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CONTENTS

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TERMINAL EQUIPMENTS

The first part of this article, appearing in the last number of THE MARCONI REVIEW, *dealt with the conditions prevailing in radio telephone circuits, and the development of an anti-singing device of general type was discussed. In this, the concluding section of the article, the practical operation of such a device is considered.*

Protection of Received Speech.

THE requirements imposed on the terminal include the protection of received speech against interruption by speech for transmission or by echoes back from the trunk behaving similarly.

Now the mechanism so far described will depend on the differential balance obtained for the extent to which it affords this type of protection. If the receiving side of the differential has a higher output than the transmitting when received noise alone is present, the occurrence of received speech will leave the ratio of the outputs undisturbed but will increase the actual negative voltage on the first bias control grid. That is, with an unbalance opposing transmission, the occurrence of received speech will raise the threshold transmitting level.

With a perfect differential balance, since the differential is an almost linear device, the occurrence of received speech will not affect the threshold transmitting level.

With a differential unbalance favouring transmission, the first valve of the bias control will be partly activated by noise alone. When received speech occurs, the differential unbalance ratio remains constant, but the positive output of the differential is increased. The first bias control valve is thus further activated, and may be fully so. In the latter case, false operation occurs, suppressing the received path and so the energy causing the situation. Restoration then takes place, when the cycle of activation and suppression is repeated. The effect appears as intermittent received speech and bursts of speech or noise to the transmitter, or, if the time constant, etc., involved are favourable, as a stabilised condition of part suppression.

To improve the protection afforded received speech, an additional piece of apparatus is provided in the "lock." This has been already described, and is essentially a detector having a high degree of level discrimination. The detector output is arranged to disable the transmitting side of the differential input when the level exceeds a pre-determined value. The lock input is bridged across the input to the receiving differential gain control, so that the lock has the benefit of the frequency discrimination provided by the receiving A.S.D. filter.

If the sensitivity of the lock is set so that it is just satisfactorily operated by received speech, it will not be operated by received noise alone for any normal received signal to noise ratio. The conditions prevailing for no speech and for transmitting speech are therefore undisturbed. On the occurrence of received speech, operation of the lock follows and the transmitting side of the differential is effectively paralysed regardless of any differential unbalance. By these means received speech is protected from interruption, while transmitted speech is protected by the arrangement previously described in which suppression of the receiving path precedes activation of that for transmission. It should be noted that the successful action of the lock, under conditions in which without it false operation would occur, depends on the lock paralysing the differential transmitting side before this side of the differential has sufficient output to operate the bias control. The lock has a time of operation depending on input level, so that it is always advisable to set the lock threshold level as near that of received noise as may be practicable.

Echo Effects.

Speech currents may give rise to echoes, travelling back towards the source of the speech currents and reaching that source at an interval after the generation of the original currents depending on the speed of propagation and the point of reflection. In a terminal equipment, the chief sources of echo are the trunk and the receiver. The first type is due to points of reflection in the trunk circuit, which cause received speech sent to the trunk to be partly returned towards the terminal where the reflected currents follow the path of speech for transmission. The second type is due to a variety of causes, such as cross-talk between the local transmitter and receiver, re-radiation through the far terminal and multiple radio paths.

The first type of echo—that back from the trunk during received speech—calls for paralysis of the transmitting path during any time echoes may reach the terminal. This time may be very shortly after the establishment of received speech or an appreciable time after its cessation. The protection must be quick-acting and must be maintained some time after the operating input is removed. This is provided by the condenser across the resistance in the lock diode circuit. On operation of the lock, the diode becomes rapidly conducting, a large voltage is established across the diode resistance to paralyse the differential transmitting input and the condenser across this resistance charges rapidly through the comparatively low resistance of the activated diode. On received speech ceasing, the lock input disappears, the diode becomes non-conducting and the condenser discharges slowly through the high resistance in shunt with it. An appreciable time therefore elapses after received speech has ceased before the transmitting side of the differential is again active. This condenser is referred to as the " receiving hang-over " condenser, and is variable in steps controlled by a dial switch.

The second type of echo calls for a similar arrangement on the transmitting side, causing rapid paralysis of the receiving side on the establishment of transmitted speech and the maintenance of this paralysis for an interval after transmitted speech has ceased. The initial paralysis is already provided by the suppression of the receiving path exceeding the activation of that for transmission. The maintenance of this paralysis for an interval after transmission has ceased is obtained by the condenser shunting the first bias control anode resistance. As in the previous case, this condenser charges rapidly through the low impedance of the activated first valve of the bias control, and discharges slowly through its shunt resistance, since during discharge the first bias control valve is paralysed. This " transmitting hang-over " condenser is variable in steps controlled by a dial.

In the case of echoes of very short delay, the effect will appear as a differential unbalance in favour of transmission and may be balanced by the receiving differential gain control. As the delay is increased, the differential will suffer a " time-unbalance," i.e., an unbalance in opposite sense. If this time-unbalance is effective for delay times less than the operating time of the " lock," a burst of received speech may be retransmitted. For this reason, each half of the differential and the total differential output have hang-over circuits of definite but small time constant. This tends to reduce the possibility of a " time-unbalance " of shorter duration than the time of operation of the " lock."

Practical Operation.

The foregoing paragraphs have been concerned with the more theoretical aspects of anti-singing devices. It will be of value, therefore, to give some account of the handling of such a system as that described.

Suppose that speech for transmission is applied to the terminal and that the usual level adjustments are made, the receiving line being disconnected. If the output of the transmitting suppresser is monitored, and the loss of the transmitting differential gain control gradually diminished, the following effects will be noticed. At first the speech fails to pass, then an intermittent series of unrecognizable syllables —these being those of greatest energy. The next stage is recognizable speech, but with weak initial syllables omitted. The speech then comes through satisfactorily, but has a peculiarly abrupt sound, referred to as appearing " plosive." Finally, the speech is transmitted normally and is unaltered by further movement of the gain control. The first position at which the speech ceases to be " plosive " is the most efficient operating point, and, once this adjustment has been made, this gain control is not moved in normal operation.

The next step is to connect a receiver line carrying noise. Suppose the receiving chain adjustment is normal, and a line and network normally connected while the differential receiving gain control loss is decreased, the " lock " being prevented from activation. If intermittent transmitted speech is observed as before, no degradation will be found at first. Then, the speech will become " plosive " and finally suppressed. Beyond this point, received noise either comes through in bursts or causes partial suppression of both paths. The balance point is of course reached just before degradation appears. It will next be found that this balance point is almost independent of the actual level of received noise, but becomes increasingly critical as this level rises. If now the level of received noise sent to the line in the intervals of speech for transmission be increased, by changing the gain between the receiving side of the anti-singing device and the line, it will be found that balance is re-established by changing the differential receiving gain control an equal amount. This process can be continued, the balance becoming increasingly critical. Finally, the steps of the gain control and the capacity of the amplifiers provide a limit.

In this limiting neighbourhood, an interesting effect occurs. The balance as observed on the differential meter will be seen to fluctuate between displacement in favour of transmitting and of receiving for certain adjustments. This is due to the transient nature of the two inputs and to slight divergencies in frequency and phase characteristics between the two chains for which balance is sought. Practically, if such a limiting case has to be used, the balance is shifted so that it has a small displacement in favour of receiving, the transmitted speech then suffering a corresponding penalty in quality. This step is generally preceded by the subscriber being asked to " speak up," lines being changed, etc.

The adjustment of the " lock " is first made on the existing level of received noise. If the diode current is observed as the lock sensitivity is increased, it will be found that no operation occurs at first, then intermittent operation by peaks of noise, and finally permanent operation. The correct setting is that just before intermittent operation. The vital consideration for this apparatus is, of course, the minimum signal to noise ratio on which it will operate on speech but not noise. It will be noted that complete failure of the lock still leaves the device useable if the " balance " is displaced towards receiving. In this event, however, protection against " echo " from the trunk is much reduced.

The hang-over adjustments are not critical and are usually a matter of trial and error on particular circuits. The normal operating procedure is concerned solely with adjustment of the receiving differential gain control and, if noise conditions change, with that of the lock sensitivity.

To give performance figures for this type of device is not easy, since so many variables are involved, e.g., hybrid balance, signal to noise ratio, nature of noise, etc. The method preferred here is to regard the figure of merit as the maximum permissible ratio of received noise to that of speech for transmission as occurring on the trunk line with zero hybrid balance. For the equipment mentioned, this figure is approximately 20 dB. in the absence of trunk noise and echo. To obtain the permissible ratio of received speech level sent to the trunk to that of transmitted speech obtained from the trunk, the hybrid balance and received signal-noise ratio must be added. For example, with a hybrid balance of 5 dB. and a signal-noise ratio of 10 dB., transmitted speech may reach the terminal at a level 35 dB. below that at which received speech is applied to the trunk.

The limiting received signal-noise ratio for satisfactory operation of the lock is approximately 10 dB.—a figure on which improvement appears of doubtful utility on account of the difficulty of conversation under these conditions.

