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THE MARCONI-WRIGHT FACSIMILE SYSTEM

DESCRIPTION OF THE APPARATUS.—I

The Marconi-Wright system of facsimile transmission and reception is briefly described below under the following sectional headings :—

(1) *Commercial requirements of any facsimile system.*
(2) *Description of Transmitter.*
(3) *Method of synchronisation employed, including,*
(4) *An account of the thermostatically controlled Tuning Fork.*
(5) *The Receiver.*

This article, which will be concluded in the March number, follows the reference which was made to the success of the system in the January issue of THE MARCONI REVIEW, *where a photograph of the apparatus used at the Transmitter end will also be found.*

THE main conditions which must be satisfied by any facsimile telegraph system which is to be operated commercially as distinct from purely laboratory experiments are :—

(1) It is essential that there should be no intermediate process between the acceptance of a message at the transmitting end of the circuit and its handling by the transmitter. By this is meant that there must be no necessity for the reproduction of the message photographically as a transparency, in relief or otherwise.

(2) The transmitting and receiving machines must run continuously. In other words, it must be possible to feed messages into the transmitter and take them off at the receiver without starting and stopping the synchronised rotating parts.

(3) Phase setting at the receiver must be a running adjustment. This can only be achieved if the position of the received message on the receiving surface is at once obvious to the receiving operator.

(4) Ordinary commercial bromide paper must be directly usable in the receiver.

(5) It must be possible to send a message in facsimile, without delay, no

matter what its shape and size may be (of course, provided that it does not exceed certain maximum dimensions governed by the size of the machines).

These conditions are satisfied by the Marconi system, as will be apparent in the following description of the apparatus. The problem, then, broadly, is:

(1) To cause a spot of light to move in a regular fashion over the whole surface of the message, and to modulate a wireless telegraph transmitter so that the depth of modulation is proportional at every instant to the intensity of the light scattered from the message surface.

(2) To cause another spot of light to move in an exactly corresponding manner over the light sensitive surface at the receiver and to vary its intensity with the depth of modulation of the high frequency carrier wave received by the wireless telegraph receiver.

Transmitter.

Fig. 1 is a schematic sectional view of the optical parts of the transmitter.

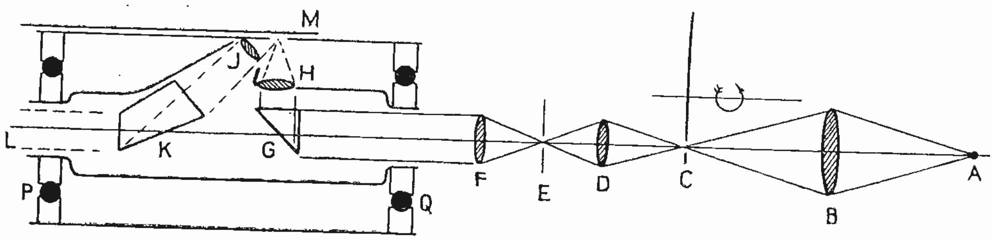

FIG. 1.

A is a light source and consists of a standard pattern concentrated filament heavy current lamp.

The light from this source is collected by a corrected condenser lens B, and a sharp image of the filament is projected on the surface of the chopper disc C. This chopper consists of a steel disc with equally spaced holes near its periphery. The chopper disc runs in a cast iron housing for the sake of quietness and to reduce windage.

The interrupted light beam emerging from the chopper is collected by a second condensing lens D (Fig. 1), and is focussed down to give an intense illumination of the pinhole E. A corrected lens F then collects the light passing the pinhole and converts it into a parallel beam, which travels down the hollow spindle of the synchronous driving motor referred to later.

Reverting again to Fig. 1, the parallel beam from lens F passes down the axis of the optical rotor, falling on the prism G, and thence radially to the lens H. This lens (H) is a fully corrected one and forms a sharp image of the pinhole E on the surface of the message M which is lying on the surface of a cylinder surrounding

New York T

MARCONI
USA -

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NEW YORK, SATURDAY, FEBRUARY 2, 1929.

London Music Put on American Radio Chains; Concert Rebroadcast in 'Surprise' Program

Millions of persons in the United States received a radio surprise yesterday afternoon when the music of a symphony concert in Queen's Hall, London, came in over their loud-speakers or head sets.

The London concert was re-broadcast in this country over the National Broadcasting Company's WEAF and WJZ networks, following the broadcasting of the Bok Bird Sanctuary dedication at Mountain Lake, Fla. At the conclusion of the ceremonies in Florida, the American announcer asked all listeners to stand by for "an unusual surprise" in the form of "a program from London, England, over a radio path 3,000 miles long." It was then 4:45 P. M. in New York and 9:45 P. M. in England. Presently the American audience heard the London orchestra playing the last movement of Rachmaninoff's symphony in E minor, which ended at 5:15 P. M. here.

Behind the seemingly simple radio feat lay an intricate scientific arrangement. The music was carried by land wire to the short wave transmitter 5 SW at Chelmsford, thirty miles northeast of London, whence it was broadcast on a 25.53-meter channel. It was picked up at the receiving station of the Radio Corporation of America at Riverhead, L. I., amplified there, transmitted by wire to the distributing panel in the control room of the National Broadcasting Company at 711 Fifth Avenue, then routed to forty radio stations across this country.

The London concert, as it flashed across the ocean, was marred at times by static explosions like the sound of big guns. O. B. Hanson, chief broadcast engineer of the NBC, said this was due to a magnetic storm somewhere on the Atlantic.

Mr. Hanson said the re-broadcast yesterday was "only 50 per cent perfect," adding that in tests conducted over the last three months, foreign programs had been reproduced 90 per cent perfect, but had not been put on the air. He said, however, that the test demonstrated that radio engineers had made big strides in overcoming fading since 1924, when Americans heard Big Ben and the Savoy dance band in London. Yesterday's test marked the first attempt at re-broadcasting a foreign program since 1924.

Officials of the NBC said the English broadcasters were unaware that the program was being re-broadcast in this country. American listeners were critical of the intermissions and the lack of announcements on the part of the English station, both before the music began and after it stopped.

Full scale reproduction of facsimile received across the Atlantic of portion of New York Times *placed direct on Transmitter Drum.*

the optical rotor. The exact disposition of the message will be made clear later when the traversing mechanism is described. Light is then scattered by the paper on which the message is written or printed and of course, the intensity of the scattered light depends upon the darkness of tone of the spot on which the light falls.

A portion of this light is then collected by the lens J and converted to a parallel beam, which is turned through a suitable angle by the prism and emerges from the rotor axially at L to fall on the active surface of a photo-electric cell.

The whole system of lenses and prisms (G, H, J, K) are mounted in a bronze casting which runs in ball bearings, P and Q.

The optical rotor is mounted in a brass cylinder, having a circumferential slit in the middle in order that the scanning spot may fall on the surface of the message, which is placed face downwards on it.

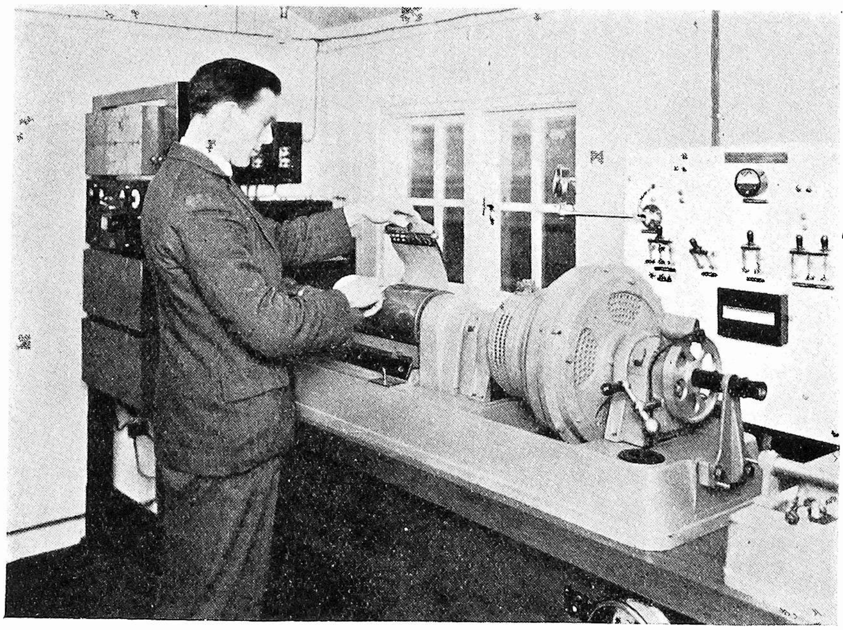


FIG. 2.

The method of inserting the message and of retaining it is shown above (FIG. 2). It will be seen that there is a flexible band supported by a hinged carrier which can be raised from the surface of the cylinder, and when it is so raised the message may be laid, face downwards, on the cylinder. The carrier is then lowered and the flexible band comes down on the back of the message, keeping it in close contact with the curved surface.

