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A STUDY OF WAVE SYNTHESIS BY MECHANICAL MEANS—III

PART II.—SOME USES OF THE SYNTHESIS MODEL, IN PARTICULAR THOSE RELATING TO WIRELESS PRACTICE

This article was commenced in the June number of The Marconi Review. *In the following section the phase relationship of carrier to side bands is dealt with and the effects of alteration of their relative phases on the envelope. Examples are given to show what happens when the phases are shifted and what are the effects of frequency alteration. Further, the problem of suppression of one side band as well as the carrier is considered and some peculiarities of this system given.*

Section 2—The Phase Relationship of Carrier and Side Bands and Suppressed Carrier System.

Carrier Suppression.

In a previous section it was clearly shown that the present carrier system of wireless signalling is very uneconomic owing to the large proportion of power that is of necessity transmitted in the carrier, and it is of interest to discuss the possibility of carrier suppression.

Referring back to the brief definition of the high frequency spectrum, it is observed that all the intelligence is conveyed in the side bands. The carrier is of course essential; at the transmitter for the initial production of side bands, and again at the receiver for the purpose of improving its mentality. But since the carrier is merely a continuous wave of constant frequency and amplitude it need not be supplied with the side bands, but can, if desired, be suppressed at the transmitter, and a local carrier of the same frequency and phase added at the receiver, with a consequent saving of power efficiency.

As it has been stated that a carrier must be produced at the transmitter, it may not be obvious how any power economy can be obtained, and although we are not concerned in this discussion with possible methods of working suppressed carrier systems, it may not be out of place to explain one or two features of circuits which have been used.

A carrier of small power is set up and modulated, thus producing side bands; the carrier is then suppressed by some convenient circuit, an example of which will be described, and the side bands remaining are then amplified through a power amplifier of the usual design to the full power required for the final output. As a properly designed power amplifier has a large step up power ratio from stage to stage, one can assume that almost the full carrier power can be saved, as the initial carrier set up, which is suppressed at the first stage, would be of negligible power compared to the final output.

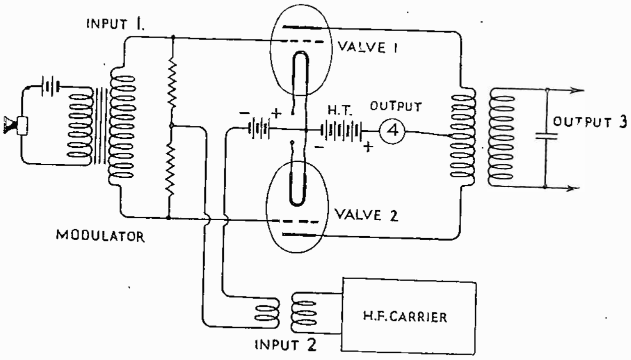

Fig. 8.

To suppress the carrier a filter is not used, as it is not entirely suitable for the suppression of a single frequency, but some form of balanced system is to be preferred, the best known being a type of "push pull" circuit as shown in Fig. 8.

We have in such a circuit two inputs, 1 and 2, and output at 3. Input to 1 acts differentially on the system as regards output 3, but input to 2 acts in opposition as regards this output. For any A.C. voltage applied from input 1 impulses the valves in anti-phase and because the feed to the two valves is drawn from the centre point of the output system, the anti-phase currents resulting become additive in action as regards this output system. On the other hand, any A.C. voltage applied through input 2 impulses the valves in phase and because of the centre point tapping, the "in phase" currents resulting oppose in action as regards output 3.

Of course, had the output been put in the common feed limb 4, the effects would be exactly reversed. If one considers the supply of input voltages of different frequency, say n and m, to inputs 1 and 2, outputs will appear of frequencies as shown in the following table :—

Input		Output	
1	2	3	4
m	—	m	—
—	n	—	n
m	n	m $(n+m)$ $(n-m)$	n

From this table it can be seen that if a carrier of frequency n, say, is applied to input 2 and a modulating signal to input 1, then at output 3, the carrier is suppressed and only the sidebands $(n+m)$ and $(n-m)$ appear. The signal component also appears, but if output 3 is a high frequency circuit, m need not be considered.

The advantage of such a balanced system is that the carrier can be suppressed even though the modulation frequency approximates to zero, thus producing side bands which are only a few cycles either side of the carrier, so close that a filter circuit would not be effective.

Having isolated the side bands, they can be amplified as required, or if one side band is wanted the output from 3 will be passed through any necessary filter system so that the lower side band is separated from the upper.

From the foregoing it is clear that there is no difficulty in suppressing the carrier from a modulated high frequency spectrum and transmitting only the side bands, thereby obtaining power economy, and in Fig. 9 is shown the beat wave produced by the side bands alone for the case of a sine signal*.

FIG. 9. *Carrier suppressed. Both side bands.* 100% *mod. Sine signal.*

If one traces out the signal component, it will be observed that the datum line of the signal wave now coincides with the zero line of high frequency, thus conforming to the definition of a non-carrier system, given in Section 1, but because of the image created, frequency doubling (with distortion) occurs. An interesting point to observe is the phase reversal which

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* It should be noticed that where the word 'signal' is used in this article it applies to the modulating signal and not to the radiated signal complete with carrier.

occurs at every half cycle of modulating component, which is analogous to the phase current change occurring in the line case. This can be seen clearly in the figure.

The automatic phase reversal makes it clear how the addition of polarising carrier at the receiver builds up the correct envelope shape; for the side bands each being displaced on the frequency band an equal amount above and below the carrier frequency, when added to each other, form a beat wave of the carrier frequency, and if a homodyne carrier is added so that it is in phase with the one half cycle of the modulated wave it just pushes the envelope up, and because of the phase reversal, the carrier automatically assumes an antiphase condition with the second half cycle, the result being a corresponding reversal of envelope shape, and a correct reproduction of the original signal wave.

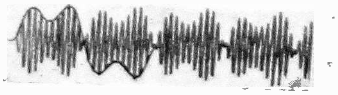


FIG. 10. *Suppressed carrier. Both side bands. 100% mod. Signal with 3rd harmonic.*

Fig. 10 shows the side band spectrum for a signal with a third harmonic in phase. Here again the datum line of the signal wave will be found to coincide with the zero line of high frequency and the phase reversal at the half cycle of signal is still in evidence.

If reception of this carrierless spectrum is considered it will be clear that demodulation will not give the original signal because the detector is unable to understand the meaning of the phase reversal at the half cycle, and in consequence the signal received will be of double frequency and distorted. To obtain the original signal it will be necessary to polarize the receiver with a high frequency carrier of the correct frequency and having the correct phase. The question that occurs is, can one obtain a frequency constant enough to be able to phase it and produce the required result, and what difference does a phase shift make on the envelope.

These points have been investigated and the results for the case of a sine signal are shown in Figs. 11 and 12.

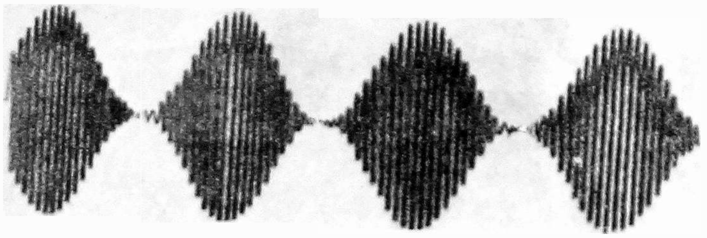


FIG. 11A. *Sine signal. Carrier correct frequency. Both side bands. Carrier correct phase.*

Figs. 11A, B, C and D are for the sine signal case and show the effect of the addition of a carrier of the correct frequency, but having a phase shift of different amounts, and from these figures it can be seen that distortion of envelope is considerable even with quite a small phase shift.

Fig. 11A shows the carrier introduced at correct phase, Fig. 11B with a 10° phase shift, 11C with a 45° phase shift, and 11D with a 90° phase shift. It is to be noticed that a small phase shift introduces considerable distortion, and where the phase shift is 90° the distortion appears to take the form of frequency doubling. Unlike most frequency doubling the envelope produced appears to conform reasonably well to a pure sine wave of twice the frequency and half the amplitude. Note that a phase shift of carrier does not alter the phase of the signal wave on the time base but distorts.

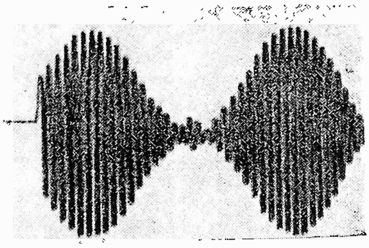


FIG. 11B. *Both side bands. Carrier* 10° *advance.*

If a carrier is introduced of a different frequency it will beat with the side bands spectrum and there will be transient conditions only where the envelope is produced correctly as shown in Fig. 12.

The conclusions one arrives at are, therefore, that, unless not only the frequency, but the phase of carrier, is correct, considerable distortion of signal envelope will result, and since it is practically an impossibility to obtain a correct phase, a suppressed carrier system is not a practicable proposition, except for I.C.W. telegraphy, where the character of envelope shape is of no importance. For telephony or facsimile work it is out of the question.

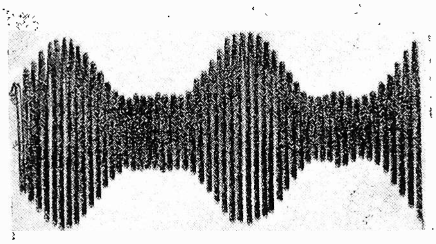


FIG. 11C. *Both side bands. Carrier* 45° *advance.*

Of course it is not really a matter of phasing—presumably this could be done if the frequencies of carrier and side band spectrum were the same—but the impossibility of keeping a high frequency wave constant to within narrow enough limits.

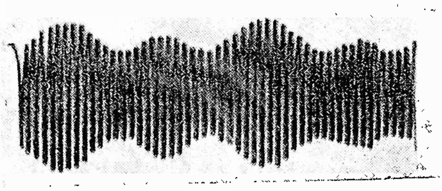


FIG. 11D. *Both side bands. Carrier* 90° *advance.*

We are accustomed to think of our driven transmitters as giving constant frequency, and further thinking of a zero beat case as showing that two frequencies are exactly the same. But a frequency constancy of one part in 100,000 is sufficient to give such conditions, whereas before one can consider phasing high frequency waves, a constancy of one part in several million will be necessary, even on a comparatively long wavelength.