The previous sections have described the fundamental difficulties which are found in terminal equipments and a particular means used to obviate them. Terminal equipments, however, provide a number of additional facilities and some description of these is merited beyond the general schematic of Fig. 7.

Volume Control.

Through the terminal pass, of course, speech for transmission and that from reception. The speech reaching the transmitter must, of course, be maintained at as constant a level as possible despite changes of speaker, for otherwise the transmitter is not used at maximum efficiency, but the speech from the receiver, must be regulated according to conditions depending on the subscriber's line, the radio-noise level, etc. At the same time, it is highly desirable that the speech in either direction be kept at a constant level through the anti-singing devices and the privacy apparatus, if used.

To meet these conditions and the possibility of varied attenuations in the lines to the transmitter and from the receiver, each speech path includes two repeaters and a main gain control. In the transmitting case, from the hybrid coils the order is—main gain control, repeater, anti-singing and privacy devices, repeater, transmitting line. The main gain control and the first repeater serve to adjust all speakers to the predetermined levels for the devices mentioned, while the second repeater serves to change this level as required by the attenuation of the line to the transmitter and the design of the latter.

In the receiving case, the receiver is presumed to supply a constant speech level, so that the incoming speech passes first through a repeater adjusted to bring that level, as diminished by the receiving line, up to that required for the privacy and anti-singing devices. After passing through these devices, the speech reaches a main gain control and a second repeater before passing to the hybrid coils.

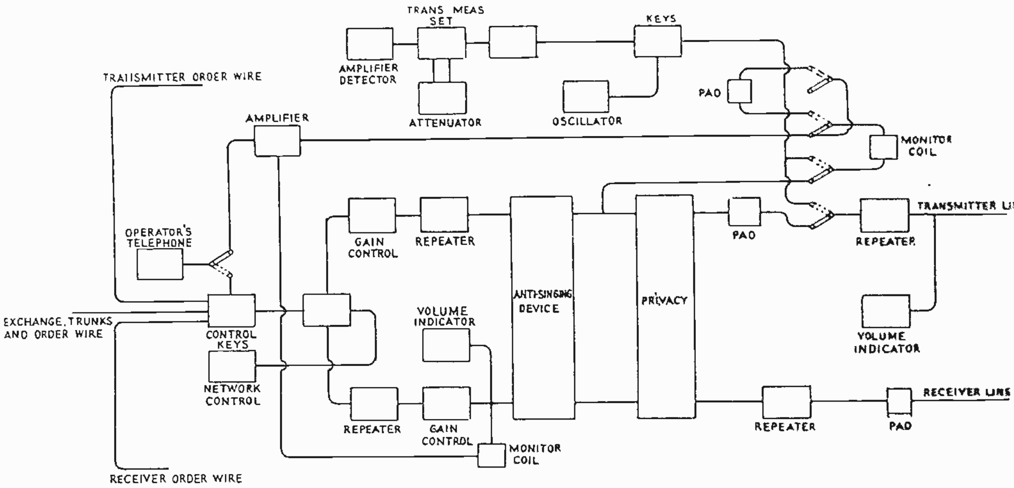

FIG. 7.

Each chain has thus two sets of controls—those concerned with compensating for line attenuations and those concerned with operating adjustments to meet speaker and noise conditions.

Each chain is bridged by a volume indicator, on the transmitting side across the final output, on the receiving side across the input to the main gain control. These indicators are set when aligning the circuit, and the operator has then only to see that his main control adjustments cause them to show the assigned readings.

Monitoring.

The information the operator receives from the volume indicators is not complete, for they will not tell him of failures in the quality of speech. Monitoring facilities are therefore arranged so that the operator listens to speech at points where any degradation likely to occur will be obvious, and where, even if privacy is used, he will hear plain speech. For this purpose monitoring coils are bridged across the trunk side of the hybrid coils, the output of the transmitting side of the anti-singing device and across that of the receiving side of the same apparatus. These latter two points are also points of constant level, so that an aural check on adjustments is available. The outputs of these two coils are taken to amplifiers, having a common plate circuit normally connected to the operator's headset, a gain control enabling the operator to adjust the level he hears to that he desires.

Measuring Equipment.

In addition to the apparatus normally in use on traffic centres, equipments of this type usually carry one set of certain audio-frequency measuring equipment. Experience has shown the value of this inclusion to be considerable, both for routine tests for the maintenance of a satisfactory service and the provision of special facilities for, e.g., broadcast relay programmes of topical events.

This group is formed by a source of continuously variable tone, a high-output amplifier, a transmission measuring set and attenuator and an amplifier-detector. The tone-source chosen is a heterodyne oscillator having a frequency range from less than 50 p.p.s. to 12,000 p.p.s. low harmonic content and considerable stability. From this source the output is taken through an amplifier of controlled gain and high overload point to the transmission measuring set.

The transmission measuring set may be considered as having two purposes—the one to simulate a generator of known impedance and power, the other to apply the output of this generator either through the apparatus on test or directly to a detector, while making provision for the insertion of auxiliary attenuators and terminating impedances. The first purpose is fulfilled by an inefficient " sender " circuit consisting of a low impedance control section, resistance coupled on the output side, transformer-coupled on the input side, so designed that the output impedance is almost independent of the amplifier impedance. To obtain a definite E.M.F. in this constant impedance, a thermo-couple is included in the low-impedance section, and a direct-current calibration position provided. The procedure is to establish a direct current of the required value through the thermo-couple, observe the couple E.M.F. and reproduce this couple E.M.F. with A.C. of the required frequency flowing through the thermo-couple. The circuit will then simulate a generator of known frequency, impedance and power—usually of 600 ohms impedance and delivering 1 milliwatt to a 600 ohms resistive load. An additional separate control enables this power to be diminished in decibel calibrated steps without other effect.

The amplifier-detector may be considered as a valve-voltmeter, whose sensitivity may be controlled in decibel steps, permitting the procedure in using the apparatus for measurements of gains, losses, frequency response, etc., to be comparatively easy. The sender circuit is first calibrated to give the requisite power at the required frequency, when this output is then applied directly to the amplifier-detector and subsequently via the apparatus on test. Adjustment of the amplifier-detector sensitivity between the two positions to preserve the same detector current provides a dial reading of the equivalent of the apparatus on test to $\pm$ 0.1 dB. at the frequency chosen. Such is the broad outline of a system which in practice has a number of refinements.

The amplifier-detector may be chosen by key operation, to have either a high or a low input impedance. In the former case, the apparatus may be bridged across lines without disturbing them and will give an indication of the line level in terms of decibels referred to 1 milliwatt in 600 ohms resistance. This feature is of considerable value in the measurement of incoming noise levels, since the amplifier-detector is direct dial reading for levels down to 31 dB. below the figure stated.

Operator's Circuits.

The operator at a terminal equipment is responsible for the maintenance of satisfactory communication throughout the longest possible period. It is therefore necessary that he should be able to converse as readily as may be with his transmitter and receiver operators, his own exchange or traffic operator and the distant terminal or technical operator. For most of these purposes telephone facilities alone are adequate, but for the last, under bad conditions, it may be necessary to use tone telegraphy.

These requirements are not unusual, but in this type of terminal equipment some care has been exercised to render the operations easy and available without the use of plugs and cords, or auxiliary telephones. The operator wears the usual type of head telephone receiver and breast-plate microphone and these serve him for monitoring as well as all telephone facilities. Order-wires are provided from the terminal to the transmitter, the receiver and the exchange, and calls down these lines are effected by key operation and ringing current, incoming calls being indicated by lamp glows and answered by key operation.

When the technical operator desires to speak on the radio-channel, the operation of a key disconnects his monitoring circuits, connects his telephone set to the hybrid coils, provides these coils with a special balancing network and inserts attenuation in the transmitting path to compensate for the operator's proximity to the equipment. This attenuation may be manually controlled or pre-set. In addition, the exchange trunk is terminated in 600 ohms and a lamp glow warns the technical operator that his microphone is connected to the transmitter.

Should conditions prove such that telephony is impossible, the technical operator speaking on the circuit throws a second key to a " tone-telegraph " position. This routes the output from the heterodyne oscillator through a telegraphist's key direct to the input of the final transmitting repeater and so to the transmitter. At the same time the operator's telephone set is restored to the normal monitoring position, with the exception that the transmitting monitoring circuits include extra attenuation. The operator can then use the telegraph key for communication and hear any incoming signals at any time while hearing his own outgoing signals at low level. Similarly should he so desire he can send continuous tone modulation by throwing the same key to the " tone " position. It may be added that the necessary level adjustments are pre-set and that these facilities are not available unless the key connecting the operator's telephone set to the radio-channel has been previously operated.

The remainder of the circuits associated with the exchange are subject to alteration to meet local conditions. When the trunk exchange and terminal are very near, it is not uncommon for the balancing networks for various trunks to be supplied or switched from the exchange, while automatic insertion of attenuation, connection of networks, and direct current calling are sometimes provided. In such cases, different coloured lamp glows are used to advise the technical operator of changed conditions.

Supply Circuits.

