THE MARCONI REVIEW

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COMMERCIAL SHORT WAVE WIRELESS COMMUNICATIONS*

Part II.—THE "VIA MARCONI" SERVICES

The first part of this article appeared in last month's issue and dealt with the Empiradio Beam services.

In the second part, which is given below, the "Via Marconi" services are described.

The concluding section will appear in The Marconi Review *for December and will deal with the important foreign services which have their centres at New York, Paris and Berlin.*

THE Empiradio Beam services are exceptional in several respects.

They provide a self contained world system giving an exclusive service between centres serving vast continents that have growing business interests, and which therefore are able to draw on a large and increasing traffic supply.

They work on strong signals with aerial systems and apparatus which are identical at all the terminal points.

A working arrangement with all competing cables has been reached.

In contrast to this approach to the ideal in wireless communications, we shall now consider that extensive and important group of circuits which has its centre at Radio House, London, and is known as the "Via Marconi Telegraph Services."

Spreading over the whole world is a comprehensive network of inter-communicating commercial wireless circuits having its principal centres at London, New York, Paris and Berlin, and the Via Marconi services comprise that large section of this network which is controlled from London.

Many of these communications employ long wave channels, but the majority use short wave, and the number of short wave channels in commercial use is steadily increasing.

What this means can be better understood by reference to the following table.

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* The following is a reprint of a lecture delivered by H. M. Dowsett, M.I.E.E., F.Inst.P., M.Inst.R.E., before the Radio Society of Great Britain, at the Institute of Electrical Engineers, on September 27th, 1929.

"VIA MARCONI" SERVICES

London—New York Circuit.

English Transmitters :—			United States Transmitters :—	
GLS	15·00 m.	Ongar.	WKM	15·907 m.
GLG	15·74 m.	Dorchester.	WTT	15·84 m.
GLH	22·16 m.	Dorchester.	WLL	16·760 m.
GLK	37·476 m.	Dorchester.	WIK	21·54 m.
			WEQV	21·63 m.
			WAJ	22·24 m.
			WHR	22·35 m.
			2XAM	25·8 m.
			WEL	33·52 m.
			WEC	33·595 m.
			WQO	35·0 m.
			WEM	40·54 m.
			WIZ	43·0 m.
			WEB	43·25 m.
			WQN	59·0 m.
GLC	9,630 m.	Ongar.	WSO	11,652 m.
MUU	14,037 m.	Carnarvon.	WRT	13,265 m.
			WRQ	13,423 m.
			WGG	13,575 m.
			WII	13,750 m.
			WSS	15,950 m.
			WCI	16,300 m.
			WQK	16,400 m.

London—Buenos Ayres Circuit.

English Transmitters :—			Argentine Transmitters :—	
GLS	15·0 m.	Ongar.	LSE	14·38 m.
GLW	15·707 m.	Dorchester.	LSG	15·03 m.
GLY	26·269 m.	Dorchester.	LSF	15·35 m.
GLQ	27·45 m.	Ongar.	LSH	26·0 m.
			LSI	30·20 m.
			LSD	34·0 m.
			LSC	8,800 m.
			LSA	12,630 m.
			LSB	17,430 m.

London—Rio de Janeiro Circuit.

English Transmitters :—			Brazilian Transmitters :—	
GLS	15 m.	Ongar.	PPX	14·45 m.
GLW	15·707 m.	Dorchester.	PPS	14·5 m.
GLY	26·269 m.	Dorchester.	PPU	15·6 m.
			PPW	27·4 m.
			PRLB	37·6 m.
			PRLA	39·0 m.
			PPX2	43·45 m.
			PPR	21,818 m.

London—Belgrade Circuit.

English Transmitters :—			Serbian Transmitters :—	
GLP	5,332 m.	Ongar.	UNB	3,455 m.
			UNA	11,150 m.

London—Moscow Circuit.

English Transmitters :—			Russian Transmitters :—	
			RKV	21·0 m.
			RPK	33·8 m.
GLP	5,332 m.	Ongar.	RNO	3,475 m.
			RDW	3,500 m.
			RET	3,800 m.
			RAI	7,600 m.
			RAM	10,175 m.

London—Paris Circuit.

			FRE	15·45 m.
			FSI	25·125 m.
			FTL	30·0 m.
			FS2	40·03 m.
GLB	3,890 m.	Ongar.	FTP	2,725 m.
			FTS	3,280 m.
			FTR	9,850 m.
			FTT	14,346 m.

London—Berne Circuit.

English Transmitters :—			Swiss Transmitters :—	
			HBC	34·5 m.
GLA	2,947 m.	Ongar.	HBB	3,135 m.
			HBA	4,230 m.
			HBG	4,400 m.

London—Madrid Circuit.

English Transmitter :—			Spanish Transmitters :—	
			EAN	25·03 m.
			EAQ	30·456 m.
			EAM	30.7 m.
GLO	4,330 m.	Ongar.	EAA	3,660 m.

London—Barcelona Circuit.

English Transmitter :—			Spanish Transmitters :—	
			EAX	31·8 m.
GLO	4,330 m.	Ongar.	EAB	3,760 m.

In the above table spaces have been left between long and short wave stations.

"VIA MARCONI" SERVICES—*continued*

London—Vienna Circuit.

English Transmitters :—	Austrian Transmitters :—
GLQ 27·45 m. Ongar.	VOX 23·33 m. UOR 29·9 m. UOK 40·6 m.
GLP 5,332 m. Ongar.	UOF 2,740 m. UOW 3,050 m. UOD 3,896 m.

London—Lisbon Circuit.

English Transmitters :—	Austrian Transmitters :—
	CUW 15·66 m. CUS 18·17 m.
GLC 9,630 m. Carnarvon.	CUN 1,950 m. CUE 6,120 m.

London—Stamboul Circuit.

English Transmitters :—	Turkish Transmitters :—
GLQ 27·45 m. Ongar. GLC 9,630 m. Carnarvon.	TAA 10,600 m. TAF 1,947 m.

London—Beyrouth Circuit.

English Transmitters :—	Syrian Transmitters :—
GLL 21·962 m. Dorchester.	FY { 18·6 m. 22·6 m. 38·0 m.
GLC 9,630 m. Carnarvon.	FZ 10,220 m.

London—Cairo Circuit.

English Transmitters :—	Egyptian Transmitters :—
GLL 21·962 m. Dorchester. GLQ 27·45 m. Ongar.	SUZ 21·7 m. SUW 25·17 m. SUY 44·248 m. SUX 38·5 m.
GLC 9,630 m. Carnarvon.	SUC 11,000 m.

London—Bangkok Circuit.

English Transmitter :—	Siamese Transmitter :—
GLQ 27·45 m. Ongar.	HSP 16·911 m.

London—Sofia Circuit.

English Transmitters :—	Bulgarian Transmitters :—
	LZA 20·0 m. LZB 40·0 m.
GLO 4,330 m. Ongar. GLP 5,332 m. Ongar.	LZS 2,850 m.

London—Tokio Circuit.

English Transmitters :—	Japanese Transmitters :—
GLX 15·244 m. Dorchester. GLY 26·269 m. Dorchester.	JNI 15·79 m. JNR 24·59 m.

Radio House is at present conducting 17 services, namely, to

New York.	Paris.	Lisbon.	Cairo.
Buenos Ayres.	Berne.	Vienna.	Bangkok.
Rio de Janeiro.	Madrid.	Stamboul.	Sofia.
Belgrade.	Barcelona.	Beyrouth.	Tokio.
Moscow.			

The "Via Marconi" services on these 17 circuits transmit on 16 wavelengths, 6 long wave and 10 short wave, and the traffic from the corresponding 17 stations is received on some 94 different wavelengths, 38 long wave and 56 short wave.

To run an undertaking of this magnitude on a successful commercial basis calls for technical and business skill of no mean order, particularly as every one of these routes is already well served by cable or trunk line telegraphs and there is active competition between the rival systems.

The Main Telegraph Office at Radio House with its high speed Wheatstone transmitters, and Undulator recorders and its efficient methods of handling traffic, deserves something more than a brief reference, but I must now pass on to describe the wireless terminal stations.

The transmitters keyed from Radio House are distributed between three stations :—

(1) Carnarvon—All long wave.
(2) Ongar—Some long wave and some short wave.
(3) Dorchester—All short wave beams.

Ongar Transmitting Station.

Ongar has three widely separated station buildings all originally erected for the long wave services.

One of these, known as " C " station, houses in addition, two short wave transmitters, namely :—

(A) GLQ, wavelength 27.45 m. A self-oscillator, which normally works to Madrid, Vienna and Berne, the power supplied to the anode being about 6 kw. 350 cycles unsmoothed. This transmitter is connected by a Lecher wire feeder to a single horizontal doublet aerial.

(B) GLS, wavelength 15 metres. A driven set which normally works to Cairo and Bangkok, the drive being a plain oscillator, or alternatively, crystal controlled, and the power input to the last stage of the magnifier being about 8 kw.

This transmitter is connected by a Franklin feeder system with a single broadcast aerial of the Franklin Universal type.

The four long wave transmitters we need not at present discuss.

Ongar is served with 8 land lines from Radio House, through Brentwood, in addition to two lines from Radio House direct. At present, Radio House keys 5 transmitters at once, and there are sufficient channels to easily increase this number.

Dorchester Transmitting Station.

Dorchester is an up-to-date multi-beam transmitting station. Built for one type of aerial and transmitter, it has been laid out in a well balanced and pleasing manner, and although it is the transmitting terminal point for many services, its operation is simple and efficient.

One row of five masts is erected on a line at right angles to the great circle bearing on New York.

Each of the four bays is provided with two aerial systems, one on each side of the central reflecting system so that the four bays can therefore serve eight channels.

Three of the aerial systems on the one side of the line of masts are for working with New York, and two aerial systems on the other side of the line of masts are used to communicate with Egypt.

