it is in contact. If this were not so there would be a slight drop between the two, which might make it slightly more

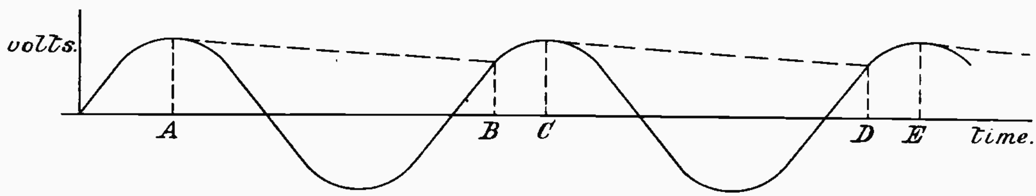


Fig. 11.—Line wave of supply voltage indicating the correct instant for contact.

induction motor by substituting rotating magnets for the squirrel-cage rotor, and using the stator winding on the supply mains in the usual way. Starting might be effected either by a short-circuited winding on the rotor causing it to start up itself and finally fall into step, or a small auxiliary battery motor.

advantageous to maintain contact a little past the maximum, as in Fig. 12.

Generally speaking, however, it would be near enough if the moment of maximum supply voltage coincided with that of the disconnection of the condenser.

The best moment for connection would depend on the extent to which the condenser was discharged, as premature or retarded contact would lead to sparking and loss of power. A machine designed for small voltage fluctuation would require a very narrow "live" segment, while one worked near its maximum output would be better, with a wider contact. This factor is variable in the rotating contact type, but is fixed where a commutator is used. Another necessary adjustment is a device for rotating the contacts through a double-pole pitch of the motor, in order to arrive at the correct points C, E, etc., this being done whilst watching the output voltmeter to obtain the optimum point.

If the condensers were connected up in the usual manner, only one half of the wave could be utilised. To use both halves the connections are as in Fig. 13 for a four-stage set.

The motor must have as many poles as there are contacts—in this case eight—and with a 50-cycle supply will run at 750 r.p.m., charging each condenser twenty-five times per second.

The remaining particulars are calculated as for the D.C. machine, remembering, however, that the maximum voltage is 1·414 times the R.M.S. or rated voltage.

Readers of EXPERIMENTAL WIRELESS need hardly be warned that all due care should

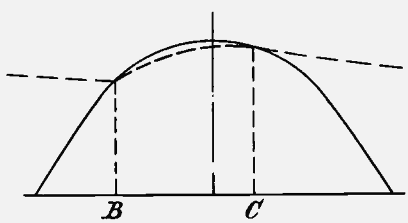


Fig. 12.—Curve showing duration of contact.

be taken in working with this class of machine, both as regards the power mains and the high voltage output, as a shock from the latter might easily prove fatal.

In particular the circuits should be well protected by fuses, and no part of the transmitter or its associated circuits should be directly earthed, as the output terminals of the machine are at a variable potential with respect to the mains, which are usually earthed somewhere. To guard against trouble a mica condenser should be placed in the earth or counterpoise lead, the capacity not above 0·01μF, as otherwise the H.T. supply will be reduced. In the writer's case, on one occasion when this condenser was not in use all six wires of the counterpoise were immediately fused across through falling on to a roof gutter.

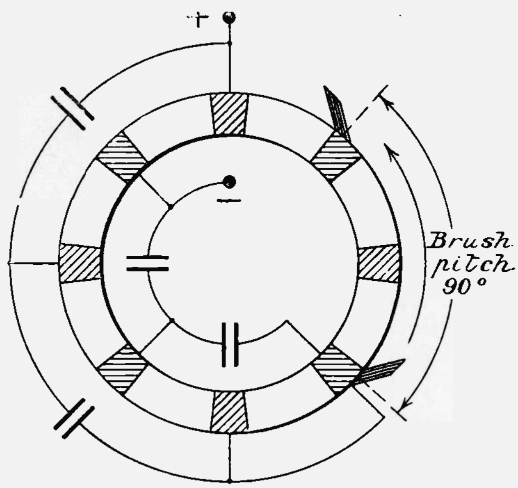


Fig. 13.—Showing the arrangement of the connections for a four-stage set.

The writer would be very interested to hear of any experimenter who has the facilities for investigating these machines with an oscillograph, as actual output curves would be very valuable and interesting in connection with the theory that has been given.

Transatlantic Messages.

On the night of January 16 2OD sent the following message to Hiram P. Maxim, of the A.R.R.L., via 1BQ, Canada :—

"Hiram Maxim, A.R.R.L., Hartford, Connecticut :

English Radio Transmitters Society send American Amateurs greeting stop Great pleasure that a number our Members have worked both ways with you on low power stop Hope next year we may assist you form round world amateur chain stop Happy New Year. IAN FRASER, Chairman, Radio Transmitters Society."

On the night of January 20 2KF received the following reply from Mr. Maxim (1XW) :

"Chairman Radio Transmitters Society :

Your message received and very much appreciated by all at A.R.R.L. Headquarters. Hope I may soon see you in London in March. HIRAM PERCY MAXIM, President."

A New System of Radio-Transmission.

We summarise below a system of transmission which has been developed in America, and while it is not yet possible to give an opinion as to its value, it certainly provides much scope for amateur experimental work.

THE defects of present-day radio-transmission are many, and radio engineers have been experimenting for years in an attempt to improve existing methods. At present it is impossible to have more than a limited number of stations working on any particular band of wave-lengths, and when two stations "clash" the transmissions of both are usually spoilt as regards reception, particularly in the case of radio-telephony. Also static disturbances render communications unreliable quite frequently. Again, there is no secrecy in the normal method of transmission. These defects are all serious, and many different schemes have been propounded to surmount one or more of them. A new method will be described here of getting rid of all these troubles, which is due to the work of Mr. H. J. Tyzzer, of U.S.A.

Many radio engineers have suggested various methods of "note tuning," *i.e.*, obtaining a beat-note of definite frequency and passing the resultant through filters, and, in fact, such systems are very widely used, but, unfortunately, this is not always entirely effective.

Similarly, interrupted C.W. has been used, and the note of interruption passed through filters, etc., but this is no better, if as good, as the previous system. In this new system interrupted continuous waves are used, but instead of interrupting the wave at an audible frequency a radio-

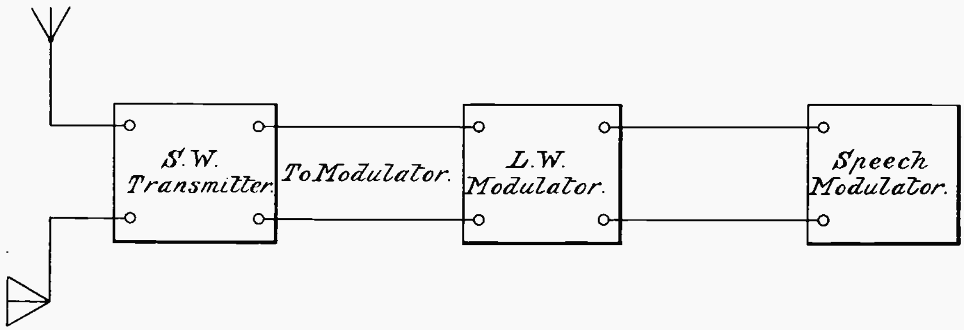


Fig. 1.—A diagramatic representation of the transmission system.

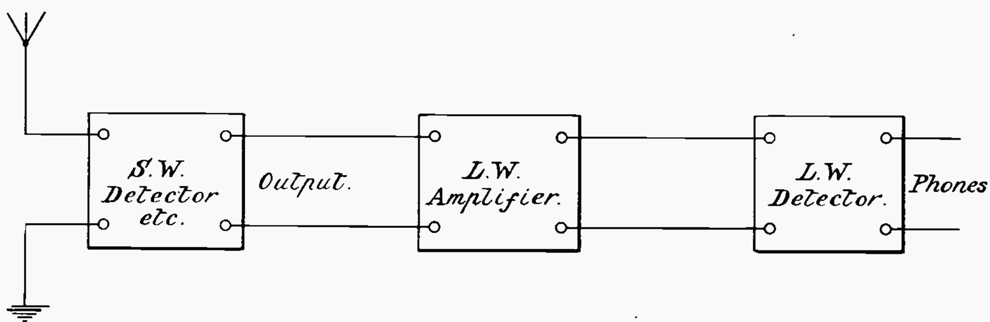


Fig. 2.—Illustrating the arrangement of the special type of receiver.

frequency is used. For example, if the normal transmission takes place on 200 metres this might be interrupted at a frequency of 100,000, corresponding to a wave-length of 3,000 metres. (These figures merely suggest a basis on which to work.) At the receiving end the 200-metre signal is received in the usual way, except that instead of the telephones a circuit tuned to 3,000 metres is used. Then several stages of R.F. amplification, and, finally, a detector, are used. The receiver is thus similar to the supersonic heterodyne without its separate heterodyne, though the system does not work on the same idea at all. It will be seen that it is only possible to receive signals when the receiver's first valve is tuned to the carrier frequency and the plate circuit to the modulation frequency. On an ordinary receiver only the pure unmodulated carrier is heard. We have here the possibility of getting a far greater number of stations in the wave-band at our disposal, as a large number of stations can operate near the same wave-length provided their modulation frequencies are sufficiently separated.

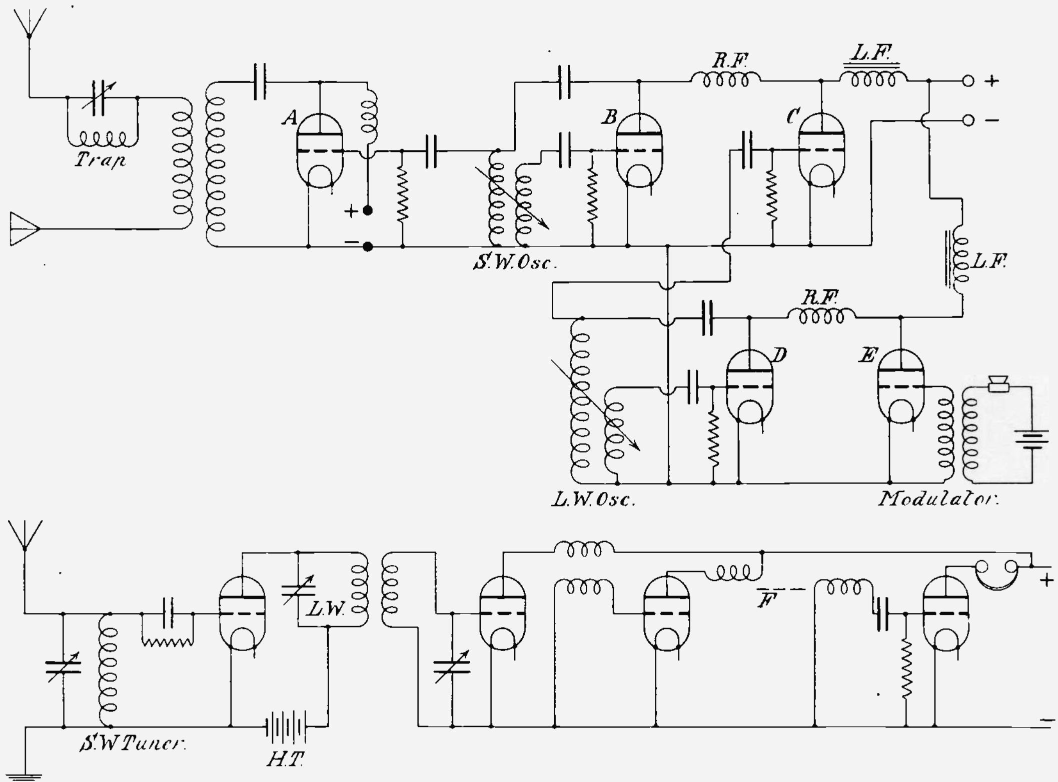


Fig. 3.—Above, is shown a complete arrangement for telephony control of the modulator frequency, while a suitable receiver is shown below.

Also static disturbances do not influence the receiver at all greatly because the incoming disturbance will set up a train of oscillations in the first valve circuit at the frequency of the carrier, which will not appreciably affect the modulation frequency amplifier, as it is tuned to such a widely different wave-length. Obviously the modulation frequency amplifier must be carefully shielded to avoid picking up static and other disturbances directly on its own wave-length.

Further, telephony can be used by this system. The modulation frequency can, in its turn, be modulated at speech frequency, and so we can carry on telephone conversations by this method with great freedom

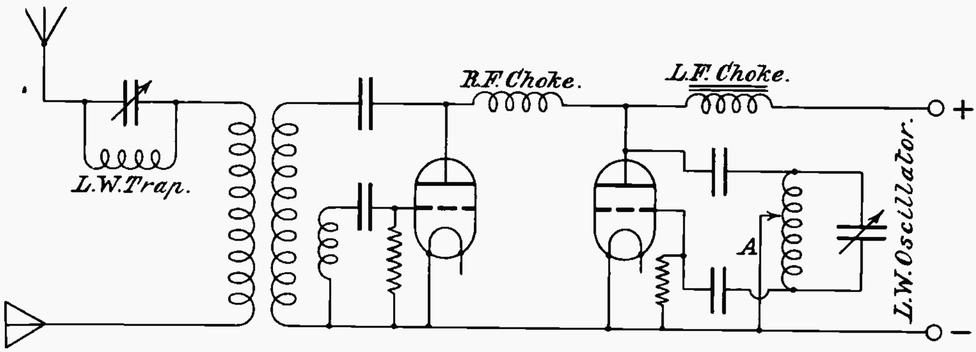


Fig. 4.—A simplified form of transmitter. The tuned trap prevents radiation of the modulator frequency.

from interruption. There are here incidentally possibilities of secret duplex working, which is much sought after.

It will be noticed that the modulation frequency must be of lower frequency than that of the oscillator. It is desirable that the frequencies should be well separated, and so it will be seen that the possibilities of this system are greater on short waves. The modulation frequency must not greatly exceed 20,000 cycles, and if telephone work is intended the speech quality will suffer if a lower frequency than about 30–40,000 cycles is used. A practical transmitter for C.W. is shown in the diagram, as is also a telephony set. A tuned trap should be used in the aerial circuit tuned to the modulation frequency, to prevent the radiation of that wave, or, alternatively, a loose-coupler should be used, or both on high powers. The diagram also shows a suitable receiving system. As many R.F. stages as desired may be used after the first short-wave detector, according to what is required. This system presents endless possibilities, and works as well in practice as it sounds in theory, so it is to be hoped that amateurs will experiment in this direction.

The Horticultural Hall Demonstration.

PERHAPS one of the most difficult tasks which the wireless enthusiast, whether amateur or professional, is called upon to perform is that of giving a successful public demonstration of broadcasting. By the use of suitable circuits it is possible to obtain practically distortionless amplification, and consequently it appears that the problem should be comparatively simple. This, however, is certainly not the case, and the difficulty lies in the acoustical rather than the electrical side of the problem. The amount of probable distortion, when using ordinary loud speakers, increases very rapidly with the volume of sound required, and as soon as any attempt is made to cover a large area it is almost essential to adopt entirely different methods. The demonstration at the Royal Horticultural Hall on the occasion of *The Model Engineer* Exhibition proved to be no exception to the rule; in fact, the acoustical and electrical conditions of the environment were far from what was expected, with the result that the special apparatus which had been built for the demonstration was substituted at the eleventh hour by other equipment.

The initial experiments were made in the EXPERIMENTAL WIRELESS laboratory, where it was hoped to duplicate the conditions likely to obtain in the Westminster district. The laboratory is situated about ¾ mile from 2LO. An inside aerial, about 15 ft. long and 2 ft. below a lead roof which covers the laboratory, was used for testing the tuning and rectifier apparatus. The measured rectified current from 2LO was found to be of the order of 60 microamps. The amplifier was built in the laboratory and tested some 15 miles out of London, a crystal rectifier and an ordinary outside aerial being used. The rectified current from this was approximately equal to that obtained in London. The amplifier and loud speaker gear were tested in the open between two houses, so as to imitate more nearly the conditions likely to be found in the Hall. After some little experiment with a four-valve resistance-coupled note magnifier in conjunction with Amplion loud speakers, excellent quality speech and music were obtained at a distance of about 30 yards from the loud speakers. The apparatus was then transferred to the Horticultural Hall on the evening prior to the Exhibition. An attempt was then made to determine the most suitable aerial, and a wire about 50 ft. long and 15 ft. high was tried was a 100-ft. wire attached to the top of the glass roof of the hall. This, it may be mentioned, necessitated a hazardous climb over a multiplicity of iron ladders and duck boards, at all angles between the horizontal and the vertical, which terminated in a kind of hatchway. Through this we crawled, together with a collection of aerial wire, insulators, wire cutters, etc., and found ourselves on a little trolley some 80 ft. up in the ether. The trolley had to be moved to the centre of the roof. This was accomplished by turning a crank connected to a sprocket, which transmitted our muscular energy to the driving wheels *via* what seemed to be a very slender bicycle chain. We were much too interested in the probable efficiency of the new aerial to consider how one reaches *terra firma* when the chain breaks. Having made fast the aerial to a neighbouring girder, and left the free end in the care of an assistant below, who meanwhile entangled it amongst

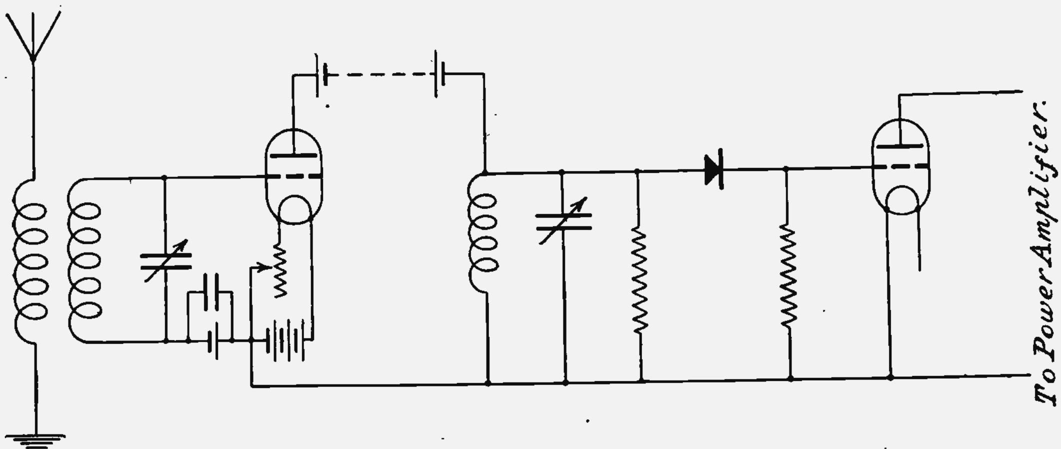


Fig. 1.—Showing the tuning, radio frequency amplifier and rectifier circuits. Note the various control devices.

stretched diagonally across the lounge. To our surprise the received energy from 2LO, about one mile away, was a negligible quantity. We were quite aware of the fact that the building was a steel structure, and, although considerable screening was expected, the results obtained were not in accordance with our previous experience under very similar conditions. As it was desired to limit the amplification as much as possible, the obvious procedure was to improve the aerial. The next system to be all the available power lines, telephone lines and exhibitors' stands, we cranked our way back to the hatchway and repeated, in reverse order, our simian antics of half an hour before.