The supply system for such an equipment is of course somewhat extensive, and follows the practice of telephone repeater stations in providing indications of failure to expedite fault clearing. Apart from the special anti-singing device supplies, all the direct current circuits are provided with fuses of the indicating type, throwing a bead forwards and making an alarm bell and lamp circuit on failure. The valve filament circuits include relays, so that, should a valve filament fail, the relay restores and completes an individual alarm lamp circuit and the common alarm bell circuit.

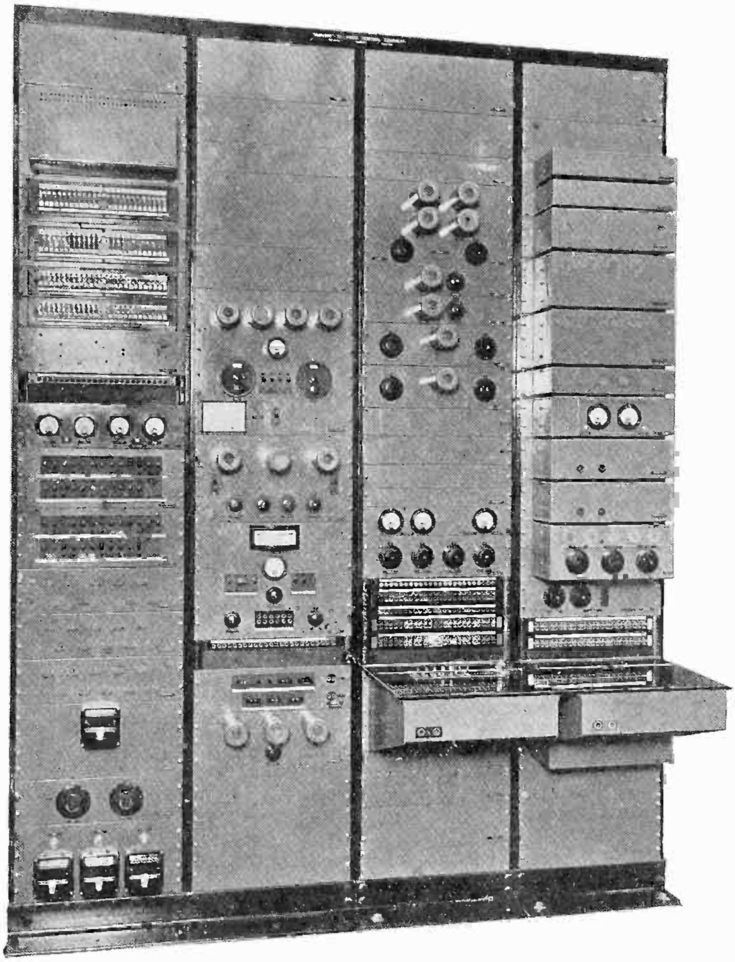

FIG. 8.

The valve circuits are arranged for centralised metering, operation of any one of a bank of keys causing a suitable meter to read the corresponding circuit current.

In the operation of a terminal equipment times occur when sections are not required—the measuring equipment may be idle, or, during a stand-by period, the telephone facilities alone are needed. The main supply for the valve plates is therefore through a common circuit breaker, but the filament supply is divided so that one circuit breaker and rheostat controls the traffic circuits, a second similar arrangement the measuring equipment circuits, and a third breaker the auxiliary relay, lamp and telephone circuits.

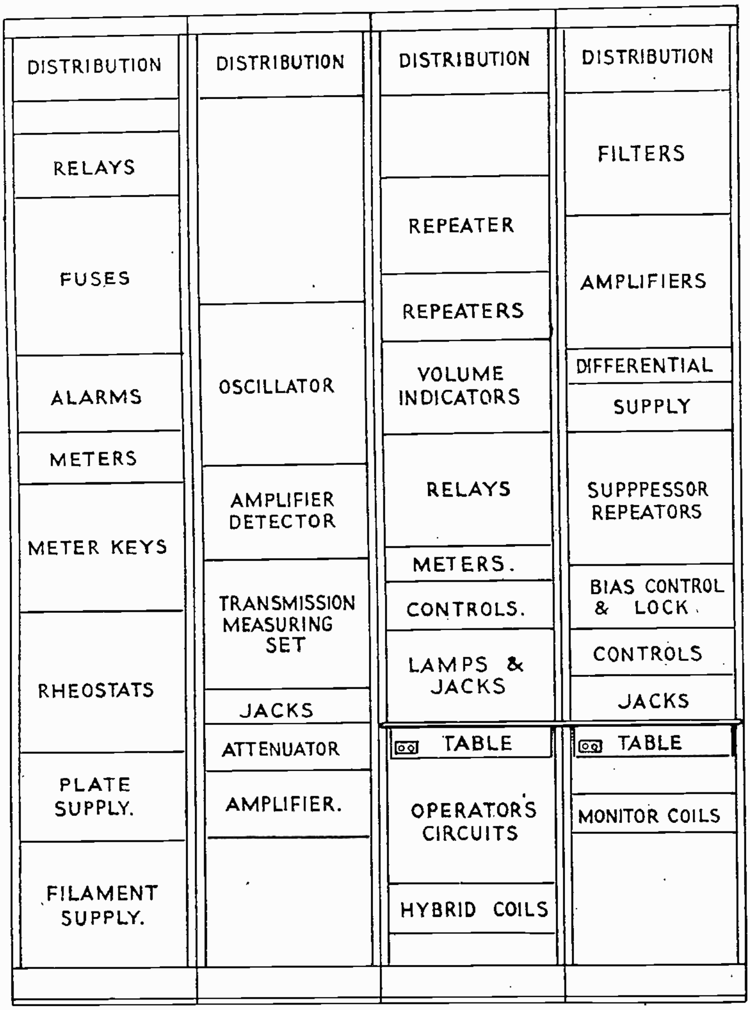

FIG. 9.

Main supply voltmeters and smoothing are provided and, to allow of variations between replacement valves, individual pre-set rheostats are included in important filament circuits. This last provision is necessary to obtain the maximum valve life, the duration changing rapidly with filament current.

Layout.

The form taken by such a terminal equipment is seen in the photograph (Fig. 8), the function of the various panels being shown on the line drawing of the layout

(Fig. 9). It will be seen that the four racks mount respectively supply, measuring, control and anti-singing equipment, and that the operator's controls are all conveniently placed on or over hinged desks sufficiently large to allow for his log-book, etc. The line calling and indicating lamps are all either next to their corresponding keys or over the line jacks, while the main gain controls are easily reached just below the relevant volume indicators and anti-singing device indicator.

The incoming supplies are brought to the bottom of the supply rack, while the incoming lines—usually three pairs in each case to the exchange, transmitter and receiver—are taken to the top of the control rack.

Conclusion.

Terminal equipments have a number of inherent difficulties to face and these difficulties may be very largely surmounted. These equipments are also the control centres of a radio-telephone service, and therefore some elaboration is justified by improvements in the service.

The extent to which the inherent difficulties may be overcome and that to which elaboration may be usefully carried must be decided by the traffic conditions. Low traffic density, a small local telephone area, and an uncritical clientele may permit of simple equipment, while, at the other extreme, equipments such as that described are necessary to ensure the minimum of lost time and the highest performance.

F. M. G. Murphy.

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DIRECTIVE PROPERTIES OF MEDIUM WAVE AERIALS

In the following article it is shown that directive polar diagrams of the radiation from medium wave aerials can be obtained quite simply. These diagrams have many uses in the design of transmitting stations where some degree of directive radiation is required.

TRANSMITTING aerial systems can be divided into two broad classes according to their polar diagrams. These are :—

(1) Slightly or non-directive.
(2) Highly directive.

In the first of these classes, of which broadcast transmitter aerials are an example, it is desirable that the radiation from the aerial system shall be uniform in all directions, while in the second class it is generally required to confine the radiation into a very limited angle, thus increasing the efficiency of transmission to a particular receiving station. The short wave Beam stations are a well-known example of this latter class.

Now while broadcast aerials belong in general to the first system, yet occasions arise when a certain measure of directive effect is of great benefit. For example, should a transmitter be situated in an important town near the frontier of a country, then an adequate service can be most efficiently provided for each portion of that country if the polar diagram is directive, conforming in general shape to that of the country itself. Again, should the shape of the area to be covered be unsymmetrical, a suitable polar diagram will greatly assist efficient transmission. It will be clear, however, that in the majority of cases the measure of directive radiation required will be small compared with that experienced in a short wave Beam array. Another consideration which necessitates a departure from the technique of the short wave arrays is the tremendous size which such arrays would assume when applied to the broadcasting wavelengths. It is clear that any directive effect will be uneconomical if it can only be achieved at the expense of a complicated aerial system.

Having all these considerations in mind, experiments have been made with simple aerial systems and, as this account will show, it has proved possible to obtain a useful series of polar diagrams by quite simple methods.

The Polar Diagram of Two Spaced Quarter-Wave Aerials.

After consideration of various simple aerial systems, that consisting of two quarter-wave aerials spaced apart by a definite amount was decided upon as offering the largest possibilities. Consider two such aerials, spaced apart by, say '$a\ \lambda$' metres.

