SECOND • EDITION

RADIO! RADIO!

JONATHAN • HILL

The Author —

Jonathan Hill grew up in Mutley, Plymouth where in the 1960s he attended Sutton High School and later won a scholarship to Plymouth Art College. Arriving in London in the early 1970s, he studied 3-D design at the ceramics department of the Central School of Art, obtaining a B.A. Honours Degree in 1974. Initially a lecturer in ceramics, he became increasingly interested in photography and writing, and is now a freelance portrait & still-life photographer and the author of several books. His involvement in radio began during his time at Central where he wrote a thesis on wireless cabinet design and also began collecting receivers from the 1920s and 1930s periods. In 1976, along with five other collectors, he jointly founded the British Vintage Wireless Society which is dedicated to the preservation of obsolete wireless equipment and to promoting the study of wireless and broadcasting history, and which today has a worldwide membership approaching 1,000.

Jonathan Hill has designed and presented two major exhibitions in London — *"The Cat's Whisker"* radio exhibition at the Geffrye Museum in 1978, and *"Television In The Home"* at the Royal Festival Hall in 1986 which celebrated the 50th anniversary of BBC tv. His radio collection forms part of the Bampton Communications Museum which he runs next to his home in Devon.

Also by the author —

The Cat's Whisker, 50 Years of Wireless Design Oresko Books, London. 1978.
Television In The Home Museum of the Moving Image, London. 1986.
Old Radio Sets Shire Publications Ltd., Princes Risborough. 1993.
Bampton Bounds (with Kenneth Dives), Westbrook Publishing, Bampton. 1993.

Recommended further reading —

History of the Radio Valve by Keith R. Thrower. Published by MMA Int. Ltd., Ropley, Hants. 1992.
Made In Japan by Akio Morita. Published by Collins, London. 1987.
The Set Makers by Keith Geddes with Gordon Bussey. Published by BREMA, London. 1991.
Historic Televisions & Video Recorders by Michael Bennett-Levy. Published by MBL Publications. 1993.
Buygones by Victor Lewis Smith & Paul Sparks. Published by Banyan Books, London. 1988.

Radio! Radio! is a celebration in words and pictures of the development of the wireless set from its experimental beginnings in Victorian England, through the foundation of a domestic wireless manufacturing industry and the inception of broadcasting in the early 1920s, until after the introduction of the first transistor radio in the second half of the 1950s. With nearly 1,000 photographs, informative captions and carefully researched text, ***Radio! Radio!*** is the first truly comprehensive book of its kind ever to be published.

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RADIO! RADIO!

Jonathan Hill

JONATHAN HILL

For Juliet

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Preface To The Second Edition

The first edition of *Radio! Radio!* was published in 1986 and altogether some 6,000 copies were printed and subsequently sold. Since then I have been surprised to find that the demand for the book has not stopped. The numerous requests I have received for producing this revised second edition have certainly shown that interest in radio history is still gaining ground, as with each passing year, many hundreds of new collectors join those already captivated by this fascinating subject.

Much new archive material comes forward all the time and on this page I briefly acknowledge the minor role played by two early radio experimenters whose stories I should have included when this book was originally written. The first was Mahlon Loomis. He was an American dentist from Washington D.C. who, in the 1860's, carried out several experiments with a system of wireless communication using two copper gauze-covered kites flown on copper wires from adjacent mountain tops in West Virginia — this was long before Guglielmo Marconi 'invented' wireless (see page 12). The gauze of the transmitting kite became charged by atmospheric electricity and by means of a switch, was discharged to earth, and a reciprocal current pulse was registered on a galvanometer in the circuit of the receiving kite several miles away. Loomis believed that he had a marketable product, and was even granted a patent for "establishing an electric current for telegraphic or other purposes without the aid of wires, batteries or cables". Unfortunately, he was unable to find the necessary financial backing needed to support and to exploit his ideas — he just failed to get an appropriation of $50,000 from Congress. If he had, the history of radio may have been rather different.

The other experimenter omitted from the first edition was Robert Goldschmidt, who, just before WWI, carried out a series of unscheduled broadcasts of both speech and music from a transmitting station he had set up at Laeken in Belgium. He began broadcasting in March 1914 using an arc transmitter and continued for a few months until the station was dismantled when German troops crossed the Belgian frontier on August 3rd. Both Loomis & Goldschmidt deserve further investigation and perhaps one day may appear next to Marconi and other pioneers in the radio 'hall of fame'.

Considered redundant in most electronic circuits by the mid-1970s, the valve in recent times has made a remarkable comeback — not in radio though, but in domestic hi-fi amplification. The current demand for the *valve-sound* in music reproduction has meant the re-establishment of a valve supply industry principally from manufacturers based, not in this country, but in China — some of whom are employing English valve-making equipment once considered obsolete and sold off. Alongside the manufacture of new valves, 'vintage' valves are being resurrected and incorporated into the circuits of state-of-the-art audio equipment. The most extreme case of the old-with-the-new can be found in Audio Note's *Gaku-On* monoblock amplifiers. Upon their launch in 1993, these retailed at an astonishing £128,125 and each feature a pair of semi-ancient (and collectable) directly-heated 845 power triodes, which were once designed for bomber transmitters and popularly used by the American Airforce during and after WWII (see the feature in *Hi-Fi News & Record Review*, May 1993).

It would be difficult to discuss radio collecting as a hobby in this country without mentioning the British Vintage Wireless Society and the contribution it has made to preserving and promoting radio history. Founded in 1976, today its combined membership of nearly one thousand strong must hold the most comprehensive archive of British radio history that exists in the world, and many members are acknowledged to be leading experts in their particular fields. For a new collector today, help and advice is therefore readily at hand. There is a bookcase full of reference material on the subject, as well as several established vintage radio-type magazines. There are regular vintage radio gatherings around the country, specialist auctions, museums and numerous shops which buy and sell old radios. It's a well organised hobby, even for those who have no wish to join a club. But in the early 1970s, before a few of us got together and founded the BVWS, we were among only a handful of collectors in isolated pockets, with no contemporary books to help us and only the occasional reference to the vintage days of radio through such articles as Colin Riches' *Going Back* which appeared in *Practical Wireless*. We would scour street markets and antique fairs for old sets and were surprised when we chanced upon anybody else doing the same on our patch.

In 1972, things began to change when an electronics technician from the Physics Department of Bristol University with a love of vintage cars and a flair for repairing the radios that went inside them started a vintage car radio repair business from home. Within a couple of years Tudor Gwilliam Rees opened a specialist vintage radio business at premises in Broad Street, Bristol, by which time he had also branched out into domestic models, repairing and supplying parts and complete sets, and accessories such as headphones and loudspeakers. By the middle of 1975 he was sending out an annual catalogue and a monthly newsletter to his growing list of customers detailing his vintage radio services and the radios currently available in the shop — issue number 5 (from September 1975) notes several round Ekcos "Five in stock - all different models, £7.00 to £15.00". On sale too were period sales catalogues, leaflets and literature, plus a huge variety of vintage radio components including a selection of valves from his stock of 40,000. There was useful information for newcomers to the hobby ("Valve of the Month" and "Radio Wrinkle" sections), and customers were encouraged to conduct research into radio history in their local area and to contribute short articles.

Following a meeting the year before, Tudor Rees threw open his shop again on Sunday March 7th 1976 for a general get-together with the idea of stimulating the formation of a vintage wireless society or at least providing a stopgap until one was formed. On that particular occasion only 5 collectors managed to make the effort. Despite this, three of us, Tony Constable, Tim Richie and myself (all from London) decided to pursue the idea. The historic inaugural meeting of the British Vintage Wireless Society was duly arranged by Tony at his house in Ealing for 3pm on Sunday April 25th 1976. Besides Tony (who was the driving force behind the BVWS) and myself, the founding committee comprised John Gillies, Dennis Grey, Ian Higginbottom and Norman Jackson — Tim Richie never showed up and was never heard of again! Being heavily involved in the business side of vintage radio, Tudor Rees felt that he shouldn't be part of a committee running a club. However, he was happy to have been instrumental in providing a base for its launch and helped out in those early days by printing a membership application form in his newsletters and reviewing and promoting the Society's activities.

Other pioneer vintage radio-based businesses started up around this time: *The Vintage Radio Mart* in Greenwich, *Gramophones et Alia* in Fortune Green Road, Cricklewood and *Rupert's* in Ealing. These three, along with Tudor Rees' shop in Bristol and the infant BVWS, formed the basis of the radio collecting scene that has developed today.

Here, then, for collectors old and new, is the second edition; with a new easy-to-read subject index, the few previous inaccuracies ironed out, and a list of all the radio models illustrated abstracted and put together in the form of a simple A-Z directory, so it's now much easier to look up that old radio!

Jonathan Hill, Bampton, Devon. July 1993.

CONVERSION TABLES

Reference is made throughout the book, especially in the captions, to measurements of cabinets etc. in inches ('in.'), and prices of receivers etc. in the old pounds, shillings and pence ('£.s.d') monetary system. These units were in common useage in the years that the book covers and the conversion tables are given below as a guide to their present day equivalents. (Guineas, abbreviated to 'gns', were formerly gold coins, so-called because originally they were minted from gold brought from the Guinea coast of West Africa in the early 1660s. In 1717, their nominal value was fixed at 21 shillings (£1.05p), and while they were no longer in use in Britain by the 1920s, many things, such as doctors', solicitors' and other professional fees, and also consumer items especially those bought from 'posh' retailers, were often impressively quoted in guineas and half guineas right up to the changeover to decimal currency on February 15th 1971).

INCHES and INCH FRACTIONS into CENTIMETRES and METRES

⅛in.	0.318cm.	9in.	22.86cm.	26in.	66.04cm.	43in.	1.092m.
¼in.	0.635cm.	10in.	25.40cm.	27in.	68.58cm.	44in.	1.118m.
⅓in.	0.847cm.	11in.	27.94cm.	28in.	71.12cm.	45in.	1.143m.
⅜in.	0.953cm.	12in.	30.48cm.	29in.	73.66cm.	46in.	1.168m.
½in.	1.270cm.	13in.	33.02cm.	30in.	76.20cm.	47in.	1.194m.
⅝in.	1.588cm.	14in.	35.56cm.	31in.	78.74cm.	48in.	1.219m.
⅔in.	1.693cm.	15in.	38.10cm.	32in.	81.28cm.	49in.	1.245m.
¾in.	1.905cm.	16in.	40.64cm.	33in.	83.82cm.	50in.	1.270m.
⅞in.	2.223cm.	17in.	43.18cm.	34in.	86.36cm.	51in.	1.295m.
1in.	2.540cm.	18in.	45.72cm.	35in.	88.90cm.	52in.	1.321m.
2in.	5.080cm.	19in.	48.26cm.	36in.	91.44cm.	53in.	1.346m.
3in.	7.620cm.	20in.	50.80cm.	37in.	93.98cm.	54in.	1.372m.
4in.	10.16cm.	21in.	53.34cm.	38in.	96.52cm.	55in.	1.397m.
5in.	12.70cm.	22in.	55.88cm.	39in.	99.06cm.	56in.	1.422m.
6in.	15.24cm.	23in.	58.42cm.	40in.	1.016m.	57in.	1.488m.
7in.	17.78cm.	24in.	60.96cm.	41in.	1.041m.	58in.	1.473m.
8in.	20.32cm.	25in.	63.50cm.	42in.	1.067m.	59in.	1.499m.

POUNDS, SHILLINGS and PENCE & GUINEAS into POUNDS and DECIMAL PENCE

1d.	½p.	1s.	5p.	12s.	60p.	½gn.	52½p.	11gns.	£11.55p.
2d.	1p.	2s.	10p.	13s.	65p.	1gn.	£1.05p.	12gns.	£12.60p.
3d.	1p.	3s.	15p.	14s.	70p.	2gns.	£2.10p.	13gns.	£13.65p.
4d.	1½p.	4s.	20p.	15s.	75p.	3gns.	£3.15p.	14gns.	£14.70p.
5d.	2p.	5s.	25p.	16s.	80p.	4gns.	£4.20p.	15gns.	£15.75p.
6d.	2½p.	6s.	30p.	17s.	85p.	5gns.	£5.25p.	16gns.	£16.80p.
7d.	3p.	7s.	35p.	18s.	90p.	6gns.	£6.30p.	17gns.	£17.85p.
8d.	3½p.	8s.	40p.	19s.	95p.	7gns.	£7.35p.	18gns.	£18.90p.
9d.	4p.	9s.	45p.	£1	£1	8gns.	£8.40p.	19gns.	£19.95p.
10d.	4p.	10s.	50p.	£1.1s.	£1.05p.	9gns.	£9.45p.	20gns.	£21.00p.
11d.	4½p.	11s.	55p.	£1.2s.	£1.10p.	10gns.	£10.50p.	21gns.	£22.05p.

Introduction To The First Edition

Radio has been a part of home entertainment for well over 60 years. For most people in Britain in the pioneering broadcasting days of the 1920s, their first experience of a 'wireless set' came after the introduction of official broadcasting in 1922, when the British Broadcasting Company opened its first transmitting station in London. Although the wireless rapidly found its way into the homes of people all around the country, the technical development of transmitting and receiving equipment had not suddenly occurred overnight. The behind-the-scenes evolution of radio was a long and gradual process which started in the laboratories of Victorian scientists experimenting with electricity and magnetism, and developed through the research of both amateurs and professionals investigating *wire-less* systems of communication. These used at first telegraphy and later telephony, and until after the First World War were employed mainly for maritime, military and other official purposes - all long before radio was conceived around the early 1920s as a broadcast entertainment for the general public.

At the end of 1922, there were just four B.B.C. stations on the air transmitting within the medium-wave 'Broadcast Band', these being in London, Birmingham, Manchester and Newcastle. There were comparatively few 'listeners-in'; some 35,000 people had taken out a receiving licence, and these mainly lived within the immediate local area served by each transmitter. Most people listened-in on headphones to a simple crystal set, but for the better off there were battery operated multi-valve sets which could drive a horn loud-speaker. Within a few years, more stations were opened serving individual towns and cities and by the end of 1924 there were 21 stations and getting on for a million licence holders. In 1925, a high power long-wave station opened at Daventry in Northamptonshire marking the experimental beginning of the Regional Scheme which, serving whole regions rather than just single towns and cities as before, was to bring the B.B.C.'s programmes to practically the whole country. By the early 1930s broadcasting had become a national institution with the introduction of the National and Regional Programmes, and the wireless, now powered from the mains, had become an indispensable part of family life and the centrepiece of home entertainment.