Another pair of masts supports the aerial and reflector system for working to South America, while three further masts provide two bays, one of which has two aerials arranged back to back and a common reflector system for working with Japan and the Far East on the one side, and with South America on the other side.

The illustration (Fig. 16), shows the seven transmitters in the station building which are employed on the following circuits :—

GLG	15·74 m.	to New York.
GLH	22·16 m.	,, ,,
GLK	37·47 m.	,, ,,
GLL	21·962 m. / 37·783 m.	,, Cairo.
GLX	15·244 m.	,, Japan or South America.
GLW	15·707 m.	,, Japan.
GLY	26·269 m.	,, Japan or South America.

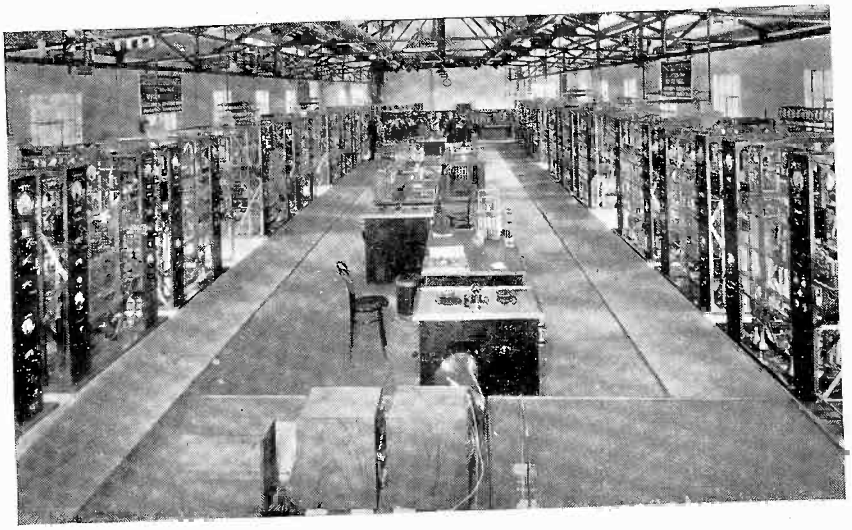


FIG. 16.

Mounted on the control tables along the centre of the transmitter hall are the precision wavemeters for the various circuits, and at the end are the two monitoring recorders with a plug board by means of which the operator on duty is able to check the incoming line signal and outgoing transmitter signal on any individual circuit.

For the Japanese service, signals are sometimes sent by the Eastern route and sometimes by the Western route, by changing over from the aerial on one side of the reflector to the aerial on the opposite side.

This is done by means of a switch worked by distant control from the transmitting station which operates at the end of the main feeder near the masts, and makes contact on to one or other of the two branches which feed the two aerials. An indicator lamp at the station shows when the change over has been completed.

The Egyptian transmitter has two panels which are common for both the 21 and 37 metre transmissions, but the third panel containing the drive and two magnifier circuits is special and is changed over when the wavelength is altered.

London is able to work all the seven transmitters at once. For this purpose, the station has five landlines and one double telephone line and the telephone line can be split and each side used for keying one transmitter while it is still used as a speaking circuit.

Brentwood Receiving Station.

The Brentwood receiving station was originally built for the long wave services, and at the present, the long wave traffic which in itself has considerable volume, all passes through this station.

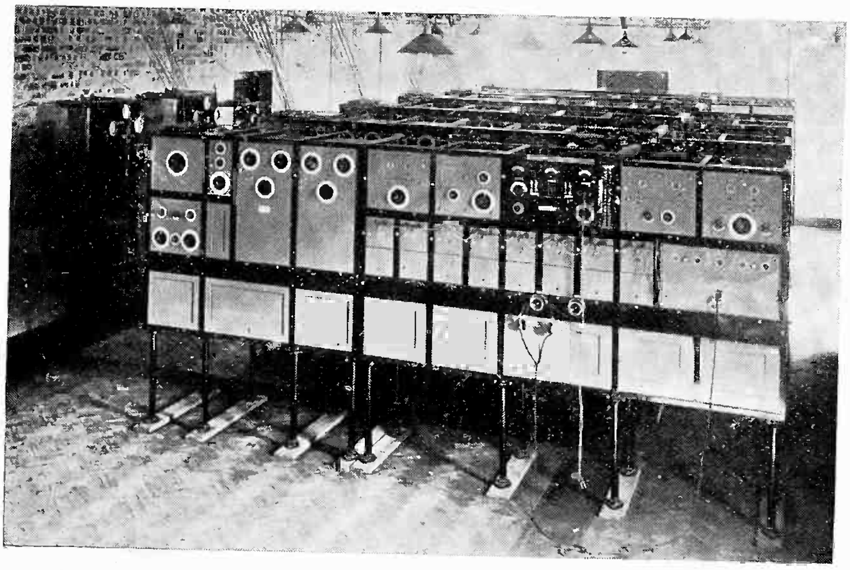


FIG. 17.

During the last few years, its short wave receiver equipment has been steadily increasing, and now the station has some 24 long and short wave receivers employed on traffic circuits which use some 60 wavelengths within the wide range of 15 m. to 30,000 m.

A bay of long wave receivers is shown in Fig. 17, and a group of some of the short wave receivers in Fig. 18.

The Brentwood aerial equipment is necessarily varied in character and illustrates the progressive changes in design which the development of new ideas is constantly bringing about.

In addition to the directional and broadcast long wave aerial systems, the station uses the following short wave arrangements :—

(A) Two wide angle beam aerials of the Franklin Uniform type, both without reflectors, one used for the 34·5 m. service to Berne and the other for the 31 m. service to Madrid, both aerials being coupled to their respective receivers by concentric tube feeders.

(B) Three directional aerials of the R.C.A. Broadside type, which will be described later on in this paper, one for the short wave services to New York, Vienna and Beyrouth ; another for the short wave service to Bangkok and the third for the short wave services to Rio de Janeiro, Lisbon and Tokio. These aerials have parallel wire feeders.

(C) Four Broadcast Uniform type receiving aerials for general purposes with concentric tube feeders.

FIG. 18.

The monitoring arrangements are such that signals from any receiver can be checked on any one of three undulators or by telephone. All incoming signals sent by Radio House through Brentwood by any of the eight lines to Ongar transmitters can also be checked, as can any radiated signals from Ongar.

The silent working of this station is very noticeable. For convenience of rapid change-over, the bus-bars of the various aerial feeders run unscreened transversely over all the short wave receivers. As this might encourage the pick-up of key click induction effects caused by the working of the various relays on the station, every relay has been eliminated and replaced by a valve circuit.

Brentwood has to change its aerial-receiver connections several times a day, and it may be asked by Radio House to pick up a new or unfamiliar station. With several directional aerials to choose from, it solves the difficulty of which to employ by means of a gnomonic projection chart of the world having its centre at Brentwood,

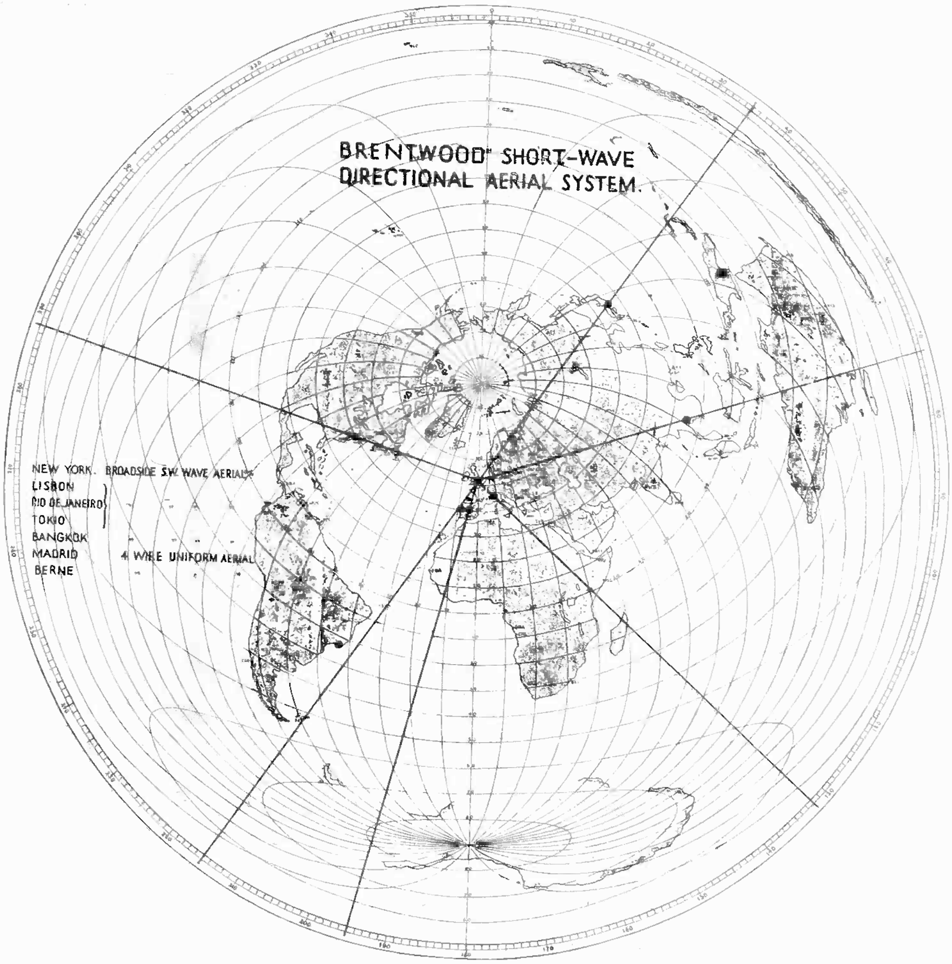


FIG. 19.

on which are drawn straight lines having the same angular direction as its various aerials. It can then be seen at once which aerial is the most suitable for the service concerned.

This chart is shown in Fig. 19.

Somerton Receiving Station.

