B·B·C

THE EMPIRE SERVICE

THE BRITISH BROADCASTING CORPORATION
BROADCASTING HOUSE, LONDON, W.1

THE EMPIRE BROADCASTING SERVICE

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BROADCASTING HOUSE, LONDON

1935

You shall hear their lightest tone
Stealing through your walls of stone;

Till you loneliest valleys hear
The far cathedral's whispered prayer.

Daventry calling . . . Daventry calling . . . Daventry calling . . . Dark and still
The tree of memory stands like a sentry . . . Over the graves on the silent hill.
—Alfred Noyes.

ERRATA

On PAGE 23 read as follows :—

(*Line* 34)

GSC	C for Corporation	9,580 kc/s	31·315 metres

(*Line* 38)

GSG	G for Greeting	17,790 ,,	16.863 ,,

(*Line* 43)

GSL	L for Liberty	6,110 ,,	49·100 ,,

PAGE 31 (*lines* 2 *and* 8) 'gauged' should read 'ganged'

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THE EMPIRE BROADCASTING SERVICE

The Empire Broadcasting Service consists of transmissions effected on short wavelengths, from the Empire Station established at Daventry, England. The Service should not be confused with the National and Regional programmes radiated on long or medium wavelengths broadcast by the B.B.C. for reception in Great Britain and Northern Ireland.

The Empire programmes are divided up into a number of transmissions daily spread over the twenty-four hours. Each transmission is designed to coincide with an evening period in some part of the Empire, and is radiated from aerials which favour the country or countries in which local time is most convenient for listening. At the same time, it is possible for Empire Station listeners to hear transmissions from Daventry at times of day when they are not *primarily* intended for their particular area in terms of convenient listening hours. The Empire Station is not generally receivable in, nor is it intended for, the home country; but it provides a daily programme, when reception conditions are favourable, for every part of the Empire at suitable times for local listening.

The wavelengths and appropriate call-signs used for the Empire Service are given on page 23. Normally, two wavelengths are in operation throughout each transmission, and the choice, in order to achieve the best possible conditions of propagation, is dependent upon seasonal and atmospheric conditions. Frequent announcements of the wavelengths in use are made from the Empire Station and are communicated to the overseas Press. Current schedules of transmission times (which are also liable to seasonal change) and wavelengths are available, post free, on application to the Empire Department, B.B.C., Broadcasting House, London, W.1. The detailed programmes for all transmissions are published in the form of a weekly pamphlet, which will be supplied in return for payment of five shillings a year, to cover cost of postage. Appropriate sections of the programmes are also republished in the overseas Press.

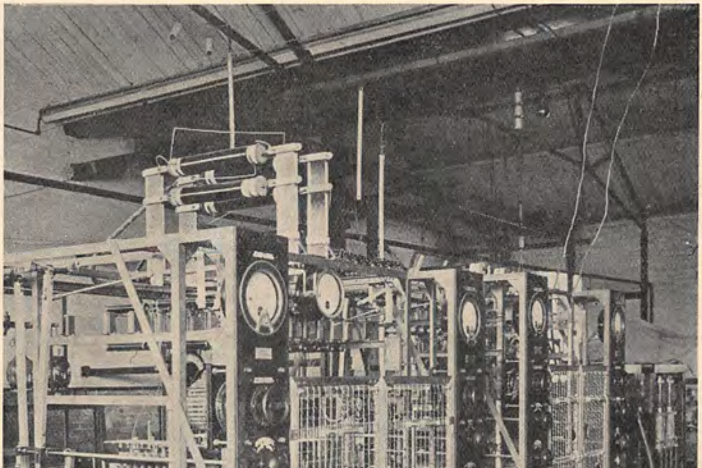
¶ HISTORICAL

It is now generally known that after a period of uncertainty as to the best method of broadcasting over long distances, such as would be necessary for a British Empire Service, the B.B.C., by arrangement with the Marconi Wireless Telegraph Company, established an experimental short-wave transmitter at Chelmsford, towards the end of 1927. Five years later, on December 19th, 1932, a regular broadcasting service for all the Empire was inaugurated by the B.B.C. from short-wave transmitters built at Daventry (on a site adjoining the long-wave National transmitter for the home country). With the removal of the 'home' station from Daventry to Droitwich the Empire Station and its attendant aerials are now left in sole occupation of this site with space for expansion.

The experimental operation of the station at Chelmsford stimulated interest overseas, and it became obvious that a demand for a regular service existed. Interest was greatest in the Colonies, but the Dominions were also anxious for opportunities to hear events of Imperial and National importance, as well as interesting programmes originating in the home country. Detailed examination of all the relevant information enabled the B.B.C. to submit to the Colonial and Imperial Conferences in 1929 and 1930 a fairly precise scheme for the establishment of an Empire Broadcasting Service, but owing to various difficulties which, at the time, could not be overcome, no definite decision was taken. In 1931 the B.B.C., realising that financial assistance would not, owing to general conditions, be forthcoming, decided that in view of the demand and in the interest of British prestige in the domain of short-wave broadcasting, it must assume the necessary financial responsibility and proceed with a practical scheme.

It was hoped that once the new station was in operation the interest which it would undoubtedly arouse would result in some return of expenditure in the form of contributions from Colonial listeners, possibly as a proportion of the licence fee paid by such listeners to local administrations. By the end of 1934 the Governments of two Colonies had decided to make contributions from their budgets towards the cost of the Empire Service.

Since 1932 the Empire Service has steadily developed, and in this development a large measure of co-operation has been accorded to the B.B.C. by the overseas listeners who have received the transmissions from Daventry. Up to the end of April 1935, over 35,000 reports on reception and letters about programmes had reached Broadcasting House. The information thus made available to the B.B.C. has been carefully collated and studied, and has provided guidance of the greatest possible value to programme-builders and technicians alike. A steady increase in the volume of correspondence has given definite evidence not only of maintained interest but also of a growing audience.



THE TRANSMITTER AT THE ORIGINAL EMPIRE STATION, CHELMSFORD, G.5SW

¶ PROGRAMME SECTION

From the beginning it was realised that the time differences between the various parts of the Empire would have to be studied carefully to determine the most suitable hours of transmission. In the course of development this time factor has remained an important consideration at the basis of programme action. To ensure a universally acceptable time medium, Greenwich Mean Time is observed as a standard in Empire transmissions throughout the year.

When the Service was inaugurated there were ten hours of transmission daily, at suitable intervals, spread over the twenty-four; but by the Spring of 1935 daily transmission time had increased to over sixteen hours. Until October 1933, the periods of transmission were based on a division of the world into five zones, comprising geographical areas to which the Daventry transmissions were directed at a Greenwich time suitable for convenient local listening. But in the light of experience gained during the early months of operation it became obvious that the zonal basis as an indication of defined areas of reception would have to be abandoned, as each transmission was, in fact, being received at varying times in widely separated parts of the Empire. Accordingly, since the autumn of 1933, the programme periods have been divided into transmissions identified numerically and, within certain broad limits imposed by purely technical considerations, time alone is the criterion by which the audience for any particular programme is determined.*

Programmes for the first few months were of an experimental nature; but the general development of the Service and a careful study of available reports sent to the B.B.C. by overseas listeners soon made it possible to develop programmes for each transmission, taking into account the special needs of those countries which the programmes reached at suitable listening hours and where the maximum audience was expected.

PROGRAMMES

In dealing with specific sections of programmes it will probably be of interest to quote extracts from actual listeners' letters received by the B.B.C. during 1934. Such extracts are, therefore, included in the following summary.

'Your "This is London calling" has a wonderful tonic effect on our imagination.' *from New Zealand.*

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*A map showing time differences throughout the Empire will be found on pages 20–21.

READING THE NEWS TO EMPIRE LISTENERS

'We like to hear Big Ben: it kind of makes the end of a perfect day. We also like to hear that "Goodnight, everybody", and that ever-welcome "God save the King".' *from Canada.*

All the Empire transmissions open with the chiming or striking of Big Ben in the Clock Tower of the Houses of Parliament. Big Ben's chimes are also used at appropriate intervals during periods of the transmissions, each of which always ends with the playing of 'God save the King'.

'News is, perhaps, of most interest. When I mention that I am frequently at sea for more than a month on end, completely cut off from the rest of the world, you will easily understand how particularly welcome the Empire News Bulletins are.' *from the Chief Officer of a British Steamer, writing from South Africa.*

News bulletins are broadcast regularly in all Empire transmissions. Each bulletin is designed to cover the events of importance taking place throughout the Empire and the world during the twenty-four hours preceding its transmission.