It is clear that the resulting polar diagram will depend upon three main factors :—

(A) The aerial spacing—'$a\ \lambda$'.
(B) The relative phase of the currents in the two aerials.
(C) The relative magnitude of the currents in the two aerials.

Now it is not generally desirable to vary the spacing of the aerials, particularly as the main effect of this is the same as (B), i.e., a change of relative aerial current phase. We are thus left with two variables—the relative phase and magnitude of the currents in the aerials. The theoretical investigation of the resultant polar diagram is complicated owing to the fact that there is a component of current in each aerial induced from the other aerial. The general effect of this is shown in Fig. 1.

In this figure are shown :—

A. Nominal aerial current in aerial A.
B. Nominal aerial current in aerial B.
A^1. Aerial current in aerial B induced from aerial A.
B^1. Aerial current in aerial A induced from aerial B.
X. Actual current in aerial B.
Y. Actual current in aerial A.
θ. Nominal phase angle.
ϕ. Actual phase angle.

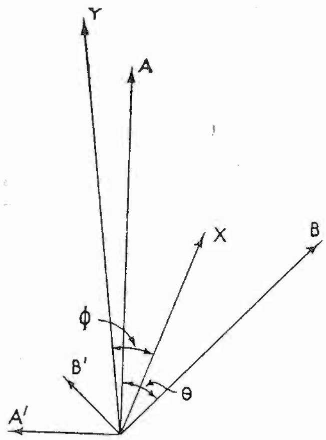


FIG. 1.

Note that the term "nominal" is used to indicate conditions obtaining in the absence of aerial interaction and the term "actual" to conditions with interaction. In practice the "nominal" ratio of aerial currents is fictitious since the only aerial current measurable is the actual one. The nominal phase angle has a practical significance, however, for it is the phase angle represented partially by aerial spacing and partially by the phase displacement in any system of phase control we may use. Thus theoretical diagrams have to be worked out in terms of *nominal* phase displacement and *actual* aerial current ratio, in order that they may be compared with the diagrams as actually measured.

The laborious nature of the determination of theoretical polar diagrams, together with certain departures from the ideal in practice, placed the theoretical investigation of the problem at a disadvantage compared to the experimental one, which was therefore adopted. A theoretical check of individual cases was undertaken however. A description of the investigation can best be made by outlining the aerial systems used, the method of measurement employed and finally discussing the results obtained.

The Aerial System.

We have seen that the system used must control both the relative phase and magnitude of the aerial currents. This was achieved in the present arrangement, which is shown in Fig. 2. In this figure :—

A and B are the two quarter-wave aerials, suspended at a slight angle to the vertical and having a small top.

T_A and T_B are the aerial termination boxes.

M and M are the earth mats. These were employed to maintain symmetry in the earthing system, no buried earth being available at one end of the site.

F, F_1 is the twin wire feeder linking up aerial A with the transmitter T_r.

P is a feeder at right angles to F, bridged by links B_r, and used for phasing purposes.

The method of relative phase variation is based upon the principle that there is a regular change of phase along a transmission line which is terminated by an impedance equal to its surge impedance. A feeder of variable length (P) is inserted in series with the main supply feeder to one of the aerials, the relative phase of the

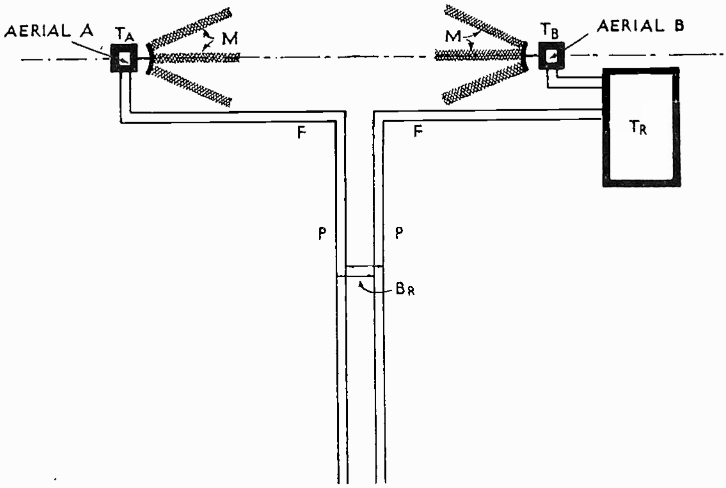


FIG. 2.

aerial currents then being determined by the length of the phasing feeder in circuit. This feeder was broken up into short lengths, joined by links, and only the required amount of feeder used in any given instance.*

The aerial current ratio was varied by means of independent inductive couplings for both aerials on to the single transmitter employed (T_r). This method proved sufficiently flexible, and was free from any secondary phase change effect.*

The transmitter employed (T_r) had an H.F. output of about 250 watts and consisted of a master oscillator with a single amplifier stage.

Since the normal application of such aerial systems is in broadcasting, the wavelength employed may be anywhere within the broadcast wavebands—i.e., 1,875-1,132 metres and 545-200 metres. Owing to the fact that the site available was somewhat limited and, also, because the accuracy of measurement of polar diagrams near to a transmitter increases with decreasing wavelength, it was decided to use a wavelength just below the broadcast band, namely 150 metres. The results thus obtained should be completely applicable to the longer waves met in practice, since we are only concerned in both cases with the direct ray.

Method of Measurement.

The radiated field was explored by means of two portable calibrated radio-scopes. A schematic diagram of the circuit employed in these radio-scopes is given in Fig. 3. The H.F. radiation was picked up on a frame F, rectified by two diodes

* See Appendix 1.

D1 and D2, connected in push-pull, and the resulting D.C. output was amplified by a two-stage D.C. amplifier A.

For the purpose of these experiments only relative values of field strengths were required, but it was clear that the whole radio-scope must either be free from amplitude distortion or else such distortion must be allowed for by some system of calibration. The method employed was to calibrate the radio-scope against a standard

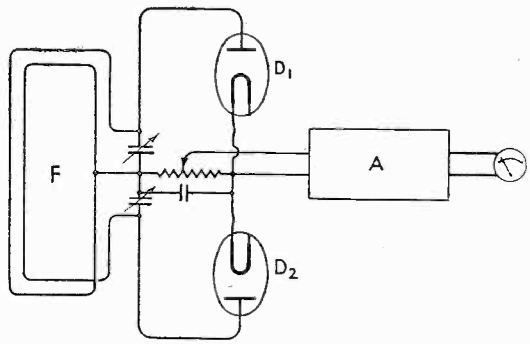


FIG. 3.

field strength measuring apparatus, both measuring simultaneously the field strength from a variable output transmitter. By this means both the radio-scopes could be calibrated simultaneously against a primary standard.

Having established a method of measurement, the relative magnitude and the relative phase of the currents in the two aerials were varied between the possible limits, polar diagrams being taken at regular phase and magnitude intervals. Two general methods of measuring polar diagrams were used. Firstly, to set up a given condition at the transmitter and measure the relative field strength at each position in turn, thus obtaining a single diagram for that condition. Secondly, to set up a given phase condition and run through various aerial current ratios obtaining a series of curves for each position showing relative field strength against aerial current ratio for various phasing conditions. From these curves any desired polar diagram could be deduced. This latter method was found to be by far the more rapid.

Experimental Results.

The results may be broadly divided into two portions, namely, those dealing with the effect of phase change and those affecting the aerial current ratio change.

(A) *The effect of phase change.*

It was found that phase control had a major effect on the general shape of the diagram. A series of polar diagrams for various phase relationships are given in Fig. 4.

It will be seen that a considerable variety of diagram shape is obtainable, two particularly useful diagrams being those marked "A" and "B." "A" has a front to back ratio of approximately 2.5/1, while "B" is a "dumb-bell" shaped diagram of front or back to side ratio of approximately 2/1. This latter diagram would be of particular service in a long and narrow country.

