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TONE MODULATION OF TELEGRAPHIC TRANSMITTERS.

The speed at which telegraphic traffic on short waves can be handled is almost entirely limited by the effects of fading, therefore any method by which fading may be reduced merits considerable attention.

One such method is to modulate the carrier wave of the telegraphic transmitter by a tone frequency, and it is pointed out in the following article that this represents the best means at our disposal at the present time for increasing the speed of telegraphic traffic, as distinct from speech and picture transmissions.

The effects of tone modulation on both the transmitter and receiver are given, and the article concludes with a summary of the advantages, conditions and limitations of the method.

Effect of Modulation.

WHILE fading may be pronounced at any instant of time between two stations communicating, say, on a 20,000 kilocycle frequency (15 metres), it is an established fact that on a second frequency only differing by a few hundred cycles from the first, fading may be appreciably less or even non-existant; again, at another instant of time the effect may be such that there is no appreciable fading on the former but bad fading on the latter frequency. It follows that if two frequencies can be transmitted simultaneously and received simultaneously, the evils of fading are reduced, while if we take some particular frequency and transmit on several frequencies above and below this datum, then, provided our receiver is sensitive over the full wave band, the improvement becomes more marked; but this group of frequencies is precisely such as is created when a C.W. Transmitter is tone modulated, and the resultant improvement in reception of morse signals in actual practice affords a striking proof of the validity of the foregoing statements. At some stations the speed has increased, in other cases, where high speeds were already attained over certain periods, the amount of "words once" traffic has gone up to five times the original average. If, however, such results are to follow it is important to appreciate the limitations outlined in the following brief notes.

Side Bands.

Were it possible to produce a pure sine form continuous wave and modulate it to some pure sine variation in amplitude, Fig. 1, the result would be only three waves, that is, the original wave and an upper and lower side wave whose frequencies are respectively original frequency plus modulation frequency and original minus modulation frequency; tabulating these we have:

Carrier wave of original frequency.
Upper Side Wave, of Carrier + Fundamental Modulation Frequency.
Lower Side Wave, of Carrier — Fundamental Modulation Frequency.

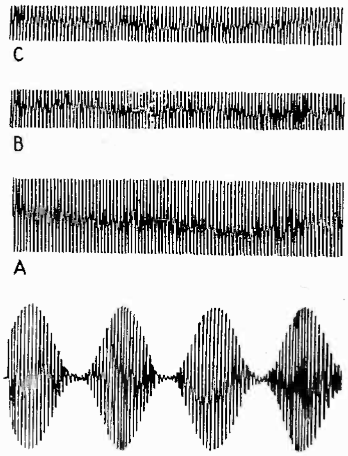


FIG. 1.

On the other hand if modulation gives a square form of variation in amplitude, Figs. 2 and 3, there will be a series of waves as follows:

Carrier Wave.

Upper Side Band.	Carrier + Fundamental.
	Carrier + 3rd Harmonic (i.e. plus three times fundamental frequency).
	Carrier + 5th Harmonic.
Lower Side Band.	Carrier — Fundamental.
	Carrier — 3rd Harmonic (i.e. minus three times fundamental frequency).
	Carrier — 5th Harmonic.

and so on, indefinitely. The higher and lower frequencies on either side of the carrier frequency constitute the upper and lower side band waves.

Power Distribution.

Complete, or 100 per cent. modulation is indicated in Figs. 1 and 3 and partial, say 50 per cent. modulation, in Fig. 4. It is fairly obvious that the amplitude of the side waves, and hence the power conveyed by them, increases with the percentage of modulation, and it may be shown that for complete sinusoidal modulation one third of the total power radiated resides in the side bands, while for complete square form modulation one half of the power resides in the side bands : thus in the case of pure sine modulation one third of the total output is carried by two side waves, while in the case of square form modulation one half is spread over a wide series of upper and lower frequencies, residing mainly in the earlier components.

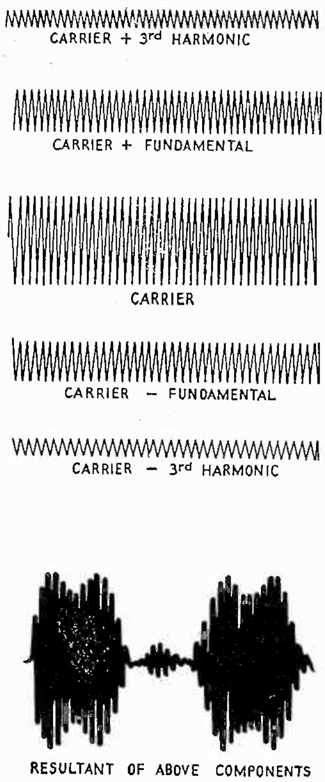


FIG. 2. *The first five radio components of square wave formation.*

Width of Band.

An impression will probably be given that the wider the band and the greater the number of side frequencies, the better the results, but this is emphatically not so because, in the first place, it has become apparent that a diverse fading effect exists between two frequencies removed from each other by a very slight amount, such as a separation of 250 cycles between 20,000,000 and 20,000,250 cycles, which implies that a narrow band of a few frequencies differing from each other by only a slight amount, tends to maintain uniform reception. In the second place when reception is highly selective and receivers are equipped with filter circuits (limiting the width of band it is possible to receive for one channel) the narrow wave band will convey more effective energy and yield greater effective signal strength than a wide band, where a large percentage of the side frequencies is attenuated in the receiver filters : this point has been proved at many receiving stations.

Finally the most important consideration of all is that the narrow band occupies less space in the Ether.

Receiver Band.

Since the transmitted power is now spread over several frequencies it is clear that the receiver should be capable of receiving simultaneously all these frequencies ; in the case of the Marconi Beam Receiver the first filter circuit is adjusted to a band 5,000 cycles wide (157,500 cycles to 152,500 etc.) the original idea being to allow a variation of 2,500 cycles on either side of the first heterodyne beat frequency and thus allow for a drift of that amount up or down in either transmitter or receiver. We may adopt 5,000 cycles as typical of a modern type receiver filter band, bearing in mind the probability of narrower widths in the near future.

Now in practice, probably because either the modulating or the fundamental wave is symmetrically distorted, the odd harmonics appear to be always present

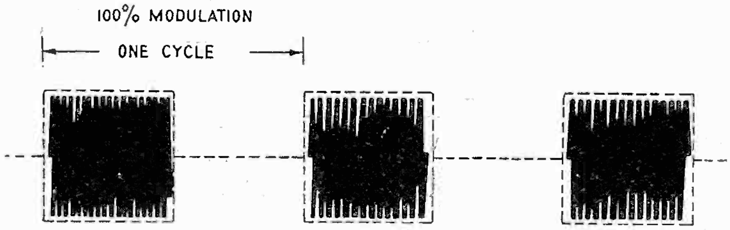


FIG. 3.
A series of dots is equivalent to 100% square wave modulation at the dot frequency.

and sometimes pronounced ; therefore in considering the effect of, say, a 1000 cycle modulation, the more important side frequencies will be :—

Carrier Frequency	± 1,000	cycles	(1st Harmonic)
,, ,,	± 3,000	,,	(3rd ,,)
,, ,,	± 5,000	,,	(5th ,,)

and from these figures it will be seen that the 2nd and 3rd terms lie outside the receiver filter band and are lost. On the other hand, taking a 250 cycle modulation we get :—

Carrier Frequency	± 250	cycles	1st Harmonic)
,, ,,	± 750	,,	(3rd ,,)
,, ,,	±1,250	,,	(5th ,,)

in which case both 3rd and 5th terms lie within the receiver filter band.

In a few cases of non-symmetrical distortion the even harmonics may be prominent but whether the harmonics are odd or even in no way alters the argument.

Considerations of the conditions at the Receiver thus point to the desirability of a narrow band.

Lower Limit of Modulation Frequency.

Apart altogether from the main issue of overcoming fading, the frequency of modulation has an obvious lower limit, for it should be above the speed of morse keying. A speed of 150 words per minute is equivalent to 60 dots per second, in other words the time period for a dot mark is 120th of a second ; at such a speed and taking the frequency of modulation to be 250 cycles, there will be slightly more than two impulses to form or sustain one dot mark, and for a modern receiver, equipped with a limiting device this is sufficient for good tape formation.

Actually, with a modern receiver, the question of *note frequency* has little to do with signal formation, for whether there be two impulses per dot, as with a 250 cycle note, or twelve impulses, as with a 1,500 cycle note, the energy passed through the rectifier, that is, the energy effective for marking, remains virtually constant.

Power Radiated.

The effect of modulation is to modify the even radiation of pure C.W. either into periods of radiation and periods of non-radiation, or into periods of rising and diminishing radiation ; obviously from the point of view of effective power radiated it is preferable that the periods be balanced. For ordinary telegraphic transmission, however, a compromise is necessary in order to obtain reasonable power radiation ; this calls for a somewhat unbalanced modulating wave form, but when modulation is effected by means of a tone oscillator it is quite possible, indeed practical, to mould the modulation envelope either by suitable adjustments in the circuit constants, or by double rectification of the oscillator output.

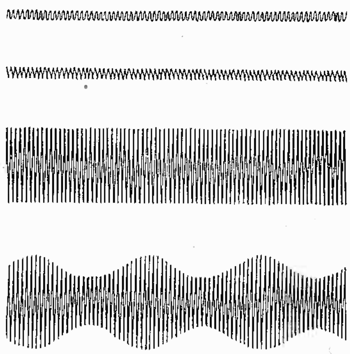


FIG. 4.