Now, assuming that the optical rotor is rotating with uniform velocity, it is only necessary to traverse the carrier by means of the usual lead screw, when the flexible band will carry the message with it across the light slit in the cylinder and so the whole surface will be scanned by the spot.

The cast iron saddle is traversed by means of a half nut, which engages with the buttress thread of the lead screw.

Engagement between the lead screw and the main shaft is obtained by a dog clutch hidden by the gear casing. This clutch is operated by the lever, which can be seen projecting up from the front top surface of the bedplate in the photograph. The lever in this picture is in front of the message cylinder and just to the right of the straining weight.

The operations involved in traversing a message therefore are :

(1) With the main shaft carrying the optical rotor running out of engagement with the lead screw (*i.e.*, dog clutch out) the message is placed on the cylinder and is held in position by lowering the flexible band on it.

(2) By means of the lever referred to in the last paragraph the dog clutch is engaged and the message commences to traverse.

(3) At the conclusion of the message the dog clutch is tripped, thereby bringing the carrier to rest.

(4) The flexible band is raised and the message removed.

(5) The carrier is slid along to the left to the starting position in readiness for the next message.

It will be realised that during these operations the optical rotor is revolving continuously, and no phase adjustment or synchronisation is necessary at the commencement of a message.

Driving Machine.

The optical rotor is direct-coupled to the shaft of the driving motor. It consists of a synchronous motor whose speed can be controlled by the frequency of the alternating current supplied to it.

Speed control is secured by supplying the synchronous motor with current from an electrically maintained tuning fork, which is maintained at constant temperature. Variations in speed are secured by either :

(A) Multiplication of the fundamental frequency of the tuning fork, or in the case of a permanent change in the range of speeds :

(B) Substitution of a fork having a different frequency.

In the case of both the transmitter and the receiver the whole driving motor is mounted in trunnions, and can be rotated by the handle seen on the right in the photograph. The purpose of this mounting is to enable phase identity to be secured at transmitter and receiver, and for "inching" to correct wandering of phase due to small variations in the frequencies of the controlling tuning forks.

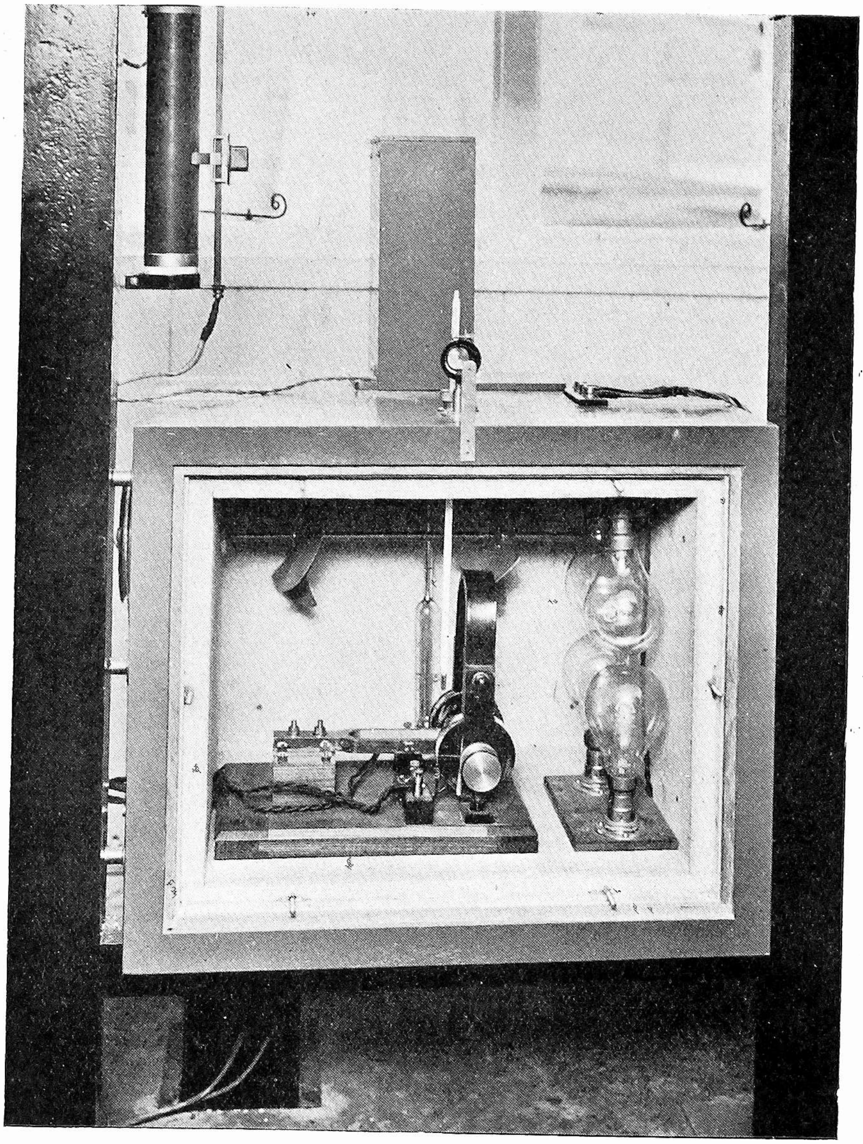


FIG. 3.

On the end of the motor shaft is mounted a stroboscope wheel for setting the motor speed when synchronising the machine with the tuning fork frequency. The toothed periphery of this wheel is illuminated by a small neon tube contained in the shield situated immediately above it. This neon tube is supplied with current from a branch of the tuning fork circuits.

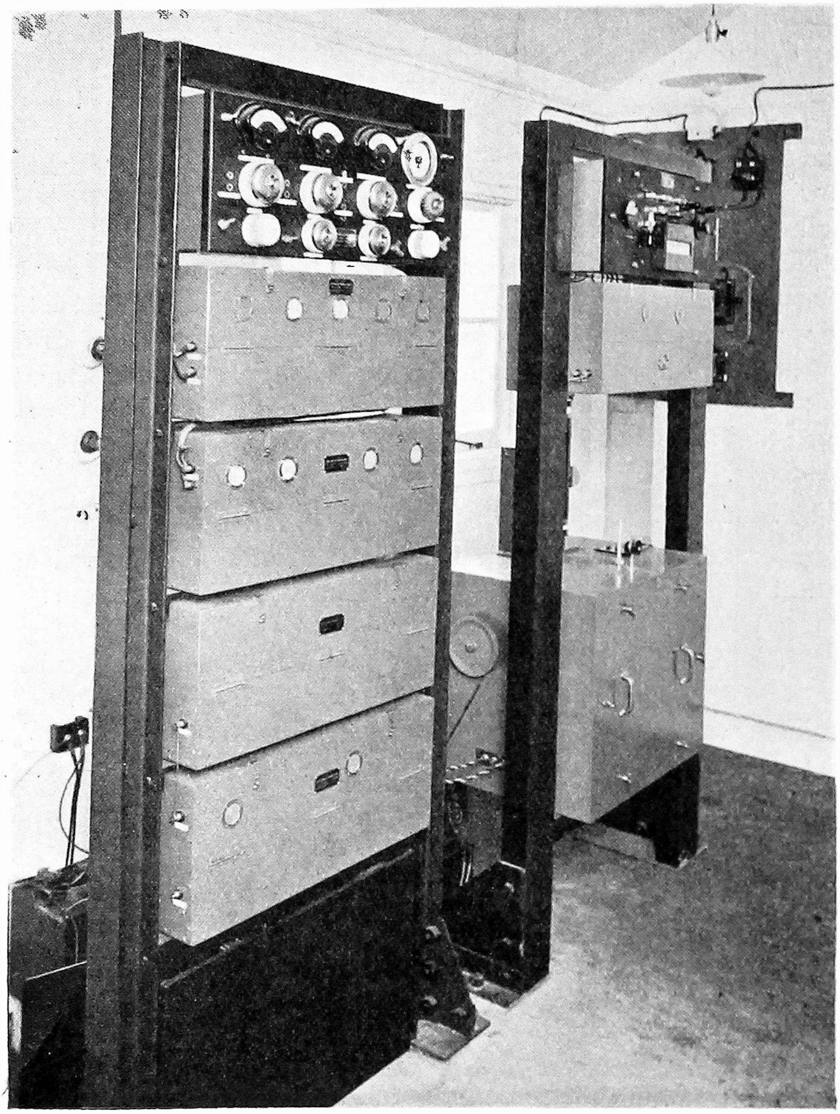


FIG. 4.

Tuning Fork.

The tuning fork is a mild steel one of low damping. It is seen in its mounting in Fig. 3. It is maintained in continuous vibration by reaction in the well-known manner. The whole fork and mounting is placed in the heat insulating box, shown with front removed in photograph, and is maintained at a steady temperature (above that of the room) by means of the toluol regulator seen at the back of the champer. This regulator closes a contact when the temperature reaches a certain pre-determined value, and through the intermediary of a relay, switches off the heater lamps seen on the right of the chamber. As soon as the temperature falls the contact opens and the lamps are switched on again. The air in the chamber is vigorously stirred, by means of two fans at the top back of the box, to avoid a temperature gradient. By this means the temperature of the fork is maintained constant to within about 0.1 degree Fahrenheit. The temperature can be observed by means of the thermometer which projects from the top of the chamber and in front of which is a magnifying glass and peepsight.