With a mean aerial spacing of $\lambda/4$, the aerial current phase displacement without any phasing feeder in circuit should be 90 degrees. A case was worked out theoretically for a phase displacement of 150 degrees corresponding with 60 degrees phase change along the phasing feeder. This is also plotted on Fig. 4, and it will be seen that there is quite fair agreement between it and the one for a feeder

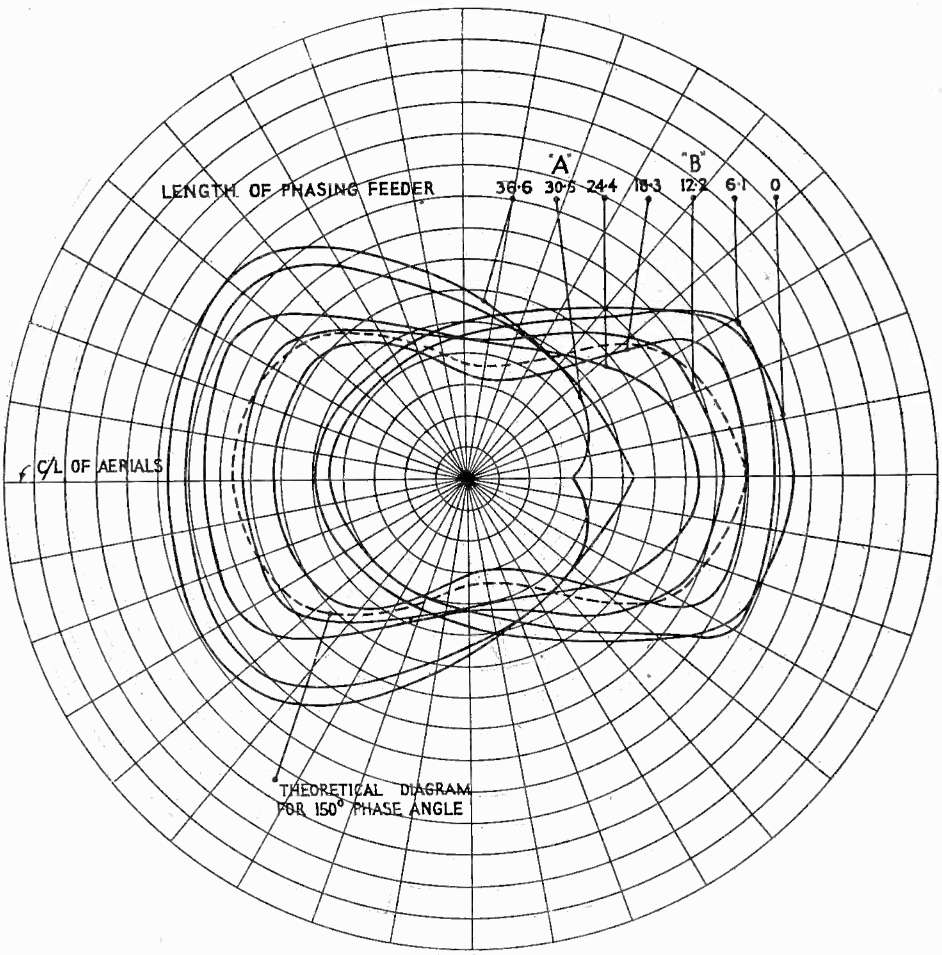


FIG. 4.

length of 18.3 metres, which should correspond with 158 degrees displacement.

It is not expected that the variation of phase angle with phasing feeder length will be quite linear, however, owing to inter-action effects between the "go" and "return" sections of the feeder. The exact nature of this effect will be dependent upon the orientation of the phasing feeder. In particular on the longer wavelengths it will be desirable to "fold" the phasing feeder into a more compact shape, and this will naturally cause a greater degree of inter-action between the various portions of the feeder than in the more simple arrangement suitable for the shorter wavelengths. This departure from linearity is only a second order effect and does not affect the usefulness of the system to any degree.

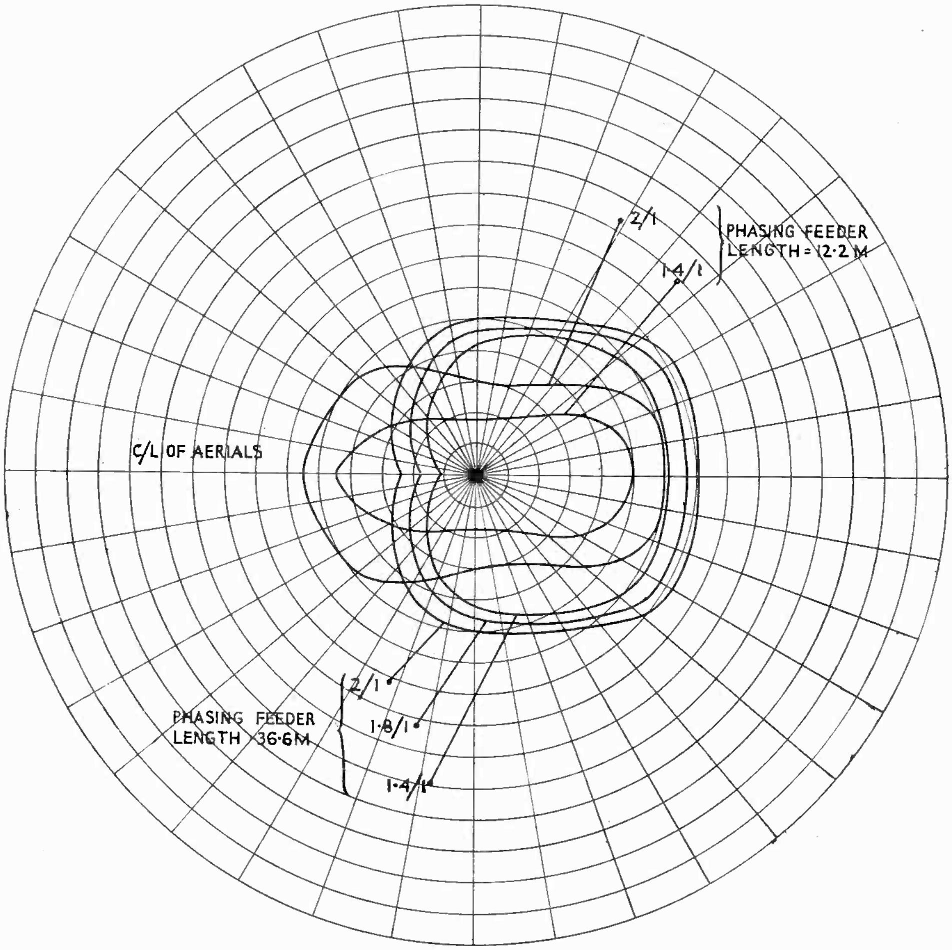


FIG. 5.

(B) *The effect of current ratio change.*

A set of polar diagrams for two lengths of phasing feeder, and for various aerial current ratios is given in Fig. 5.

It will be seen that the effect of the alteration in current ratio is only a second order effect, compared to that produced by phase change. The change of ratio has most effect along or near to the line of the aerials. For example, by suitably proportioning the phase and magnitude of the two currents, it would be possible to produce a diagram differing little from that of the 36.6 metre phasing feeder, 1.4/1 current ratio case, except that along the line of aerials the radiation is zero in one direction. This condition would, of course, be generally unsuitable for broadcasting purposes.

To summarise, it can be seen that a series of very useful polar diagrams can be obtained by means which are sufficiently simple, both in the aerial system and in the methods of aerial current control to lend themselves to applications in the field of broadcasting. Nor should the application be limited to that field, for there are many cases of medium wavelength stations working on fixed services where a measure of directional effect would be very useful.

APPENDIX 1.

The General Accuracy of Measurements.

(A) *Site Error.*

Experiments were made to find if the diagram of each aerial energised independently was circular, or if local conditions upset the measurements, and in all cases the diagram was proved to be a circle.

(B) *Random Variations.*

Since fairly high winds were blowing during portions of the tests, experiments were carried out which proved that they had no effect either due to swinging of the aerial system or due to movements in the frame aerial windings.

(C) *The Effect of "Tail" of the Phasing Feeder.*

Experiments were made to find out the maximum length of phasing feeder that could be carried as a "tail" without introducing measurable errors. The whole phasing feeder was then constructed so as to be capable of being split up into units of length not greater than the length so determined.

(D) *Finite Distances of Measurement-Positions from the Aerial System.*

Owing to the impracticability of extending the distance of measurement on the site used beyond one and a quarter wavelengths, errors were introduced. These existed, firstly, because of the different relationship of the electrostatic and electromagnetic components of the field near to the aerials as compared with those at a considerable distance, and, secondly, because of the appreciable angle subtended by the aerials at positions approaching 90 degrees from the line of the aerials.

It is estimated that the inaccuracy due to this cause was between 5 per cent. and 10 per cent.

(E) *Phase Change Variation due to Coupling Variation.*

It was found that if a reactive component existed in the aerial termination arrangements, then the variation of aerial coupling produced a phase change as well as a magnitude change. This change was small in all practical cases and was removed by prevention of reactive components in the aerial terminations.

H. J. Wassall.

POWER SUPPLY FOR AIRCRAFT WIRELESS APPARATUS

The use of wireless apparatus on board an aircraft necessarily involves the provision of a source of energy from which to operate the apparatus. Energy for an aircraft in flight must obviously either be generated during flight or must be derived from a source of previously stored energy carried in the aircraft and expended during flight.

The aim of this article is to explore the relative merits and disadvantages of the various available methods of meeting these requirements. It is seen that the matter is not by any means so straightforward as might at first sight be imagined, and that, actually, there is no one best method to employ, the most suitable in any specific case depending upon a number of factors particular to that case.

BEFORE dealing with the methods of obtaining the energy required, it would be well to consider the expenditure of energy necessary in various cases. Aircraft wireless transmitters and receivers require power for both anodes and filaments of their valves. In the case of transmitters, the power consumed at the valve anodes may vary between about 10 and 250 watts (at from about 250 to 1,500 volts D.C.) according to the type and number of valves employed, while the power consumed by filaments varies between about 3 and 50 watts, the voltage in this case being normally 6, and the supply being generally D.C., except in the case of valves of the indirectly-heated cathode class, where either D.C. or A.C. may be used. Receiver valve anodes, on the other hand, may consume anything between about 1.5 and 6 or 7 watts (at from 100 to 200 volts D.C.) while receiver valve filaments may require from about 0.6 to as much as 36 watts (the latter where a number of valves of the indirectly-heated cathode class are employed), at either 2, 4 or 6 volts. It will be seen, therefore, that vastly different conditions have to be met, according to the type of transmitter, receiver, or combination of transmitter and receiver which is to be employed.