Single Side Band Working.

To overcome the extreme difficulty of working a suppressed carrier, a compromise has been effected by adopting what is known as single side band working, and compromise though it is, this system is of considerable interest, for it reduces the frequency spectrum used to half, and further, helps to solve certain propagation difficulties encountered in ultra-short wave work.

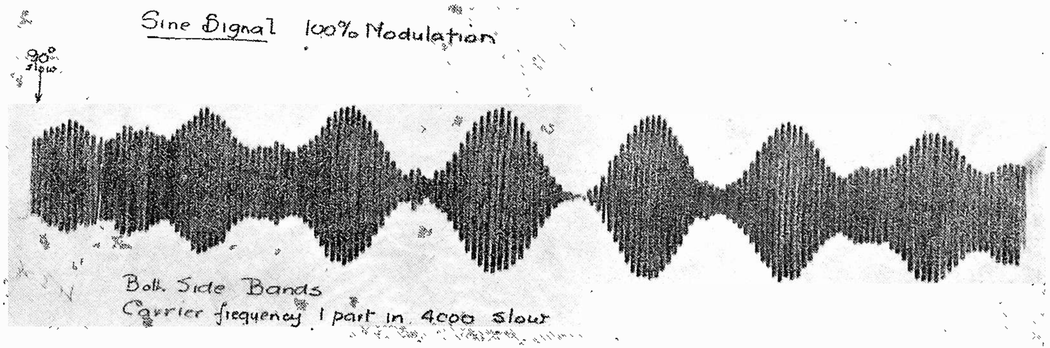


Fig. 12.

It should be pointed out, however, that single side band working has no power economy over full side band working with suppressed carrier. Further, it has its limitations and, as will be seen, it is not a perfect system.

Consideration of the original high frequency spectrum shows that either side band contains all the components necessary for the transmission of intelligence. Single side band working, therefore, consists of suppressing at the transmitter not only the carrier, but one side band as well. Thus one group of waves is transmitted in which are waves having the frequency of the carrier plus (or minus) the signal component frequencies.

Suppression of the carrier can be carried out by a balanced circuit, as described, the side bands being separated by some form of filter circuit.

As in the case of suppressed carrier working, to reproduce the signal at the receiver it is necessary to add a polarizing wave of the same frequency as that suppressed, as demodulation of the side band alone does not result in the extraction of the signal component.

The usual theory of the action is that because the carrier differs from the waves of the side band by amount of the signal components, the beating of the group produces a synthesis wave whose envelope shape is the signal.

Thus in the case of a sine signal of frequency f modulating a carrier of frequency n, two side band waves are produced $(n+f)$ and $(n-f)$. Thus, if the upper side band is being received it will consist of a frequency $(n+f)$. The addition of a carrier of frequency n at the receiver before demodulation, produces a wave whose beat envelope will have a frequency of $(n+f)-n$, namely f, the original signal frequency.

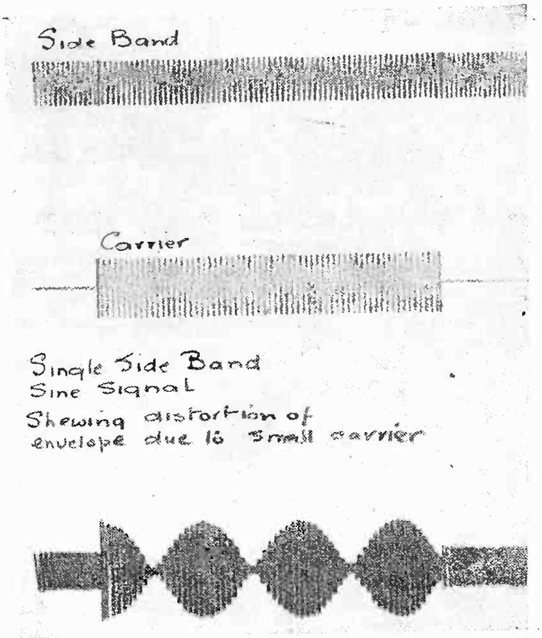


FIG. 13.

This simple arithmetic, however, is somewhat misleading, and it will be found that although f does appear as the chief frequency in the demodulated signal, the original envelope shape is not reproduced, although under certain conditions the distortion can be reduced to a small amount. Consider the case above for a sine signal. Single side band working for a sine signal is the transmission of a single wave differing in frequency from the carrier by amount of the signal frequency. Addition of a local carrier of the correct frequency certainly produces an envelope of the original signal frequency as shown in Fig. 13, but from observation the envelope is certainly not a sine wave. If the carrier added is large in amplitude compared to the side band the envelope appears to approach more to a sine shape as is shown in Fig. 14 which should be compared with Fig. 13 and this indicates that for single side band work a very large local carrier is necessary if good reproduction is required. Exactly how an envelope shape can change its character with change of the relative amplitudes of the beating waves is not easy to understand, but this result has been confirmed mathematically. Stated briefly, the mathematical expression for the rectified envelope of the beating of two simple waves in terms of these waves is not a simple function and such an envelope can only be expressed as the product of two simple functions. If the amplitude of one wave is infinitely large compared to the other one function goes to unity, thus leaving the envelope expressed as a simple function.

The more pure the signal wave, the larger the carrier amplitude necessary to give correct reproduction. This is to be expected for the amplitudes of the harmonics of a signal are usually small compared to the fundamental and a carrier of given amplitude will be larger in proportion to the harmonics than to the fundamental, and hence the harmonics will be distorted least. Since it is the harmonics which give character, a signal having harmonics will be less distorted than one consisting of a single frequency, and this effect can to some extent be seen by studying Fig. 15, where the signal wave consists of a fundamental and third harmonic, and the carrier amplitude is of just sufficient amplitude to reproduce the envelope. Compare this with the envelope of Fig. 16.

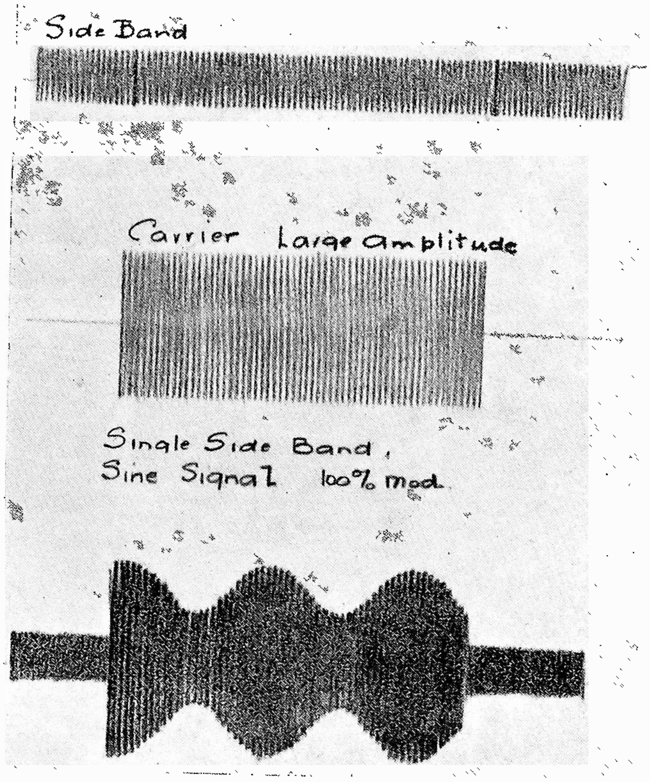


FIG. 14.

It is of interest now to consider various phase conditions of the added carrier.

Considering the sine signal case, since the side band consists of one wave only, it is obvious that the same envelope will be produced whatever phase is considered, although of course, the phase of envelope is not a constant. If we have a pure sine signal, then a phase shift of 90° of carrier will bring about a phase shift of 90° in signal, and thus if the carrier is replaced 180° out of phase the sense of the signal will be exactly reversed. This is different to the suppressed carrier case where a phase shift of carrier did not shift the signal phase but merely distorted. This phase sense does not matter for telephone work. If the signal is not a pure sine wave the different frequencies comprising it will all get different phase shifts as will be shown later.

It was felt that the sine case was not sufficiently comprehensive for an analysis of single side band working and therefore this system has been studied using a signal having a third harmonic. The original modulated wave produced by the transmitter for a signal having a third harmonic is as shown in Fig. 16. If we suppress the carrier and one side band what is radiated will be one side band only, say the upper, and Fig. 17 shows what this radiated wave comprises, from which one can see that the envelope appears to have no obvious relation to the signal. In this connection it is to be observed that it is extremely difficult to obtain any satisfactory physical conception of single side band working. For instance, a continuous wave telegraph signal might be single side band working of an I.C.W. signal.

As stated previously, to be able to obtain the correct signal, it is necessary to add a carrier before demodulation, and it is of interest first to consider the introduction of a carrier of correct frequency but having different phases.

Fig. 18A shows a carrier introduced with correct phase, Fig. 18B with carrier 45° phase shift, and Fig. 18C with a 90° phase shift. Had the phase shift been 180° the envelope would have been completely reversed in sense. At first sight these envelopes look all different, but actually they all contain the same audio frequency components with different amounts of phase shift, and we must consider what effect this has.

FIG. 15.

In Fig. 19 is shown the resultant of a wave consisting of a fundamental and third harmonic, the latter having different phase shifts as indicated. If these waves are compared with the modulated envelope in Fig. 12 it is easy to observe that these modulated envelopes can always be identified with the third harmonic wave. Further the phase shift of signal harmonic is different to the phase shift of signal fundamental. Considering the case of the carrier introduced with a 90° phase shift, it appears that whereas the fundamental of the wave is shifted 90° the third harmonic is shifted 270°, *i.e.*, into anti-phase with the signal fundamental. This means that with a wave rich in harmonics not only will the phase of the fundamental be shifted but the phase of each individual harmonic shifted a different amount, and if one considers the general case it is observed that the phase shift of the different component frequencies is directly proportional to the frequencies. Thus, if one had a wave containing frequencies having multiples of 1, 2, 3, 4 and 5, if the carrier frequency is shifted 10°, then the phase shift of the frequencies of the envelope would be shifted 10° for the fundamental 20°, 30°, 40°, 50°, etc., for the harmonics.

