

THE MARCONI REVIEW

No. 46.

January-February, 1934.

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THE MARCONI-STILLE RECORDING AND REPRODUCING EQUIPMENT

Among the many systems for the recording and reproduction of speech and music, the magnetic system evolved by Stille, and further developed by the Marconi Company, is proving of great utility, and it is felt that an article that briefly sets forth some of the features in the processes of magnetic recording and reproduction will prove of interest.

THE general principle of magnetic recording was discovered as long ago as 1900 by V. Poulsen, who used it in the "Telegraphone." This instrument was developed primarily for the recording of high-speed telegraph signals, which were transcribed from the magnetic record by running it at a slower speed so that the reproduced signals were received at speeds normal for aural transcription. The possibilities of the system for recording and reproducing telephony were recognised by many scientific workers soon after Poulsen's original discovery, but the advent of methods of amplification and frequency correction using thermionic valves, alone made practical the utilisation of these possibilities, as the advent of broadcasting provided the incentive to develop them. To the German engineer Herr Stille must be given the great credit of developing the system with the aid of amplifiers up to the point where it could be practically applied for broadcasting purposes, whilst the engineers of the British Broadcasting Corporation, in collaboration with Mr. Von Heising, of Stille Inventions, Ltd., by applying frequency correction circuits to the system as developed by Stille, first succeeded in producing an arrangement which satisfactorily met the stringent conditions as to quality of reproduction which broadcasting imposes. The Marconi Company have further developed the system of amplification and correction used, and research work is being carried out in order to effect improvements in the magnetic materials and processes.

Before describing the apparatus, it would seem advisable briefly to outline the theory of magnetic recording. It will be clear upon a little consideration that whereas in mechanical recording it is possible to make a record directly from sound waves, it is necessary with magnetic recording first, by the use of a microphone and its associated circuits, to convert the acoustic speech waves into their equivalent electrical speech currents (for broadcasting this is done as part of the regular broadcasting process and the speech currents are already available). The speech currents are then made to produce corresponding magnetic flux changes in a moving "carrier" of suitable magnetic qualities such as retentivity and coercivity. This "carrier" may be in the form of relatively fine steel wire or of thin flexible steel ribbon or tape.

For high quality reproduction the latter form of "carrier" is used, although wire is satisfactory for commercial speech and is being developed for medium quality broadcasting.

One of the advantages of magnetic recording is that the same "carrier" may be used over and over again without deterioration not only in the reproduction of any recording which has been made on it, but also when the recording on the "carrier," or tape as it will be called in future, is no longer required it can be completely obliterated, and in the process of doing this, the tape is magnetically prepared for a new record. In actual practice this obliteration, or "wipe-out" process as it is called, is carried out simultaneously with the new recording.

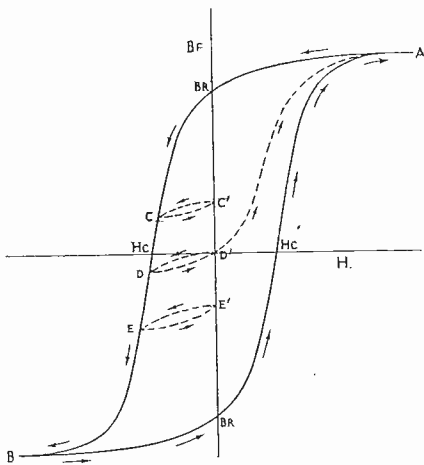


FIG. 1.

The process of magnetic recording depends essentially on the property associated with magnetic hysteresis that when changes of magneto motive force are made progressively through a cycle in one direction, a certain definite hysteresis loop will be traced out by the curve expressing the relationship between the magneto-motive force and the intensity of the resultant field in the iron, but if the cycle be interrupted at any point and the magneto-motive force reversed, a minor hysteresis loop will be traced out which will not lie upon the main loop. This is illustrated in Fig. 1, in which the thick curve shows the main hysteresis loop obtained with the type of material used in magnetic recording, and the dotted line indicates the initial process of taking the material from the de-magnetised state up to the saturation tip A. On decreasing the magneto-motive force to zero the curve is

traced out to B_R (the value of the Remanence) and on reversing the portion of the curve to H_C (the value of reversed magneto-motive force required to reduce B_f to zero, or the Coercive Force) is traced out, further increase of reversed magneto-motive force bringing conditions to those represented by B, the lower saturation tip. On reducing the reversed magneto-motive force to zero, the lower value of B_R is arrived at. Now restoring the magneto-motive force to its normal direction, the positive value of H_C is reached, further increase bringing conditions back to the top saturation tip A. It should be clearly appreciated that if at any portion of the cycle such as C, D and E, the magnetisation were removed and then restored, the minor loops C—C', D—D' and E—E' would be swept out in the direction of the arrows. If then a tape were magnetised to saturation as at tip A by passing under a magnet or electro-magnet, on removal from the magnet system (i.e. removing the magneto-motive force) the steel would be left magnetised with a value of remanent flux given by B_R . Now continuing round the main hysteresis loop in the right direction by applying a de-magnetising force of the correct value (by moving the magnetised tape under a magnetic system of opposite polarity), points such as C, D and E, can be reached. Removing the tape from under this second magnetic system carries the magnetic change in the opposite direction to that of the main loop, the portions of the minor loops to C', D' and E' being swept out, leaving these respective remanent

magnetic values on the tape. It will be seen that between the limits C and E on the main loop, corresponding changes of remanence varying between the limits C' and E' are produced when the hysteresis cycle is interrupted by the removal of the tape, and these remanence changes are a linear function of the value of H at which the cycle on the main loop is interrupted. It is the above relationship which makes possible distortionless recording, and a failure to fulfil it will result in distortion in the recording process.

We will now show how these conditions are realised in practice. There are very many possible arrangements by which the necessary magneto-motive forces to effect the above described cycle of operations can be provided, such as single pole systems, open core double pole systems, double pole systems with a closed magnetic circuit, and those with partially closed magnetic circuits. Any of the double pole systems may use both poles on the same side of the tape, or they may be placed on opposite sides as in the Marconi-Stille apparatus, and this type of arrangement has been chosen as best meeting the specific requirements of both recording and reproduction. Fig. 2 (A) shows diagrammatically to a relatively large scale the arrangement and relative disposition of the three electro-magnetic systems or "heads," as they are called. The first head encountered by the tape in its motion is the one which wipes out the previous recording, or Wipe-Out Head. This is a bipolar magnet system with blunt pole pieces pressing up against opposite sides of the tape and staggered longitudinally relative to the direction of motion of the tape, the amount of staggering being relatively large compared to the pole-pieces of the other two heads. The coils of the Wipe-Out Head are fed with direct current, the polarities of the resultant bar magnets being of opposite sign at the respective ends which press upon the tape, thus forcing a longitudinal flux down the tape. The value of the ampere-turns in the coils must be sufficient to bring the tape up to saturation as in A in Fig. 1. After leaving the Wipe-Out Head the tape is left at the point on the loop B_R corresponding to saturation remanence. The tape next moves under the Recording Head where it is subjected to a composite field, the D.C. component of which serves to de-magnetise the tape to the point D of Fig. 1; the A.C. component, which of course alternatively adds and subtracts to the result of the D.C. field, is provided by the speech currents, and it is clear that for distortionless recording the resultant flux changes must lie within the limits C—E. (B), (C) and (D) show the process at different points of the A.C. cycle of the recorded speech. At (B) the A.C. field is zero, and thus when the tape moves away from the recording head it is left with a value of remanent magnetism of D' or practically zero for the case illustrated (although this need not necessarily be the case). At (C) the tape has moved forward and at that instant the speech flux is at its greatest negative value, with the result that when the tape moves from under the pole pieces a remanent value of flux corresponding to E' of Fig. 1 is left on the tape. Similarly (D) shows the effect when the tape has reached C, the A.C. field then being at its maximum positive value.

In Fig. 2 (A) it will be noticed that the pole pieces of the Wipe-Out Head are shown as making contact with the tape over their full width, whereas those of the Recording and Reproducing Heads are shown as chisel-edged. As the Wipe-Out action is effected by a steady field it should be clear that the separation of the pole pieces and their contact area are relatively unimportant, it only being necessary to secure a longitudinal flux up to saturation value with a reasonable value of ampere

turns through the polarising coils, and a large area of contact is therefore preferable. In the case of the Recording and Reproducing Heads, however, it is necessary to make the longitudinal strip, or magnetic slot as it may be called, as narrow as practicable compared with the magnetic wavelength. The magnetic wavelength is the actual physical distance on the tape between two points on the same portion of the magnetic cycle for any given frequency. It will be clear that the frequency \times magnetic wavelength = the tape speed. Now a tape speed of $1\frac{1}{2}$ metres a second has been found the best practical compromise between tape economy and good reproduction of high frequencies. At 5,000 cycles, therefore, the magnetic wavelength will work out at $1,500/5,000$ millimetres, or $\cdot 3$ millimetre. The pole piece spacing of both Recording and Reproducing Heads to secure distortionless reproduction up to this top limit of frequencies has to be about $\cdot 05$ millimetre, but the effective magnetic slot is actually broader than this owing to the spreading action of the flux where it passes from the pole-piece to the tape.

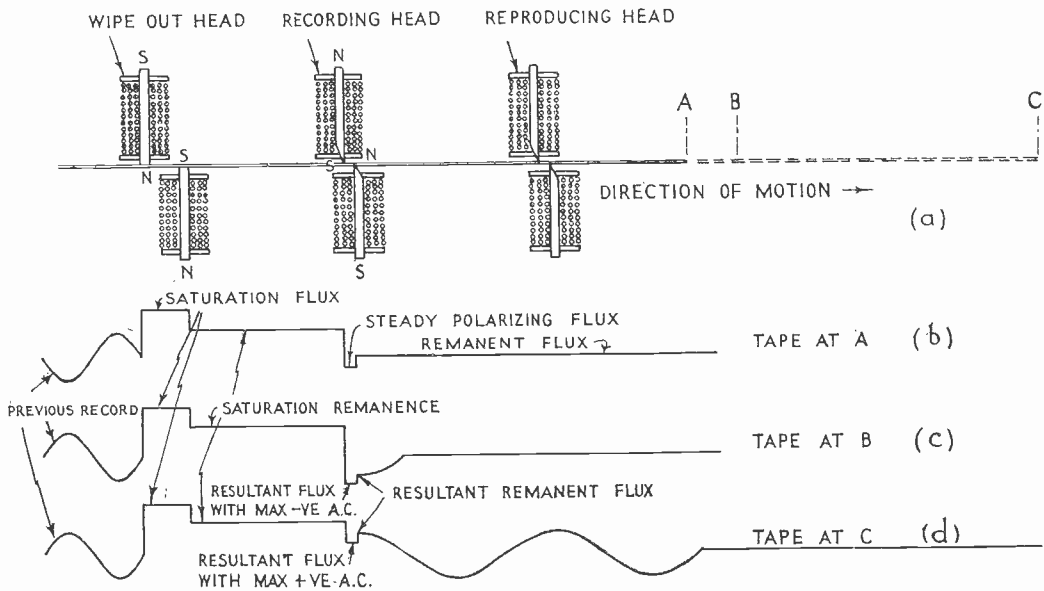


FIG. 2.