When modulation is effected by full wave rectified (unsmoothed) single phase A.C. supply little can be done to mould the wave form, though with a good machine the resulting wave form is generally quite satisfactory.

When modulating by means of an unsmoothed rectified A.C. supply it is advisable to include a certain amount of capacity between the H.T. lead and earth as this rounds off the wave " corners " and reduces harmonics ; also it causes a certain percentage of pure C.W. (residual C.W.) which, as will be shown in the next paragraph, is an advantage.

Before leaving the subject of power radiated it is well to point out that by careful design all harmonics after the first can be practically suppressed.

Conditions and Speed.

It seems to the writer that the only factor for good tape formation at very high speeds is the condition of the space intervening between transmitter and receiver. When conditions are good and stable, in other words favourable to very high speeds, we approach the stage during which pure C.W., with its energy concentrated into a single unfading frequency will give stronger signals and higher speeds than modulated C.W. But conditions can seldom be trusted, and modulated C.W. gives an unquestioned improvement in traffic at most times, so that some compromise seems indicated ;

thus in many instances and in general practice, it will be an advantage to run with a certain amount of residual C.W., provided that the system of keying is such that the whole of the received energy is available to form signals.

As a side light on the value of modulation the writer has observed while receiving signals for which the modulation has been only 30 per cent, and even less, that when conditions were in any way poor the large C.W. component has almost entirely disappeared, whereas the sidebands were still coming through to give commercially strong signals.

Diversity Reception and Tone Modulated Signals.

It has been stated that frequencies differing from each other have diverse rates of fading : it is equally true, in fact it follows from what is known of wave propagation in our variable medium, that the fading of waves of the same frequency at points removed from one another by an appreciable amount, say twenty or more wavelengths, is diverse ; thus a similar effect to modulating the transmitted wave is attained by receiving the signals at several places separated from each other by some little distance. In practice three points of reception is found to be a satisfactory arrangement.

In cases where "Diversity" reception is in operation the logical procedure would be to employ pure C.W. transmission, but here again in practice some compromise is more effective.

Choice of Modulation Frequency.

We might summarise the last few paragraphs somewhat arbitrarily as follows :

(A) For a wide aperture Beam Reception aerial system, or for combined "Beam" and "Diversity" Reception, *i.e.*, three small "Beam" aerial systems separated for Diversity fading, a modulation frequency of 250 cycles is suitable.

(B) For small "Beam" aerial systems, or for Diversity Reception employing three simple aerials, a modulation frequency of 500 cycles is suitable.

(C) For Broadcast Reception a modulation frequency of 1,000 cycles is suitable.

Conclusion.

Modulation, by creating side bands of different frequencies is a means of neutralising the effect of fading.

There are two methods of controlling the width of band, first by the purity of wave formation and secondly by the frequency of the modulating note.

With respect to the circumstances surrounding modulation, two facts emerge, first the necessity of keeping the transmitted wave band within such limits as will avoid interfering with other services, and secondly the necessity of keeping the frequencies within the reasonable limits of selective reception, *i.e.*, within the band to which the corresponding receiver is designed—otherwise an appreciable amount of the received energy will be cut off in the filter unit and lost to the subsequent circuits.

It must not be over looked that under very stable conditions pure C.W. will give higher speeds than tone modulated C.W. because the energy is concentrated into a single frequency in the former, and distributed over several frequencies in the latter ; nevertheless the average results over any considerable period are strongly in favour of modulation. Generally speaking a modulated wave does not rise to the same high peak values of signal strength as a pure C.W. wave, because some of the energy is in the side bands, yet for this very reason the energy arriving at the receiving station has a much more even flow, with the resultant improvement in traffic.

The writer is indebted to Mr. A. W. Ladner for figures 1, 2, and 4.

N. Wells.

MARCONI SHORT WAVE TELEGRAPH TRANSMITTER

TYPE S100

The Transmitter described below has been designed for permanent installation in a vehicle or at a fixed point, and is so arranged that either telegraphic or telephonic communication can be maintained over comparatively large distances on short wave lengths.

Simplicity of control and complete accessibility are the outstanding features of the S100 Transmitter and these facts together with the easily erected aerial system and high overall efficiency of the set have proved to be of considerable use in maintaining reliable short wave communication under severe conditions of service.

THE S100 Transmitter, a photograph of which is shown in Fig 1, is arranged to cover a wave range of from 30 to 60 meters by means of two interchangeable inductance coils.

It will be evident from the photograph that the component parts are so arranged as to form a compact and accessible unit. This accessibility enables the operator to have complete control of the apparatus.

Modifications of the S100 Transmitter have been designed in order to enable (*a*) a drive to be used as the fundamental source of oscillations in place of the self oscillator, and (*b*) telephony modulation to be applied either to the driven or undriven telegraph set.

The various combinations that can be obtained are given below :—

S100 Undriven telegraph transmitter.

S100*a* Complete driven transmitter arranged either for telegraphy or telephony.

S100*b* Driven telegraph transmitter.

S100*c* Complete undriven transmitter arranged either for telegraphy or telephony.

Range.

As is well known the range obtainable by short wave transmitters depends to a large extent on conditions determined by the time of day or night at which transmission is carried out and also on the period of the year and on the wavelength used.

Considerable information on these points will be found in the article on "World Wide Communications with short Wireless Waves" published in No. 17 of THE MARCONI REVIEW for February, 1930.

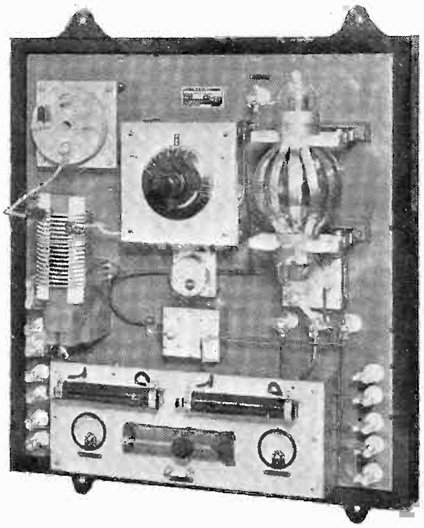


FIG. 1.

It is therefore impossible to define the range which will be obtainable from a transmitter of this nature unless the exact conditions under which the transmitter is working are known.

A short table is, however, appended indicating roughly the distances at which transmission is effective during periods of daylight and darkness. These figures are based on the supposition that reasonably open country and favourable atmospheric conditions prevail.

DAYLIGHT.	
50 — 60 metres	0 — 400 miles.
40 — 50 ,,	200 — 300 miles and upwards.
30 — 40 ,,	From 250 miles upwards.
NIGHT.	
50 — 60 metres.	0 — 300 miles.
30 — 50 metres.	From 300 miles upwards.

Equipment.

The normal equipment provided with the S100 series of Telegraph Transmitters includes the following :—

Transmitter Panel.
Manipulating Key.
Motor Generator Set providing both high and low tension.
Accumulator Battery for low tension supply.
Switchboard.
Wavemeter.
Aerial System.

Additional items for combined C.W. Telegraphy and Telephony include :—

Telephone Modulator Panel.
Microphone.

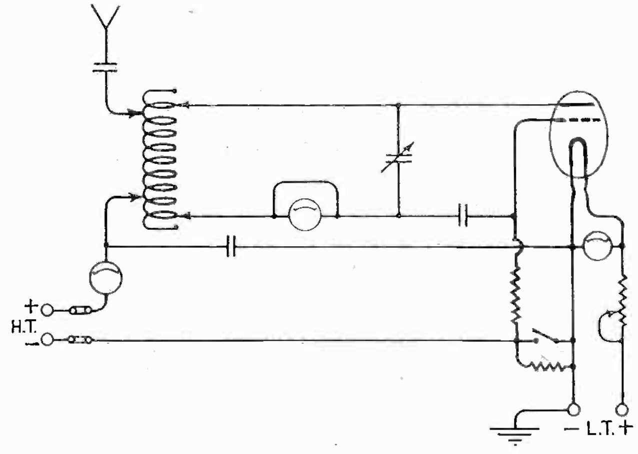


FIG. 2.

Power Supply.

The power supply to the anode of the transmitter valve and the filament supply to this valve, are obtained from separate generators which are coupled to a motor wound to suit the available electric supply.

The H.T. generator in the case of the S100 transmitter delivers 2,500 volts, and the L.T. generator delivers up to 16 volts. The accumulator battery of 14 volts is normally floated across the L.T. generator.

The Transmitter.

The components of the transmitter are fixed to a panel which is arranged for wall mounting in a vertical position. A simplified diagram of the transmitting circuit is shown in Fig. 2. It will be seen that a fundamental oscillatory circuit is employed with an auto coupling to the aerial. The aerial tuning inductance is tapped for grid, anode, aerial and earth connections and the required wavelength is finally obtained by means of the variable condenser which is connected across the grid and anode tappings of the aerial tuning inductance. The closed H.F. circuit of the valve includes an inductance and a tuning condenser, and is completed to earth through a resistance which is inserted between the grid and filament. The anode of the valve receives H.T. through the tuning inductance, and the negative of the H.T. supply is connected to earth, keying being accomplished by means of a key inserted in the return part of the grid circuit, and arranged so that when it is open the grid circuit is broken and also the negative of the high tension supply is isolated from earth.

A feed milliammeter is inserted in the high tension supply circuit to the valve and an indicator in the form of a hot wire ammeter is provided in the oscillatory circuit as an indication that the transmitter is working.