Because the shape of the resulting envelope depends upon the relative phases of the different components of the signal, then in single side band working, the envelope shape alters considerably with a phase shift of carrier. If, however, such a wave is being received aurally, the intelligence conveyed by ear to the brain will be exactly the same whatever envelope shape is made by the combination, for the ear is only capable of interpreting frequencies and amplitudes, and not phases. It interprets frequencies accurately, amplitudes indifferently, and phases not at all. This is true of all waves which are not transients in character. Thus, provided the same frequencies are present, (and no other), their relative phases do not matter, and their amplitudes only matter to a small extent. When one considers that the diaphragm of a recording telephone must vibrate to trace out the resultant wave, it seems amazing that the ear cannot detect any difference and the ear therefore appears to act as a very efficient phase destroying device.

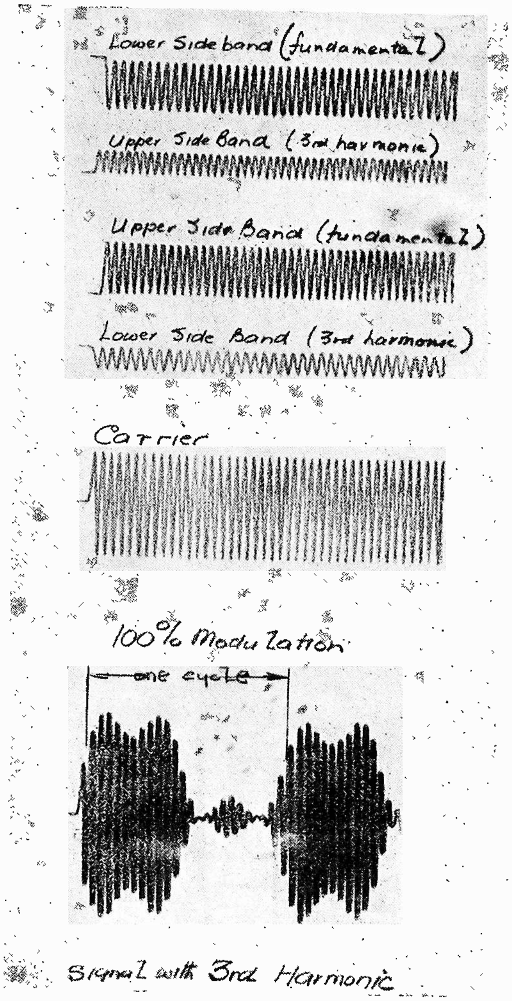


FIG. 16.

Thus one must be very cautious in interpreting the meaning of the shape of a modulated wave, or for that matter the mathematics of it, when it involves aural reception, or perhaps to put it another way, one must not take the results of aural reception as a basis of calculation for the behaviour of any type of detecting apparatus. For instance, single side band is quite sound for aural reception, but it would be out of the question for facsimile work where the detector is a glorified oscillograph and would record envelope shape. Apart from this point, as a matter of fact, it is difficult to see any possibility of single side band work, or suppressed carrier, for facsimile, on account of the fact that facsimile is a type of C.W. or square wave keying, varying

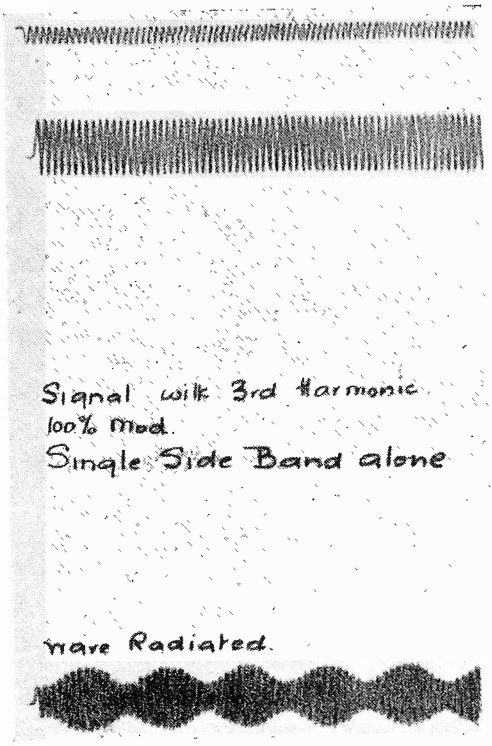


FIG. 17.

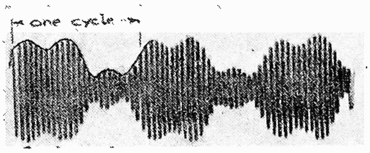


FIG. 18A. *Signal with 3rd harmonic. 100% mod. Single side band. Carrier of correct frequency. Normal amplitude.*

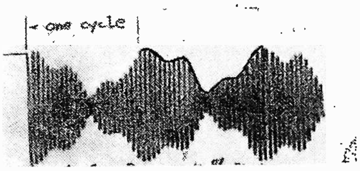


FIG. 18B. *Signal with 3rd harmonic. 100% mod. Single side band. Carrier misphased 45°.*

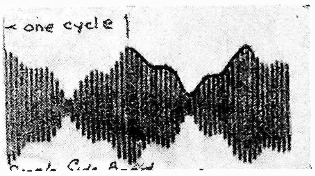


FIG. 18C. *Signal with 3rd harmonic. Single side band. Carrier misphased 90°.*

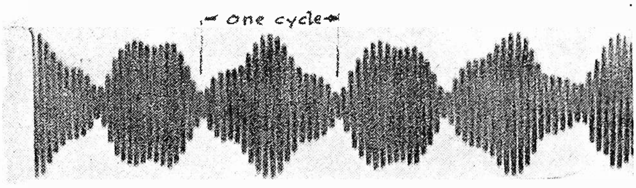


FIG. 20A. *Single side band. Signal with 3rd harmonic. Upper side band and carrier. Carrier frequency lowered.*

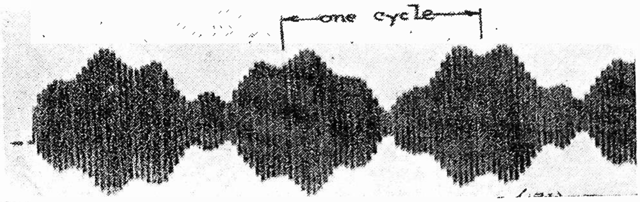
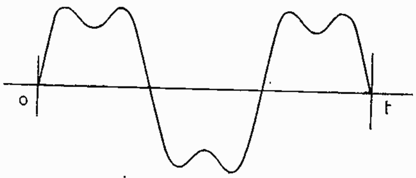
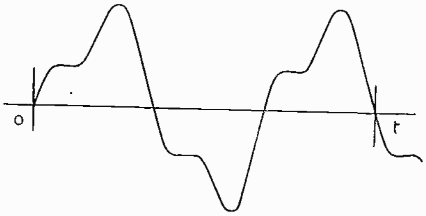


FIG. 20B. *Carrier frequency raised.*

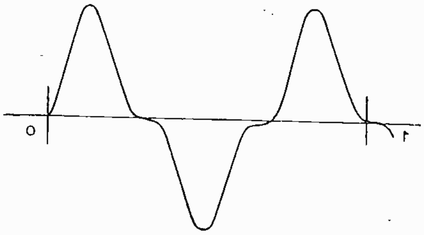
in speed from ultra high to zero. This means that the side bands at certain periods are separated from the carrier, but at other times they merge so toward one another and to the carrier as to make them impossible of separation by filters.



3RD HARMONIC IN PHASE



3RD HARMONIC IN 90° PHASE SHIFT



3RD HARMONIC 180° PHASE SHIFT

FIG. 19

There is one further point before concluding: the introduction of a carrier of a slightly different frequency.

If the carrier is altered in frequency the pitch of the fundamental will alter, and since the difference frequency to the harmonics change, the signal harmonics will alter relative to the signal fundamental, but it should be observed that because the signal fundamental has the smallest difference of frequency to the carrier, a small change of carrier frequency makes a larger change in the fundamental of the signal than it does to the harmonics. Now, if one considers an aural signal, the fundamental conveys mostly pitch and the harmonics mostly character and intelligence, and presumably because the harmonics are changed comparatively slowly compared to the pitch, one can stand for quite a remarkable amount of detuning before a speech signal becomes unintelligible, the most marked alteration being the rapid change of pitch. This effect is shown in Fig. 20, where a considerable alteration of fundamental pitch has been made, but the character of envelope can be seen still to contain much of its original characteristics. This fact may be the salvation of single side band work on ultra short waves, for, as far as can be seen at the moment, it is quite impossible to keep a carrier constant to a few cycles on these frequencies. The above statements are true for speech but not for the transmission of music. In the latter case much of the pleasure (or otherwise) of music lies in the combination tones of the various frequencies, and if these are upset, the result is discord.

The general inference is then, that single side band working offers a new field of development for certain classes of traffic, but that field will be limited to systems employing aural reception, unless distortion of envelope can be permitted.

A. W. LADNER.

MARCONI AIRCRAFT TRANSMITTER

TYPE A.D.18

The Type A.D.18 transmitter represents a departure from standard aeroplane transmitter practice in that a drive oscillator is employed to stabilise the frequency of oscillation of the main transmitting system.

The set is designed chiefly for use in two-seater and larger aeroplanes, seaplanes and flying boats.

Any of the standard Marconi aircraft receivers can be used in conjunction with this transmitter, although a special receiver has been designed for use with the A.D.18 and will be described shortly in The Marconi Review.

General Description.