Fig. 3 has been drawn to illustrate the variation of the output E.M.F. with frequency for a constant input E.M.F. if various theoretical assumptions are made. As will be pointed out below, the assumptions are only completely justifiable at relatively low frequencies, but the analysis will illustrate how the frequency response curve which obtains in practice, results. The first assumption to be made is that the flux variations in the recording system are proportional to the speech currents at all frequencies over the working range. This is secured in practice by energising the Recording Head from the anode circuit of a valve which is of relatively high impedance to the Recording Head at the highest frequency used. A pentode valve well suits this purpose. The second assumption to be made is that the "magnetic slot" for both the Recording and Reproducing systems is small compared with the "magnetic wavelength." This assumption is only true up to medium frequencies

under practical working conditions. The third assumption made is that the impedance of the Reproducing System is small compared with that of the load into which it works at the highest frequency. This can be secured by employing a transformer of the correct ratio to fit the Reproducing Head on to the grid of a valve, although in actual practice in order to obtain an improved output from the Reproducing Head and to facilitate frequency correction, this condition is not rigidly adhered to.

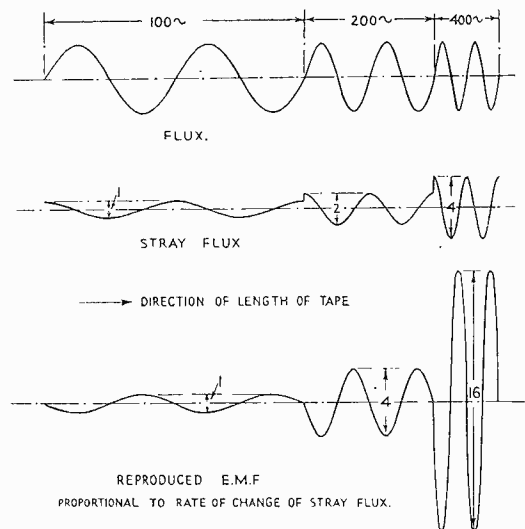


FIG. 3.

A fourth assumption made is that iron loss effects may be neglected, an assumption which is approximately true up to the middle of the frequency range, but which becomes increasingly erroneous from the middle of the range to the highest frequencies. The two top curves refer to the flux actually recorded on the tape. The top curve representing the value of the remanent flux left on the tape for sine wave speech input of frequencies of 100, 200 and 400 cycles respectively (of the same input E.M.F. to the Recording device). As flux in the magnetic slot will be proportional to the ampere-turns in the Recording Head coils, which we have assumed to be proportional to the E.M.F., and the remanent flux is proportional to the flux in the slot, the flux curve will follow the speech E.M.F.

curve. The lines which actuate the Reproducing Head system are not the ordinary remanent lines in the tape but the stray lines which actually leave the tape. Just as in a bar magnet the stray lines vary in density according to the space rate of change of the main flux along the bar (S, the stray flux, varies as $\frac{d\phi}{dl}$), so in the case of the tape

the stray flux emanating from it will vary directly as the space gradient of the flux along the tape. The Stray Flux curve may, therefore, be obtained from the main Remanent Flux curve by differentiating it, the horizontal axes being in each case the length of the tape. It will be clear, therefore, that the stray flux will vary proportionately to the frequency. The stray flux is picked up by the pole pieces of the Reproducing Heads and in cutting the coils which surround the pole pieces an E.M.F. is produced. The value of the E.M.F. will be proportional to the time rate of change of the stray flux or to the product of the frequency \times stray flux. As the stray flux is itself proportional to the frequency, the reproduced E.M.F. will be proportional to the frequency squared. Under practical conditions it is found that up to the middle of the frequency range the output E.M.F. for constant input varies between the first power of frequency and the square of the frequency, drops to a power of the frequency below one as medium frequencies are passed until a peak output is reached at about 2,000 cycles. Above this frequency the various loss effects combine to produce a drooping characteristic. A typical uncorrected overall characteristic is shown in Fig. 4 (a). It will be seen that the shape of the uncorrected curve is very similar to that of the resonance curve of a bluntly tuned parallel

resonant circuit, which immediately suggests the use of a bluntly tuned series resonant circuit as a correction circuit, and this type of circuit is the one actually used in practice. Curve (b) in Fig. 4 shows the type of corrected curve obtained.

Having described the general principles of operation, the apparatus by which the principles are applied will be described.

It will be appreciated that it would be neither convenient nor indeed practicable to build the speech amplifiers and correction circuits into the magnetic recording machine itself. The most convenient division of apparatus has been found to be the following :—

- (1) The magnetic recording and reproducing machine itself.
- (2) The amplifiers, correction circuits, measuring circuits associated therewith, plugs, jacks and switches and monitoring instruments necessary for the switching and control of the programmes to be recorded or reproduced.
- (3) A loud speaker and associated amplifier for the checking of the resultant record and for the comparison of the quality at the input (before recording) against that at output (as recorded).
- (4) A power supply rack to supply the necessary high and low tension voltages to the amplifiers. This is usually fed from A.C. mains, supplying rectified and smoothed D.C. supplies.

The Magnetic Recording and Reproducing Machine.

A photograph of this machine is shown in Fig. 5.

It will be understood from what has been said above that the machine has to fulfil two different functions. The first is the mechanical function of unwinding the tape from the reel upon which it is stored, through the magnetic system which effects the magnetic recording and reproduction at the correct speed, and winding up again on to another tape reel. This process must be reversed when the recording or reproducing operation has been finished, thus leaving the tape on the reel from which it was taken at the beginning. The process of feeding the tape through the machine in the direction required for recording or for reproducing is termed "winding," and the process of feeding the tape back on to the original reel, is termed "rewinding." Referring to the photographs reproduced in Fig. 5. In the front view, the reel which will be unwound in the winding process is shown on the left, the tape passing from the top of the reel under a floating jockey pulley, over another jockey pulley which is mounted on top of the tower upon which the various heads are supported, through the heads which effect the actual recording, underneath and round the tape driving wheel (against which it is pressed by an endless friction belt which runs round four small jockey pulleys), then round another floating jockey, and finally on to the other tape reel. Fig. 6 perhaps makes this rather clearer.

Now it will be clear that the tape driving wheel, or "driving drum" as it is called in Fig. 6, must revolve at an absolutely constant speed in order to impart a uniform motion to the tape. The Drums A and B to which the left and right hand tape reels are fixed respectively (by means of special catch fastenings which allow tape reels to be changed rapidly when required), on the other hand have to be driven at varying speeds according to whether the reels are full or empty. The tape wheel is driven by a three-phase synchronous motor (of the self-starting type) through a

reduction gear. To ensure a steady drive a flywheel is fixed on the same shaft as the tape wheel and a flexible coupling is inserted between this flywheel and the gear box. The drums are actuated from a similar type of three-phase motor. This again drives through a gear box on to a special endless belt drive, which actuates two slipping plate clutch drives to drums A and B. A reference to Fig 6, upon which is marked the direction of rotation of the driving element of the clutches which drive the drums, will make it clear that for winding, in which the tape wheel is driven anti-clockwise, Drum B takes up the drive from the clutch whilst Drum A slips in the opposite direction to its clutch drive while,

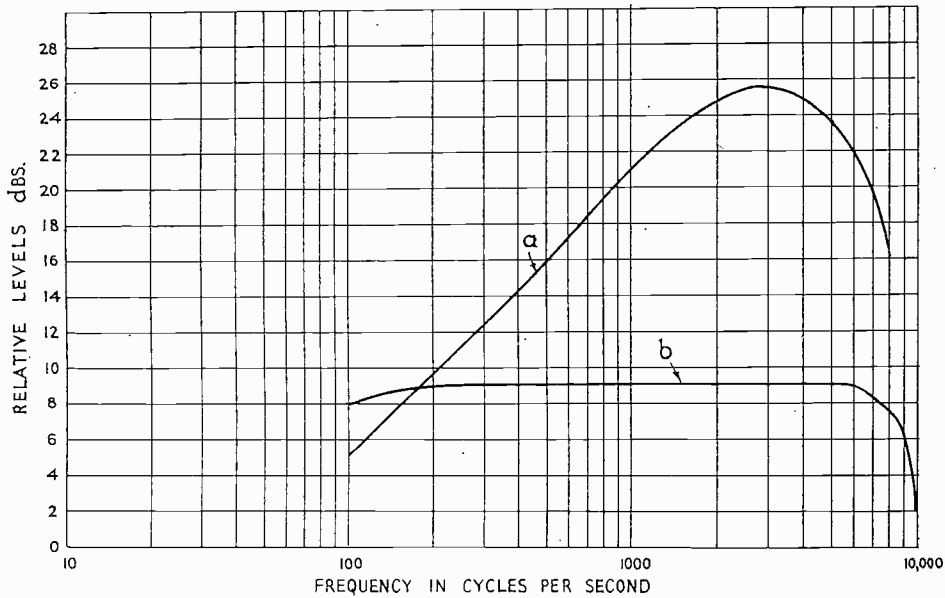


FIG. 4.

however, maintaining tension on the tape, and thus preventing it from looping. On rewinding, the tape wheel driving direction is reversed (the motor being reversible) and drum A takes up the drive from its clutch, drum B's clutch slipping. The gear ratio of the drum drive is so chosen that the clutches can take up the drive for the fastest required speed of rotation, i.e., when the drum upon which tape is being wound is empty. In order to prevent tape breakages, the motor starters are interlocked, so that the drum driving motor has to be started up first, with the result that when the tape drive motor is started the drum drives are already in operation to take up the tape in whichever direction is required without snatching or looping. The tape reels are made deep enough to store tape sufficient for 35 minutes' continuous recording, at the normal tape speed of 90 metres per minute.

The second and vital function which the machine must perform is the actual electro-magnetic operation of recording and reproducing the speech currents, and of course the mechanical function of winding the tape through the part of the apparatus for doing this, which has been described above, is only subsidiary to this. The coils or "heads" as they are called, which fulfil this second function, and

which have already been described in principle, are clearly shown in the photograph, Fig. 5. It will be noted that there are five heads, the reason for this being that as the pole pieces in the recording and reproducing heads have to be kept relatively sharp, it is of advantage to be able quickly to change over to a recording or reproducing head in which the pole pieces have not suffered from wear. A spare recording and spare reproducing head are therefore provided with change-over switches by means of which rapid changes can be made when required.