Somerton is complementary to Dorchester, being a multi-beam receiving station, with two lines of masts supporting "Franklin" aerial and Reflector systems, connected by shielded feeders with the receivers.

The photograph in Fig. 20 shows eight short wave beam receivers. There are now 10 installed, and it is intended to increase this number to 16.

The undulators of the check circuits are mounted on the bench along the middle of the room.

To economise operators' time, the tape from the undulator checking one service is fed through the undulator of a second service, so that the two records appear one above the other on the same tape. Four services can thus be recorded on two tapes, and unless one of the services is really working badly and requires close attention, it is possible for one operator to supervise both tapes and therefore four services.

FIG. 20.

In this station, all the feeders are effectively screened, and the change-over of receivers to the different feeders coupled to the various beam aerials is carried out in the specially screened feeder distribution box shown in Fig. 21.

A new box is being fitted to accommodate 24 aerials and 16 receivers.

This feature of changing aerials is a very necessary one, and may take place a dozen times a day. New York for instance may be working on six or seven transmitters, some of them running on idle tape until they are required for service, and in order to keep a watch on the signal strength of all of them in case it becomes necessary, due perhaps to faulty reception on one circuit, to ask them to go over to another, or to advise them whether signals are strong enough for traffic when it is offered on a transmitter not yet so employed, several aerial-receiver changes may be necessary.

Owing to the thorough screening and the efficient bonding to earth of all those parts in the complete receiver equipment which carry out the function of shielding the circuits, no trouble is experienced from key clicks, and relays are in use wherever necessary.

At Somerton, the problem of choosing the best directional aerial for a service is somewhat different to that at Brentwood.

The aerials all have reflectors and they are erected to receive in directions normal to the planes of the two lines of masts, but one may wish to pick-up a station which is not on one of these particular bearings.

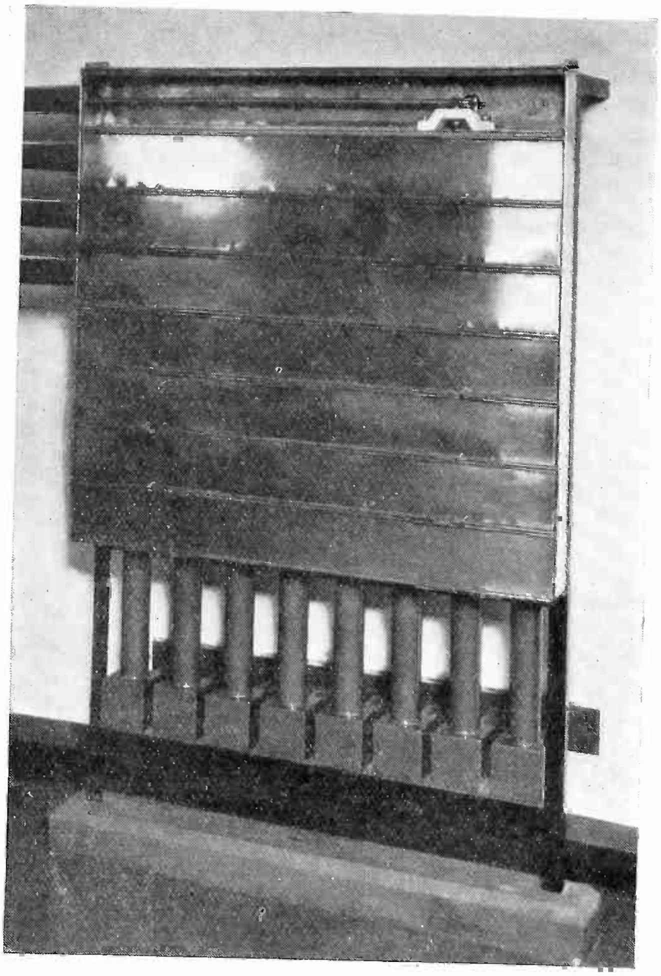


FIG. 21.

Now the polar diagram of the intensity of signals picked up by such an aerial as is well known, shows one main lobe of reception within a certain limiting angle, and on either side of this angle are nodal spaces of no signal intensity.

The first thing to determine then is the main angle of reception of the beam aerial within which there is one optimum direction, and on either side of it other directions from which the pick-up decreases as the angle increases, but which under certain conditions may still be of use for traffic purposes.

Continuing the search for signals at still wider angles from the normal to the aerial, it is found that beyond the nodal spaces there are other angles at which weak signals can be received.

There are in fact secondary lobes of reception at certain angles, the position of which, and the strength of signals received in these directions being determined by the apertures of the respective aerials in wavelengths.

When the aerial is several wavelengths wide, reception within the angle of one of these secondary lobes is so weak as to be of negligible value, but may be of a useful order if the directional aerial has a width for instance, of one wavelength only.

The chart shown in Fig. 22 is therefore employed at Somerton which enables the positions of the main lobes, nodes, and secondary lobes of the various beam aerials at their respective apertures employed on the station, to be readily determined. Lobes above the second order, when they exist, are not utilized.

Operating Conditions.

One has to realise that outside the Imperial Beam stations, the wireless services of the whole world are inter-connected commercially, and to a large extent technically, and form practically one network. Owing to alternative routes by long, or medium, or short waves, one need never be out of touch with the corresponding station.

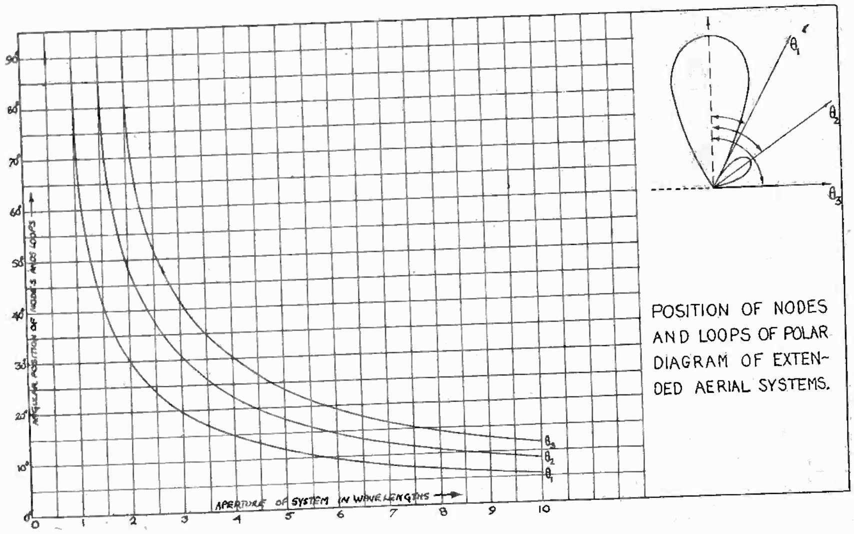


FIG. 22.

When there is not sufficient traffic to run a 24 hours service, then work is done at programme times. If traffic arrives out of programme hours, it can either be sent through a third station known to be working to the second station, or a message can be sent through the third station asking the second station to listen in for the traffic from number one.

If for any reason a particular service should break down, the outside network is there, and becomes aware of it, and is at hand if need be to carry the traffic.

The change-over from day wave to night wave does not take place until the receiving station advises that signals are failing. A station may therefore sometimes work 24 hours on its day wave.

The same transmitters which are normally working at 100 to 150 words per minute may be called on to work down to 15 words per minute twice, as is sometimes the case when starting a new service.

Wireless has the advantage that its transmitters can be switched from one service to another. For economical running of a number of short programme services, this becomes a necessity, and it is also brought about by the need to change wavelengths to avoid interference, or because of weak signals.

The New York service from Radio House is almost entirely carried on short wave, but the long wave transmitter is kept running the whole time as a stand-by on idle tape, and is available at any moment for use as an extra channel. The

22 m. wave is usually employed to New York. If this fades during the summer, the 15 m. is used, if during the winter, the 36 m. wave is used.

Service Records.

In order to make a service pay, the economic aspect must be closely studied, and this calls for the compilation of statistics.

We can start our records for instance by noting the Wheatstone transmitter tape speeds in five letter words per minute for the 24 hours.

This can be extended, as in the charts of the Paris-Rio service kindly sent me by the Cie Radio France, which give the hourly speeds for the 24 hours, averaged for a complete month (Fig. 23). These curves show the average rate of the outgoing traffic on 15·45 m. and the average rate of the incoming traffic from Rio to Paris on 14·35 m.

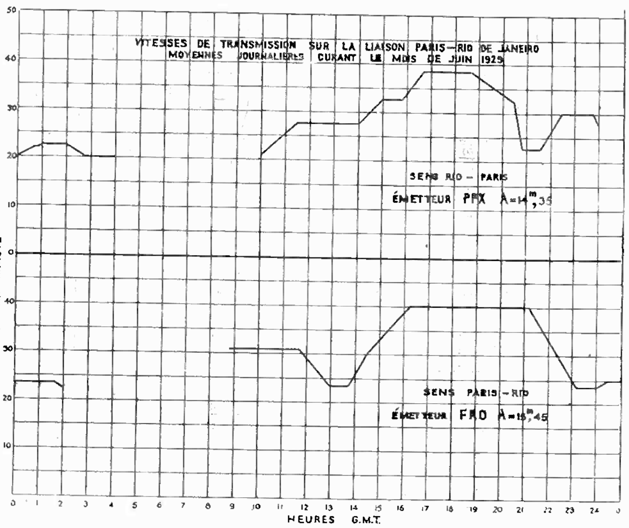


FIG. 23.

The mean speed during the working hours for the whole month of June is seen to be about 30 words per minute.

A further example of the same type is afforded by the Radio France chart of mean traffic speeds on the Paris-New York service, also for the month of June last (Fig. 24). In this case, the outgoing traffic is sent at a mean rate of about 97 words per minute, and the incoming traffic is received at a rate of about 73 words per minute.