Programme details and transmitter wavelength information of B.B.C. stations appeared in *The Radio Times*. At first in the 1920s, stations were known by their own particular call-signs, most famous of which was the B.B.C.'s first station in London, 2LO. Dials were calibrated in degrees only which meant that listeners-in had to make a note on a separate card of their own particular tuning dial settings for each station they wanted to hear; for example, 2LO on 361 metres might be 120 degrees and 5IT (Birmingham) on 420 metres might be 165 degrees and so on. Station names did not appear printed on the dial until the early 1930s and this made tuning-in very much easier and enabled listeners to select at will a whole galaxy of stations, not just in this country, but also from Europe by merely pointing the cursor at the station required. Foreign station listening was tremendously popular with British listeners throughout the 1930s and many stations became household words during this period. Could you say where some of those stations were? - stations such as Hilversum, Konigswusterhausen, Motala, Huizen, Kosice and Sottens.

The number of European broadcasting stations grew tremendously during the 1930s, but in Britain by 1936 the number of B.B.C. stations had fallen to 15. The Home Service arrived in 1939 sweeping away the National and Regional Programmes just before the outbreak of the Second World War, and was joined in the immediate post-war years by the Light and the Third Programmes which all lasted until 1967 when a 'trendier' sounding Radio 1, 2, 3, and 4 network took over.

By this time, valve receivers had been superseded by the transistor, and the television service, started in 1936, suspended in 1939 and re-introduced in 1946, gradually in post-war years established the television as the centrepiece of home entertainment and displaced the radio.

For those without an atlas, here are the locations of the foreign broadcasting stations referred to: Hilversum (Holland), Konigswusterhausen (Germany), Motala (Sweden), Huizen (Holland), Kosice (Czechoslavakia) and Sottens (Switzerland).

Jonathan Hill. London W3 9AH. April 1986.

KEY TO ABBREVIATIONS USED IN CAPTIONS

3-v	3-valve receiver etc.
+R	Plus valve rectifier
+MetR	Plus metal rectifier
+Bar	Plus Barretter
+West	Plus Westector
6-Tr	6-transistor receiver etc.
HF	High frequency stage
DET	Detector stage
LF	Low frequency stage
AC	Alternating current mains powered
DC	Direct current mains powered
AC/DC	Alternating or direct current mains powered
M/Batt	Mains and battery powered
Batt	Battery powered
SHet	Superheterodyne receiver
TRF	Tuned radio frequency ('straight') receiver
SW	Short waveband
2SW	2 short wavebands etc.
MW	Medium waveband
LW	Long waveband
VHF	Very high frequency band
AM	Amplitude modulation
FM	Frequency modulation
0-100 deg	Tuning calibrated in 0 to 100 degree markings
Mtrs	Tuning calibrated in metres
Kcs	Tuning calibrated in kilocycles
Mcs	Tuning calibrated in megacycles
StN	Tuning showing station names
300/500m	Wave-range 300 to 500 metres etc.
A.T.I.	Aerial Tuning Inductance
LT	Low tension battery
HT	High tension battery

Early Developments In Communication

The sending of messages over long distances by pre-arranged signals has been practised since ancient times. For centuries, fire and smoke and other primitive devices were in widespread use in various parts of the world, and in Britain right up to the late 18th century, at a time when signalling by flags was considered a sophisticated method of communication, it was still common to light beacons on high ground in order to give signals and warnings. But then these simple and basic methods of communication rapidly began to be supplemented at first by mechanical and later in the mid to late 19th century by quite advanced wired electrical devices such as the telegraph and the telephone. However, it was only in the last few years of the 19th century that the beginnings of an efficient *wireless* communications system began to emerge, an offshoot of which ultimately led to the development of radio broadcasting in the 1920s. (The term 'radio' as applied to a form of communication, was first suggested by J. Munro in an article entitled "RADIO-TELEGRAPHY" which appeared in *The Electrician* in 1898).

One of the earliest mechanical signalling devices used in Britain was the semaphore telegraph which was first established in 1774 between London, Portsmouth and Newmarket. In 1826 another semaphore telegraph was erected on hills between Liverpool and Holyhead and comprised a 70 mile chain of eleven signalling stations placed about 7 miles apart. A signal could be sent from one end to the other and back again in just over twenty three seconds. Various other forms of semaphore were soon being developed in Europe and Russia but they all suffered from the serious limitation of being rendered useless in fog, mists, storms and of course at night.

In the late 18th century, unsuccessful attempts at producing electrical machines for signalling were also made but it was not until the development in the 1790s of a continuous source of electric current (the Voltaic cell) and Oersted's discovery in 1819 that a magnetised needle was deflected by an electric current flowing through a wire placed near the needle, that the possibilities of developing a successful electrical signalling system were realised. Oersted's discovery laid the foundation of the wired telegraph and soon several scientists including Schilling and von Steinheil were endeavouring to perfect a communications system in which the movement of a magnetised needle could be used to indicate transmitted messages.

In England in 1837, the British physicist Charles Wheatstone in association with William Fothergill Cooke, took out a patent "for improvements in giving signals and sounding alarms in distant places by means of electric currents transmitted through metallic circuits". Wheatstone's system used a five-needle telegraph. By changing the direction of the current, five pivoted needles could be made to move, two at a time, either to the left or to the right and point towards a letter of the alphabet marked on the dial of the instrument. It was first fully adopted in 1839 by the Great Western Railway when it was used to connect the stations at Paddington and West Drayton.

In America, in the year that Wheatstone's needle telegraph was patented in England, Samuel Morse with his partner Alfred Vail produced an experimental system of electric telegraphy which used an automatic printer to record incoming messages on a continuous roll of paper tape. To enable this to have a more practical use he invented a code, the Morse Code, tapped out by a Morse key. The received Morse symbols (dots and dashes) were at first embossed on the tape by a steel needle, but in a later development ink was used to print them and the printer became known as the Morse Inker. Alternatively in place of the inker or in conjunction with it, a Morse Sounder was used which was either a bell producing a ring or an instrument producing a click every time a dot or a dash was received. Morse also invented the relay which reinforced feeble signals at the receiving end by means of a current produced by a local battery. Although the results of his system were satisfactory, it was not until 1842 that Morse won support from the American Government and established the usefulness of his invention. Congress advanced money for the setting up of a telegraph system between Baltimore and Washington and a year later the service began.

In 1843, the Wheatstone needle telegraph from Paddington to West Drayton was extended to Slough and opened to the public for the first time, becoming the world's first commercial electrical communications system. For one shilling, the public could enter the telegraph offices at the termini and view this new wonder of science, and for a further shilling they could even send a telegram.

From the start, the British railway telegraph was intertwined with the public telegraph system and soon several rival telegraph companies and telegraph lines had been established. By 1868, 16,000 miles of line had been erected in Britain and the wires had already become a familiar sight, strung up on telegraph poles running alongside the railway or beside roads. At first, the charges made for sending telegrams were thought excessive, and the inconvenient situation and opening times of many telegraph offices made the public a little hesitant to use the system. However in 1870, the Post Office took over the whole telegraph network under the Telegraph Acts of 1868 and 1869 and at once began a great scheme of reorganisation by amalgamating the rival companies into one uniform and fair system. The Post Office completely disentangled the railway telegraphs from the ordinary public telegraph system and set about the immediate construction of 6,000 miles of new telegraph lines. Lines were laid to Post Offices in outlying suburbs and business hours extended, and by the turn of the century the telegraph system had been even extended to remote villages.

For several years following its adoption in 1839, the Wheatstone needle telegraph was widely used in Britain, with the number of needles soon being reduced to two and then to one and used in conjunction with a code of needle movements. In this form it was still being employed as a railway telegraph a hundred years later. However, within the Post Office and in most other fields, the Morse Code, tapped out by the Morse key or later by high-speed automatic machines or supplemented with teleprinters which had their own codes, became the universal language of telegraphic communication.

COMMUNICATION BY CONDUCTION

Other systems of telegraphic communication were being experimented with during the 19th century and these included three methods which did not use wires to connect the transmitting and receiving points. In 1843, Samuel Morse successfully transmitted across the Susquehanna River using the river itself as the conductor rather than wires, and similar wireless experiments sending signals through water by conduction were later made by several other investigators including J.B. Lindsay who used the river Tay at Dundee in Scotland. Lindsay's work subsequently came to the attention of William H. Preece and sparked off a great interest in the subject of communication without wires. In 1870, Preece was appointed Divisional Engineer to the General Post Office and later (in 1892) became Engineer-in-Chief, and in that capacity he ultimately sponsored the young Guglielmo Marconi when he came to England with an improved system of wireless telegraphy (see 1896).

Having begun a wired telegraph on land, it was inevitable that experimenters were drawn towards laying lines to places overseas. In 1851, the first successful undersea telegraph cable was laid across the English Channel and from its inauguration on November 13th it continued in public service for the next twenty four years. Links were also made between the Isle of Wight and Hampshire, England and Holland, and Scotland and Ireland, and soon, short-distance undersea cables were being laid in many other parts of the world.

The success of these short-distance cables inspired thoughts of linking the American and European Continents, although the bulk of scientific and commercial opinion was at first very much against such a scheme: laying some 2,000 miles of continuous cable seemed far too big an undertaking and fraught with potential disasters. However, after a short-lived triumph in 1858, (the cable parted within a few months), success came in 1866 when more permanent sub-marine links were establised with the laying of a cable between Ireland and Newfoundland. Over the next few years undersea telegraph cables were being laid all around the globe and they revolutionised the transmission of public, private and commercial communications between the continents and soon the phrase "sending a cable" had become part of the English language.

In 1882, the undersea telegraph cable linking the Isle of Wight with the mainland broke down, and Preece, who had some first hand knowledge of telegraphing through water, stepped forward to help. A 6 ft. square plate of copper was immersed in the sea at the end of Ryde Pier and from there an overground wire passed westwards through Newport ending in a second copper plate in the sea at Sconce Point. On the mainland shore at Hurst Castle, another wire led from a third immersed copper plate and ran through Portsmouth and Southampton terminating in a fourth copper plate in the sea off Southsea Pier, thus completing the circuit. Using a Morse key and the power from thirty Leclanche cells, two-way Morse Code communication was sucessfully established between Southampton and Newport with Preece using both a sounder and a telephone earpiece to hear the signals.

Normally, Morse signals at the receiving end would have been recorded by an inker or heard on a sounder only, but as in the Isle of Wight experiment, telephone earpieces were now beginning to be used as well. In 1876, Alexander Graham Bell had sent the first practical message on his newly invented telephone and by the end of the decade, public telephone services had been introduced in both America and Europe. In 1879, the first British telephone exchange (with lines to just a handful of 'subscribers') was opened in London at 36 Coleman Street by the Telephone Company Limited (Bell Patents), and this was quickly followed by further installations at Leadenhall Street and Palace Chambers. In the same year a rival company, the Edison Telephone Company of London, Limited (Edison Patents), was formed and opened exchanges at Lombard Street and Queen Victoria Street, and soon other companies were operating exchanges in various parts of the country. In 1889, the principal rival exchanges in Britain were amalgamated into one company under the title of the National Telephone Company which then provided a service to about 24,000 subscribers, and having a control of the telephone patents, gradually acquired most of the telephone services in Britain. By 1890, with many trunk lines already laid between cities and large towns, it was possible to speak from London to the Midlands and the North of England. In 1896, in a move to secure public control, the Post Office purchased these lines, leaving local exchanges mainly in the hands of the National Telephone Company. On January 1st 1912, the Post Office took over the whole of the National Telephone Company's service, bringing under State control virtually the whole of Britain's local and trunk telephone system, which then comprised some 1,565 exchanges and over 560,000 subscribers. The effects of this unified system were quickly apparent, for in the three years up to the outbreak of the First World War, the Post Office opened no less than 450 exchanges in small villages and rural areas.

WIRELESS BY ELECTRO-MAGNETIC INDUCTION

In 1831, the British chemist, physicist and electrical pioneer Michael Faraday made a discovery which was to become one of the fundamental principles of electrical, and later, radio engineering: the electro-magnetic induction effect between two entirely separate circuits. Many years later in 1880, Professor John Trowbridge of Boston, Massachusetts, first suggested that one of the principles of Faraday's discovery might be used for a form of wireless communication between ships at sea. He experimented with using a large coil of multi-stranded wire stretched from the yard arms and connected to a powerful battery or dynamo in one ship, and a similar coil connected to a telephone earpiece on the receiving ship. He achieved some measure of success, finding during experiments that signals were strongest when the two coils were parallel to each other. But the problems of this system were too great to be overcome for the further apart the ships were, the larger the radius of the coil needed to be, and in order to produce an audible signal in the telephone earpiece of a ship even half a mile away, coils with a radius of about 800 ft. would have been required.

Preece was also interested in the work being done by Trowbridge on wireless communication by induction, and from about 1885 carried out various experiments in different parts of Britain. He used the inductive properties of two circuits parallel to each other and determined how far apart the parallel wires in each circuit could be separated before the inductive influence ceased. Preece achieved quite a measure of success, but only over comparatively short distances of a few miles. Like Trowbridge's, for practical purposes his system too was limited, for although wireless communication was established between the two circuits, the length of the actual wire that went to make up each circuit could be quite considerable. Very long wires laid parallel to each other were needed at the transmitting and receiving stations and in order to increase the distance over which signals were transmitted, it was necessary to increase proportionally the length of the parallel wires opposing each other. As the wires had to be approximately as long as the distance between them, development of the system as a means of long-distance communication reached an unpractical dead-end. Preece however had gained familiarity and knowledge of the problems of conductive and inductive wireless communication through his experiments and this enabled him at once to recognise the potential worth of Marconi's system when he saw it for the first time in 1896.

Faraday's principle of electro-magnetic induction did lead to more positive and practical inventions though, including the dynamo and the transformer. But it was of more use to early radio science when in 1851 the induction coil was developed by the Parisian instrument maker H.D. Ruhmkorff. Towards the turn of the century the induction coil evolved into a standard piece of equipment used in wireless telegraphy to produce a spark across the spark gap of a transmitter and thus radiate electro-magnetic waves (radio-waves).