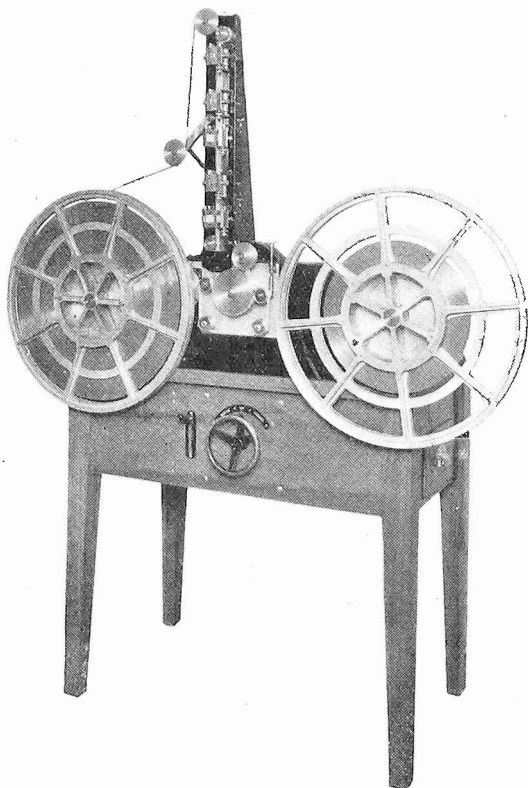


FIG. 5.

As the motion of the tape is downwards through the heads for the winding direction, i.e., for recording or reproducing, the heads, in order downwards from the top, are as follows: 1st (top) Wipe-Out Head, 2nd Recording Head, 3rd spare Recording Head, 4th Reproducing Head, 5th (bottom) spare Reproducing Head. The heads are all mechanically alike in construction. The coils of the heads are faced back and front with ivory, and are let into insulating blocks. These blocks are hinged and very carefully fitted so that the blocks can be swung together, thus enclosing the tape between them (a shallow groove is cut in the blocks and the ivory faces of the coils to accommodate the tape). The pole pieces are guided by the front and back ivory coil end plates in which they are a good fit, and are made to press on the tape by springs, an adjustment being provided to control the pressure, although this is not very critical. In each case the right-hand block can be moved longitudinally relative to the left hand block by means of a micrometer adjustment which can be locked. Means are thus provided for altering the staggering

of the pole pieces in order to obtain the required response characteristic. Stalloy pole-pieces are used for recording, as saturation effects due to the polarising D.C. field must be avoided. Permalloy C, however, is used for the Reproducing Heads, as a higher permeability material can here be used with advantage, as there is no D.C. field to cause saturation.

Photographs of the Amplifying and Control Rack (above) and Loud Speaker Unit are shown in Fig. 7. Upon the Amplifying and Control Rack are situated the Amplifiers, Control and Switching arrangements, the meters for checking the supply voltages and feed currents of the valves, and a Programme Meter for adjusting the recording level to the right value to secure distortionless recording. The equipment is designed to take in a programme for recording at a level of well below one milliwatt,

The Marconi-Stille Recording and Reproducing Equipment.

and to give an output from the record on the tape of over one milliwatt. In practice, it is found that studio switching and control operations are simplified if the input level to the apparatus be made equal to the output from it, although, of course, these levels can be made different if required. The circuits on the Amplifying and Control Rack all receive their high and low tension supplies from the Power Supply Rack, which is shown in Fig. 8, and which is fed normally from 50 cycle A.C. mains, and supplies smoothed H.T. for the 200 volt anode circuits, a 4 volt 50 cycle supply for the Programme Meter, and a 24 volt smoothed D.C. supply to light the filaments of the D.L. type of valves used on the Recording and Reproducing Amplifiers. The

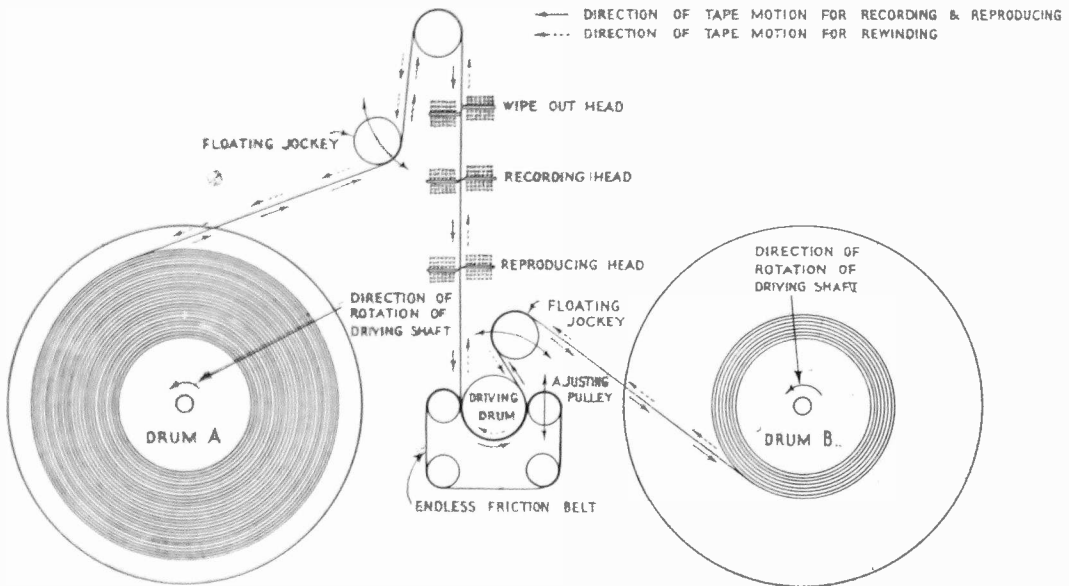


FIG. 6.

Loud Speaker unit, which requires an input signal of a level of one milliwatt and gives an output of ten watts, has its own A.C. power unit so that, if required, it may be used away from the other units.

As has been already mentioned, the Recording Amplifier employs a pentode valve. This unit is placed in the middle of the rack, level with the telephones which are shown on the left of the rack. The recording level can be adjusted to suit any programme level above -10 db. (reference 1 milliwatt) by means of the key attenuator on the left and the potentiometer which is actuated by the knob and dial in the middle. The wipe out current to the "Wipe-Out Head" is controlled by the top knob on the right, whilst the knob immediately under it controls the polarising current to the "Recording Head." Both these knobs are furnished with locking arrangements. The panel immediately above the Recording Amplifier is the Programme Meter, which is a special type of slow return peak voltmeter having an approximately linear scale in decibels, and which, in conjunction with a potentiometer controlling the input to it, will give speech level readings of from -20 to $+20$ db. (reference 1 milliwatt). By means of the Jack Field (which is immediately

The Marconi-Stille Recording and Reproducing Equipment.

above the Switch Panel at the bottom of the rack) the Programme Meter can be plugged across any part of the Recording or Reproducing Amplifier circuits where it is required to check levels. The Jack Field also picks up lines in and out, and the connections to the Heads on the machine itself.

Above the Programme Meter is placed the Reproducing Amplifier, which is a standard three-valve studio A amplifier having a gain of 60 dbs. slightly modified to enable the insertion of the Equaliser Unit between the grid of the second valve and earth. The gain of this amplifier is controlled by means of the potentiometers P on the left of the Amplifier. The Equaliser unit is above the Reproducing Amplifier and is a very simple circuit consisting of an inductance, condenser and resistance connected in series, all these elements being variable over the ranges of adjustment required in practice. The knobs which control the adjustments are fitted with locking devices.

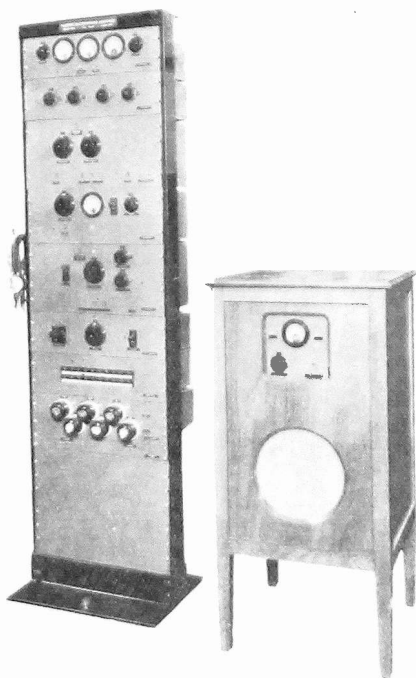


FIG. 7.

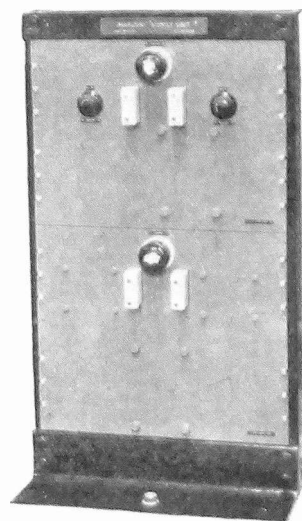


FIG. 8.

The top panel is the Instrument Panel upon which may be read the anode feed currents of all the valves, the wipe out and polarising currents in the Wipe-Out and Recording Heads respectively, and high and low tension voltages to all the amplifiers.

The panel between the Jack Field and the Recording Amplifier is the Control Panel. The key on the left of this switches the necessary connections over to change from Reproducing to Recording. When the switch is in the Recording position a red light serves as a warning that the wipe-out current is on, and therefore rewinding in this position must not be carried out as the record on the tape would be obliterated.

The key on the right hand of this panel switches the Loud Speaker Unit either across the input to the Recording Amplifier, or across the output from the Reproducing Amplifier. By means of the Attenuator controlled by the knob in the middle of the panel, and possibly also the adjustment of the controls the Recording and Reproducing Amplifiers, the volume from the Loud Speaker may be made equal either for output or input. As the reproduction from the tape occurs only about one-tenth of a second later than the recording, and as the ear does not notice this slight interval of time, a ready and very effective means of comparison is given between the quality of the programme before and after the complete recording-reproducing process. Any maladjustment is therefore at once detected, showing up as either a difference of volume between input and output, or a difference of quality. It may be remarked that with correct adjustments, and under normal running conditions, it is difficult to detect the difference in quality between the input and the output signal.

It may be helpful to sum up this short description by enumerating some of the advantages that make this method of Magnetic Recording of special advantage for broadcast purposes as compared with other known methods such as gramophone and film recording.

- (1) Long records, up to 35 minutes duration, may be obtained without interruption.
- (2) The record may be used indefinitely without loss of sensitivity or deterioration of quality.
- (3) Previous recordings on a tape can be obliterated, when these are no longer required, and the tape used again. The processes of recording and obliteration can be repeated indefinitely without damage to the tape.
- (4) Lengths of tape from different programmes can easily be joined together to make up a composite programme. Alternatively, portions of a programme may be obliterated and other matter recorded in their place without any aural trace that this has been done.
- (5) The processes involved are entirely electrical and are very easily followed by the ordinary technical staff of a broadcast studio, and no specialised mechanical or photographic knowledge is required as with alternative methods.
- (6) The instantaneous play-back check makes possible the maintenance of a very high standard of reproduction, as even slight deteriorations of quality are readily observable and can be corrected before they develop further.