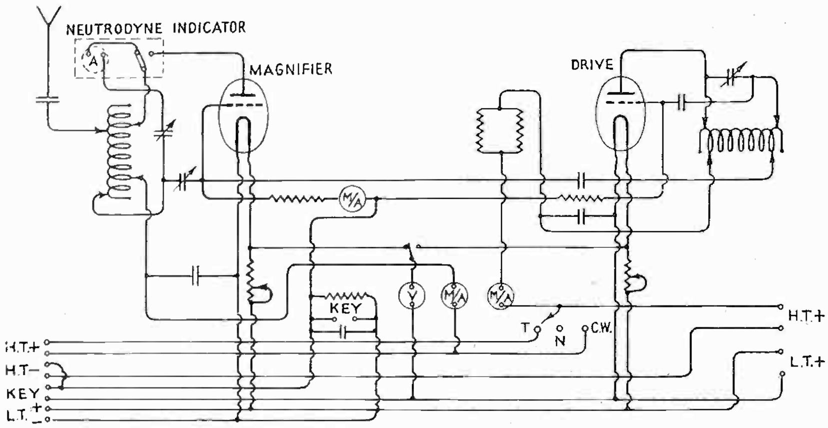


FIG. 3.

Aerial System.

A single wire aerial 30 metres in length is provided. Any length of aerial however may be used as long as its length exceeds 12 metres approximately.

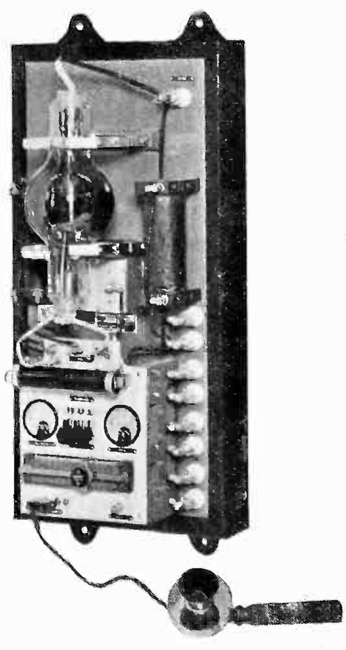


FIG. 4.

Driven Telegraph Transmitter Type S100B.

In place of the undriven self oscillator employed in the S100 transmitter a power magnifier and drive are included in the S100*b* telegraph Transmitter.

A diagram of connections of the set is given in Fig. 3. The drive circuit employs a MT12A valve and a similar oscillatory circuit to that employed on type S100 set.

The power magnifier valve is neutrodyned by means of a .000055 mfd. variable condenser. An indicator is fitted in this circuit to enable the valve to be properly neutrodyned. The method of neutrodyning is as follows. The proper coils are inserted in their correct positions and all connections to these coils made with the exception of the aerial tap which should be left disconnected. The link on the neutrodyne ammeter should be placed in the "neutrodyne" position and the plug should be inserted in the "neutrodyne" socket. H.T. should then be applied and

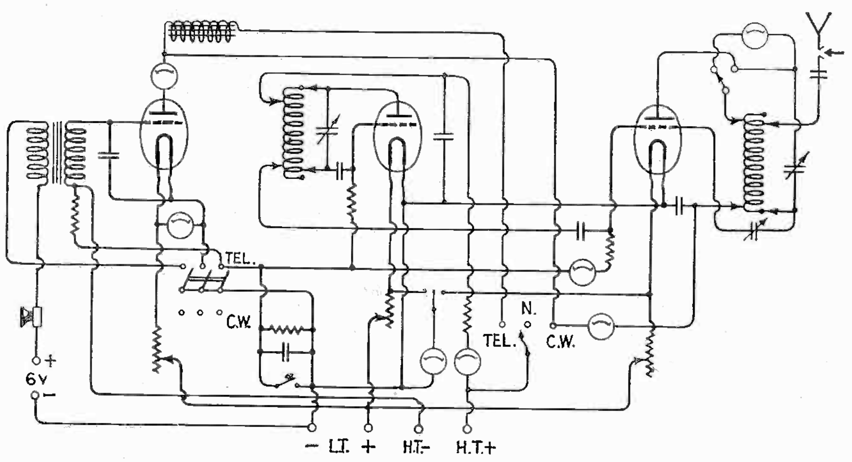


FIG. 5.

on pressing the key the drive valve should oscillate. The wavelength should be checked on a wavemeter and the magnifier should be tuned to the drive by means of its condenser. The neutrodyne condenser should then be adjusted until the reading of the meter is reduced to zero.

The set is now balanced for the particular wavelength and the connections should be made for normal working.

Variable tuning condensers are provided for tuning (*a*) the drive closed circuit and (*b*) the magnifier closed circuit, each of these condensers being provided with removable extension handles which eliminate hand capacity effects during tuning.

In other ways the driven telegraph transmitter resembles the undriven telegraph transmitter, the method of keying being similar and interrupting simultaneously the grid filament circuit of both the power magnifier and drive valves and also the negative high tension connection to earth.

Telephone Modulator Panel.

The telephone modulator panel which can be used in conjunction with either the driven or the undriven transmitter comprises a MT12A valve on the grid of which the speech variations are impressed through a microphone. The anode of this valve is connected through a speech choke to the anode of the oscillating valve on the telegraph panel. A photograph of the unit is shown in Fig. 4.

Driven Telegraph-Telephony Transmitter Type S100A.

This transmitter comprises the driven telegraph set together with the modulator panel. When transmission of telephony is desired the link between terminals 3 and 4 on the telegraphy transmitter should be removed and the modulator panel connected up. The various telegraph-telephone switches should be put to the appropriate position. A simplified diagram of connections and a photograph of the complete transmitter are shown in Figs. 5 and 6.

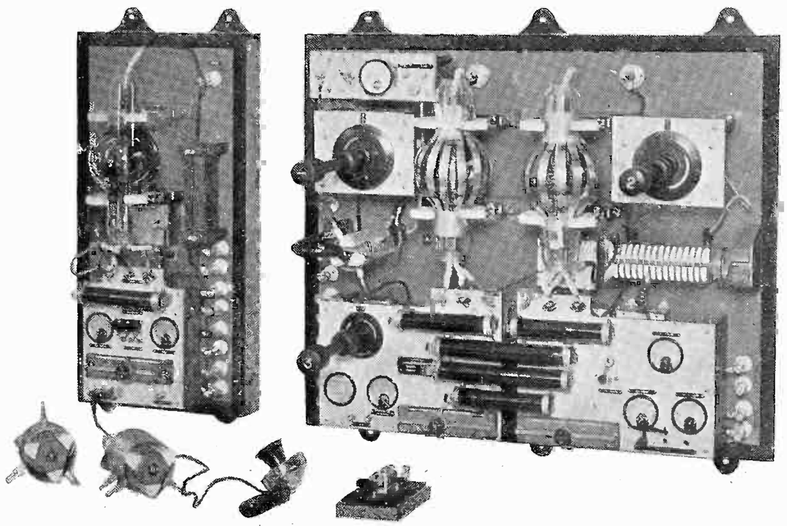


FIG. 6.

Valves.

Type MT12A valves are used throughout on the S100 series of transmitters. The filament voltage of these is 12.5 volts and the current taken by each is 5.5 amps. Copper shielding is placed over the valves as is usual on short wave sets in order to avoid unequal stress and consequent breakage of the valve.

A MASTER OSCILLATOR OF HIGH CONSTANCY OF FREQUENCY

Oscillators of the valve capacity-inductance type, intended as primary drives for broadcast stations, have certain advantages over tuning fork and crystal drives, chief among which is the fact that such an oscillator can be made tunable over a wide range of frequencies so that the wavelength of the station it is desired to control can quickly be altered if necessary.

The valve oscillator described below is capable of very constant performance in spite of relatively large variations in temperature and voltage supply.

As the number of Broadcast Stations in Europe is rapidly increasing, it has become necessary to take all possible precautions that each station shall remain on and operate on the frequency allotted to it, so that the greatest number of stations can be fitted into a fairly narrow band.

There are three well known schemes which are in operation in Europe in the attempt to keep stations to their particular frequency, these are, the tuning fork with valve drive and frequency doublers, the piezo electric oscillator, sometimes with frequency doublers and sometimes working on the fundamental frequency of the station, and finally the valve maintained condenser—inductance circuit.

Now both the tuning fork system and the piezo electric oscillator have a narrow frequency band; adjustable very largely by the temperature coefficient of the primary mechanical oscillator, and in the event of a general re-shuffle of International frequencies, the existing frequencies of these stations might cause a great deal of worry to the authorities in the re-setting of other frequencies so that the present steady frequency stations should not be disturbed. It might therefore be necessary to change these fixed frequencies, which would entail a fair amount of work and delay. Such being the case, the Marconi Company has considered it advisable to carry out some investigations with a view to producing a condenser—inductance circuit, as a primary oscillator, which circuit shall remain at great constancy of frequency during a period of daily operations, in spite of such troubles as gradually discharging batteries, and temperature changes. Also it is imperative that the master oscillator should be tunable over a wide range so that a new station could be adjusted to a frequency of such a value that it would not interfere with stations adjacent to it in frequency.

In the first place rigidity of construction was imperative, and secondly the behaviour of the materials under a fairly high temperature had to be investigated.

Some experience in the manufacture of low loss, small temperature coefficient, condensers and inductances was available, and this knowledge has been applied to the present problem.

The question of maintaining the master oscillator at a fairly constant temperature called for an investigation into thermostatic control, lagging of the chamber, and heating.