WIRELESS BY ELECTRO-MAGNETIC RADIATION

The theory of the existence of electro-magnetic waves was first worked out mathematically by the Cambridge physicist, James

Clerk Maxwell in 1864, but they were not demonstrated experimentally until 1879 when David Edward Hughes discovered the essential features of wireless communication during a series of experiments in which he became the first person in history to transmit and receive radio-waves in a communications system using electro-magnetic *radiation*, rather than electro-magnetic conduction or induction.

Hughes was a Professor of Music but he was also very keen on telegraphy and science, and had several inventions to his credit including an efficient printing telegraph and the carbon microphone. While working in his laboratory in Great Portland Street, London, Hughes noticed that his microphone was picking up sounds from a faulty circuit in his induction balance (fig. 1) while being completely unconnected to it by wires.

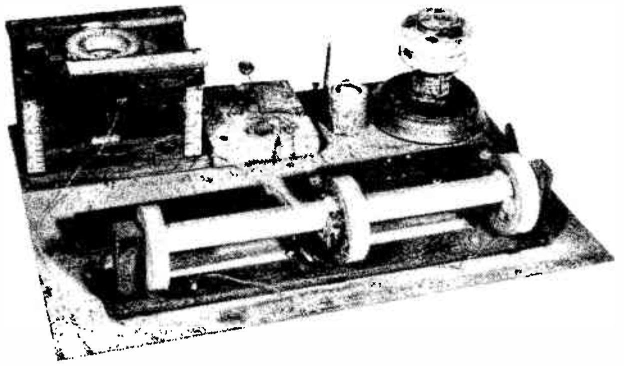


fig. 1 . Hughes' Induction Balance. 1879. Crudely made from deal, card, cork, brass wire and matchsticks. 4¾ in. x 15 in. x 11 in.

To investigate further, he made a simple automatic spark transmitter consisting of a battery, an induction coil and a clockwork contact breaker to interrupt the current passing through the coil and so send out signals in short bursts (fig. 2). Although he thought he was transmitting "aerial electric waves" which he believed travelled through the air by conduction, Hughes had in fact successfully produced radio-waves. With his transmitter running, he was able to take his receiver (consisting of a battery, a telephone earpiece and his microphone: a steel needle lightly touching a small piece of coke which acted as a detector, fig. 3) down Great Portland Street and receive good signals up to a distance of about 60 yards, after which they began to fade until at about 500 yards they disappeared altogether.

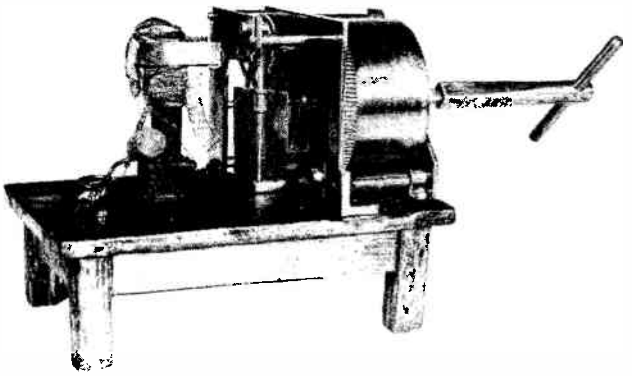


fig. 2 . Hughes' Clockwork Contact Breaker (or 'Interrupter'). 1879. Deal base with brass clock parts. 4½ in. x 6 in. x 3½ in. Part of Hughes' automatic spark transmitter.

Unfortunately, he did not proceed to carry out a full scientific investigation and without visual proof, his claims were not accepted by his scientific colleagues as being any more than well known electro-magnetic induction effects, the principle Michael Faraday had demonstrated in the early 1830s.

fig. 3 . Hughes' Microphone. 1879. Glass jar, with turned boxwood lid, housing a steel needle in contact with a small piece of coke. 4 in. high x 2½ in. dia. This acted as a crude detector of electro-magnetic waves and together with a battery and a telephone earpiece, formed part of Hughes' 'receiver'. It was used to receive experimental signals sent out from his automatic spark transmitter which comprised a clockwork contact breaker, an induction coil and a battery.

Discouraged, Hughes did not publish the results of his experiments for several years and the unique opportunity of developing a practical wireless communication system earlier was missed.

It was left to a German scientist, Heinrich Hertz, to give the scientific community the visual proof they needed. In 1887, Hertz successfully verified Maxwell's theory by generating, transmitting and detecting electro-magnetic waves (or Hertzian Waves as they soon became known to 19th century science) in his laboratory at the Technical High School, Karlsruhe, Germany where he was Professor of Experimental Physics.

Hertz's transmitter, or 'oscillator', consisted of a high voltage induction coil which was used to build up a charge across a spark gap, each side of which was connected to a large metal plate. When the charge had built up sufficiently, a spark jumped the gap and energy in the form of very high frequency electro-magnetic waves was radiated into space from the metal plates which formed in effect, a dipole aerial.

On the other side of Hertz's laboratory was his receiver, or 'resonator', which comprised a large hoop of thick metal wire broken by a small adjustable spark gap. Every time the oscillator produced a spark, a corresponding spark would instantly appear across the spark gap of the resonator, even though both instruments were completely unconnected by wires.

In a series of experiments, Hertz measured the length and velocity of the waves and he was able to demonstrate their susceptibility to reflection (by bouncing them off a large metal plate placed at the far end of his laboratory) and refraction (he bent them out of a straight course by passing them through a wedge of pitch), showing that they behaved in accordance with light waves.

Hertz published the results of his experiments and they were soon being repeated by scientists in other parts of the world, including Oliver Lodge in England and Professor Augusto Righi of Bologna University in Italy, and it was as a student of Righi's in 1894 that the young Guglielmo Marconi first became interested in the new science surrounding electro-magnetic waves.

In 1889, the English physicist Oliver Lodge began to employ a spark gap as a detector of weak electrical discharges. Lodge had originally employed a spark gap in his experiments with lightning and had observed that the spherical knobs used in standard lightning protectors often became fused together by the current discharged between them. On further investigation he discovered that even an extremely feeble spark was sufficient to produce the effect, providing that the spheres were almost touching. The adhesion of the two spheres was demonstrated by an electric bell and a battery in series with them: every time a spark occurred, the spheres joined and the bell rang and immediately broke the contact with its vibrations, therefore restoring the gap to its original condition. Unknown to him, Lodge had discovered a principle that was later to be applied to one of the basic components used in the apparatus of wireless communication when this new technology emerged towards the end of the 1890s: the filings coherer. (The word 'coherer' at least, was Lodge's invention).

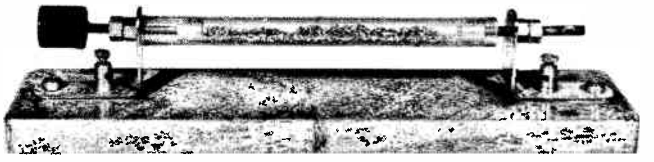


fig. 4 . Branly-Lodge Coherer. 1894. One of Lodge's 'filings' coherers based on those by Branly of 1890. Glass tube, brass fittings, deal base. 2 in. x 7 ½ in. x 4 in.

The filings coherer was invented in 1890 by Professor Edouard Branly, not during the course of investigations into methods of communication, but into the influence of electro-magnetic discharges on various forms of imperfect contacts. Although Branly was unaware of it at the time, his coherer was the first practical device for detecting the presence of radio-waves and in this capacity was used by Lodge when he gave the first public demonstration of wireless transmission and reception in 1894. Branly's coherer consisted of a horizontal glass tube containing metallic filings loosely packed between two metal plugs. At each end of the tube a wire was placed in contact with the plugs and this completed a circuit through which an electric current could be passed. In their normally loose condition, Branly found that the filings allowed the passage of only a small current, but as soon as electric sparks were generated in a nearby Hertzian oscillator, the filings suddenly became much more conductive, and allowed a much greater current to pass through them. A mechanical shock in the form of a slight tap on the glass tube re-set the filings back to their original poor conductive condition. Later, electro-mechanical tappers were developed for this purpose. Branly had re-discovered what David Hughes had observed in 1879: that a loose contact in an electric circuit was sensitive to electro-magnetic waves. Hughes' microphone had one loose contact (a steel needle resting lightly on a piece of coke) while Branly's metal filings formed a number of loose contacts in its electrical circuit.

By June 1894, Oliver Lodge had been working on electro-magnetic waves for over four years and had reached the conclusion that they could be used in a form of wireless communication. In that month he gave the world's first public demonstration of wireless transmission and reception at the Royal Institution in London. Using his spherical oscillator as the transmitter (fig. 5), he radiated electro-magnetic waves of about 18 cms over a distance of up to 150 yards. In his receiver, Lodge had replaced Hertz's thick wire ring with two metal plates (a dipole aerial) and the small spark gap with a filings coherer based on Branly's (fig. 4). The filings coherer was more sensitive than the spark gap and it could detect weaker signals at much greater distances. During his demonstrations he also employed a 'Spiral Wire Coherer' which he had developed in 1890 (fig. 6).

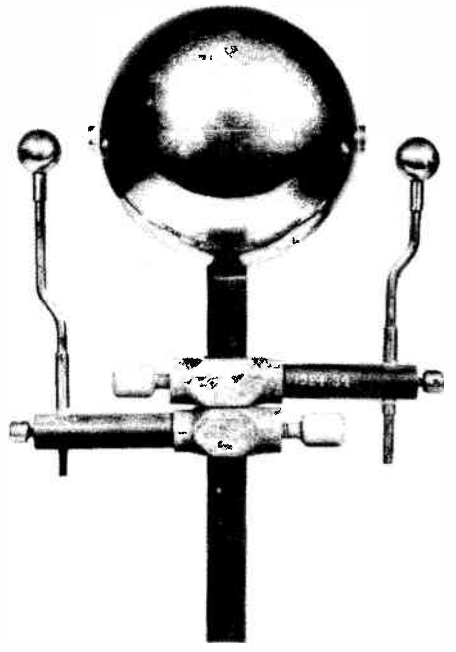


fig. 5 . Lodge's 'Spherical Oscillator'. 1894. Part of one of the transmitters used by Oliver Lodge when he gave the world's first public demonstration of wireless transmission and reception in June 1894 in front of an audience at the Royal Institution. Ebonite support rods, wood cleats, miniature brass spheres, large nickel sphere. 6 in. diameter.

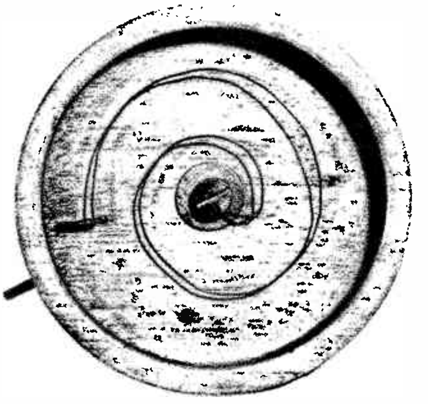


fig. 6 . The underside of Lodge's 'Spiral Wire Coherer' which was used in his Royal Institution lecture in June 1894 as a detector of wireless signals. Made by Lodge's assistant, E.E. Robinson in c.1890. Turned mahogany base. 3 in. diameter.

MARCONI'S EARLY EXPERIMENTS

Lodge's transmitting and receiving system was similar to the ones soon to be used by other wireless pioneers, including Marconi in Italy who, in 1894, was beginning to make his own independent experiments with Hertzian waves at his family's country retreat, the Villa Grifone at Pontecchio, near Bologna.

Marconi was just 20. He was keen on physics, chemistry and above all, on electricity, although he had had very little formal education and had failed to gain a place at Bologna University. However, he was allowed to attend lectures given there by Professor Righi who was a neighbour and friend of the Marconi family. Since reading about the experiments of Hertz, Righi had been working on the relationship between the behaviour of very high frequency electro-magnetic waves and light. He was one of the few scientists who had a thorough grasp of Hertz's work in this field and was able therefore to give Marconi a practical understanding of how to generate, radiate and detect electro-magnetic waves. Marconi also had access to Righi's laboratory and apparatus, and to his library where Marconi read about Hertz's work in detail both in contemporary articles and in Righi's own memorial paper to Hertz, who had died in January 1894.

Marconi though was interested in using Hertzian waves for wireless telegraphy and in the attic at the Villa Grifone he began to put together apparatus borrowed from Righi's laboratory. To generate sparks, Marconi used an induction coil whose secondary winding was coupled to a double spark gap of Righi's own design and this was to form the basis of Marconi's early transmitters. The spark gap used four spheres, with the two larger central ones immersed in oil coupling the discharge to them from the two smaller outer spheres and producing a train of sparks of high intensity and regularity. The primary winding was connected to a battery and a Morse key, and the transmitted signals were picked up by a coherer-type receiver. Marconi had read about Branly's coherer and no doubt about its use in Lodge's pioneering demonstration of wireless transmission in June 1894. Although it was more efficient than a spark gap detector, Marconi still found it relatively insensitive and unpredictable in response. So he set about improving it and achieved greater sensitivity by reducing the distance between the two metal plugs, using filings sieved to a uniform size, and heating the glass tube just before sealing it to create a partial vacuum. (Branly's coherer operated under atmospheric pressure). A mechanical tapper was used to re-set the filings.

By the summer of 1895, Marconi had succeeded in transmitting signals a matter of only a few yards. Until then he had been using horizontal dipole aerials but soon he began experimenting with an elevated aerial and a buried earth at both the transmitting and receiving ends (fig. 7). By August, using this improved system, he was able to extend significantly the range of his transmitter and at once he came to realise the commercial possibilities of using electro-magnetic waves for long-distance wireless communication.