A continuous band machine is being developed, which will have several interesting and useful applications for broadcasting. By its use in conjunction with special circuit arrangements, artificial echo effects can be produced simply and with relatively little apparatus as compared with methods ordinarily in use. This machine can also be used for short announcements, phrases of music, or any special signal, which may be made to repeat indefinitely as required.

N. M. RUST.

ELIMINATION OF NIGHT EFFECT WITH A PULSE TRANSMITTER

In one of the methods adopted for Ionosphere investigations, a short transient is radiated from a transmitter, and the received pulse due to the direct ray is received, followed by pulses which have been reflected one or more times at the Ionosphere.

In the following article, a method for the elimination of night effect in direction finding is described, which utilises a method similar to that described above. Pulses are radiated from the transmitter and the direct ray received pulse, as viewed on the screen of a cathode ray oscillograph, is employed for the indication of the bearing.

THE application of the art of direction finding by wireless to navigation has been seriously hampered by the difficulty of obtaining accurate and consistent bearings at night.

Although in certain cases the drawback is not serious, as for instance that of the ship beacon D.F. service, where only a limited range is required, there are cases, especially in air navigation, where the errors of night bearings make this means totally useless for navigational purposes during practically all hours of the night. The cause of these errors is now well known; the errors are attributed to the effect of the energy reflected at relatively high angles from the Heaviside layer. Such reflected waves, in contra-distinction to the waves propagated over the surface of the earth, may be partially or wholly polarised with the electric force horizontal plane.

The magnetically doubly refracting Heaviside layer is responsible for this effect. Any ray in its passage through the layer may have its plane of polarisation twisted through many complete rotations, or by differential absorption may be transformed from a plane polarised ray to an elliptically or circularly polarised ray. In either case there will be a horizontal component of the electrical field which will induce currents in a receiving frame even when this is oriented so that its plane is perpendicular to the ray and will thus cause errors.

Attempts, with varying success, have been made to eliminate this error by the use of directional aerials which do not respond to the effect of the horizontal electric force.

Adcock aerials and spaced differential frame aerials are examples of this type.

The error can be avoided by the use of waves so short that no energy is reflected from the Ionosphere.

A system of this kind has been tried out in America quite successfully within the limits of its range.

The direct ray range of waves less than 9 m. is, however, small; not greater than the undisturbed range at night of the usual 900 m. aircraft wave. Not much is gained in practice by the use of such ultra short waves.

The method of eliminating night effect to be described here depends on the separation of the direct from the reflected ray by the emission of sufficiently short

Elimination of Night Effect with a Pulse Transmitter.

transients—a method considerably developed in the technique of Ionosphere investigation.

Thus if a sufficiently short transient is sent out, the pulse due to the direct ray arrives first and the echoes that have been reflected one or more times at the Ionosphere arrive successfully later. These can be represented on the screen of an oscillograph, by the usual methods of echo technique, and we have a representation in which the direct ray is separated from the echoes. If the signals are received on a frame or combination of frames or any other directive aerial, the indication of the direct ray can be made to vanish when the plane of the frame is oriented at right angles to it and an indication of the correct bearing is given.

All that is required is that the echoes should not overlap, and with modern technique this should not be difficult.

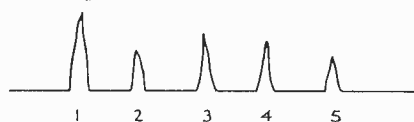


FIG. 1.

Experiments to test the working of this scheme were carried out in June, 1933.

A small portable transmitter capable of delivering about 50 watts to the anode was set up. It had a wavelength range of 100 to 200 metres and gave from 0.4 to 0.8 amp. in an aerial 30 ft. high.

A rotary commutator interrupter served to supply transients of a duration about one-third millisecond repeated regularly at about 80 to 100 per second.

Signals were received on the signal analysing unit consisting of two crossed frames of the Bellini-Tosi type connected to the two field coils of a goniometer.

The crossed frame system was capable of rotation about a vertical axis so that the arrangement could either be used with each single frame alone and the minima found, or else it could be used as a Bellini-Tosi aerial with the bearing shown on a goniometer.

A mutual inductance in each aerial was connected to the output of a signal generator and attenuator unit so that the field intensity of the direct ray and each of the echoes could be measured separately. Finally by misphasing the currents in the aerials (by mistuning) one 45° ahead of the E.M.F. and the other 45° lagging on the E.M.F., the arrangement could be used to determine the polarisation characteristics of the reflected rays. Thus a fairly complete analysis of the signals was possible.

A cathode ray oscillograph was used as an indicator, the horizontal movement of the electron beam being controlled by a Thyatron synchronised with the pulse frequency of the transmitter and the vertical movement being caused by the signal. A typical signal under night reflection conditions is illustrated in Fig. 1, in which 1 represents the direct ray, and 2, 3, 4, etc., the echoes.

The determination of the bearing then consists in orienting the frame or goniometer until signal No. 1 vanishes.

There is no doubt which of the various signals received is the direct ray since this alone remains constant in intensity (for a given orientation of the frame) and also this signal alone gives a definite indication of direction by vanishing at one particular orientation of the aerials.

Elimination of Night Effect with a Pulse Transmitter.

TABLE I.

Date.	Time of Test G.M.T.	Transmitter Location.	Distance Km.	Aerial Current Amps.	Field Intensity.		Corrected to 0.5 aerial amps.	Bearing.	True Bearing.	Remarks on Echoes, etc.
					Pulse.	C.W.				
June 9	1100-1200	Heybridge	17.5	0.57		145	127	93.5	95	Pulse weak, no measurements.
	1400-1500	"	17.5	0.83-0.72						
June 12	1400-1900	Heybridge	17.5	0.80 ?		144	90 ?	95	95	Pulse poor. After returning better results, strong E echo at 1645. Strong E ₁ and higher order echoes, but good bearing on main signal (3 or 4 echoes).
	2100-2200	"	17.5							
June 14	Afternoon	Heybridge	17.5	0.7-0.6		174 } 161 }	133 } 124 }	95	95	Strong E echoes E ₁ , E ₂ , E ₃ , E ₄ , left hand polarised, R hand present for short time at end of programme.
	2145-2245	"	17.5	0.7-0.6						
June 16	Evening 2100-2200	Woodbridge	70	0.5-0.45	<4 v/m		<4			Direct ray pulse only just above noise. Difficult to D.F. Echoes strong.
June 19	1500-1600 2100-2200	Woodbridge	70	0.45-0.40 0.5-0.45						Not recorded. Tuned in to Ratchliffe's transmission at Cambridge on nearly same wave and did not realise mistake till after programme. No direct Ray observable.
June 21	1500-1600	Colchester (Monkwich)	33	0.4-0.35		Varying { 17.1-23 12.6-16 }	22.4-28.7 } 15.8-20 }	75-80	74	Jammed by London National Harmonic 130.5. Echoes strong and jumbled. Bearings difficult on account of unsteadiness and noise.
	2145-2300	"		0.4	16-17.8					
June 23	1500-1600	Colchester (Monkwich)	33	0.5-0.45		{ 16.0 12.5 }	16.8 } 13.0 }	73	74	Good pulse, small E echo. E echoes up to 2200 composite R and L. F echoes developed after 2200.
	2100-2300	"		0.4-0.37	18.8					
June 27	1500-1600	Colchester (Higham)	43	0.5-0.45	13.7		14.4	66	56	Jamming severe.
	2100-2245	"		0.45	9.5		10.5	64-68	56	E Echoes up to 73 μ v/m. Mixed L and R more distant, mainly left.

Elimination of Night Effect with a Pulse Transmitter.

The echo signals were in general variable in intensity and did not vanish for any position of the frame, or of the goniometer when the arrangement was used as a Bellini-Tosi aerial.

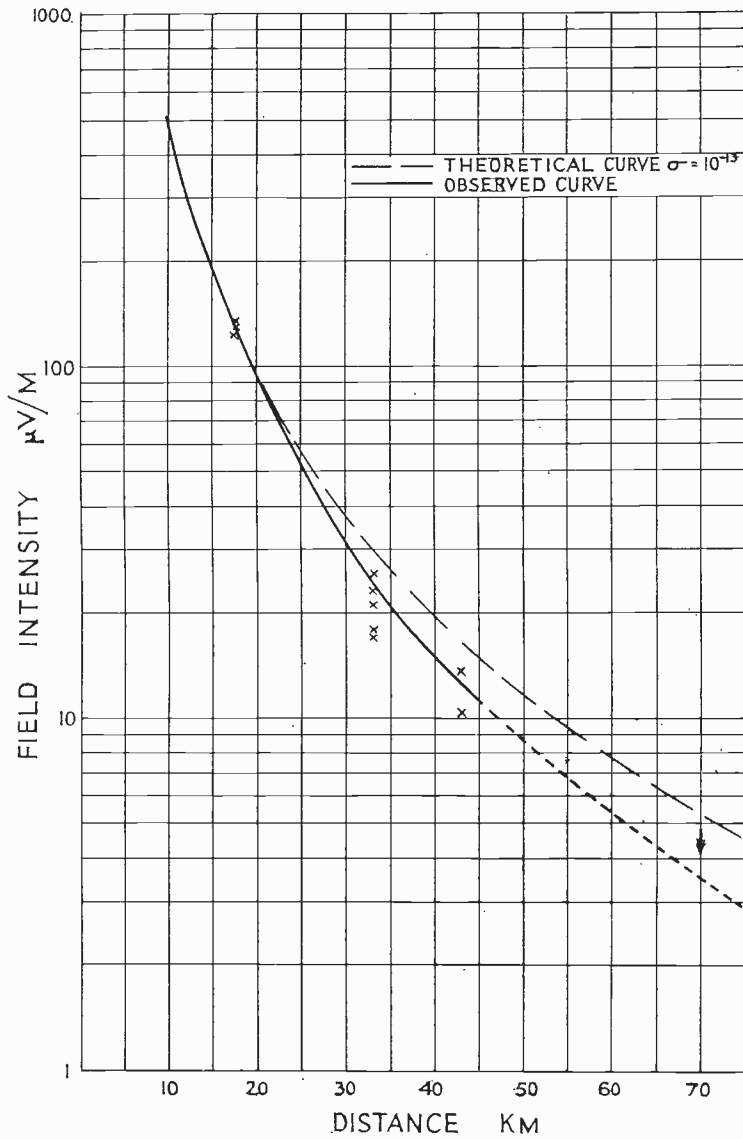


FIG. 2.

Results.

The table given on p. 14 gives a summary of the tests made.

The direct ray field strength corrected to 0.5 amp. in the aerial is shown in Fig. 2.

Elimination of Night Effect with a Pulse Transmitter.

For comparison, the theoretical curve (λ 150) which fits the points at $d = 20$ km. is given.

The actual attenuation is slightly greater than the theoretical one, with $\sigma = 10^{-13}$ C.G.S. units.

Thus the direct ray field intensity falls away approximately as the theoretical Sommerfeld formula indicates.