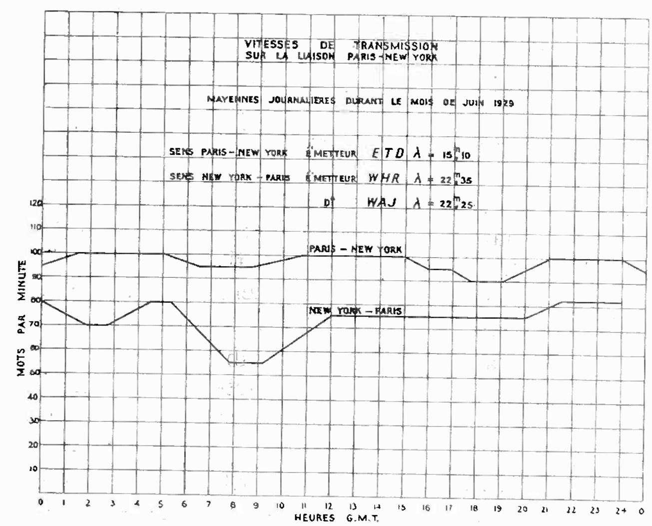


FIG. 24.

But it is unusual for traffic to be sent during the whole of this time, periodically the transmitters are run on idle tape while they are waiting for traffic.

This has given rise to another form of chart in use at Radio House, on which is recorded the percentage time each hour of the 24 that the transmitter is actually sending traffic on a given service, with notes to indicate what it is doing during the remainder of the time.

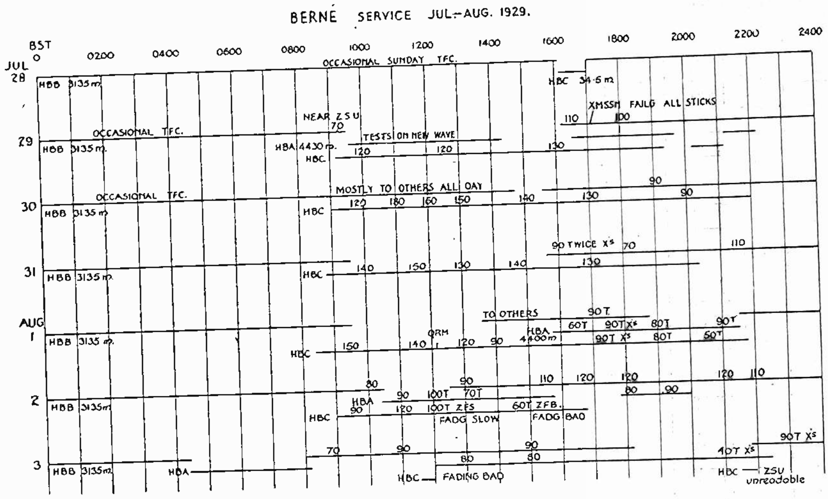


FIG. 25.

One transmitter may be used for instance on several part time services. As traffic increases during the day, so the stand-by transmitters come into use, or perhaps due to strong atmospherics on a long wave, a change-over is made to a short wave transmitter, or because of interference or fading on one short wave transmitter, a change-over is made to a transmitter sending on another short wave which is not so affected.

Records of these changes of call sign and wavelength on any given service are noted at the receiving station, and a typical chart of this character from Brentwood showing the transmitters employed at Berne during one week on the Berne-London service is shown in Fig. 25.

In general, this chart indicates the number, call signs, and wavelengths of the transmitters in use during the rush hours, that is when the circuit is working under full service conditions. To meet the traffic demands some of these transmitters may have been deflected from other services. Some transmitters therefore work on short time, others on practically a 24 hour load.

It therefore becomes necessary to keep a record of the number of hours each transmitter is actually sending traffic, and a table of this character for the transmitters used on the "Via Marconi" services during the month of June, 1929, is shown below.

It will be noted for instance, that the best load factor is still held by a long wave transmitter, namely GLP, the 5,332 m. set at Ongar, which during the month had an average working day of 12·6 hours.

Another chart records the average hourly speed of short wave transmission and reception taking into account that the transmitter may be occupied during part

Circuit.	Normal Transmitter.	CARNARVON.			ONGAR.						DORCHESTER.						
		GLC	MUU	GLJ	GLB	GLA	GLO	GLP	GLQ	GLS	GLH	GLG	GLK	GLW	GLY	GLL	GLM
		H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.
New York ...	GLH GLK	99.8	87.38	—	—	—	—	—	3.35	—	238.24	9.10	5.55	—	—	—	—
(Ph'grams) ...	MUU GLC	3.30	—	—	—	—	—	—	—	—	26.40	19.20	2.35	—	—	—	—
Paris	GLB	—	—	—	190.14	80.18	25.10	8.14	.55	—	—	—	—	—	—	—	—
Berne ...	GLA	2.20	8.20	4.55	.10	222.59	34.32	42.25	3.15	—	—	—	—	—	—	.25	1.0
Madrid ...	GLO	—	—	—	—	3.7	131.45	28.4	48.18	—	—	—	—	—	—	—	—
Barcelona ...	GLO	—	—	—	—	—	82.39	18.12	21.34	—	—	—	—	—	—	—	—
Vienna ...	GLP	—	—	—	—	7.15	29.59	112.24	121.2	—	—	—	—	—	—	.20	—
Belgrade ...	GLP	—	—	—	—	—	—	74.5	—	—	—	—	—	—	—	—	—
Buenos Ayres...	GLW GLY	—	—	—	—	—	—	—	2.22	—	—	—	—	81.27	22.49	—	—
Rio de Janeiro	GLW GLY	—	—	—	—	—	—	—	—	—	—	—	—	24.50	6.56	—	—
Moscow ...	GLP	—	1.3	—	—	—	—	91.27	14.37	—	—	—	—	—	—	—	—
Lisbon ...	MUU	.25	93.15	—	—	1.17	—	4.56	—	.40	—	—	—	—	—	—	—
Stamboul ...	GLC	28.32	.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cairo	GLL GLM	—	—	—	—	—	—	—	5.0	68.6	—	—	—	—	—	63.11	17.52
Beyrouth ...	GLL GLM	—	1.20	—	—	—	—	—	.10	.16	—	—	—	—	—	46.54	9.52
Bangkok ...	GLS	—	—	—	—	—	—	—	—	55.53	—	—	—	—	—	.37	—
Total		133.55	191.43	4.55	190.24	314.56	304.5	379.47	220.48	124.55	265.4	28.30	8.30	106.17	29.45	111.27	28.44

of the hour only, while the average speed is calculated over the whole hour. All these traffic results are analysed and serve as a helpful guide for the introduction of further improvements into the operating organisations.

Under certain conditions it may be found more economical to use many slow speed transmitters on a service instead of running a few at high speed, and it may happen that several hundreds of miles of poor landline between the Central Telegraph Office and the transmitting station rule out the use of high speed keying; each traffic organisation has its own problems and must decide them for itself and it is not intended in this paper to do more than point out what are the actual conditions of working of the wireless services to-day.

The value of Monitoring.

Much of the success of a commercial wireless service depends on the efficiency and effectiveness of the monitoring. If the quality of signals falls off, the operator whether at the Central Telegraph Office or Radio House is only in a position to recognise faults due to bad keying or badly punched tape the other end, if it is due to any other cause than faulty transmission, he concludes the conditions are worse, and he is inclined to ask for the message to be sent twice—which drops the effective speed to half—or alternatively, for the operator to send at a lower speed.

The monitory operator on constant watch at the receiving station, however, is immediately able to diagnose the trouble, whether it is due to atmospherics, fading, echo, or jamming, or some fault in the apparatus or landline link.

He saves traffic time by indicating the source if it is at his end of the channel, and can often minimise it or clear it altogether by balancing adjustments on his receiver, or by advising a change of wavelength if the source is to be found in changes which are taking place in the physical conditions of the intervening medium between the two stations, or by interference from some other transmitting station.

The cost of monitoring is more than made good by the higher speeds of transmission which are maintained in consequence, and its actual cost is not great when it is considered that a traffic speed of 150 words per minute on for example an Empiradio beam service, every yard of tape scanned by an operator carries a message value of about £1.

THE MARCONI TUNING FORK AS A FREQUENCY STANDARD

For many purposes in connection with radio work it is essential that reliable tone generators should be obtainable in order to provide standards of frequency to which other frequencies may be referred.

All accurate frequency measurements depend, in the first place, on an accurately adjusted fundamental frequency, the source of which depends on the band of frequencies involved.

The frequency spectrum may be divided into the following rough groups, as far as radio purposes are concerned.

(A) 50—3,000 *cycles. For this range a tuning fork is generally employed where a stable oscillator is required.*

(B) 3,000—10,000 *cycles. Magneto-strictive oscillators are useful for these frequencies.*

(C) 10,000—75,000 *cycles. For reliable oscillations of from* 10,000 *cycles upwards stabilised Inductance Capacity valve oscillators are generally employed.*

(D) 75,000—3,000,000 *cycles. Either* (1) *Piezo-electric crystal controlled oscillators or* (2) *Valve oscillators may be utilised in this range.*

(E) *Above* 3,000,000 *cycles. Valve oscillators are the only form of oscillators which can be practically employed at frequencies above* 3,000 *kilocycles.*

To cater for the band of frequencies from 50 *to* 3,000 *cycles the Marconi Company has evolved the tuning fork and associated apparatus to be described below.*

The chief applications of this tuning fork are :—

(1) *It can be applied directly as a control for the automatic synchronisation of facsimile systems.*

(2) *It can be employed as a control of the frequency of radio transmitters, when the fundamental frequency of the fork has been suitably multiplied.*

THE Tuning Fork Oscillator has been developed as a means of securing a source of oscillations of extremely constant frequency. It is suitable for purposes for which a constancy closer than 1/100,000 is required.

The Marconi Tuning Fork Oscillator is capable of such a degree of accuracy, and comprises a mild steel Fork which is maintained at a constant temperature in an Incubator or heating chamber fitted with a very high grade temperature control.