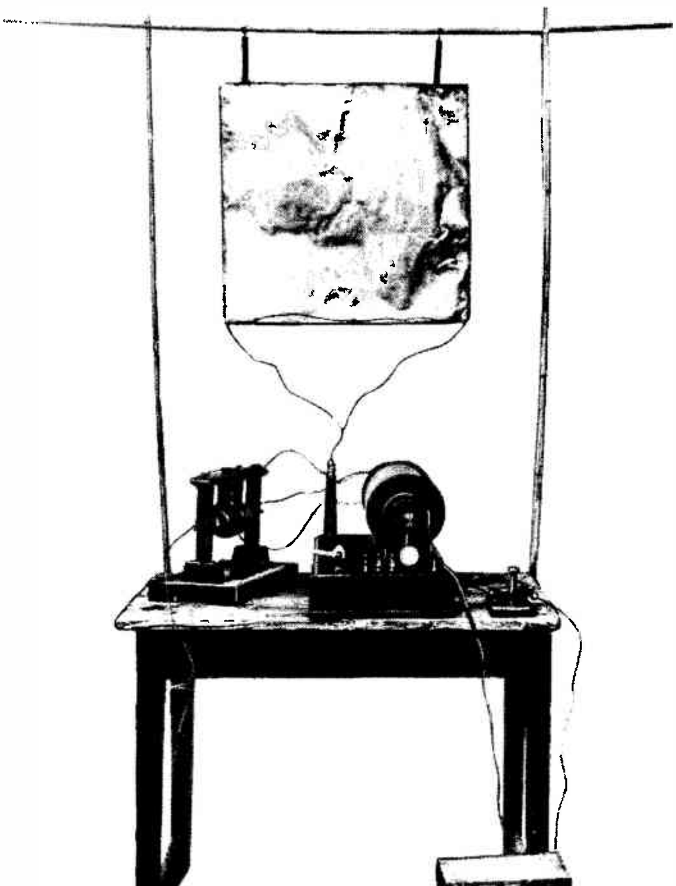


fig. 7 . Model of Marconi's experimental transmitter used in Bologna during the summer of 1895, showing the spark gap, induction coil and an elevated copper sheet aerial supported by a bamboo frame.

EXPERIMENTS BY OTHER SCIENTISTS

From around the mid-1890s, many other scientists began experimenting with the transmission and reception of electro-magnetic waves. In 1895, the English scientist, Ernest Rutherford, detected signals from a Hertzian oscillator sent over a distance of just under a mile to his Cavendish Laboratory in Cambridge. He used a sensitive magnetometer (an instrument for measuring magnetic field strength) which changed its deflection when a pulse of electro-magnetic energy arrived at the receiving aerial and this idea was later modified by Marconi in 1902 when he designed his Magnetic Detector (see 1902).

In Russia, the physicist Admiral Popoff transmitted over a distance of 5 miles from a Hertzian oscillator set up at Petrograd (Leningrad) using a modified version of Branly's coherer. The incoming signals triggered off a relay which in turn caused a hammer to strike both a bell and the coherer, re-setting its filings and stopping the flow of current. The relay worked with a current supplied from its own local battery and enabled the hammer to strike with the same force irrespective of how strong the transmitted signals were. Popoff later used a Morse inker in place of the bell to obtain a permanent visual record of the signals received and the system he employed (a coherer, a relay and either a Morse inker or sounder) was within a short time to become the standard approach to receiver design.

Wireless Telegraphy & Telephony, And The Years Leading Up To Broadcasting, 1896 - 1921

1896

By 1896, Marconi had further improved his equipment and now believed that he had devised a sound, workable system of wireless telegraphy. It was in Marconi's mind to use this specifically for marine communication and having failed to interest the Italian Ministry of Posts & Telegraphs, he sailed for Britain, which at that time was still the world's leading naval power and boasted the world's largest merchant marine. It was also the hub of international trade, finance, insurance and marine intelligence. One other reason for choosing Britain was that he had strong, and probably more importantly, well-off family connections here.

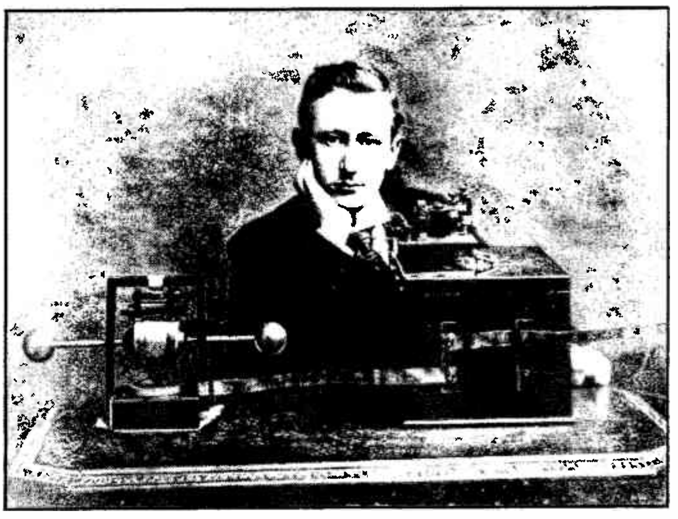


fig. 8 . The young Guglielmo Marconi photographed in London shortly after his arrival in February 1896. In front of him on the desk is the wireless apparatus he brought over from Italy. A Righi oscillator (part of the transmitter) is on the left, while on the right, a Morse sounder sits on top of a wooden box which contained a self-tapping coherer and a relay, making up the receiver. On the front of the box are two copper strips which acted as the receiving aerial.

Accompanying him on his voyage was Marconi's Irish-born mother, Annie, who had been a great support to him during his initial experiments in Italy and who was now determined to see him succeed. Annie was the grand-daughter of John Jameson who had emigrated from Scotland and had founded the Jameson Irish Whiskey distillery in Bow Street, Dublin in 1780. She was also related to the Haig and Ballantyne whisky families of Scotland. Annie had married against family wishes in 1864 and had settled with her silk merchant husband, Giuseppe Marconi, in Bologna, the place where they had first met when as a young girl she had been sent to Italy to study singing. In the intervening years, she had made the occasional conciliatory visit to Britain, and Marconi, at the age of about five, is thought to have come with her on one of these visits and even attended school in Rugby for a short time.

It was against this background that Marconi set foot in England in February 1896. From the moment of his arrival, he was helped and guided by his mother's cousin, H. Jameson Davis who found accommodation for him in Hereford Road, Bayswater. The wireless equipment Marconi had brought over from Italy had been damaged during examination by British Customs officers, and over the next few months he was able to repair, set up and adjust it and prepare the provisional specification of a patent for "improvements in transmitting electrical impulses and signals and in apparatus therefor" which he filed on June 2nd 1896. Although he has often been credited with "inventing wireless", Marconi, who was then just 22, did not in fact invent any new device. He simply adapted and improved the discoveries of many other men like Hertz, Lodge, Branly, and Righi, set them free from the laboratory and combined them into the first practical and commercial system of wireless communication.

A good example of the way Marconi worked is demonstrated by what he did with Branly's coherer. Although Lodge was the first to use the coherer as a detector in wireless reception, he did not feel that he had made an invention and did not therefore apply for a patent. Branly too had not patented it, for he did not realise its worth. Marconi on the other hand improved the coherer and was later able to get the basic patents for its use in wireless, ably demonstrating his ability as an opportunist rather than as an inventor. By improving on important discoveries rather than doing fundamental laboratory work, Marconi was able to succeed in gaining possession of many principal wireless patents and thereby raise the companies he formed to a dominant position which far exceeded any of his competitors.

Answering the question, "Who invented wireless?", Judge William Townsend of the United States Circuit Court gave this answer in May 1905 during an action brought by Marconi's Wireless Telegraph Company of America against the De Forest Wireless Telegraph Company. "Other inventors, venturing forth on the sea of electrical movement, met the rising tide of the Hertzian waves and allowed them to roll by without appreciating that this new current was destined to carry onward the freight and traffic of world commerce. They noted the manifestations, suspected their possibilities, disclosed their characteristics, and hesitated, fearing the breakers ahead, imagining barriers of impracticable channels and shifting sand bars. Marconi, daring to hoist his sail and explore the unknown current, first disclosed the new highway."

Soon after Marconi's arrival in England, H. Jameson Davis arranged a meeting with the well-known electrical engineer, A.A. Campbell Swinton, who gave Marconi a letter of introduction to William H. Preece, the Engineer-in-Chief of the General Post Office. Preece himself was a keen experimenter in many branches of electricity, and having heard about the young Marconi was naturally very anxious to see an early demonstration of his system. This, Marconi gave in July. His spark transmitter was set up on the roof of the General Post Office in St. Martin's le Grand in London, and in front of Preece and several officials, he succeeded in sending an unofficial telegram a distance of just over half a mile to his wireless receiver on the Embankment. The Post Office, and especially Preece, were impressed, and it was primarily due to Preece's interest and encouragement that for nearly a year during the critical early stages of the development of Marconi's system, the Post Office worked closely with Marconi and willingly supported his experiments out of public funds, Preece putting his own private laboratory at Marconi's disposal as well as some of his staff.

On September 2nd, Marconi demonstrated his apparatus on Salisbury Plain to Post Office officials and representatives of the Army and Navy and this time achieved an improved range of just under 2 miles using directional parabolic metal reflectors at both the transmitting and receiving ends, with the apparatus earthed to ground. The directional properties of the parabolic reflector meant that messages could be beamed directly to the receiver which allowed some form of secrecy: something the Military were very interested in. His transmitter, sending out waves of about 2 metres in length, comprised a Righi double spark gap oscillator, an induction coil and a battery, with a Morse key inserted into the primary of the induction coil. For his receiver he used a Branly-type coherer, an electric bell and a relay in a similar arrangement to that used by Popoff. The use of directional aerials and parabolic reflectors had first become very familiar to Marconi in Righi's laboratory at Bologna when they were originally being used in Hertzian wave experiments. Although Marconi soon abandoned the idea of directional aerials and short-waves in favour of large, high elevated aerials and longer waves, he was to return to the idea on later occasions.

At the end of September, Preece introduced Marconi and his wireless system to the scientific community in a lecture to the British Association entitled "Telegraphy Without Wires", and on December 12th, Preece repeated his lecture to the general public for the first time, at Toynbee Hall in London, and gave a practical demonstration with Marconi acting as his assistant.

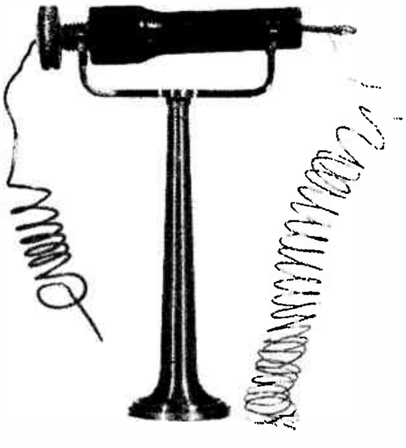


fig. 9 . Jackson's Coherer. c.1895. Used by Capt. Henry Jackson during his wireless telegraphy experiments of 1895/6. Brass mounting and fittings, ebonite tube. 3 in. high.

Meanwhile, other experimenters were also having some measure of success. For several months from December 1895, Captain Henry Jackson had been conducting a series of experiments into wireless telegraphy on board H.M.S. *Defiance*, the Naval Torpedo Training School at Devonport, using a coherer of his own design (fig. 9). In the spring of 1896, he successfully transmitted and received Morse Code messages, and this reinforced his original idea, first put forward in 1891, that electro-magnetic waves should be used for Naval communication. (In 1899, wireless telegraphy was first introduced into the British Navy, largely through the efforts of Jackson but using Marconi's system).

In Germany during 1896, Dr Slaby, a professor at the Technical High School of Charlottenburg in Berlin, was experimenting with electro-magnetic waves as a means of communication but had only succeeded in transmitting over a distance of about 100 yards. It was not until he came over to England in the following year to witness and actually take part in experiments using Marconi's apparatus that he was able to improve his own system. In the early 1900s, the Telefunken Company, using Slaby's patents together with those of Arco and Braun in a high-quality wireless telegraphy system, became one of Marconi's major competitors.

1897

In the early days of wireless telegraphy, spark transmitters and receivers were untuned. Waves were sent out from transmitters at no defined frequency and receivers themselves responded to a wide range of frequencies and were incapable of being selectively tuned to the required station to the exclusion of all others. Two or more spark transmitters in the same vicinity would therefore cause mutual interference. With the foreseeable growth in the number of wireless transmitters, one major problem to be solved therefore was how to make a transmitter radiate a wave of definite frequency and how to make the receiver respond selectively only to that particular frequency.

Much pioneering work was done on this subject by Oliver Lodge who discovered that by adding an inductance coil to an aerial, selectivity was greatly increased. On May 10th, Lodge took out a patent for a method of tuning entitled "IMPROVEMENTS IN SYNTONIZED TELEGRAPHY". His patent was for a complete system of wireless telegraphy specifically designed to transmit at a particular frequency and as such described the very first tuned circuit (see 1900).

In the same month, Marconi conducted experiments across the Bristol Channel assisted by Post Office engineer George S. Kemp. For these experiments, Marconi made a new multiple spark gap consisting of four brass balls, each about 2 in. diameter spaced about ¼ in. apart in an ebonite frame. The results achieved were very much better than with his original Righi spark gap oscillator and he later improved his induction coil by winding it with thicker wire "in order to get a thicker and heavier spark". On May 11th signals were transmitted a distance of over 3 miles from Lavernock Point, South Wales to a receiver set up on the Island of Flat Holm in the Bristol Channel, using aerials consisting of metal cylinders supported on masts. A week later, on May 18th, Marconi was able to send signals right across the Bristol Channel from Lavernock Point to Brean Down in Somerset, some 10 miles away. This time he used high flying kites covered with tin foil as the transmitting and receiving aerials. These were the first in a series of wireless experiments that Marconi carried out over water, and he later wrote, "It was soon obvious that signalling by wireless could be more easily carried out across stretches of water than over land. As it is precisely in those circumstances that ordinary telegraphic communication was least adequate, the sea was clearly the natural field for the development of wireless telegraphy." Marconi's aim therefore was to provide wireless telegraphic communication for ships at sea. Preece, too, sympathised with this, and in June announced to an audience at the Royal Institution that enough had been done to prove the value of Marconi's system and to show that for shipping and lighthouse purposes it would be a "great and valuable acquisition".