It is to be noted that the ordinary methods of C.W. measurement will not give a reliable attenuation curve for the direct ray since such measurements include the effect of the reflected ray which even in daytime in midsummer have been found to be appreciable at more than about 30 km. The ranges to be expected with 150 m. transmission will be considerably greater, even in summer daytime, than those predicted by the direct ray formula, and the increase will probably be particularly marked in winter daytime.

The results show that bearings free from night effect can be taken so long as the direct ray signals are above noise level. Even though, as was observed, no sign of a bearing was obtained with telephone reception.

With the apparatus as constructed this requires a level of field strength above about $5 \mu\text{V}/\text{m}$.

There was no difficulty, other than that occasioned by noise and the unsteadiness of the transmitter, in taking bearings, even when the reflected ray was some 5 to 10 times the intensity of the direct ray, and when ordinary methods (e.g., telephone reception) gave absolutely no indication of direction.

The bearings at the shortest distance, i.e., 17.5 km., were good, those observed being 93, 95, 95 with a true bearing of 95° .

At greater distances the uncertainties were greater. At Monkwich, near Colchester, bearings of 73 were obtained in daytime and 75 to 80 at night with a true bearing of 74° . The night bearings were chiefly marred by noise and unsteadiness of transmitter and I do not think there was any significance in the difference between day and night bearings observed, since the former were partially jammed.

The difference at Higham, near Colchester, is greater, 66° being the observed and 56° the true bearing. The apparatus and frames were all housed in a hut and distortions due to wiring, etc., have been observed. The errors are, I am convinced, instrumental, and occasioned by the necessarily limited space in the hut. This is confirmed by the fact that bearings remained constant during the worst night effect conditions. No special precautions were taken to obtain high accuracy.

The results show quite definitely that the scheme is workable.

Even with the small frames at our disposal, directional measurements could be made down to field strengths at which the original longer wave Adcock (900 m. for aircraft work) was limited. With suitable design the signal to noise ratio could be considerably improved. The chief drawback of the scheme is that the noise level of the arrangement is necessarily high on account of the wide band receiver used. This is required to give a faithful representation of the transients without overlapping.

The analysis of the echoes received is of more scientific than practical interest, but it is of interest to note that in contrast to what have been previously observed, there are occasions when the reflected ray is right-hand circularly polarised.

T. L. ECKERSLEY.

MARCONI PRECISION MODULATED RADIO FREQUENCY GENERATOR AND ATTENUATOR TYPE 487

Following the introduction some months ago of the unmodulated Radio Frequency Generator and Attenuator Type 479 (described in THE MARCONI REVIEW, No. 38), the Marconi Company now introduces a companion model which provides a modulated carrier output.

In effect the new instrument is a reproduction in essentials of the Type 479 instrument (a great many of which are already in use) with the addition of extra circuits to enable the modulation of the carrier output to any depth up to 80 per cent. A modulating voltage source is provided as an independent unit.

The new instrument will perform with equal facility all the functions of the Type 479 instrument, but naturally it possesses much wider fields of application.

Some improved design features are incorporated in the radio frequency attenuating system of the Type 487 instrument.

Purpose of the Instrument.

MODERN standards of radio receiver production and maintenance require accurate quantitative measurement of every type of overall and stage-by-stage performance. Until comparatively recent times it was customary to form an idea of some aspects of a receiver's performance from an aural estimate of relative output values. In most cases the magnitude of the input signal was, in turn, also the subject of an estimate. Subsequently more accurate methods of measurement were employed; one method was to use field strength measuring equipment to ascertain the field intensity at the receiver aerial of a distantly radiated signal and to measure the ratio of the receiver power output, due to the received signal, relative to some predetermined output level. If proper precautions are taken such a method is capable of providing accurate data, but the disadvantages of this and other similar methods are obvious. From practical considerations it is equally obvious that full local control of all the essentials necessary to the completion of accurate and reliable radio receiver tests and measurements is required. Briefly the requirements are to simulate locally the conditions of the incoming signal and to match the normal aerial and input conditions of the receiver under test. Full control and knowledge of signal intensity and frequency must be at once available. The primary function of the Precision Modulated R.F. Generator and Attenuator Type 487 is to enable the fulfilment of these requirements in such a manner that the test operator is provided with absolute control at the receiver of all the essentials necessary to the completion of any type of performance measurement. The required data can be accurately and rapidly determined. Simple calculation is sufficient to reduce the readings obtained with the instrument to quantitative form.

Applications.

The following are a few of the radio receiver characteristic measurements that the Type 487 instrument will perform.

Sensitivity, selectivity, ambiguity or image signal discrimination, high frequency and overall response curves, test of automatic volume control, calibration of output detector in terms of signal modulation, etc., etc. The stage-by-stage characteristics of R.F. and (in superheterodyne receivers) I.F. amplifiers and detector characteristics can also be measured.

For test purposes the instrument can be used as a low power transmitter of known power output.

In view of the very numerous test uses to which the instrument is adaptable it will provide a very valuable addition to the equipment of radio test and research departments.

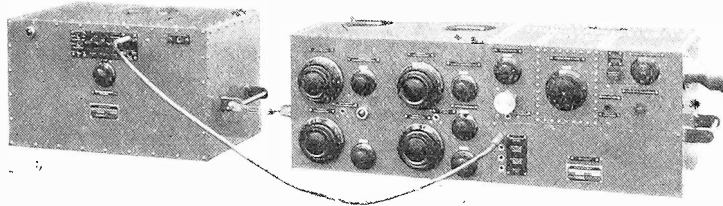


FIG. 1.

Design Features.

The following are some of the salient features of the design :—

- (1) A wide range of operating frequencies.
- (2) A wide ratio of maximum to minimum voltage output.
- (3) Low percentage carrier scintillation.
- (4) Ability to vary the output without disturbance to carrier setting or depth of modulation.
- (5) Low output impedance at all output levels.
- (6) Adaptability to various types of receiver input.
- (7) Extremely efficient R.F. screening at all frequencies.
- (8) Low percentage harmonic distortion.
- (9) Universal metering.
- (10) Availability either in battery or A.C. mains operated form.
- (11) Accessibility of interchangeable components.
- (12) Smallest possible variation of performance with frequency over the full frequency range.
- (13) Minimum physical dimensions.

The complete equipment comprises two independent self-contained units and is illustrated in Fig. 1. The main unit embodies all the circuits which operate at radio frequencies, whilst the auxiliary unit carries the circuits comprising the modulating voltage source. The equipment is designed for bench use and its proportions are such that it is readily transportable to any desired location.

Operating Ranges.

The operating ranges of the equipment are as under :—

(A) *Wave Ranges.*

For modulated outputs 14 metres to 2,000 metres.

„ unmodulated „ 14 „ „ 5,000 „

(The unmodulated output range is extensible to 22,000 metres to meet special requirements.)

(B) *Voltage Output Ranges.*

Maximum modulated voltage output 25 metres to 2,000 metres 200* millivolts

Minimum „ „ „ 14 „ „ 25 „ 160 „
Minimum „ „ „ 14 „ „ 2,000 „ 0.185 microvolt

(* This value is slightly greater on some wave ranges.)

Maximum unmodulated voltage output 14 metres to 5,000 metres 320 millivolts

Minimum „ „ „ 14 „ „ 5,000 „ 0.185 microvolt

In all cases the voltage output is continuously variable between the maximum and minimum output values.

(C) *Modulation Ranges.*

Maximum depth of modulation 80 per cent.

Minimum depth of modulation 10 per cent.

The depth of modulation is continuously variable over the whole range. Provision is made for the use of external modulating voltage sources and when such are employed, in conjunction with a calibrated low frequency attenuator, very low values of percentage modulation are possible.

Radio Frequency Circuits.

The radio frequency circuits consist of a generator and a modulator-isolator stage. Suitable switching is incorporated for the exclusion of the modulator-isolator stage when an unmodulated radio frequency output is desired. For modulated carrier outputs the generator serves as a drive to the screened grid modulator-isolator valve circuit.

Modulation is effected by superimposing an audio frequency voltage on the D.C. voltages applied to the screen grid and anode of the isolator valve. This method minimises carrier frequency scintillation, particularly at very high carrier frequencies. The radio frequency output of the modulator-isolator valve is substantially linear with respect to anode and screen grid voltages well over the range of voltage variation equivalent to 80 per cent. modulation. Fig. 2 gives the modulation characteristic of a typical modulator valve. There is thus very little carrier amplitude distortion during modulation.

The depth of modulation is measured by the ratio of the radio frequency current rise during modulation. The sensitive galvanometer incorporated with the equipment enables the accurate checking of this current ratio.

Two main radio frequency voltage output levels, possessing a generous overlap, are available through the operation of a selector switch. The final output is controlled by (A) variation of radio frequency input current to the attenuating system, and (B) manipulation of the controls of the attenuating system. In practice method (A) is only employed for the purpose of setting a general level about which the output

Marconi Precision Modulated Radio Frequency Generator and Attenuator Type 487.

voltage may be varied by method (B). To avoid disturbance to modulation setting on variation of the radio frequency current input to the attenuating system, a load compensating control is provided. Measurement of the radio frequency current is effected by a thermo-junction in association with a very sensitive unipivot galvanometer.

The main radio frequency attenuator consists of a resistance network of an unbalanced π section form specially designed as to radio frequency screening and method of operation. It provides a total attenuation of 60 db. calibrated in four equal steps of 15 db. The radio frequency output potentiometer supplies intermediate variation in 2 db. steps over the range of the main attenuator steps. This unit, which is also specially designed to ensure satisfactory performance at very high frequencies, provides a total attenuation of 15 db. The total overall attenuation is therefore 75 db.

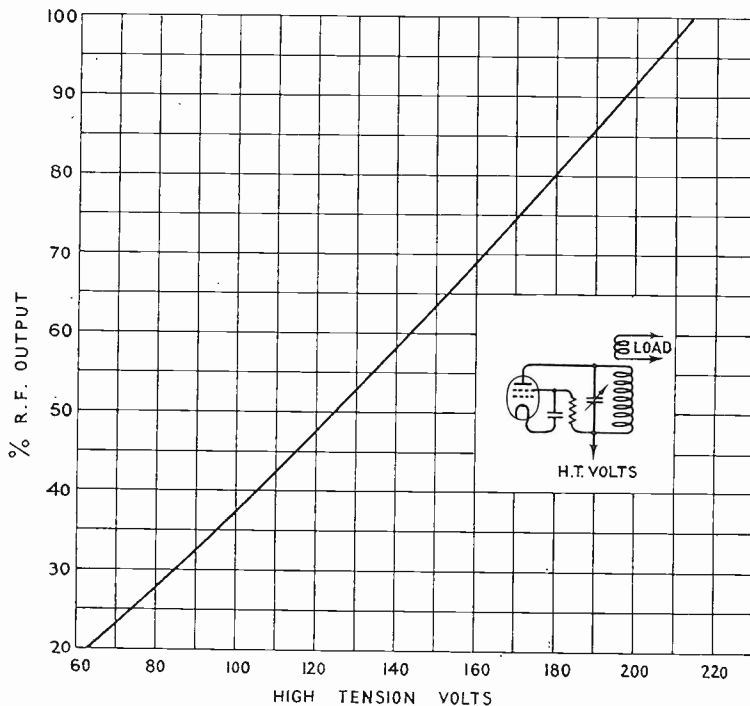


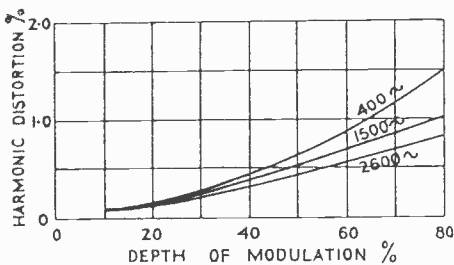
FIG. 2.