Tuning Fork.

The material ordinarily used for the Marconi Forks is a special grade of very uniform mild steel, which is fully annealed in the course of the manufacture of the fork. The exceptional uniformity both of the material and of its physical condition

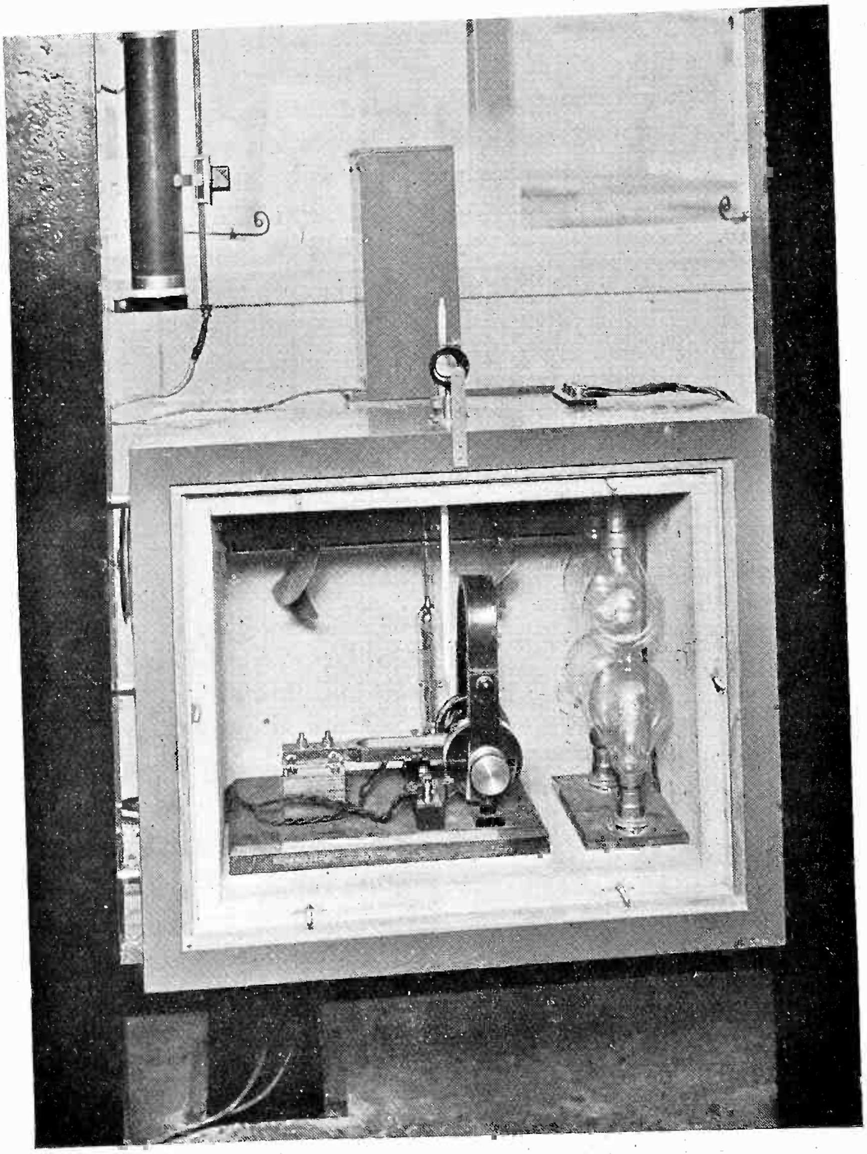


FIG. 1.

ensures great permanence in the frequency of the finished fork. In a fully annealed state, this material has exceptionally small internal friction under small periodic stresses, such as occur when a tuning fork vibrates with small amplitude. The finished fork has, in consequence, a very low decrement, a feature of importance in a fork which is used as the master frequency control of an electrical system.

The shape of the fork is in some respects a departure from previous practice. It has been specially designed by ourselves with a view to obtaining exact mechanical balance between the prongs with the object of reducing to a minimum the reaction of the butt of the fork on its support. Special attention has been paid to the attachment of the fork to its support, and to the nature of the support itself. These factors are of importance for reducing to a minimum the effect of the support on the frequency of the fork and particularly its effect on the constancy of the change of fork frequency with temperature.

The saddle which holds the butt of the fork is mounted on a Fork Driving Base in such a position that the prongs of the fork are near pole pieces consisting of bundles of iron wire, which are polarized by a permanent magnet. Mounted on these pole pieces are two coils of wire, one of which serves to transfer the impulses originating from the fork, to the grid of the first valve of a valve amplifier, while the other coil drives the fork by means of impulses derived from the plate circuit of the last valve of the amplifier.

The circuits employed are specially designed to render the fork frequency as independent as possible of such factors as battery voltages, etc.

Before proceeding to a description of the incubating arrangements, it may be mentioned that nickel chrome steels, such as Elinvar, have been used for forks in certain cases, in preference to mild steel, owing to their smaller change of frequency with temperature. These steels have certain disadvantages owing to their peculiar physical properties. Changes in the physical properties of these steels resulting from a change of temperature do not follow the change of temperature immediately. There is a time lag resulting in a slow progressive change in frequency which may be perceptible for weeks.

Incubator and Thermostat.

To attain a high degree of constancy of frequency in a fork made either of mild steel or of nickel chrome steel, it is necessary that the fork should be maintained at an even temperature by means of a high grade incubator. The incubator consists of a heat-insulated wooden box containing the Tuning Fork with driving magnet, and a Thermostatic regulator having a glass bulb containing Toluene, a stable liquid having a high co-efficient of expansion with temperature. The expansion and contraction of the Toluene actuates a Mercury column in a capillary tube fitted with electrical contacts which form part of the grid circuit of a triode valve. The temperature inside the Incubator is maintained at a predetermined value (about 140° F.) by means of heating lamps fitted in the Incubator. These heating lamps are so adjusted that, if they are left continuously in circuit, the temperature of the chamber will rise above the operating value. On the temperature of the chamber reaching this value, however, the Toluene regulator is so adjusted as to close contacts in the grid circuit of a control valve (thereby applying a negative potential to the grid of the valve). Connected in the anode circuit of the valve is the operating coil of a sensitive relay, the contacts of which make and break the heating lamp circuit. On the closing of the contacts of the Toluene regulator, the contacts on the Thermostat relay are arranged to "break," thus switching off the heating lamps. A Rheostat in series with the heating lamps is so adjusted

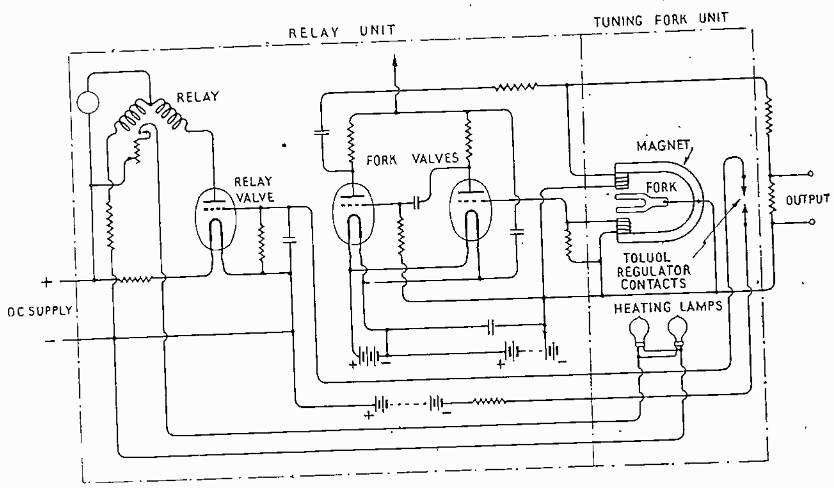


FIG. 2.

that the periods when the lamps are "on" and "off" are approximately equal, and the Thermostat relay is actuated at intervals of a second or so. In order to avoid a temperature gradient in the heating chamber, a motor-driven fan is provided which vigorously stirs the air in the chamber. The incubator heating lamps are provided in duplicate, a simple change-over switch being provided for changing from one set of lamps to the other in the event of a lamp burning out. The temperature of the chamber can be observed by means of a Thermometer which projects from the top of the chamber, a magnifying glass and peep-sight being provided to facilitate accurate reading.

The anode circuit of the Fork Driving Valve includes a resistance across which is obtained an oscillatory potential having a frequency identical with that of the tuning fork. Provision is made for coupling this circuit through a Triode "Frequency Selecting Valve," to a closed resonant circuit which is tuned to either the frequency of the fork or to a multiple of that frequency according to the purpose for which the Tuning Fork oscillator is required.

This Frequency Selecting Valve is arranged to give an output wave form which is rich in harmonics, to one of which the resonant circuit is tuned.

This circuit may be followed by one or more stages of amplification, with or without frequency change, as may be desired for any particular purpose.

The Marconi Tuning Fork Oscillator is pre-eminently suitable for all purposes where an extremely constant frequency source is required whether the frequency be of the order of audio frequencies or radio frequencies, the principal difference in the equipment for the two types being in the number of stages of subsequent amplification and frequency change.

The standard arrangement of the equipment consists of vertical steel racks carrying the various units.

Thus the heating chamber containing the fork may be mounted in the lower section of a rack, above which are mounted the relay unit, containing the thermostat relay and driving valve, and the control unit mounting the necessary switchgear for the supply to the fan motor and valve filaments and anodes and the relay feed milliammeter.

The equipment can be supplied for operation from either D.C. or A.C. supply mains as desired. In the case of the A.C. equipment, rectifying valves, with the requisite filament and anode transformer, are fitted in the relay unit for supplying D.C. to the valve anodes and the relay.

The total power taken from the mains is of the order of 250 watts.

A photograph of the complete mounting is shown in Fig. 1 and a typical diagram of connections of the Tuning Fork Oscillator in Fig. 2.