The new aerial was worse than the first. True, the amount of energy which it passed on to the rectifier was infinitely larger than from the first aerial, but as this energy was derived chiefly from the aforementioned power lines it seemed to be of little value for our purpose. However, the result was interesting, and we felt that our labours had not been in vain. The only alternative now remaining was an outside aerial. This proved to be impossible in the strict sense of the word, and the arrangement finally adopted consisted of an interior vertical down lead and an interior horizontal span disappearing through the top of an open window, continuing at some unknown angle to the top of an inclined flag pole on the entrance porch. All this, it may be mentioned, was on the far side of the building with respect to 2LO. The received current was now just measurable.

All hope of obviating the use of radio-frequency amplification had now been abandoned, and accordingly the original tuner and rectifier were hurried back to the workshop for the inclusion of one stage of H.F. amplification. While these alterations were being carried out the Exhibition opened and gave us an opportunity of examining the true electrical and acoustical conditions of the Hall. The result of the investigation showed that the following were in operation throughout the day :—

Straight wiring on power lines.
Straight wiring on light lines.
Electric motor (one yard from receiver).
Electric flashing signs.
Wimshurst machines.
Spark coils.
Ultra-violet ray device.

However, by the use of three tuned circuits the above were reduced to little more than a threshold effect, even on full power. The converted tuner had now arrived, and the rectified current from 2LO was found to be of the order of 40 microamps., which it was hoped would be of sufficient magnitude to operate the resistance amplifier. The resistance amplifier, it may be mentioned, was designed to operate at a moderate efficiency with a fairly high input. On connection the amplifier was now found to be inoperative after the second stage. Why it should have broken down is difficult to suggest, and it now only remained to return it to the laboratory and search for the broken-down condenser, resistance or leak. By this time both the authorities and the public were making anxious inquiries as to the existence of the Broadcasting Demonstration. It was no good offering technical explanations; we could do little else than crave their patience. While another amplifier was being procured it was found that the coupling between the aerial and closed circuits had to be so reduced to eliminate interference, that the rectified current was considerably diminished, thereby lowering the output to the resistance amplifier to such a degree as to make it of little value. This pointed to the use of an amplifier of much greater efficiency and a two-stage transformer-coupled power amplifier, preceded by a direct-coupled note magnifier was employed, the standard Western Electric power amplifier meeting the requirements. This was operated in conjunction with two Western Electric loud speakers, which were very

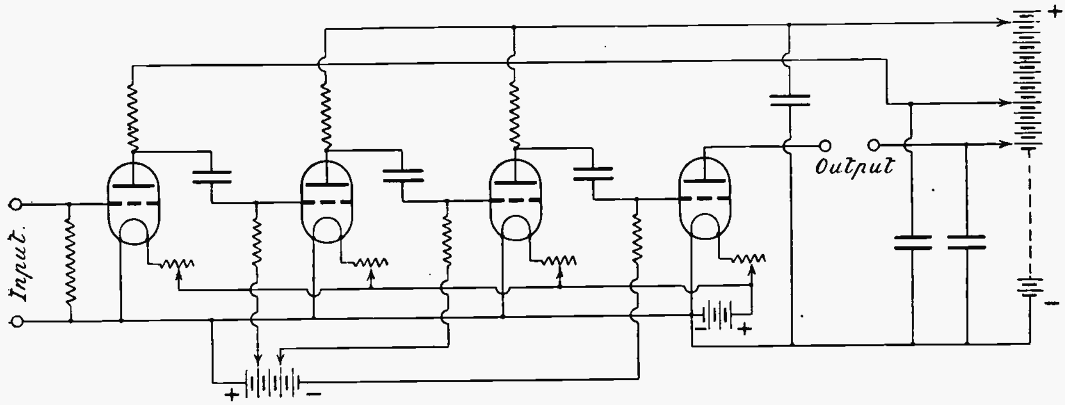


Fig. 2.—In the resistance coupled power amplifier all variable quantities were provided with separate control, as shown.

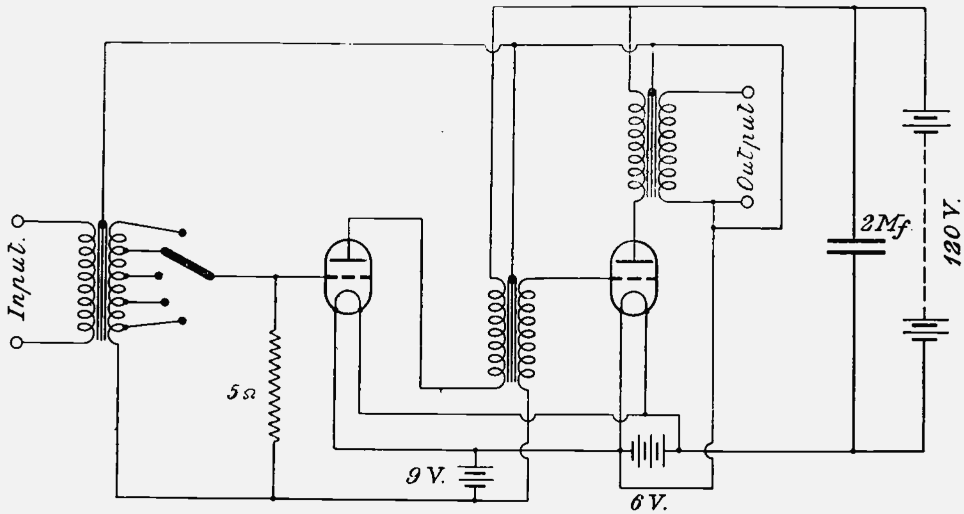


Fig. 3.—The arrangement of the amplifier shown above ensures stability and quietness in operation. The valves used were Western 216a type.

kindly lent by the Western Electric Co., Ltd., to whom we offer our thanks.

When the amplifier was finally in working condition the amplified output was examined by a shunted telephone, and it was found that both speech and music were of excellent quality. Accordingly the loud speakers were connected to the output—with terrible results! The loud speakers were mounted on a bracket some 8 ft. high in the corner of the lounge. Apparently half the emitted sound impinged upon a very deep girder in the middle of the lounge and over almost the entire frequency range the resonance was considerable. This was overcome by lowering the loud speakers to a height of only some 4 ft. from the floor. Everything within the lounge now seemed very beautiful, but on walking into the body of the hall amongst the nearby stands the most appalling noise ever heard reached our ears. It appeared that the sound waves were following a multiplicity of paths among the numerous gangways, and on reaching the ear the direct and reflected waves were all out of phase. At the farther end of the hall this effect was not noticeable, due, perhaps, to the fact that the angles of incidence and reflection were more obtuse.

Perhaps a few details of the apparatus used will be of interest. Throughout the whole circuit every effort was made to eliminate distortion. Excessively sharp resonance in the high-frequency circuits should be avoided, and for this reason the aerial circuit consisted merely of an inductance; this arrangement, in conjunction with a fairly highly-damped aerial, was not very resonant. Both the capacity and inductance in the closed circuit were capable of adjustment, and the inductance was wound with fairly fine wire. A similar arrangement was used in the tuned anode circuit; in this case a 50,000-ohm resistance was shunted across it. Every precaution was taken to reduce retroactive effects to zero. Rectification was accomplished by a galena crystal, which operated on a fairly parabolic portion of its characteristic. The crystal was connected to the grid of the first amplifier, the potential being controlled by the input resistance. This was either resistance-coupled to the resistance power amplifier or to the input transformer of the other amplifier. The output from the amplifier was shunted by a variable non-inductive resistance. The transformer-amplifier calls for some comment. The ratio of the input transformer is variable, being tapped on the secondary and shunted by a half-megohm resistance. The transformer cores are electrically connected and earthed. The actual transformers are specially built for speech amplification, and give practically equal amplification at all speech frequencies. Unfortunately, we are not at liberty to disclose the special method of construction employed, although, no doubt, many readers are really familiar with the principles which are involved.

Valve Manufacture : Some German Methods.

BY DR. A. NEUBURGER.

While experimenters are familiar with receiving and transmitting valves of all types, probably little is known of the method of manufacture, and the following description of German methods should be of great interest.

As the manufacture of German valves was developed during the recent war, it was not influenced to any great extent by those methods employed in other countries, and, therefore, a great many distinctive features are to be found. The first apparatus for valve manufacture on a commercial scale was installed by the Telefunken Co., after a considerable amount of experimental work. Previous to this valves had only been manufactured in a very primitive manner and

Fig. 1.—Turning the glass feet on a "lathe."

only in very small quantities. In these early experimental valves it is interesting to note that the electrodes were hammered out from ten-pfennig pieces, which, of course, consisted essentially of nickel. The preliminary experiments proving successful, a large-size factory was erected, equipped with machinery of the latest type, including several machines for special work. Much time was then devoted to the development of methods suitable for mass production. The results obtained were very gratifying, as similar experiments on other forms of tubes, such as the Roentgen tube, had not been very successful in many directions.

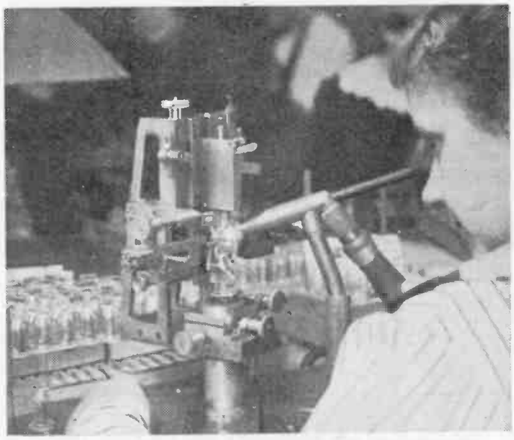


Fig. 2.—A machine which forms and welds the electrodes.

The machinery used for the mass production of the electrodes is of considerable

Fig. 3.—Welding the foot into the bulb.

interest. Essentially the machines are fitted with a number of levers and other arrange-

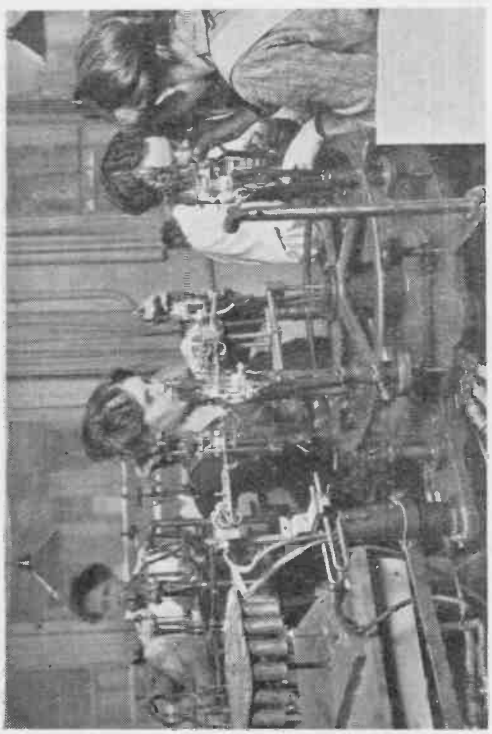


Fig. 4.—A near view of the foot pressing machine.

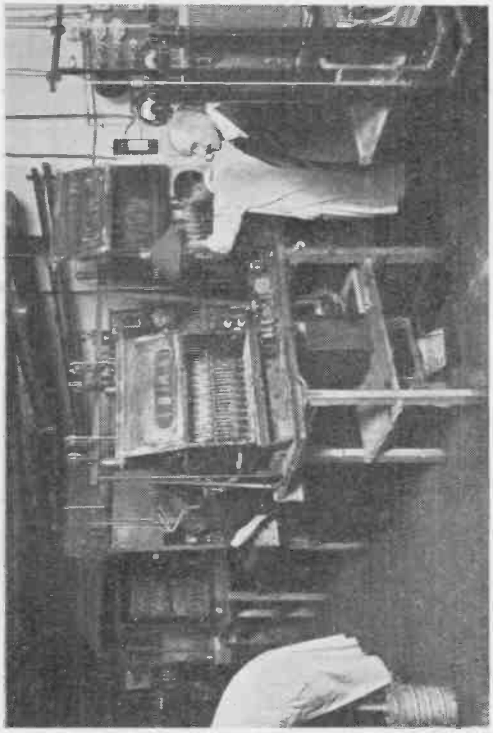


Fig. 5.—An evacuation room in which 2,000 valves are pumped daily.

Fig. 6.—Valves connected to glass "forks," prior to entering the furnace.

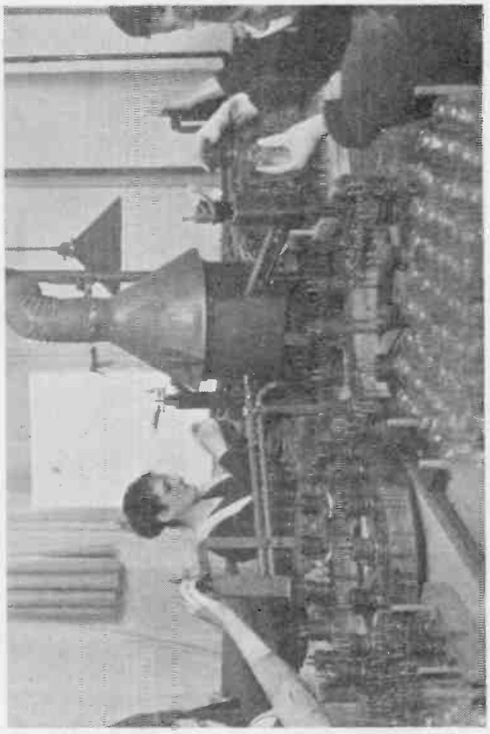


Fig. 7.—The machine used for fixing the caps to the valves.

ments, which are operated in a pre-determined order, so that when each electrode has been bent into shape by the machines, they mechanically come into the correct position in respect to each other. As the method of manufacture of transmission and receiving valves are in many ways identical, we will consider general manufacturing processes first, and deal with each individually subsequently.

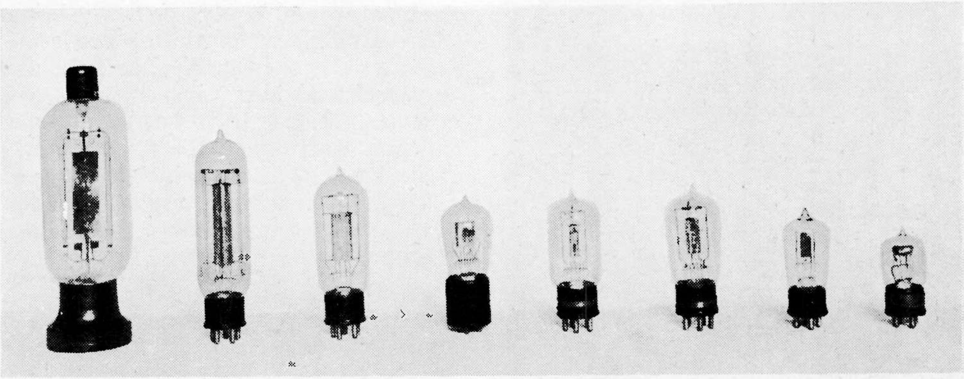


Fig. 8.—Some latest types of German receiving valves.

The "glass feet" are made from glass tubing cut off in short lengths. One end of each tube is softened in a flame and enlarged by turning in a machine which somewhat resembles a lathe. The leads and supports for the electrodes are then fixed to the feet and are then melted into the stump. Both the leads and the electrode supports are prepared in an automatic machine, which adjusts their length accurately. Before they are fixed into the stump they pass through a gauge, which determines their relative positions and depth of sealing. The stump is heated in two flames. The first flame gently warms it, while the second one gently softens it. The feet are then placed in an annealing installation which consists of a small cylindrical box containing asbestos heated by a gas flame. They are then passed to the presses, which are foot operated and are capable of dealing with some sixty feet in an hour. The presses work so successfully that only about one foot in a thousand will burst. The annealed foot first goes into the work-

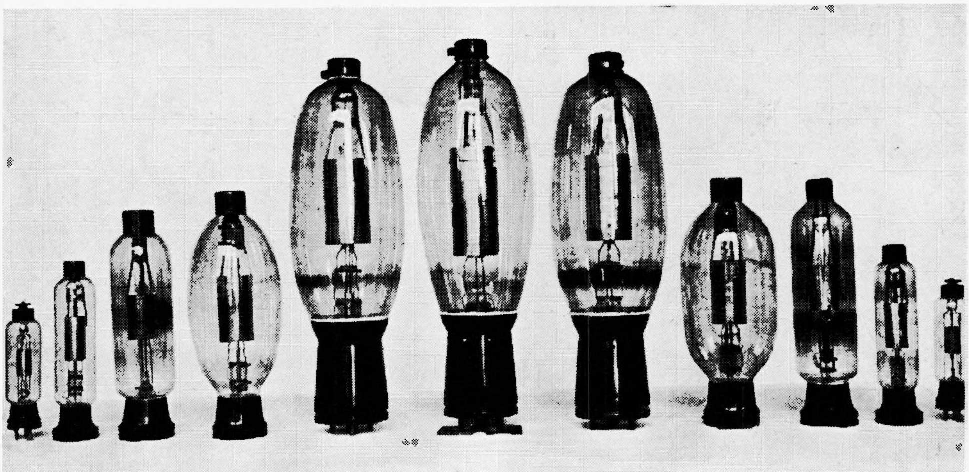


Fig. 9.—A collection of German transmitting valves. Note the peculiar shape of the bulbs.

shops, where the electrodes are mounted. First the electrode supports are shaped, and then the grid and anode and finally the filament are fixed. The electrode supports and the grid are both made in the same machine. The construction of the grid is

Fig. 10.—General view of testing room.

interesting. The blank grid is first stamped out from a thin sheet, and the stamping then goes into a second press, where it is stamped into the form of a grid-iron, finally being rolled and bent. For each of these operations a special machine is employed, which

Fig. 11.—Measuring the vacuum.

accurately determines dimensions and shape. As soon as the electrodes are made they have to be fixed to their supports, which is accomplished by spot welding. For this purpose electric welding machines are employed, and the actual welding is carried out in an atmosphere of hydrogen. The object of the hydrogen atmosphere is to prevent oxidation of the metal or alloys of which the electrodes are made. It is for this reason that the electrodes in a valve of German manufacture are always perfectly bright.

The attachment of the electrodes to the supports is semi-automatic, and the apparatus, which embodies various gauges, ensures an extraordinary high degree of equality. The first electrode to be fixed is the grid, after which the anode (which is stamped out in a similar machine to that used for the grid) is fixed, and finally the filament is attached to its supports.

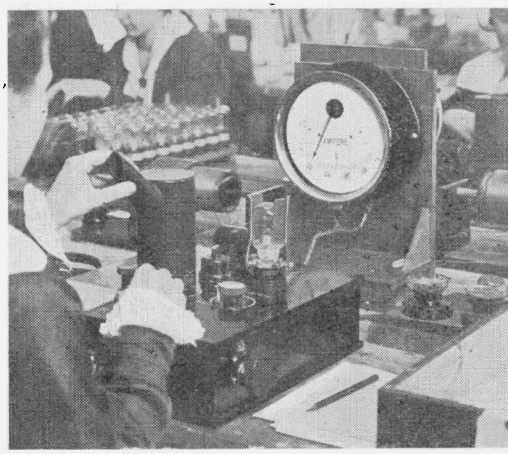


Fig. 12.—Measuring the amplification.