The output impedance of the attenuating system does not exceed 8 ohms under any condition of operation. This low value is deliberately employed in the design in order to give the instrument the widest possible range of useful application. A higher value of output impedance would have provided a correspondingly higher maximum output voltage, but with this class of instrument it is a usual condition of operation, if the performance of the instrument is not to be impaired, that the value of any load impedance employed across the output terminals of the attenuator must be of a high order compared with the output impedance. Many classes of

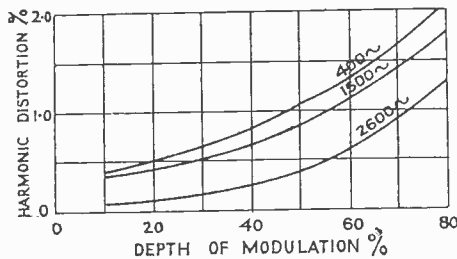
measurement, however, preclude the use of extremely high impedances. The voltage output of the Type 487 instrument is considered to be sufficiently high for the great majority of purposes.

A dummy aerial, primarily intended for matching the conditions of half-wave vertical aeriels, is included internally in series with the output terminals of the instrument, while suitable provision is made for the alternative substitution of any other desired type of dummy aerial circuit.

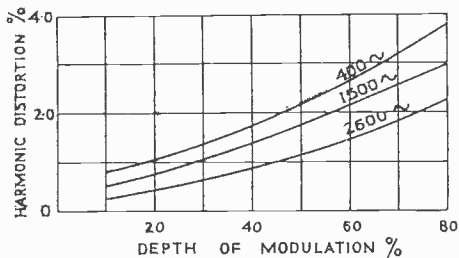
The satisfactory performance of any radio frequency test source depends almost entirely on the efficiency of the internal and external radio frequency screening.



(A) *Harmonic Distortion Curves of Sub-Modulator.*



(B) *Harmonic Distortion Curves of Modulator.*



(C) *Overall Harmonic Distortion Curves.*

FIG. 3.

In fact, accurate quantitative measurement, especially at very high frequencies, is impossible unless internal "jump over" effects and external leakage are entirely negligible. In designing the Type 487 instrument, extreme care has been exercised to ensure the degree of screening efficiency requisite for accurate quantitative measurements at all the frequencies over which it operates. Internally, the various circuits and components are adequately screened from each other, and suitable radio frequency filter circuits are included where necessary. Double screening is employed at all points where external leakage is likely to occur. Supply batteries, or the A.C. mains supply units, are included internally owing to the impossibility at all frequencies to effectively preclude stray radiation from external connecting leads when limits are imposed on the D.C. resistance value of any filter system that may be employed. When operating from A.C. mains, suitable filters are included in the mains supply leads.

Modulating Voltage Source.

The circuits of the modulating voltage source comprise a low frequency generator, an harmonic filter and a sub-modulator, together with power output controls. The standard equipment provides modulating tones at 400, 1,500 and 2,600 cycles. These three frequencies effectively span the commercial speech frequency band. Other frequencies, between the limits of 100 and 5,000 cycles, are available to meet special requirements but in every case no more than three internal fixed frequencies can be provided in an individual instrument (see subsequent paragraph *re* the employment of external modulating tone sources).

The power output from the sub-modulator circuit is sufficient at all frequencies to modulate the maximum radio frequency carrier output to any depth up to 80 per cent. The output at any level is balanced between each frequency so that a modulation setting on any one frequency holds good for each of the other frequencies. This feature facilitates rapid test operations.

The design of the modulating circuits is such that at all modulating frequencies the percentage of harmonic distortion present in the modulated carrier output is of a very low order. Fig. 3 gives the results of harmonic distortion measurements made with the Marconi Bridge Type Harmonic Distortion Factor Meter on a representative equipment.

Provision is made at two points in the equipment for the employment of modulating tone sources at frequencies alternative to the internal tone frequencies. In one case an external tone source may be connected to the input circuit of the sub-modulator valve in such a manner that the internal modulation depth controls remain in circuit. For this arrangement an input 3.0 milliwatts is required for 80 per cent. carrier modulation. In the other case an external tone source may be connected direct to the modulator circuit but in this case the external source must possess its own power output control. Also, for this case, when the instrument is being employed at very low radio frequency output levels, and to avoid misleading measurements, the external modulating voltage source must be adequately screened. For this arrangement a power input of 120 milliwatts is required for 80 per cent. carrier modulation. For each of these external modulating voltage source arrangements the input impedance is 600 ohms.

Metering.

A very useful feature in connection with the satisfactory operation of the equipment is the provision of jack points to enable the checking of valve feed and grid currents and high tension voltages. All these measurements, in addition to the radio frequency current measurements, are made through the galvanometer incorporated in the radio frequency unit. The performance of any circuit can thus be instantly checked.

Supply Voltages.

All valves in the equipment are of the 2 volt filament class operating at anode potentials up to 150 volts. Each unit is fitted with self-contained D.C. voltage supply sources whether the instrument is battery or mains operated. The mains operated model is designed to operate from a 50 cycle 200/250 volts supply. Incidentally, this model is easily convertible at will to battery operation by the mere substitution of the necessary batteries for the mains unit and the changing of a few simple terminal connections.

Mechanical Design.

The physical dimensions of the equipment have been kept as low as possible consistent with satisfactory operation. The cases and inter-compartment screening

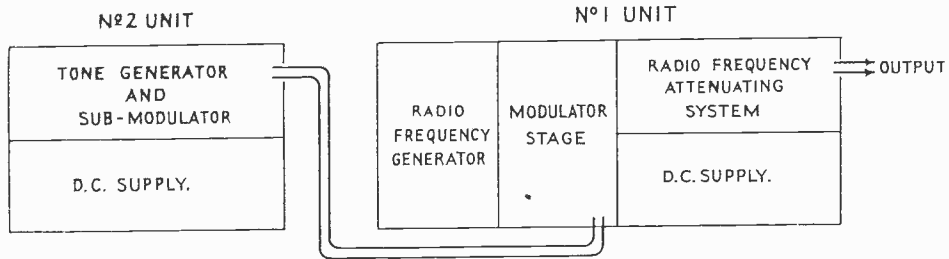
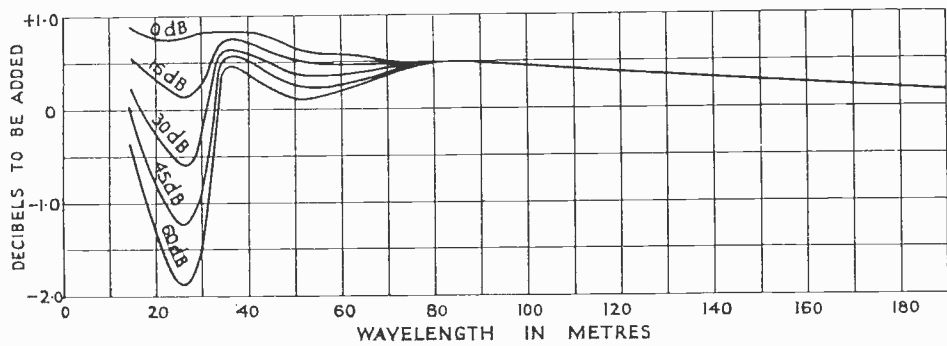


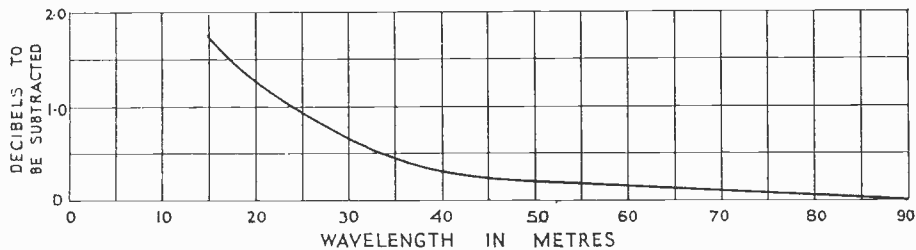
FIG. 4.

partitions of the instruments are carried out in copper or brass. These materials were found to be the most satisfactory to the achievement of the standard of screening efficiency, at all frequencies, aimed at.

Each unit of the radio frequency attenuating system is removable as a whole from the main screening case, whilst the resistance network system of the main attenuator can be instantly withdrawn from the instrument for inspection without the removal of any covers or connections.



(A) Low level output. Overall frequency correction curves.



(B) High level output. Overall frequency correction curves.

FIG. 5.

All controls are arranged to operate from the front of the instruments. Their operation is smooth and they are without backlash. Each control is fitted with a

name-plate indicative of its function. The frequency controls are fitted with suitable reduction gears to facilitate tuning operations. All the interchangeable components of the equipment are readily accessible.

The sensitive unipivot galvanometer used with the equipment is conveniently accommodated in a small drawer fitted with a travel stop to prevent its accidental complete withdrawal or damage. The meter operates inside the drawer and its movement is automatically clamped when the drawer is closed, thus avoiding damage during transport.

Fig. 4 illustrates the schematic layout of the apparatus.

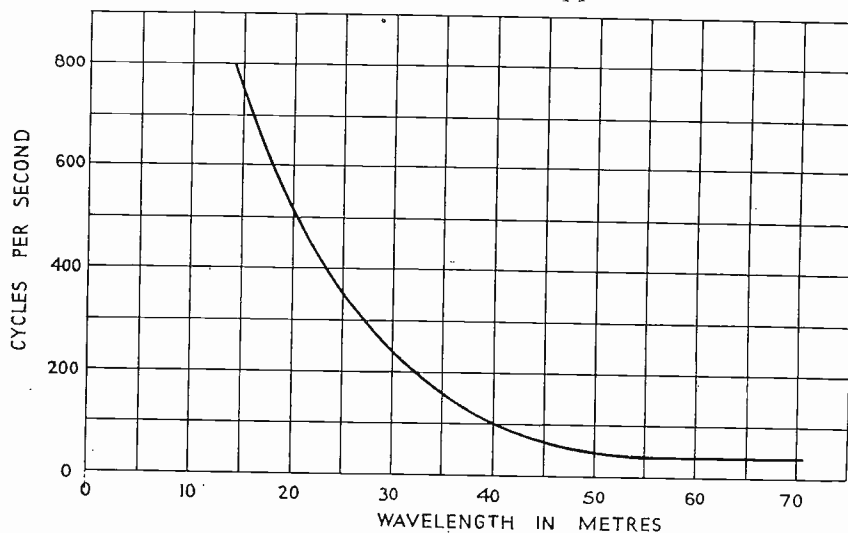


FIG. 6.