A CONSTANT FREQUENCY CONTROL FOR BROADCAST TRANSMITTERS.

In the previous article a description of a thermostatically controlled tuning fork, manufactured by the Marconi Company, was given, and in the following pages the application of such a fork to the strict control of transmitter frequencies will be discussed. All such controls are similar in general principle in that they consist of stabilised oscillators of relatively low power which drive the main transmitter oscillator.

In the control to be described below, the fundamental frequency of the tuning fork is multiplied to give the required frequency for the transmitter.

The very high degree of accuracy of frequency rendered necessary by modern transmission conditions calls for the increasing use of such controls, especially on any of the shorter wavelengths.

An excellent example of such a case is the simultaneous transmission of the same signals by stations working at an identical frequency. In this type of arrangement any discrepancy between the radiated frequencies would cause an unintended heterodyne, and so render the reception of the signals unsatisfactory. The B.B.C. relay stations, which radiate identical frequencies, and are each controlled by a tuning fork, provide evidence of the accuracy obtainable. It may be noted that in the case cited an error of 1 *in* 20,800 *in any one tuning fork would cause a heterodyne note of* 50 *cycles per second, while in actual experience the heterodyne between the stations rarely attains so great a value as* 15 *cycles per second.*

A TUNING fork of fixed frequency, which can be chosen between 700 and 1,400 cycles, is taken as the standard frequency source This fork is maintained by a tuning fork drive circuit whose output is amplified and its frequency is doubled ten times, thus giving a final output frequency of from 700 × 1,024 to 1,400 × 1,024 or from 716·8 kc. to 1,473·6 kc. according to the frequency of the fork. This corresponds to a final wavelength range of from 203·5 to 418·5 metres approximately, while other wavelengths involve the addition or elimination of doubling stages. The general layout of the apparatus is shown in Fig. 1.

Tuning Fork and Thermostat.

The tuning fork and thermostat is similar in construction to that used in connection with the facsimile apparatus and described in the previous article. A photograph of the actual fork employed in this apparatus is shown in Fig. 2. A toluol-mercury thermostat is used to regulate the temperature, and this thermostat and its associated relay equipment, etc., are very similar to the corresponding components in the facsimile apparatus.

The actual frequency of the fork is, of course, fixed by its physical properties and dimensions, but this frequency can be varied very slightly by adjustment of the working temperature and of the valve voltages, *i.e.*, plate voltage, grid voltage, and filament voltage in the tuning fork drive circuit. Any fork can be supplied within the frequency limits given above, for which range of frequencies the doubling circuits, etc., have been designed.

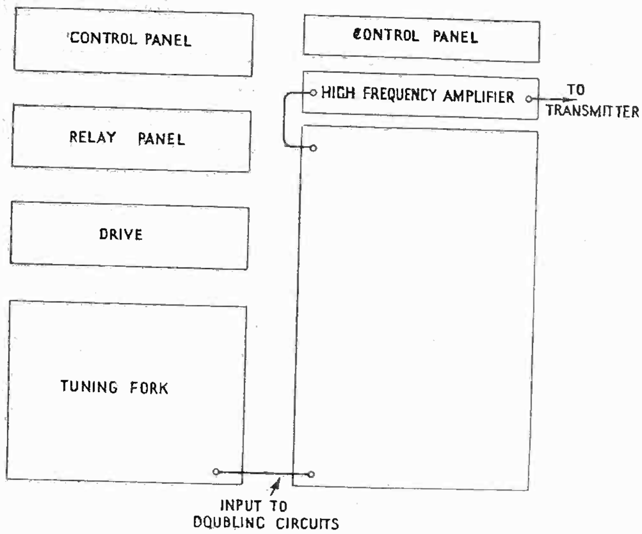


FIG. 1.

The fork is enclosed in a heat insulating box, which is also electrically screened by a copper covering. As will be seen on reference to Fig. 1, the relay box is mounted above the fork box, and consists of the circuits and relays which switch the heater lamps on and off. The air in the fork box is kept constantly stirred by means of two fans at the back of the box, and the temperature of this air stream is maintained constant to within about 0·1°F. in this manner.

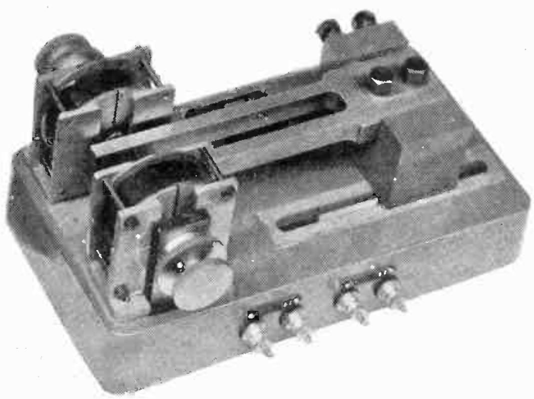


FIG. 2. *Marconi Tuning Fork.*

Tuning Fork Drive.

The circuit diagram for the tuning fork drive is shown in Fig. 3, and will be seen to consist of two tuning fork maintaining valves, resistance capacity coupled, and one stage of transformer coupled amplification.

The frame of the tuning fork is connected to earth, and to one side of one of the maintaining coils. The other coil is in the grid circuit of the first valve, and the anode of this valve is connected to the grid of the next valve in the usual way through a condenser. This condenser fulfils two functions: It couples together the grid and anode circuits of the valves, and also ensures that the currents shall be in the correct phase. Its value is approximately ·01 ufd.

The next valve has its output taken through a condenser and a potentiometer to earth. The potentiometer is calibrated roughly in T.U's and serves to adjust the output of the entire drive. The tapping from this potentiometer is taken to the

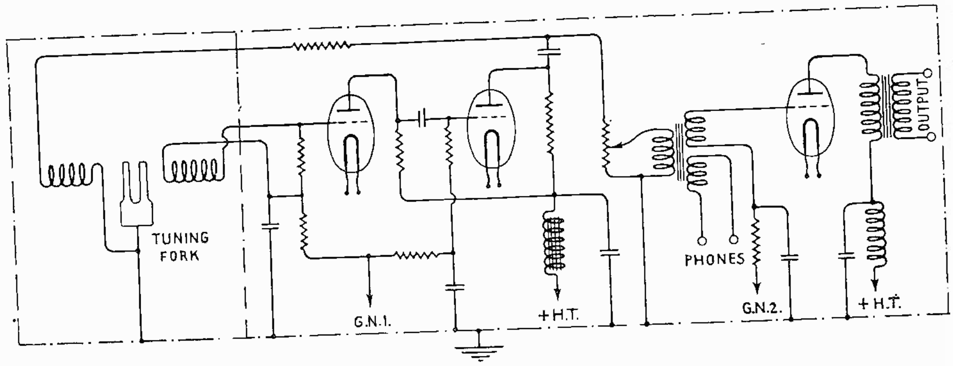


FIG. 3.

primary of the intervalve transformer, and the next valve is coupled to this in the normal way. A listening point is provided at this stage. Arrangements are made to ensure that the inclusion of the telephones in the circuit do not disturb the output of the drive.

The actual line of demarcation between the fork box circuits and the drive box circuits is shown in the diagram as a dotted line.

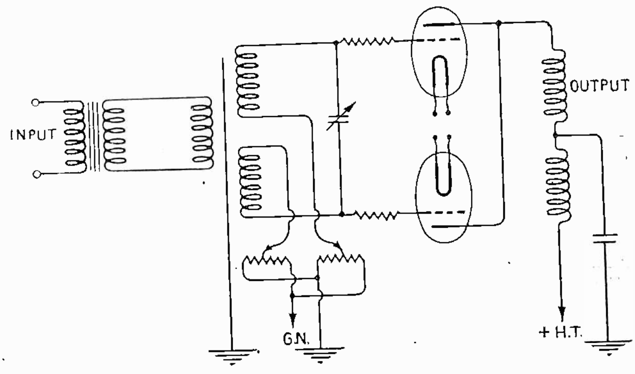


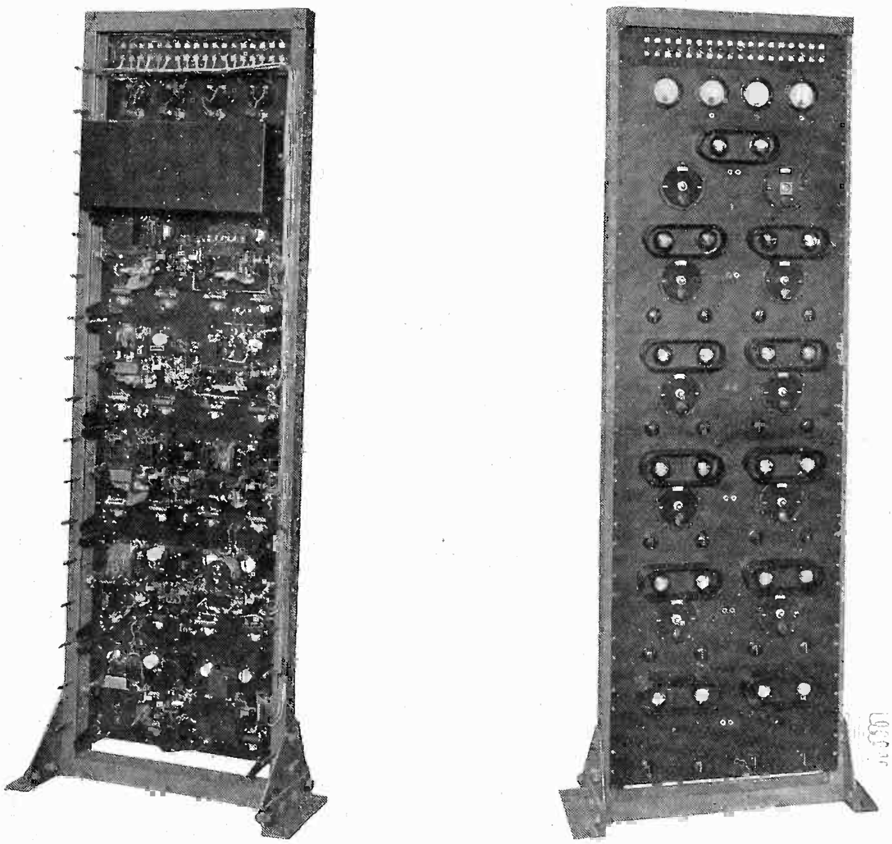
FIG. 4.