Because of this the bulletins are perhaps of greater value to isolated listeners than to those who are situated in main centres of population in the Dominions and Colonies, where a normal newspaper service is available. As a supplement to the bulletins in certain transmissions, weekly market notes on dairy produce and fruit are supplied by the Imperial Economic Committee. Other market information of a general nature is given periodically, and in 1935, it is proposed to introduce in all transmissions a short weekly bulletin giving, briefly, the main tendencies of major commodity markets and other relevant information.

'From a distant suburb of Brisbane I write to let you know of the very great pleasure you made possible for our home when you broadcast the marriage ceremony of the Duke and Duchess of Kent. The lovely music from the Abbey stirred our hearts very deeply and made us feel that, after all, we are very near to the heart of the Empire.' *from Australia.*

'As a keen sportsman your many sports broadcasts are very acceptable, especially the Rugby matches, boxing, and the Boat Race; while church services and Armistice Day brought one into touch with the more solemn side of old England's life.' *from Africa.*

Broadcasts in connection with public events and ceremonies of all kinds are regularly transmitted. Direct broadcasts simultaneous with radiation in the home country are arranged from the Empire Station in the transmissions which are in progress at the time. A system of electrical recording makes it possible for such relays to be heard at a convenient local listening time in all parts of the Empire, the recording being reproduced round the circuit of subsequent transmissions immediately following the initial broadcast. The same principle of direct broadcasts and recording is observed in the case of sporting events, such as the Grand National, International Rugby Football Matches, Test Cricket Matches, and so on.

'With the best of good wishes to you and the several orchestras and bands which afford me a pleasant evening at all times.' *from Barbados, British W. Indies.*

'I am a lover of music, and certainly enjoy your broadcasts. One of my favourite serenades came in to-day. I did enjoy it so much.' *from Newfoundland.*

'I enjoyed your tour of the "Old Music Halls".' *from Western Australia.*

THE B.B.C. EMPIRE ORCHESTRA

In certain transmissions which take place during evening hours, Greenwich Mean Time, considerable sections of the programmes radiated from the home medium and long-wave stations are broadcast simultaneously from the Empire transmitters. The great time difference, however, between Great Britain and certain sections of the Empire means that some transmissions take place early in the morning and late at night in England when such home programme material and facilities are not available. Similar difficulties are encountered in the case of afternoon transmissions, when there is need for a more varied programme for Empire purposes than is available from the home stations during afternoon hours. Programmes of music, drama, light entertainment, and variety are, however, provided in all Empire Station transmissions. There is a B.B.C. Empire Orchestra which works under its own Musical Director, who is also responsible for the supervision of all music in Empire programmes. This orchestra contributes frequently to late night, early morning, and afternoon transmissions, for which other regular B.B.C. orchestras are not available. There are also many other programmes of a special character designed by the staff of the Empire Department to meet not only the requirements of an overseas audience but also the technical conditions of propagation on short waves, which are different from those experienced in broadcasting in Great Britain. The process of electrical recording referred to above is also employed for the purpose of making many of these special programmes available for radiation in all Empire transmissions.

> 'At first we could hardly believe that it was from England, it was so plain; but after the prayers the minister said that his church was situated at the north end of Regent Street, London.' *from Canada.*

A religious service is broadcast in each main transmission on Sundays. Due regard is given to the inclusion of services representative of the various denominations. In addition to the Sunday broadcasts, Evensong is relayed once weekly in afternoon transmissions, either from Westminster Abbey or York Minster. On special anniversaries appropriate services are provided from the Empire Station.

> 'I was particularly pleased to listen in to Sir Ian Hamilton's talk on Anzac Day, being an ex-service man who served at Gallipoli.' *from Australia.*

> 'We thoroughly enjoy the talks. They do so much to stave off the mental stagnation inseparable from life on an out station.' *from Malaya.*

> 'When Howard Marshall spoke about the fog, my wife, who spent last Christmas at home, crouched nearer the fire and eventually had to go outside to make sure that ours was a glorious winter night, with a sky studded with millions of stars.' *from India.*

Talks are a regular feature of all transmissions from the Empire Station. The speakers include statesmen, distinguished visitors from overseas, and leaders in various walks of life. There are also individual and serial talks by authors, critics, travellers, and people in touch with current events in every part of the world. These talks aim at representing all aspects of life and activity not only in the home country but in the Empire overseas. Of a more informal nature are the very short topical talks of five minutes' duration which, on many occasions, supplement the news bulletins. These are descriptions of anything of particular importance which happens to be taking place in England at the time—an exhibition, a race-meeting, some interesting event, or even a word-picture of some place which is figuring in the news. The process of electrical recording brings to all Empire listeners at a convenient listening time talks which are of general entertainment value.

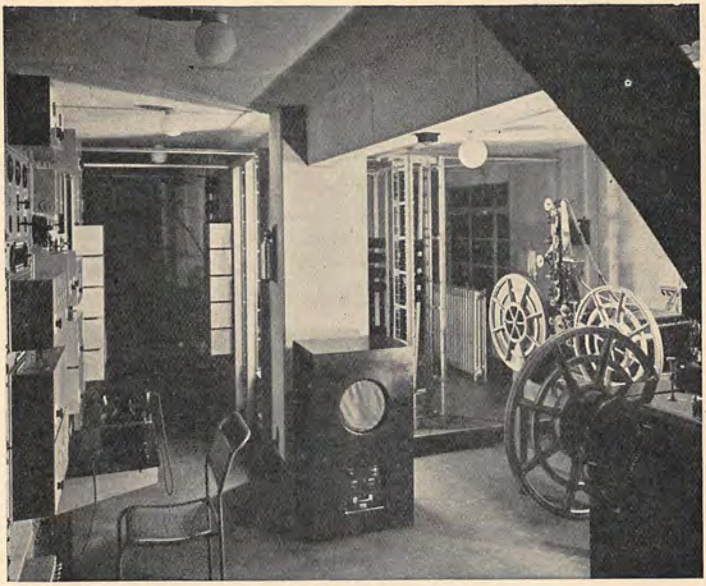
RECIPROCAL PROGRAMMES

There is close co-operation between those in charge of the Empire Service and overseas broadcasting organizations in the Empire. No opportunity is missed of bringing to an Empire-wide audience events which are of real Imperial interest and significance. With the development of Empire communications as a whole there will be an extension of these reciprocal programmes. The Christmas Day broadcasts of 1932, 1933, and 1934, culminating in messages from H.M. the King to the people of the Empire demonstrated the manner in which the British Commonwealth of Nations can be linked through the medium of broadcasting and the Radio Telephone Services. Overseas relays have already been taken from all the Dominions with which telephonic communication has been established, and these broadcasts have included: from Australia, Test cricket eyewitness accounts in 1933, an Empire Day programme in 1934, and several relays associated with the Melbourne Centenary celebrations; from Canada, a Dominion Day programme in 1934; from South Africa, a descriptive broadcast from the top of Table Mountain, and speeches associated with the unveiling of the Livingstone Memorial at Victoria Falls; and from India, a broadcast of native music and a commentary on a Bombay street scene. New Zealand, together with the other Dominions, has contributed to each of the Christmas Day programmes.

TRANSMISSION PERIODS

The manner in which programmes are divided into periods is indicated below. The actual times of transmissions are liable to change (particularly in April, when Summer Time is introduced in Great Britain, and in October when there is reversion to Greenwich Mean Time). Reference is made in the introduction to this booklet to the availability of current time schedules. At the time of writing these notes, there are six periods of transmission, but changes in the present division of the daily programmes may be made as the Service develops and extends.

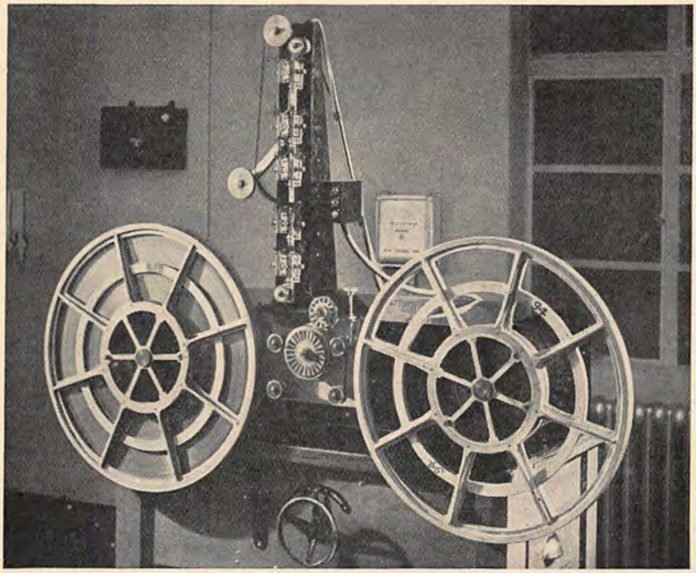
TRANSMISSION 1 is radiated during early morning hours in England for late afternoon or evening reception in the Antipodes, although it is also heard at correspondingly earlier hours in countries between England and Australasia in an easterly direction: similarly it is also picked up occasionally in Western Canada (especially in late spring and early summer) on the previous night (local time in Western Canada). For



A RECORDING ROOM

technical reasons the time of this transmission is changed at approximately monthly intervals. During midwinter the period of transmission is from 8.30 to 10.30 a.m., G.M.T., and in midsummer it is moved to 4.30 to 6.30 a.m., G.M.T. There is gradual change between these two extremes in the intervening months. The time difference between Greenwich Mean Time and local time varies from 8 hours fast on Greenwich in Western Australia, to 12 hours fast in New Zealand and certain Pacific Islands. It will readily be seen that this transmission comes entirely outside the normal programme hours of the home service, and in consequence a specially-built programme has to be provided.