Frequency Correction.

The controls of the radio frequency attenuating system give a true indication of the attenuation in circuit for all frequencies up to 2,000 kcs. A correction, which reaches an overall maximum of less than 3 db. at the highest operating frequencies is applicable at frequencies above 2,000 kcs. This correction is, however, almost negligible up to 3,000 kcs. Fig. 5 shows some representative overall frequency correction curves.

Carrier Frequency Variation with Voltage Output.

At output levels up to 32 millivolts no carrier frequency shift occurs at any part of the frequency range with variation of the attenuating system controls. At higher levels of output and at the higher frequencies only a small percentage carrier frequency change occurs with variation of the voltage output.

Harmonic Distortion.

The harmonic distortion present in the modulated carrier output at 80 per cent. modulation is less than

4.5	per cent.	at a modulation frequency of	400	cycles.
3.5	"	"	"	1,500 "
2.5	"	"	"	2,600 "

Carrier Scintillation.

The carrier scintillation or "wobble" at 80 per cent. modulation does not exceed

1,000 cycles at a carrier frequency of 20,000 kcs.

500 " " " " 10,000 "
and is negligible at carrier frequencies less than 3,000 kcs., as is shown in Fig. 6.

Output Impedance.

The output impedance of the radio frequency attenuating system varies between 6 and 8 ohms over the range of output up to 32 millivolts, and between 4 (approx.) and 8 ohms over the range of output between 32 millivolts and maximum output. These values are subject to a slight variation at very high frequencies. Load impedances connected across the output terminals of the instrument must, in general, be of a sufficiently high value as to have no appreciable effect on the output impedance. For particular cases lower load impedance values may be employed if due allowance is made when calculating the output voltage. Instruction on this point is supplied with the instrument.

Leakage.

The maximum radio frequency leakage does not exceed a total E.M.F. of 0.25 microvolt at the higher frequencies and 0.5 microvolt at the lower frequencies. To detect these very localised fields it is necessary to use a high quality triple detection narrow band commercial receiver and explore the control bearings and covers of the instrument. Simple unscreened receivers and coupling devices can be tested in close proximity to the instrument without serious errors being experienced.

THE M.G.8A FREQUENCY METER

The following article concludes the description of the M.G.8a frequency meter, the first part of which was given in the last issue of THE MARCONI REVIEW.

NOW if a 4-electrode valve is connected by condenser-resistance unit to a tuned circuit, and if the anode of that valve is a simple circuit including only a milliammeter and battery, it will be found that when the complete instrument is undisturbed by a frequency, then the anode current is perhaps 4 milliamps. Upon the circuit being tuned to an incoming frequency the valve and consequently the anode current suffer a change and this current may be reduced to say 3 milliamps. Thus only 25 per cent. of the milliammeter scale is useful and moreover, the indication is from maximum to minimum. With the system illustrated in Fig. 1, the fixed resistance in the anode circuit of the valve is approximately equal to the static resistance of the valve anode to filament. The potentiometer and its connections to valve, fixed resistance battery, etc., constitute a bridge and if this is adjusted by means of the potentiometer when the instrument is at rest, then when the disturbing force, i.e., the frequency to be measured, appears, the valve resistance changes and the bridge becomes unbalanced. A current will flow through the galvanometer and as this galvanometer may now be of 0.5 milliamps. full scale deflection, the deflection is much greater than when using the simple circuit with the coarse milliammeter and the deflection is now from zero to a maximum.

It will be appreciated that with the system in use the sensitivity is greater than in other arrangements and in consequence the instrument need not be so tightly coupled to the frequency generator to be measured. The presence of the potentiometer in shunt with the galvanometer does not greatly reduce its sensitivity as the potentiometer resistance is of the order of 2,000 ohms and that of the galvanometer about 30 ohms. On account of the bridge system and other connections to the valve, only three battery supply leads are necessary. These are Common Negative; L.T. Positive and H.T. Positive. The high tension voltage should be of the order of 120 volts, but this is not very critical and whilst the instrument can be supplied with high tension from a common station battery, it is preferable that a separate battery should be used for the purpose, as unless precautions are taken with other apparatus on the common battery there may be some disturbing feed back from this other apparatus. In spite of the precautions which have been taken to produce a low resistance measuring circuit and a highly sensitive detector, it will be realised that a visual indication of a change of 1 part in 10,000 in frequency is a somewhat difficult matter.

To overcome this difficulty a very simple scheme is adopted. In Fig. 1 will be found two small condensers each connected to a key and each small condenser and key shunting the appropriate fixed and variable portion of the measuring condenser.

If a curve is drawn showing galvanometer deflection against condenser scale with the small condenser disconnected, a figure results as shown in Fig. 3. If now the small condenser is connected to the main condenser another figure appears similar in all respects to the previous curve but somewhat displayed in terms of the

The M.G.8a Frequency Meter.

condenser scale from the previous curve. Further, if the value of the small condenser is properly adjusted in terms of the main condenser, the two curves will intersect at a point where the slope is steep, and the point of intersection will be as far removed from the true resonance point of the system without the extra small condenser as with it. This scheme is used for obtaining fine discrimination in the instrument. In practice, the instrument having been set up with the correct inductance battery supplies, and the galvanometer balanced to zero, the frequency to be measured is introduced. The instrument is brought to resonance by the adjustment of the condenser whose adjusting handle is found sunk in the right hand lower

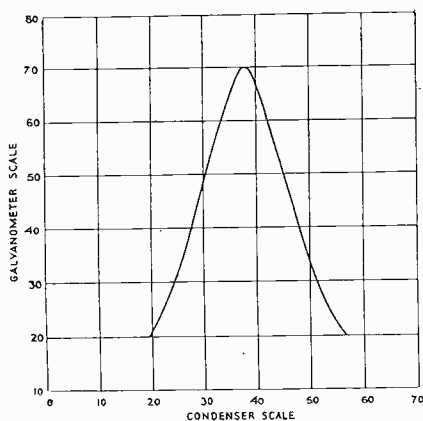


FIG. 3.

portion of the front end of the instrument. At the left hand side of the instrument will be found a small press button. Resonance having been effected the button is pressed, resulting in a change of galvanometer deflection. The instrument is then retuned somewhat, in this case by increasing the scalar position of the condenser, and the button released. By continuing these operations a position of condenser will be found where pressing or releasing the button does not change the galvanometer indication, as the condition shown in Fig. 4 at the point R marked "Balance" is attained. This scale position is then referred to the calibration chart and the frequency read off. It has been stated previously in returning after depression of the button, the condenser scale position must be increased. This is because as the instrument is normally calibrated in frequencies the condenser has been arranged to have its maximum capacity at zero scale position. This gives a right hand slope to the characteristic of frequency against scale position. Whilst it is usual to calibrate the instrument in frequency, there is no objection to a calibration in wavelength, or even in both systems. This has been done at the request of clients. Calibration of the instrument is made at a fixed temperature, against standard frequencies checked daily against Greenwich time.

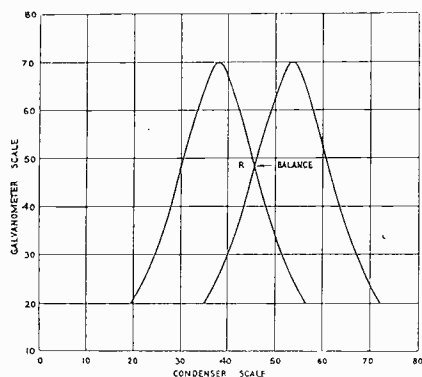


FIG. 4.

The temperature co-efficient of every range is measured and recorded upon the range chart.

For extra accuracy a thermometer is fitted to the instrument, so that the temperature can be taken into account.

The whole apparatus normally consists of an instrument body, a periodic pick-up coil, 25 range inductances, set of calibration charts and carry case.

Although 25 ranges are necessary for the complete band width of 100-3,000 kcs., fewer coils to cover a restricted band can be

The M.G.8a Frequency Meter.

supplied. The photograph, Fig. 5, shows the complete instrument. Here will be seen at the top and in the centre the handle of the galvanometer protecting key and shunt. Below this is the handle of the balancing potentiometer. Flanking this potentiometer on either side are two octagonal caps, that on the left covering the valve well and that on the right the inductance well. Below the galvanometer is the scale window, and still lower the thermometer.

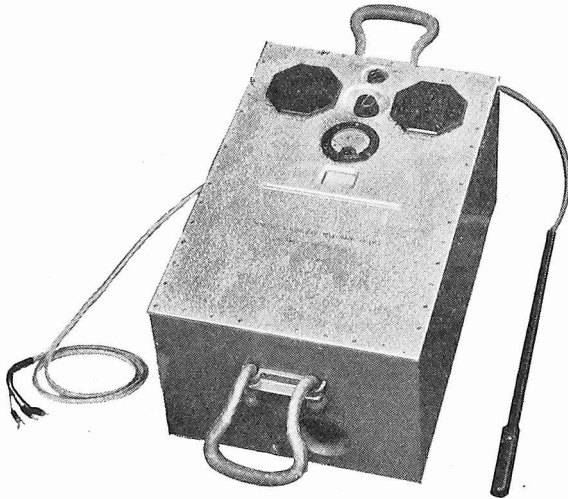


FIG. 5.

At the front in the right hand lower portion and sunk is the main tuning handle, whilst on the left, not seen in the photograph, are the battery lead socket and "de-tuning" or "balancing" device. At the far end of the instrument is fitted the aperiodic "pick-up" coil, cable and plug, the plug fitting into a suitable socket. As far as possible all fittings, tuning handles, etc., are flush with the case so that damage in transit may be avoided. Only one "pick-up" coil is supplied for all ranges. This has been made of a value suitable for the complete instrument.

The covers capping the wells in which are situate the valve and measuring inductance are of insulating material and are retained in position by means of spring controlled ball and socket catches. To remove the cap is rotated slightly and the cover lifts a little and is easily withdrawn. To replace the cap is pushed in and rotated until a slight "click" is heard indicating locking.

Two stout handles, one at each end of the instrument, assist in transportation.

Plug-in covers are supplied for the vents into which the "pick-up" and battery leads are inserted.

The instrument is sealed after calibration and these seals should not be broken, as, if the cover is removed, the screening will be disturbed and the calibration affected.

As it is possible that the galvanometer, the potentiometer, or even the galvanometer protecting resistance and short circuit key may be damaged by accident or other cause, arrangements have been made to prevent removal of these items without breaking the sealing. To effect these removals the screws about the items are withdrawn and it will then be found that the defective details can be gently pulled from their seatings. These are all on efficient plug connections and, if damaged, can be removed, repaired and replaced with ease.