THE transmitter is enclosed in a duralumin box whose sides are strengthened by corrugated duralumin strips, and whose front is readily detachable by means of ten spring clips. The box itself is supported on an elastic suspension system and is divided into four compartments, the first of which contains the valves, the second the independent drive circuit, the third the control panel, and the last the aerial tuning panel.

The disposition of these components can easily be seen from the photograph. The independent drive is completely screened from the remainder of the set and is provided with an automatic indicator which shows the wavelength to which the circuit is tuned.

To the left of the drive compartment are the four transmitting valves, details of which will be given later. In the middle compartment are the various controls, and the bottom compartment contains the reaction and aerial tuning circuits.

The set is adapted for use on either C.W., I.C.W. or Telephony, and has a wavelength range of from 300—1,550 metres when using an aerial system of approximately 0.003 mfds. capacity, this capacity being of the same order as that given by the ordinary type of trailing aeroplane aerial.

Owing to the limitation of space considerable experimental work has been necessary to ascertain the correct arrangement of the components for best results to be obtained ; the most difficult of the problems arising in this connection being the disposition of the drive and magnifier systems, as it is not possible to separate these by more than a few inches.

Description of Circuits.

The circuit of the independent drive oscillator is given overleaf : Fig. 1.

The valve used in this oscillator is an M.T.5B and the circuit is a modification of the well-known arrangement in which the coupling between grid and plate circuits is capacitative. This type of circuit is very stable. The output circuit of this oscillator is capacity coupled to the grid of the driven magnifier valve.

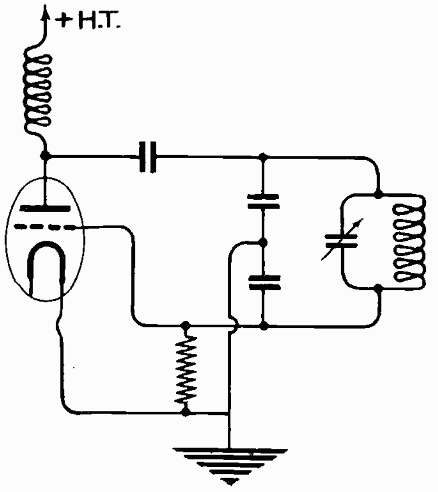
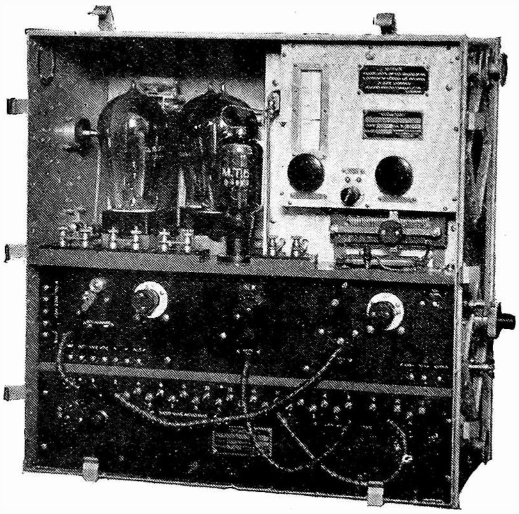


FIG. 1.

An indicating mechanism is provided on this circuit for tuning the drive to any particular wavelength. The handle which controls the drive closed circuit inductance switch also revolves a drum on which is marked a scale for each position of the stud switch. A pointer, which is geared to the variometer spindle, moves along these scales and indicates the exact wavelength to which the drive is set.

The magnifier system, consisting of two D.E.T.1 valves in parallel in the C.W. and I.C.W. position, and one D.E.T.1 in the telephony position, are capacity coupled to their output circuit, which consists of the aerial tuning inductance.

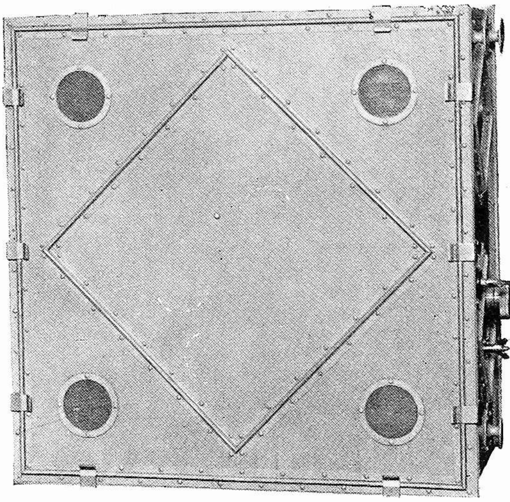
Self-oscillation of these valves is prevented by means of a semi-variable neutrodyne condenser which is adjusted to give zero coupling between the anode circuit (aerial tuning inductance) and the grid circuit (closed circuit of drive valve). The adjustment, once made for any particular wavelength, is found to remain sufficiently constant over the wave-range of the transmitter to render further adjustment unnecessary.



The Modulator valve system, which is, of course, only used on telephony, consists of two D.E.T.1 valves in parallel with the microphone current applied to their grid circuits by means of a step-up transformer. Modulation of the magnifier valve is accomplished by choke control in the usual way.

Keying.

Keying on the C.W. telegraphy position is carried out by breaking the grid leaks circuits and the negative H.T. supply simultaneously away from earth by the manipulating key, the action of which will be readily understood on reference to the diagram of connections in the C.W. and I.C.W. position.



On I.C.W. the grid circuit of the magnifier valve is broken at regular intervals by means of an interrupter which is mounted on the generator shaft.

Tuning.

The adjustment of the anode tap must be made by observing the total feed current of the valves. The set should be tuned to minimum feed and not to maximum aerial current, and the anode tap then adjusted to give the correct feed. If the set is tuned to maximum aerial current it is found that it will not be working efficiently and the valves will be overrun.

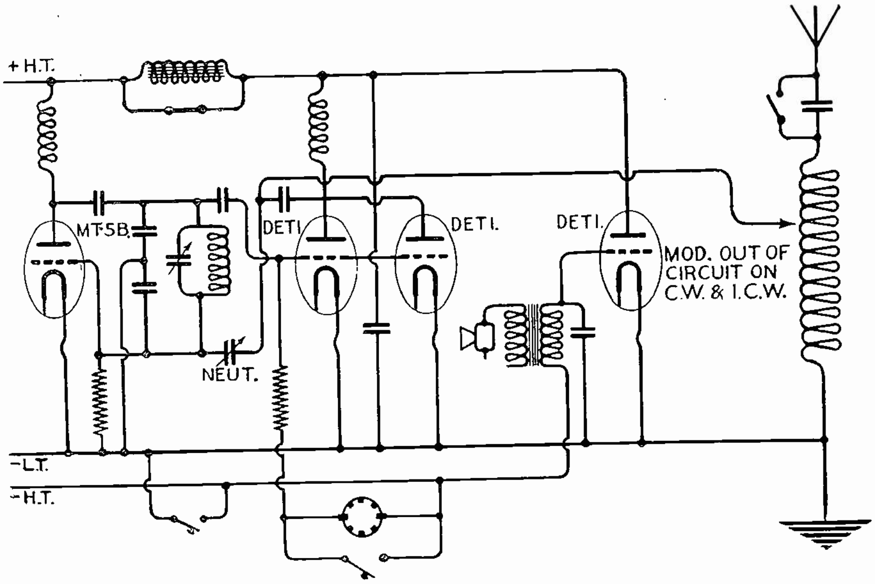


FIG. 2.—*Diagram of connections on C.W. and I.C.W.*

Control.

Bowden controls are provided for the following purposes :—

(1) Switching over to I.C.W./C.W./Telephony.
(2) Switching from "Send" to "Receive."
(3) Tuning the aerial variometer.

An aerial ammeter and total grid milliammeter are provided external to the transmitter and mounted on a suitable instrument board.

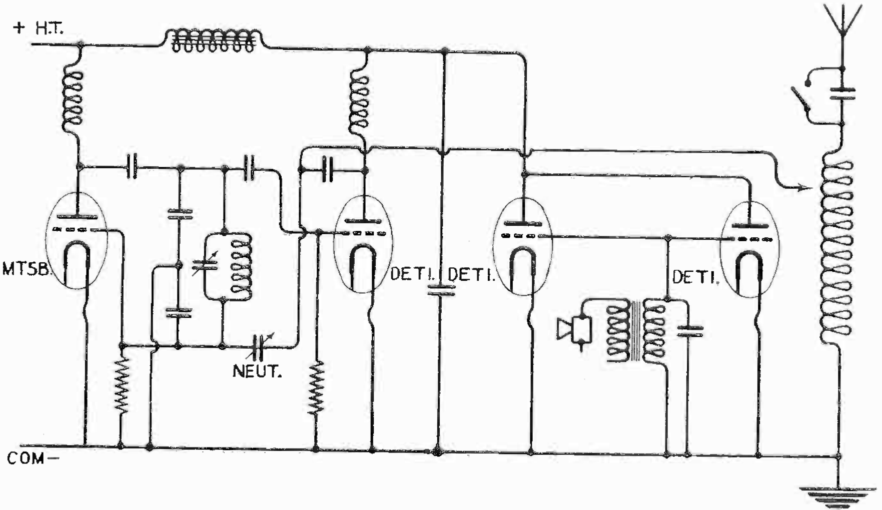


FIG. 3.—*Diagram of connections on Telephony.*

As a separate unit an instrument board with drive feed, modulator feed, and magnifier feed milliammeters on it can be supplied for testing purposes only.

Battery Supply, etc.

The main supply to the set is by wind-driven generator fitted with a constant speed propeller. This generator delivers H.T. current at 1,200 volts for the valves, and L.T. current to charge the 6 volt 25 ampere hour battery supplied with the set.

Range.

Assuming normal conditions and a Standard Marconi Aerodrome Station Direction Finder, such as a Type Rg.14 Receiver, the range from aircraft to ground with the A.D.18 are approximately :—

C.W. Telegraphy	400 miles.
I.C.W. Telegraphy	250—300 miles.
Telephony	150—200 miles.

The total weight of the complete transmitter equipment is approximately 124 lbs.