TRANSMISSION 2 takes place normally from, approximately, 11.0 a.m. to 2.0 p.m., and is primarily intended for evening reception in Malaya and the Far East (and Western Australia), where the time difference is from 7 to 8 hours fast on Greenwich Mean Time. This transmission was, until the autumn of 1934, regarded as primarily an omni-directional programme; but since then technical arrangements have been modified to provide for better reception in the areas indicated above. The programme consists in large part of relayed excerpts from the home stations' programmes, together with recordings of events,



ONE OF THE STEEL TAPE RECORDING MACHINES

ceremonies, special Empire programmes, and talks. A News Bulletin has been a regular feature of this transmission since October, 1934.

TRANSMISSION 3 is timed approximately for the period 2.0 p.m. to 5.0 p.m., G.M.T., and provides an evening listening programme for India, Burma, and Ceylon—where local time is 5½ hours fast on Greenwich. It is also received during mid-day or morning hours on the American continent, and provides an afternoon programme for Mediterranean countries and the Near East generally. In the programmes for this transmission considerable use is made of excerpts from the home service, and there are also many specially produced programmes and talks of all types, together with recordings of events and ceremonies. The actual broadcasts of running commentaries on sporting events in this country usually come within the period of this transmission, and listeners in the area primarily served have shown great interest in such relays.

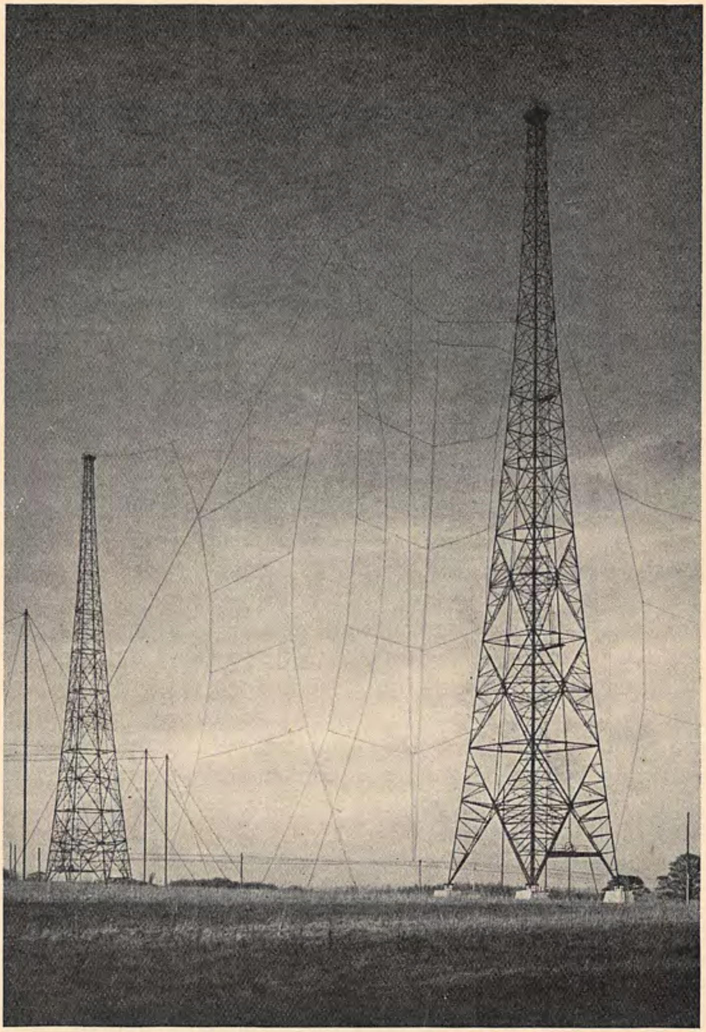
TRANSMISSION 4 has the longest period of the day's service, usually from about 5.15 p.m. to 10.45 p.m., divided into two parts by a short interval. The early part of this transmission is intended primarily for evening reception in South and East Africa, Mediterranean countries, and outlying islands (2 or 3 hours fast on G.M.T.); and the latter part for countries whose local time is from 1 to 4 hours slow on G.M.T.—West Africa, islands in the South Atlantic, the British West Indies, and the British communities in South America. The technical transition from area to area is, of course, gradual, and sections of the programmes are also heard in North America generally, and in New Zealand (at early morning hours especially during English summer months). The programmes consist in the main of suitably selected excerpts from the principal evening programmes broadcast from the home stations, although recordings of special Empire programmes, talks, events, and ceremonies, are also included.

TRANSMISSION 5 from 11.0 p.m. to 1.0 a.m. is designed to serve Canada, Newfoundland, the West Indies, and British listeners generally in North and South America, where local time is from 4 to 8 hours slow on G.M.T. This transmission, as in the case of Transmission 1, gives little opportunity for using the home service, and consequently a specially-built programme of a similar character is required. Much interest has been shown in the Empire Service on the part of listeners in Canada and other parts of North America and in South America.

TRANSMISSION 6. An experimental transmission from 3.0 a.m. to 4.0 a.m. G.M.T. was inaugurated early in 1935 on four days a week. The programme at this time is intended primarily to give evening reception in Western Canada, although it is also heard at various hours in other parts of the world. An extension of this service to provide daily transmissions will be considered in the light of reports received during the early months of operation.

* * *

It is hoped that these notes will be of interest particularly to those who have not yet experienced reception of the Empire Broadcasting Service. No summary of the Service would be complete without an expression of gratitude to those listeners who have during the early years of Empire broadcasting sent to the B.B.C. reports on both programme and technical aspects of the Service. The value of suggestions and criticism embodied in such reports from overseas cannot be over-estimated. It is hoped that new listeners will similarly provide reports, upon which the development of the Empire Service so greatly depends.



THE 350 FT. MASTS SUPPORTING EXPERIMENTAL AERIALS
AT THE EMPIRE BROADCASTING STATION, DAVENTRY

¶ TECHNICAL SECTION

TRANSMISSION

The British Empire Broadcasting Station is situated at Daventry, Northamptonshire, its exact geographical position being 1° 08′ 00″ W, 52° 15′ 00″ N. The site was originally chosen in 1925 for the long-wave (1500 metre) National programme transmitter of the B.B.C. In 1927 a medium-wave transmitter was added which has since become known as the Midland Regional transmitter.

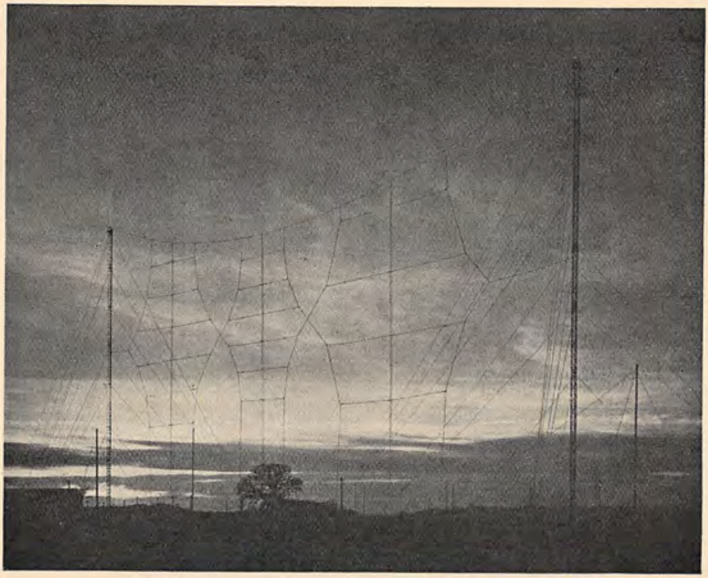
With the general development of the B.B.C. network, the long-wave transmitter and the Midland Regional transmitter at Daventry have been replaced by a new station which was opened at Droitwich towards the end of 1934. The whole of the Daventry site is therefore now available for the development of the Empire Broadcasting Service.