The instrument, being of high precision, should be handled with care and protected from mechanical shocks. It should not be stored in a place subject to severe changes of temperature, but if possible in a dry place of equable temperature. If possible, occasional checks against a known standard should be made so that the behaviour of the whole can be known.

T. D. PARKIN.

MARCONI NEWS AND NOTES

IMPORTANT NEW BROADCASTING STATIONS.

THE Marconi Company's premier position in the design and construction of broadcasting stations is again demonstrated by the fact that the three latest European broadcasting stations, including two of the "super-power" class, are all to come from the Marconi Works, Chelmsford.

The Swedish Royal Telegraph Administration has just ordered a new Marconi broadcasting station to replace the existing station at Motala, in accordance with the Swedish Government's decision to improve the existing broadcasting facilities in that country. The aerial energy of the new Motala transmitter will be 150 kilowatts unmodulated aerial input, while the design is being so arranged that this input may be increased to 220 kilowatts if desired at a later date. An unusual feature of the station is that it will also be capable of operation for high-speed telegraph transmission with a power of 100 kilowatts.

The Roumanian Broadcasting Company have also placed an important order with the Marconi Company for the supply of two broadcasting stations, one with an aerial energy of 150 kilowatts and the other of 20 kilowatts. The latter is now temporarily operating at Bod until the 150-kilowatt station is completed, when it will be transferred to another site.

The design of these stations incorporates in every case the Marconi system of series modulation, ensuring the highest quality of transmission for every class of programme, and special arrangements have been made for frequency control of the highest degree of accuracy.

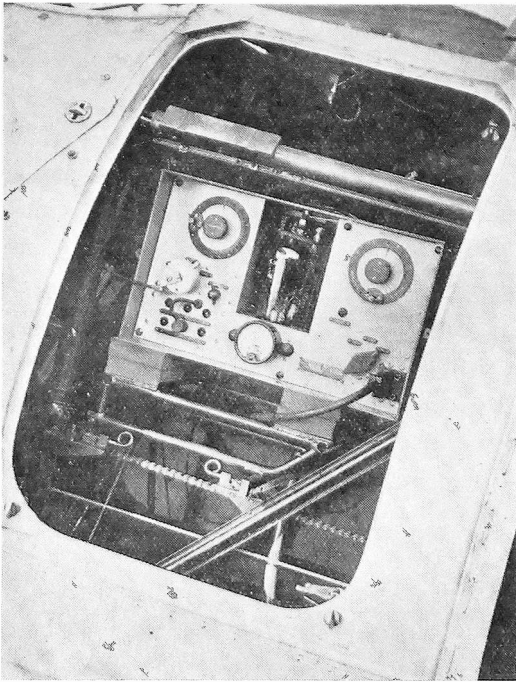
Cape Town : "Listeners Enthusiastic."

Beyond the borders of Europe, a Marconi station just completed is the 10-kilowatt installation at Milnerton, near Cape Town, replacing a Marconi station supplied in 1924. The following Press reports of the station's first test transmissions need no further comment :—

"Listeners are enthusiastic about the half-hour test programme which was broadcast by Cape Town's new transmitter on Thursday night. The programme consisted of gramophone records, and was broadcast immediately after the regular evening transmission. Letters of appreciation from listeners ranging between Muizenberg and Maitland were received by the studio yesterday. All spoke of greatly improved reception and remarkable freedom from atmospherics.

"The broadcasting officials, the most cautious of men, are also delighted with the results.

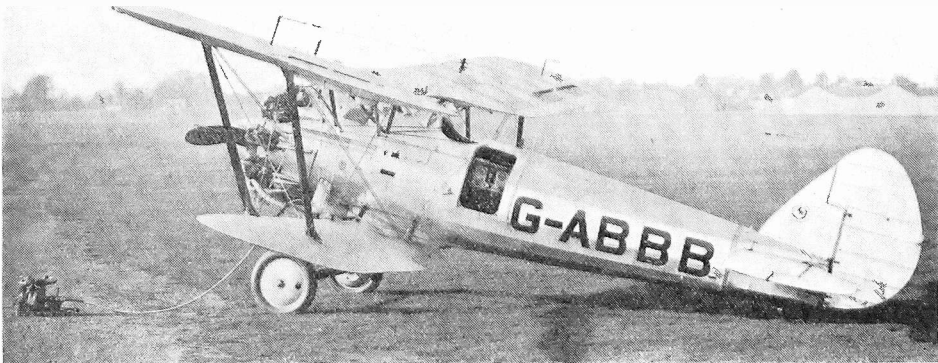
"The broadcasting manager (Mr. R. S. Caprara) tested the transmission with his private car-radio, and was delighted with the clarity of the reception."



" An unofficial engineering test of the new Milnerton wireless station caused quite a sensation in Port Elizabeth on Monday night. The broadcast was carried out on 500 metres to test the strength of the transmitter, full power being put on the aerial. Gramophone records were used, and according to a telegram received from Port Elizabeth, the broadcast was 'unusually clear and strong and the tonal quality of the music was much commented upon.'

In a " Fighter " Aircraft.

Marconi Type A.D.43a/44a transmitting and receiving equipment fitted in a Bristol " Bulldog " single-seater fighter aircraft. Inter-aircraft telephone ranges of 32 kilometres and air-and-ground telephone ranges up to 224 kilometres have been attained with this installation.



Marconi Veterans' Reunion.

A MEETING was held at Electra House, Victoria Embankment, London, on the 30th October, 1933, to elect officers for the coming year, and new Members who had become eligible during the year 1933, on completion of 25 years' service with the Marconi group of Companies. The following Members were invited to accept office, and on their consent being obtained, were duly elected :

Chairman	Mr. H. M. Dowsett.
Deputy Chairman...	Monsieur M. Travailleur.
Hon. Treasurer ...	Mr. W. J. Collop.

Marconi News and Notes.

1895
His Excellency Marchese Marconi.



1897.

Col. H. Jameson Davis, H. W. Allen,

1898.

P. W. Paget, C. E. Rickard,

1899.

W. Densham, Andrew Gray, H. M. Dowsett, R. T. Munson, F. S. Stacey,

F. Woodhouse, C. S. Franklin, P. J. Woodward, A. B. Blinkhorn, M. Travailleur, G. Périer

1900.

W. H. Corby, R. N. Vyvyan, A. J. Clark, F. Archer, J. Harvie Clark,

Sir Ambrose Fleming, A. H. Atkinson, E. E. Triggs,

1901.

W. S. Entwistle, W. J. Willey, G. H. Green, A. Eve, Capt. C. M. Daly, G. Pells, E. G. Tyler,

F. E. D. Pereira, F. K. May, A. H. Ginman, A. Vanderpooten, R. Foupart, H. E. Dunn, F. Huff,

1902.

E. Berry, W. F. Thomas, R. D. Bangay, F. E. Burrows, W. Davies, Capt. H. J. Round,

H. A. Ewen, E. C. Richardson, A. A. Kift, J. Lewis, H. E. Watterson, R. G. Newman, W. M. Sampson

1903.

D. W. Tullock, J. R. Stapleton, F. Jones, J. Harvey, A. J. Huff, H. T. Worrall, E. T. Hills, L. Verbrugghen,

1904.

H. Tattersall, A. J. Irvine, T. Iddon, W. A. Taylor, W. McGhee, J. R. Robinson, W. Platt, W. J. Collop,

W. N. Ball, F. S. Hayburn, A. Cappelaere, W. Tasker, H. Cornwall, F. Delasse, W. J. Gray

1905.

S. C. Parish, J. N. Johnson, W. B. Cole, E. J. Wagstaff, C. A. Manson, C. A. Mason, H. M. Burrows,

C. James, F. W. M. Herring, P. Treacy, A. C. Lewis, G. Ludwig, D. Macdonald, F. R. Pells, E. Horton,

1906.

C. J. Ketteridge, Marquis L. Solari, F. Beatson, A. J. Chesterton, E. Hill,

A. M. Young, D. Sutherland, S. Stansbridge, Seton Smith, A. Ashley, W. Rogers,

F. Baker, S. C. Hills, C. C. Howe, H. D. Humphries, J. C. Hawkhead,

S. Kent, A. Fournier, A. Maernoudt, Annie König, M. J. Tastenoy, R. C. A. Kroes,

1907.

H. Caswall, C. G. Rattray, T. Cox, J. H. T. Leggett, J. Connell, J. T. Marler, R. Cox, T. H. Stubbs,

E. J. Moore, C. Newer, H. Nicholls, G. E. Turnbull, A. Hubert, E. C. Montague, A. Cobham,

1908.

W. J. Baden, J. F. Menear, T. E. Hobbs, F. Hance, W. D. Lacey,

W. Shore, E. Dyer, J. Campion, L. Atkinson, P. D. Outred,



Standing Committee :—Messrs. H. W. Allen, C. S. Franklin, A. H. Ginman, F. S. Hayburn, A. A. Kift, J. Lewis, C. E. Rickard, H. J. Round, Andrew Gray and Capt. C. V. Daly.

Mr. Dowsett, Chairman for 1934, agreed to continue in the capacity of Hon. Secretary until a successor could be appointed.

The Secretary reported, with great regret, the death of two Members during the year, Mr. G. S. Kemp and Mr. R. Leith.

It was announced that the total number of Members on the Roll amounted to 135.

It was decided that instead of holding the Reunion Dinner before Christmas it would suit the convenience of Members better to hold it in the Spring of 1934, possibly the first week in May. The Veterans' Roll, however, has now been completed, and is published herewith.

Madrid-Las Palmas Air Line.

A COMPREHENSIVE wireless organisation is being prepared in connection with the establishment of a new air route between Spain and the Canary Islands, to be operated by the L.A.P.E. Company (Lineas Aereas Postales Espanolas), the organisation which at present operates the Madrid-Barcelona and Madrid-Seville airways.

Communication will be effected on both medium and short wavelengths in order to ensure reliable contact even under very unfavourable conditions, following the practice that has been so successfully adopted on the African and Indian air routes of Imperial Airways Limited.

The aircraft will be fitted with the Marconi dual-wavelength equipment Type A.D.37a/38a, which is capable of communication by telegraph and telephone on the wavebands of 40-80 metres and 500-1,000 metres, and with which short-wave communication has been effected between aircraft in flight and ground stations over distances as great as 4,000 miles—easily a record for two-way working to and from commercial aeroplanes.

For the terminal airport of the projected air route in the Canary Islands a new ground wireless station is to be erected at Gando, Las Palmas, where will be installed the latest types of Marconi transmitters, receivers, and direction finders, providing a complete service of medium and short-wave ground-and-air communication, with wireless navigational aid available on request.

At the Madrid aerodrome a half-kilowatt Type "U" transmitter and a receiver Type R.g.27 were installed last year for medium-wave working, and a transmitter Type T.N.19 and a receiver Type R.g.28 are now to be installed for short waves.