THE DESIGN OF WAVE FILTERS—II

The first part of this article, published in the July number of The Marconi Review, *dealt briefly with the following subjects :—*

(1) *General introduction.*
(2) *Types of filter sections.*
(3) *Formulæ for wave filter.*
(4) *Effects of dissipation on prototype sections.*
(5) *Impedance variation in prototype sections.*
(6) *The derived type of filter section.*

The concluding part of the article is given below.

---

7. Method of forming Composite Filters.

From the foregoing discussion of the " m derived " type of filter it can be seen that by suitable choice of various sections it is possible to obtain a sharper cut-off with fewer sections than would be required if prototype sections alone were employed. On Fig. 4 there are two main attenuation frequency characteristics, the one representing the characteristic of four prototype L.P. sections ; the other representing a composite L.P. filter having the same number of coils and condensers as the former. The remaining three curves are characteristics of the sections making up the composite filter. The sections are respectively one section of m derived ($m = 0{\cdot}65$), one section with ($m = 0{\cdot}45$), and one half prototype section. Addition of the attenuation constants for the various sections produces the attenuation constant for the composite filter. The values of m correspond to a ratio of $a = \frac{f_\infty}{f_c}$ of 1·32 and 1·12 respectively.

It is seen that the cut-off of the composite filter is considerably sharper than that of the prototype. The latter, however, for values of $\frac{f}{f_c}$ greater than 1·4 gives a higher attenuation than the former. If, however, the maximum attenuation required is only of the order of 40 TU, then the high attenuation of the latter is unnecessary, while the sharp cut-off of the composite filter is very useful.

Fig. 5 shows the measured attenuation characteristic of a composite filter developed along similar lines. The effect of dissipation is clearly seen by the rounding off of the boundary between the pass and attenuation regions.

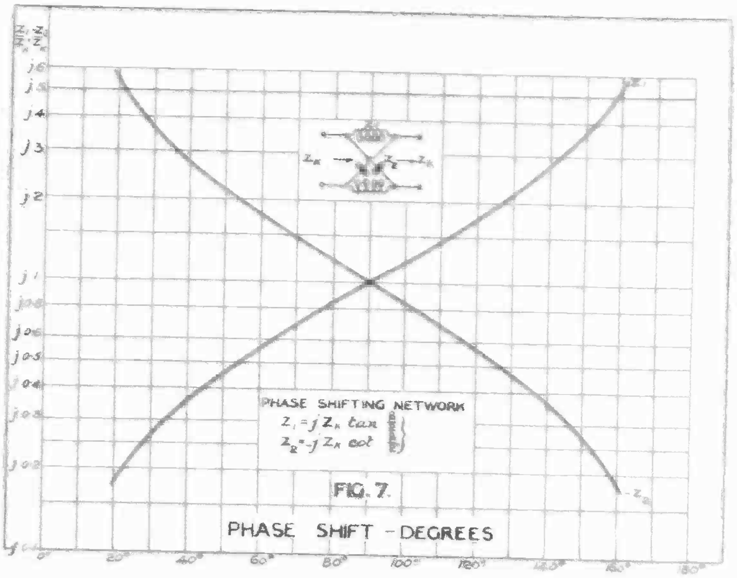


FIG. 7.

8. Constancy of Iterative Impedance in the Pass Region—Equivalent "*m* derived" Sections.

It has already been stated that the "*m* derived" and prototype filters have the common relation that their iterative impedances obey the same equations.

If now we examine the third set of sections on Fig. 1, called the "equivalent *m* derived" sections, we find that their relation to their neighbours immediately above them on the figure is simply that the "equivalent *m* derived sections" are the equivalent *Π* section derived from the T section above, and the equivalent T from the *Π* section above. In other words, the structural

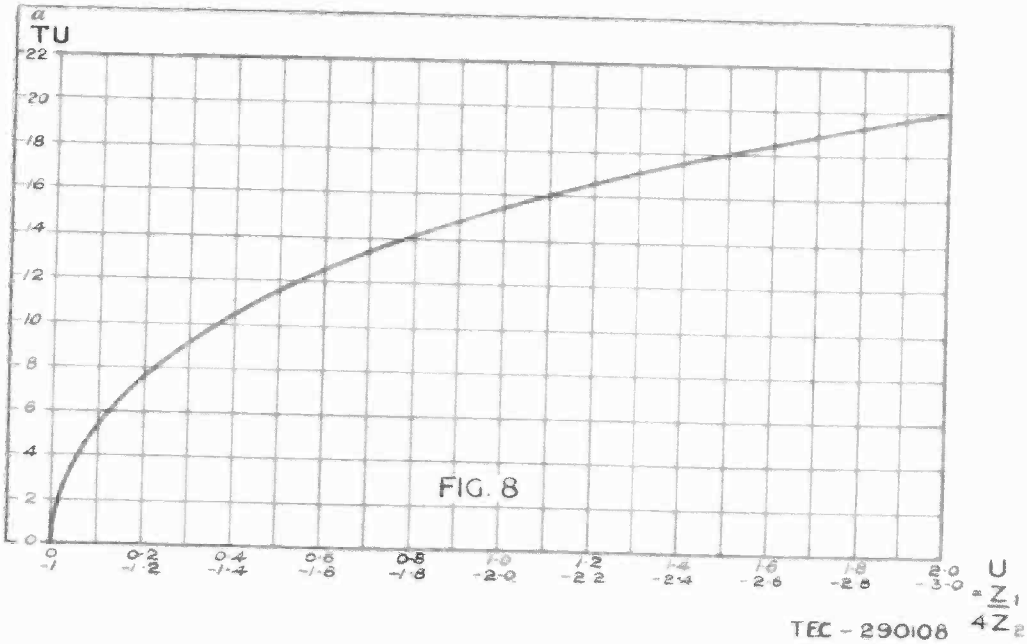


FIG. 8

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relation between the "*m* derived" and its equivalent is the relation between the prototype T and *Π* sections.

We have now two new derived sections having precisely the same attenuation characteristics as the "*m* derived" sections already mentioned. The difference in this case lies in the fact that the equation for the characteristic impedance is no longer the same as for the prototype, but is now a function of *m*.

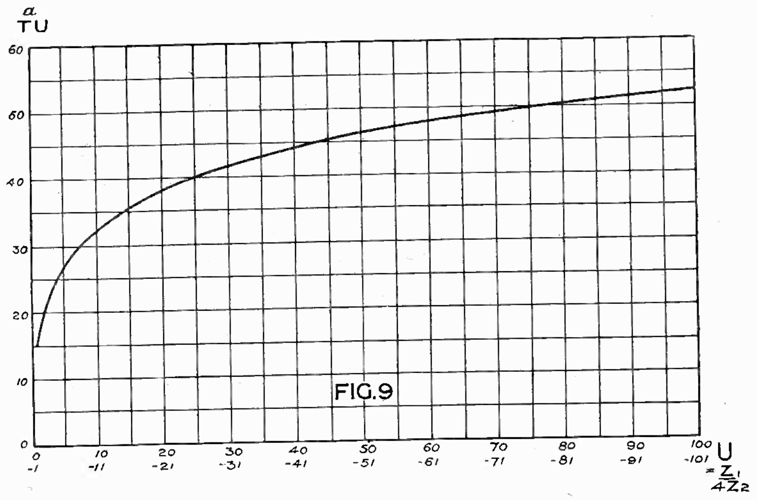
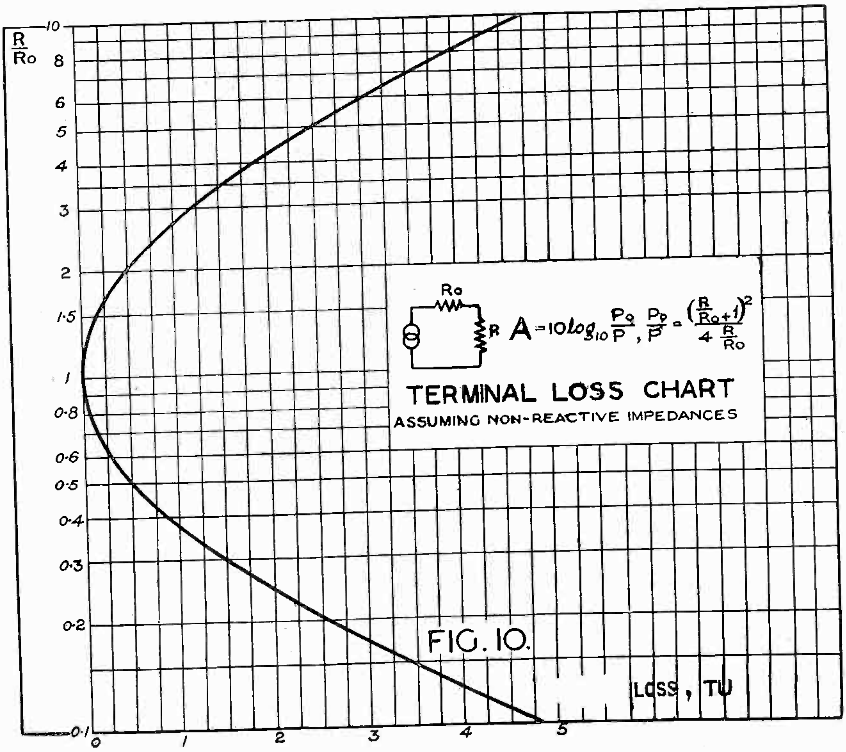