The Empire Station began its test transmissions from Daventry in November, 1932, and the first regular programme transmissions were made on the 19th December, 1932. In deciding on the number of transmitters to be installed, it was felt that at the outset it would be desirable to transmit on two different waves in the same direction, until sufficient data had been accumulated to forecast with reasonable precision the optimum wavelength for a given transmission.

A consideration of the time difference between the various parts of the Empire showed furthermore that it would not generally be necessary to serve more than two directions at the same time. Two transmitters were therefore installed, each capable of supplying a power of 10-15 kW to the aerial.

As far as the high frequency characteristics of the transmitter are concerned, it is desirable that the stability of wavelength should be high, and in this respect the transmitters conform to the recommendations of the International Technical Consulting Committee for Radio Communications, i.e. an error not exceeding plus or minus one part in 10,000. Actually, quartz crystal drives are used, giving a better performance than this (to wit, one part in 25,000), and in order to permit the necessary flexibility of operation of the two transmitters on eleven wavelengths, some twenty-four separate crystals are provided.

It might seem that an exacting specification for frequency characteristic of the modulation system of the transmitters would not be necessary, since conditions of short-wave reception, particularly during times of differential fading, are generally unfavourable to the reproduction of high musical quality.



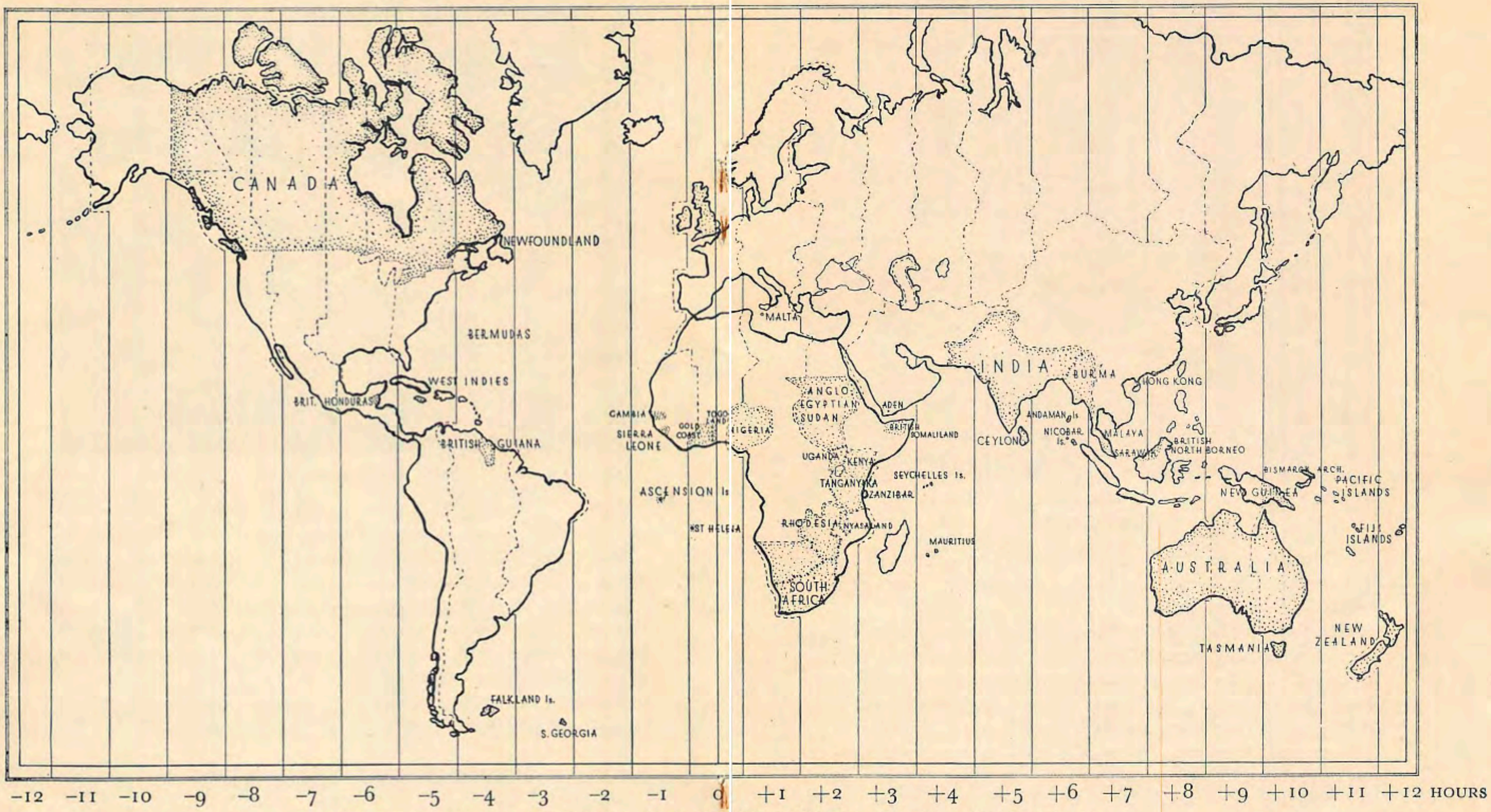
THE CANADIAN AND EAST AFRICAN SHORT-WAVE AERIAL ARRAYS

The Daventry transmitters have, however, a very good overall frequency characteristic, similar to that of modern medium-wave broadcasting transmitters, so that the best quality may be obtained when reception conditions are good. It is important that a high mean degree of modulation should be employed, in order to give the best possible chances of reception, and the transmitters were designed to be capable of a high peak modulation without distortion.

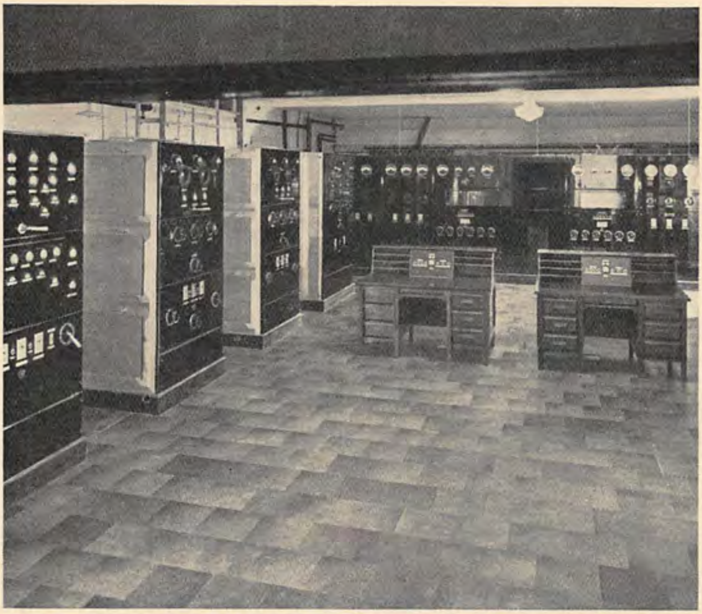
Initially, eleven directional aerials and six omni-directional aerials were provided, the former giving transmission in selected directions to serve the five zones into which the Empire was originally divided for Empire broadcasting purposes.

During October 1933, changes in the arrangement of the transmissions were made, since it became increasingly obvious that the zonal basis, as an indication of the geographical areas of reception, was unsuitable. Reports were received on the reception in the West Indies of the so-called Indian Zone programme, and of reception in New Zealand of the African Zone programme. The daily transmissions from the Empire Station are now divided into six periods known as Transmissions 1, 2, 3, 4, 5, and 6.

In designing a system which relies for its success on the use of short waves, it is desirable to make the system as flexible as



TIME-ZONE MAP OF THE WORLD SHOWING THE COUNTRIES OF THE BRITISH EMPIRE



THE TRANSMITTER HALL AT THE EMPIRE BROADCASTING STATION, DAVENTRY

possible, and accordingly the aerials originally installed at the Empire Station were simple in construction, supported by masts 80 ft. in height.

With the development of the service, experiments have been carried out using types of aerial different from those initially installed, and the results obtained so far are most promising. Further changes and additions to the aerial system are made from time to time as experience shows them to be necessary.

In general, the results of the experiments have indicated that the use of high aerials at Daventry gives better reception conditions than the use of low aerials, and that the question of the correct choice of polar diagram of the aerial in the vertical plane is at least as important as the correct choice of polar diagram in the horizontal plane. While this latter point has long been appreciated for point-to-point service, it was not known whether similar principles could be applied to a broadcast service.

Wavelengths and Frequencies

Until several years ago, there were only two groups of waves generally used for broadcasting. These were known under the names of 'long waves' and 'short waves'. Subsequently shorter wavelengths have come into use for broadcasting, making it necessary to use the term 'medium waves' for the original short waves, and to define the newer short-wave bands as 'short' and 'ultra-short'.