The glass bulbs in which the foot supporting the electrodes is to be fixed are made elsewhere, and are delivered to the valve factories in bulk. First of all a glass tube is melted on to the top of the bulb, which not only enables the bulbs to be handled easily, but allows air to be blown into them, which is necessary for subsequent processes. The bulbs are made somewhat longer than is required at the open end, and when this is adjusted to the correct length, the foot is brought into position and melted in. Then a second small tube is fixed to the bottom of the bulb, which serves for the subsequent evacuation process. After the second tube is melted on the first tube is removed and the opening closed in a flame. The small tubes fixed to the bottom of the bulb are then melted on to a series of other tubes, which communicate with the vacuum pumps. The preliminary vacuum is obtained with ordinary mercury pumps, which are substituted by the familiar charcoal and liquid air device for final evacuation, during which process the bulbs and tubes are heated to the highest degree possible. During the process of evacuation the filament is, of course, heated and a high voltage placed on the electrodes in order to remove any occluded gases by bombardment. When the highest degree of evacuation is reached, as indicated by the vacuum meter, and further pumping shows that the vacuum is not increased, the small glass tube is closed by melting and effectively seals the bulb.

There are certain differences between the manufacture of reception and transmission valves. The anodes and grids of the transmission valves must have a greater efficiency than those in the ordinary receiving valves. For example, they must be capable of dissipating greater electrical energy, and there are only a few metals which, if heated even to red heat, are capable of maintaining a high vacuum. For transmission valves such metals as tantalum, tungsten, and molybdenum are employed, also certain alloys of various other metals are sometimes used. Care has to be taken when selecting suitable glass and Thuringia glass is universally employed. For transmitting valves the securing of the electrodes to the stump is always carried out with the aid of a foot-operated press. The filament is of tungsten, and is electrically connected to its supports by spot welding, and is kept in its correct position by a spiral spring. For the anode tantalum is used, which is stamped out from sheet, finally being rolled and made into the form of a cylinder with the aid of electrical welding part. Before mounting the electrodes occluded gases are removed by placing them for several hours in electrically heated high vacuum furnaces, a very high temperature being maintained. When evacuating transmitting valves the preliminary vacuum is obtained by means of a diffusion pump, which gives a very high vacuum, the final vacuum being secured by the absorption method mentioned before. Great skill is required for the final evacuation process, as otherwise it is very easy entirely to ruin a valve. The completed valves go through various testing processes before being finally passed out of the fac-

Fig. 12.—Ageing test of valves subjected to abnormal anode voltages.

tory. First of all, each valve is roughly examined by inspection. The filament is then tested in order to see that it has not been overheated during the evacuation process. This is determined by measuring the current necessary to make the filament begin to glow. The conductivity of each electrode is noted with the aid of a galvanometer. The degree of vacuum is measured by a special method described below. The procedure consists in measuring the ionisation which takes place with a definite voltage on the anode, the ionisation current being measured by the galvanometer. During this process, of course, the filament is kept glowing at a definite intensity. During these tests it is of the utmost importance to ensure that no oscillations are produced by the valve, and special arrangements are adopted with this end in view. Assuming that the vacuum has been found correct, the valve undergoes an ageing test with a super-normal anode voltage. If the valve passes the last test satisfactorily, it is stamped, marked, etc., and finally some of the tests just described are repeated once more in order to see that no change takes place in its characteristics. The valves are then considered as being suitable for wireless work and are then passed out from the factory.

Design for a Duo-regenerative Receiver.

By Capt. St. CLAIR-FINLAY, B.Sc.E. (Laus.).

In response to enquiries from experimenters wishing to set up the circuit described in the first issue of this journal in an article entitled, "The Design and Operation of Tuned Anode Receivers," a suggested layout for such a receiver employing three valve stages is here given.

It will be noticed that the circuit has been somewhat simplified in certain respects, the L.T. connections to the first valve having been modified so as to give a neutral grid potential thereto suitable for all-round work with the majority of valves without necessity for special adjustments to provide this, and the final power stage originally shown having been omitted, since this will not usually be necessary, and can always be added if required as a separate unit, which many experimenters will already possess. The shunt leak between V1 and V2, the purpose of which is the maintenance of the grid circuit of the latter at a suitable normal potential, is now shown fixed instead of variable, as the value is not really critical, and will usually lie between 1 and 2 megohms, only the grid-leak proper being now variable ; and the A.T.C. is now arranged permanently in series to enable short waves to be received, the A.T.I. being shunted by a vernier condenser of about ·0001 mfd. or less for fine-tuning, this being of some importance when a series-tuner is used, as it resonates the A.T.I. and considerably corrects the tendency to flatness of tuning which ordinarily characterises the series arrangement. Suitable tuning condensers of about ·001 mfd. capacity, in which a vernier adjustment, consisting of a small independent condenser of two or three plates arranged coaxially with the main set, is incorporated, are obtainable, and can easily be rearranged so that the main part is in series and the vernier in parallel with the A.T.I., and such an arrangement, which affords a neat and compact design, is shown in the present diagram, which also shows suitable switchgear enabling the L.F. stage to be cut in or out at will.

The switch is not arranged to control the filament simultaneously, as this is, in the case of the H.F. and detector stages, controlled by the rheostats only, switchgear being unnecessary, and it is thought better to standardise controls and make all alike as far as possible.

A circuit diagram and wiring diagram of the modified receiver are given in Figs. 1 and 2 respectively.

With regard to details—the panel should

not be made much smaller than shown in Fig. 2, as avoidance of cramping is essential if the full merits of the receiver are to be obtained. Components of really good quality should be used throughout, and will be found amply to repay any slight extra trouble or expenditure involved; and whereas this, of course, applies throughout a receiver, it is of special importance in the case of the intervalve transformer, poor quality of which may result both in loss of efficiency and in ruination of the quality of reception, and to the stopping condenser between V1 and V2, any leakage in which will cause more or less complete paralysation of the receiver through conveyance to the grid of V2 of high potentials from the H.T. battery. Good mica dielectric and not paper should be used here, and a transformer of reliable make for L.F. coupling, whilst a reliable type of variable grid-leak is also essential.

For the guidance of those who may not wish to make up their own components, it may be mentioned that the following proprietary makes have, amongst others, been found satisfactory by the writer, and may be used with confidence :—

Transformers.—R.I., Igranic, Sullivan, Lissen, Burndept and M.L.

Fixed Condensers.—Edison-Bell, Mullard, Dubilier and Burndept.

Variable Leaks (continuous).—Watmel and Lissen.

Variable condensers of the mica-dielectric type are compact, comparatively free from body-capacity effects, and, having a practically 360° movement, are less critical in adjustment than the usual air type and are very suitable for tuning purposes, particularly as regards the anode circuit. A rheostat with vernier adjustment is of advantage for control of the detector.

The wiring of the receiver should be carried out with clean copper wire of 18 or 20 S.W.G., preferably enamelled to prevent development of skin-resistance, particularly if the receiver is to be used in a large town, manufacturing district, or near the coast. For certain reasons, too involved to be entered into here, the writer is not in favour either of tinning of the wire or soldering of the connections, and whilst this latter may, of course, be done if desired, and will be reasonably satisfactory if carefully carried out, it is suggested and hoped that the bare statement will, for the present, be accepted that connections made with thoroughly cleaned wire and screw-terminals, well tightened up and finally shellacked at the joints, will be better electrically than the majority of soldered connections. The wiring should be carefully arranged, and that of the H.F. and detector circuits particularly kept as well spaced and isolated as possible.

No switchgear is provided on the H.F. side, as this is neither advocated nor neces-

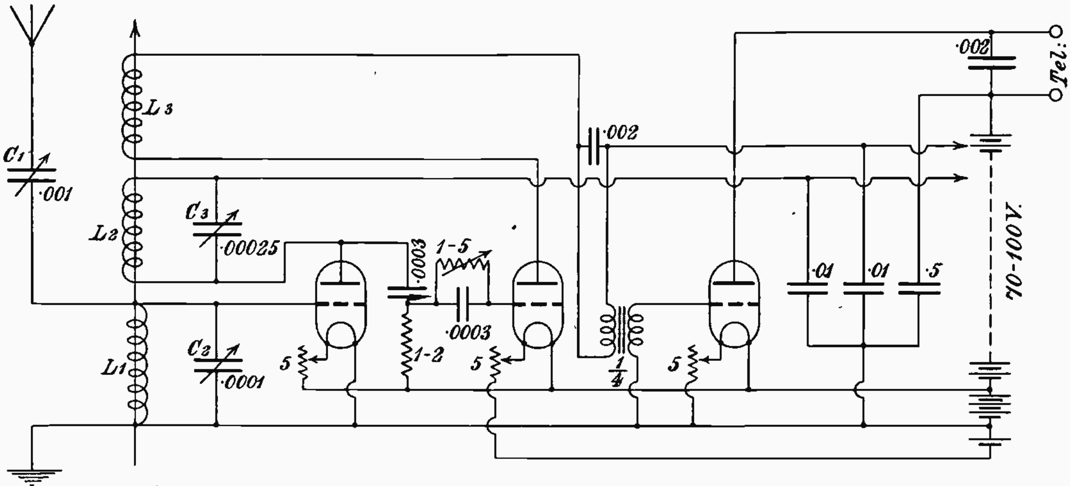


Fig. 1.—A modified form of the tuned anode circuit given by the author on page 41, October issue.

sary in the present case, since, when H.F. amplification is not required, V1 can be cut out of action and an ordinary regenerative closed-circuit receiver formed merely by turning out its filament—a feature of this circuit, further mention of which is made elsewhere in these pages.

A three-coil holder suitable for the usual plug-in coils is shown in the diagrams, and an instrument of the geared type is recommended as being really substantially made and affording a valuable degree of fine adjustment, although for short-wave work Gimbal-mounted coils would be somewhat better, and a holder suitable for this can easily be substituted if desired.

Direct 'phone connections are shown to permit of the addition of a power stage or the use of high or low-resistance instruments, as may be desired, in which latter case, of course, a suitable transformer would be connected externally.

It should here be mentioned that the value of the by-pass or telephone condenser shown in the diagram as ·002 mfd. should not be regarded as arbitrary. It should in no case be smaller than ·001 mfd., as this would interfere with its functions as R.F. by-pass and A.F. float, but it has the additional function of resonator to perform in regard to the transformer primary when the L.F. stage is in operation, and as this has an important bearing upon the resultant quality of reception and individual transformers, even of the same make and type, are apt to vary considerably in this respect,

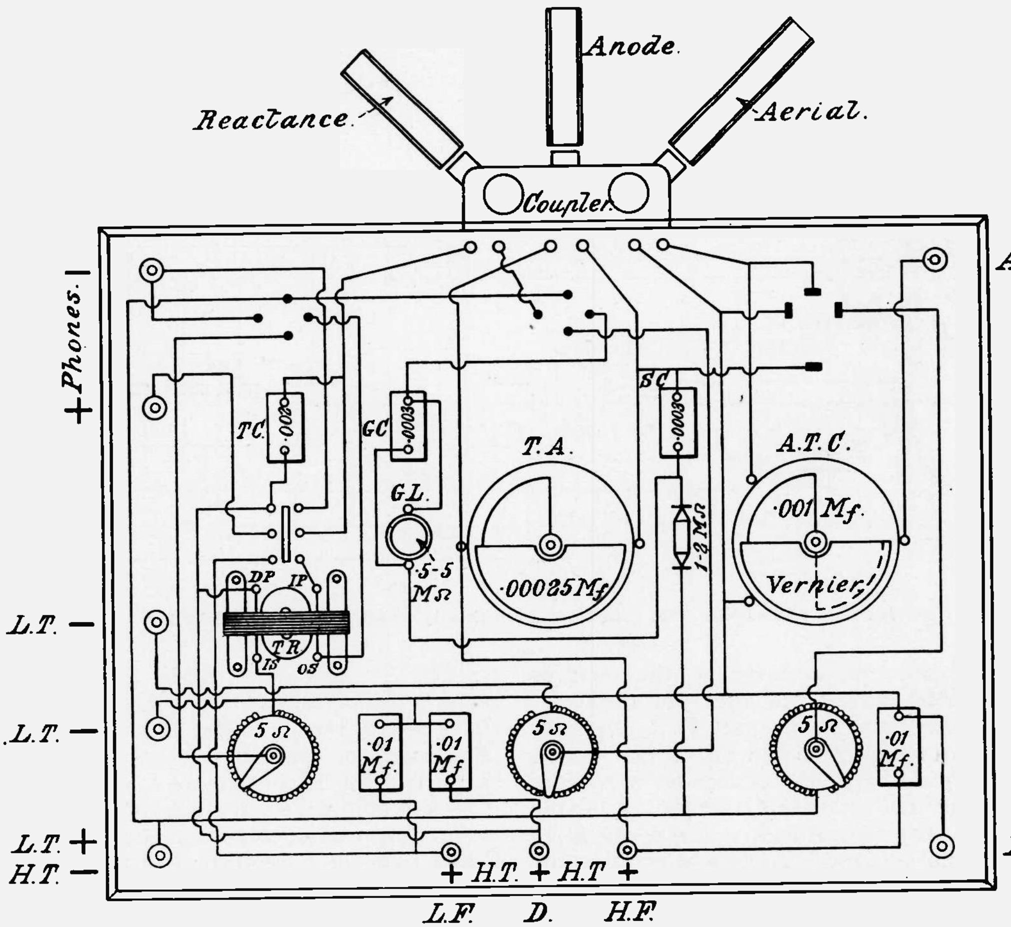


Fig. 2.—A correctly designed panel lay-out ensuring maximum electrical efficiency.

experiments with various values between ·001 and ·005 mfd. should be made until the particular transformer to be used has been suited. The same applies to the fixed shunt leak between V1 and V2, the best value for which should be determined by experiment with signals of medium strength before final installation.

Whether bright or dull-emitter valves are to be used, it is strongly recommended that a semi-soft detector of the Dutch type be used, as this will be found to suit the receiver particularly well and markedly to effect its efficiency, and to this end it will be noticed that a separate L.T. tapping is provided for the detector. These valves operate on about ·5 amp. at 3·5–4 volts, so that when dull-emitter valves are used at V1 and V3 the separate tapping, enabling an extra cell to be brought into the detector L.T. circuit, will usually be found necessary, though, of course, when bright-emitters are used throughout this will be unnecessary, and the two L.T. minus terminals should be shorted together by means of an external connecting strip, as shown in Fig. 2.

Should it be particularly desired to use dull-emitters throughout the B.T.H. B/4 valve will be found a very efficient detector, but here again the separate tapping will be called for, as this valve works on about ·25 amp. at 5–6 volts. Being hard, the plate voltage will not be found critical, but in the case of a semi-soft Dutch valve not more than about 50 volts H.T. should be applied, and should be kept well below the "blueing" point, which will usually be found to lie between about 60–80 volts.

With regard to operation of the receiver, tuning of the aerial circuit will differ somewhat from the more usual case where the main A.T.C. is arranged in shunt with the A.T.I., as in the present case C1 should be kept at as large a setting as possible consistent with correct tuning for reception of signals above about 300 metres, which means that the smallest possible size of coil, rather than the largest, should be used for the A.T.I. For short waves, on the other hand, almost the reverse applies, as in this case the largest possible size of coil should be used consistent with a reasonable setting of C1, which should not be allowed to fall to, or too closely approach, the zero mark. Initial tuning should in either case be done with the vernier C1 at a midway setting, use of the latter being finally made for fine tuning in either direction. The anode circuit should be tuned as usual, *i.e.*, the largest coil and smallest possible condenser setting being adopted in all cases unless a marked tendency to self-oscillation arises, in which case the policy may be reversed with advantage.

The couplings between the three coils L1, L2 and L3 should be so set that, with the two former tuned to resonance, and the most suitable size for the latter being used, V1 and V2 both just oscillate freely with full H.T. voltage and reasonably bright filaments, the H.T. and filament temperature being then reduced until oscillation ceases and stability of both circuits is obtained. Regeneration will then be adjustable at will simply by variation of the H.T. and filament temperatures, without disturbance of the couplings or tuning of the circuits.

If H.F. amplification is not required, it is merely necessary to turn V1 out, slightly tightening the coupling between L1 and L2, and re-tuning if necessary, whilst V2 can, of course, be cut in or out equally readily by throwing over the switch controlling it and turning out its filament, one, two or three stages in any desired combination being thus instantly obtainable at will.

The receiver should be found very manageable, and no difficulty whatever should be experienced in its operation, whilst, if carefully constructed and handled, its efficiency should be about 50 per cent. greater than an equal number of stages ordinarily arranged, and quite as great as four stages (2H.F.) without reaction. Should any difficulties arise, however, they will gladly be cleared up, and experiences of amateurs with this receiver will in any case be learned with interest by the writer.

The Month's "DX."

Recorded by HUGH N. RYAN (5BV).

The increasing efficiency of amateur transmitters and receivers is resulting in the creation of many new long-distance records which are undoubtedly worthy of mention. It is proposed to record month by month work in this direction, and the Editor will be pleased to receive details for inclusion in these pages.

THE latter half of December and the first half of January is always the most interesting part of the year from the "DX" point of view, and this year has been no exception. At the beginning of December no British station had succeeded in sending signals across the Atlantic. We all hoped that the coming trans-Atlantic tests would result, at any rate, in a few of our best stations "getting over," and the more sanguine among us hoped that two-way working on fairly high power might be accomplished before the winter was over. But few even considered the possibility of two-way working before the tests commenced.

Events have moved very fast since the beginning of December, and it is now ancient history that 2KF established two-way working with 1MO on December 8, though the news only got into the tail end of these notes. This success was quickly followed by those of 2SH, 2OD and 5BV, all of whom established two-way communication across the Atlantic before the end of 1923.

The total numbers of American and Canadian stations worked by these four stations, and the approximate powers used, are as follows:—2KF, five Americans, one Canadian, 90 watts; 2SH, two Americans, one Canadian; 2OD, one American, one Canadian, 40 watts; 5BV, two Americans, two Canadians, 45 watts.

The most remarkable performances are those of 2KF and 2OD, the former because of the large number of stations worked, the latter because of the low power and also because 2OD has worked Canadian 1BQ so very often and consistently.

Since the end of 1923 we understand that a number of other British stations have established communication with America, but full details are not yet available. These stations include 2SZ, 2NM and 2FU.

That is a fairly complete account of the results obtained apart from the official trans-Atlantic tests. These tests extended from December 22, 1923, to January 10, 1924, and during that time the stations who had entered for the tests sent ten-minute schedule transmission every night, and each station had a different five-letter code word for each night. This code word he sent with the schedule transmission each night, and reception on the other side could thus be verified.

At midnight every night during the tests American 1XW (Hartford, Conn.) sent, on 100 metres, a report of the previous day's reception results in America and Canada. These transmissions were received in Europe by 8AB, PCII, 2KF, 5KO, 2KW, 5BV and others during the first part of the tests, but towards the latter part it is to be feared that most of these stations found that keeping up during the test periods of each night was quite a sufficient tax on the constitution, without listening for American reports as well!

At 12.45 each night R.S.G.B. station, 6XX, broadcast the results of the tests up to date. Up to the time of writing the following stations have been recognised by the R.S.G.B. as having been received, with code words verified, in America:—2FQ, 2KF, 2SZ, 5LC, 5PU, 6NI, 5BV, 2KW, 2NM and 2OD.

These are all ordinary amateur stations, and in addition to these 6XX, the special R.S.G.B. station, and 6YA, which, we understand, is being run by the members of a radio society, have been successful.

5KO does not yet appear in the R.S.G.B. lists, but 1XW has reported this station as having been received, with code word, and 1BQ gave me a message for him recently, giving his code word, which has been verified.

In addition to these British stations, six French stations (8AB, 8AE, 8BF, 8CT and 8LD) and three Dutch (PA9, PCII, oDV) have been received in the United States.

The tests have been very interesting from several points of view. Firstly, they have shown very clearly the differences between the two classes of transmitting men. We have those who are keen experimenters, who design and make their own apparatus, and who operate it themselves. Also we have those who never perform any experimental work, who buy their sets ready made, who usually know no Morse whatever, and who are usually best known for the great number of gramophone records which they send.