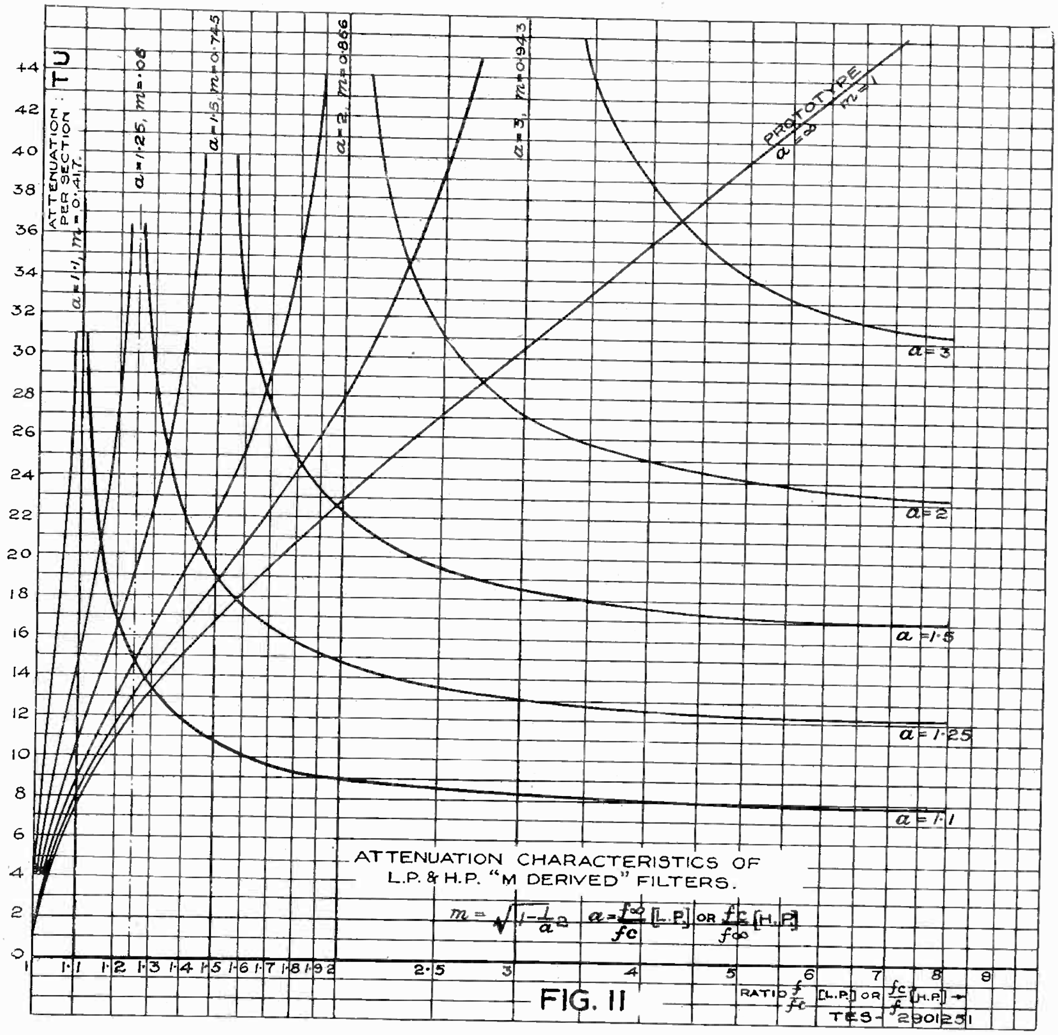
FIG. 9



$$A = 10 \log_{10} \frac{P_0}{P}, \quad \frac{P_0}{P} = \frac{\left(\frac{R}{R_0}+1\right)^2}{4\frac{R}{R_0}}$$

FIG. 10.

On Fig. 6 is found a series of curves showing the relation of the characteristic impedance in the pass region of all types of " equivalent *m* derived " low pass and high pass filters. It will be seen that for values of *m* near 0·6 (or for a value of $\frac{f_c}{f_c}$ or $\frac{f_c}{f_\infty}$ near 1·25) the characteristic impedance is approximately constant over the major part of the pass region. For this reason in a composite filter " *m* derived sections " having a value of *m* near 0·6 are generally halved, the two halves being placed at either end of the filter as " equivalent *m* derived " half sections. In this way the terminal losses at the input and output are minimised.



ATTENUATION CHARACTERISTICS OF L.P. & H.P. "M DERIVED" FILTERS.

$m = \sqrt{1 - \frac{1}{a^2}}$ $a = \frac{f_\infty}{f_c}$ [L.P.] OR $\frac{f_c}{f_\infty}$ [H.P.]

FIG. 11

9. Phase Shifting Structures.

The structures considered up to the present have the property of attenuating currents at certain frequencies, or bands of frequencies while (ideally) allowing others to pass through without loss. Consideration of the theory (Equation 1) shows that within the limits of a pass region the phase constant will vary between zero to $(2n + 1)\pi$, where n is integral. A consideration of Fig. 2 shows the phase shift

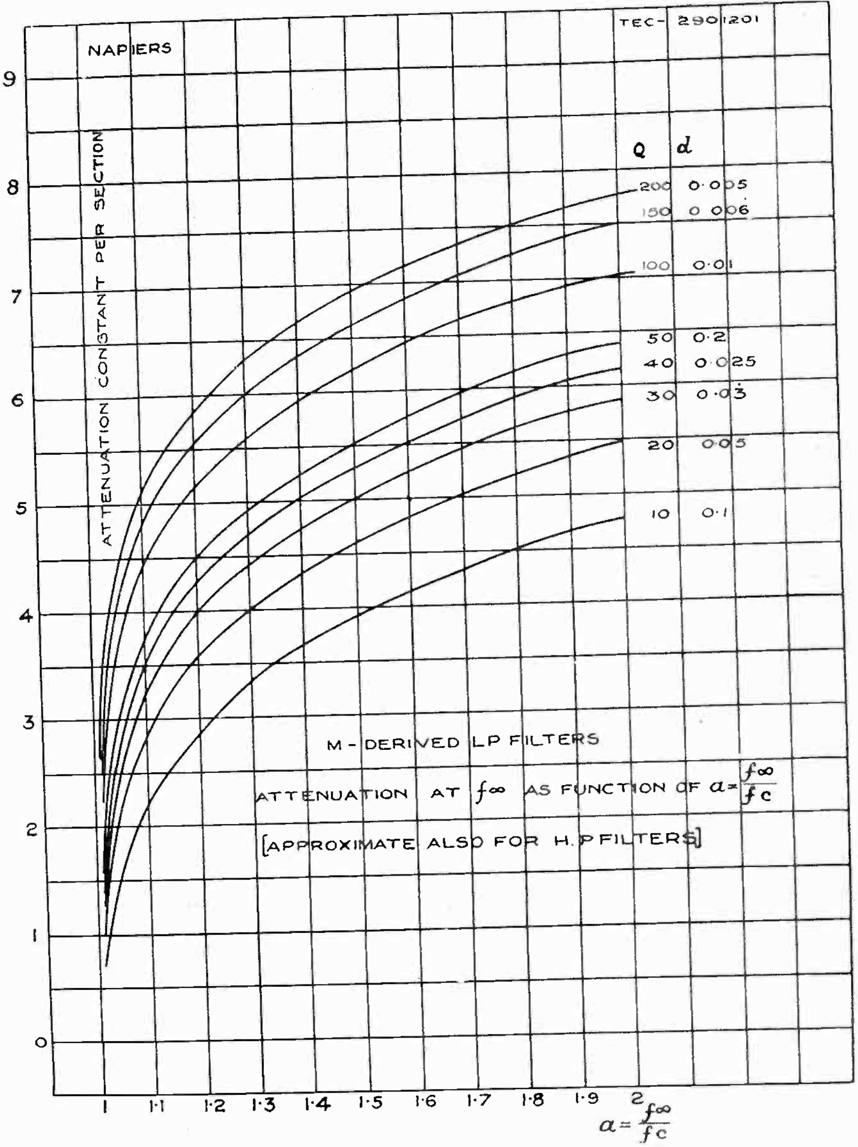


FIG. 12.

in degrees through any ideal low pass filter section. It is seen that the phase change through the section progresses from zero to 180° at the frequency of cut-off, after which it remains constant.

Although use of a structure such as a low pass filter working within its pass region has been made in the past, yet there are disadvantages due to increase of attenuation as the frequency of cut-off is approached, and to the variation in impedance previously referred to, within the pass region.

The type of structure usually employed for phase changing structures is the lattice, or bridge type. Fig. 7 shows the circuit of a simple phase shifting section together with the derivation of its elements.

This section has no frequency of cut-off, and in the ideal case therefore never attenuates. Further, its characteristic impedance is a constant being independent of frequency.

Such structures are used with others derived from them to make up composite networks for phase-correction on submarine cable circuits for improvement in signal shape and picture transmission circuits over long trunk lines.

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W. PROCTOR WILSON.

A MARCONI NAVAL TRANSMITTER

TYPE T.N.3

In THE MARCONI REVIEW *published in December of last year a short description of a Naval Transmitter Type T.N.1 was given. A further modification of this set has been designed using a coupled aerial system, but with the same input and output power ratings. This transmitter has been given the type title of T.N.3 and will be described in the following article.*

Similar switching devices to those used on the T.N.1 are incorporated in this new transmitter, and although, of course, extra controls are needed for the coupled aerial circuit, it is almost as easy to handle and adjust as is the T.N.1.

The salient features of the T.N.1 which have been enumerated in the article referred to above, such as robust construction, large waverange, etc., have been kept in the T.N.3 transmitter, and in addition, the coupled aerial circuit permits far greater selectivity to be obtained.

THE Type T.N.3 transmitter has been designed to cover a waverange of from 400 to 3,000 metres with a power of three kilowatts to the magnifier anode. The interchanging of the various combinations of inductances and condensers is accomplished from the front of the panel of the transmitter, and the various switches, etc., are provided with interlocking devices, to ensure the correct combinations and to prevent accidental damage when under power. Safety gates also automatically cut off the power when opened.

Power Supply.

The following machines are provided for the power supply to the transmitter :—

1. Motor alternator for H.T. supply.
2. Motor alternator for filament supply.
3. Motor generator for grid negative supply.

A small motor interrupter is also used for transmission on I.C.W.