Undoubtedly, an instrument such as the toluene regulator together with a stirring fan in the oscillator chamber, is one of the best methods of keeping such a chamber at a constant temperature throughout its bulk, but in a very large number

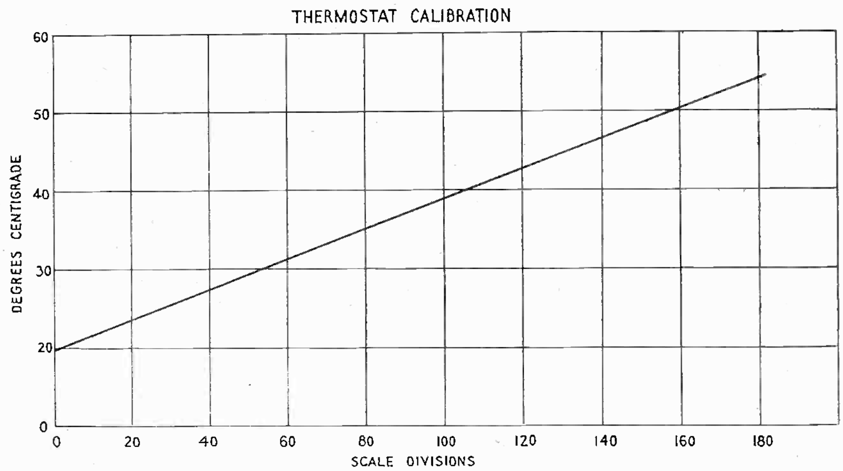


FIG. 1.

of cases this system is inconvenient, solely on account of the large amount of room required for the individual items comprising the whole regulator. Hence, it appeared necessary to reduce the regulator to the smallest dimensions, and the simplest form, and at the same time to avoid the use of a mechanical stirrer, and rely solely upon the convection currents set up by the heaters within the chamber.

The thermostat finally adopted is a simple bi-metal instrument and consists of a steel base at the ends of which are welded or brazed two small steel blocks. To these blocks are secured, by screwing, pinning and soldering a strip of metal of dissimilar temperature coefficient to that of the steel base, and this strip is "set" in a definite manner. At the centre of the strip is a platinum iridium contact and above the strip is mounted on an insulating bridge a contact screw with a platinum iridium point. A scale and pointer is provided on the thermostat so that the instrument can be adjusted to a temperature within the range. A typical calibration of such a thermostat is given in Fig. 1.

In conjunction with this thermostat is a heavy current relay for switching the main current of the heater system. This current is of the order of 1 amp. at 220 volts, and such a current would of course soon ruin the delicate contacts of the thermostat. The current actually handled by the thermostat is of the order of 100 milliamps at 6 volts which current operates the relay. This relay is a very simple affair, being an electro magnet with a light armature carrying a lever engaging with a spring controlled moveable contact arm. It is quite efficient and the certainty of action is due to the care with which the various dimensions of the moving parts were designed and to the provision of the various adjustments.

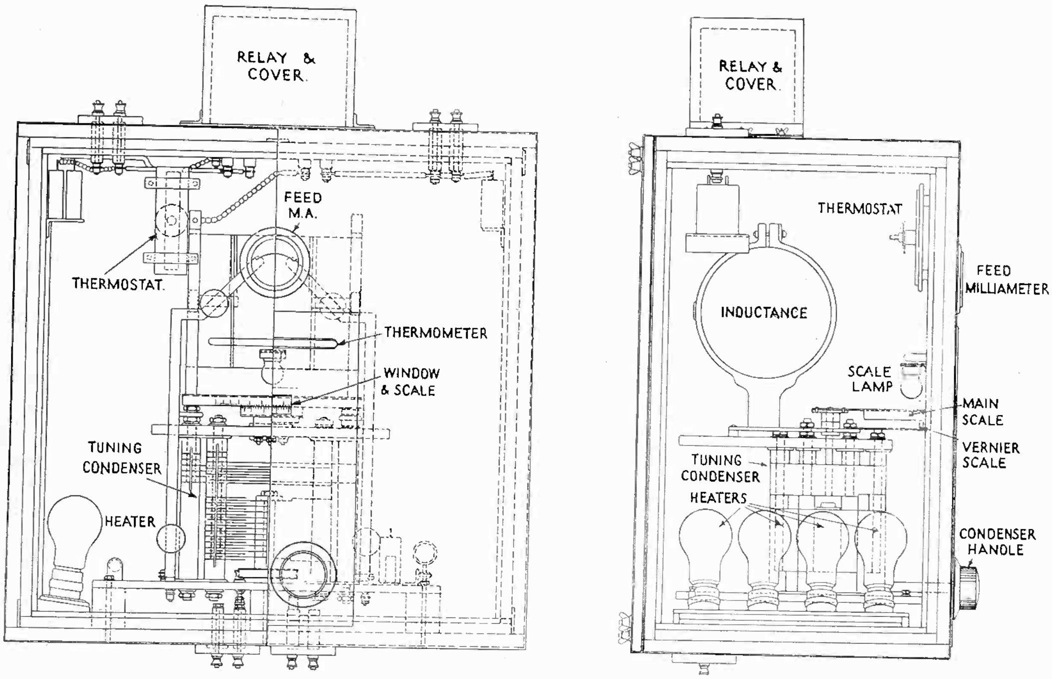


FIG. 2.

The heater consists of a bank of four lamps, which are placed in the lagged chamber at a position which was found to be the best for the maintenance of even heating throughout the system.

The chamber containing the Master oscillator is a stout wooden case, electrically screened by a copper covering on the outside, and heavily lagged on the inside surfaces. The back is entirely removeable so that inspection of the complete apparatus can be made when necessary. To avoid the necessity of removing the entire back to replace a burnt-out valve, a small hand hole closed by a lagged and screened cover is provided in the back.

Within the chamber is mounted the complete master oscillator, together with the thermostat and heaters. Suitable connections are brought through the walls of the chamber, and on the top is mounted the heavy current relay for switching the heaters.

At the front of the chamber are the condenser adjusting handle, a thermometer, a window showing the scale and a feed milliammeter for the H.T. circuit.

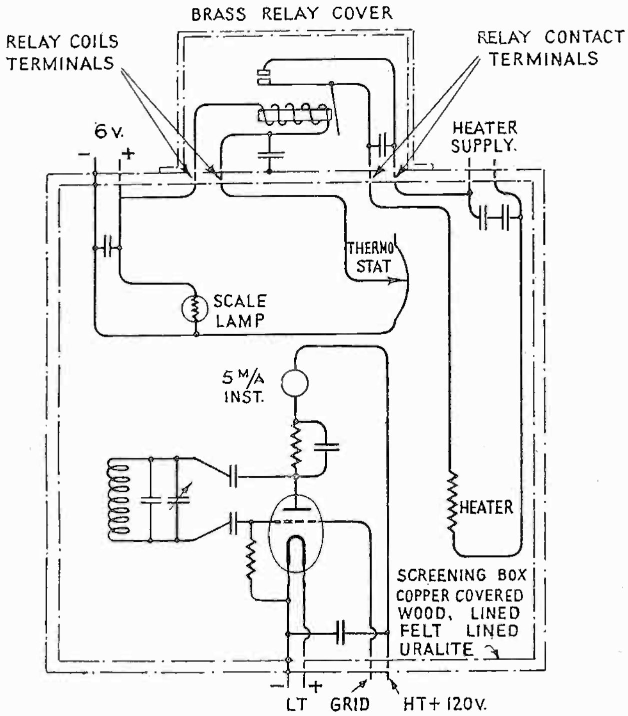


FIG. 3.

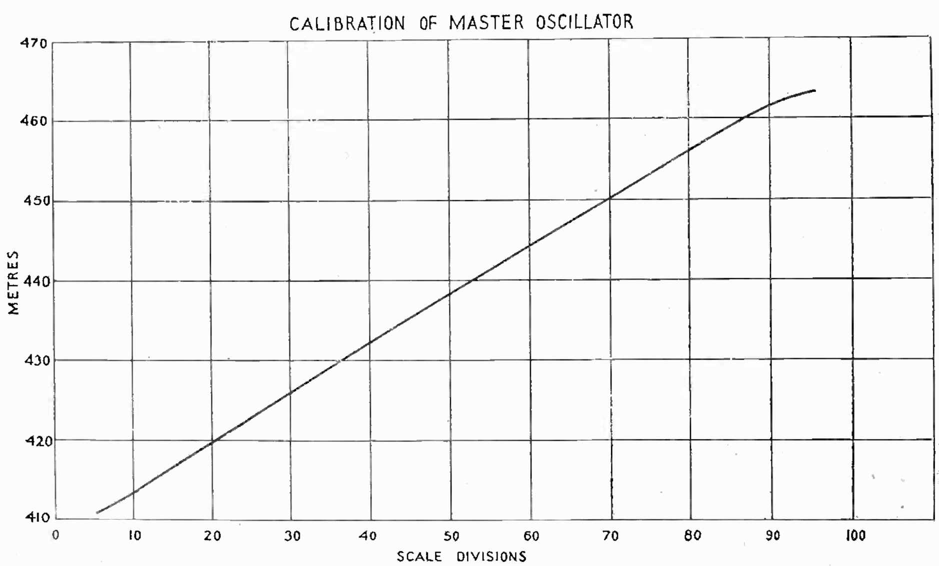


FIG. 4.

The condenser used in this master oscillator is of the air dielectric "series" type. This condenser is a very stoutly constructed item and is similar in type but of different capacity to that described in a previous article on a Portable Precision Frequency meter. The insulating base of this condenser carries on its under surface various connections. On the upper surface are fixed such details as feed condensers, resistances and the valve.