Source of Power.

Turning now to the question as to whether the power required is to be generated on board the aircraft during flight, or derived from a source of previously-stored energy which is carried in the aircraft and expended during flight and will accordingly have necessarily to be renewed either sooner or later, it is a generally accepted requirement of those operating aircraft for either commercial or military purposes that the power supply system as a whole must be " self-supporting " under normal conditions of flight, i.e., must not require the replacement of energy from an external source except as a result of exceptional rather than normal usage. An exception can be made to this principle where the need for replacement is relatively infrequent, such as, for example, in the case of an aircraft receiver which consumes such a small amount of power that this can be derived from primary or secondary cells, which will only require replacement or recharging respectively at long intervals. In general, however, and particularly where transmitters are concerned, the principle that the power supply system must be self-supporting in normal conditions of flight is regarded as essential.

Generation of the necessary power on board the aircraft for the wireless apparatus is therefore essential in most cases, and the means by which this can be accomplished are as follows :—

(A) To obtain the necessary power direct from the aircraft engine.

(B) To obtain the power required indirectly from the aircraft engine, i.e., via the propeller, airstream and generator windmill.

Of these two alternatives there is no doubt that the former is preferable from nearly all points of view : the advantages it possesses over the latter are :—

(1) The generator being mounted within the fuselage of the aircraft, no loss of power will occur due to the generator carcase being exposed to the air stream. With the high speeds of modern aircraft, this is a matter the importance of which cannot be over-stressed.

(2) The coupling between engine and generator being direct—or at the worst via a flexible shaft—is more positive, and hence more efficient, than via aircraft propeller, air stream and generator windmill. This, too, is a matter of greatest importance with modern high efficiency aircraft.

The disadvantages (which are due rather to the state to which the art has progressed at present than to purely technical considerations) are :—

Only very few types of aircraft engines, at any rate as far as those of European manufacture are concerned, are at present provided, as a standard measure, with a coupling to which an electrical generator can be connected, and those that are so arranged usually have provision made for one particular make and rating of generator alone, which may be—and often is—a low-power, low-voltage D.C. generator only suitable for aircraft electrical services, and entirely inadequate to cope with the additional load imposed on the system by a wireless transmitter of even moderate power.

In cases where the generator is direct coupled to an aero engine, having—particularly in military or naval aircraft—quite a wide speed range between normal cruising and full throttle r.p.m., constancy of generator speed is not easily obtainable. This, of course, is a difficulty which will be overcome by suitable methods as the use of engine-driven generators becomes more universal.

If therefore we consider the many different types of aircraft driven by all makes of engines to which suppliers of aircraft wireless apparatus have to adapt their equipment, we have sufficient justification for the fact that wind-driven generators are necessarily supplied as standard practice, special generators being supplied only where an engine coupling happens to be available and is insisted upon by the customer as the method to be adopted of driving the generator.

Summarising, therefore :—

(A) Power for the wireless apparatus must normally be generated on board the aircraft.

(B) The best way of achieving this end, from a purely theoretical point of view, is by direct drive from the aero engine, while

(C) The method which is practically realizable at the present time is, as a rule, by indirect drive from the aero engine, i.e., via aircraft propeller, airstream and generator windmill.

Power Supply Requirements.

Arising out of the above conditions, it becomes necessary to study the various methods by which power generated by the wind-driven generator may be applied to the wireless apparatus. In addition to providing the power for the wireless apparatus, it is often desirable, in order to economise in weight and drag, that the generator should supply the requirements of lighting and other electrical services on the aircraft, these services (apart from certain of the largest aircraft, which are operated at 24 volts) being invariably run at 12 volts D.C.

In general, therefore, power supply requirements are as follows :—

(A) For combined transmission and reception services : a supply at a relatively high D.C. voltage and a supply (normally D.C. but sometimes A.C.) at 6 volts.

(B) For combined transmission and reception services, with electrical services also to be provided for : as under (A) above, but with an additional supply at 12 volts D.C.

(C) For reception services alone : a small capacity supply at an intermediate D.C. voltage and a supply (either D.C. or A.C.) at 2, 4 or 6 volts.

(A) Wireless Transmission and Reception Services Alone.

Where wireless transmission and reception services alone are required, it is possible either to generate power simultaneously for valve anodes at a high (D.C.) voltage and valve filaments at a low (D.C. or A.C.) voltage by means of a double output wind-driven generator, or to generate power at a low (D.C. or A.C.) voltage for valve filaments, by means of a single output wind-driven generator and to transform a portion of this power to a high (D.C.) voltage for valve anodes, by means of a suitable transformer (and rectifier, in the case of A.C.).

Of these two alternatives, the first, i.e., the use of a double output wind-driven D.C. generator is almost universally employed, the method in which a low voltage wind-driven D.C. generator with rotary transformer is employed being needlessly complicated, bulky, and heavy. In fact the only advantage of the latter method over the former, in such cases, is that for testing or adjusting the wireless apparatus with the aircraft stationary, or for (temporary) emergency transmission the rotary transformer may be put into operation quite simply from the accumulator forming part of the low voltage system. Against this, however, can be offset the fact that when an accumulator is used to " steady-up " the low voltage D.C. output of the double-output generator, this can also be used temporarily to " motor " the generator and to provide a means of testing the apparatus, or of carrying out short-period emergency transmissions at reduced power.

In cases where a low voltage A.C. generator is used as the prime source of power, or where a smoothing unit is employed in place of an accumulator across the low voltage output of the D.C. generator, these facilities can only be provided where an external source of power is available to drive the generator when the aircraft is stationary. For testing purposes on the ground, this may be conveniently effected by means of a small petrol or electric motor coupled to the generator by a flexible shaft, but it is not, of course, practicable in many cases to carry such an engine in the aircraft solely to provide such emergency transmission services.

(B) Wireless Transmission and Reception Services Combined with Electrical Services.

In cases where electrical services have to be provided from the same source of supply as wireless transmission and reception services, these former have, almost without exception, to include lighting services, i.e., navigation, cockpit or cabin, and instrument lighting. In the case of commercial aircraft, there is in most countries a regulation specifying that, should the generator providing power for lighting services break down during flight, there must be an emergency source of energy on board the aircraft capable of providing the necessary power to operate these services for a period of at least half an hour after the generator has broken down, while similar conditions usually apply in respect of military or naval aircraft.

Furthermore, with any type of aircraft operated at night it is necessary to make provision for the illumination of navigation lights, such as riding lights in the case of marine craft, for periods while the aircraft is stationary outside its hangar or at its moorings; for mechanics working on the aircraft at night, outside the hangar, too, it is often extremely useful to be able to switch on cabin or cockpit lamps or to plug-in an inspection lamp, and it is clear that all these considerations necessarily involve the use of a power supply system incorporating an accumulator, and hence the use of a D.C. system.

Any common source of power for these services as well as for wireless transmission and reception services must accordingly incorporate a 12 volt accumulator and a means for keeping this charged during flight, quite apart from any considerations of power supply for the wireless services. There are two principal methods by which these requirements can be met, which are :—

(1) The use of a double output wind-driven D.C. generator giving an H.T. supply for transmitter and receiver valve anodes, and an L.T. supply of suitable characteristics (i.e., voltage, output and load regulation) to keep the common 12 volt accumulator fully charged under all conditions of load, the transmitter and receiver valve filaments being fed from a section of the 12 volt accumulator. With this arrangement, a suitable switchboard is provided to control the L.T. output from the generator, which output may be either hand-regulated (according to the load on the L.T. system) by means of controls in the switchboard, or automatically regulated by virtue of the design of the generator, or by other devices.

(2) The use of a single output wind-driven L.T., D.C. generator of suitable characteristics (i.e., voltage, output and load regulation)

to supply current to a 12 volt accumulator through a control switchboard, and hence to provide the necessary supply for electrical services.

Power supply for the transmitter and receiver valve anodes is obtained from either (A) a rotary transformer operating off the 12 volt system, or (B) from a second wind-driven generator having a single (H.T., D.C.) output and having its field energised from the 12 volt system.

Supply for transmitter and receiver valve filaments is normally obtained from a section of the 12 volt accumulator, although in cases where a rotary transformer is used for valve anode supply this is sometimes provided with a second (L.T.) output of suitable characteristics to supply current to the valve filaments direct; this latter method is only employed where the valve filament load is unduly heavy, i.e., where the out-of-balance load on the accumulator might be serious.

Whether methods 2 (A) or 2 (B) are employed, regulation of the output of the L.T. charging generator according to the load on the system (in order that nett charge or discharge rates to the accumulator may be kept low, and hence the capacity and weight of this heavy component also be kept as low as possible) may either be manual, by means of controls in the switchboard, or automatic, by virtue either of the design of the generator or by the use of some voltage regulating device such as a voltage control unit, etc.