Small variations in synchronism are corrected by adjustment of the temperature chamber. There are adjustments made so that this can be done easily by altering the setting of the toluol regulator externally, so that the chamber need not be opened.

The weak alternating current delivered by the tuning fork circuit is amplified for the control of the synchronous motor by the magnifying circuits contained in the rack shown in photographs. Fig. 4 is a view of the front of the rack, and it will be seen that the circuits are contained in four units with the control switchboard mounted above.

Receiving Machine.

The general mechanical, electrical and optical features of the receiving machine are identical with those of the transmitter. The main differences are :—

(1) The pick-up lens for scattered light is omitted from the optical rotor.

(2) A light shutter, operated by the received signal, is substituted for the lamp, chopper and collimator in the transmitter.

The light control device makes use of the Kerr effect in nitrobenzine.

The layout of the optical parts is shown diagrammatically in Fig. 5.

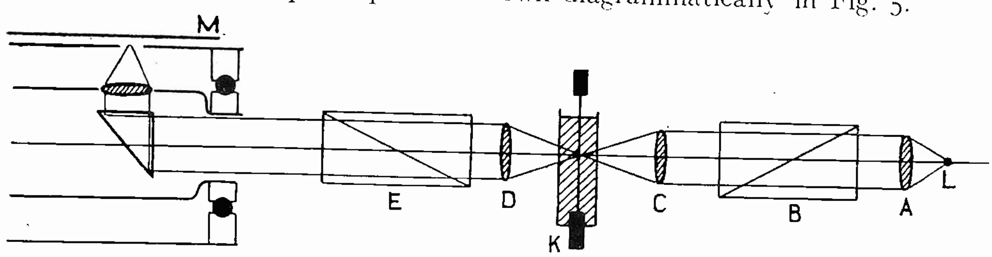


FIG. 5.

A cone of light from the source L is collected by the lens A and emerges as a parallel beam, which is plane polarised by the Nicol prism. After polarisation, the light is focussed by lens C on the gap of the Kerr cell K, and it then falls as a divergent beam on the collimator lens D. This lens again converts the light to a parallel beam, which traverses the second Nicol prism E, and so passes into the receiver optical rotor. This rotor needs no special description. It is precisely the same as that already described in connection with the transmitter, except that the pick-up lens and prism are omitted. The light is finally focussed by the rotor lens as a small spot on the message receiving surface M.

G. M. WRIGHT.

(To be continued).

A SHORT WAVE NAVAL TRANSMITTER

Type T.N.7.

The use of short waves on warships for transmission between ship and shore and for inter-ship communication is becoming more and more general.

The advantages of short wave transmission apply especially to submarine work, where the fact that only a short aerial system needs to be employed is of great importance.

The T.N.7 transmitter has been designed, as have other transmitters of the T.N. type, especially for naval use; and their simplicity of control and efficiency make them peculiarly suitable for this purpose.

The transmitter, which is a medium power set with a wide wave range of 16-135 metres, is contained in a brass frame, and its components are suitably screened.

THE Type T.N.7 transmitter has been designed as a compact medium power set for use on warships and submarines. It has an input rating of 500 watts to the anodes of the magnifiers and an average input to the anode of the drive of 200 watts. The average aerial power is 250 watts. The nominal waverange of the set is from 16-135 metres, and transmission can be effected either on C.W., I.C.W. or telephony over this waverange.

The complete transmitter consists of three main components :—

- (A) The drive ;
- (B) The magnifier ;
- (C) The modulator ;

the circuits of which are contained in brass frames suitably screened where necessary.

The general design of the H.F. circuits is as follows. A fundamental oscillator, using an M.T.12 valve, drives the magnifier, which consists of two M.T.12 valves in parallel with their associated circuits. The aerial is magnetically coupled to the output circuit of the magnifier. An L.S.5 valve is used as the modulator for telephony, and modulates the magnifier valves by grid leak control. I.C.W. is provided for by a note-oscillator, having three frequencies of oscillation, which works into the microphone transformer of the modulator.

The H.T. supply to the set is by means of a motor generator giving 2,500 volts, and separate voltages of 16 volts and 6 volts are supplied for filament lighting, relay working, etc. Grid negative for the modulator is supplied by dry cells.

To enable a clearer idea of the transmitter to be obtained, we shall describe the components under the following heads :—

- (1) Drive and Magnifier circuits.
- (2) Aerial System.
- (3) Keying and Modulation.

(1) Drive and Magnifier Circuits.

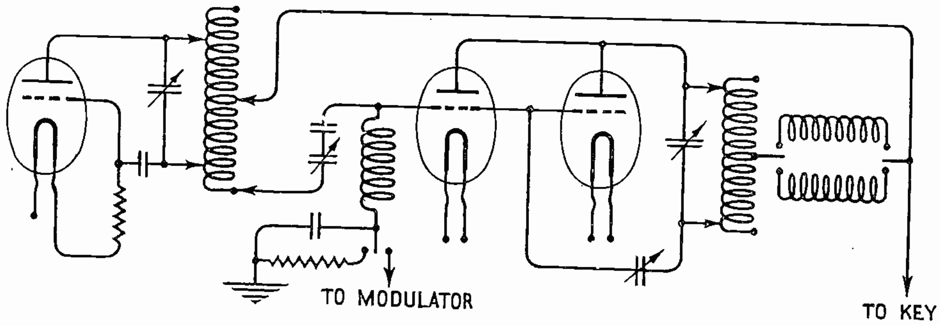


FIG. 1.

A simplified diagram of connections of the drive and magnifier circuits is given above (Fig. 1). The drive will be seen to consist of a simple oscillator with adjustable grid and anode taps to the main inductance. This inductance consists of one coil mounted horizontally, and constructed so that turns can be added one at a time by means of switches. Five values of this inductance are needed to cover the wave-range of the transmitter.

The closed circuit condensers consist of a variable air condenser and a semi-variable air condenser, of which one plate can be switched in at a time. The control of both of these is by handles on the front of the panel.

The drive is directly coupled to the grids of the magnifier valves, a third clip on the main drive inductance being connected to the grids of the magnifier through two condensers, one fixed and the other variable.

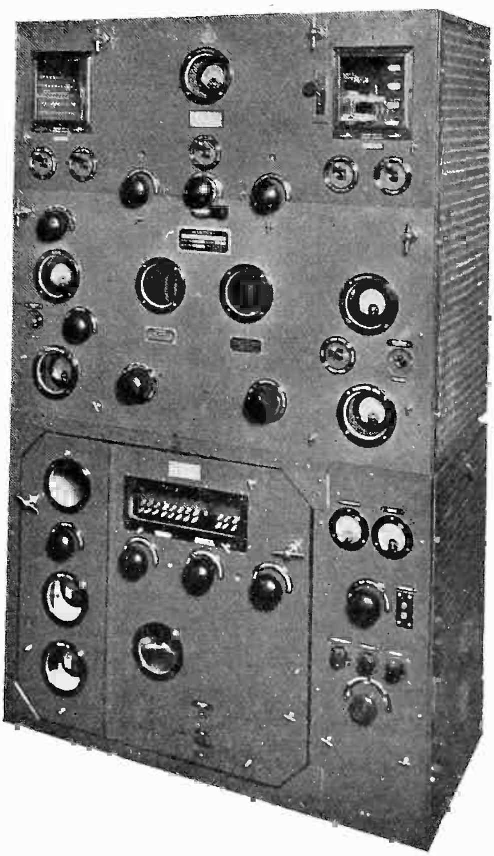
The variable condenser provides a fine control of the voltage swing on the grids of the magnifier valves at the shorter wavelengths.

The magnifier closed circuit consists of two coils mounted astatically, H.T. being fed into the centre of the system through one or other of two air core chokes. One choke is used for wavelengths below 60 metres and the other choke for wavelengths above.

Two condensers, similar to those used in the drive circuit, are connected across the ends of the coils. Four values of inductance are needed to cover the waverange of the set.

A slow motion movement is fitted to the variable condenser, to enable the circuit to be accurately adjusted to the drive circuit.

A hot wire ammeter is provided at the mid point of the astatic inductances for neutralising purposes. This ammeter is shunted when the set is under power and then serves as a magnifier closed circuit current indicator.



T.N.7 Transmitter completely assembled.

The grid bias of the magnifier valves is set either by a fixed resistance for C.W. or by the modulator valve impedance for I.C.W. or telephony. More will be said of this later.

Aerial Circuit.

The aerial is magnetically coupled to the output circuit of the magnifiers. As has been stated above, the aerial impedance is controlled by means of one of two variable condensers, in conjunction with the coils coupling to the output circuit of the magnifiers. The two variable condensers can be connected either in series between the aerial and the coupling coils or in parallel with the coupling coils. The two coupling coils also can be arranged in series or in parallel by switches.