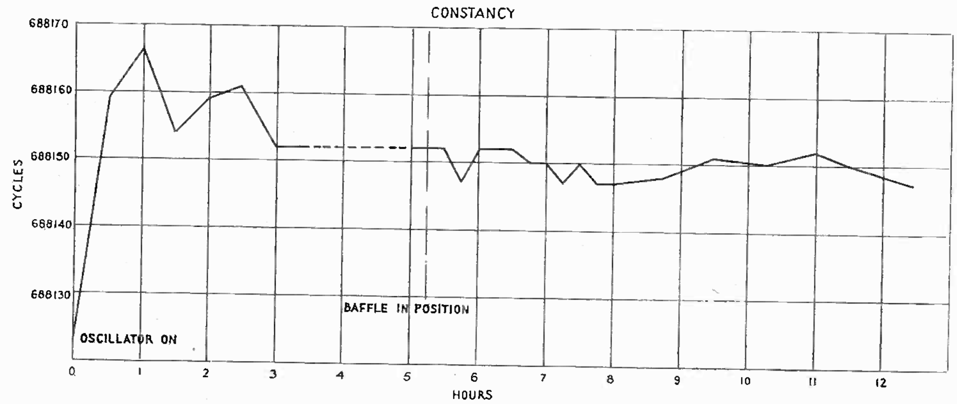


FIG. 5.

The vertical shaft of the condenser has fixed at its base a worm wheel which engages with a worm, the shaft of which is brought through the front of the lagged chamber and fitted with a handle.

On the insulated top plate of the condenser is fitted the inductance of the circuit and to the upper extremity of the condenser shaft is secured a brass sector upon the edge of which is engraved a scale. Beneath this scale is a vernier scale. On the main scale 100 divisions subtend an angle of 90°, and 9 divisions of the main scale are equal to 10 divisions of the vernier scale. The main scale rotates, whilst the vernier scale remains fixed. This permits of a very small window being cut in the screened lagged chamber and the disturbance of screening and lagging is thus reduced to a minimum. The scale and window are lighted by a small lamp connected to the L.T. battery of the valve circuit.

The inductance used is of copper wire wound on a porcelain former. Depending upon the total frequency band to be covered by the oscillator, so the size, type and number of the inductances vary.

For a short band a large porcelain tube can be permanently fixed to the instrument, but where a wide range must be covered, it has been found convenient to use smaller tubes and greater numbers. Fig. 2 gives a general idea of the chamber and the disposition of the various items included therein. This is typical of a narrow band master oscillator. The valve is at the back of the condenser and not shown.

In Fig. 3 is given a typical diagram of connections for the master oscillator, scale lamp, thermostat, heater relay and heater. The values of the various components change to some extent with the frequency it is desired to generate and also with the number of ranges.

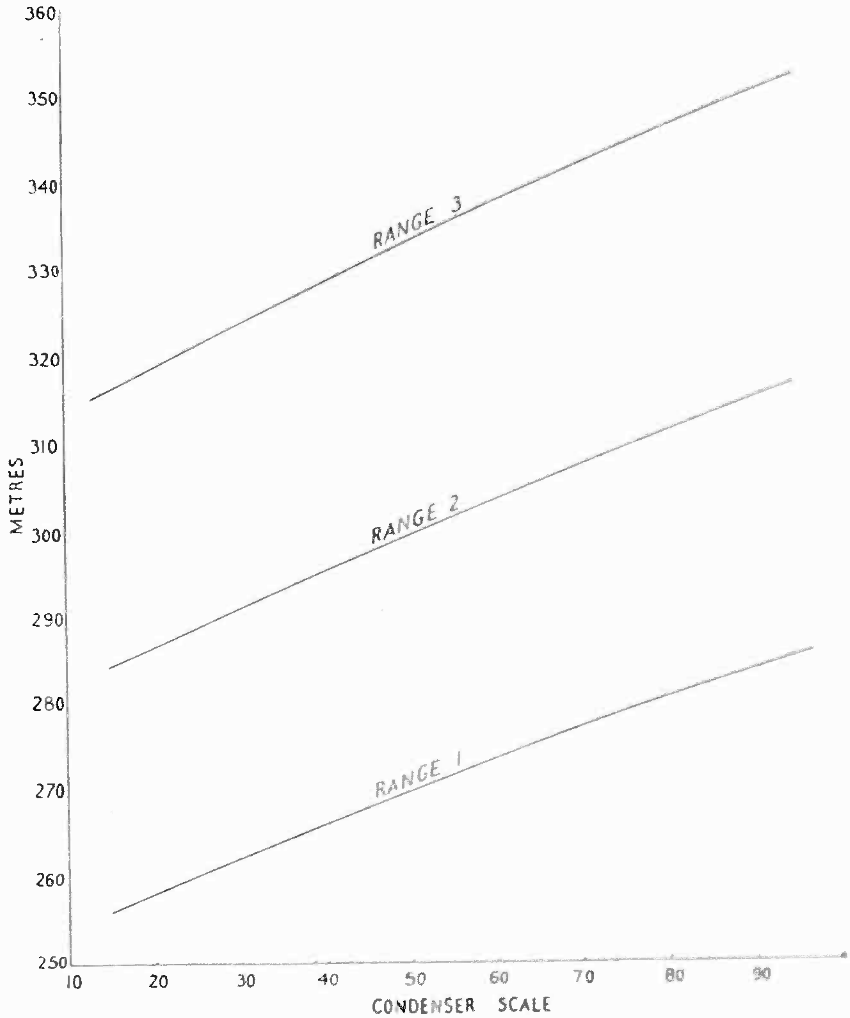


FIG. 6.

In practice it has been found desirable to arrange for the master oscillator to generate at half the frequency of transmission. From the master oscillator a suitable connection is taken to a frequency doubling circuit, and on by means of power amplifying circuit to the final circuit of the system.

A calibration of a narrow frequency band oscillator is given in Fig. 4. In this calibration the condenser scale is plotted against the output wavelength of the station. In this instrument a condenser change of 1 vernier division at 10 divisions and 1

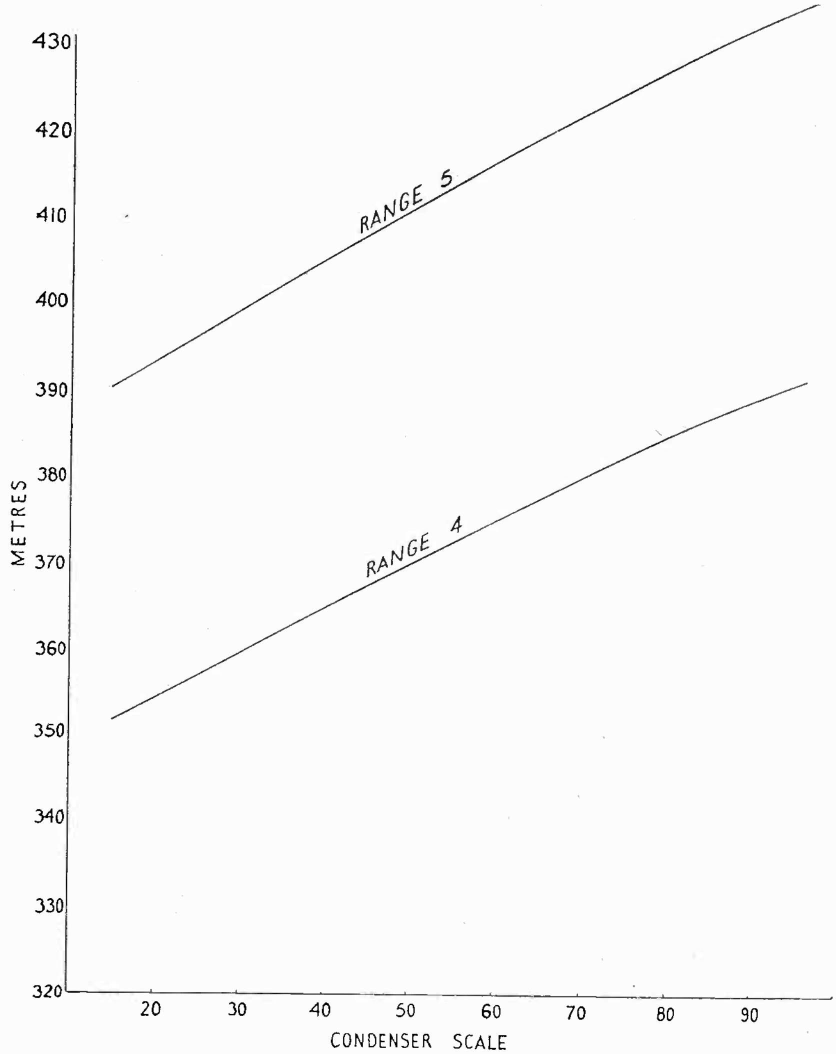


FIG. 7.

vernier division at 90 divisions of the condenser scale represents a change of final wavelength of 1 in 7,000 approx. at that point of the scale.

Fig. 5 shows the constancy of the master oscillator over a number of hours. It will be seen from this figure that a rapid change of frequency occurs at the beginning of the run, but as the temperature of the complete apparatus becomes uniform so greater steadiness is maintained. At a point in this figure is marked "Baffle in position." This refers to the insertion of a plate beneath the master oscillator unit to disperse an updraught of cool air and maintain the cooling of the apparatus at a more uniform rate. From that time to the end of the run, the stability of the frequency is indicated by the curve.