On July 2nd, the full patent for Marconi's system of wireless telegraphy was granted and in the same month he returned to Italy and gave several successful demonstrations of his wireless telegraphy apparatus to the Italian Government and to the Navy. While he was away, the Wireless Telegraph & Signal Company, Limited was formed on July 20th. Earlier in April, H. Jameson Davis had begun to make behind the scenes moves to persuade Marconi that instead of working towards a contract with the British Post Office, a private company should be set up using capital from the Jameson and Davis families to develop the commercial possibilities of Marconi's wireless telegraphy system and to work towards establishing regular wireless telegraphic services both nationally and internationally.

As soon as this proposal had been put to him, Marconi had quite properly confided in Preece who had acted immediately in a belated attempt at securing the rights to Marconi's system on behalf of the British Government. However, while Preece's recommendation of a £10,000 offer was still under discussion by the Treasury, the Wireless Telegraph & Signal Company was incorporated. Its offices were at 28 Mark Lane, in the City of London and H. Jameson Davis, representing the interests of the family, became its first Managing Director. Marconi transferred all except the Italian rights to the new company, and in exchange received £15,000 plus £60,000 in paid-up shares and a three-year contract worth £1,500 employing him as an engineer. The remaining £40,000 in ordinary shares was subscribed mostly by the Jameson and Davis families.

Since it had been Preece who had freely offered Marconi Post Office facilities and staff, and had given him every support and encouragement during his first 12 months in this country, a feeling of resentment over the fact that they had not acquired the rights to his system lingered between the Post Office and the Wireless Telegraph & Signal Company: Preece had been so convinced of the commercial possibilities of Marconi's system, that he had already lent Marconi one of his most trusted assistants (George Kemp), but even following the setting up of the new company, Kemp and Marconi continued to work closely together until Kemp's death in 1933.

Marconi's new financial independence from the British Post Office came at just the right moment, for on August 6th, Preece was obliged to write to Marconi and inform him that the Post Office was no longer able to support his experiments out of public funds. However, although they had been outmanoeuvred by the Wireless Telegraph & Signal Company, the Post Office's discontent was not directed personally at Marconi, who for a time continued to work with them. Having returned to England, Marconi conducted further experiments on Salisbury Plain during September and October, and using a high single wire aerial supported in turn by a balloon and a kite, he was able to transmit messages to a receiving station taken by a Post Office official to Bath, 34 miles away.

On November 1st 1897, the Wireless Telegraph & Signal Company set up their first British wireless telegraphy transmitting station in the grounds of the Royal Needles Hotel, Alum Bay, Isle of Wight and experiments were conducted between here and a chartered wireless-equipped steam tug cruising in the neighbourhood of Bournemouth, Boscombe, Poole Bay and Swanage. Readable signals were received at a distance of as much as 16 miles in all weathers, and were recorded on a Morse inker: Marconi expressing delight, in a letter to Preece dated December 26th 1897, that he was "able to prove repeatedly beyond a doubt that the thickest fog does not in the slightest way diminish the distance to which signals can be transmitted".

1898

During 1898, interest in Marconi's wireless system was greater than ever, and requests for demonstrations came from every quarter. In May, a short-distance experiment was set up at the request of Members of Parliament and this was carried out across the Thames between the House of Commons and St. Thomas' Hospital on the opposite bank.

On June 3rd, the first official paid wireless telegram was sent by Lord Kelvin who had come to view the Marconi transmitting station on the Isle of Wight. The telegram was transmitted by wireless telegraphy to a newly erected wireless station at Madeira House, Bournemouth, some 15 miles away. From here the message was then sent by conventional wired postal telegraph to the Physical Laboratory at Glasgow University. Lord Kelvin had insisted on paying a one shilling royalty as he wished to show his appreciation of the system and to illustrate its commercial possibilities. (Telegrams sent by wireless were subsequently called 'Marconigrams', and were known by this term until well into the 1920s). Towards the end of the year, the wireless station at Bournemouth was removed to the Haven Hotel, Poole Harbour where it was maintained as an experimental station until 1926.

In July 1898, the Company received a request from the *Dublin Daily Express* to report the Kingstown Regatta held in Dublin Bay. A shore receiving station was erected in the grounds of the Harbour Master's house in Kingstown and a steamer, the *Flying Huntress*, was chartered and equipped with a spark transmitter. While the regatta was in progress, reports in Morse Code were transmitted from the steamer and the messages were received at the Harbour Master's house. From here they were telephoned to Dublin 6 miles away and were published in the editions of the evening newspaper.

Having been informed by some of her Cabinet Ministers of the House of Commons demonstration, Queen Victoria now showed great interest in Marconi's wireless system. At her request, a station was erected at Ladywood Cottage in the grounds of Osborne House, near Cowes on the Isle of Wight (where she had arrived for Cowes week) so that she might communicate with her son, the Prince of Wales, who was on board his wireless-equipped yacht, *Osborne*. During the sixteen days that the system was in use, over 500 messages were passed between the Queen and the Prince, and other members of the Royal family, who were all reported as being "exceedingly pleased with the demonstration". The *Osborne* also made contact with the Royal Needles Hotel station, which was some 8 miles away at the time.

In August, at the request of Lloyd's, the maritime insurance and intelligence association, an experimental wireless station was erected at Rathlin Island lighthouse and another on the opposite mainland at Ballycastle, Co. Antrim, so that Lloyd's could report shipping in that area. A few years later in September 1901, when wireless telegraphy (mostly using Marconi's system) was beginning to be widely used for maritime communication, Lloyd's awarded a large contract for the permanent installation of Marconi's wireless apparatus at their signalling stations around the coast of Britain and abroad, to report passing ships and to facilitate commercial telegraphic traffic to and from ships (see 1901). Lloyd's had until then conducted ship to shore signalling by means of a series of flags hoisted according to international code: a primitive method that had been in use for centuries.

THE FIRST 'WIRELESS AMATEURS'

In the late autumn of 1898, a young 17-year-old wireless enthusiast named Claude Willcox set up his own experimental wireless station in the garden of his parents home in Warminster (fig. 10). In doing so, Willcox became one of the very first 'wireless amateurs' and was one of a small section of the British public who pursued scientific hobbies during their leisure hours and who were now keenly following the achievements of Marconi and other wireless pioneers like Oliver Lodge, whose activities were regularly reported in the Press. In the summer, it had been announced that Lodge had invented a form of telephonic relay which was designed to operate a telephone earpiece. Weak signals were fed through the relay's coil which was caused to move in a magnet's field and thereby amplify the signal. This actually anticipated the moving-coil loudspeaker eventually developed in the early 1920s.

Detailed accounts of scientific experiments often appeared in such publications as *The Electrical Review*, *The English Mechanic & World of Science* and *The Times* and the excitement generated by reading about these experiments prompted many ordinary people to take up wireless as a hobby and to try and repeat some of the experiments in their workshops at home. Willcox was one of the few who were lucky enough to be able to afford commercially manufactured scientific apparatus but for most, such equipment was a luxury and they had to be content with constructing apparatus from improvised 'bits and pieces'.

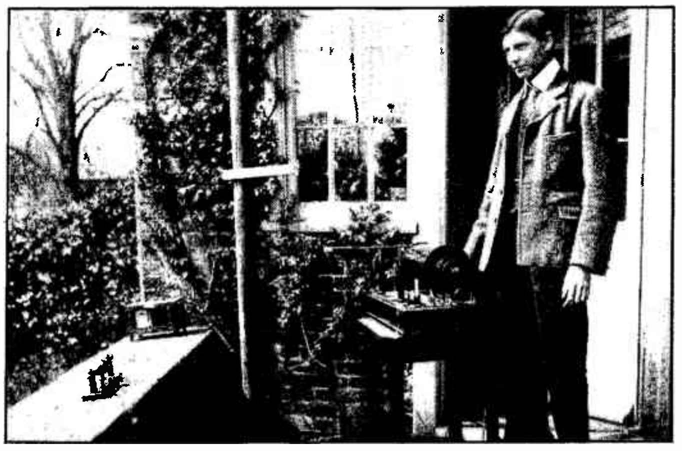


fig. 10 . Claude Willcox, pictured here with his transmitter in 1899, was one of Britain's first 'wireless amateurs' and set up an experimental spark transmitting station in 1898 at the home of his parents in Warminster, Wiltshire. Over the years, his station grew to impressive proportions, and in 1913 was featured on the cover of Gamage's first *Directory of Experimental Wireless Stations* (fig. 21). By then, he had become Director of the Warminster Motor Company, which later during the First World War manufactured wireless apparatus for the Army under the name of the British Telegraph Instrument Company. By the end of 1922, Willcox had progressed to telephony, and operated his own amateur broadcasting station, call-sign 2FL, transmitting talks and musical items in the late evening as soon as the B.B.C. had closed down for the night.

1899

During a gale in January, the East Goodwin lightship was badly damaged by heavy seas. By chance only a few weeks before, both she and the South Foreland lighthouse near the port of Dover some 12 miles away had been equipped with experimental Marconi wireless apparatus by arrangement with Trinity House, and as a result, a report about the damage was able to be quickly sent. On March 3rd, during the early hours of the morning, the lightship was again in difficulties when in dense fog she was rammed by the London steamship *R.F. Matthews*. By being able to transmit an immediate distress call to the receiving station at the South Foreland lighthouse, the first sea rescue through wireless took place and all hands were promptly saved. The incident made world-wide news and gave Marconi's system a great boost.

On March 27th, the English Channel was for the first time spanned by wireless telegraphy when communication was maintained between the British Association meeting at Dover Town Hall via a land line to the South Foreland wireless station, and the French Association meeting at Boulogne via a land line to a wireless station at Wimeraux. At this time, Marconi was directing his attention towards increasing the range of communication and the spanning of the Channel by wireless aroused even more Press attention than the East Goodwin rescue, and filled newspaper columns with descriptions, comments and wild prophecies. By increasing the height of the aerial it was possible to send messages over far greater distances, but since there was a practical limitation to the height of masts on both land and sea, improving sensitivity of receivers was another avenue receiving attention.

In July, Marconi's system of wireless telegraphy was used for the first time by the British Navy when H.M.S. *Alexandria*, *Europa* and *Juno* were fitted with apparatus during manoeuvres. The Admiralty were so impressed with the experiment that a year later, in July 1900, they awarded a contract to Marconi for equipping 26 Navy ships and 6 land stations and their maintenance for a period of 14 years (the life of Marconi's British Patents).

In October, the War Office officially adopted Marconi equipment, and on November 2nd, following the outbreak of the Boer War, five portable stations that were originally supplied by Marconi for installation on board ship, were sent out to the field in South Africa to form the first Wireless Telegraphy Section, R.E. Following their use at the reliefs of Kimberley and Ladysmith in 1900, they were subsequently transferred to the Navy.

On November 15th, the steamer *St. Paul*, bound for England from America, established communication with the Royal Needles Hotel station when over 60 miles away. On board the ship was Marconi, who had been in America superintending wireless coverage of the International Yacht Race for the *New York Herald*, and who on the homeward journey had installed his apparatus on the *St. Paul*. Several Marconigrams were received from the ship and these were telephoned to the Totland Bay Post Office for despatch by wire to various parts of Britain. Messages were then transmitted from the Royal Needles Hotel to the *St. Paul* giving news of the Boer War in South Africa and news of the sinking of the U.S. cruiser *Charleston*. These reports were assembled and printed on board in a souvenir issue newspaper called *The Transatlantic Times*, which was sold direct to passengers while they were still at sea.

During 1899, premises were acquired for the Wireless Telegraph & Signal Company in Hall Street, Chelmsford, specifically for the manufacture of Marconi's wireless apparatus. Until then, the few pieces of transmitting and receiving equipment that had been ordered had been made up as and when required using various modified apparatus bought from well-established science laboratory suppliers. These were supplemented by parts made by Marconi, Kemp and their assistants but with the forseen rapid expansion of wireless communication, it was decided to set up a large-scale wireless factory to cope with the quantity production of standardized equipment. In September, a transmitting station was installed at the Hall Street works, while at Dovercourt near Harwich a station was erected for communicating with ships at sea, bringing the total number of such shore-based installations carried out by the Wireless Telegraph & Signal Company since their first one at the Royal Needles Hotel, to around a dozen.

Developments in wireless continued to take place in other countries. In Germany, Ferdinand Braun was granted a patent for his system of wireless telegraphy which was manufactured by Siemens and Halske. During experiments, Braun successfully established communication between his spark transmitter set up on the North German coast at Cuxhaven and his receiver comprising the standard type of coherer, relay and Morse inker arrangement on the island of Heligoland nearly 40 miles away.

In Italy, the mercury-iron 'Italian Navy' coherer was first developed for wireless reception (fig. 11). It comprised a glass tube with an iron plug at one end and a carbon plug at the other, bridged by a globule of mercury. Normally a coherer had a 'latching' action in which once it had been made conductive by an incoming signal, it would remain in that condition until re-set (de-cohered) by a mechanical shock. With this coherer, the resistance of headphones in series with it was sufficient to make it 'self-restoring', with current only being conducted so long as the signal was present. Marconi was to use one of these coherers in Newfoundland when he received the first transatlantic signals from Cornwall in 1901.

In America, Marconi's Wireless Telegraph Company of America was incorporated on November 22nd for the purpose of exploiting Marconi patents in the United States. Other developments were also taking place in that country and one of the most important of these was the introduction of the Continuous Wave High Frequency Alternator by Nikola Tesla. Continuous waves (C.W.) were a sequence of electro-magnetic waves of uniform amplitude produced without interruption or variation. From the earliest days of wireless, the need for a source of continuous oscillations was recognised by several pioneer wireless experimenters, for the spark method of oscillation sent out damped waves in bursts with breaks during each burst where no waves were being sent out and this had serious limitations. Continuous waves had the following advantages over spark oscillations.

(1) they were well adapted to high speed transmission by automatic machinery, and C.W. transmitters were capable of very much greater ranges,

(2) sharper tuning was possible. Spark oscillations spread out their energy over a wide band of frequencies whereas a C.W. transmitter sent out a very narrow band of frequencies lending itself to sharp tuning. A well designed transmitter would cause minimum interference to other operators using the same waveband,

(3) they were to be absolutely essential for the quality transmission of wireless telephony when it developed later.