With this arrangement of aerial control it is possible on any length of aerial to so adjust its impedance for any wavelength that, with the amount of coupling provided by the coupling coils, sufficient energy can be transferred to the aerial to fully load the magnifier valves. The only limitation with regard to the length of the aerial is that it should not be less than one-fifth of the longest wavelength to be used.

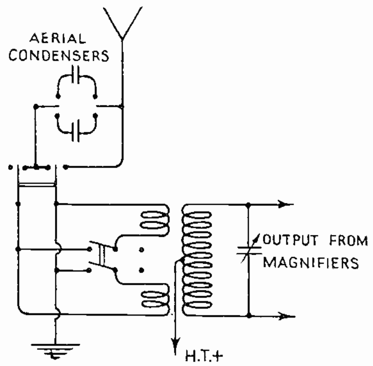


FIG. 2.

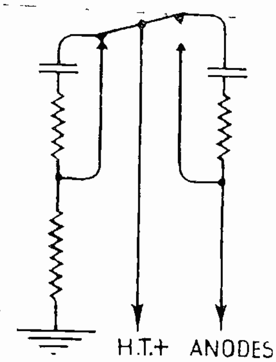


FIG. 3.

This complication of aerial adjustment is rendered necessary by the fact that the set is designed for use on warships, etc., where a variable length of aerial is not generally available.

Keying on C.W.

Keying on C.W. is accomplished by the back load method (Fig. 3). The main H.T. supply to the set is broken by the key on spacing, when the full load of the generator is absorbed by a resistance down to earth.

The key has resistances and condensers across its contacts to eliminate sparking as far as possible.

The method has the advantage that violent fluctuations of anode voltage are avoided, as the load on the generator remains constant.

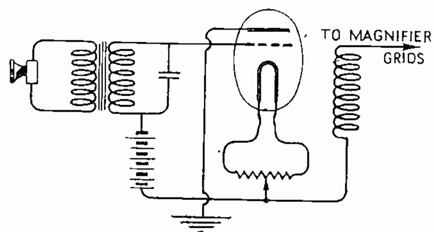


FIG. 4.

Modulation on I.C.W. and Telephony.

As has been stated above, the grid leak method of modulation is used on the T.N.7. This method consists in controlling the input of the magnifier valves by varying the resistance of the magnifier valve grid leak.

The anode impedance of the modulator valve is used as this grid leak resistance, and the impedance is varied by applying the required modulation on to the grid of this valve. The modulator valve is connected with its filament to the grid of the magnifiers and its anode to earth in order that it may pass the grid current of the magnifier valves. The filament battery of the modulator must, of course, be insulated from earth. A diagram of connections of the modulator is given in Fig. 4.

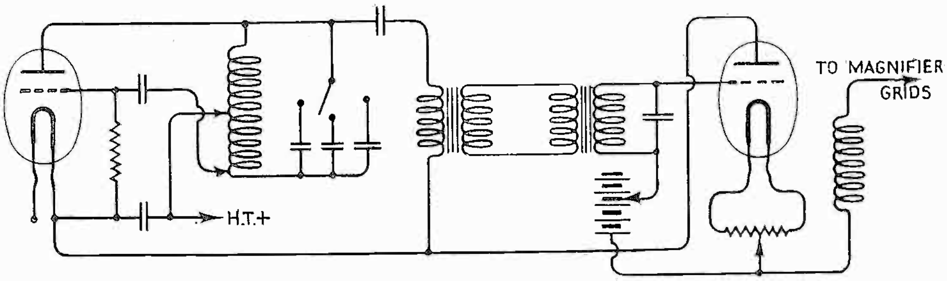
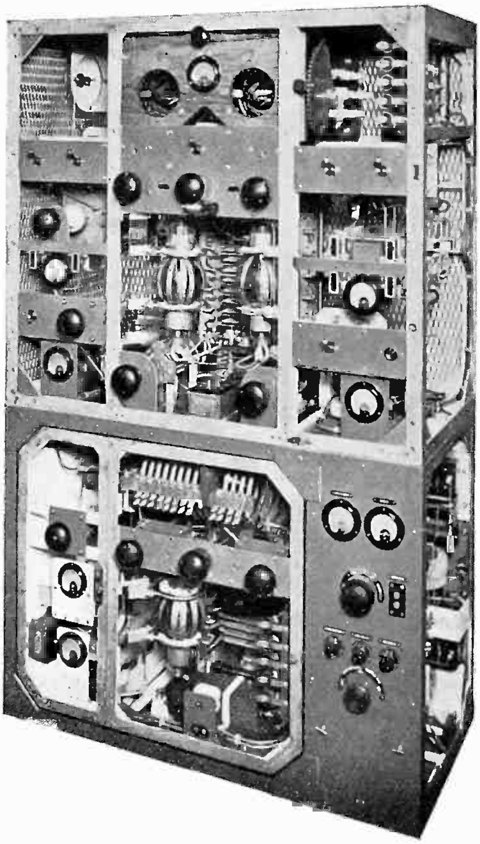


FIG. 5.

The degree of modulation obtained on telephony in this transmitter is of the order of 70 per cent.



T.N.7 Transmitter with front covers removed to show essential circuits.

Note Oscillator for I.C.W.

The note oscillator which is used for I.C.W. signalling is a simple circuit adapted to give three frequencies by the use of three condensers, which can be switched into and out of circuit (Fig. 5).

THE B.B.C. IMPERIAL BROADCAST EXPERIMENTAL SHORT WAVE TRANSMITTER 5SW

As a result of the success attending the use of short waves for establishing communication between Great Britain and Australia, the public in the British Dominions overseas expressed its keen desire to participate in the National Broadcast movement at home, and asked for special Short Wave programmes to be transmitted for this purpose.

It was recognised by the B.B.C. that provided the obstacles in the way were not too great, it was very desirable that a system of Imperial Broadcast Transmissions which would enable selected programmes from Great Britain to be relayed throughout the British Empire should be introduced.

It was found, however, on examination, that the problem was beset with difficulties, some known, others which were anticipated but could not be defined without trial.

To obtain telephony of good broadcast quality on short waves is more difficult than on long waves; the wavelength which would be most suitable for one Dominion might not be so good for another; the daylight and all-darkness attenuations and the best hours for working to the different Dominions and the fading would be different; also the radical difference in Broadcast hours G.M.T. raised a very important issue.

A compromise service seemed to be indicated, and in order to determine the best arrangement for permanent use, experimental Short Wave plant was installed at Chelmsford, and the now familiar transmissions from 5SW were begun in October, 1927.

AT the Chelmsford Works of the Marconi Company is situated the Short Wave Broadcasting Transmitter working on 24 metres under the call sign of 5SW.

The station is operated on behalf of the British Broadcasting Corporation by the Marconi Company, and the normal duty of the set is to relay the London programme for the benefit of listeners in the British Dominions overseas. The set itself is recognised as being of an experimental character, and no particular trouble has been taken to instal it in a permanent manner. In spite of this, the station has proved very successful during the twelve months it has been in operation, and good reception has been reported from practically every part of the world. Numerous relays of the transmission have been carried out in Australia, South Africa, Canada and the United States.

The station works normally each day, excepting Saturdays and Sundays, between the hours of 12.30 and 1.30 p.m., and from 7 p.m. until midnight. Duplex working with 2XAD Schenectady, U.S.A., is also carried out each Monday and Thursday from 5 to 6 p.m.

The apparatus forming the transmitter consists of the high frequency units of a standard Marconi Beam Type Transmitter, together with a modulator unit and the necessary rectifying and smoothing apparatus. A schematic diagram of the installation is given below (Fig. 1).

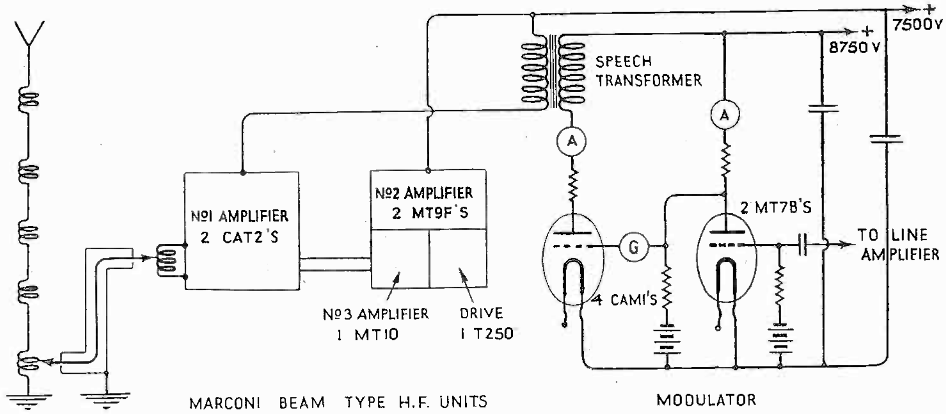


FIG. 1.

The high frequency units, occupying two brass frameworks, comprise a drive, isolator, and intermediate amplifier complete with their oscillatory circuits in one panel, and a main amplifier with oscillatory circuit in the other panel.