Both classes of station took part in the tests (the latter employing operators), and success was, fortunately, almost entirely with the experimenters.

It was to be noticed, however, that while the stations of the former type transmitted only during their schedule periods, as was requested, and gave other people a clear field at other times, those of the latter type transmitted nearly the whole of every night, with a fine disregard for anybody else. But for this it is probable that more of the better type of stations would have been successful and none of the others.

Now that the tests are over we hear of an extraordinary trans-Atlantic success obtained by a station whom we usually associated with excellent short-distance telephony in and around London rather than with DX.

On the evening of December 27 2XZ was working on his usual 10-watt set, with another station only about 1½ miles away, and experimenting with pianoforte transmission. His transmission was received, on a nine-valve super-hetrodyne set, at Kansas City, Mo., 5,000 miles away. The speech and music are accurately reported, and there appears to be no doubt about the authenticity of the reception. There is no doubt that that night was an exceptionally fine one for long-distance work, and this result is in the nature of a "freak reception." But, nevertheless, it speaks highly of the transmission, and we congratulate 2XZ.

It was on this night that I first worked Canadian 1BQ, and his signals were of such great strength on one valve that, bearing in mind having been "had" on previous occasions by humorists with hetrodynes, I did not believe that he was a Canadian, much to his amusement, and that, I believe, of several British stations also! Later the same night 2OD worked him, and his signals were reported to be very strong, so it seems that it was a very fine night.

The best night since the tests so far was that of January 12—13, when some thirty Americans were heard in England on 100 metres alone.

By this time everybody knows that the 100-metre transmission of KDKA, mentioned in last month's notes, is a separate transmission and not a harmonic, as many thought at first. It is a very good transmission and will often work a loud speaker on two or three valves.

Some confusion was bound to arise in trans-Atlantic work owing to the fact that British and French call signs have their duplicates both in America and Canada. During the tests, of course, where only single-way work was involved, British stations prefixed their call signs with the letter G and French stations with F. This becomes very clumsy in two-way working, and the Americans have adopted the practice of using a distinguishing "break" sign instead of the usual "de." The sign is composed of the letter corresponding to the "called" station's country, followed by that corresponding to the "calling" station's country. The letters used are:—Britain, G; France, F; Holland, N; U.S.A., U; and Canada, C. Thus, American 2AGB calling Dutch PCII would call PCII nu 2AGB, and PCII would reply 2AGB un PCII. This is the most convenient way of avoiding confusion.

European "DX" is now in evidence again, though it was less interesting after the American work. However, much remains to be done in European work, chiefly in designing receivers which are selective enough to receive through the terrible QRM which we get nowadays, and sensitive enough to enable less power to be used by the transmitter, thereby lessening the QRM.

Nearly a year ago we used to read in French radio papers of a Swiss amateur transmitter, known as XY, but I do not think that he was ever heard in this country. He has apparently increased his power recently, as he is now quite strong. He first came in on January 6 at about 4 p.m., and at 5 p.m. 5DN called him, was heard, and worked him for some time. Another record for 5DN. This station seems to favour

Switzerland as the recipient of his record transmissions. He was using 10 watts, but his aerial current is now up to ·5, instead of the ·4 reported last month. No doubt he will reach the desirable ampère before long. May it travel in proportion to its size!

Mr. Neill, of Belfast, whose work I mentioned last month, has been doing well again this month, chiefly in reception of telephony from England. His best stations are 2ON and 2NM, both of whom he receives very well on telephony, the latter sometimes on one valve. He also receives speech from 2ZK, 2VF and 2IN, all of Liverpool district, the first of whom sometimes only uses 110 volts H.T.

In the West of England 5KO is going strong, having been heard in Algiers. 6RY is a fairly recent station, at Bath, but has already worked 8CT of Bordeaux.

I have just received from 7QF some particulars of amateur work in Denmark. He has sent me an enormous list of British, French, Dutch and Italian amateurs whom he has received. The very size of the list testifies to the excellent reception conditions in Denmark.

There are three active Danish transmitters at present:—7ZM, 200-220 metres, D.C. C.W.; 7EC, 190-210 metres, A.C. C.W.; 7QF, 180-210 metres, rectified A.C. All are near Copenhagen, and all have been heard in England on one valve. 7ZM and 7QF work on Saturday evenings, 7EC nearly every evening.

Yet another European country has entered the field of amateur transmitting work. Italy now has one transmitter—1MT, situated at Venice. He has already made a good start in "DX" work. 7QF has heard him often, and he has worked two British stations —2HF, near Birmingham, on December 9, and 5DN, of Sheffield, on January 13. 5DN was again using an aerial current of only ·5 amp. Some of the London stations must look to their laurels. They almost monopolised the success in trans-Atlantic work, but the North look like beating them in European "DX."

By the way, what extraordinary call signs we hear nowadays! PA9 sounded curious at first, but what about PAR14, who is often to be heard now? I believe he is somewhere in Holland. ACD is another mystery station, who often works 1MT (Venice).

TRANS-ATLANTIC TELEGRAPHY.

In view of the recent trans-Atlantic amateur transmissions it is thought that details of the apparatus used by some of the most successful participants will be of value to many experimenters.

British 2OD.

By E. J. SIMMONDS.

THE object of this article is to give the outline of a special transmitter, the construction of which was commenced late in November to participate in the recently closed trans-Atlantic tests. Owing to various delays, however, which will be discussed later, this set was not finished, and ready for test until December 21.

In view of this fact, and also because of the astounding success of 2KF in effecting two-way communication with U.S.A., it was decided to make an initial test with the same object, using the standard transmitter at the writer's station. From the diagram it will be seen that the circuit is one much used in U.S.A., being the well-known Hartley, employing as oscillator, Marconi AT.40X valve, H.T. from stepped-up A.C., 50 cycles, full wave rectification, and filament lighting from A.C. mains.

At 0315 G.M.T. Sunday, December 16, calls ARRL, etc., were transmitted for fifteen minutes with an input of 900 volts and 35 milli-amperes. At the termination of this transmission, and on switching over to the receiver, a reply was immediately heard from American 2AGB, of Summit, New Jersey, who gave QSA. Two-way communication was at once established, and tests proceeded, until 0430 G.M.T., when 2AGB closed down.

The writer is bound to admit that his hand was distinctly shaky when recording the first reply from 2AGB, as it seemed so absurd and improbable, in view of the small power and valve in use.

It should be mentioned that through the kindness of Mr. Davis, of the G.E.C. Technical Department, Magnet House, Kingsway, a M.O. 250-watt valve was available, but the great difficulty was to obtain the necessary supply of H.T. to feed such a large valve, expense being, of course, a serious item. This difficulty was partially solved by the following method.

The H.T. for the small set is obtained from a step-up transformer, which has the usual centre tap on the secondary, and the approxi-

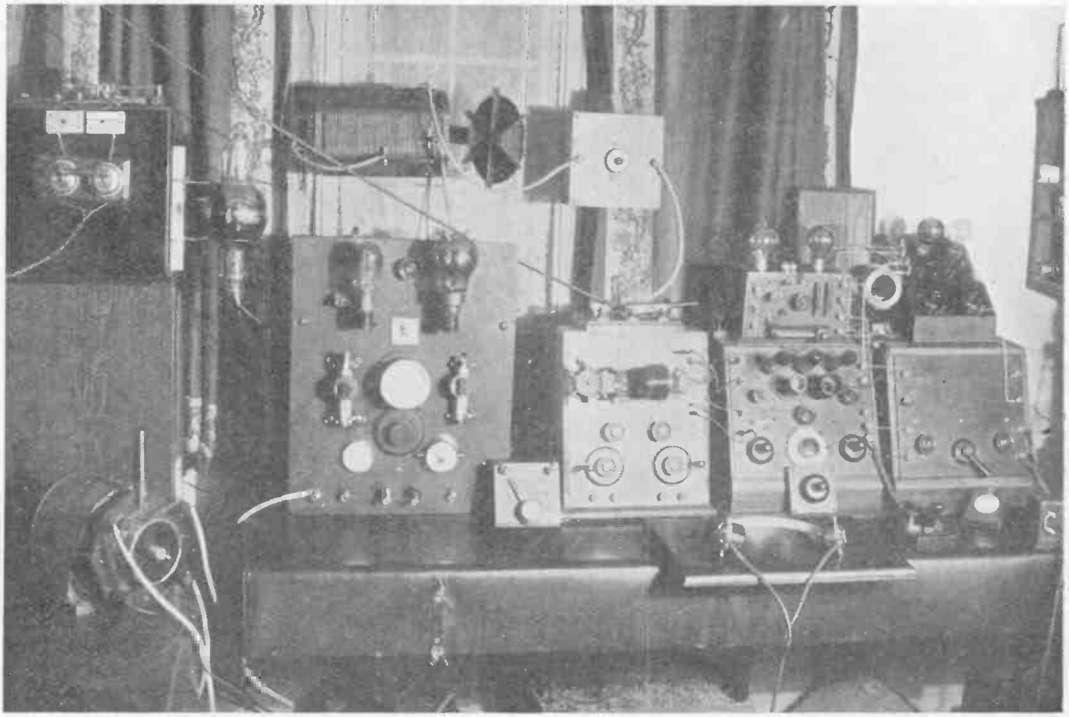


Fig. 1.—General view of set showing MO 250 and AT 40X valves, and also supersonic receiver.

Surely this is a world's record for two-way trans-Atlantic working, as at no time did 2AGB have any difficulty in reading signals from the British station, which were readable through QRN and QRM.

Confirmation has been duly received from 2AGB regarding the strength of signals.

Incidentally, the American reception must have been of high efficiency, and it is understood that a super heterodyne receiver was used. In view of this result it was decided to push forward the completion of the larger set with all speed.

mate voltage between this tap and the outers, when on load, is 600 to 800 volts, depending, of course, on the main supply voltage, and the load on the secondary. It was, therefore, decided to use the two outers of the transformer, and rectify by a synchronous rectifier, and by this means double the H.T. voltage and also avoid the voltage losses so apparent when rectifying valves are used, and, of course, obtaining full wave rectification.

In practice, however, it was found that with a load of 70 to 80 milli-amperes the

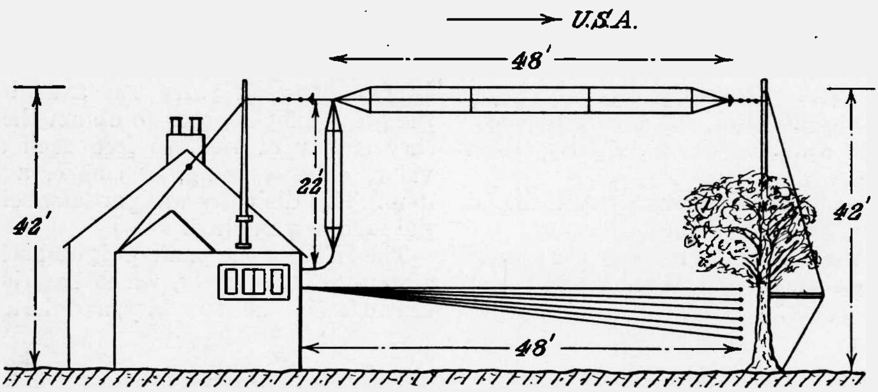


Fig. 2.—Arrangement of aerial and counterpoise systems.

voltage of the transformer secondary dropped to 1,200 to 1,300 volts.

This was, however, better than 600 volts, and the actual input to the 250-watt valve was 1,200 volts, at 75 milli-amperes, which, of course, is much under the rating of the valve.

Protecting fuses were inserted in the H.T. leads from the transformer to the rectifier disc, to obviate any chance of breakdown; as a matter of fact, in the initial tests, a short

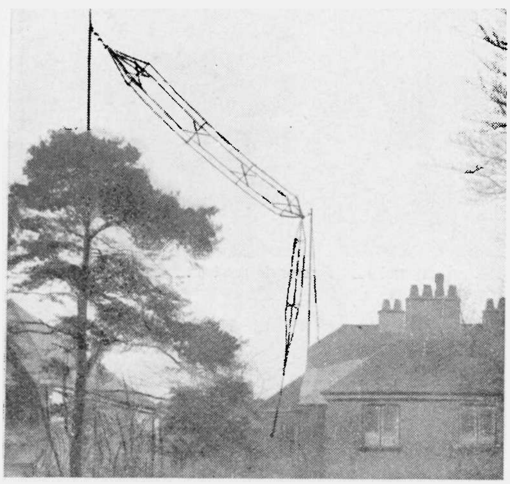


Fig. 3.—Aerial and surroundings at 2OD.

did take place in the transmitter, and these fuses undoubtedly saved the H.T. winding from being burnt out. The fuses were of platinum-silver wire, ·0015 diameter, and blow at about 250 milli-amperes.

The oscillating circuit used was the reversed feed back, with the addition of a tuned circuit in the plate lead to power valve. This tuned circuit sharpens up the wave considerably and effects a desirable decrease in plate current.

The main inductance consists of a skeleton hexagonal former, 6″ in diameter, wound with 28 turns of 12 S.W.G. bare copper wire, spaced one diameter, and the reaction is a pancake skeleton former, wound with 18 S.W.G., bare copper wire; this is tuned with a variable condenser, maximum capacity ·0003. The grid condenser and plate stopping condenser are each ·002, and made of mica from a smoothing condenser of a B.T.H. generator.

The R.F. choke coil consists of 300 turns of 24 S.W.G., space wound on 4″ former. The A.T.I. is fixed well away from all earthed bodies to avoid capacity losses, which at the high radio frequencies used become of great importance.

The shortening condenser used in the aerial calls for some comment. In constructing a condenser for this purpose the following points should be observed. Solder all the plates (which should be of copper or brass) into the supports, and pig-tail the shaft by a flexible connection, also the supporting insulation should be kept as far as possible outside the field.

Attention is here directed to the Cardwell condensers (see Q.S.T.), which are designed especially for transmitting circuits.

The remarks regarding the fixing of A.T.I., apply equally to the aerial condenser.

The grid leak is wound to a maximum

resistance of 15,000 ohms, tapped every 1,500 ohms, and is the vitreous type, supplied by the Zenith Co.

Much valuable time was lost in efforts to obtain a suitable synchronous motor to operate the rectifier disc, but the machine was ultimately furnished by the Crypto Co., and has proved most satisfactory in every respect.

The writer wishes to record his appreciation of the valuable assistance afforded to him by Mr. Sharp, of the designers' department of that company.

The speed of the motor is 1,500 r.p.m., when run from 50-cycle supply. It is self-starting, and synchronises in a few seconds of starting up.

The construction of the two-part commutator for the rectifier was a difficult task, in view of the fact that the lathe available had only 3" centres and no back-gear.

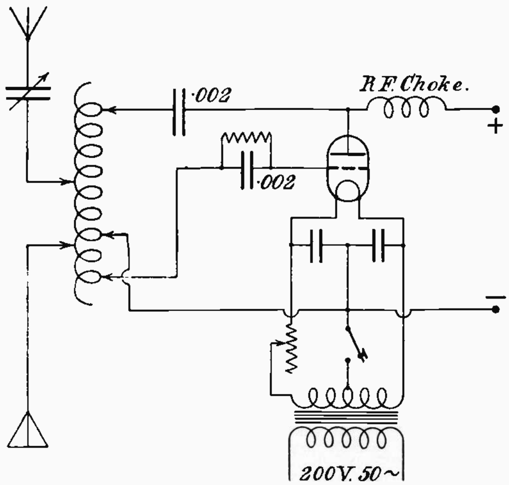


Fig. 4.—Circuit used with AT 40X valve.

As the diameter of the disc is 5" there was insufficient room to use a slide-rest, and in consequence all the turning had to be done by hand tool with a hand-rest.

The insulating core was turned from a slab of ebonite 1" thick, and on this was mounted a piece of 5" outside diameter solid-drawn brass tube, ¼" thick (obtained from Messrs. Smith & Son, clockmakers, Clerkenwell), and the tube is screwed to the insulating disc by 12 studs, screwed 3 B.A., the method employed being to tap the hole both in brass

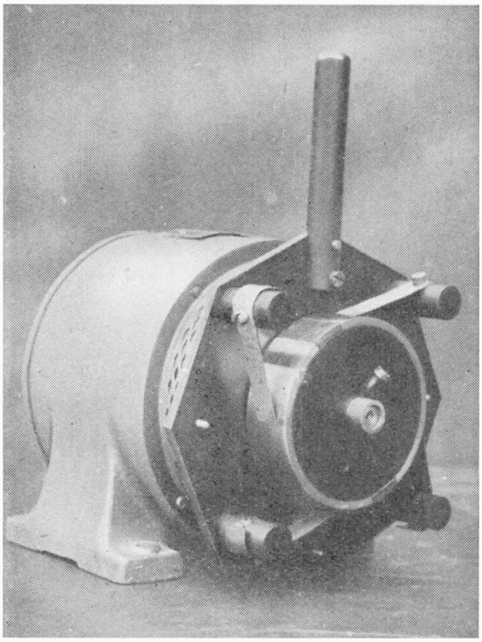


Fig. 5.—Rectifier and brushgear on synchronous motor.

tube and ebonite, and cut off level with surface.

The brass tube is split as shown, and insets of ebonite, or, better, mica on edge, fixed, the whole then being carefully trued up in the lathe. There is also a brass bush with ½"

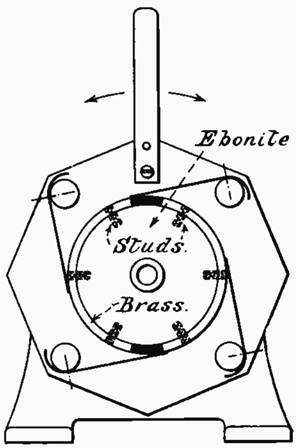


Fig. 6.—Showing arrangement of rectifier disc and brushes.

diameter centre hole and grub screw to clamp the screw to motor shaft.

The insulation between the two sections

must be very good, in order to stand up against the voltage of the transformer.

The brush rocker carries four brush supports 90° apart, and is capable of being rotated by the insulated handle to the position of sparkless commutation.

Brushes are of copper gauze, with the usual supporting strips, and the leads to the four brush holders are of good quality H.T. cable ; a short here would be a disastrous thing.

The aerial, built of 12/25 enamelled H.D. copper wire, is a six-wire cage, 70 ft. long, including lead-in, and runs due east and west, being directional for Holland.

The diameter of the cages is 30″ for the horizontal portion, and 18″ for the lead-in, and the position is far from ideal, as can be seen from the photograph, being much screened by adjacent large trees.

The lead-in is through a hole ground out of one pane of glass in the window of the operating room.

As the garden is a very small one the earth screen had to be designed to meet the existing conditions and is a 6″ wire fan, 48 ft. long, average height 10 ft., also of 12/25 enamelled H.D. copper wire; great care was taken to make each wire, both in aerial and earth screen, of equal length. The earth screen terminates immediately under the free end of aerial, although, of course, it is preferable to extend it beyond the garden mast, but there was no available ground to permit of this.

The average experimenter always works under adverse conditions, especially as regards suitable space for an adequate aerial and earth screen, and has to make the best of local conditions.