The generally used designations for broadcasting waves are now as follows :—

LONG WAVES

150-300 kilocycles per second (2,000 to 1,000 metres)

MEDIUM WAVES

550-1,500 „ „ „ (545-200 metres)

SHORT WAVES

6,000-30,000 „ „ „ (50-10 metres)

ULTRA-SHORT WAVES

Above 30,000 „ „ „ (below 10 metres)

The transmissions from the Empire Station are made within the band of short waves, namely between 6,000 and 30,000 kilocycles per second, that is between 50 and 10 metres.

Seven short-wave bands within the above limits have been allotted to broadcasting. These are of different widths and are in the neighbourhood of the following waves :—

6,000	kc/s	(50	metres)	
9,500	„	(31.6	„	)
11,760	„	(25.5	„	)
15,150	„	(19.8	„	)
17,750	„	(16.9	„	)
21,500	„	(13.95	„	)
26,000	„	(11.54	„	)

The actual waves which have been notified for use by the Empire Station, together with their call-signs and the words used to facilitate identification over the microphone, are as follows :—

GSA	A for Aerial	6,050	kc/s	49.586	metres
GSB	B for Broadcasting	9,510	„	31.545	„
GSC	C for Corporation	9,580	„	31.297	„
GSD	D for Daventry	11,750	„	25.532	„
GSE	E for Empire	11,860	„	25.284	„
GSF	F for Fortune	15,140	„	19.815	„
GSG	G for Greeting	17,790	„	17.863	„
GSH	H for Home	21,470	„	13.972	„
GSI	I for Island	15,260	„	19.659	„
GSJ	J for Justice	21,530	„	13.934	„
*GSK	K for King	26,100	„	11.494	„
GSL	L for Liberty	6,100	„	49.110	„

* The use of this wave is not contemplated at present.

RECEPTION

The B.B.C. has received a large number of inquiries from intending or actual listeners to short-wave transmissions since the experimental transmitter G5SW at Chelmsford was opened in 1927. These inquiries have been either by letter or from personal callers, and many of them seek advice on the type of equipment with which they should provide themselves to receive these transmissions. In addition, the B.B.C. has received a large number of reception reports from those who listen to the short-wave transmissions from Daventry in various parts of the Empire.

The remarks which follow are based largely upon the experience of Empire listeners themselves, and they are made in the hope that they will prove of assistance to the many new listeners to the Empire Broadcasting Station. In order that the B.B.C. may be in the best possible position to help both Empire listeners and manufacturers of receivers, it is requested that readers should communicate with the B.B.C. if they find in these remarks anything which is definitely contradictory to their own practical knowledge, or if they have any additional information which they feel may be in the general interest.

Readers will appreciate that it is necessary for the B.B.C. to be strictly impartial in matters affecting the interests of the individual wireless manufacturers, and it therefore follows that the B.B.C. cannot give advice on, or make recommendations concerning, specific makes of short-wave receivers. Nevertheless, in order to provide listeners with general information regarding British short-wave receivers, a pamphlet has been prepared in collaboration with the Radio Manufacturers' Association, and this may be obtained from the B.B.C. The following general remarks are made to assist those who are contemplating the purchase of a short-wave receiver, either abroad or when on leave in England.

Transmissions from the Empire Station may be received in two ways: firstly, they may be picked up directly by listeners equipped with a short-wave or all-wave receiver. Secondly, they may be received at a central receiving station established for the purpose by Dominion or Colonial organizations, and thence relayed for public reception over the local medium-wave broadcast transmitter or transmitters, or the central receiving station can relay the received programme by line to local subscribers. This system is commonly termed 'rediffusion'.

It will be obvious that direct reception is the only possible means of receiving the Empire Station in districts where no central broadcasting organization or rediffusion system exists. It is not within the scope of this pamphlet to deal with the relatively expensive and complicated apparatus which can be used with advantage for relaying short-wave transmissions, as this is generally a matter for a central broadcasting authority. The B.B.C. will be pleased, however, to supply information to broadcasting and other authorities on request, this information being based on its own experience in relaying short-wave programmes during the past eleven years. The lonely listener or the listener who has no local service will, however, be prepared to accept something which, although less good from the technical point of view than a local re-broadcast, may well be sufficiently good to enable him to enjoy a large part of the programme without difficulty and without great expense.

Receivers for Direct Listening

The first main division among would-be short-wave listeners is between those who already have a *medium-wave* broadcast receiver and those who have not. For the former it may be found that the simplest solution is to buy a short-wave adaptor or converter, of which there are already several available on the British market, and which will make it possible to convert the ordinary broadcast receiver into a short-wave receiver.

For those who do not possess a receiver, the factor which should govern its choice is the power supply available. This point is discussed at some length later in this pamphlet. It should be borne in mind, however, that in addition to receivers which are constructed solely for use on short waves, there is at present available on the market a number of receivers known as 'all-wave receivers', i.e. these receivers are suitable for reception of short waves such as are used by the Empire Station, as well as of medium waves such as are used by local or regional broadcasting stations. In addition, some of these receivers also provide for reception of stations in the long-wave broadcasting band.

The adaptor or converter is a small and simple unit having one or more valves, and costing a relatively small sum. Adaptors and converters are already available which take their supply from A.C. mains, and these, of course, may be employed in connection with A.C. mains operated receivers.

The distinction between the adaptor and the converter is one of convenience of definition. It is usually agreed that an adaptor is a simple detector valve with reaction, the output of the unit being connected to the low frequency stages of the existing broadcast receiver, and it is suitable for broadcast receivers which have no high frequency stages, or do not use them when the short-wave adaptor is connected. The converter is a frequency changer of the superheterodyne type, which changes the frequency of the incoming short waves to a frequency within the band for which the broadcast receiver is suited. In purchasing one of these converters, care should be taken to see that it is suitable for the waveband covered by the broadcast receiver.

Some of these superheterodyne short-wave converters consist of only one valve working on the auto-heterodyne principle, and these are not generally suitable for use in conjunction with a broadcast receiver which has not a 'long-wave' range.

Outside Europe, however, these so-called 'long waves' (1,000-2,000 metres) are not at present used for broadcasting, and the normal broadcast receivers in use there do not in general cover this band. In these circumstances, it will usually be preferable to use a short-wave converter which provides a separate oscillator, a heptode, or a triode-hexode frequency changer. Either a short-wave converter or an adaptor is simple to install, and the results to be obtained from the best of them leave little to be desired.

As the use of an adaptor or converter presupposes that a broadcast receiver is already available, it follows that this method of receiving the Empire transmissions will normally be limited to those areas which already have a local broadcast service. The fact that there is a local broadcast service generally means that there are no particular difficulties in the choice of power supply for the receiver, for either mains are available or battery charging is easily arranged.

All Mains Receivers

If a current supply is available, the most convenient type of short-wave receiver is one which takes its supply from the mains without the use of batteries, that is, an all-mains receiver. An all-mains model of the universal type (AC/DC) can be used with either type of mains supply. Other all-mains models must only be connected to the type of power supply for which they are designed. In the case of A.C. models, the periodicity and, within limits, the voltage for which the set is designed must correspond with that of the mains. For D.C. models only supplies of 200 volts and over are generally satisfactory, although moderate results can be obtained from lower voltages.

High and Low Tension Power Supply

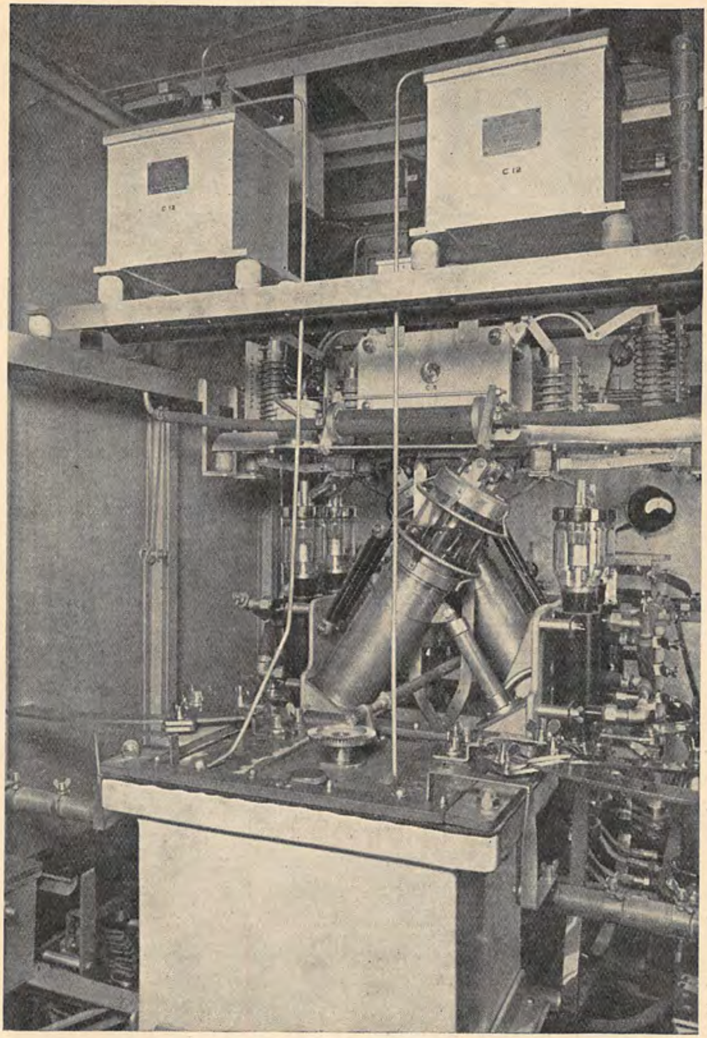
The actual current consumption of a wireless set is low, being only approximately 40-60 watts, or the same as that taken by an ordinary electric lamp. If electric mains are not available at the point where the receiver is to be used, but if either electric mains or battery charging equipment is available at a short distance from the place where the receiver is installed, a good solution to the power supply difficulty would be to install accumulators both for low tension and high tension supply.