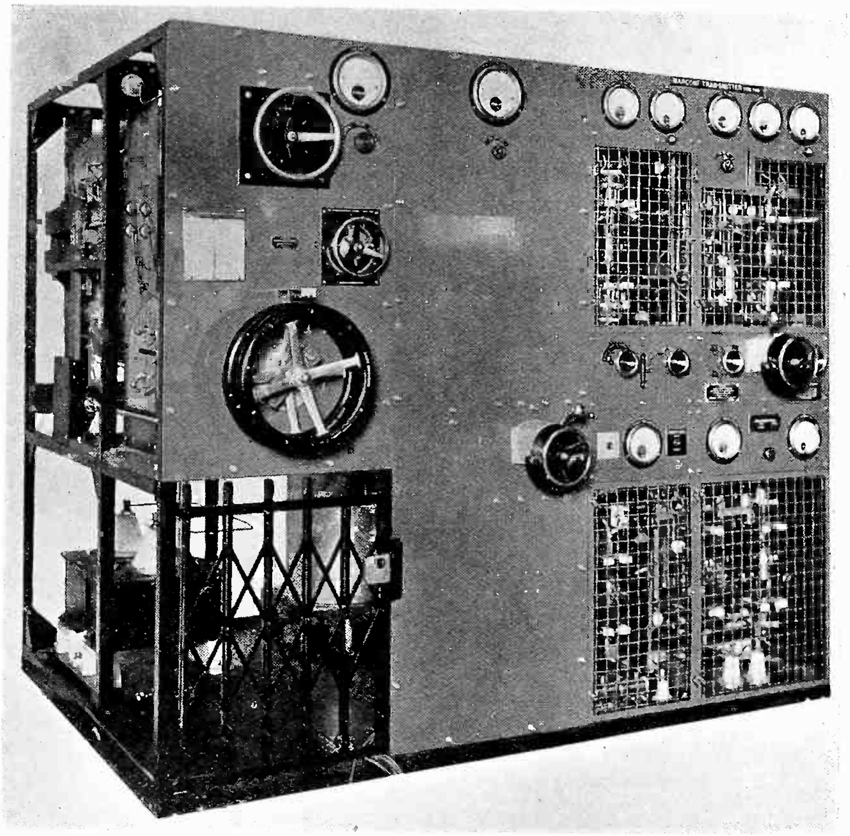
The H.T. supply for the anodes of the valves is obtained by the transformation and rectification of the A.C. generated by the motor alternator. Double wave rectification is employed and two valves, type M.R.7a, are used as the rectifiers.

Circuits.

The circuits of the T.N.3 are similar to those described in the case of the T.N.1, and can be divided, as there, into four groups :—

1. The rectifier system.
2. The drive.
3. The magnifier.
4. The absorber.

These need no special description apart from what has been already given in connection with the T.N.1. The aerial circuit is, however, in the case of the T.N.3 entirely distinct from the closed circuit, and consists, as will be seen from the diagram of connections (Fig. 1), of a variable aerial tuning inductance, two fixed aerial series condensers, a tuning variometer, a variable coupling system to the closed circuit, and an aerial ammeter.



T.N.3 Transmitter.

Keying.

Keying is by the absorber valve method, and is accomplished by the reversal of the potential on the grid of the absorber valve. The scheme of grid negative supply to the valves is shown in (Fig. 2), and it will be seen that, when the key K is closed the negative potential on the absorber valve A is changed to positive. The other valves D and M can have their grid potentials adjusted by the tappings on the potentiometer P. This keying relay K functions, of course, in the opposite sense to the manipulating key.

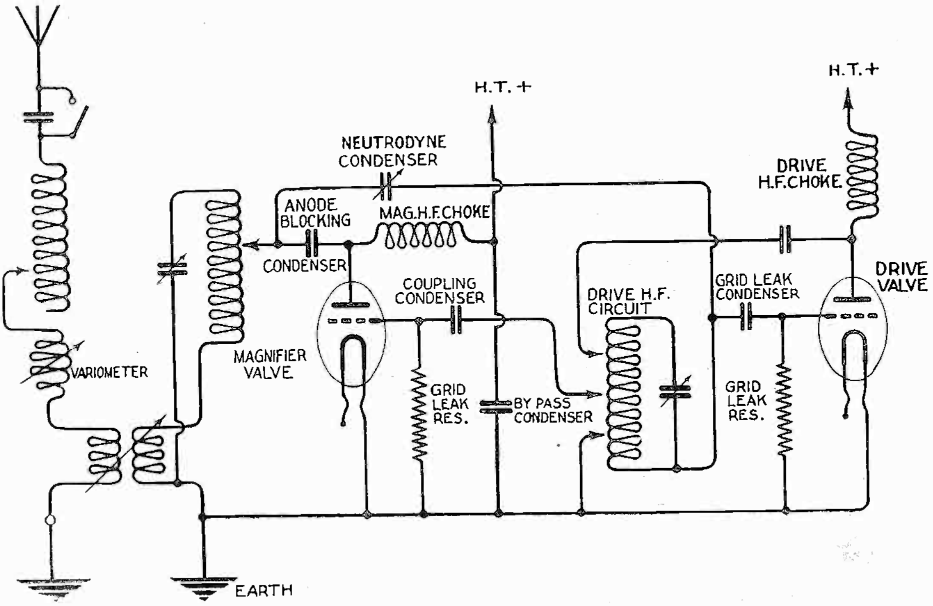


FIG. 1.

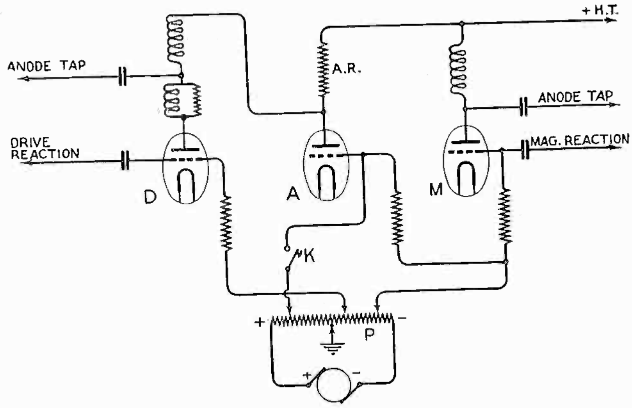


FIG. 2.

MARCONI NEWS AND NOTES

MARCONI EXHIBITS AT THE INTERNATIONAL AERO EXHIBITION

The Marconi Stand at the Aero Exhibition at Olympia.

One of the most important technical exhibitions seen in Europe for many years was the International Aero Exhibition held in London from July 16th-27th. In the great halls at Olympia were displayed the leading aircraft of many nations, and aeronautical experts from all parts of the world gathered in London for the occasion.

The Marconi Company, whose wireless apparatus has played a considerable part in developing the safety and reliability of modern air services, was represented at Olympia by a stand that proved one of the most attractive and interesting in the exhibition. The theme of the exhibit was to demonstrate the importance of wireless to civil, military and naval aircraft services, and the apparatus displayed ranged from powerful transmitters for use in aerodromes to lightweight equipment specially designed for the light aeroplane which is now becoming so popular for the owner-pilot.

The Marconi apparatus was displayed against a scenic background depicting a busy scene at a commercial airport, with the control tower and directional receiving aerials in the foreground and the masts of the aerodrome transmitting station in the distance. This panorama showed in a graphic form the utility of the apparatus displayed on the stand.

Exhibits of Popular Interest.

A new Marconi aircraft set that aroused great interest, particularly among private owner-pilots, was the type A.D.22 telephone transmitter and receiver, which has been designed along entirely fresh lines for use in light aeroplanes of the class that are highly popular among the flying clubs and for touring and sporting use. It is probable that this set will still further accelerate the popularity of the light aeroplane movement by simplifying the problems of aerial touring and enabling amateur pilots to obtain very much the same weather and aerodrome report services as are available to commercial machines. The importance of the contribution of such services to safety in the air is endorsed by international regulations, in force practically throughout the civilised world, requiring all passenger-carrying commercial aircraft to be equipped with suitable wireless apparatus.

The Marconi A.D.22 set will also provide owner-pilots with a means of position finding when they are flying over Europe or other parts of the world where there are aerodrome ground stations equipped with wireless direction finders, thus affording a valuable safeguard during periods of bad visibility.

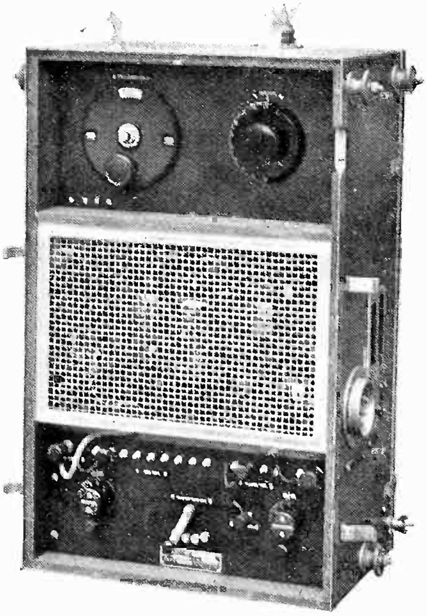
For Commercial and Military Aircraft.

Particular interest was attached also to two " All-Purpose " aircraft sets of the popular " A.D.6 " series, which are fitted in commercial, military and naval aircraft in more than 30 countries. Those shown were the Types A.D.6h and A.D.6m. Both are combined transmitters and receivers, transmitting on a power of 150 watts, and are adaptable for telegraph or telephone working.

In the case of the A.D.6h, the waverange of the transmitter is 300-1,500 metres, and of the receiver 200-1,800 metres, while the waverange of the A.D.6m transmitter and receiver is 550-1,550 metres, thus completely covering the waverange allotted to aircraft by the Washington Conference.

The new Marconi short-wave aircraft transmitter, Type A.D.21, and short-wave aircraft receiver, Type A.D.20 (described in THE MARCONI REVIEW, No. 8 and No. 9 respectively), were examined with particular interest by many visitors, as was the Type A.D.19 transmitter, which is similar in design to the Type A.D.21, but is fitted with an independent drive for maintaining constant wavelength, and provides for telephone working in addition to continuous wave and interrupted continuous wave signalling.

Also among short wave sets were the 75 watt Type A.D.5 transmitter and the A.D.12 receiver, which have proved their utility as a means of communication between small aircraft with fixed aerials. While specially designed for working together, the A.D.5 transmitter and the A.D.12 receiver are separately mounted for convenience of installation in small machines and because in the case of military aircraft it is often sufficient to fit only the squadron leaders' machines with both transmitter and receiver, and other machines with receivers only.