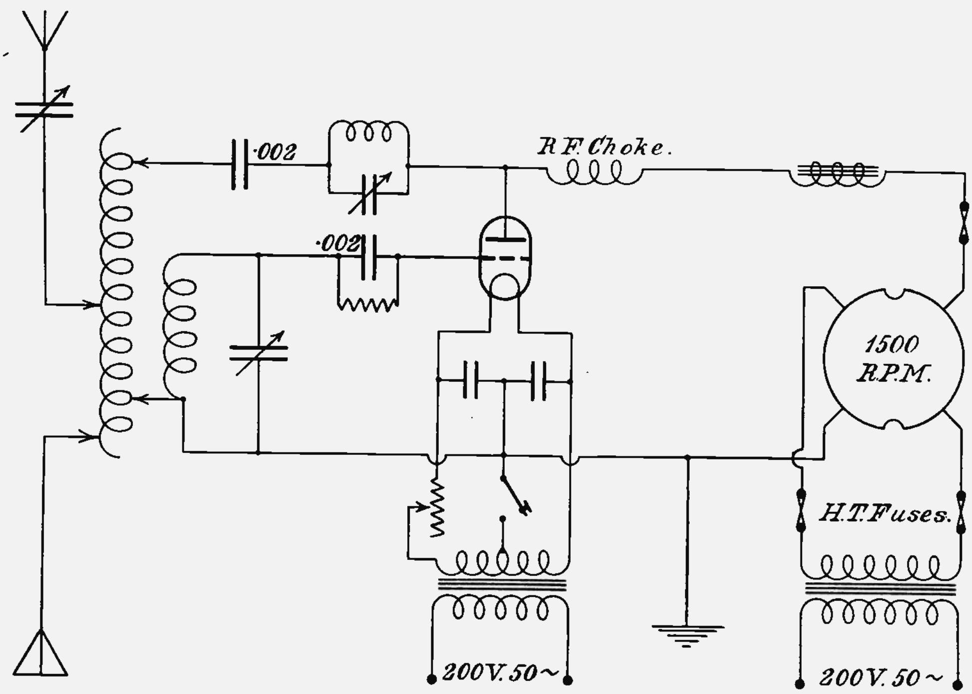


Fig. 7.—Circuit used for 200 metres test, using synchronous rectifier.

This station was duly reported in the trans-Atlantic tests, and code verified, but at the time of going to press full details of receptions are not to hand. Apart from that, a long series of regular and consistent two-way tests were carried out with Canadian 1BQ, and shorter tests with U2ACB, also U1CMP, and it is of interest to quote from one of 1BQ's reports : " You are now best European station heard here," and in a later report, " If you want me, just call, as you always come through when any get through."

French 8AB.

By LEON DELOY.

I HAVE always been very keenly interested in the study of short-wave wireless. My transmitting licence gives me the right to use many waves up to 1,500 metres, and the first transmitter I built worked on that wave. The next one worked on a shorter wave, and so forth until I came down to 100 metres. Every time I decreased the wave-length I increased the range of my station, which was quite contrary to everybody's expectations a few years ago.

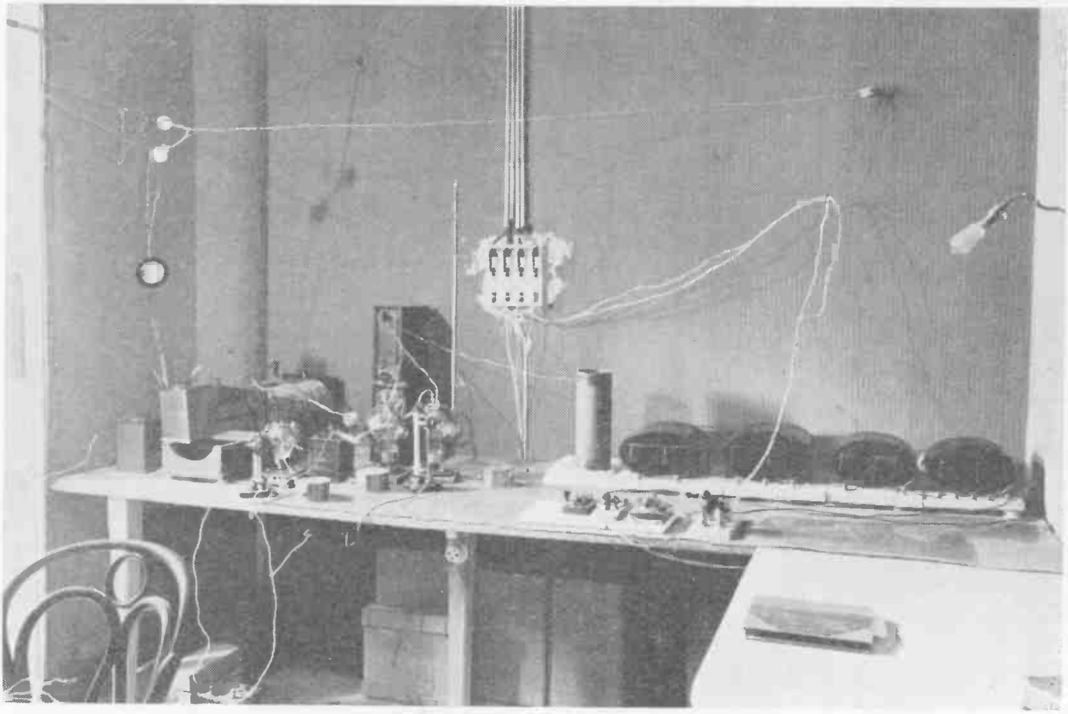


Fig. 1—A general view of the transmitter at F8AB.

On the other hand, I noticed that when the British amateurs were working on 1,000 metres I never heard any of them. When they came down to 440 metres I heard very few of them, but when they were on 360 I started hearing and working them regularly. Now that they send on 200 metres they are very easy to receive, and some of them have been heard at my station in Nice, when they were using exceedingly little power.

During last year's trans-Atlantic tests I used a wave of 190 metres, and I was heard in America "one hour steadily," also several times after the tests, and all the way to Texas. That 190-metre wave was, as far as I know, the shortest one that had ever spanned the Atlantic.

All these and other remarks made me decide to attempt two-way communication with the American amateurs on a wave of 100 metres. During a short trip I took to America this summer I convinced some of them of the interest of the experiment, and Mr. Fred H. Schnell, among others, built a special station to try and communicate with me on that wave. On my return home I dismantled immediately my old station, however good it had proved to be, and rebuilt it for 100-metre work. It immediately proved to be a great improvement. For a couple of weeks I conducted nightly tests on schedule, and all reports showed that my signals were much louder than on my old set, in spite of the fact that I was using only half power. I am especially indebted for very regular and accurate reports to Mr. E. J. Simmonds, British 2OD, whose co-operation was very useful in getting the best efficiency out of my set. The reports were so encouraging that I decided to attempt to reach America even before I had re-installed my transmitter for full power. A first attempt was a failure because my correspondent could not believe I had rebuilt my set in so short a time, and he listened for me on my old wave of 190 metres. When this was cleared we tried it again.

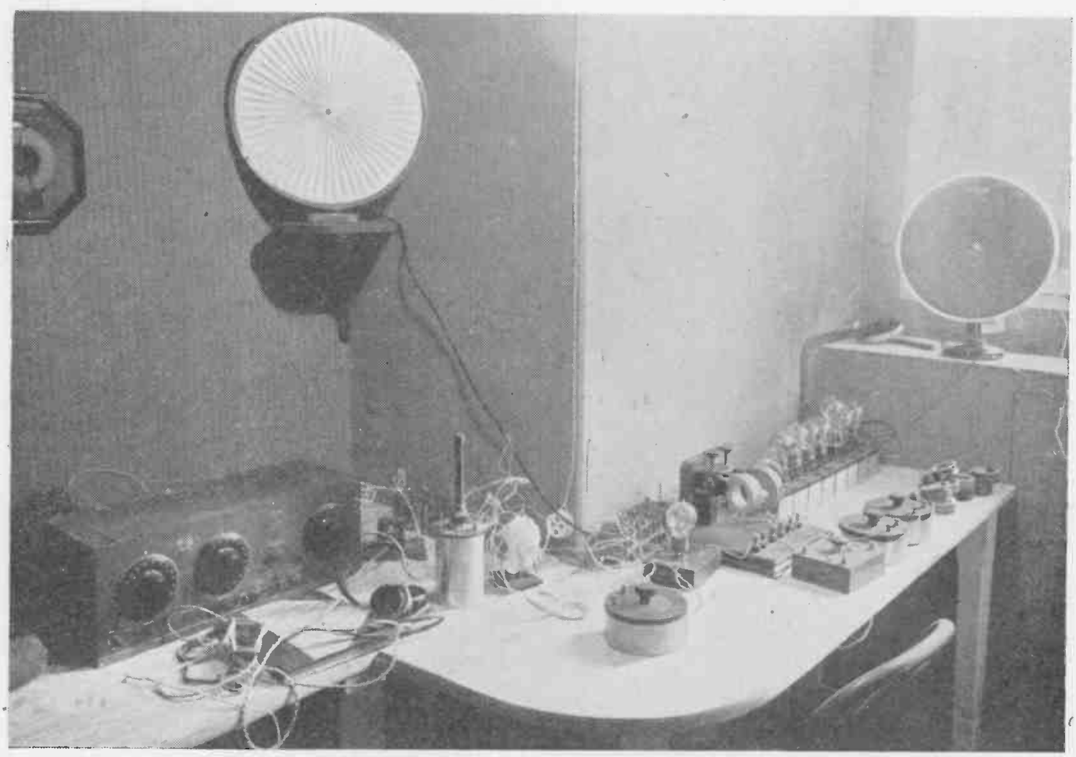


Fig. 2.—Receiver, showing "Grebe" on the left, and home-made super-heterodyne on the right.

I called for one hour on the morning of November 26, calling ARRL, signing F8AB, and sending a code group of five letters to avoid any error in reports of reception. When I woke up late that morning, after a few hours sleep, I found a cable had arrived saying: "COPIED SOLID CONGRATULATIONS." That was quite good news, and I considered it so encouraging that next night I sent a message of greetings in the name of the French amateurs to the American amateurs, and another message about a change of schedule. I asked my correspondent if the new schedule suited him, to "cable agreement." A few hours later a cable was here saying "AGREEMENT!"

In the course of the same day I had another cable from Mr. Schnell saying he would be ready to transmit on 100 metres the next night, and so it happened that November 28 was to be the long-looked-forward-to day when two-way communication between Europe and America was to be established by amateur stations.

On the morning of the 28th I transmitted as agreed, from 0230 to 0330, and then switched over to reception. A few seconds passed, which seemed very long indeed, then came the strong whistling of an A.C. C.W.

signal, and sure enough it called 8AB and signed 1MO! 1MO had again received all I had sent. His signals were readable 6 ft. from the 'phones on two valves, one radio-frequency and one detector. When I said so to him, he came back with: "U ALSO VY QSA TWENTY FEET!! FB!" He has told me since that his receiver uses one detector with tuned plate circuit and one step of low-frequency amplification. We went on talking for a little while as easily as if we were in the same town, although we are about 4,000 miles from each other. Then Mr. Warner took the key at 1MO. His first remark was: "HR WARNER GE OM A PROUD MOMENT OF MY LIFE TO TALK TO U FM MY OWN HOME OM SINCERE CONGRATS ON WONDERFUL ACHIEVEMENT"; and a little later: "MAKING HISTORY TONITE OM." I surely was as glad as they were over there, as this was the reward of three years' work! Then Mr. Schnell took the key again, and said: "SA OM PSE GIVE ME MEG FOR WNP FOR OUR RELAY TEST TOMORROW"; and I sent a message of greetings of the French amateurs to the amateur on board the *Bowdoin*, somewhere near the North Pole. How the world looked small, and how wonderful it is to see far-distant friends become so near just because one has a few feet of wire on one's roof and a couple of glowing valves on one's table!

For the last eleven days I have been in daily two-way communication with American amateurs. About 2,000 words have been exchanged and six stations worked. They are 1MO, 1XAM, 1XAQ, 2CQZ, 2CFB and 1CMP.

A few words about my transmitter may be of interest. I am using two 250-watt (input) S.I.F. French tubes in parallel in a Hartly circuit, with some modifications suggested by Mr. John Reinartz. As will be seen from the accompanying simplified diagram of connections, these modifications are the use of a variable condenser both in the aerial and counterpoise. These two condensers should always be on the same reading, and the counterpoise should be so built that the current in it is the same as in the aerial. The wave-length can then be adjusted simply by adjusting the condensers. The aerial and counterpoise current is between 2·5 and 3 ampères, but I have tried to decrease it, and down to 2 ampères 1MO did not report any appreciable change. When I made it 1 ampère, though, he said it was enough reduction as it became weak. On full power I have been received in America "on 20-ft. indoor aerial," and even "without aerial." My longest range so far reported is Kitchener, Ontario.

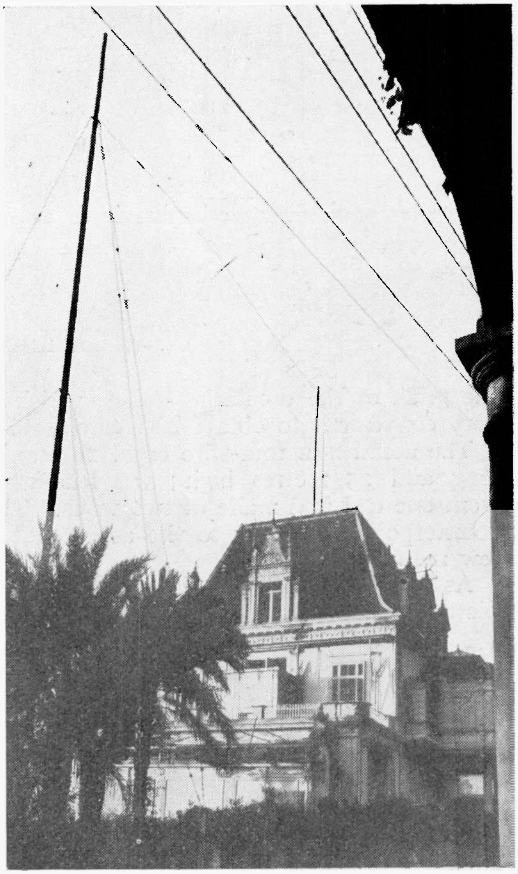


Fig. 3.—Aerial and counterpoise, the far end spreader of the latter being to the right of the palm tree leaves.

The plate high tension is simply furnished from the 25-cycle town supply by a step-up transformer. The filaments had to be heated by batteries instead of A.C. on account of the changes of tension of the supply here. These changes of tension are responsible for the only fading ever noticed during these experiments.

For a grid-leak I am using the plate-filament space of a 50-watt (input) S.I.F. tube. By controlling the filament temperature of this tube one controls the tension on

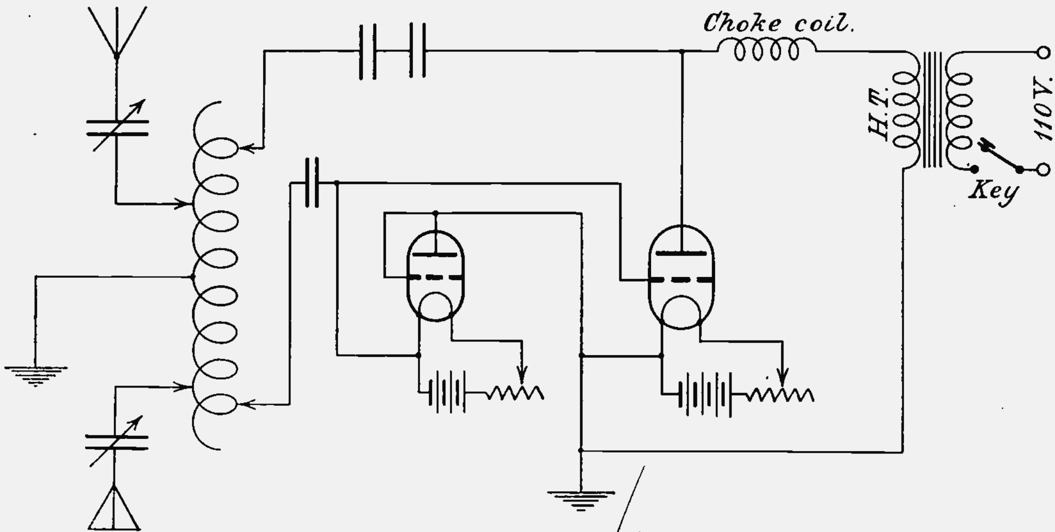


Fig. 4.—The transmission circuit using a valve as a grid leak.

the grids of the oscillating tubes, which is very convenient to obtain best efficiency.

The aerial is a four-wire cage, 10 metres long and 25 metres high; the lead-in is from one end and made of two wires. The counterpoise is similar to the aerial, but a few metres longer.

As will be seen from the accompanying pictures, this set is yet in an experimental stage, and such ranges were certainly not contemplated at such an early date.

The most remarkable point about these tests is that they have shown that waves of the order of 100 metres have wonderful possibilities which were until now almost unsuspected. There seems to be no fading on those waves, and interference, especially from arc harmonics, is very reduced.

Electrical Impulses.

By Dr. N. W. McLachlan, M.I.E.E., F. Inst. P.

Although most experimenters are familiar with the properties of sustained oscillations, the subject of impulses seems to have been neglected. As atmospherics are intimately connected with impulses the following article should be of considerable importance.

An impulsive force in mechanics is one which is communicated suddenly, so that the system or body to which it is applied, *i.e.*, upon which it acts, tends to undergo a rapid change in its state of motion. For example, when the clutch of a motor-car is engaged suddenly, a violent jerk ensues as the car leaps forward under the impulse from the engine. The effect is of a temporary or transient nature, and does not persist when the car is running at a constant speed. Let us take an example in which the impulsed system is capable of vibrating or executing oscillations. Suppose a tuning-fork is struck by a soft-ended hammer. It is set into vibration at its own natural frequency, and the vibration gradually dies away after the blow has been delivered. A pianoforte string under the action of the hammer is another example of a similar nature. The next case is one in which the system has no natural frequency, because it is so heavily damped that vibrations cannot occur. If a tennis ball is dropped from a height on to some very thick oil, it sinks in to a certain extent and then gradually comes up again. There is no vibration up and down, owing to the fact that the oil damps out vibrations which occur if the ball were dropped on a hard wooden or concrete floor.

It must be clearly realised that the impulsive forces which are called into play do not act merely in an instantaneous manner. They must be applied to the impulsed system for a definite length of time. A change in the motion of a body or a mechanical system due to the type of impulse cited above necessitates a definite supply of energy to the body, and this requires a certain lapse of time to be accomplished. With a force of constant magnitude, the energy added to the system is directly proportional to the square of the time of the application of the force. Thus if one unit of energy is added in one second, four units will be added in two seconds, nine units in three seconds and so on. In general, however, impulsive forces are not constant, and it is often impossible, without definite experimental evidence, to predict their effects to any degree of accuracy.

In treating the problem of electrical impulses, there are two different types of electrical circuit which may be considered: (*a*) one akin to the tuning-fork which will oscillate freely when it is impulsed; (*b*) one like the tennis ball when dropped on the oil, in which vibration or oscillation does not occur, but in which the current merely rises to a certain value, and thereafter dies away to zero. Type (*a*) is the ordinary tuned circuit, either high frequency or audio frequency, with which everyone is familiar in radio-telegraphy. Type (*b*) is obtained if a resistance of suitable magnitude is inserted in a circuit of type (*a*). The effect of the resistance is to apply an electrical damping to the circuit of such a magnitude that oscillations cannot occur. The nomenclature applied to these circuits is respectively "periodic" and "aperiodic." In radio we are not usually concerned with the aperiodic class of circuit, so that our attention will be confined to the usual type, *i.e.*, "periodic" or oscillatory circuits.