Another method is to use a large capacity low tension accumulator, which not only provides the low tension supply direct, but which is also used to drive a small rotary converter which provides the high tension supply. Special precautions have to be taken to prevent this machine from creating electrical disturbances which interfere with reception, but machines are now available which are specially designed for the purpose, and which incorporate the necessary silencing device to suppress this interference. It is, of course, essential that there should be no serious difficulty in re-charging the low tension accumulators. This method has the advantage that the heavy duty low tension accumulator is very much more robust than the small high tension accumulator, and is less likely to be damaged in transit for re-charging. Indeed, the normal type of accumulator fitted as a starting and lighting battery on a motor car is entirely suitable for this purpose. The new Universal (AC/DC) valves have 13-volt heaters which are suitable for connection direct to a 12-volt car battery.

There is a further type of high tension supply which consists of a high tension accumulator, fitted with a series-parallel switching device so arranged that in the 'on' position the cells are connected in series for supplying high tension to the receiver, whereas in the 'off' position they are connected in parallel for charging from a 6-volt or 12-volt L.T. accumulator, the latter being used to give L.T. supply to the receiver.

In this way, it is only necessary to remove the L.T. accumulator for re-charging, and the remarks made above as to its robustness are also applicable here.

Yet another method of obtaining high tension supply is by the use of dry high tension batteries. The initial cost of these is considerably less than that of high tension accumulators, but they cannot be re-charged when exhausted and have to be thrown away. It is not possible to judge the performance of high tension batteries in the tropics merely from a knowledge of their performance in a temperate climate, where they are used in very large numbers and with entire satisfaction for this purpose. In tropical and humid climates it may be found that a type of cell known as the 'inert' cell may be advantageous. This type of cell is not rendered active until it has been filled with water, and there is, therefore, less likelihood of its deteriorating between



ONE OF THE EMPIRE TRANSMITTERS
BACK VIEW OF THE INSIDE OF A POWER OUTPUT STAGE

the date of its manufacture and the date of its being taken into use by the listener.

Listeners who have No Electric Supply Available

Although the percentage of Empire Service listeners who are more than two days' journey from an electric supply is comparatively small, their number taken all over the Empire is considerable, and it is certain that these listeners, above all others, are those who most appreciate the Empire Service. As they are faced with difficulty in re-charging accumulators and in securing fresh high tension batteries, it is most desirable that they should use a receiver which consumes the absolute minimum of low tension and high tension current. It is therefore strongly recommended that they should content themselves with reception on headphones, for a considerable saving in current without a loss of quality can thus be obtained. It should be mentioned that there are several advantages in headphone reception for long-distance broadcasting, because it is easier to understand speech on headphones than on a loudspeaker, when a background of interference is present, or when the speech is distorted due to the effects of fading. It is often worth while using headphones even when there is no need to economise in valves and batteries. A simple two-valve receiver, consisting of a detector valve and one stage of low frequency amplification, may be found satisfactory for this purpose, and is most economical in operation. Indeed, the low tension consumption would be limited to about 0.3 amperes at 2 volts, while the high tension consumption would be limited to 5 or 6 milliamps at 60 volts. The addition of a screened grid high frequency valve, making three valves in all, would simplify the operation and improve the performance of the receiver. Such a receiver need not consume more than ½ amp. at 2 volts low tension, so that a 40 amp. 2-volt accumulator should last for about one month on a basis of two hours' listening per day.

The high tension current consumption, even on the basis of headphone operation, presents rather a problem, mainly because the use of a screened grid valve calls for a greater high tension voltage than would otherwise be necessary for satisfactory headphone reception. Nevertheless, dry high tension batteries or 'inert' cells will help to solve this difficulty. With the simple three-valve receiver mentioned above, a 100-volt inert cell high tension battery should last for approximately two or three months on the basis of a discharge rate of 10 milliamps for two hours per day.

It is useless to contemplate the installation of a powerful and expensive radio-gramophone type of receiver if adequate power supply is not available, and it is, therefore, better to use headphone reception in those localities where no battery charging can be carried out.

Selectivity It is difficult to say definitely whether it is better to use a superheterodyne type receiver or a straight type receiver, for there are several points of view which must be considered. Both are known to give good results in particular conditions, and the performance depends very largely on the particular design of receiver, irrespective of its type. As a general rule, however, it may be said that, unless special precautions are taken with the superheterodyne, the straight receiver is likely to give a more silent background. On the other hand, the question of selectivity on the short-wave bands is becoming increasingly important. In the past the separation between short-wave broadcasting stations was often 30 kc/s or more. At the present time it is, in many cases, 10 kc/s, and the short-wave bands are becoming more and more congested. It may happen that a broadcasting channel is adjacent to a fixed station telegraph channel, and, if unselective receivers are used, serious interference will certainly be experienced.

The subject of selectivity is sufficiently important to warrant the following comparison between selectivity on the medium-wave broadcasting band and on the short-wave broadcasting band. A medium-wave broadcast receiver working on 1,000 kc/s (300 metres) would be considered selective if it were capable of separating two broadcasting stations giving equal strength signals, the two broadcasting stations working with a separation of 10 kc/s. Assuming the same selectivity for a receiver working on 10,000 kc/s (30 metres), the receiver would only be capable of separating two signals of equal strength 100 kc/s apart. In other words, it would be capable of producing interference from some 8 or 9 stations on either side of the frequency to which it was tuned. Moreover, it must be remembered that the 'wanted station' may be in the trough of a fade when the 'unwanted station', adjacent in frequency, is at the peak of a fade. Thus the receiver has a much more unfavourable ratio of signal strengths to deal with than that encountered on the medium-wave bands when listening to a 'wanted' local station.

It would seem difficult at the present time to construct a straight receiver with single knob tuning having adequate selectivity on the short-wave bands, and from this point of view the superheterodyne receiver has a considerable advantage.

THE CONTROL ROOM, BROADCASTING HOUSE, LONDON

Image Signal or Second Channel Interference

In the superheterodyne receiver, in which the oscillator tuning condenser is not gauged to the signal frequency tuning condensers, two tuning positions of the oscillator tuning condenser will be found for each station. These two positions will be respectively at points on the oscillator tuning condenser scale where the oscillator frequency is equal to the frequency of the wanted station plus or minus the intermediate frequency. Even if the oscillator condenser is gauged to the signal frequency tuning condensers, it may be found that stations tune at two points if the signal frequency circuits have not adequate selectivity to prevent this taking place. While it may not matter that each station can be tuned in on two adjustments—although even this is inconvenient—it also means that two stations can come in at any one adjustment, which is a serious disadvantage.

This image signal or second channel interference becomes less acute as the selectivity of the signal frequency circuits is increased and/or as the intermediate frequency is increased.

Receivers for Use in Tropical Climates

Whether the receiver chosen be a superheterodyne or a straight receiver, it is most important that its mechanical design and construction should be suitable for the conditions of transport and climate to which it is likely to be subjected. This, of course, is a matter for the manufacturers in the first instance. As far as the listener is concerned, he would do well to look out for such points as robust construction and attachment of the various components, and the provision of a container for the receiver which is capable of resisting mechanical shock, as well as heat and damp. Materials and methods of construction must be suitably chosen for tropical climates. The listener himself, who has had experience of these conditions, is the best judge in this matter.