Tesla's alternator produced a frequency of 30,000 cycles per second and although at this stage of development it was only capable of sending C.W. over a distance of about 20 miles, it did mark the beginning of the successful development of C.W. transmission which ultimately led to the age of wireless telephony and broadcasting.

fig. 11 . 'Italian Navy' Coherer. c.1899. A 'self-restoring' mercury-iron coherer, originally devised by P. Castelli, a signalman in the Italian Navy. The illustration shows the original one used by Marconi during his transatlantic wireless telegraphy tests of 1901. Ebonite base, brass fittings, glass tube containing an iron plug and a carbon plug bridged by a globule of mercury. Base, 1¼ in. x 3¼ in. 2 in.

1900

On April 25th, the Marconi International Marine Communication Company, Limited, was formed to develop the Marconi system for ship to ship, and ship to shore two-way wireless telegraphy communication, not only in this country but also throughout the world. Wireless installations built in the future by this company were to remain Marconi property and the equipment was to be operated by Marconi personnel. Ship owners requiring Marconi's wireless telegraphy facilities would therefore lease a system that used standardized apparatus and operating methods.

To train personnel, the world's first wireless technical school was set up during the following year at Frinton-on-Sea, Essex to supplement students' engineering knowledge with the theory and working principles of Marconi's system. Except in the case of a distress call, Marconi operators were under strict instructions not to accept any messages from wireless stations not equipped with Marconi apparatus, and this essentially created a private, closed system.

In 1900, the parent Wireless Telegraph & Signal Company was re-named Marconi's Wireless Telegraph Company, Limited, and in October, work began on the erection of a new high-power transmitting station at Poldhu in Cornwall for long-distance communication with ships at sea. The station at first used a circular 210 feet high aerial supported by twenty masts, but this was later wrecked by a severe gale in September 1901. It was hurriedly replaced by a fan-shaped aerial array, supported by two masts, and this in turn was replaced in 1903 by an aerial supported by four timber towers.

Since Oliver Lodge had filed his tuning patent in 1897, Marconi had himself been experimenting with making Lodge's method more practical. On April 26th, Marconi filed his own patent (No.7777) for an improved method of tuning which made receivers much more sensitive and much more selective than ever before. The 'four sevens' patent became one of the most famous in wireless history for with it, Marconi was able to bring a series of successful suits against most of his early rivals and further reinforce his dominant patent position in the world of commercial wireless communication. Among the improvements detailed in the patent specification was the addition of what we recognise as a tuning dial, and his new tuning circuit not only enabled messages to be received at far greater distances, but also enabled a number of wireless transmissions to be carried on without interference being caused between them. Marconi paid no royalties to Oliver Lodge for manufacturing equipment which, although based upon the four sevens patent, ultimately derived from Lodge's 1897 patent for syntonized telegraphy and much bitterness grew up between the two men which was not resolved until 1911 (see 1911).

Marconi applied for patents on practically everything he did, and by the mid-1900s his companies had won world-wide prestige and were in a dominant patent position with the Marconi name on three fundamental wireless patents: on improved types of vertical aerials, on the Magnetic Detector and on methods of selective tuning.

In America, Reginald A. Fessenden, a Canadian-born Professor of Electrical Engineering working for the U.S. Weather Bureau, made his first experimental attempts at transmitting wireless telephony (his own voice) by a spark transmitter over a distance of 1 mile on Cobb Island. Although the experiments were crude and scarcely capable of development, Fessenden persevered with the basic idea and within a few years, this time using a high frequency alternator, he was able to transmit wireless telephony over a distance of several miles (see 1906).

In England, while experimenting with an electric arc lamp at the Central Technical College on London, the scientist W. Duddell found that it could be made to produce a steady musical note by connecting its two carbons to a condenser and a coil of wire. He went on to discover that by altering the size of the condenser and the coil, the note of his 'singing arc' could also be altered. This musical note was caused by an oscillation set up in the circuit containing the arc, condenser and coil, but the frequency he produced was far too low to be of practical use in wireless transmission, and it was left to Valdemar Poulsen a few years later to discover a way of raising the frequency, so that it could be used for C.W. transmission (see 1903).

1901

During 1901, Marconi coastal transmitting stations each equipped with Marconi apparatus throughout, were opened at Caistor, Crookhaven, Holyhead, Lizard, Malin Head, Niton, North Foreland, Port Stewart and Rosslare for communication with ships at sea. On May 21st, the first permanent installation of wireless telegraphy equipment in a British ocean-going merchant vessel was made on board the S.S. *Lake Champlain* of the Beaver Line on the day she sailed out of Liverpool for Halifax, Canada with about 1,200 people on board. Wireless communication was established with the Marconi coastal transmitting station at Holyhead and later with Rosslare, arousing tremendous interest among the passengers and crew on board who crowded around the tiny wireless cabin from morning to night.

In September, Lloyd's signed a contract with Marconi's for the erection of permanent wireless installations around the coast of Britain and abroad. At that time, Lloyd's had a huge network of over one thousand agents in all the major seaports of the world and a great many of the minor ones whose duties were to report by cable shipping movements and arrivals. The use of wireless therefore would not only vastly improve efficiency, but would also enable direct communication with ships at sea. It was one of the conditions of the contract that Marconi equipment was to be used exclusively and that communication was not to be made with ship and shore stations using systems made by other manufacturers except in the case of a distress call. These restrictions were applied to all installations of Marconi apparatus and even though other systems were being developed by other competitors, the Marconi companies were to have a virtual monopoly in ship to ship and ship to shore traffic for several years (see 1908).

During 1901, the Lodge-Muirhead Syndicate was formed as a limited liability company to manufacture and sell wireless apparatus based on Oliver Lodge's syntonic and other wireless telegraphy patents. Since 1894, when he gave the world's first public demonstration of wireless transmission and reception, Lodge had been at work perfecting his system. At the 1894 demonstration, Lodge had met Dr. Alexander Muirhead who with his brother Henry was a partner in a well-known firm of telegraph instrument manufacturers with a factory at Elmer's End in Kent. It was largely through Alexander Muirhead's involvement that Lodge's apparatus developed into a commercial system, but unlike that of Marconi's, it never went into full-scale operation and was essentially a side-line for both parties. Lodge's system was designed for low-power operation over relatively short distances. The Syndicate provided equipment but not trained operators. Instead, printed instructions were included so that purchasers could install and operate the equipment themselves. There was no mass-production, for while Marconi installations ran into many hundreds during the Edwardian period, those by Lodge-Muirhead amounted to less than a dozen over a period of some ten years, with most of these being Government owned stations in the Far East, Burma, Africa, and the West Indies. In this country, only three installations were brought into service: at Elmer's End and Downe in Kent (experimental stations owned by the Syndicate), and at Heysham Harbour for communication between steamers owned by the Midland Railway plying between Heysham Harbour and the Isle of Man. The Syndicate was finally dissolved in 1911 (see 1911).

On September 28th 1901, R.A. Fessenden filed a patent in America for his 'heterodyne' principle of circuit design. Ahead of its time and remaining unexploited for several years, Fessenden's heterodyne circuit eventually gave rise to E.H. Armstrong's 'supersonic heterodyne' principle which was patented in 1918 and ultimately became the standard approach to receiver design throughout the world (see 1924).

In December 1901, a great surge of public interest was created by the news that while conducting experiments at the old Military Barracks, Signal Hill, St. John's, Newfoundland, Marconi had received the first wireless signals ever to be transmitted across the Atlantic Ocean. They comprised a series of S's (... ... ...) and were sent by Dr. Ambrose Fleming from the new Marconi station at Poldhu, Cornwall on receipt of a message by sub-marine cable to begin transmitting. They were heard by Marconi and his assistant Kemp about twenty-five times through a telephone earpiece (fig. 12) in conjunction with an 'Italian Navy' coherer, and were picked up by a flying aerial wire suspended 400 feet in the air from a kite. It had been decided not to use the usual recording method of a relay and a Morse inker (which would have made a permanent record of the incoming signals on paper tape) since the human ear was far more sensitive, and this led to more than a few sceptical comments. The results of the transatlantic experiments were not totally accepted by all those within the scientific community or the technical Press, some believing that they were merely due to atmospherics or to the presence of a Cunard ship fitted with Marconi apparatus and sailing within range of St. John's at the time. However, the tremendous distance involved (over 2,000 miles) was far greater than anything so far achieved and the excitement over this great event fired the imagination of many people throughout the world. The cable companies on the other hand were understandably worried that this newcomer to the world of overseas communication might soon become a serious rival to their long established monopoly and were beginning now to show some signs of nervousness and apprehension.

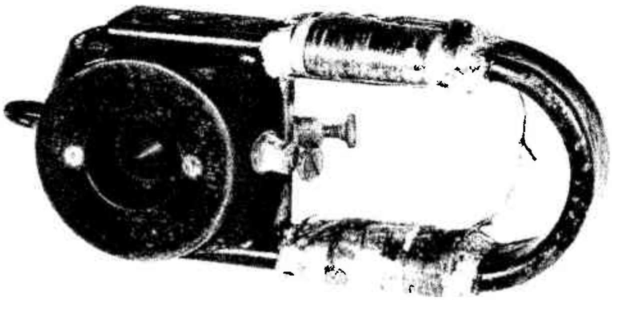


fig. 12. Telephone earpiece made by Collier-Marr Telephone & Electrical Manufacturing Co. Ltd., Manchester. 1901. It uses two diaphragms located on either side of a central ebonite-cased bobbin and placed between the two poles of a horse-shoe magnet. The one illustrated is the actual earpiece used by Marconi in conjunction with the 'Italian Navy' coherer (fig. 11) to hear the famous transatlantic wireless telegraphy tests of December 12th 1901. To improve sensitivity, the magnet has an extra winding. Overall size, 6 in. x 2 in. x 2 in.

1902

One of the most important advances in the efficiency of ship-board wireless reception took place in 1902 when Marconi patented his 'Magnetic Detector' (fig. 13), which was widely used as standard receiving equipment on board English and most European ships from 1903 to 1912: the first being installed in the Italian cruiser *Carlo Alberto*. The Magnetic Detector was found to be much more sensitive than any of the coherer type and because of its great reliability was generally preferred by wireless operators who affectionately referred to it as "Maggie". The introduction of the Magnetic Detector marked the end of the coherer era and made possible the reception of wireless messages at much greater speeds although the one disadvantage was that signals could only be heard as sounds in a telephone earpiece and could not be recorded on paper tape.

In the detector, an endless band of soft iron wire was passed around two pulleys which were driven by a clockwork motor at about 5 inches per second. The lower straight portion of the band passed through a coil of wire, one end of which was connected to the aerial and the other end connected to the earth.

Outside this coil was a second coil, the ends of which were connected to a telephone earpiece, and immediately above the two coils were two horseshoe magnets. As a portion of the soft iron wire passed under the magnets that portion became temporarily magnetised by induction and as the same portion passed away from the magnets, it lost its magnetism. When transmitted waves reached the aerial a tiny current passed through the first coil which caused the rate at which the soft iron wire lost its magnetism to alter slightly, and this in turn caused a small current to flow through the second, outer coil, and a consequent sound was heard in the earpiece.

In October, tests were carried out between Poldhu and a tuned wireless receiving station on board the American liner *Philadelphia*, en route from Southampton to New York. With the receiving aerial fixed to the main mast, readable messages were received up to a distance of 1551 miles and were recorded on paper tape by an ordinary Morse inker, and test letters were received as far as 2009 miles amply proving to all the long distance over which Poldhu was capable of transmitting.

Having been granted a subsidy of £16,000 by the Canadian Government to support his experiments, Marconi formed the Marconi Wireless Telegraph Company of Canada, Limited and commenced the construction of a long-distance high-power station at Glace Bay in Nova Scotia. In December 1902, an experimental transatlantic service began when messages were exchanged for the first time between here and Poldhu in Cornwall.

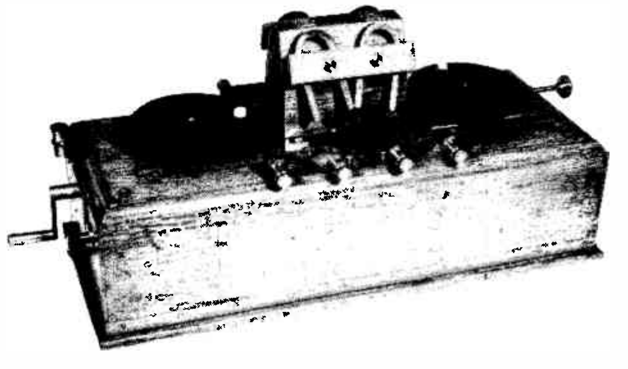


fig. 13 . 'Magnetic Detector', by Marconi's Wireless Telegraph Co.Ltd., Hall Street, Chelmsford. 1902. Solid teak case, ebonite wire reels, brass fittings and clockwork motor to drive an iron wire loop (label says "Rewind every half-hour"). 9½ in. x 19 in. x 8 in.

1903

On August 22nd, the Poldhu station began transmitting a regular Morse news service to shipping on a fixed wavelength of 2,800 metres and as experiments continued, it became possible in October to supply the Cunard steamship *Lucania* with news direct from shore during her entire crossing from New York to Liverpool. The number of shore-based wireless stations which had been erected or were in the course of erection by Marconi's and its associated companies in Britain and in countries abroad now exceeded fifty, and the Marconi system was now in regular use on board over forty merchant ships owned by ten major shipping lines. At Seaforth Sands near Liverpool, the first Marconi Service Depot was established to cope with the repair and maintenance of the Company's equipment, and in the same building a technical school room was set up to train service personnel.

A new development now took place in high frequency C.W. generation when, using the singing arc developed by Duddell in 1900 (see 1900), the Dane, Valdemar Poulsen succeeded in raising the arc's frequency so that it could be of practical use in wireless transmission. Poulson did this by placing the flame of the arc in a strong magnetic field induced by an electric current and burning the arc in hydrogen or coal gas. During the coming years, it was successfully developed as a reliable C.W. generator and was used in many high-power, long-distance wireless stations as well as in a smaller portable form by wireless amateurs. From 1906, the Poulsen Wireless Telegraphy System employed the Pedersen 'Tikker', which was a C.W. detector specially designed by Professor Pedersen for use with the arc.

1904

Realising the need for an internationally recognised distress signal, Marconi's issued a general order that from February 1st 1904, the call to be given by ships in distress, or in any way requiring assistance, was to be "C.Q.D.", made up of the old telegraphic general call "C.Q." with the additional letter 'D' for distress.