Each of the alternative methods 1, 2 (A), or 2 (B) of obtaining power have their advantages and disadvantages according to the conditions to be met in any particular case. From a general point of view, however, method 1 is usually preferable, and is certainly to be recommended in place of using a rotary transformer in all cases where the H.T. power input to the transmitter is in excess of about 100 watts: in such cases the load on the L.T. system due to the rotary transformer alone becomes unduly heavy, with the result that unless either an excessively high-capacity accumulator is included in the system, or the load-regulation of the system as a whole is extremely good, the voltage of the system will fall when the load due to the rotary transformer is applied, particularly if other electrical services are in operation at the time.

If the voltage of the system falls, this will not only cause the valve anode voltage to be low, but may also reduce the valve filament voltage below the critical value at which the valve ceases to function correctly. It will be obvious, therefore, that unless the characteristics of the L.T. system as a whole are carefully chosen in conjunction with the various combinations of loads which may be applied (and which may vary between extremely wide limits according to whether lighting, electrical and wireless services are in use independently or simultaneously) it is possible for method 2 (A) (i.e., with rotary transformer) to be very unsatisfactory in practice.

From the point of view of weight, again, method 1 usually scores, particularly where the necessary H.T. input to the transmitter is much in excess of 100 watts, since not only may the carriage of an unduly high-capacity (and hence heavy) accumulator be necessary if method 2 (A) is employed as mentioned above, but the weight; power ratio of rotary transformers having low voltage inputs increases fairly rapidly with the power output. For transmitters of medium power, there is, of course, less difference in the all-up weights of the alternative power supplies, while for transmitters of low power, method 2 (A) often shows an actual saving in weight.

Looked at from the equally important point of view of "drag," method 2 (A) usually scores over the others, since it is possible to design an L.T. generator of given power output of smaller dimensions, and hence (if properly stream-lined) of lower "drag" than one of equal power but having an H.T. output: furthermore, in the somewhat rare cases in which engine drives are available, these are usually arranged to take a standarised type of L.T. generator, in which case the power supply system causes no "drag" at all. Method 2 (B), where a second small wind-driven generator for H.T. purposes alone is employed is, without doubt, the worst offender from the point of view of "drag," but is particularly convenient where it is desired to fit wireless transmission and reception apparatus to an aircraft already equipped with a 12 volt electrical system. The "drag" caused by method 1, i.e., the use of a common double-output generator, is intermediate between the two cases quoted above.

Another aspect of the matter which may be of the utmost importance is the necessity, which often arises, that wireless transmission and reception may be possible while the aircraft is at rest on the ground, or on the water, either for the purpose of adjusting or checking the apparatus, or for providing an emergency communication service, as in the case of a forced descent. The service required under these conditions may be purely temporary, or it may have to be continuous over a period of several days. In either event, the source of power available during flight will probably no longer be available and (at any rate where emergency communications are concerned) power will have to be obtained from a source of energy carried on board the aircraft during flight and available for use under such conditions.

Where a purely temporary short-period service alone is required, the necessary power is usually obtained from the 12 volt accumulator, which is used either to "motor" the wind-driven double output generator (in method 1) or to operate the rotary transformer (in method 2 A). The electrical efficiency of the rotary transformer will, of course, be appreciably higher than that of the wind-driven generator "motored" in this way (even with the windmill removed) and, furthermore, the rotary transformer will—until the accumulator becomes exhausted—give its full rated H.T. output at the correct voltage, and so run the transmitter at full power, which the wind-driven generator used in this manner will not do; hence an accumulator of given capacity will give not only a longer, but a more efficient service, before it is exhausted, and, from this point of view, therefore, the method in which a rotary transformer is employed (method 2 (A)) undoubtedly scores—provided always, of course that the use of this method under normal conditions, i.e., during flight, is practicable.

Method 2 (B), where a separate single output H.T. generator is employed, is obviously useless from this point of view, since the generator cannot be "motored" from the 12 volt accumulator.

Where a long-period, but nevertheless temporary, service is required, the amount of energy stored in an accumulator of reasonable size and weight will obviously be insufficient to provide the necessary power over the required time, as the power will therefore have to be obtained from another source. In such cases, a small and light-weight petrol engine is usually employed for this purpose, being carried on the aircraft during flight (if an engine of this nature is not already provided on the aircraft for engine-starting, air-compressing, bilge-pumping or other purposes), and being brought into action to drive the (otherwise wind-driven) generator when emergency communication is required for lengthy periods. The existing wind-driven generator is usually unshipped from its normal mounting and coupled to the engine for this purpose, or left in position and driven from the engine by means of a flexible shaft, but where considerations of weight are not of prime importance a duplicate wind-driven type of generator, permanently coupled to the engine, is employed; the advantage of this lies, of course, in the speed and ease with which the emergency service may be put into operation, as compared with the time and energy spent in removing the wind-driven generator from its normal mounting and coupling it to the engine, or removing the windmill and coupling-up the flexible shaft in its place.

Whether a spare generator is carried or not, however, there is little to choose in this respect between methods 1 and 2 (A) of obtaining power supply; whichever method is employed, full power is available, for as long as petrol supply for the small engine holds out, for both wireless and electrical services. Method 2 (B) is, however, not applicable in this particular respect, since to drive both H.T. and L.T. generators simultaneously is obviously impracticable.

(C) Wireless Reception Services Alone.

Where such services alone have to be provided, the valve anode voltages and loads are usually relatively low, as are the filament loads. For this reason, as mentioned earlier in this article, it is not considered necessary for the power supply system in such cases to be "self-supporting," and a dry type of battery is normally employed for valve anode supply, a small capacity accumulator being used for valve filament supply, the battery being replaced, and the accumulator removed and re-charged as requisite; in cases where the aircraft is already equipped with a 12 volt electrical system, however, a section of the accumulator forming part of the system can of course be used for valve filament supply instead of a separate accumulator being carried for this purpose.

Cases do, however, arise in which receiver valve filament loads are relatively heavy, such as where multi-valve receivers of the indirectly-heated cathode class are employed. Receivers of this type are normally not used on aircraft without their associated transmitters; it may, however, be necessary, for operational purposes such as may obtain in military or naval services, for a certain aircraft to be arranged for either transmission and reception services, or for reception services alone, the receiver (when used in conjunction with its associated transmitter) employing valves of the indirectly-heated cathode class and the conversion having to be effected with the minimum of time and trouble. Under these conditions, the filament load may be too heavy to impose on an accumulator which is not being charged during flight, and, unless a constantly charged accumulator is available on the aircraft (such as where the aircraft is already equipped with a 12 volt electrical system) it will be necessary for the energy necessary to operate the receiver to be generated during flight: this requirement may also arise where the use of dry H.T. batteries is not permitted for operational or climatic reasons.

In such cases power supply is obtained either by means of a light-weight, double-output, wind-driven generator, if wireless reception services alone are required, or by means of a small rotary transformer, if electrical services are also required, or already available, on the aircraft.

Summarised Recommendations.

The numerous considerations which obtain in the various cases considered above make it difficult to summarise, in tabular form for quick reference, those methods of obtaining power which are most to be recommended. Dealt with on broad lines, however, and until such time as engine drives become more generally available, the recommendations are as follows :—

(1) Wireless Transmission and Reception Services Alone.

A double-output wind-driven D.C. generator, to supply power for valve anodes and filaments in both transmitter and receiver : an accumulator floating across the L.T. output, to provide an easy means of testing the apparatus or giving a short-period emergency service when the aircraft is at rest. If a smoothing unit is used in place of the accumulator, or an A.C. generator be used with rectifying unit, these desirable facilities cannot be given unless external means are provided to drive the generator, but, on the other hand, the use of an accumulator is eliminated, which from the point of view of maintenance, and in certain climates, may be an advantage.

(2). Wireless Transmission and Reception Services Combined with Electrical Services.

(A) *Low Power Transmitters.* A wind-driven L.T., D.C. generator, to charge a 12 volt accumulator of suitable capacity through a control switchboard (for electrical services) and a rotary transformer to provide power for both transmitter and receiver valve anodes, valve filament supply being obtained from a section of the 12 volt accumulator (or in certain cases from a second output on the rotary transformer). With this method of power supply, short-period full-power ground transmission for testing or emergency comminication can be provided without additional equipment, while for long periods, all that is required is an external source of power such as a petrol engine.

(B) *Medium or High Power Transmitters.* A double-output wind-driven D.C. generator to provide power for transmitter and receiver valve anodes, and also for charging a 12 volt accumulator (for electrical services) through a control switchboard, power for valve filaments being obtained from a section of the 12 volt accumulator. With this method of power supply, ground transmission (on reduced power) for testing and short period emergency commiuncation purposes can be provided without additional equipment, while full power transmission can be provided when an external source of power, such as a petrol engine, is available.