Automatic Gain Control

The strength of signal received from a short-wave station at great distances varies over very wide limits, even during the period when reception might be considered fairly steady and good. Many short-wave receivers are, therefore, fitted with an automatic device for controlling the amplification of the receiver, the amplification increasing as the signal gets weaker and decreasing as the signal gets stronger. The result is that over a certain range of variation of the incoming signal, the acoustic output from the loudspeaker will remain sensibly constant. This device is called either automatic gain or automatic volume control.

A false impression seems to be current that automatic gain control is a complete cure for fading. While this may be true when fading is limited to a reasonable depth, it is not true if the fading is exceedingly deep and the signal is fading practically to zero. The automatic gain control alters the gain of the receiver in order to compensate for variation in signal strength and the result may be that the noise level at times is increased to a point where the signal is swamped.

Aerials

It is sometimes stated that considerable advantage is to be derived from special types of aerial for short-wave reception. These may take the form of a vertical half-wave aerial, a dipole aerial, a horizontal doublet, and so forth. Some of these special types of aerial are suitable only for a particular wavelength, to which the dimensions are proportionate, i.e. a half-wave aerial would have a length of 25 metres for a 50-metre wave, or a length of 7 metres for a wave of 14 metres. While there is generally no disadvantage in using these various special types of aerial in comparison with an ordinary good broadcast receiving aerial, it is worth noting that it is not likely that much advantage will be gained unless the necessary arrangements are made to connect the aerial to a suitable place on the receiver aerial coil.

A quarter-wave aerial, an Inverted 'V' aerial (see page 33), certain dipole aerials, and a feeder line connecting to a distant aerial, are of relatively low impedance and must be connected to a point near the bottom of the aerial coil, whereas a half-wave aerial is of high impedance and should be connected to a point at the top of the aerial coil. It is advisable to find the most suitable point by trial and error before making a permanent connection and to remember that the optimum tapping point may be different on the various wave ranges.

For the reception of the Empire Broadcasting Station, it is obviously desirable that an aerial should be efficient on all the wavelengths used. Of the many different types of aerial which can be used, there is at least one which combines simplicity and effectiveness. This was designed by Bruce, and listeners interested in the theory are referred to a paper by Bruce which

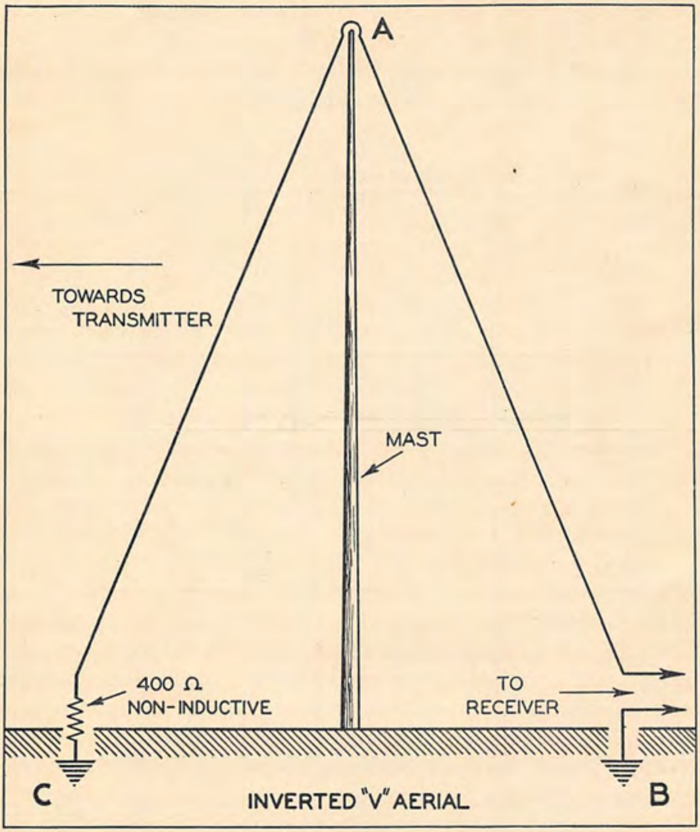


FIG. I

appeared in the *Bell System Technical Journal*, October 1931.

The sketch in Fig. 1 shows that the aerial consists of a single length of wire bent into the form of an Inverted 'V', the apex being supported at a distance above the ground. The general design data for this type of aerial are quite simple.

For maximum efficiency the apex of the V should be as high as possible, and the length of wire used should be one wavelength longer than its projection on the ground at the fundamental frequency of the aerial, i.e. in Fig. 1 the length of wire represented by CAB should be one wavelength longer than the base line CB. In order to obtain a maximum signal to noise ratio, it is desirable also that each side of the Inverted 'V' should be an odd number of quarter wavelengths long.

The tables printed here show the dimensions of aerials for different heights of mast designed to have optimum response at 17, 20, and 25 metres, respectively. In general, listeners will not conveniently be able to use higher masts, and, therefore, data for aerials for 32 and 49 metres are omitted.

TABLE I

Where length of side = 3/4 wavelength.

Wavelength Metres	Height of Mast in feet	Length of base line in feet	Length of wire (CAB) in feet
17	40	28	84
20	44	33	98′ 6″
25	60	42	125′ 6″

TABLE II

Where length of side = 5/4 wavelength.

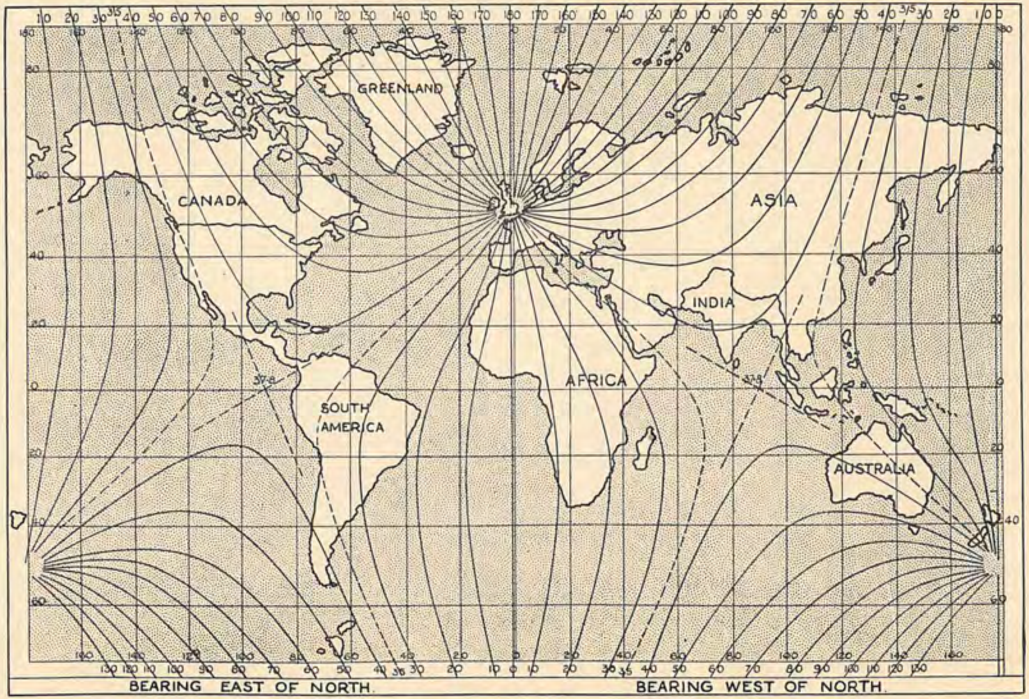
Wavelength Metres	Height of Mast in feet	Length of base line in feet	Length of wire (CAB) in feet
17	58	84	140
20	66	98′ 6″	164
25	83′ 6″	125′ 6″	209

The Inverted 'V' aerial, although designed in terms of a fundamental wavelength at which its performance is an optimum, gives a satisfactory response over a comparatively wide waveband ranging from about 0.7 to 3 times the fundamental wavelength. When two alternative transmissions are normally received it will, therefore, be desirable to design the aerial to give maximum response for the shorter wavelength transmission.

The measured performance of an Inverted 'V' aerial designed for 17 metres and using a mast of 42 ft. was found to be about five times that of an ordinary aerial on 17 metres; on 20 metres a gain in signal strength of about three times was obtained, whilst on 25 and 30 metres a gain of from two to one-and-a-half times in favour of the Inverted 'V' was observed. On 50 metres no appreciable difference between the sensitivity of the two aerials could be found.