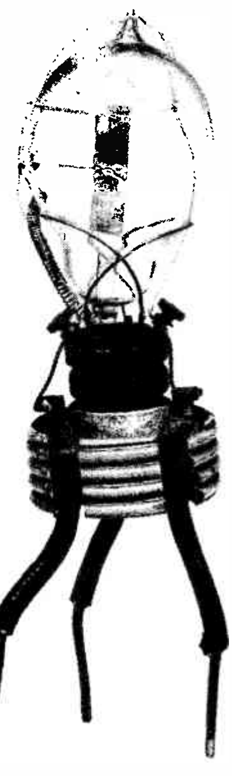


fig. 14 . 'Fleming Diode'. c.1904. An experimental 'diode', used as a detector and rectifier of wireless signals. Turned boxwood socket, brass terminals. 8¾ in. high x 2¼ in. diameter.

On August 15th, the *Wireless Telegraphy Act, 1904* became law giving the Post Master General responsibility for administering wireless telegraphy in Britain and Ireland. The establishment of any wireless telegraphy station for transmitting or receiving on land or on board any British ship was only permitted under a special licence granted by the Post Office and failure to comply with this Act could mean a term of imprisonment of up to twelve months with hard labour. Up to this time the number of wireless telegraphy stations around the British Isles (including transmitting and receiving stations run by amateur experimenters) had been growing steadily and the Government saw that legislation was needed in order to secure adequate control of all such installations. The Act was the first piece of legislation of its kind in history, and it remained in force until July 31st 1906, after which date it was extended on a year-to-year basis under the *Expiring Laws Continuance Act until replaced by the Wireless Telegraphy Act, 1924.* Although the 1904 Act made no mention of wireless *telephony* or broadcasting (neither of which at the time were even remotely developed in Britain), the powers of the Post Office to control these were later seen as an extension of the Act. (This can be traced back to a High Court judgement in the early 1880s which established that a telephone was a 'telegraph' within the meaning of the Telegraph Acts of 1863, 1868 and 1869 in which the Post Master General was given a virtual monopoly to operate all forms of telegraphic communication).

On November 16th 1904, Dr. John Ambrose Fleming, Scientific Adviser to Marconi's, filed a patent for his 'diode valve' which was the first true rectifier used for the detection of electro-magnetic waves (fig. 14). In the following year, Fleming sent five of his prototype diodes to Marconi at Poldhu for a service trial, and they were so successful that Marconi's designed and later manufactured a receiver specially for the valves which by then had been put into commercial production by the Edison Swan Electric Company (see 1910).

1905

From January 1st, Marconigrams could be accepted from members of the public at any British Post Office for transmission to ships via the Marconi coastal stations. Since Lloyd's had equipped their coastal signalling stations with wireless, those who wished to receive progress reports about the passage of any vessel merely had to contact the Secretary of Lloyd's in London.

By now, the British Navy had some 80 ships equipped with Marconi's wireless telegraphy system and these were capable of receiving transmissions from the Poldhu station as far away as their bases in Gibraltar, the Mediterranean and the Atlantic. Transmissions could also be picked up from the new high-power station at Norddeich in Germany, which in 1905 began regular wireless telegraphy transmissions and sent out a programme of news and weather reports in Morse Code.

With regard to amateurs, provision was now made for the issuing of experimental wireless licences and the Post Master General, Lord Stanley, displayed a very sympathetic attitude and gave an undertaking that no request for a licence would be refused unless the refusal had been personally approved by him. And so, applications began to be received by the Post Office, and during the year, the first official printed licences were issued. On the application form, the applicant merely had to enter details of his wireless qualifications and experience (if indeed he had any), and clearly state "the particulars of the nature and objects of the experiments which it is desired to conduct". If the applicant satisfied the Post Master General that he was a bona-fide experimenter, then the licence would be granted with "no rent or royalty charged".

While working at the Glace Bay station in Canada, Marconi had devised a horizontal inverted-L form of aerial, which was found to have marked directional properties and which was a great improvement on other types of aerial used in long-distance long-wave wireless telegraphy. He patented his idea, which was an early step in the development of the Beam System of transmission (see 1927), and, using this new type of aerial, it was decided to build a new high-power station at Derrygimla, Clifden on the West coast of Ireland to take over the transatlantic service from Poldhu (see 1907).

1906

From 1906, 'crystal detectors' using crystalline minerals began to be developed for wireless reception and the first experimental crystal receivers were produced. Some thirty-three years after he had first reported the discovery of crystal rectification during his experiments in Germany from 1873 to 1874, Professor Braun patented a psilomelan (hydrated oxide of manganese) crystal detector on February 18th 1906. In England a few days later, on February 21st, Dr. L.W. Austin patented his tellurium/silicon detector and in America in March, General H. Dunwoody of the United States Signal Corps patented a carborundum/steel detector for receiving spark transmissions. Carborundum was not a 'natural' crystal but was a compound of carbon and silicon first discovered accidentally in 1891 by an American chemist while attempting to make artificial diamonds. Dunwoody's detector used a contact comprising a disc of polished steel, and it proved to be so reliable that in America especially it was soon being widely and successfully used in many ships' wireless installations. (On this side of the Atlantic for a few more years at least, Marconi's Magnetic Detector continued to be unrivalled in maritime use, although crystal detectors were being looked at with growing interest and were soon adopted by the Military). To those wireless operators on board ship who worked with carborundum detectors, a good sensitive piece of this crystal was considered a most treasured possession and it became common practice that whenever an operator changed ships, the crystal went with him.

By June 6th 1906, sixty-eight amateur experimental licences had been granted and a list giving the details of the licence holders was prepared by the Post Master General and published on June 13th. This was the first such list ever compiled and it contained the names of several eminent men including Dr. John Ambrose Fleming, who being Scientific Adviser to Marconi's and having to his credit the world's first valve patent, could hardly be described as an "*amateur* experimenter".

The world's first successful experimental broadcast of wireless telephony took place in America in December between stations at Brant Rock and Plymouth, Massachusetts, a distance of about 11 miles. Using a high frequency alternator made by General Electric, R.A. Fessenden transmitted a programme in which he played the fiddle, sang Christmas carols and played Handel's Largo on the phonograph. Although the signals were very weak they travelled further than expected, and they were heard by several startled ships' wireless operators out in the North Atlantic who of course until then had heard nothing but Morse Code through their telephone earpieces.

1907

On January 29th, a second important development in valve technology took place when Lee de Forest filed a patent for his three electrode 'Audion triode' (fig. 15). It was a 'soft' (low vacuum) valve which was not only capable of rectification and detection, but also of amplification, although this third property was not fully exploited for a few years.

A new development also took place with crystal detectors. During the year in America, the 'Perikon detector' first appeared: the term being derived from PERfect pICK and CONtact. It was patented by Greenleaf Whittier Pickard and originally applied to a rectifying contact between a crystal of synthetic fused zincite and a brass point. Later, Pickard applied the name to designate a contact between natural zinc and copper pyrites and by the 1920s, 'perikon' generally meant a crystal detector comprising *any* two compatible crystals.

The successful use of crystal detectors in wireless reception caused a good deal of research work to be done in Edwardian England, and the quest for new rectifying combinations of crystals and contacts proceeded rapidly. Molybdenite, various pyrites, anatase, galena, hessite, cassiterite, bornite and a host of others were experimented with by scientists such as Professor Pierce, Dr. Eccles, P.R. Coursey and L.W. Austin, and many were found to be 'radio-sensitive'.

But in later years, the gradual development of the thermionic valve as a detector, rectifier and amplifier, with its ever increasing role during World War One in a 'hard' (high

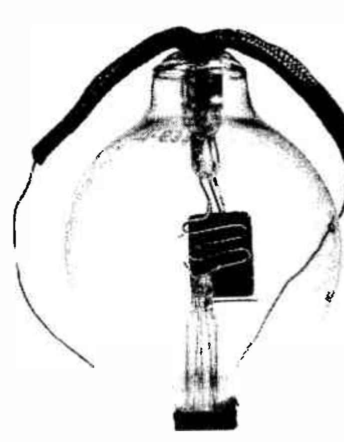


fig. 15 . De Forest 'Audion Triode'. 1907. Screw base, glass bulb. 2 in. diameter.

vacuum) form, caused a waning of the experimental interest which until then had been shown in the crystal. Although carborundum/steel and perikon detectors played an important part in Military wireless reception during the war, it was not until the advent of official broadcasting from the B.B.C. in the early 1920s that a widespread revival of interest in the crystal occurred: an interest which achieved a summit of popularity then with the mass introduction of the domestic 'crystal set' which gave tens of thousands of ordinary people their first taste of 'listening-in' (see 1922).

A new and important piece of receiving equipment was introduced by Marconi's during 1907. Patented by Charles S. Franklin, the 'Multiple Tuner' (fig. 16) was capable of tuning over the wavebands 80/150, 150/1,600, 1,600/2,000 and 2,000/2,600 metres. It was extensively used as part of the wireless receiving equipment on board ships, normally in conjunction with the Marconi Magnetic Detector. In the 'stand-by' position, operated by a switch on top of the panel, the detector was connected directly to the aerial circuit which enabled a watch to be kept over a very wide range of wavelengths.

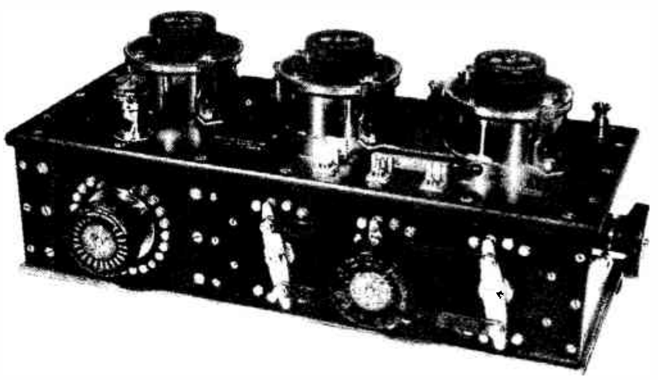


fig. 16 . 'Multiple Tuner', by Marconi's Wireless Telegraph Co. Ltd., Hall Street, Chelmsford. 1907. Patented by C.S. Franklin. The receiver has three circuits (aerial, intermediate and detector), each of which had to be tuned. Rough tuning of the circuits was obtained simultaneously by a control which linked the three stud switches in the front, and then finer individual adjustments could be made by means of the variable condensers mounted on top of the case. Polished ebonite, brass fittings, mahogany base. 5¼ in. x 19 in. x 8 in.

Following on from Fessenden's pioneering success with wireless telephony the previous year, an enthusiastic British amateur called H. Anthony Hankey used a 250 watt portable Poulsen arc transmitter during the summer of 1907 to broadcast wireless telephony for the benefit of the War Office. His transmitter was powered by a dynamo connected to a 4-cylinder petrol engine, and was set up at Aldershot with General French and his staff listening-in on a crystal receiver in the neighbourhood of Midhurst. Hankey's programme consisted of a number of songs and monologues which he personally conducted, and in a letter published in *Wireless World* on May 11th 1932, Hankey said that he believed that this was the first occasion that pure wireless telephony had been used in Britain.

On October 17th, the new high-power long-wave station at Clifden was opened for Morse Code communication with the Glace Bay station in Nova Scotia. Clifden used the improved inverted-L directional aerial, and the public could now for the first time send Marconigrams from Britain to Canada. The Clifden station was in operation until, during the Irish Civil War, on the night of Tuesday July 25th 1922, it was attacked by anti-Treaty Irregulars who caused irrepairable damage to the equipment.

1908

In 1908, the Lloyd's contract of 1901 became null and void when the *International Convention on Wireless Communication at Sea*, signed in 1907, became effective. The Convention was held largely at the insistence of the United States and Germany, both of whom had by then developed their own efficient wireless communication systems. In the United States, the United Wireless Company, using a system based on De Forest patents, operated a network of stations handling marine traffic on the Atlantic and Pacific coasts, and in Germany, the Telefunken Company, using Slaby-Arco-Braun patents, were establishing a European maritime network. Having suffered from what they saw as unfair competition from Marconi's, both these countries had called for unrestricted interchange of communication between all wireless stations regardless of the type of system installed.

During 1908, a new 5 kW spark transmitting station was completed for the British Admiralty at Horsea near Portsmouth, with the result that it now had the power to control the movement of its fleet by wireless telegraphy over a very large area of the seas. The signals were now picked up by 'cage' aerials introduced and generally adopted by the British Navy that year.

"S.O.S" was officially adopted as the international distress call, replacing "C.Q.D", although the majority of wireless operators on board British ships clung on to the old distress call until as late as 1912. (Wireless operator Phillips used both "C.Q.D." and "S.O.S." on the sinking Titanic. See 1912).

In Italy, Professor Q. Majorana transmitted speech from Rome to Sardinia and Sicily using a C.W. arc oscillator and his 'liquid microphone'. One difficulty experienced in early wireless telephony experiments was due to large currents which had to be handled by the microphones and this often caused them to overheat. Some circuits employed two microphones in which if the one in operation began to get too hot, the other cold one could be switched into the circuit. But in a few years (see 1913), the introduction of the valve oscillator brought about vast improvements since its frequency could be as high as 1,000,000 cycles per second and this could then be modulated by the output of a microphone placed in a low current part of the circuit so that it would not get hot.

1909

The controlling power of the Admiralty was further reinforced when a new 100 kW transmitting station was built at Cleethorpes, while the power of the Horsea station was increased to the same level during the year.

Experiments in wireless telephony continued. In March, a Poulsen arc transmitter at Lyngby put out an experimental wireless telephony transmission of phonograph records and speech in English, Dutch, French and German on 1,000 metres. Later, in June, the Cullercoates station in Newcastle conducted wireless telephony test transmissions with Lyngby, although according to Hankey who listened-in on a crystal receiver fitted with a perikon detector, "a bad cough appeared to be troubling the operator!"