An electrical impulse is obtained when a sudden variation in the electrical or magnetic state of space occurs. Such an effect must be distinctly differentiated from a steady train of electro-magnetic waves. One of the commonest instances of impulsing is found with the ordinary buzzer. A buzzer circuit is one supplied periodically by a certain quantity of electricity, which charges the condenser of the buzzer oscillatory circuit. After being energised by the local battery, the circuit executes free oscillations at its own natural frequency, this being determined by the values of the condenser and inductance. When the buzzer circuit is coupled to another circuit which it is desired to tune to the same wave-length, it gives this latter circuit a series of sudden shocks, which in general cause two main sets of oscillations.

Assume the second circuit to be tuned to 400 metres and the buzzer circuit to 450 metres. There will, broadly speaking, be oscillations of both frequencies in the 400 metre circuit, but they will be comparatively feeble. The impulse causes the circuit to oscillate at its own natural frequency, and also forces another oscillation of 450 metres. If now the circuit be tuned to 450 metres, there will be only one main frequency of oscillation, and owing to the effect of resonance, the response or amplitude of the damped oscillation will be a maximum. The value and duration of the current depends upon the duration of each oscillatory discharge in the buzzer circuit, and also on the resistance of the tuned circuit which is being impulsed. If the resistance of the latter circuit were gradually reduced, the effect of an impulse of short duration would become less and less. This is due to the fact that a certain time elapses before the current attains an appreciable value in the circuit. When the impulses are of comparatively long duration, however, the current in the tuned circuit has more chance to build up, and it therefore attains a larger value than before. The magnitude of the current induced by an impulse of given duration depends upon the strength of the impulse, *i.e.*, on the energy supplied to the tuned circuit. With a low resistance oscillatory circuit in which the damping is small, the time taken after the termination of the impulse for the current to decay to, say, 10 per cent. of its maximum value may be quite considerable compared with the duration of the impulse. Thus if comparatively long impulses follow one another fairly frequently, the current in the tuned circuit will never be zero, and if the impulses are properly timed, the current may attain a large almost steady value. This effect is similar to that obtained with the Marconi-timed disc apparatus used at Stavanger. On the other hand, with moderate impulses, the amount of the energy supply to the tuned circuit is small, and owing to the appreciable time taken for the current to build up, the effect of the impulses is not marked. If, however, the impulses are very strong, there is an appreciable current induced in the tuned circuit. The same reasoning clearly holds for spark reception, since the effect is identical with buzzer excitation of the tuned circuit. Moreover, when receiving spark stations the resistance of the circuits must not be too low. Thus the use of reaction to reduce the resistance of a spark receiver is limited.

We are now in a position to examine the most important form of impulsing which is encountered in radio work, namely that due to "atmospherics." Hitherto no reference has been made to any peculiarities in the shape or wave form of an impulse. If a graph is made showing the intensity of an electrical disturbance at all times during its occurrence the result gives the wave form of the disturbance. It may not resemble an ordinary sine wave at all, but for technical purposes it is convenient to use this terminology. For example, the wave form might resemble a simple rectangle or a simple triangle. Whatever the wave form of the impulse, it is possible by mathematical analysis to resolve it into a series or spectrum of continuous waves of different wave lengths. Before the disturbance starts, these waves, which are really mathematical fictions, are related to each other so far as position (phase) and strength is concerned, so that the net result is zero. After the termination of the disturbance, the same condition also holds. During the epoch or time the disturbance lasts the waves add and subtract so as to yield the actual wave form of the disturbance.

Before passing on to the next phase of the subject, it will be advisable to consider the initial effect of a series of continuous waves of different frequencies on a circuit tuned to the same frequency as one of the series of waves. When the waves arrive originally, say at the beginning of a dot or a dash, the circuit is acted upon suddenly, and the initial effect is in the nature of an impulse. The circuit responds most readily to the waves of its own frequency, but in addition to this the waves of other frequencies eventually force oscillations of their own frequency, and owing to the impulsing effect, they initially assist in augmenting the main or central oscillation. Consider now an atmospheric with its accompanying spectrum or series of continuous waves of different frequencies. The amplitude of some of these may be many times that of the signal, and in addition to impulsing the circuit at its own natural frequency, they introduce oscillations of other frequencies on either side of the central or main frequency. With a strong atmospheric these side oscillations may be much more intense than that due to the signal. The result is that the signal strength is increased when the oscillations add, and it is decreased or increased according to the strength of the atmospheric when the oscillations subtract. In certain cases the signal may be obliterated for a portion of a dot or a dash, and the character is therefore split up into sections, and may be rendered unintelligible. During spacing the effect of the atmospheric is to fill up the gap with dots whose duration depends on the duration and strength of the atmospheric. The atmospheric may therefore be regarded as interpolating an irregular form of jamming.

The inference to be drawn from this analysis is that as many as possible of the frequencies on either side of the central frequency should be eliminated. In this way the energy of the atmospheric which penetrates the receiving system is reduced. The usual mode of cutting out undesirable frequencies is to employ a series of selector or filter circuits, but in the practical radio of to-day there are limitations to the degree of filtering which is possible. Hence the degree of reduction of the atmospheric by this process is also limited.

The Making of Pure Shellac Varnishes.

By J. F. CORRIGAN, M.Sc., A.I.C.

Although shellac varnish is universally employed for wireless purposes the importance of purity is possibly not fully realised. Below will be found details for manufacturing high quality varnish possessing good insulating properties.

SHELLAC varnish, as it is usually prepared, takes the form of a thick, often viscous, and almost opaque liquid which contains many impurities in a suspended or undissolved state. It is easily made by allowing a quantity of flake shellac to soak in rectified alcohol or methylated spirit for a few hours, and subsequently ensuring the entire completion of the solution by warming the mixture. For the " rough " work of wireless construction, such as the varnishing of hidden inductance coils, etc., the above varnish is, of course, eminently suitable, for in these cases it is employed chiefly on account of its insulating and binding properties.

For the purpose of delicately lacquering metal-work, however, and of giving a final layer of insulative varnish to the surface of any coils which may be mounted on the instrument board or the panel of the wireless set or any other type of electrical apparatus, shellac varnish prepared in the above fashion is apt to possess many disadvantages. In the first place, such a varnish does not leave a perfectly smooth surface when dry, no matter how carefully it may have been laid on. Again, the varnish, not being composed of perfectly pure shellac, is apt to be deficient in di-electric properties, and in very accurate work this deviation from the theoretical may sometimes attain serious proportions.

The muddy and opaque appearance of ordinary shellac varnish is really due to the presence in the solution of waxes and fatty substances, which exist as impurities in ordinary commercial shellac to the extent of about 4 per cent. Not being very soluble in alcohol, they remain suspended in the solution, thus causing the turbidity of the latter. However, they can be removed by suitable means, which are about to be described, and if these purifying operations are carefully carried out an alcoholic solution of shellac will be obtained which will present a golden yellow or reddish appearance, and which will be entirely free from any undissolved fatty or waxy substances.

The first method for obtaining a perfectly clear and pure solution of shellac consists in making up the shellac varnish with alcohol or methylated spirit in the ordinary manner, and then adding about an eighth of its weight of precipitated or finely-powdered chalk. The

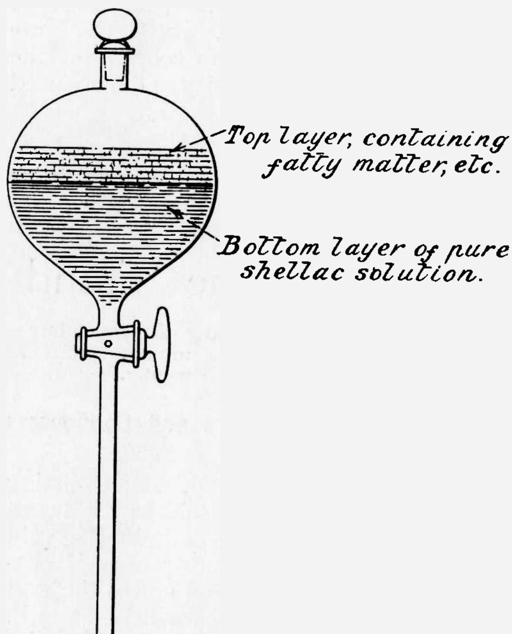


Fig. 1—Showing preparation of varnish.

mixture is then slightly warmed and well stirred, and allowed to remain undisturbed overnight. The chalk will fall to the bottom of the vessel, and will retain the suspended impurities of the varnish, leaving an almost clear solution above. The solution is then carefully poured off from the bottom layer of chalk, and filtered, first through a cloth of fine mesh, and finally through a filter-paper or a sheet of ordinary blotting paper. The use of a vacuum filter pump, such as is to be found in any chemical laboratory, will greatly facilitate the filtering operations.

Another method by means of which ordinary shellac varnish may be purified consists in adding to it a quantity of petroleum-ether or benzine, in the proportion of one part of the latter to three parts of the varnish. This operation will require the use of a chemical separating-funnel, as shown in the illustration. The liquids are poured into this funnel and, after the stopper has been replaced, they are well shaken up and allowed to stand for about an hour. After the elapse of this period, it will be found that the liquid in the funnel has separated into two distinct layers. The upper and lighter coloured layer of petroleum-ether or benzine, as the case may be, contains the dissolved waxes and fatty matters, whilst the pure alcoholic solution of shellac constitutes the lower layer. If any difficulty is experienced in getting the liquid to separate completely and distinctly, the addition of a few drops of water, together with a further shaking will rapidly bring about the desired end. The lower layer of liquid is now run off by means of the tap which is provided at the bottom of the separating-funnel, and it may be of interest to the radio experimenter carefully to evaporate the upper petroleum or benzine layer and observe the quantity of impurities which have been extracted from the shellac.

Shellac varnish, when prepared by either of the above methods presents a perfectly clear and transparent golden-yellow appearance, and it is free from all undesirable impurities. For accurate, highly-finished, and experimental work its use is greatly to be recommended, because by its employment all the characteristic properties of the shellac are utilised to their fullest extent.

The Trend of Invention.

We summarise below the more important wireless inventions which have been disclosed during the month, special reference being made to those of immediate interest to the experimenter.

Arrangement of Grid-leaks and Condensers in Valve Oscillators.

When the grid condenser of a transmitting valve is connected in the usual way between the grid and the upper end of the grid oscillating circuit trouble may arise if controlling apparatus is shunted across the grid condenser. Such apparatus will be at H.F. potential, and is not only liable to give rise to capacity and leakage losses; but is unsafe for the operator to touch while the set is working. A familiar example is a one-valve grid-control set where the modulation transformer is shunted across the grid condenser, or, again, the system of modulation in which a three-electrode thermionic valve takes the place of the usual grid-leak.

One obvious remedy for this difficulty is to place the grid condenser at the filament end of the grid coil. Another way (British Patent 190,177, G. A. Beauvais) is illustrated in Fig. 1. A separate path B, A, is provided for unidirectional grid currents or modulating currents, a choke B being inserted to keep H.F. currents out of this path and confine them to the proper H.F. path D. Any modulating device is connected in series with, in parallel with, or in place of the resistance A.

The idea of this invention does not seem very new, and, in any case, would occur to any resourceful experimenter if he came across the above-mentioned difficulties.

Electrolyte for Electrolytic Rectifiers or Condensers.

British Patent Specification No. 207,987 (M. A. Codd) prescribes a mixture of sodium bicarbonate and sodium phosphate as an electrolyte for rectifiers. According to the specification the salts may be in equal proportions, or the bicarbonate may be present in excess, about a pound of the mixture being dissolved in one gallon of

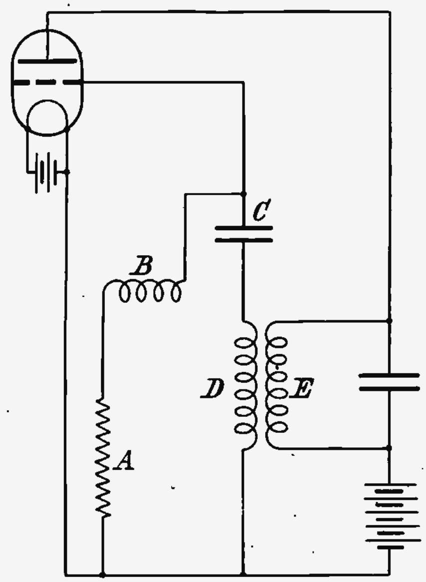


Fig. 1.—Illustrating British Patent 190,177, which covers the use of a grid choke for separating the D.C. from the H.F. components in the grid circuit of a valve oscillator. The choke B is uncoupled with any other H.F. coil.

water. It is stated that four or five pennyweights of calcium carbonate may be added, and also about fifteen grains of a colloid such as gum arabic. The actual functions of the last two substances are not mentioned, but it is stated the electrolyte shows distinct

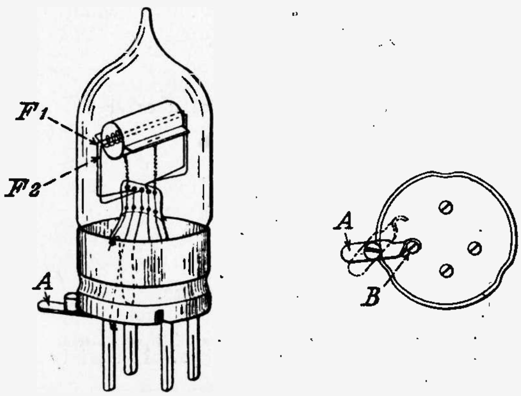


Fig. 2.—Illustrating British Patent 207,740. A spare filament can be brought into play by bringing the clip A into contact with the stud B.

advantages over others in that the heating up is less, rectification continues to take place at a higher temperature, and the plates of the rectifier keep cleaner.

[N.B.—We are not responsible for the archaic system of weights and measures given in the above recipe.]

Valve with Spare Filaments.

Although some of the very earliest round valves were provided with spare filaments to extend their useful life, this practice has not been very widely followed. Fig. 2 shows a recently patented arrangement whereby a valve may be provided with one or more spare filaments, which can be brought into play when desired. When the clip A is in the position indicated by the dotted line the first filament F only is across the filament pins ; by throwing the clip over to the position indicated by the thick line the

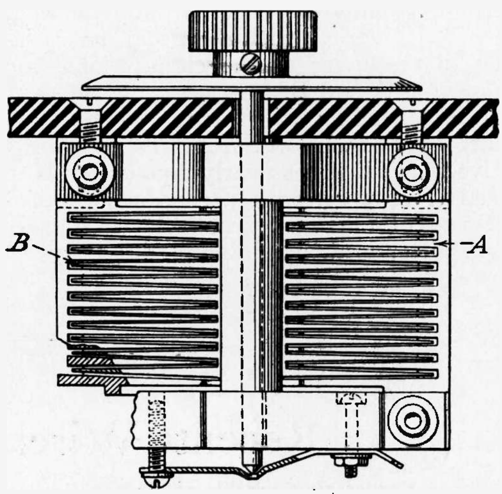


Fig. 3.—Illustrating British Patent 203,660. The radial taper of the plates serves the double purpose of ensuring rigidity and facilitating the removal of the casting in one piece from its mould.

second filament is thrown in parallel with the first (British Patent 207,740, H. C. Phillips).

Condenser Construction.

A good deal of attention is being devoted nowadays to the subject of condenser losses, and especially to the improvement of variable condensers for high-frequency circuits. The construction indicated in Fig. 3 will appeal to the reader as being very sound both electrically and mechanically. (British Patent 203,660, Western Electric Co., Ltd.) The moving vanes and central column B are made in one casting, as are the fixed vanes A. The noval feature lies in the radial taper of the moving vanes. The fixed vanes also have a corresponding taper in thickness, which leaves an air-gap of uniform thickness between fixed and moving vanes.

Use of Magnetic Amplifier with Valve Transmitter.

Since his invention of the magnetic amplifier, Alexanderson, the American radio engineer, has filed numerous patents involving the use of this ingenious piece of apparatus. Fig. 4 shows the magnetic amplifier adapted to modulate the output of a valve generator. The coils A and B are wound over an iron core, whose degree of saturation is varied by means of a polarising winding C carrying the modulating currents. Thus the effective inductance of the coils is varied, with a consequent variation of resonance of the circuit, including these coils A and B.

It is claimed for this method of modulation that the back E.M.F. from the oscillating valve is at all times nearly equal to that of the H.T. supply, with a consequent maintenance of efficiency when the output of transmitter is at a minimum. It is stated that in most other systems of control that when the H.F. output is at a minimum the conversion efficiency of the valve generator is lowered, and that a consequent heating up of the anode or anodes is liable to take place. (British Patent 186,070, The British Thomson-Houston Co., Ltd., and E. F. W. Alexanderson.)

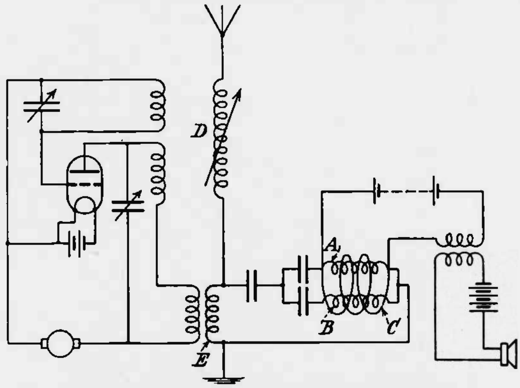


Fig. 4.—Illustrating British Patent 186,070, which provides a means for modulating a valve transmitter without seriously affecting the H.T. input-to-aerial efficiency. The Alexanderson magnetic amplifier is used, and is diagramatically shown by the coils A, B, and C.

Recent Wireless Publications.

Figures after the title of each publication indicate Volume and Number of Publication containing the article. Where only one number is given, this indicates the serial number of the publication. The abbreviations used in this bibliography will be found in the early issues of "Experimental Wireless."

Abbreviations of Titles of Journals Used in the Bibliography.

Amer. Acad.—American Academy of Arts and Sciences.
Am.I.E.E. J.—Journal of American Institute of Electrical Engineers.
Ann. d. Physik—Annalen der Physik.
Boll. Radiotel.—Bolletino Radiotelegraphico.
Elec. J.—Electric Journal.
El. Rev.—Electrical Review.
El. Times—Electrical Times.
El. World—Electrical World.
Electn.—Electrician.
Frank. Inst. J.—Journal of the Franklin Institute.
Gen. El. Rev.—General Electric Review.
Inst. El. Eng. J.—Journal of the Institute of Electrical Engineers.
Inst. Rad. Eng. Proc.—Proceedings of the Institute of Radio Engineers.
Jahrb. d. drahtl. Tel.—Jahrbuch der drahtlosen Teleg, etc.
Mod. W.—Modern Wireless.
Nature—Nature.
Onde El.—L'Onde Electrique.
Phil. Mag.—Philosophical Magazine.
Phil. Trans.—Philosophical Transactions.
Phys. Rev.—Physical Review.
Phys. Soc. J.—Journal of Physical Society of London.
Q.S.T.—Q.S.T.
R. Elec.—Radio Electricité.
Roy. Soc. Proc.—Proceedings of the Royal Society.
Sci. Abs.—Science Abstracts.
T.S.F.—Telegraphie sans fils, Revue Mensuelle.
Teleg. without Wires, Russia—Telegraphy without Wires, Nijni Novgorod.
W. Age—Wireless Age.
W. Trader—Wireless Trader.
W. World—Wireless World and Radio Review.

I.—TRANSMISSION.

A Constant Frequency Set with a Record.—Capt. T. C. Rives (*Q.S.T.*, 7, 6).

Low-power Loop Transmission.—Oliver Wright (*Q.S.T.*, 7, 6).