The drive uses one valve, Type T.250, and is mounted in a screened case. The anode voltage is given by a 1,000 volt dynamo, and the filament is lit from an accumulator battery. Experience has shown that by carefully maintaining the filament voltage at a fixed value, a very high degree of frequency constancy is obtainable. The input power to this stage is approximately 55 watts.

The isolator is likewise enclosed in a shielding box and consists of one valve, Type M.T.10, with an anode input of 100 watts.

The intermediate amplifier consists of two air-cooled valves, Type M.T.9F, working with an anode input of 500 watts. This stage is arranged to form a completely balanced bridge.

The main amplifier, also arranged in bridge formation, comprises two valves, Type C.A.T.2. These valves are cooled by oil for reasons of efficiency, the oil being pumped through a closed system which passes through a water cooling tank.

The input to this stage is 12 kw. at 7,500 volts in the carrier condition.

The anode circuit is coupled through an intermediate tuned circuit to a feeder of the enclosed type, that is, a pair of concentric tubes, the outer being earthed along its length and the inner being insulated by porcelain separators. The feeder, approximately 320 feet in length, is connected to a coupling inductance at the base of the aerial.

The aerial is a single wire supported from a triatic about 340 feet high, and is of the Franklin type, incorporating phasing coils, or lumped half-wave inductances, in order that the radiating parts of the aerial may add their fields in phase.

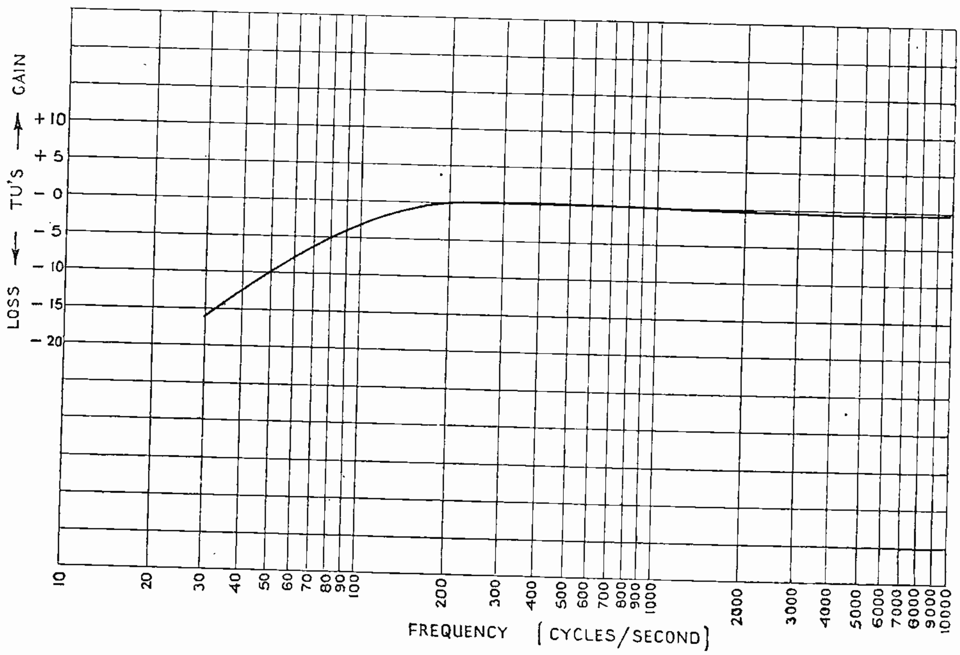


FIG. 2.

The modulating portion of the set consists of a main modulator bank of four C.A.M.1 valves, using water for cooling purposes, and a sub-modulator of two M.T.7B air-cooled valves. The input to the modulator is 14 kw. at 8,750 volts. Modulation is carried out by voltage variation on the anodes of the main amplifier, through the agency of a one to one ratio iron-cored transformer. The full power modulation method is probably the most effective for use on such short wave transmitters, in which there are various difficulties involved in obtaining the required output unless the main amplifier is operating at full efficiency, which, of course, could not occur if the main stage were acting as an amplifier of modulated high frequency in a low-power modulation system.

This arrangement shows an advantage over the more usual single winding speech choke, as the anode currents of the amplifier and modulator can be connected in opposition in the transformer windings, thus balancing out their magnetising effect on the iron, so that the core need only be of sufficient section to deal with the alternating current component.

Two rectifying and smoothing banks are in use, one supplying the modulator and the other the high frequency stages, although this is not essential.

A degree of modulation of approximately 80 per cent. is obtainable without distortion. The usual land line amplifiers step up the received signals from the London studio to the required level to operate the sub-modulator stage. The connection to London, about 30 miles, is by air line for the greater part of the distance. A frequency characteristic of the set is shown in FIG. 2.

A DISCUSSION ON H.F. VALVE COUPLED TUNED CIRCUITS

The demand for careful design of high frequency amplifying systems, due to the modern conditions under which they work, has, naturally, led to divergent opinions as to the factors on which efficient design should be based.

In this article, the author discusses the tuned circuit type of high frequency amplifier from two points of view :—

(1) *Voltage Amplification.*
(2) *Selectivity.*

The effect of the output circuit on these two factors is calculated, and the result of tapping the inductance in this circuit is considered.

Lastly, the article deals with the questions of the limits of "goodness" of coils and of valve amplification factors and impedances.

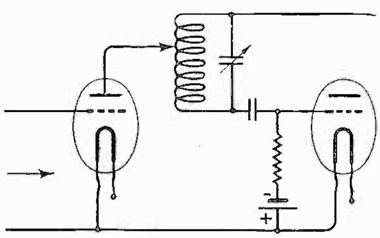
THE high frequency system of a receiver has to satisfy two conditions, selectivity of a given amount, and amplification, but before discussing the modern valve coupled tuned arrangement, it may be of interest to review the development of general purpose receiver design.

Soon after hard valves came into general use (1918), the number of wireless stations in operation in even the most crowded areas of the world was comparatively few, and in consequence no great degree of selectivity of the tuning circuits was necessary in the design of general purpose receivers. Thus the tendency then was to employ a separate tuning system which would incorporate one or, at the most, two circuits of very ordinary "goodness" and follow this with an H.F. amplifier of the aperiodic type. Such an amplifier, because it was aperiodic, had a high noise level, and hence the total amplification by such means was limited.

With the passage of time, however, because of the large increase in the number of working stations, the conditions under which receivers work have become more exacting and hence receiver design has had to adapt itself to meet new conditions ; whereas in the past, receivers of the general purpose type were of the same broad selectivity, whether they were for C.W. reception or telephony, now they will be designed so as to admit exactly that band of frequencies necessary for the particular type of signal being received. Because a simple tuning system is no longer sufficiently selective for any type of work, and more circuits are wanted, it is found easier to adopt a combined amplifying tuning system, and the aperiodic amplifier has for the moment become a thing of the past. Further, our modern requirements call for greater total amplification, and it will be desirable to say a word as to the limit of amplification. We may say there are three things which limit the amount of amplification. The first is noise level. One can continue to amplify only so long as the ratio of signal to noise is good. In the older types of amplifiers this was a very important factor which prevented the building of amplifiers having very high amplification. The 55 type, for instance, had an overall amplification of about 800 at its optimum, and at this figure it was very noisy.

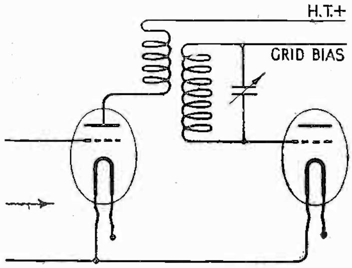
The second factor governing total amplification, if not theoretically, at least economically, is self oscillation. Self oscillation is a function first of feed-back coupling, and secondly of total amplification. Hence the more the total amplification the more the tendency to self oscillate. Thus, as greater amplification is required, greater care must be taken to avoid feed-back coupling, and in modern amplifier design considerable trouble is taken to avoid this by using astatic coils, good screening and careful wiring. The inherent reversible coupling due to valve capacity must also be avoided either by balancing, as with three electrode valves, or by eliminating, as with the screen grid type of valve, the latter method now being universal, where large amplification is desired.

The third factor, governing the amplification per stage rather than total amplification, is the loss of selectivity which may be sustained, but more of this later.



TUNED ANODE

FIG. 1A.



TRANSFORMER COUPLED TUNED GRID

FIG. 1B.

There are two circuit arrangements for the modern type of valve coupled tuned high frequency amplifier, both of which are essentially the same theoretically, the tuned anode which will be analysed, and the transformer coupled tuned grid, one stage of each being shown in Figs. 1a and 1b. In the tuned anode a second winding is saved, but owing to the grid coupling condenser necessary, grid blocking may occur with a high transient voltage such as a strong atmospheric. In both cases we have a valve whose load impedance consists of a tuned circuit, and the aim is to get the biggest voltage step up from grid to grid.

It is desirable to show first the effect of external impedance on the step up obtained with a valve, and Fig. 2 gives the percentage step up of valve volts in terms of M for different load impedances Z_e, the latter being in terms of valve impedance. From this curve one can see that the step up increases rapidly from zero to a point where the load equals the valve impedance (where it is ·5M) and from this point onwards the step up increases slowly, only reaching M when Z_e becomes infinity.