The output from the drive to the doubling circuits is shown on the extreme right, and consists of an iron core transformer in the anode circuit of the last valve.

Frequency Doubling Circuits.

The output from the tuning fork drive is taken through a lead covered cable to the input stage of the frequency doubling circuits. A typical stage of doubling consists of an input transformer with a split secondary, a secondary winding tuning condenser, two valves with a push-pull input and parallel output, and grid negative and high tension feeding circuits. The circuit diagram for one of these stages is shown in Fig. 4.

The valves are set at their rectifying point, which operation is carried out by means of the controls, as will be described later. The form of circuit employed has the advantage that only the even harmonics are passed.



Frequency doubling circuits (back and front view).

The question of the design of the input transformers presented much difficulty, as all frequencies from approximately 1,400 to 1,500,000 cycles had to be dealt with, and transformers which were suitable for the former were useless in the case of the latter frequencies. Further, the voltage amplification between the primary and tuned secondary had to be kept within certain limits.

Ultimately the form of transformer shown in Fig. 5 was adopted in the case of the lower frequencies, and consists of a primary of one section, block wound with stranded wire, and a secondary of two sections, mounted on each side of the primary also block wound with the same type of wire. All the sections are screened from each other by means of copper gauze, which is broken to avoid short circuited turn effects.

In the case of the higher frequencies, the transformer consists of two secondary sections mounted side by side on an ebonite tube (Fig. 6) The primary sections are block wound on an ebonite rod passing through the centre of this tube, and supported by means of two screws at its ends. These two screws allow of the adjustment of the primary section with respect to the two secondary sections in order to obtain the best balance, etc. In the case of these transformers, the shielding is of copper sheet broken in a similar manner to that already described.

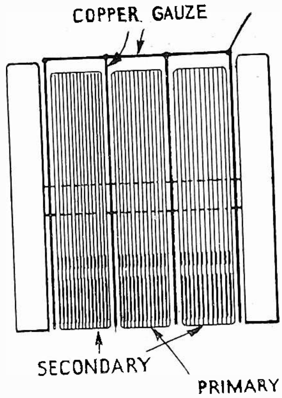


FIG. 5.

All the grid connections and the connections between the transformers and the condensers are made with special shielded wire to reduce interaction effects, etc., and the screens of the transformers are bonded to earth.

Since any alternating voltage across the direct current supplies to a doubling stage will be fed to the two valves in parallel, it will appear in the output. The next stage of doubling will then act as a modulator, and the final output frequency will be modulated by the alternating voltage across the direct current supplies. To avoid this most

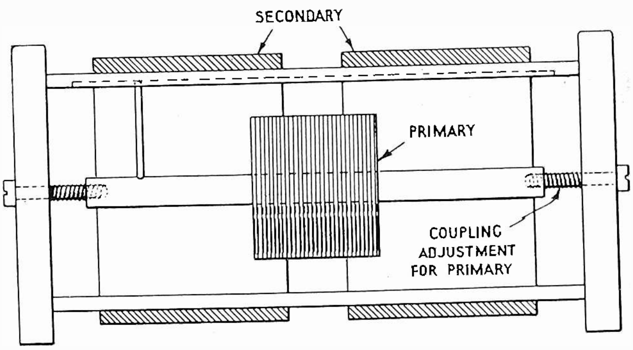


FIG. 6.

undesirable feature, all direct current supplies to each doubling stage are carefully blocked—the grid supplies by resistance-capacity, and the anode supplies by choke-capacity in the earlier stages, but resistance-capacity in the later stages.

In all, ten stages of doubling are employed, thus giving a frequency multiplication of 1,024 as has been stated before.

All the frequency multiplying apparatus is contained in an iron framework and is suitably screened.

Control Panel.

The control panel is mounted at the top of the doubling circuits, and includes three voltmeters for the measurement of High Tension, Low Tension and Grid Negative respectively, and a milliammeter for the correct adjustment of the valves in the doubling circuits. This milliammeter may be plugged into any pair of valves, and the valves may be adjusted either :

(1) By removing one valve and adjusting the grid negative on the other to give a suitable indication of anode feed with the working input, and then putting in the other valve and adjusting this in the same way ; or

(2) Putting excess grid negative on both valves and reducing this for each valve in turn until each begins to show a slight anode current with no input.

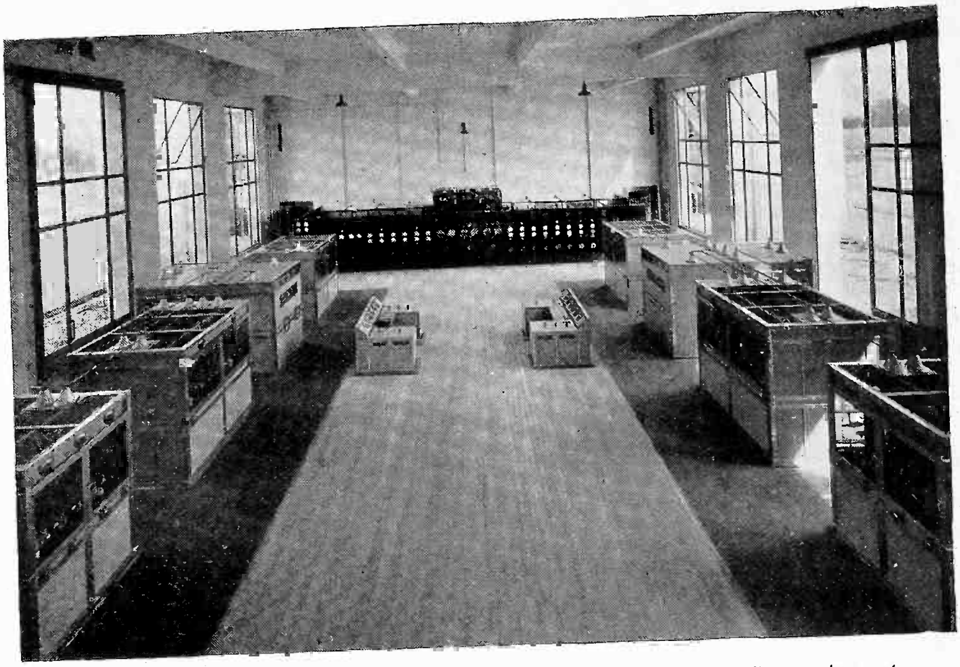
On the control panel are also mounted all the fuses. Three fuses—one for H.T., one for G.N., and one for L.T.—are provided to each set of four valves, and three main fuses are also permanently in circuit.

Final Amplifier.

The output from the multiplying circuits is taken to a transformer with tuned secondary, and through one stage of push-pull amplification to the main transmitter.

MARCONI NEWS AND NOTES

BRITISH REGIONAL BROADCASTING.



A general view of the transmitter hall at the new B.B.C. station at Brookman's Park.

As foreshadowed in THE MARCONI REVIEW, No. 12, Brookman's Park Regional Station has now taken over the entire transmission of the London broadcasting programmes. Thus 2LO changes its home for the third time and enters on what may now fairly be expected to constitute its permanent quarters.

The call sign 2LO was originally allotted by the British Government to the Marconi Company for its experimental transmitting station at Marconi House and was used to identify the first regular broadcasting programmes transmitted by the Marconi Company from London—as distinct from their earlier broadcasting from Writtle—in the spring of 1922.

In March 1925 the second 2LO, again manufactured by the Marconi Company, was opened by the British Broadcasting Company—now the British Broadcasting Corporation—on the roof of a well-known London store in Oxford Street. The transmitter at Marconi House was, however, retained as a stand-by and until very recently its voice was still heard on the air at regular intervals when tests were made to ensure its constant readiness in case of emergency.

At length, however, its work is concluded after more than seven years of sterling service in the new art and science of broadcasting, and early listeners will learn with regret that the veteran transmitter has now been dismantled. As a matter of historical interest, we reproduce a photograph of the Marconi House broadcasting transmitter as it was in its earliest days. A comparison with the Marconi P.B. transmitter, illustrated on page 26 of THE MARCONI REVIEW, No. 12, and with the photograph of the Brookman's Park transmitter, published on page 27, indicates the progress that has been made in the design of broadcasting transmitters during the last eight years.

The B.B.C. station at Oxford Street embodied the experience gained in the operation of the first London station at Marconi House, and during the years of its active life it participated with marked success in many famous broadcasts, as well as maintaining with remarkable efficiency and reliability the daily transmissions of the regular programmes.

Success of the new 2LO.

The new transmitter at Brookman's Park, which took over the London programmes on the afternoon of October 21st, in its turn embodies the result of experience gained in the operation of the other broadcasting stations that have been transmitting programmes daily for some years past. The new station is operated on an aerial power of 30 kilowatts compared with the 2 kilowatts of the Oxford Street station. Despite some prophecies of difficulties that might occur on account of the greatly increased power and the changed location of the station—now situated 15 miles from the centre of London instead of in the heart of the West End—the change-over was effected with the minimum of inconvenience to the listening public, and a high degree of popularity has already been won by the new transmitter, which was manufactured by the Marconi Company in accordance with the special requirements of the B.B.C.