Microphone Amplifier and Control Circuits.—Alan L. M. Douglas, M.I.Radio.Eng. (*Exp. W.*, 1, 4).

Aerial Design for 200-metre Transmission.—G. L. Morrow (*Exp. W.*, 1, 4).

Short Wave-length Transmission. The Master Oscillator System.—W. James (*W. World*, 228 and 229).

The Holweck Valve.—(*W. World*, 230).

Commercial Radio Tube Transmitters.—W. R. G. Baker (*Proc. I.R.E.*, 11, 6).

Radio Transmission Measurements on Long Wave-lengths.—H. H. Beverage and H. O. Peterson (*Proc. I.R.E.*, 11, 6).

C.W. and Radiophone Transmitters.—L. R. Felder (*R. News*, 5, 7).

Microphones for Broadcast Purposes.—P. P. Eckersley (*Electn.*, 2,382).

II.—RECEPTION.

Anti-Regenerative Reception.—Lewis Hull, Ph.D. (*Q.S.T.*, 7, 6).

Information on Receiving Tubes. Part I.—J. C. Warner (*Q.S.T.*, 7, 6).

The Design of a Radio-Frequency Amplifier to Operate on a Wave-length Range of 300 to 1,000 Metres.—G. L. Morrow, F.R.S.A. (*Exp. W.*, 1, 4).

Discussion on Loud Speakers for Wireless and other Purposes.—(*Exp. W.*, 1, 4).

A Short Wave-length Receiver with Two Stages of H.F. Amplification.—W. James (*W. World*, 227).

The Fundamentals of Loud Speaker Construction.—A. Nyman (*W. World*, 227).

Some New Ideas in Receiver Design.—F. H. Haynes (*W. World*, 228 and 229).

A French Circuit with some Interesting Features.—(*W. World*, 229).

Galena—Natural and Artificial.—James Strachan, F.Inst.P. (*W. World*, 229).

Discussion on Loud Speakers for Wireless and other Purposes.—(*W. World*, 230).

La protection contre les parasites.—Marcel Bernard (*R. Elec.*, 4, 19).

Receiving Measurements and Atmospheric Disturbances at the Bureau of Standards, Washington, D.C., May and June, 1923.—(*Proc. I.R.E.*, 11, 6).

Recent Developments in High Vacuum Receiving Tubes—Radiotrons, Model UV-199 and Model UV-201-A.—J. C. Warner (*Proc. I.R.E.*, 11, 6).

High-frequency Amplification and its Problems.—R. W. Hallows, M.A. (*Mod. W.*, 2, 4).

Some Notes on Low-frequency Amplification.—G. P. Kendall, B.Sc. (*Mod. W.*, 2, 4).

A Practical Neutrodyne Receiver.—Allan T. Hanscom (*R. News*, 5, 7).

Distortion-free Amplifiers.—A. Ringel (*W. Age*, 11 3).

The Screening of Radio Receivers.—R. H. Barfield, M.Sc. (*El. Rev.*, 2,406).

III.—MEASUREMENT AND CALIBRATION.

The Application of Oscillating Valve Circuits to the Precise Measurement of Certain Physical Quantities.—J. E. P. Wagstaff, M.A. (*Phil. Mag.*, 47, 227).

IV.—THEORY AND CALCULATIONS.

Alternating Currents and Wireless.—Capt. P. P. Eckersley (*Exp. W.*, 1, 4).

An Inductance Calculator.—E. J. Hobbs, M.C., A.M.I.R.E. (*W. World*, 230).

Skin Effect in Slot-wound Conductors.—A. Press (*Electn.*, 2,381).

The Inductance of Coils.—(*W. Trader*, 1, 11).

V.—GENERAL.

Directive Radio-Telegraphy and Telephony.—R. L. Smith-Rose, Ph.D., M.Sc., D.I.C., A.M.I.E.E. (*Exp. W.*, 1, 4).

Frequency Transformers.—H. T. Davidge (*Exp. W.*, 1, 4).

Both-way Amplification.—Alexander J. Gayes (*Exp. W.*, 1, 4).

The "Old Vic" Wireless Relay.—A. G. D. West, B.A., B.Sc. (*Exp. W.*, 1, 4).

Notes on Sources of Energy Loss in Condensers. Part II.—Philip R. Coursey, B.Sc., F.Inst.P., A.M.I.E.E. (*Exp. W.*, 1, 4).

The Construction of a Tuned Reed Rectifier for 200-volt 50-cycle Supply.—E. J. Simmonds (*Exp. W.*, 1, 4).

The Thermionic Rectifier for Battery Charging.—R. L. Smith-Rose, Ph.D., M.Sc. (*W. World*, 227 and 228).

Variable Condensers.—W. James (*W. World*, 227).

The Leafield Imperial Wireless Service.—E. H. Shaughnessy, O.B.E., M.I.E.E. (*W. World*, 229 and 230).

Stationary Waves on Free Wires and Solenoids.—A. Press (*Proc. I.R.E.*, 11, 6).

Digests of United States Patents Relating to Radio-Telegraphy and Telephony. Issued August 28, 1923—October 23, 1923.—John B. Brady (*Proc. I.R.E.*, 11, 6).

The New Low-Filament Current Valves.—A. D. Cowper, M.Sc. (*Mod. W.*, 2, 4).

Break-in Radio Relay Communication.—Col. J. O. Mauborgne (*R. News*, 5, 7).

The Equipment of KDKA.—D. G. Little (*Electn.*, 2,381).

The Beverage Aerial.—T. L. Eckersley (*Electn.*, 2,382).

Untersuchungen unter die Erzeugung sehr kleiner Wellen mit Glühkathenodröhren nach Barhausen und Kurz.—(*Ann. d. Physik*, 73, 1 and 2).

Variable Single Band Acoustic Wave Filter.—G. W. Stewart (*Phys. Rev.*, 22, 5).

The Scientific Applications of Radio-Telegraphy.—Gen. G. Ferrié (*J. Frank. Inst.*, 196, 6).

Radiation. Part XI.—(*W. Trader*, 1, 11).

Les Origines de la T.S.F. (*R. Elec.*, 5, 51).

Pertes diélectriques dans les isolants utilisés pour la construction radioélectrique.—P. Bouvier (*R. Elec.*, 5, 51).

Longeur d'onde optimum.—Léon Bouthillon (*R. Elec.*, 5, 51).

La radiogoniométrie à bord des navires.—(*R. Elec.*, 5, 51).

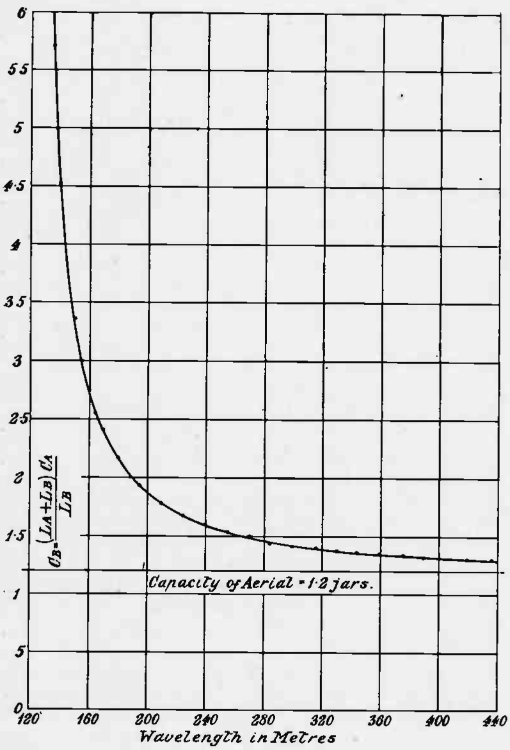
Enroulement à faible capacité propre.—(*R. Elec.*, 5, 51).

Correspondence.

To the Editor of EXPERIMENTAL WIRELESS.

SIR,—The statement that the capacity of an antenna varies with the wave-length used, contained in Mr. Andrewes' article on "Antenna Constants" in your October issue, is not proved by his experiments. The incorrect conclusion arose from the assumption that, for the purpose of the tests, the inductance of the antenna could be neglected.

The curve 1 actually shows that until a point beyond the bend (marked *x* on curve) is reached, the readings of the substitute condenser are valueless as an approximation of the antenna capacity, and that for higher wave-lengths than *x*



they are approaching and approximating to the antenna capacity C_A.

When the condenser and resistance are substituted for the antenna, provided that the inductance added to the closed circuit is small as compared with the antenna inductance, the curve obtained by plotting condenser readings against wave-lengths can be used for obtaining a close approximation to the true capacity of the antenna, which is constant for all wave-lengths; a rough approximation of the capacity of the antenna can be read off once the meaning of the curve is understood; and, finally, a very close approximation of the true value of the antenna capacity can be obtained by calculation from the data furnished by the curve.

Let C_A = capacity of antenna.

C_B = capacity of substitute condenser.

L_A = inductance of antenna.

L_B = inductance added for increasing λ.

AERIAL CAPACITY = 1·2 jars.

Wavelength in Metres.	L_mC_j (mic-jars).	L_m, when C_a=0·5 jars.	$L_b = L_m - L_a$, where L_a is inductance of aerial (304 mics in this case).	$C_m = \frac{C_a(L_a+L_b)}{L_b} = \frac{L_mC_j}{L_b}$
120	3·65	3·04	0	8
135	4·62	3·85	0·81	5·71
150	5·7	4·75	1·71	3·35
165	6·9	5·75	2·71	2·55
180	8·2	6·84	3·8	2·16
195	9·63	8·02	4·98	1·925
210	11·2	9·34	6·3	1·78
225	12·8	10·67	7·63	1·68
240	14·6	12·15	9·11	1·605
255	16·5	13·75	10·71	1·54
270	18·5	15·4	12·36	1·498
285	20·6	17·15	14·11	1·43
300	22·8	19·00	15·96	1·412
315	24·7	20·58	17·54	1·409
330	27·6	23·00	19·96	1·38
345	29·5	24·6	21·56	1·365
360	32·8	27·4	24·36	1·348
375	35·6	29·6	26·56	1·338
390	38·5	32·1	29·06	1·325
405	41·8	34·8	31·76	1·312
420	44·7	37·2	34·16	1·305
435	48·0	40·0	36·96	1·298
450	51·3	42·8	39·76	1·288

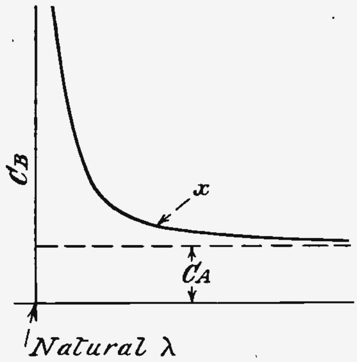
Then $L_A C_A$ represents the LC value for the natural wave-length of the antenna, and its LC value for any higher wave-length is $(L_A + L_B)C_A$; the inductance added to produce any given wave-length is—

$$L_B = \frac{\text{LC for that } \lambda}{C_A} - L_A$$

In substituting a condenser, C_B, for the antenna, some value of C_B is found which, when multiplied by L_B, gives the same product as $(L_A + L_B)C_A$, *i.e.*, $L_BC_B = (L_A + L_B)C_A$ and $C_B = \frac{(L_A + L_B)\,C_A}{L_B}$.

So the ordinate should read: "Capacity of substitute condenser $= \frac{(L_A + L_B)C_A}{L_B}$," not "Capacity of antenna."

It is obvious that $\frac{C_B}{C_A} = \frac{L_A + L_B}{L_B}$, and that with small loading, the value of C_B will greatly exceed



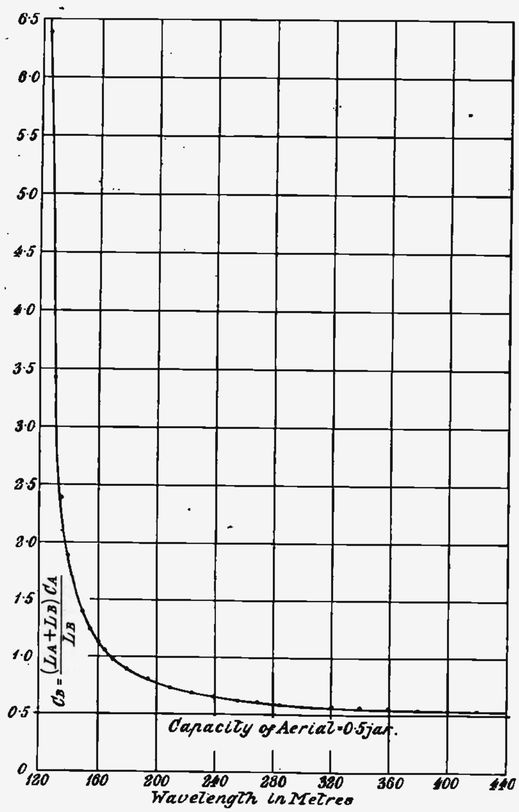
that of C_A; also that these ratios will decrease logarithmically as the wave-length is increased by raising the value of L_B; and that C_B will approximately equal C_A only when the expression $\frac{L_A + L_B}{L_B}$ is approaching unity; all of which is demonstrated by the curve.

I have tabulated the necessary data and prepared two curves showing the variations of C_B with λ, between 120 and 440 metres, assuming in each instance a natural λ of 120 metres, and in the first case an antenna capacity of 1·2 jars, and in the second case 0·5 jars.

AERIAL CAPACITY = ·5 jars.

Wavelength in Metres.	$L_m C_j$ mic-jars).	L_m when C_a = 1·2 jars	$L_b = L_m - L_a$ where L_a is inductance of aerial (7·3 mics. in this case).	$C_b = \frac{(L_a (L_a + L_b)}{L_B} = \frac{L_m C_j}{L_b}$
120	3·65	7·3	0	∞
125	3·96	7·92	0·62	6·38
130	4·28	8·56	1·26	3·42
135	4·62	9·24	1·94	2·38
140	4·97	9·94	2·64	1·88
150	5·7	11·4	4·1	1·39
155	6·09	12·18	4·88	1·24
160	6·49	12·98	5·68	1·14
165	6·9	13·8	6·5	1·06
170	7·32	14·64	7·34	0·97
180	8·2	16·4	9·1	0·9
195	9·36	18·72	11·42	0·82
210	11·2	22·4	15·1	0·74
225	12·8	25·6	18·3	0·7
240	14·6	29·2	21·9	0·67
255	16·5	33·0	25·7	0 ·64
270	18·5	37·0	29·7	0·625
285	20·6	41·0	33·7	0·598
300	22·8	45·6	38·3	0·595
320	25·94	51·88	44·58	0·58
340	29·3	58·6	51·3	0·57
360	32·8	65·6	58·3	0·565
380	36·6	73·2	65·9	0·555
400	40·53	81·06	73·76	0·55
420	44·7	89·4	82·1	0·545
440	49·0	98·0	90·7	0·54

To calculate the antenna capacity is simple, and based upon the following: The oscillation constant for any wave-length is the product of the antenna capacity and the total inductance; if increasing the total inductance from a to a_1 mics increases the LC value from A to A_1 micjars, then $\frac{A_1 - A \text{ micjars}}{a_1 - a \text{ mics}}$ = capacity of antenna. The procedure then will be to obtain the LC constant for a wave-length,



divide this by C_B, the condenser value, thus giving L_B, the added inductance; take the LC values for the two wave-lengths and subtract them; take the two L_B values found for these wave-lengths and subtract them; divide the difference of the L.C. constants by the difference of the L_B values, and the antenna capacity, C_A, is found.—Yours faithfully,

G. CAMERON MASON.

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—There seems to be some confusion with regard to effective height and actual height of aerials, as judged by recent correspondence in your columns. May I point out that the formula

$$Rr = 160\pi^2 \left(\frac{h}{\lambda}\right)^2$$

takes account of the *actual* height, and not *effective* height; it is subject to correction by a "form factor" for certain types of aerials, but this is so near unity for all ordinary antennæ that it makes no practical difference. The formula is, I believe, an empirical one, based on actual measurements, and, therefore, incorporating the correction for effective height; thus, if we introduce effective height, found in another way (or estimated), we lay ourselves open to large errors by introducing a correction twice. The fact that Mr. Hogg's measurements agree so nearly with the calculated value, assuming $h=28$ ft. should help to decide the controversy. This formula and a table and worked example may be found in Hoyle's "Standard Tables and Equations in Radio Telegraphy," by those caring to follow the matter up. There are, of course, further losses in trees, masts, etc., which are sometimes included, sometimes added as correction factors, in various formulæ for effective height, radiation, and so on; other writers, again, put these losses down to actual transmission (wave), and many pitfalls of the kind exist for the unwary. In all these cases it is necessary to keep a sharp look-out, as a correction may be included three or even four times, with obviously fatal results.

Passing to other letters, may not Mr. Ryan's better results with thick wire be due to its *greater* damping effect than to less resistance compared with moderately thin wire? Greater surface area may be more than nullified by more eddy current losses. "Better" results do not necessarily mean greater signal strength. I do not like to drag in trade matters, but it is almost necessary to illustrate my point. The most scientifically designed plug-in coils on the market are those sold by Messrs. Gambrell Bros.—due, I believe, to Mr. Onwood. For a given inductance they go much lower than other coils, even single layer-types, owing to their very small self capacity, and I have found that signals are clearer and more sharply tuned on these coils than on any others—and I have made some hundreds of comparisons, usually with a high resistance crystal (carborundum), and no reaction to upset the damping. (Let me disclaim any connection with the firm in question at once.) Now the short wave coils of this series are wound with finer wire than some of the long wave ones; A, B and C appear to be wound with 28 or 30 S.W.G., whereas E has 22 S.W.G.; a designer producing a series of coils with so many evidences that he knows his subject would not be likely to neglect a study of optimum wire sizes. I am afraid, then, that I must disagree with Mr. Ryan and affirm that the H.F. resistance of a comparatively fine wire may be less than that of a thick wire, and this difference is accentuated in the case of a coil. As to the controversy which has always raged round "litz" wire, I do not want to open up that, so will do no more than mention it.

In the matter of the heterodyne, I beg leave to change sides, and differ from Mr. de Burgh. It does not matter what proportion the rectified current bears to the unrectified; if, before rectification we have the amplitude of the beats in one case greater than they are in another, then the rectified current will be greater. To get loud signals, it is necessary to get the maximum amplitude in the beats produced, and there is only one way of doing this, that is, the incoming oscillations and the local heterodyne oscillations must be of *equal* amplitude at the point of introduction of the latter. If the local oscillations are either stronger or weaker than the incoming signals the beat amplitude suffers, and the resultant in the telephone is weaker. Taking the case where the local currents are weaker than the incoming, we have greater selectivity on weak signals, as a strong signal cannot make more noise than a weak; on the other hand, in the more common case where the local oscillations are more powerful than the incoming, signal (telephone) strengths are proportional to the incoming signals only—whether directly or as the square or root or what not makes no difference, the strong signal wins every time. The effect on the detector action mentioned by Mr. de Burgh could be likened to a sort of wipe-out artificially produced, and does not seem to increase the *variation* in telephone current at all; it would be much more logical to put in some H.F. amplification and control the grid potential to get an almost similar result. I cannot quite see how this action would apply in the case of grid-condenser rectification, as we do not reckon to work on either of the bends of the curve in that case, and the whole arrangement would suffer from the wipe-out effect of a strong local oscillation. In dealing with weak C.W. practically I have always found it of advantage to use a heretodyne with a very small coil and large condenser—the latter giving a wide λ range on the one instrument, and the former having a very small field, rendering possible the adjustment of the heterodyne as to strength without having to place it six feet away or in another room to come down to weak signals. As a detector a valve of the universal type (R, ORA, V24, etc.), with leaky grid condenser, works well on weak signals when used with a weak heterodyne as well. (For spark and telephony, on the other hand, a valve such as the Q, with controlled grid, or a crystal, will give purer tone, but this is by the way.)—Yours faithfully,

LEONARD J. VOSS.