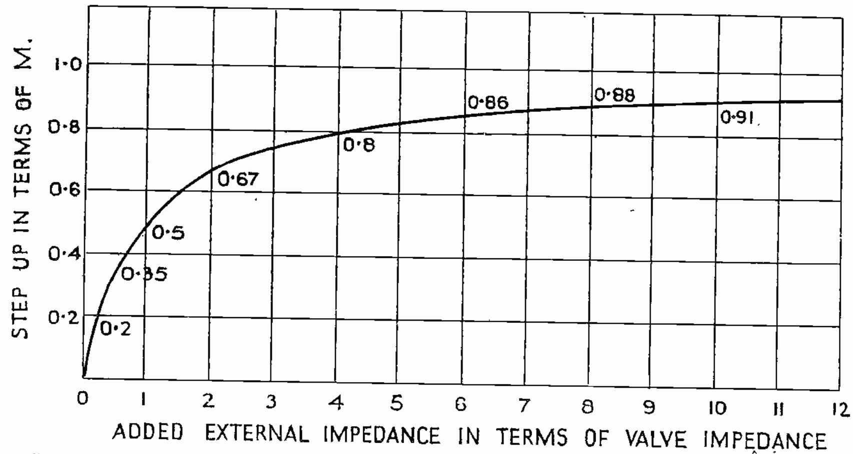


FIG. 2.—*Curve showing the step-up obtained in terms of M for added impedance of different values.*

In the present case the external impedance is a parallel tuned circuit and it is of interest first to consider the ideal. If the circuit has no resistance its effective impedance at resonance is infinity. Thus, if an AC resonant supply is tapped across the whole coil, there is a circulating current set up in LC such that the volts across AB equal the supply volts.

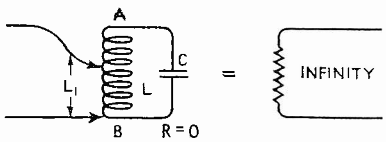


FIG. 3A.

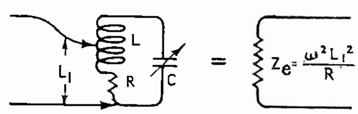


FIG. 3B.

If now the supply is tapped across a part of the coil L_1 say, the effective impedance across L_1 still remains infinity, because the circulating current is boosted up until the back volts across L_1 equal the supply volts. (Fig. 3A.)

Thus considering the perfect tuned circuit as an interstage, if L_1 is included in the plate circuit of the previous valve, because the circuit acts as an infinite impedance load, we could get a change of M volts across L_1 (where M is the voltage factor), and if the grid circuit of the next valve is tapped across the whole coil, we could get a step up of the turns ratio roughly, i.e., $\frac{L}{L_1}$, all assuming zero resistance and no drop in coupling to the grid.

Note now, how considerably the effect of resistance modifies the action. Resistance in a parallel tuned circuit means the circuit now takes feed current (in proportion to the resistance), and hence such a parallel circuit is no longer an infinite impedance at resonance, but an equivalent finite impedance Z_e (almost resistive) of value $\frac{v}{i}$, where v is the applied A.C. voltage and i the feed current. (Fig. 3B.)

As the feed current is directly proportional to the resistance in the circuit and inversely proportional to the square of L_1, one can find the equivalent resistance Z_e, knowing the constants of the circuit by the formula—

(approximate) $Z_e = \dfrac{w^2 L_1^2}{R}$ where $w = 2\pi n$ .. .. (1)

L_1 = Inductance between points of tap.
R = Series resistance of LC circuit. We can assume all the resistance is in the coil.

An alternative formula is—

$$Z_e = \frac{L}{CR} \quad \text{.. .. .. ..} \quad (2)$$

NOTE.—Both these formulæ only apply at resonance.

From formula (1) it is seen that as one taps down the coil the effective value of Z_e decreases rapidly, and if some actual cases are worked out it will be found that it is not possible to get very high values for Z_e unless the resistance in the circuit is reduced to a very low figure, that is by using very good coils. Thus the effective resistance of a parallel tuned circuit is far from being the infinite impedance one imagines, and the impedance very rapidly comes down as the tap is lowered.

For instance, consider the following quite ordinary circuit working at a frequency of 10^6.

L = 200 mics.
C = ·00013 mfds.
R = 20

The equivalent impedance Z_e at different points of tap will be as follows :—

Tap whole coil =	80,000 ohms.	160,000	
,, $\frac{3}{4}$,, =	45,000 ,,	90,000	
,, $\frac{1}{2}$,, =	20,000 ,,	40,000	
,, $\frac{1}{4}$,, =	5,000 ,,	10,000	
	If R = 20	If R = 10	

(The above figures are approximate only.)

Had one used better wire such that the series resistance of the circuit was halved, the figures would be as in column 2, showing a maximum value of 160,000 ohms.

If now we think of such a parallel circuit having resistance, as the load impedance, we can see that as long as we do not fall off the flat part of the curve, we can benefit by tapping down, because by tapping down we can get a turns ratio step up, and this is an advantage, provided the primary volts do not fall off in greater proportion. Thus, if we are using a valve whose impedance is really low compared to the Z_e of the parallel circuit, we can get an advantage of voltage step up by tapping down, but if the valve is comparable with Z_e no advantage can be gained.

For instance, consider a valve of impedance 10,000 ohms with an M value of 10 in whose anode is the previous LCR circuit considered. At the whole tap the Z_e of LCR is 80,000 ohms, eight times the valve impedance, and hence the primary volts are ·88 M. Since there is no step up the secondary volts are ·88 M also, assuming no drop in coupling. If we tapped down half way, the Z_e of LCR is 20,000 and hence the primary volts are ·67 M. But there is now a turns step up of roughly 2/1 and hence the secondary volts are 1·34 M. It will be found that the maximum secondary volts are given when $Z_e =$ the resistance of the valve, the curve (Fig. 4) showing this relationship for circuits of different values. These curves are very instructive as they show clearly that unless the $\frac{L}{R}$ of the circuit can be made sufficiently high, so that its impedance is many times the valve impedance, it is not worth while tapping down from this point of view. But there is an equally important point still to discuss, namely, the selectivity of such a system, and how the valve modifies the selectivity at different tappings.

Selectivity.

The selectivity of a parallel resonant circuit is determined by the ratio $\frac{L}{R}$, hence the better the coil the greater its selectivity. If across such a tuned circuit we have a shunt resistance, the latter will damp the circuit in inverse ratio to its resistance and may be considered as throwing back into the circuit an equivalent series resistance of value $\frac{w^2 L_1^2}{Z_e}$, where $w = 2\pi n$, L_1 the inductance between the taps, and Z_e the shunt resistance.

Thus with a shunt resistance infinity no damping is added, but if the shunt resistance approaches that of the equivalent resistance of the tuned circuit considerable effect may be noticed unless that shunt resistance is across only a small portion of the coil.

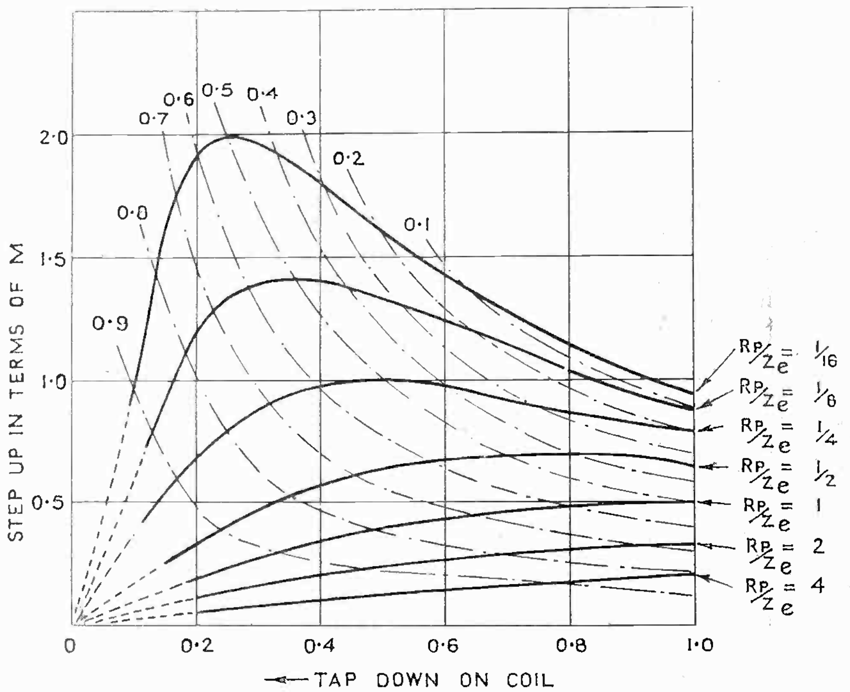
Now across the tuned circuit we are considering is a valve whose shunt resistance may be comparable to the equivalent shunt resistance of the circuit, and hence the valve will tend to destroy the selectivity of the circuit. The effect will be very marked unless

(1) The valve resistance is very high compared to the equivalent resistance of LC.