This figure gives the frequency as that of the final frequency of the complete apparatus.

It is of interest to note the changes of frequency due to changes of L.T. and H.T. voltages. These are given in the following table :—

	Volts. L.T.	H.T.	Final Freq.	Change.
Normal	6	119·2	688,186	
	6	119·2—5%	688,169	—1 in 41,000
	6	119·2+5%	688,198	+1 ,, 57,000
	6—5%	119·2	688,179	—1 ,, 95,000
	6+5%	119·2	688,186	No change.

These frequencies were measured by a valve maintained, constantly running, thermostatically controlled, tuning fork, as were all other frequencies given in this paper.

A change of valve of the same type was found to give a frequency variation of 1 in 95,000.

Figs. 6 and 7 show the calibration of a multi-range oscillator. In these figures the final wave length is plotted against the condenser valve and at the extremities it will be found that a condenser variation of 1 vernier division gives a change of wavelength of 1 in 8,000 approx. at the upper limit and 1 in 6,400 approx. at the lower limit.

Measurements have shown that the frequency variation in this multi-range instrument amounts to $\pm$ 9 cycles in 877,500 final frequency during a 6 hours run after the apparatus had been running with its thermostat for four hours.

Frequency changes due to voltage changes in the multi-range model are slightly worse than with the single range instrument, but in no case does a $\pm$ 5 per cent. change of L.T. or H.T. voltage cause a change of more than 1 in 27,000.

It will be appreciated that in a multi-range instrument, where the range change is made by a change of inductance, changes in the various inductances cannot be so completely compensated for with a single condenser as in the case of a single range instrument.

Finally, it may be mentioned that in the models described here, the heating current of the apparatus was alternating at 100 ∿ and from the local town service. Some trouble was experienced in this matter due to the breaking of the main heater circuit and the "hum" of the service, but this has been overcome by suitable shunting of contacts, relay coil and service supplies, and after considerable amplification the carrier wave of the system can be said to be unmodulated by the alternating supply.

T. D. Parkin.

MARCONI NAVAL RECEIVER

TYPE R.g.27

This receiver has been developed for use as a Naval Receiver covering a waveband of 150-3000 *metres in* 4 *ranges. The design is such that overall efficiency and performance is maintained with minimum cost.*

*Its use will not of course be limited to Naval purposes, and it is anticipated that the demand for an inexpensive receiver covering this waveband will be met by the Type R.g.*27 *receiver.*

THE R.g.27 receiver Fig. 1 consists of one screened grid high frequency amplifier coupled by means of a tuned anode circuit and condenser to a detector and followed by 2 low frequency amplifiers The first of these low frequency amplifiers is always in use, but switching is provided in order to obtain either aperiodic audio frequency amplification or tuned note filter amplification at 1,200 cycles. The second low frequency amplifier may be switched on or off at will and is a straight forward untuned transformer coupled amplifier. The detector is capable of self oscillation in order that reception of C.W. signals shall be possible. The aerial circuit is not tuned and the coupling arrangements to the first valve will be described later.

The wave range of the receiver is from 150-3,000 metres and is covered by 4 positions of the range switch.

The input circuit to the high frequency valve Fig. 2 is tuned by a condenser which is permanently ganged to the condenser tuning the detector grid circuit. This ganging effects a considerable simplification in the tuning of the receiver. The method of aerial coupling has been so designed that the ganging of the 2 tuned circuits is correct for a wide range of the electrical constants of the aerial, although the actual design is such that the 2 circuits are correctly ganged when the capacity introduced between the aerial and earth terminals of the receiver by the aerial is ·0002 mfd. Any aerial of from 40 to 100 ft. will give satisfactory results on this receiver, these figures referring to single wires sloping from the receiver at approximately 60°. A volume control in the form of a resistance in the screen grid valve filament circuit is incorporated in this receiver which has the effect of increasing either the selectivity or volume of the instrument. As the signal strength is reduced so the selectivity of the high frequency stage is increased. A double ended arrow engraved round the volume control knob is marked volume in one direction and selectivity in the other, and a compromise between these two factors can be obtained for any particular working conditions.

A voltmeter is provided in the circuit, reading up to 7·5 volts for filament voltage, and up to 150 volts to enable the H.T. supply volts to be checked.

Valves.

Two alternative arrangements of valves can be adopted. In the first only 2 types of valves are needed, viz :—one 2-volt screened grid high frequency valve type S.215 and three type H.L.210 valves. A more usual arrangement consists of follow-

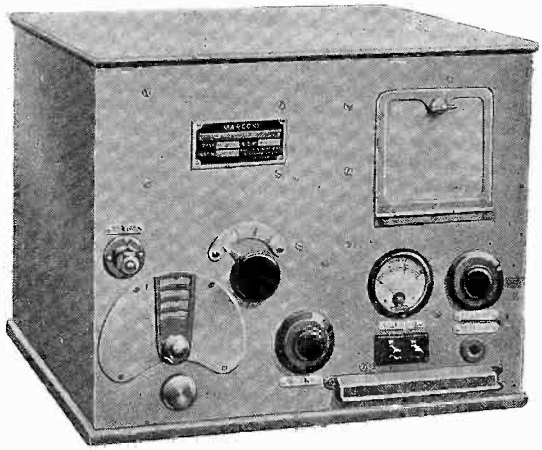


FIG. 1.

ing the S.215 high frequency amplifying valve by a DEH.210 valve as detector, and two DEL.210 valves as note magnifiers. When this latter arrangement is used greater output volume is obtained and to effect the change it is only necessary to

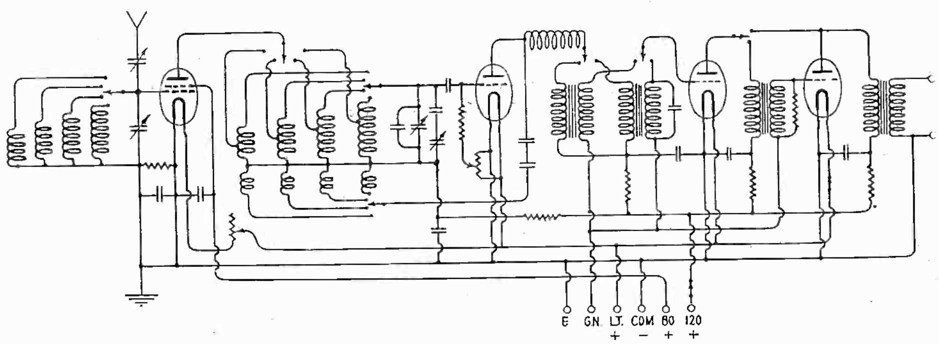


FIG. 2.

increase the grid negative on the low frequency valves. The grid bias, of ½ volt, to the high frequency valve is obtained from the filament battery so that no internal negative grid battery of special size is necessary.

Accessibility has been treated as of prime importance and by undoing 4 finger screws it is possible to remove the set from its base which will normally be fixed by shock absorbers to the bulkhead. This removal at once exposes to inspection all switch contacts, variable condensers and low frequency components. Similarly by undoing finger screws the lid of the receiver can be removed giving full accessibility to the high frequency inductances, the connections between these, and the range switch and all valve holders.

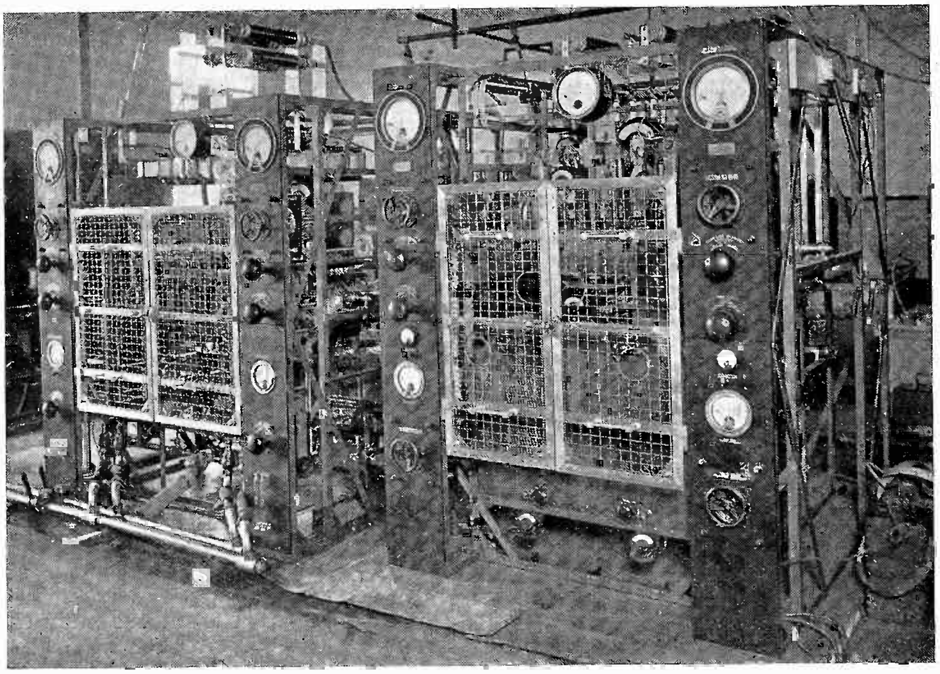
In addition a simple method is provided whereby the panel carrying all valve holders and low frequency components may be detached from the instrument case giving complete accessibility to these components.

Valves can be inserted by removing the top lid of the receiver but a hinged drop door is also provided on the front panel for this purpose.