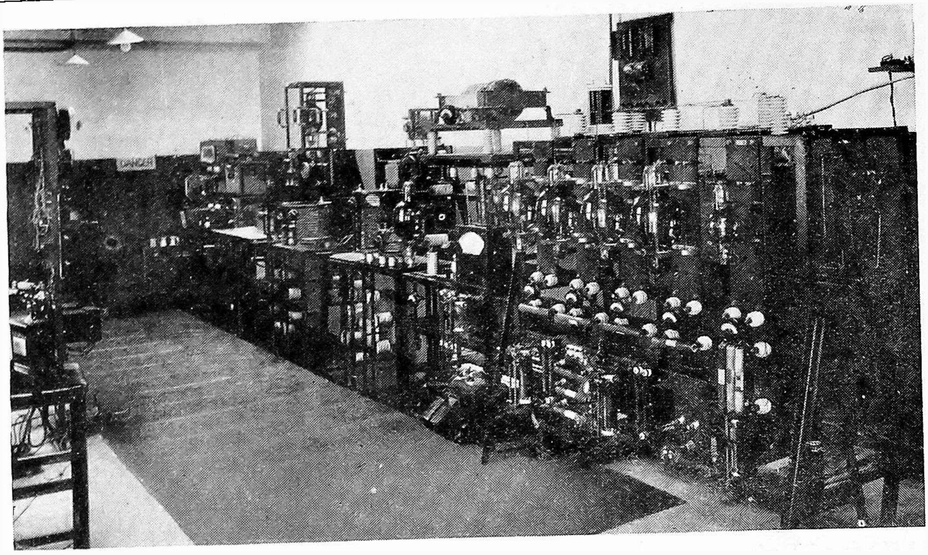
An eloquent testimony to the constancy of the transmitter is the fact that there have been no complaints that the station interferes with its neighbours in the wavelength plan, even though its power is about 30 kilowatts in the aerial.

Newspaper and public comments on the performance of the station demonstrate that it will amply fulfil its object of improving the broadcast service to listeners over a very wide area.

Reports on Reception.

The following published reports are typical of many which describe the excellent results obtained from the new transmitter.

> "Previously it had been observed that London was rather difficult to tune owing to the patent variable condenser contained in the receiver, but Brookman's Park has put an end to that. Much less reaction is required."
>
> "Until the new station, reception on 2LO was normal but without real 'kick,' combined with annoyance from a Continental heterodyne. The test, however, revealed a good increase in signal strength which of itself smothered the foreigner, producing a much happier state of affairs."



The first 2LO at Marconi House.

"The reception from Brookman's Park on this set (portable) was fine, with excellent volume. The tuning band was only spread over four degrees of the condenser scale."

"This new 2LO is the first of five similar stations which the B.B.C. are setting up in different parts of the country. When eventually they are working, Britain will have—in the Regional Scheme—the most perfect system of broadcasting in the world."

"Wide enquiries suggest that the general feeling is that the new 2LO has proved its worth and is an improvement."

"Great improvement, can easily tune in 5GB. Stuttgart, 4 metres above 2LO, is heard more easily than before. Graz, 4 metres below 2LO, was also received—an impossibility under the old conditions."

"Within ten miles as the crow flies, but not the slightest difficulty in getting any station required."

Benefit to Crystal Users.

"Crystal users situated between 20 and 30 miles from London, who have hitherto heard only a whisper, are now delighted with the volume they are getting, and districts even up to 80 and 100 miles from Brookman's Park are reporting good reception on a crystal set."

"With a two-valve set a complete amateur tuned in at good strength, and easily found also 5GB clearly and without interference.

"Reports from listeners indicate that reception is generally improved over a large area."

"Criticism of the new Brookman's Park broadcasting station has brought forth a host of letters to the B.B.C. from satisfied listeners, praising the improved quality and greater volume which they are getting."

"Reports from all districts indicate that thousands of new listeners are now able to enjoy the programmes from 2LO for the first time. It is estimated that nearly 3,500,000 listeners are being satisfactorily served by Brookman's Park."

"Hundreds of letters have been received from listeners who have picked up these transmissions, but only eight of them make complaints. Many outside the area which the new station is intended to serve heard the transmissions and the B.B.C. received compliments from the north of Scotland, South Wales and the Isle of Skye—and even from Amsterdam."

Reception on the Continent.

The Berlin correspondent of one of the principal British wireless papers wrote as follows :—

"Thanks to the Brookman's Park station listeners in the Berlin and Konigswusterhausen areas are able once more to hear with ease the London programmes, reception of which (mainly from Daventry) had been rather interfered with since readjustments under the Brussels and subsequent Plans. In spite of the narrow separation between London and its two neighbours, Graz and Stuttgart, the new station gives excellent loud speaker results, and the average strength is above that previously noted from Daventry."

Reliability of British Broadcasting Stations.

An article on "The Technique of Broadcasting," published on October 11th in *World Radio*, an official publication of the British Broadcasting Corporation, contains some further information with regard to valve life.

With regard to the average life of water-cooled valves in use at 5XX, 5GB and Brookman's Park, the writer states that while "6,000 hours is about the average life of the rectifiers, two rectifiers at 5XX recently completed their useful life after both had done over 10,000 hours work. The average for modulators and magnifiers is about 4,000 hours, but two modulators at 5XX have done over 10,000 hours."

As Marconi valves are used at 5XX, 5GB and Brookman's Park, this is another gratifying tribute to the robustness of Marconi valves, which, it should be noted, are always rated on a conservative basis.

The general reliability of the British broadcasting stations as a whole is very high, as is shown by further figures given in the article in question. It states that the hours of transmission from the British Broadcasting Corporation's stations increased from 46,215 hours in 1925 to 64,467 hours in 1928, and in the same time the breakdown percentage, which is an indication to the efficiency of the service, has been reduced from 0·9 per cent. to 0·03 per cent., which means that in 1928 the breakdown totalled only 19 hours 2 minutes, or approximately 58 minutes per station.

This report is very creditable to the manufacturers who have supplied these broadcasting installations ; further, the dependability of Marconi broadcasting stations is now recognised throughout the world as is shown by the increasing number of orders that have recently been received by the Marconi Company from many countries for this type of apparatus.

An interesting photograph taken at the opening of the Aranjuez group of wireless stations. Next to His Majesty the King of Spain (centre) are the Marchese Marconi, the Marquesa Marconi, and (on the right, in uniform) General Primo de Rivera.

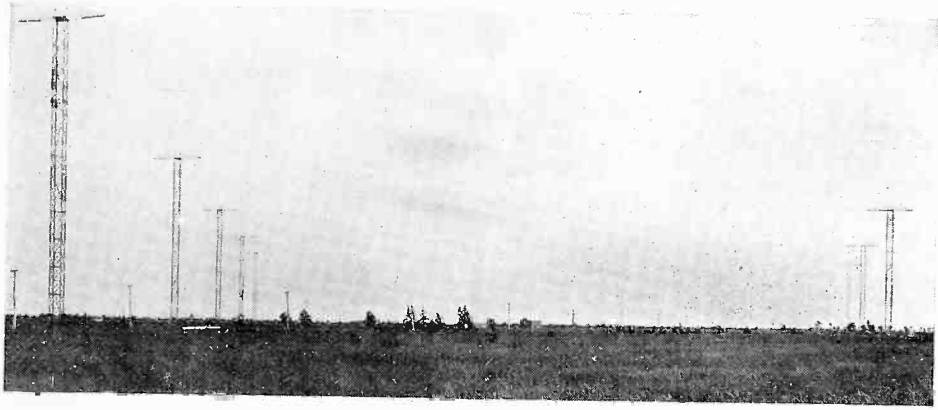
New Spanish Stations.

Marconi apparatus is extensively used in the important new group of wireless stations which were opened on October 21st by the King of Spain at Aranjuez, near Madrid, in the presence of the Marchese Marconi, the Spanish Prime Minister, and Ambassadors representing other countries.

This group of wireless stations has been designed and built to extend the range of Spanish external communications having regard to Spain's importance in the commercial life of the world and particularly of South America. Madrid is now placed for the first time in direct wireless telegraph communication with both North and South America and, by means of the Marconi short wave Beam installation which is included in the equipment of the Aranjuez station, a regular commercial telephone service between Spain and the Argentine Republic will be available in addition to high-speed Beam telegraph services.

For use in these circuits special receivers have been constructed by the Marconi engineers on behalf of Transradio Espanola, the Spanish Company to which these stations belong and which carries out the wireless telegraph services between Spain and other countries.

The supply of this apparatus to Transradio Espanola is the second big order for British wireless equipment recently received from Spain, the Marconi Company having also supplied a short wave station to the Spanish Government to establish a direct wireless service between Madrid and the Spanish colony at Fernando Po, in equatorial Africa.



The Canadian Marconi Company's Beam receiving station at Yamachiche, near Montreal.

Beam Telephony.

The British Broadcasting Corporation's broadcast of the Armistice Day Service at the Cenotaph, London, on November 11th, was successfully relayed by Beam telephony from England to Canada and re-broadcast by a chain of stations throughout the Dominion.

A sound record of the ceremony was picked up by the microphones in Whitehall, and, in addition to being transmitted by all the B.B.C. stations, was carried by landline to the Imperial and International Communications Company's short wave Beam station at Bodmin. Thence it was transmitted by means of the Marconi-Mathieu Multiplex system of telephony to the Canadian Marconi Company's Beam receiving station at Yamachiche, near Montreal, which in turn passed it on to the broadcasting stations.

The wavelength employed on the Multiplex Beam link across the Atlantic was 16·575 metres.

Reports from Canada state that this was undoubtedly the finest broadcast of the Armistice Service ever heard there. In the afternoon of November 11th the Canadian Marconi Company telegraphed to London :—

> "Have received already hundreds of messages of congratulation from all over Canada and portions of the United States."

The arrangements for this Imperial broadcast were similar to those made on Sunday, July 7th, for the relay of the Thanksgiving Service in Westminster Abbey, which was broadcast throughout Canada by means of the Marconi-Mathieu Multiplex system at Bodmin, and reported by listeners in all parts of the Dominion to be heard as clearly as a first-class local broadcast.