(2) The valve is tapped low.

Notice that with a given valve, if we make the coil of the circuit better and do not tap down we hardly gain at all in selectivity.

To show this effect clearly selectivity curves of different factors have been drawn across the impedance curves of Fig. 4, the selectivity of the original LC circuit alone being reckoned as 1. These curves show the addition of damping caused by



a shunt valve of given relative impedance at different tapping points. For instance, if the valve impedance equals the circuit impedance, then the selectivity is halved. This means that if we tap to obtain greatest amplification, *i.e.*, to where Z_e equals the valve impedance, we must sacrifice half our selectivity. At higher taps than this the selectivity is still worse and hence a tap down to below such a point will be better in order not to get too flat tuning. With low impedance valves we are very badly off in this respect, as we require a very low tap to keep up selectivity, and such a tap being critical will not satisfy every frequency. With high impedance valves it is probable we cannot tap up high enough to get anything like the maximum step up, but it may still pay us to tap down as the percentage amplification lost will not matter, and by tapping down we are gaining selectivity.

These curves in conjunction with the previous amplification curves show clearly the effect that altering the ratio of circuit impedance to valve impedance has upon both step up and selectivity.

As time progresses because design calls for more selectivity and greater amplification, the tendency is to increase the goodness of circuit and raise the M (and R) of the valves used, and it may be realised that when we have made the circuit as "good" as possible, the effect of raising the M and R of the valve is to lose less selectivity, but lose more percentage step up. Because the percentage step up falls off, this does not mean the total step up will be less, but a limit must eventually be reached beyond which increase of M and R cannot give any further increase of amplification per stage. It is dangerous to attempt to state where this limit is, but on ordinary frequencies it may be somewhere about 60. Which means that if we have a valve whose voltage factor is greater than 60, we cannot get a step up of its full M, because we cannot get a circuit good enough. For instance, the standard screen grid valve has an M of 150 at its usual working point, and hence we are working on the bottom of the family of curves shown in Fig. 4, from which it can be seen that the maximum percentage step up is very small (of the order of ·3), but the selectivity will be very good, and would be better if we tapped down a little.

As the valve impedance is raised we gain less and less percentage step up, and if the valve impedance is high enough it may not be worth while to tap down even from the point of view of selectivity. Thus the circuit goodness, when it is made as perfect as economic and practical conditions will allow, imposes a limit to the design of high M (high R) valves, above which no advantage by voltage step up can be obtained. The fact that valves are being made above this limit (a valve of M = 1,200, with correspondingly high R is proposed), does not help us to gain more amplification, but advantage will be gained in keeping up the selectivity, and it is only for such a reason that valves of such an enormous resistance will be of use.

A. W. LADNER.

MARCONI NEWS AND NOTES

THE MARCONI FACSIMILE TELEGRAPH SYSTEM

DEMONSTRATION OF TRANSATLANTIC OPERATION

A striking example of Marconi facsimile transmission received at Somerton from the United States.

A FURTHER important stage in the development of facsimile transmission over long distances was reached on February 3rd, when a demonstration of Transatlantic transmission of facsimile messages by the Marconi Short Wave Beam Facsimile system was given at the Marconi Beam Receiving Station at Somerton, in Somerset.

This demonstration was given to a number of newspaper correspondents representing the principal English newspapers and technical publications, who were greatly impressed by the excellence of the pictures transmitted from the Beam Station at Rocky Point, Long Island, New York, and received at Somerton.

Not only did the newspapers devote a large amount of space in their news columns to appreciative descriptions and illustrations of the demonstration, but many of them gave leading articles to the subject.

The *Morning Post,* for instance, said in its leading article that the Marconi Facsimile system has

> "... an advantage both in certainty and secrecy : the handwriting is evidence of authenticity, and the message could not be intercepted with the ease that Morse can be picked up. For the system is as great an advance on Morse in the intricacy of its working as the higher mathematics on the tally of a shepherd. Instead of the simple alternation of short-and-long, by which man has been accustomed to telegraph his messages, the varying resistances of a photo-electric cell to light are used to modulate the wireless transmitter and are reproduced in synchronism at the other end. Not a signal merely, but an image is telegraphed. Those varying resistances to light, which, in combination, make what we see of things, are flashed with such rapidity that the picture rolls off the cylinder thousands of miles away as it is exposed to the transmitter. Here, then, is one more development of a new economy of science which is revolutionising, if not annihilating, time and space."

Commendation from Technical Publications.

The *Electrician* and the *Electrical Review,* the two principal English electrical periodicals, also published appreciative editorial comments.

The *Electrician* says :—

> "Our first acquaintance with this system was some two years ago, when the Marconi Company was thinking of distances in yards and obtaining results considerably less definite than those now possible over 3,000 odd miles. The progress made in so short a time is nothing short of remarkable, and is indicative of the enthusiasm which has been brought to bear on the problems involved in the field of electrical research."

The *Electrical Review* writes :—

> "That photo-telegraphy has long outgrown the experimental stage is clearly indicated by the extensive and varied use that is made of the regular commercial services that are available to the public in this country, on the European Continent, and in America ; indeed, last Sunday's demonstration of Marconi's Wireless Telegraph Co., Ltd., suggested that in time facsimile services may largely replace Morse telegraphy on busy circuits, and that the receipt of photo-radiograms, *i.e.*, exact replicas of the senders' hand-written originals, will be the normal procedure.
>
> "Elsewhere in this issue a brief outline of the methods employed will vindicate the claim that they differ from others in use at present : the apparatus is certainly ingeniously contrived and reproduces beautifully clean facsimiles of the originals. Moreover, not only has it been specially

adapted to operate on short-wave beam radio circuits, thus making it possible to reduce considerably the period of transmission, as compared with long-wave services, but it is also learned with interest that the possibility is contemplated of devising a system of superimposing on one and the same beam radio circuit several telegraph channels, one for facsimile transmission, and one for telephony; in fact, a triplex circuit. Thus is the value of research clearly demonstrated, and the Company is to be congratulated on having obtained results of so high an order of merit."

These independent commendations both from the lay and technical press made after a personal observation of the apparatus at work and of the results achieved are a valuable corroboration of our own claim that we have achieved something far ahead of anything previously developed in facsimile reproduction by wireless.

How the Reporters saw it.

One or two other extracts from newspaper reports may be interesting as giving a glimpse of the demonstration as seen from the outside observer's view point.

The *Daily News*, for instance, wrote :—

From our Special Correspondent.

Somerton (Somerset), Sunday.

" In a 'dark room' at the Marconi 'Beam' Receiving Station here this afternoon I watched a message come through from the other side of the Atlantic in the handwriting of the *Daily News* New York Correspondent.

" All I saw in the dim, red glow was a spot of light running round a cylinder, but three minutes later, when a piece of photographic bromide paper was taken from the cylinder and put into a developing solution the message appeared almost immediately.

" The total time that elapsed between the transmission of the message from Long Island and its appearance in facsimile here was only 3½ minutes.

" The demonstration marks the opening of what promises to be a new era in wireless transmission. Facsimile messages and pictures have been transmitted across the Atlantic by the long-wave system since 1926, but the development of the Beam system demonstrated here to-day is quite new, and opens up many possibilities.

" It is far quicker than the existing long-wave system. The message that took only 3½ minutes to come from New York this afternoon would, I am told, have taken 2½ hours by the long-wave system.

"This increase in speed, it is claimed, means that facsimile transmission, which up to the present has been of the nature of a luxury, will become the normal thing.

"Eventually, I am assured by Marconi experts, there is no reason why the ordinary suburban telegram sent, say, by a husband delayed at the office, should not be delivered in the handwriting of the sender."

The *Daily Sketch* :—

"In the ruby light of the dark room of the Marconi Beam Wireless Station here this afternoon I watched a beam of light travelling round and round a cylinder of bromide photographic printing paper. Three minutes later I saw the paper removed from the receiving machine and immersed in a bath of developer, and within a few seconds I was able to read the message sent to the *Daily Sketch* by Gertrude Lawrence from New York.