MARCONI NEWS AND NOTES

EMPIRE BROADCASTING

SIR JOHN SIMON'S SPEECH HEARD IN INDIA.



G5SW, the short-wave Empire broadcasting station at Chelmsford. This photograph shows the main and No. 2 magnifiers.

The possibilities and importance of Empire Broadcasting could not have been more strikingly indicated than they were recently when Sir John Simon speaking from London through 5 SW, the B.B.C. short wave experimental broadcasting station at the Marconi Works at Chelmsford, was able to address the people of India on Indian affairs at a time when the Report of the Committee of which he was chairman was engrossing the attention of all classes in India. Every word he said is reported as having been clearly heard, and brought home very vividly the service that broadcasting may render to the Empire in times when matters of imperial importance are under discussion, and more particularly at any time of crisis.

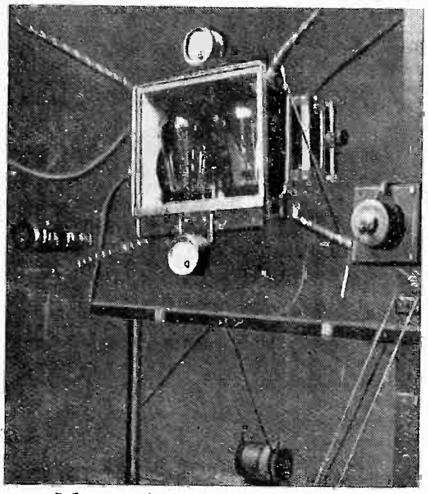
5 SW at Chelmsford has rendered good service to British broadcasting and the Empire on many previous occasions when special broadcasts from England have been relayed for the benefit of audiences overseas ; and reports on the excellence of its

transmission have been received from places as far apart as China and Peru in addition to South Africa, India, Australia and many European countries where 5 SW has a regular and enthusiastic audience.

Some of the most important occasions on which it has been used were in the transmission to the Empire of the Thanksgiving Service in Westminster Abbey for the King's recovery, and the speeches made by the King and principal national delegates at the opening of the London Naval Conference this year.

Wireless and the "Southern Cross."

Major Kingsford Smith's success in flying across the Atlantic is a triumph for wireless organisation, as he has pointed out in every message he has written concerning his experience.



Marconi apparatus in the "Southern Cross."

Like those other prudent adventurers Captain Courtney and Major Franco, Major Kingsford Smith was firmly of the opinion that pioneer flights of this kind can only be justified in so far as they add something definite to human knowledge as well as to human achievement. This he has done, for in addition to his success, the wise and thorough organisation of his flight has enabled him to put forward the definite theory that the unreliability of the compass in the neighbourhood of Newfoundland, where visual sights are bad, is the cause of the tragic failure of other gallant airmen who have essayed this perilous voyage insufficiently equipped. He has also supplied valuable knowledge as to the conditions to be expected on this particular air route.

Wireless direction finding justified itself long ago as a navigational instrument for ships at sea and commercial aeroplanes, and in Major Kingsford Smith's flight it has established itself as a vital necessity in any well organised long distance pioneer flight. As Major Kingsford Smith said, " But for the wonderful wireless we should never have got out of the fog," and the lessons they brought with them out of that great ordeal would not have been, as they are now, at the service of every airman who may attempt the Atlantic flight in future.

A Last Minute Decision.

When Major Kingsford Smith arrived in England to prepare for his flight to the United States he was equipped with only short wave wireless apparatus. While

The "Southern Cross."

this was extremely useful for keeping him in communication with wireless receiving stations on either side of the Atlantic over long distances it was not adapted to the transmission of signals for the purpose of communication with ships and coast stations and for direction finding, for which instruments working on longer wavelengths are necessary. It was decided, therefore, to complete his equipment by installing a Marconi wireless transmitter working on wavelengths of 600 and 800 metres.

This last minute decision proved the determining factor in his safe arrival in the United States, owing to the fact that it was entirely due to his ability to communicate with ships and coast stations and to receive bearings calculated from signals sent out by the Marconi instrument that he was able to find his way to land through the dense fog that enveloped him as he was approaching Newfoundland. With this installation, he states, he was in constant communication with ships throughout the flight.

Telegram to the Marconi Company.

One of the first things Major Kingsford Smith did on arriving at New York was to send the following telegram to the Marconi Company :—

Marconi Company, London.

Was altogether delighted at perfection of Marconi Wireless instrument and the tremendous service it rendered me. It was put in at the shortest notice yet it performed excellently and was vital to the success of our flight. Most enthusiastic and delighted with it. Best regards.

(Signed) KINGSFORD SMITH.

Delegates to the Empire Press Conference at the Somerton Beam station. Mr. T. Dunbabin (Australia) is speaking to Marchese Marconi on his yacht "Elettra," off Genoa. Admiral of the Fleet Lord Wester Wemyss is on the speaker's left.

Major Kingsford Smith's experience is similar to that of Captain Courtney whose rescue, after he came down in the Atlantic in his attempt to fly to the United States, was due to his having carried a Marconi wireless installation ; and of Major Franco, the well-known Spanish airman who relied on a Marconi wireless installation in his successful flight across the South Atlantic from Spain to South America.

These experiences, and the disasters which have overcome intrepid flyers who have attempted to cross the Atlantic without wireless equipment, demonstrate, as Major Kingsford Smith, Major Franco and Captain Courtney have all asserted, that no long-distance ocean flights should be undertaken without adequate wireless equipment.

Press Delegates Visit Beam Stations.

One of the most interesting functions associated with the recent Empire Press Conference in London, which was attended by journalists from all parts of the British Empire, was the visit paid by a number of the delegates to the Marconi short wave Beam transmitting and receiving stations of Imperial and International Communications Limited at Dorchester and Somerton.

While the delegates were at the Somerton station they had the novel experience of talking with Marchese Marconi who spoke from his yacht "Elettra" off Genoa, 1000 miles away.

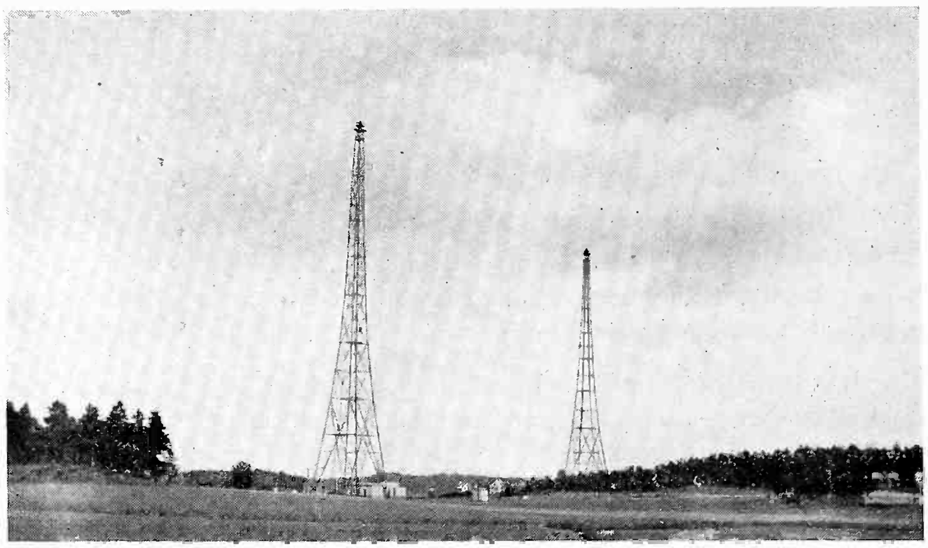
The telephone conversation had been arranged so that Marchese Marconi could offer a welcome to the visitors. Messages were first exchanged between the yacht and Admiral of the Fleet Lord Wester Wemyss, and then the company, some of whom listened through headphones while others assembled around a loud-speaker, heard Marchese Marconi explain that while he was a long way from Somerton he was glad that radio-telephony afforded him a rather novel opportunity of greeting members of the Empire Press Conference together with some of his own fellow directors.

Sir Augusto Bartolo, of Malta, expressed the thanks of the delegates and had a conversation in Italian with Italian journalists on board the "Elettra."

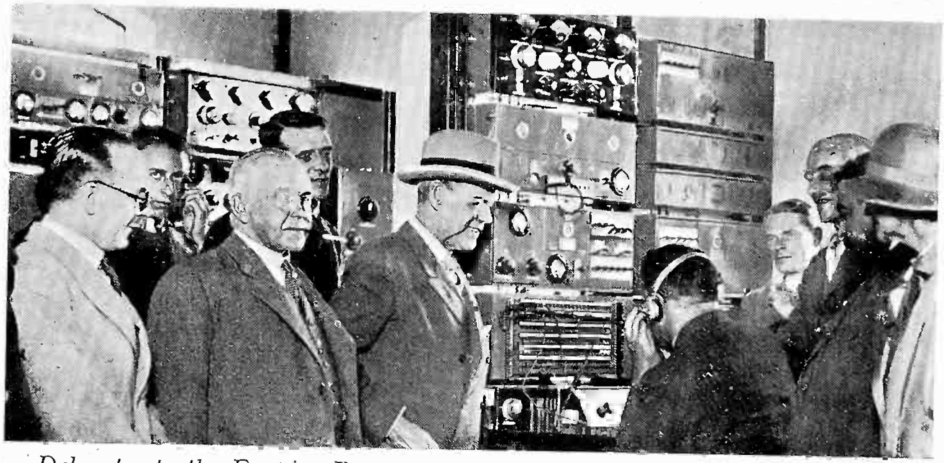
Importance of Communications.