Alternatively, a single-output wind-driven H.T., D.C. generator to provide power for transmitter and receiver valve anodes, power for valve filaments and generator field excitation being obtained from the existing electrical system. With this method of obtaining power supply, no ground transmission can be provided unless an external source of power is available and then only for a limited period, but, on the other hand, the method is particularly applicable where the aircraft is already equipped with an electrical power supply system and it is desired to install wireless transmission and reception apparatus (comprising a medium or high power transmitter) with the minimum of additional weight.

(3) Wireless Reception Services Alone.

A dry H.T. battery to provide power for valve anode supply, and an accumulator for valve filament supply, the latter forming part of the existing 12 volt accumulator where such is already available as part of the aircraft electrical system.

In special cases, either a small double-output wind-driven D.C. generator for valve anode and filament supply, or a small rotary transformer operating off the existing 12 volt accumulator for valve anode supply, filament supply being provided by a section of this accumulator.

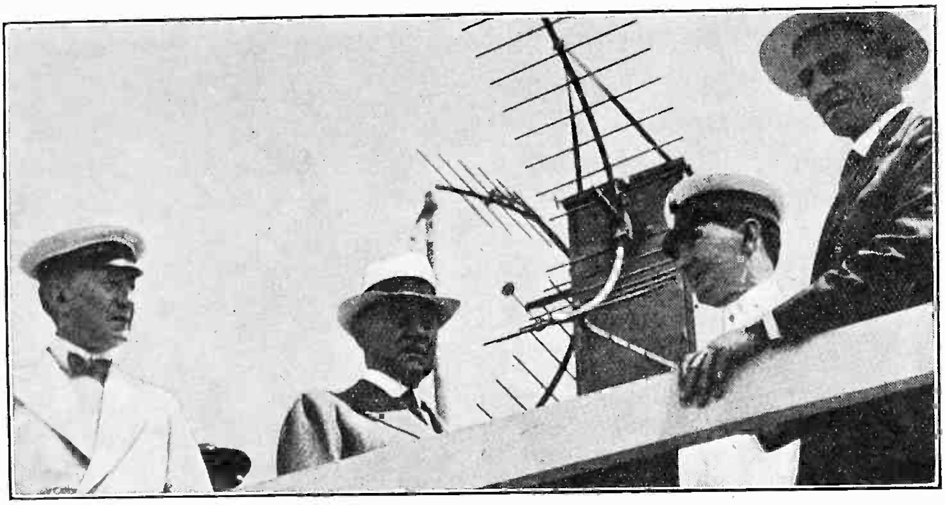
Conclusions.

The various considerations which have been outlined in this article will suffice to show that there are no hard-and-fast rules with regard to power supply which can be applied indiscriminately. There is, however, always a best method of power supply to adopt in any particular case, depending upon the various conditions obtaining in that case, and it is hoped that sufficient information has been given in this article to enable those interested to study their particular cases in detail and to decide upon that method which is most suitable, in all respects, to meet their requirements.

C. B. CARR.

MARCONI NEWS AND NOTES

DEMONSTRATION OF NEW MICRO-WAVE BEACON.



Micro-wave beacon transmitting aerials at Sestri Levante.

A NEW type of micro-wave wireless beacon for the assistance of navigation was demonstrated by Marchese Marconi at Sestri Levante, near Genoa, on Monday, July 30th, in the presence of British and Italian shipowners and representatives of shipping organisations.

The new apparatus, which has resulted from Marchese Marconi's investigations during the last three years into the behaviour of ultra-short waves, will enable a ship's Master to navigate his vessel on a straight line into the most difficult harbour entrance in spite of the worst conditions of visibility. A second application of the device will give the correct bearing of a ship relative to the beacon station while the ship is within its range. Its special value lies in its great accuracy, its simplicity in handling, its economy, and its use of a wavelength band which is free from all disturbances.

For the purpose of the demonstration, one of the new beacon transmitters was installed on the hill behind Sestri Levante, about 300 feet above sea level, and receiving apparatus was fitted on Marchese Marconi's yacht "Elettra." The wavelength employed was approximately 60 centimetres.

The yacht steamed out to sea with Marchese Marconi's guests on board, and on reaching a distance of about 10 miles was headed for Sestri Levante, where two buoys were anchored in the bay, 90 yards apart, to represent the mouth of a harbour. With the blinds of the chart room drawn so that the navigator was entirely without sights, the yacht was steered straight through the centre of this "harbour entrance" by means of the micro-wave beacon.

Steered by Independent Observers.

Navigation of the yacht in this way was undertaken with complete success not only by Marchese Marconi and his assistants but also by independent observers who had no previous experience of the operation of the beacon. Captain J. W. Harris, of the London, Midland & Scottish Railway, several times steered between the buoys, and expressed his satisfaction with the working of the apparatus.

Signals from the beacon station were audible in the chart room through a loud-speaker and were also recorded visibly on a dial in front of the navigator, the dial being divided into two sections, one coloured green and the other red.

A range-finding system incorporated with the oscillating beacon enabled the navigator to determine his distance from the harbour anywhere within a two-mile limit, adding still further to the practical utility of the instrument.

Description of the Apparatus.

The beacon station at the harbour is a small installation, about 6 feet high and 4 feet wide. Two small aerials and reflectors are mounted at right angles to each other on a platform forming the top of a cylindrical base. The platform and the aerial system swing left and right continuously about two inches from the centre line pointing to the harbour entrance. Each aerial is only a few inches in length with a reflector measuring about 3 feet in height. The reflector consists of a central metallic rod bent into a true parabola supporting a number of horizontal rods.

The basic characteristic of the transmission is the creation in space, not of a narrow beam of waves such as the conventional idea of beam transmission suggests, but of a narrow zone of silence created at the centre of a wide beam sent by the beacon. The zone of silence swings six degrees from left to right of the centre line of the harbour channel.

When swinging towards the left, the beacon sends a high note, when swinging towards the right it sends a low note. The change of note takes place when the zone of silence coincides with the line for entering the harbour.

This arrangement makes it possible to ascertain immediately if the ship is either to the left or to the right hand side of the safety line for entering the harbour, or exactly on it. When on the line the change of tone from a high note to a low note occurs perfectly smoothly, and actually takes place when the reception is nil. It is, therefore, not heard by the navigator. If, on the contrary, the ship is off the correct course the change of note becomes perceptible and one note is stronger than the other. This arrangement detects half a degree of error.

For visual working, on reception of the radio signal the needle oscillates continuously from left to right. When on the exact line of entrance, the change of tone occurs when the needle occupies its centre position, and the deflection of the needle shows the same amplitude on either side.

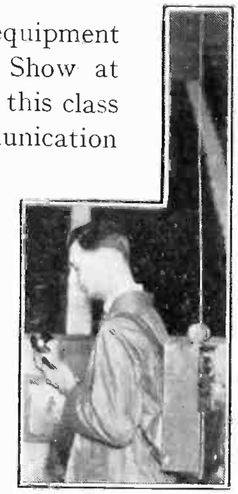
A New Rotating Beacon.

After the demonstration on the "Elettra" the party visited the radio beacon station on shore. In their presence the mechanism of the beacon was changed from the oscillating type to the rotating type of beacon for a second demonstration, when the yacht was navigated blindly, on the indications received from the beacon, over a complex and prearranged course involving several changes of course round the beacon station at a distance approximately 15 nautical miles from Sestri Levante.

For this purpose the aerial system was made to rotate a complete turn every minute, the change of tone occurring when the zero line of rotation passed exactly over the true South point of the compass. The bearing of the ship relative to the beacon station was thus ascertained by measuring, with a stop watch, the time elapsing between the change of tone and the passage of the zero line of rotation on the ship.

Marconi stand at the display of British aircraft equipment at Hendon Aerodrome (London) on July 2nd. Apparatus for civil and military aircraft was inspected by many interested visitors.

Wireless at the Horse Show.



AN interesting application of small portable transmitting equipment was noticed by visitors to the International Horse Show at Olympia, London, this year, when a Marconi apparatus of this class was used to provide a rapid and efficient means of communication between the judges in the arena and the awards office and the announcer's office, both of which were behind the crowded stands.

In previous years, the judges' decisions have been conveyed to the offices by runners who have hurried on foot from the arena, covering a total distance of several miles each day. The co-operation of the Marconi Company made all that unnecessary this year.

Standing beside the judges was an official with a small microphone in his hand and carrying on his back what looked like a small haversack with a flexible rod about 3 feet long protruding from the top. The "haversack" contained a Marconi ultra-short-wave transmitter by means of which the decisions of the judges were immediately telephoned by wireless to the offices at the other end of the exhibition building.

This enabled the announcer controlling the loudspeakers to make public the results of the judging before even the rosettes were presented to the prize-winners.

The Apparatus.

The transmitter, which worked on a wavelength of 5.75 metres, incorporated one Type D.V.C. valve working at an anode voltage of 120, the power to the anode being .35 watts—less than that consumed by an ordinary pocket lamp.

The transmitter box, including accumulators and high tension batteries, measured only 11 inches wide by 15 inches high by $4\frac{1}{2}$ inches back to front, and was arranged for carrying on a man's back, leaving both his hands free for making notes and holding the microphone.

The receivers were of the super-regenerative type, one incorporating three and the other four valves. Both were extremely compact in size and operated with small rod aerials.