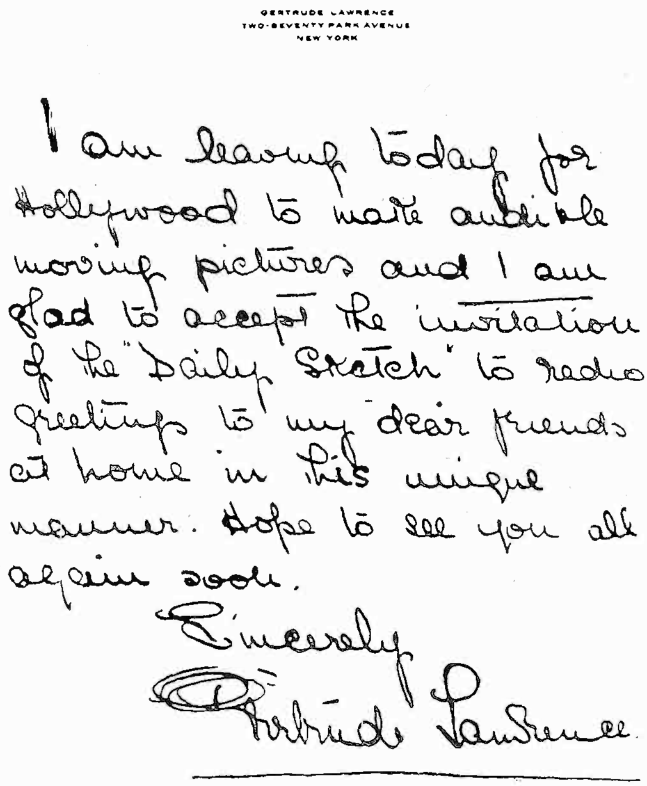
"The message was in the famous actress's own handwriting and the reproduction was perfect. A whole page of a New York newspaper was sent by facsimile transmitter during recent experiments in thirty minutes, and every word on the printed page was readable after the sheet of bromide paper on which it was received had been developed."

North Mail :—

By Candidus.

"At last we have real telegraphy. Ordinary telegraphy does not quite justify its name, for telegraphy means writing from a distance and the telegraph that all of us know sends the message indeed, but not the writing. But the message from Miss Lawrence in New York, which was printed yesterday, was in exact facsimile of her own handwriting.

"I leave the scientific aspects of this new discovery to those who understand them ; I do not. But I am interested in the practical consequence of this new method. It means that if I did not care how much it cost I could get a letter—not a message but a facsimile letter—across the Atlantic in less time than it takes the Post Office to carry it from, say, Hampstead or Wimbledon to the City of London. Does it not follow that the political effects of distance have now been annihilated, such a system which annihilates distance, as this does, has a political value to the British Empire that can hardly be exaggerated. For the purpose of sending and receiving messages, Melbourne is now no further off from London than Edinburgh.



GERTRUDE LAWRENCE
TWO-SEVENTY PARK AVENUE
NEW YORK

I am leaving today for Hollywood to make audible moving pictures and I am glad to accept the invitation of the "Daily Sketch" to radio greetings to my dear friends at home in this unique manner. Hope to see you all again soon.

Sincerely
Gertrude Lawrence

Facsimile message from Miss Gertrude Lawrence, the well-known British revue star, sent from New York to England for the Daily Sketch *by the Marconi wireless facimile system.*

" If there is an elaborate difficulty which needs careful explanation, it can be done promptly by the new wireless system, under which half a page of newspaper can be sent as easily as an ordinary inland telegram."

The *Daily Express* :—

" Strube's Little Man did a lightning sprint across the Atlantic this afternoon. He travelled from Rocky Island, New York, to the new beam Marconi Station here in Somerset—a distance of 2,800 miles—at a speed of 56,000 miles an hour. The Little Man's time for his great Transatlantic flight was only 3 minutes.

" Strube drew the cartoon of the Little Man specially for this historic feat. The cartoon was despatched by liner to America. It was taken to the Marconi transmitting station at Rocky Island and flashed across the

Strube's Little Man, who crossed the Atlantic for the Daily Express *in three minutes during the Marconi facsimile demonstration.*

Atlantic. The transmission was perfect. The wirelessed cartoon was absolutely identical in every respect with the original, a copy of which I held before me for comparison."

The *Daily Herald* :—

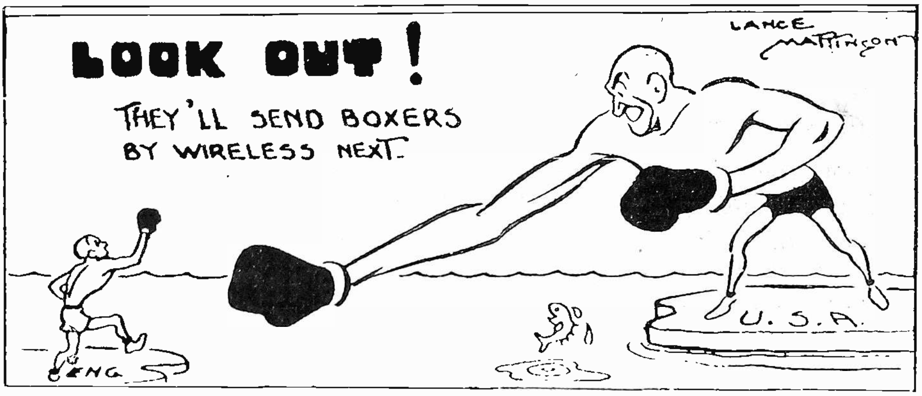
"The drawing here reproduced by our cartoonist, Lance Mattinson, was sent to New York for transmission 6 days in advance. It took just 10 minutes to come back."

History of the Marconi Facsimile Experiments.

Practically ever since the inception of the telegraph, the problem of picture transmission has fascinated electrical engineers. As early as 1842 Alexander Bain invented a highly ingenious system of picture telegraphy, and many others have followed more or less in his footsteps, with widely varying results.

The first telegraphic picture service opened to the public, however, was that, worked on the Ranger system, which has been in commercial operation between Radio House, the Marconi main telegraph office in London, and New York since May, 1926. Some hundreds of news pictures, cartoons, fashion plates, signatures, cheques, and plans have been transmitted commercially across the Atlantic by this system.

The unequalled working speed of the Marconi short-wave Beam telegraph services has now opened the way to further revolutionary achievements in facsimile transmission, and the Marconi Company has during the last three years been developing its system, adapted specially to short wave wireless and to land-line circuits, to give far higher speeds and clearer reproduction than can be obtained by any other method. When such a system is universally adopted it is expected that it will reduce the



Lance Mattinson's cartoon received at Somerton for the Daily Herald *during the Marconi facsimile demonstration.*

telegraph operating costs, with the result that facsimile telegrams instead of costing more than ordinary telegrams should actually cost less.

In order to produce a system commercially applicable for everyday telegrams, the Marconi engineers deliberately scrapped practically all that had previously been done in the field of picture transmission, and started afresh. The result is that their system differs greatly both mechanically and electrically from any other, and while there are certain difficulties still to be overcome before practical perfection is attained, it is now possible to transmit two images each 8 in. by 10 in. in less than 20 minutes. At the public demonstration messages 10 in. by 4 in. were actually received in $3\frac{1}{2}$ minutes.

These messages have the advantages of unimpeachable accuracy, and—as will be seen from the specimens printed here—the possibility of including not only handwriting but the reproduction of anything that can be written or drawn on paper in the telegrams transmitted—a particularly valuable feature when complicated columns of figures and diagrams are required.

No Stopping.

From the operating point of view, the most important novelty about the Marconi facsimile gear is that it runs continuously. It is not necessary to stop the machinery every time a new picture is put on the transmitter or taken off the receiver. As soon as one message is finished another can be placed on the cylinder and transmission begins at once. This point alone effects a great economy in obviating the running-up of the machinery and synchronising the two ends of the circuit separately for every picture. In addition, no preparation of the message to be transmitted is required ; and the reception is perfectly direct and can be checked as it is taking place, enabling faults to be instantly detected and corrected. As the apparatus is ingeniously arranged to transmit two pictures at once, in commercial working one channel could be kept busy on "ordinary" telegrams and the other reserved for "urgent" messages, thus providing a valuable commercial advantage.

Suitability for Landlines.

The new Marconi facsimile system is in every way suitable for the transmission of pictures over landlines, the speed with which pictures can be transmitted depending on the quality of the landlines. The same quality which enables landlines to carry the highest musical notes without serious diminution in volume allows the transmission of pictures at maximum speed. The Marconi apparatus is capable of taking full advantage of the quality of the very high grade landlines such as are used for relaying broadcast programmes.

The Marconi Company is indebted to the Radio Corporation of America for the use of the Beam Station at Rocky Point for the transmission of the messages sent during this demonstration.

Christmas Beam Traffic.

The English Beam Stations continue to attract an increasing amount of telegraph traffic, and the figures for the Christmas week, which are now available, constitute a record for any week since the Beam Stations have been open. The total number of words handled during this week was 1,255,201, figures for the various circuits being :—

Australia	382,886	India	368,583
Canada	199,016	S. Africa	304,716
			1,255,201

These figures, which include Christmas Greeting messages, show how efficiently the Beam services are meeting telegraph requirements between Great Britain, its Dominions and India.

Veteran Wireless Operators Pay Tribute to Senatore Marconi.

On February 12th the Association of Veteran Wireless Operators of America held their Fourth Annual Banquet in New York. Their thoughts, of course, turned to the founder of wireless for whom they naturally have a special feeling of regard. During the dinner, therefore, they despatched the following telegram to Senatore Marconi at Rome :—

> "Veteran Wireless Operators of America assembled at Fourth Annual Banquet in the Hotel Astor, New York, send a mighty voice across the ocean and *mare nostrum* to the greatest figure in the world of wireless. This voice carries the warmest sentiments of brotherhood to you our comrade, and through you it reaches the ears of all our comrades in that great society that knows no boundaries. Signed J. F. J. MAHER, *President.*"