During the sessions of the Empire Press Conference, some of the most closely followed discussions were on the subject of communications, one of the speakers being Sir Basil P. Blackett, K.C.B., K.C.S.I., Chairman of Imperial and International Communications Limited, and consequently the delegates showed keen interest in the operating details of the Beam stations.

The Rt. Hon. Lord Wester Wemyss, G.C.B., Director of Marconi's Wireless Telegraph Co., Ltd. and of Imperial and International Communications Limited speaking at a luncheon to the delegates of the importance of communications, said that he thought they would see to what extent these had progressed and how much further they hoped to get in an organisation by which they hoped to increase the happy relations which existed within the Empire.



Marconi 60 kilowatt broadcasting station, at Spanga, near Stockholm.



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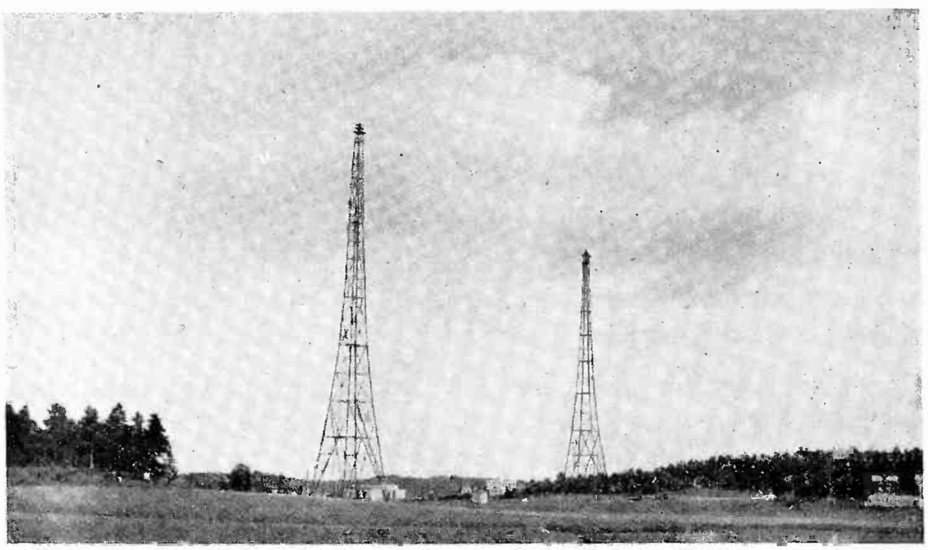
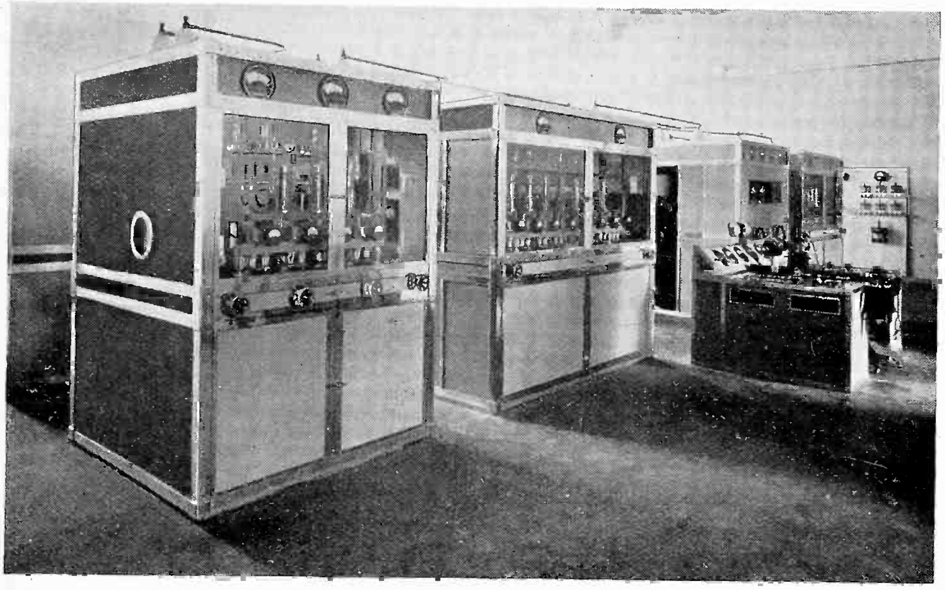


Marconi 60 kilowatt broadcasting station, at Spanga, near Stockholm.



Marconi 60 *kilowatt broadcasting station at Spanga, Sweden : view of transmitter panels.*

New Swedish High Power Broadcasting Station.

The second high-power broadcasting station to be supplied by the Marconi Company to Sweden has now been put into operation at Spanga, about 12 miles from Stockholm.

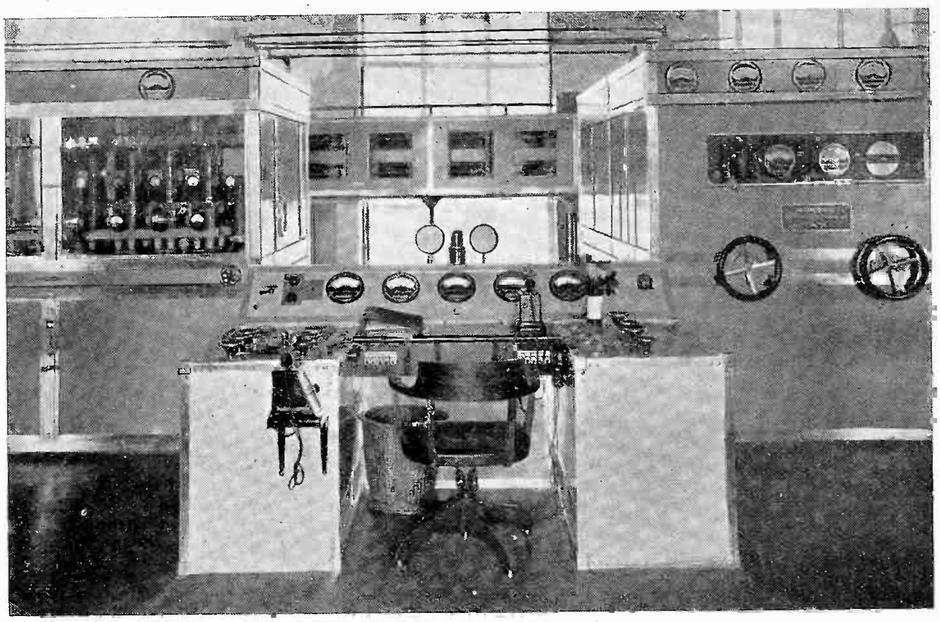
It will be remembered that the first broadcasting station supplied by the Marconi Company to Sweden is that at Motala, which has been in continuous operation since 1927 and which has been described as easily the best of the European Continental broadcasting stations in quality and strength of transmission.

The Stockholm transmitter is a Marconi Type P.B. transmitter and is worked on the principal of low power modulation which is now adopted by most European broadcasting authorities.

The transmitter can be modulated up to 100 per cent., and at 80 per cent. modulation the energy supplied to the aerial is 50 kw.

In view of the increasing number of high-power broadcasting stations which are being built in Europe some device to ensure that the transmitter adheres rigidly to its allotted wavelength is essential. In the Stockholm transmitter this has been achieved by providing a thermostatically controlled valve drive which has been developed with great success in the Marconi Research laboratories.

The Stockholm transmitter operates on a wavelength of 436 metres.



Marconi 60 *kilowatt broadcasting station at Spanga, Sweden: transmitter panels, control table and harmonic filter.*

Marconi Aircraft Apparatus on Test.

A working demonstration of the well known Marconi Type A.D.6h aircraft wireless equipment was recently given at Croydon Aerodrome to certain distinguished foreign military representatives.

One set of this type was installed in the Marconi Company's Bristol Fighter, and a second set in a D.H.50, which was chartered from Imperial Airways Limited for the purpose. The ground station with which communication was maintained during the tests was erected at the Marconi Company's experimental section at the aerodrome and consisted of a Marconi aircraft transmitter Type A.D.18a (which has a total input of approximately 350 watts, or approximately one-tenth of the power of the Croydon Aerodrome wireless transmitter) and a receiver of approximately the same sensitivity as that used at Croydon. The aerial employed had a height of only 30 feet.

The two aircraft left the aerodrome simultaneously, the Bristol Fighter flying along a direct line between Croydon and Leamington, and the D.H.50 along a direct line joining Croydon and Lincoln.

Two-way telephonic communication was maintained between the two aircraft, on their diverging courses, as far as possible, after which the Bristol Fighter returned to the aerodrome and the D.H.50 continued until the limits of ground-to-air and air-to-ground telephonic and telegraphic ranges were reached, test messages being passed at pre-arranged points,

Ranges Obtained.

The results obtained, which are given below, are interesting as showing the ranges which are easily obtainable in actual practice, and in spite of severe interference which was experienced on the wavelength allotted for these tests.

With the Type A.D. 6h equipment. :—

Inter-aircraft telephony range.	28 miles
Air-to-ground telephony range.	107 miles
Air-to-ground telegraphy range (interrupted continuous waves)	136 miles
Air-to-ground telegraphy range (continuous waves)	200 miles
Ground-to-air telephony range	55 miles
Ground-to-air telegraphy range (interrupted continuous waves)	107 miles
Ground-to-air telegraphy range (continuous waves)	147 miles