The Marconi Aircraft Telephone-Telegraph Set Type A.D.6m.

For Long Distance Air Routes.

With the inevitable development of aviation as a means of rapid long distance transport, with wide stretches of wild country or ocean to be traversed, the necessity arises for aircraft sets giving a long range of communication. On the Marconi Stand were exhibited two sets specially designed with this object in view. The Marconi Type A.D.8 telegraph-telephone set is particularly suitable for fitting in large types of aeroplanes, flying boats and airships, and the transmitter, being of 500 watts power, has a very wide range. This type of equipment is installed on the Short "Calcutta" flying boats used by Imperial Airways, Limited, on the Genoa-Alexandria section of the England-India air route.

The Marconi Type A.D.18 aircraft set also embodies a transmitter of comparatively high power (250 watts). This set was open to inspection for the first time at the Aero Exhibition, and—as in the case of all the aircraft apparatus—its light weight, compactness and accessibility were the subject of very favourable comment.

The Marconi aircraft direction finder, Type A.D.16, which is of particular value to aircraft operating over areas where direction finding ground stations are not available, was also shown. It operates on the Marconi-Bellini-Tosi system with fixed aerials, and is designed for a waverange of 600-1,600 metres, thus covering the standard ship communication wave and all wavelengths normally used in aircraft wireless practice.

For aircraft on which a special operator cannot be carried a simple type of direction finder or "homing" device, the Marconi Type A.D.17, was displayed. This apparatus enables the pilot to steer directly towards a known wireless station, a loop aerial system, with a suitable amplifying and switch device, giving both aural and visual indication of the line of flight in relation to the wireless station.

Either type of aircraft direction finder is suitable for use in conjunction with the Marconi beacon transmitter, an example of which (Type W.B.2) was shown. Designed primarily for providing shipping in congested areas with reliable wireless signals for direction finding purposes, these instruments are equally suitable for providing similar services to aircraft.

Accessories.

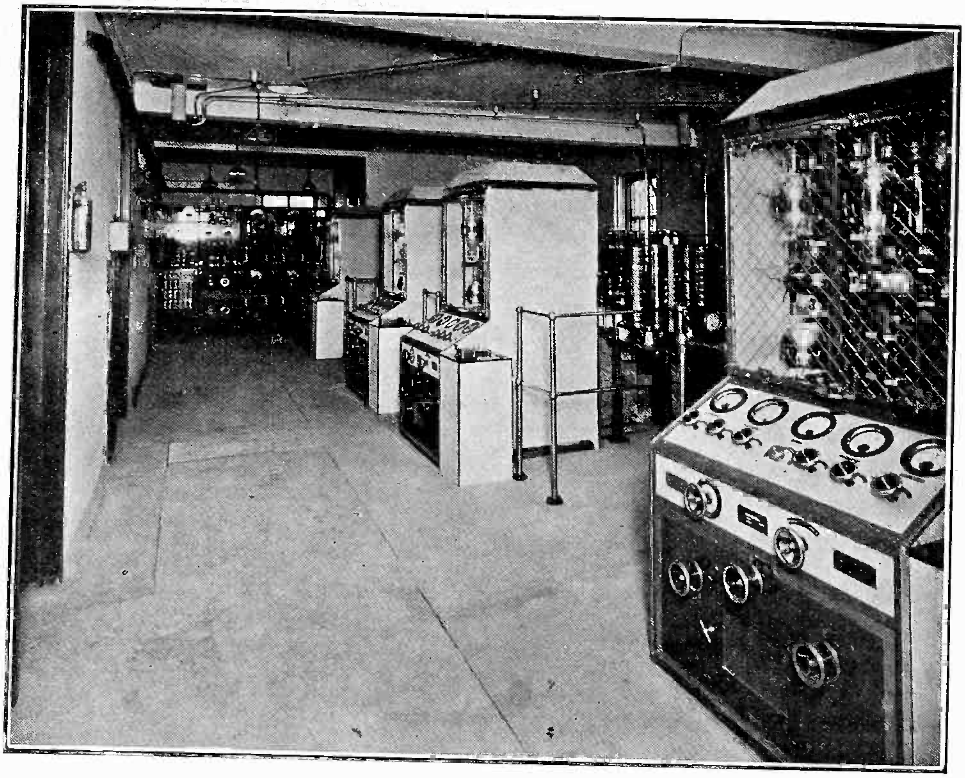
The careful attention that is paid by the Marconi Company to every detail that facilitates the most efficient operation of their apparatus was demonstrated by the accessories on the stand.

They included the Marconi special "anti-noise" flying helmet, which is designed to assist good wireless reception in the air by excluding engine and wind noises; the Marconi aerial winch which automatically unwinds a trailing aerial at a steady and safe rate; and testing sets enabling aircraft apparatus to be tested on the ground.

Another accessory that proved of particular interest was the Marconi petrol engine, a two-stroke of 1 h.p. specially designed to provide a convenient power supply for driving the wireless generator of aircraft sets in the event of an emergency landing. The lightness, compactness and robust construction of this engine was noted by many of the eminent engineers who visited the Aero Exhibition.

Historical Marconi Apparatus.

An exhibit of unique interest was a display of historical Marconi apparatus. This included the transmitter, receiver and direction finder used by Admiral Mark Kerr in preparing for his Atlantic flight attempt in June, 1919, side by side with their prototypes used by Captain F. T. Courtney in July, 1928. A striking demonstration was thus afforded of the advances made in the design and construction of aircraft apparatus in recent years. Particular interest attached to Captain Courtney's apparatus, as he has acknowledged that his rescue when his flying boat was forced to descend in mid-Atlantic was entirely due to his Marconi apparatus. It enabled him to summon ships to his assistance although he had descended far out of the regular shipping routes, while by means of the Marconi direction finder he was able to assist the rescuing ships in their search.



Four Marconi Type T.A.1 Aerodrome Transmitters at the Croydon Airport.

Aerodrome Ground Stations.

In all branches of aviation, the efficiency of the ground organisation may be said to be the keystone of success. This was emphasised by a number of features of the Aero Exhibition, and the importance of wireless in this regard was demonstrated by the Air Ministry's special display at Olympia as well as on the Marconi stand. The Air Ministry's display, which was one of the most striking features of the exhibition, included a Marconi 4 k.w. aerodrome transmitter, Type T.A.1, and a Marconi directional receiver, Type R.G.14, as installed at the London Air Port for communication with aircraft and with other aerodromes, and for position finding services.

On the Marconi stand was another transmitter suitable for aerodrome use, the Type U of 1½ kw. power, together with the Type D.F.M.4 direction finder receiver, which has been designed for use either on board ship or in land stations. The efficiency of this instrument may be judged from the fact that it has been adopted by the navies of several highly progressive nations.

The attractiveness of the Marconi exhibit was shown by the large number of visitors from all parts of the world who spent a great amount of time on the stand examining the apparatus and discussing aircraft wireless problems, and it is gratifying to record that numerous enquiries and orders were received.

Wireless aids a Damaged Air Liner.

The use of wireless probably saved a serious accident to an air liner leaving Croydon for Paris during this season. As the aeroplane took off from the ground the aerodrome officials were horrified to see the undercarriage hit a piece of uneven ground and become partly detached. As the aeroplane rose one side of the carriage seemed to be hanging from the machine. The officials realising immediately that landing with a machine in that condition must be a hazardous affair and might even end in disaster, sent a wireless message to the pilot telling him of his predicament and ordering him to turn back and land without delay. As a result the pilot made a successful landing without accident.

Wireless in Warfare.

During aerial manœuvres in the United States recently there was a striking demonstration of the value of wireless on service machines. One aeroplane circled above Government Island in New York Harbour and was able, theoretically, to reduce the headquarters of the Second Army Corps to ashes. According to the *Daily Telegraph*, United States Army officers " applauded the fact that the aeroplane with its wireless and navigating equipment was able to remain in the air when other machines not similarly equipped were compelled to seek refuge at air ports. From the time the plane left its aerodrome 700 miles away until New York was reached it was in continuous wireless communication with successive stations and was able to keep on its course without any great difficulty.

" This is the first time in the United States that a plane has taken advantage of the network of wireless stations spread across the country. Despite rough weather over the Alleghany Mountains, also low clouds, drizzling rain, fog-filled valleys and extremely poor visibility, which obliterated all landmarks, the crew had throughout complete information as to their position and the weather ahead."

Navigation by Wireless.

The navigation of a ship from Finisterre to Liverpool through fog solely on wireless bearings is reported in a communication from the Master of the motor vessel " Athelking."

The "Athelking" carries a Marconi Type 11F Direction Finder, and, commenting upon the efficiency of coastal wireless beacon installations used in conjunction with the ship's direction finder, the Captain states that he was able to take the usual four point bearings for some distance off in spite of the fog.

The report again emphasises the valuable aid rendered to navigation by wireless beacon stations, two more of which have recently been completed by the Marconi Company for Trinity House. Installed at Cromer and Dungeness Lighthouses, they will prove a very useful addition to the facilities available in the Channel and North Sea to ships equipped with wireless direction finders.

Dispersing Fog Dangers.

Following an announcement that the Institute of London Underwriters has agreed to suspend the additional premiums charged on the insurance of vessels calling at St. John, New Brunswick, when equipped with wireless direction finding apparatus, the following report received from a ship's Master on the value of the wireless direction finder for ships' navigation in Northern European waters is of interest.

Describing his experiences with a Marconi Direction Finder, the Master of a foreign steamer trading regularly to North Sea ports writes that the instrument "is worthy to be on every ship navigating in the Baltic Sea and in the North Sea, where there is so much fog and bad visibility."

He reports that bearings taken even from distances exceeding 100 miles have had a striking accuracy. By the use of the direction finder, he says, he knew exactly when to drop the lead to get his expected soundings in thick weather during a North Sea gale.

The stations upon which he obtained bearings were Scheveningen and Humber, and although the first of these was never nearer than 100 miles, the bearings obtained always coincided with those taken on the Humber station.