It is important to note that an Inverted 'V' aerial must be terminated at the end distant from the receiver by having a non-inductive resistance of approximately 400 ohms connected from this point to earth. At the same time, the aerial must be connected to an appropriate point on the aerial circuit of the receiver. This will not generally be the normal aerial terminal provided. It will be found that a tapping point at a half to one-and-a-half turns from the bottom of the aerial coil will be a satisfactory point, but it is desirable to select the point by trial and error. It is also desirable that a condenser (.001 mfd) be connected between the tapping point and the aerial, since this, having a path to earth (400 ohm terminating resistance), may short-circuit the bias which would normally be applied to the grid of the first valve of the receiver. If it is found impossible to connect the aerial to a suitable tapping point on the aerial coil, the .001 mfd condenser should be replaced by a variable tuning condenser having a maximum capacity of .00005 mfds. A suitable setting of this condenser should then be found by experiment to give a compromise between strength of signal and selectivity. When properly terminated at both ends the Inverted 'V' aerial is directional and receives best those stations which are situated in line with the plane of the aerial and whose signals arrive at that end of the aerial where the terminating 400 ohm resistance is placed.

Whether the Empire listener decides to use an Inverted 'V' aerial or not, he may well use some form of directional aerial. The accompanying chart has, therefore, been prepared to aid him in arranging for such aerials to have their directions of maximum pickup pointing towards Daventry. Owing to the impossibility of representing accurately on a flat map the spherical surface of the earth, bearings cannot be estimated by measurements on a Mercator's projection or similar chart. A special kind of chart, known as a 'gnomonic graticule' can be drawn, from which true bearings from a given point at the centre of the chart to any other place are easily obtainable. It is the reverse process, however, that is required in this case, that of obtaining the bearing of a given point (Daventry) from any other point at which a receiver may be installed. As no type of chart in



MAP OF THE WORLD SHOWING TRUE BEARING OF DAVENTRY FROM ANY POINT general use supplies this information, the accompanying map is provided.

On a map of the world a series of lines have been drawn connecting points having equal bearings on Daventry. (These lines have no relation to the directions of propagation of the transmitted waves and must not be confused with the great circles which are lines of equal bearing *from* Daventry). Lines are drawn for every 10° change of bearing, and it should be easy, at sufficiently great distances, to estimate the true bearing correct to one or two degrees. Additional lines for a bearing of 35° are drawn to fill in a region in which the lines are otherwise somewhat wide apart, and the 37.8° bearing line is also drawn, as this line follows a peculiar path. This is the maximum bearing of Daventry that exists on the equator and the minimum along the 90° longitude line.

Feeders and Lead-in Wires

It is sometimes desirable or convenient to erect an aerial some distance from the location of the receiver. For instance, some listeners experience interference with broadcast reception due to industrial apparatus and motor cars. While the most satisfactory way to deal with this interference remains to eliminate it at its source, it may be reduced by siting the receiving aerial as far from the source of interference as possible, and by connecting the aerial with the receiver by a lead-in wire which does not itself pick up interference. A suitable feeder system must, in fact, be used as a connection.

Precautions must be taken in the construction and erection of such a system, and in general those types of feeder which may be convenient for medium-wave reception are not suitable for use on the short waves. A feeder system must be capable of transmitting energy from the aerial to the receiver without appreciable loss, and must not itself act as an aerial.

For short-wave reception Empire listeners could conveniently employ a two-wire feeder line, in which the wires are either twisted continuously or transposed periodically (see Fig. 2), so that any signals picked up by successive sections cancel out in their effect on the receiver. In order to avoid appreciable energy loss in the feeder, it is necessary, particularly where a feeder of considerable length is employed, to match the impedance of the feeder with the aerial to which it is connected, and to choose a suitable coupling from the feeder to the receiver. A quarter-wavelength aerial or a half-wave type centre fed, has a low impedance of the order of 100 ohms, and this type of aerial can conveniently be connected by a feeder consisting of a twisted pair of, or two adjacent, wires; an Inverted 'V' aerial

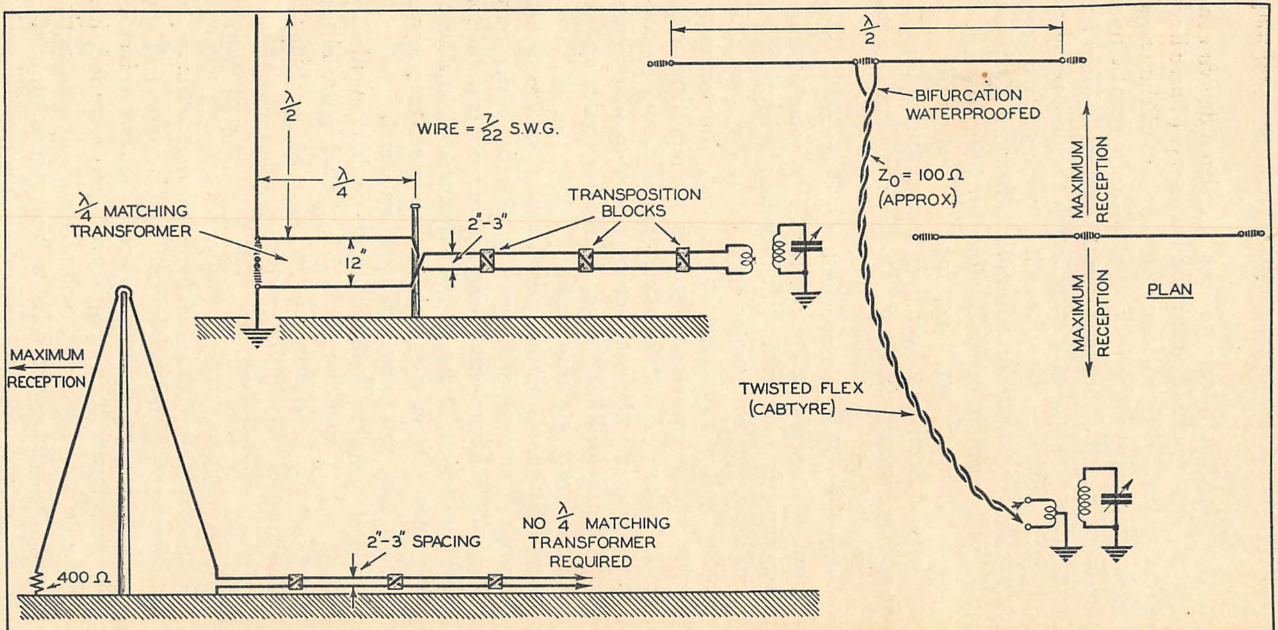

λ/2
WIRE = 7/22 S.W.G.
λ/4
λ/4 MATCHING TRANSFORMER
12"
2"-3"
TRANSPOSITION BLOCKS
MAXIMUM RECEPTION
400 Ω
2"-3" SPACING
NO λ/4 MATCHING TRANSFORMER REQUIRED
λ/2
BIFURCATION WATERPROOFED
Z0 = 100 Ω (APPROX)
MAXIMUM RECEPTION
MAXIMUM RECEPTION
PLAN
TWISTED FLEX (CABTYRE)

FIG. 2

having a characteristic impedance of about 400 ohms requires a feeder of a corresponding value, which may consist of two wires of 7/22 gauge spaced two or three inches apart and transposed at least three times throughout their length.

Half-wave aerials, in which connection is made to one end, have a comparatively high impedance of about 2,000 ohms, and no feeder can conveniently be made to match this value.

If, however, a quarter-wavelength of open-wire feeder is first used, for example two wires of 7/22 gauge, spaced one foot apart, the remainder of the feeder can conveniently be of a low impedance type suitable for a quarter-wavelength aerial.

It is never satisfactory to connect a feeder system directly across the grid tuning circuit of a receiver, and generally the receiver aerial and earth terminals will be equally unsatisfactory. Some firms market a transformer suitable for insertion between a feeder line and the receiver. Alternatively, a small coupling coil of one or two turns on the same former as the tuning coil may be tried.

Earth Connection

As far as the earth connection is concerned, while considerable latitude is allowable, yet if a receiver is to be situated in the same place for some time, it is advisable to fit a good earth connection at the outset. The most satisfactory earth is a copper plate, about 4 ft. by 2 ft., buried edgewise with the longer side horizontal and provided with a copper-strip connection to the lead-in point, this copper-strip connection being attached to the copper plate by copper rivets in order to prevent corrosion. If the receiver is to be moved from place to place, the use of an earth mat rather than a buried earth would be convenient. A suitable earth mat consists of a piece of fine copper gauze, say 10 ft. long by 2 ft. 3 ins. wide, provided with wooden battens at each end to keep it flat and to allow of its being rolled up after use. The earth wire should be connected to it at one or two points at one end. This type of earth is used quite extensively for military field station sets, and is laid out on the ground underneath the aerial.

The earth and aerial leads giving connection to the receiver should be of stranded and preferably insulated copper wire. They should be kept as short and as direct as possible. The receiver should be placed as close to the earth and aerial lead-in as possible, so that these leads are kept short. If listening is to be carried out at a distance from the lead-in, it is preferable to extend the loudspeaker or headphone connection.

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