To the Editor, EXPERIMENTAL WIRELESS.

DEAR SIR,—Referring to the article in the December issue of EXPERIMENTAL WIRELESS on "General Efficiency of Reception on Short Waves," we should like to draw your attention to a statement made by the author which may prove a little misleading to your readers. The author states: "The universal fault with all short wave plug-in coils on the market is that the wire used is far too thin. All coils for short wave work should be wound with at least 18 or 20 gauge."

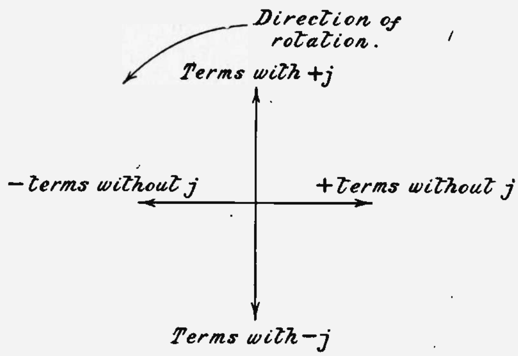
It is not always realised that the D.C. resistance of coils due to the wire gauge is often negligible in comparison to their effective resistance at high frequencies. For example, a type of coil which may be suitable for high wave-lengths and has a D.C. resistance of two to three ohms, may on low wave-lengths have a resistance of between two and three hundred ohms.

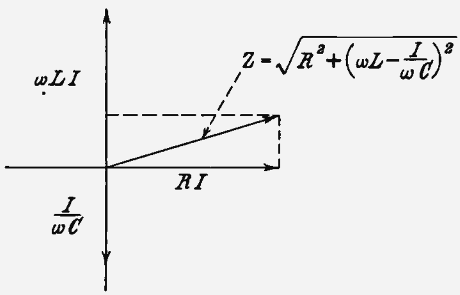
It follows, therefore, that the important point is not the size of the wire, but the design of coils. It is important that no two turns in the coil should come into contact with each other, whether well insulated or not. Coils wound in such a fashion that the turns cross each other are not suitable for very low wave-lengths, as their losses at these frequencies are very considerable.—Yours faithfully,

GAMBRELL BROS., LTD.,
R. Annan, *Sales Manager.*

To the Editor, EXPERIMENTAL WIRELESS.

DEAR SIR,—It was indeed gratifying to read in the current issue of EXPERIMENTAL WIRELESS the article by Capt. P. P. Eckersley on "Alternating Currents and Wireless." To educate the student of wireless to the use of j is, indeed, a worthy step in the right direction.





There are one or two points, however, which I should like to mention. First is it rather unfortunate that your contributor has adhered to the old-fashioned symbols, *e.g.*, C and not K is now used to indicate the capacity of a condenser, and w, not p, is more usual and preferable to the modern student. Again, in indicating the method for calculating the value of the R.M.S. current I, no mention is made of units. This is a serious omission, for it leaves the experimenter in doubt as to what substitutions to make—shall it be micro-henries or henries, etc. ?

E (R.M.S.)	should be	measured	in	volts.
I (R.M.S.)	,,	,,	,,	amperes.
R	..	..	,,	ohms.
L	..	..	..	henries.
C (or K)	,,	,,	,,	farads.
Z	,,	,,	,,	ohms.

When drawing vector diagrams it is essential to indicate the assumed direction of rotation for the vectors, and, according to modern practice, this is anti-clockwise—this is another omission.

The reason for the use of j is simply explained. Multiplying a vector by = 1 turns it round through 108°, *i.e.*, it points in the opposite direction, so that in order to turn it round through 90° it is multiplied by $\sqrt{-1}$, so that the two movements of 90° are secured by $\sqrt{-1} \times \sqrt{-1} = -1$.

Multiplying the vector by $\sqrt{-1}$ causes it to lead 90° on its previous position, and not lag, as stated by Capt. Eckersley, so that his diagram should be as shown. The numerical result is the same in each case, but confusion will arise if the value of the phase angle is required.—Yours faithfully,

H. J. BARTON CHAPPLE,
Bradford Technical College,

To the Editor of EXPERIMENTAL WIRELESS.

DEAR SIR,—I beg to submit a few results of experiments conducted upon the 4-circuit tuner. The set was constructed exactly as detailed in the first issue of EXPERIMENTAL WIRELESS, with one marked exception. During the experiments it was noticed that the tuning of the aperiodic aerial coil "A" seemed relatively sharp. As the stator of a tapped variometer was being used for this coil, the rotor was naturally included, with the result that the set was easily brought to the point of sub-oscillation accompanied with marked increase in signal strength. Upon an indifferent P.M.G. aerial averaging 25 ft. in height, all the Broadcasting stations were received, 2LO, 15 miles away, at nearly loud-speaker strength, and the more distant ones, comfortable strength on 'phones. With one stage of L.F. London worked a loud speaker easily, whilst 2NO, 5SC and several others were at about R.6 signal strength. Upon an indoor aerial 20 ft. long at an average height of 9 ft., London was received at R.5 on two valves, which is remarkable under the circumstances. With regard to re-radiation, I can state that this is nil, by corroboration with a friend using a big set at 700 yards distance.

I should earnestly advise any experimenter to make up this set, which is chock-full of possibilities, and shall be pleased to help anyone who would wish further particulars. Wishing your splendid journal the best of success, and thanking you for the opportunity of learning such a lot from it.—I remain, yours sincerely,

H. J. WYATT.

Business Brevities.

Two New Receiving Valves.

A type of valve which is well known to the Canadian experimenter as the Myers Valve has recently been placed on the market by Messrs. Cunningham and Morrison, 49, Warwick Road, S.W.5. Two types are being made, one consuming about a quarter of an ampere at four volts, while the other operates at about two to two and a half volts. We have tested both types, and find them to be very good from all points of view. The two-volt valve, besides being tested on signals, has been examined in our laboratory, and the results of the test are summarised briefly below.

A characteristic curve is given, and it will be noted that the "straight" portion is practically straight over almost its entire length. A set of curves were taken, and gave an amplification factor of 8.6, which, in conjunction with an anode filament impedance of about 50,000 ohms, should indicate a useful performance for general work. On test it was found to be an efficient rectifier, and also capable of dealing with a considerable load as an audio frequency amplifier, the saturation current being quite large. It was also found to be a quite good radio frequency amplifier, and its function in this capacity is, no doubt, assisted by a fairly low self-capacity, due to the method of construction. A general appearance of the valve can be gathered from the accompanying photograph, which indicates the special type of connection to the electrodes. A set of clips for mounting is supplied with each valve, together with a template for marking out the panel. The method of construction results in a very strong valve, which, at the same time, is very free from microphonic noises. The Myers valve should readily find a place amongst every experimenter's equipment.

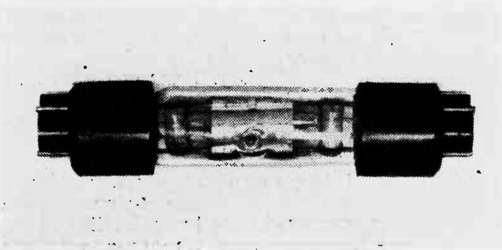


Fig. 1.—The Myers receiving valve.

* * *

A Gambrell Wavemeter.

Messrs. Eustace Watkins, Ltd., have sent us for test a standard Gambrell wavemeter, an illustration of which appears on the next page. It is one of the nicest crystal-buzzer wavemeters which we have seen and it is extremely convenient to handle. The arrangement consists of a small polished box with an ebonite panel on which are mounted the variable condenser, crystal rectifier, buzzer and telephone or battery terminals and two-way switch. The inductance is not included in the case itself, but a coil holder is mounted on the panel into which various Gambrell coils can be plugged. The normal range of 100 to 8,000 metres is covered with only four coils. The Gambrell air spaced coil it will be remembered has exceedingly small losses, the self-capacity being very small. With a given condenser, therefore, it is possible to cover a considerable range of wavelengths; and at the same time the tuning is fairly sharp. The calibration curves supplied with each instrument are checked against National Physical Laboratory Standards and on test we found them to be quite accurate. The crystal rectifier is of the perikon type and has a moderately high resistance which ensures fairly good resonance in the oscillatory circuit. On the transmission side, the circuit is excited by means of a high note buzzer which gives a group frequency of about 1200. The note is extremely clear and penetrating. The decrement of the circuit is very good as the maximum point of resonance is very clearly defined. Finally we can unreservedly recommend the instrument to any experimenter who is contemplating the purchase of a wavemeter. The price including four coils and calibration curves is £7 15s., and the London agents are Messrs. Eustace Watkins, Ltd., 91, New Bond Street, London, W.1.

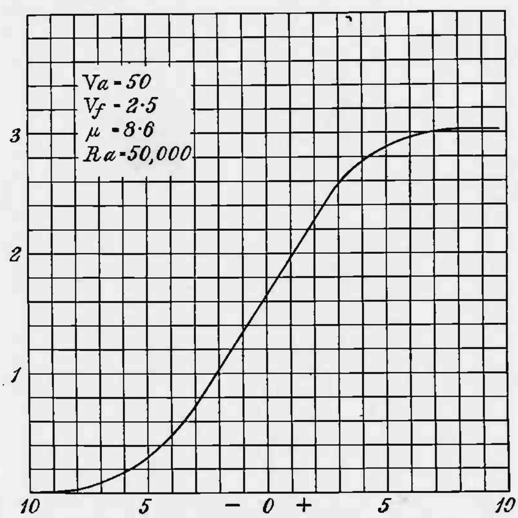


Fig. 2—Characteristic curve of the Myers valve.

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Marconi Scientific Instrument Co., Ltd.

The Marconi Scientific Instrument Co., Ltd., have recently issued a new brochure relating to their receivers specially designed for broadcast reception. A speciality is a line of three- and five-valve receiving sets mounted in handsome cabinets designed to tone in with furnishing schemes of various periods, such as Jacobean, Queen Anne and Chippendale. The circuits are such as to be suitable for receiving long wave continental broadcasting in addition to local short wave programmes. In addition to broadcast receivers we note that single and two-valve note magnifier are shown and also a compact transmitter, details of which apparently vary according to requirements.

* * *

PETO SCOTT'S WIRELESS BOOK.

We have just received from The Peto Scott Co., Ltd., "Peto-Scott's Wireless Book" which is best described as a combined catalogue, instruction and circuit book. The first part of the book is devoted to some general ideas on broadcast reception and gives advice to the beginner on all subjects ranging from the most suitable type of aerial insulator to the correct way of soldering. The last few pages of the book are devoted to circuits and chiefly illustrate the proverbial tuned anode with reaction together with one or more audio frequency amplifiers. Various dual circuits, of course, are also included. The middle section of the book, however, is likely to interest the advanced experimenter. Here will be found full particulars of the Peto-Scott "Unettes." They consist essentially of the usual variety of components each mounted on ebonite together with terminals and perhaps we cannot do better than quote from their own description :—"Panels are of uniform size. The input for the component is arranged on the left-hand side, and the output on the right, so that any component can be coupled to the preceding and following component by simply cross connecting the terminals which become opposite to each other. The variable condensers are shielded from dust and the two sizes used for tuning have extra terminals placed on the base, so that by giving the whole base a quarter turn the connections are automatically reversed from series to parallel, and *vice versa* (Pro. Pat. 21,798). All coupling panels are provided with an extra terminal so that grid control can be arranged without altering the standard wiring of these panels. Separate terminals are provided for each plate circuit so that the correct H.T. voltage can be applied to each anode. A stand-by-tune switch is provided on the three-coil tuner. Reaction can be applied to primary, secondary or tuned anode circuits as desired. Specially shaped end pieces, and also blank panels are provided so that the "Unettes" can be arranged in a double or treble bank. For further facilitating the connections from panel to panel, instead of the usual type of terminal, the special spring terminals, known as "Refty terminals" are fitted to all these panels. These terminals have ridged contact surface, and all you have to do is to press—insert wire—leave go—and you have a secure mechanical and electrical connection which cannot shake loose. . . . The panels are of best quality ebonite ⅜ in. thick, recessed on the under-side so that the wiring can be neatly carried out and concealed, and comprise three sizes, large 4¼ by 4¼ ins., medium 4¼ by 2½ ins., and small 4¼ by 4¼ ins. The components are mounted on a large, medium, or small panel, and the medium and small-size panels together are the same size as the large." It seems that these components should be of considerable value to the experimenter who has a variety of circuits to arrange as they can be screwed on to a board and all connections made above, without the necessity of drilling holes and removing wood to clear wires coming from below. In passing we may mention that "Unettes" are marked "Prov. Pat. No. 23419." Exactly what is claimed will be interesting to note as at present the subject matter of the patent is not very clear.

* * *

THE WIRELESS ANNUAL.

"The Wireless Annual for 1924," published by the Wireless Press, Ltd., is one of the most useful and dependable reference books which we have seen for some time. The first part of the book is devoted chiefly to articles which in themselves reflect the progress that has been made during the preceding year, both by the professional and amateur. Of great interest is an article by Senatore Marconi, which gives constructional data for an extra high-frequency oscillator and receiver. Perhaps of most value to the advanced experimenter is the very extensive collection of practical data necessary for any serious design work. Amongst other items is an alphabetical list of call signs of the world and also a directory of amateur calls in Great Britain and France. Another interesting feature is a list of Radio Manufacturers which should prove very useful. The comprehensive nature of "The Wireless Annual" which is priced at 2s. 6d. should readily secure for it a place on the bookshelf of every radio enthusiast.

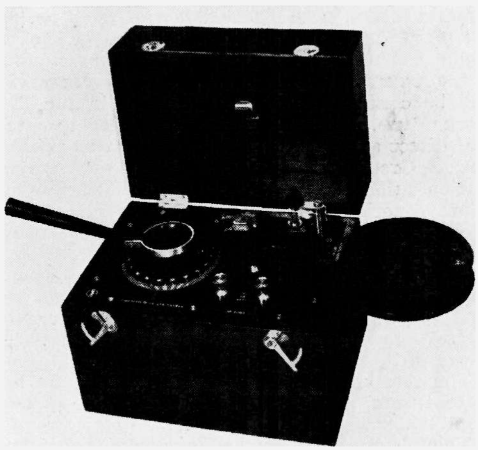

Fig. 3—The general appearance of the Gambrell wavemeter. Note the ebonite extension handle which clips into the lid when not in use.

* * *

GRIFFIN WIRELESS SUPPLIES CO.

Messrs. Griffin Wireless Supplies Co., of 80, Newington Causeway, have asked us to announce that they have now opened a branch at 18, Kingsland Road, E.2, which they think will be more convenient for many of their customers.

* * *

MESSRS. BERTRAM DAY & CO., LTD.

Messrs. Bertram Day & Co., Ltd., the well-known wireless advertising agents, inform us that once again the extent of their business has compelled them to take larger premises and the new address of the Service Department is now No. 1, Charing Cross, London, S.W.1.

"THE MODEL ENGINEER" EXHIBITION.

At the seventh annual *Model Engineer* Exhibition held at the Horticultural Hall from January 4-11 some seven wireless firms were represented including the Bowyer-Lowe Co., Ltd., Will Day, Ltd., Economic Electric, Ltd., Grafton Electric Co., W. Jones, Peto-Scott Co., Ltd., Wainwright Manufacturing Co., Ltd. Following so closely upon the Wireless Exhibition there were very few instances of new developments of any considerably importance. We noted, however, a very compact valve holder and rheostat of the wood mounting type by the Bowyer-Lowe Co., Ltd., which should prove very useful. The Patent Die Castings Co., Ltd., were showing a set of cast name plates of the usual series and should look very neat when mounted on a panel.

Experimental Notes and News.

NEW WIRELESS STATION OPENED IN ARGENTINA.

The new wireless station which has been built at Monte Grande for the Transradio Internacional Compania Radiotelegrafica Argentina for the purpose of placing the Argentine in direct wireless communication with North America, Europe, and the Far East, was recently opened, when an inaugural message was sent from the President of the Argentine to King George V. Direct services will be carried out between Monte Grande, New York, Paris, and Berlin. It is intended to extend this direct service to England as soon as possible, but as Great Britain does not possess a wireless station sufficiently powerful to communicate with South America this service cannot be brought into operation until a suitable station is available in this country.

The transmitting station at Monte Grande, 20 kilometres from Buenos Aires, covers an area of 1,200 acres. There are ten steel towers 500 metres apart, each tower being 690 ft. high. The power of the station is 800 k.w.

The receiving centre is at Villa Eliza, 39 kilometers from Buenos Aires and the same distance from the transmitting station.

The telegraph office, from which the transmitting station is automatically controlled and to which the receiving station is connected with telegraph lines and an automatic linking device, as is the case in the Marconi system in this country, is situated in the centre of the commercial quarter of Buenos Aires.

In addition to the message sent to the King, Senor Don Marcelo T. de Alvera, President of the Argentine Republic, sent the following message to the Chiefs of the States of the World, through the new Monte Grande Wireless Station :—

> The President of the Argentine Nation at the inaugural ceremony of the Monte Grande High-Power Wireless Station expresses wishes for the prosperity of all the nations of the world. In doing so he interprets the characteristic and traditional feelings of universal brotherhood held by the Argentine people who are desirous of feeling themselves always in solidarity with all these peoples who are struggling for peace and civilisation.

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AMATEUR TRANSMISSIONS IN THREE LANGUAGES.

It will be of interest to readers to know that the well-known French amateur, of Transatlantic tests fame, Dr. Pierre Corret, of Paris, has lately been sending out Morse transmissions under the call sign of "8AE2." He works at 11 p.m. on Monday, Tuesday, Thursday, and Friday of each week, and he sends out the following message in French, English, and Esperanto :—

> "Wireless amateurs who hear these signals, are requested to be good enough to report to Dr. Corret, 97, Rue Royal, à Versailles, Paris, how these signals have been received."

Dr. Corret first gives the general call "CQ de 8AE2" then the call in French, English, and Esperanto Wave-length 200 metres. We trust that this little experiment will meet with the success it deserves.

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RELAY STATION AT PLYMOUTH.

The British Broadcasting Company has received a permit from the Postmaster-General for the erection of a wireless relay station at Plymouth. Operations will be begun as soon as possible, and it is hoped the station will be working in two or three months.

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NEW STATION FOR HELP OF FISHERMEN.

In the course of the next few weeks another of Europe's northerly wireless stations will be completed at Vardoe, in the extreme north of Norway. The station will be of moderate size, but fitted with all the most up-to-date instruments, including a wireless telephone. The transmission radius will enable it to maintain communication with Spitzbergen in the north and with Fauske station in the south. The masts are each 59 metres high. The Vardoe Station will assume a position of importance in view of its situation with regard to the trawling fleets engaged in Arctic waters—along the north coast of Norway or in the region of the Shetlands. Weather and other reports of usefulness and interest to the fishing fleets will be regularly sent out.

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THE 5SC STATION.

Information has reached Glasgow that wireless transmissions from the broadcasting station in that city has been picked up at Flandreau, South Dakota, United States, and by four receiving stations in Minneapolis. The distance from Glasgow to Flandreau is approximately 4,750 miles. A reading and musical selections were clearly heard. London 2LO has also been heard at Camps Bay. On a loud speaker dance music was audible 15 yards from the instrument. Within about two months the British Broadcasting Company hopes to give an international evening with music from such places as Paris, Brussels, and an American station.