On September 29th, Marconi's Wireless Telegraph Company entered into an agreement with the Post Office which provided for the transfer to the Post Office of all the Marconi coastal stations in Britain. The Postmaster General was granted a licence to use the Company's patents and the Company received a payment of £15,000. In December, Marconi delivered a lecture at the Royal Academy of Science in Stockholm, Sweden, and here, jointly with Professor Braun, he was awarded the Nobel Prize for Physics in recognition of his outstanding work in wireless communication.

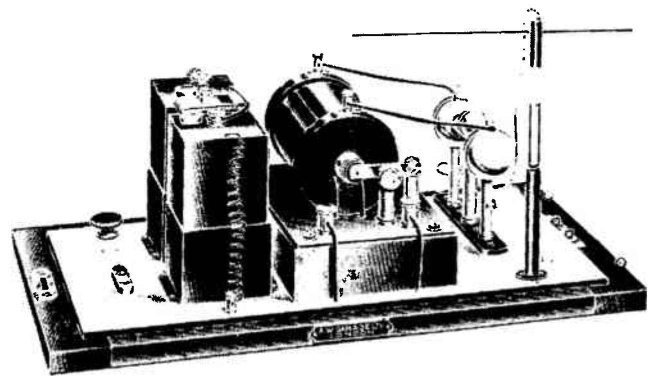
1910

One of the most spectacular cases of the use of wireless as a means of communication at sea was demonstrated with the arrest of the notorious 'Doctor' Crippen and his mistress Miss Le Neve on board the Canadian Pacific liner *Montrose*. Having recognised the pair on his ship, Captain Kendall instructed his wireless operator to contact Scotland Yard via his company's offices in Liverpool, England and from that moment until the arrest, the police and the Press were kept in constant touch with the ship by wireless, with the public eagerly following the story as it unfolded in the newspapers.

Since 1905, the number of amateur experimental wireless licence holders had been gradually increasing, and in May 1910, the Post Master General announced in the House of Commons that in company with official stations, he had now found it desirable to lay down a general rule that all experimental stations "should have a distinctive call-sign and that each station, when signalling, should begin each transmission with the call-sign of the station with which it desires to communicate and end it with its own call-sign". Notification was sent out to all those concerned in the form of a very polite letter stating the licensee's allotted call-sign, and asking the licence holder if he had any objection.

Two other events which had some significance to amateurs also occurred in 1910. In London, A.W. Gamage Ltd. of Holborn, began supplying complete wireless telegraphy outfits (fig. 17) to supplement their range of component parts which had been introduced in 1908 to enable the amateur to make up his own equipment. A.W. Gamage was one of the few concerns catering specifically for the amateur experimenter and all their wireless equipment was made for them by Ward & Goldstone Ltd. of Pendleton, Manchester. A pair of transmitters and receivers bought from Gamages were set up at a church bazaar in Bristol in the summer of 1910 by an amateur named Gilbert Tonkin (call-sign TBX). Helped by a few of his friends, he charged the public sixpence a time for the amusement of sending wireless Morse signals a distance of some 300 feet.

In France, daily wireless telegraphy transmissions of time-signals began from the Eiffel Tower Observatory (call-sign FL) making Paris the "time centre of the world", and enabling clocks and watches to be set very accurately. (On February 5th 1924, the British Broadcasting Company inaugurated the Greenwich 'dot-seconds' time signal system, later known more familiarly as 'the pips', see 1924). There were now two European wireless transmitting stations with which the wireless amateur of the Edwardian period could conduct experimental long-distance reception tests. Although the lower powered Norddeich station was more difficult to receive, it was said that the reception of Norddeich (see 1905) distinguished certain amateurs from the lesser members of the tribe who contented themselves with the comparatively powerful transmission from the Eiffel Tower.



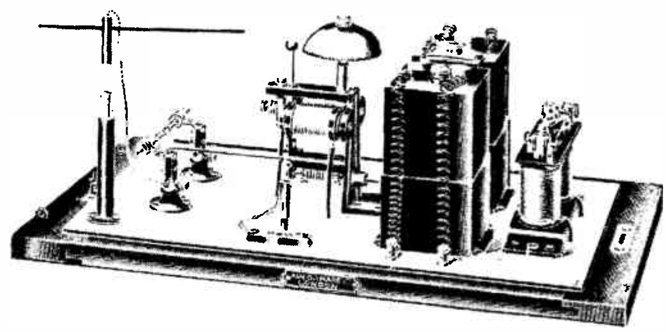


fig. 17 . The 'Atlantic' wireless telegraphy outfit manufactured by Ward & Goldstone Ltd., Pendleton, Manchester and sold by A.W. Gamage Ltd., Holborn, London EC. c.1910. The spark transmitter (top), had a range of about 250 ft. and comprised a condenser, a spark gap, a Morse key, and an 8 ft. extending aerial. The same type of aerial was fitted to the receiver which had a self-tapping coherer connected to a bell relay. Terminals were also provided for connecting a Morse printer and power was obtained from two pairs of dry cell batteries. Each unit was mounted on a mahogany base, into which was set a screw-thread which allowed the units to be conveniently supported on a standard camera tripod. Price £6.0s.0d complete with lockable mahogany covers (not shown). 18 in. x 7 in. (base).

Many amateurs were forced by financial circumstances to make up their wireless apparatus from scrap materials and to improvise with whatever came to hand. A typical amateur receiver of this period consisted of a loose-coupled tuner, and an electrolytic detector, comprising a small glass jar, a platinum spear-point sealed in a glass tube and an adjustable silver bottom plate: these being immersed in a weak solution of sulphuric acid. One owner of such a set up reported that in one spell of 'listening-in' which lasted eight hours, all he heard was one time signal from the FL station in Paris. Obviously a very keen and patient man!

A typical home-constructed transmitter of this period was operated by an amateur in Birmingham and consisted of an old motor car trembler ignition coil, a pair of brass door knobs for the spark gap, a copper helix as the tuning inductance and some old photographic plates and sheets of tin foil making up the condensers. Apparently, it worked quite well. But not all amateur wireless equipment was thrown together out of bits and pieces. Many wireless amateurs were also keen model makers, and much of their early home-made equipment was precision-made too.

At this time, wireless amateurs could read about their subject in magazines such as *The English Mechanic & World of Science*, *Model Engineer*, *Work* and occasionally in the *Boy's Own Paper*, but they had to wait until April 1911 for the first issue of a publication exclusively devoted to wireless: *The Marconigraph*. This was the house magazine of Marconi's Wireless Telegraph Company in Chelmsford, and although it contained a large amount of specialist information possibly only of interest to wireless engineers and operators, it could also be ordered, price 2d, by members of the public through most book sellers and newsagents. (It later became *Wireless World* in April 1913 and began including more items of an experimental and amateur nature and therefore catered more for general interest).

During the year, several experimental wireless telephony transmitters were made by Marconi's to the design of H.J. Round (fig. 18). They employed an arc which was burned in an atmosphere of hydrocarbon vapour, enclosed in a cylindrical arc chamber with a mica observation window set into it. One of the electrodes was kept turning by a clockwork mechanism in order to improve the steadiness of the burning, but although these transmitters were known to have been successfully demonstrated over distances of up to 100 miles, the design was never put into any quantity production.

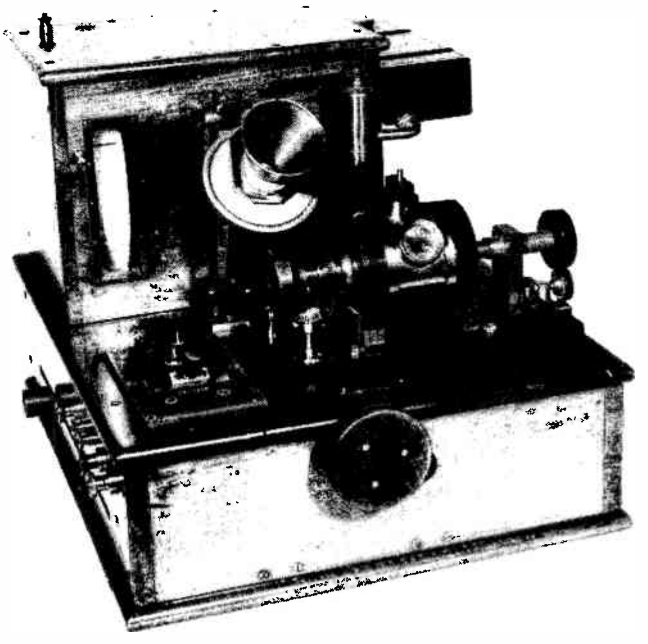


fig. 18. Wireless Telephony Arc Transmitter and Receiver, by Marconi's Wireless Telegraph Co.Ltd., Hall Street, Chelmsford. 1910. (des: Capt. H.J. Round). Mahogany case, wood and ebonite panels, brass fittings. Note rear fuel reservoir on right hand side. 14 in. x 15½ in. x 19 in.

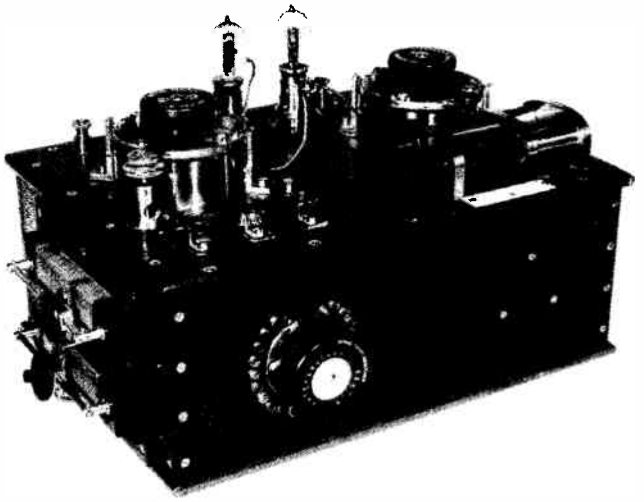


fig. 19. Marconi-Fleming Valve Receiver, by Marconi's Wireless Telegraph Co. Ltd., Hall Street, Chelmsford. c.1910. Two commercial pattern Fleming diodes, marked "Royal Ediswan Fleming Oscillation Valve. 4v", were provided with this receiver, either of which could be selected by means of a switch. Mahogany case, ebonite panel, brass fittings. 10¾ in. x 16 in. x 1¾ in.

Marconi's also produced the Marconi-Fleming Valve Receiver (fig. 19), in which two of Fleming's diode detectors were used, either one of which could be selected by means of a switch. The performance of the set depended upon the critical adjustment of two sliding resistors on the left-hand side of the set which controlled the heating of the valve's filament and the bias applied to it.

1911

During the summer of 1911, Marconi engineers at Hendon Aerodrome carried out the first regular experiments in air-to-ground wireless communication. From a 'plane circling the aerodrome piloted by Robert Loraine, Morse messages were successfully sent from a spark transmitter to a ground station erected in the Grahame-White sheds below. With petrol vapour and sparks flying in all directions this must have been a potentially hazardous situation but no fire accidents were reported. From about 1915 with the use of enclosed spark gaps and keys and later, valve transmitters, air-to-ground communication safely developed.

In October 1911, the differences between Lodge and Marconi were resolved. Lodge's patents were purchased by Marconi's for an undisclosed sum and Lodge accepted a nominal position as Scientific Adviser to the Company and a salary of £1,000 per annum for the remaining life of his syntony patents. One of the conditions of the purchase was that the Lodge-Muirhead Syndicate (hardly formidable opposition) would cease its operations and be dissolved.

1912

On April 15th, the White Star liner *Titanic* was ripped open by an iceberg just five days into her maiden voyage and over 1,500 men, women and children perished in the icy waters over the Grand Banks of the North Atlantic. Fortunately, the ship was equipped with Marconi wireless apparatus, and the Chief Wireless Telegraphist, Jack Phillips, was able to transmit a distress call using both "C.Q.D." and "S.O.S.". Principally due to this action, over 700 lives were saved and the value of wireless at sea dramatically demonstrated.

During the year, the British Government entered into an agreement with Marconi's for the erection of a chain of high-power long-wave wireless telegraphy stations around the British Empire (known as the Imperial Telegraph Service), but the First World War intervened and political wrangling further delayed the scheme until the second half of the 1920s (see 1927).

Over the years, the Marconi Works at Hall Street in Chelmsford had been slowly extended to keep pace with the development of the business. But in 1912, in order to allow for future developments, entirely new premises were designed, and within 17 weeks of the plans leaving the drawing-board, Marconi's new wireless factory opened in New Street, Chelmsford. On May 16th, the Company's administrative headquarters were moved to a new home at Marconi House in the Strand, London.

1913

A further demonstration of the life-saving value of wireless at sea was given on October 9th when the British steamship *Volturno*, fully laden with a miscellaneous cargo of oil, gin, straw, rags and chemicals and carrying over 600 emigrants from Rotterdam to New York, caught fire in mid-Atlantic. Once again, with wireless on board, help was quickly summoned and over 500 lives were saved, ten vessels having come in response to the wireless call. The *Volturno* episode prompted a famous cartoon in *Punch*, with Mr Punch saying to Marconi, "Many hearts bless you to-day, Sir. The world's debt to you grows fast." Marconi himself had said many times that the aspect of wireless which gave him, personally, the greatest gratification was its use in saving life at sea.

During 1913, some important new developments in valve technology took place. The first true 'hard' (high vacuum) triode valve (the Tungsten Wire Audion No.2) was developed by Irving Langmuir following his work on processes for creating high vacuum lightbulbs at the General Electric Research Laboratories in America. Later in World War One, because of their superior operation and efficiency as compared to the soft (low vacuum) valves which by the end of the war were practically obsolete, hard valves became the standard type.

One soft valve which did see active service during the war was designed by Captain H.J. Round of Marconi's in 1913. It was produced in two types, 'C' and 'T', and was first employed as a high frequency amplifier. Later, as an oscillator, it was used in the first practical wireless telephony transmitter for air-to-ground communication (see 1915). The grid was a long cylinder of fine mesh nickel wire surrounded by the anode cylinder, also made of nickel, while the filament was of platinum coated with a mixture of barium and calcium oxides. The coating of oxides was found to give good electron emission at low voltages: a principal first discovered by Wehnelt in 1904 and which eventually was generally adopted in both mains and battery valves towards the end of the 1920s. After continual use, the 'softness' of the Round valve diminished and so by heating the pinched neck of the glass envelope which contained a small piece of asbestos, gas was given off and the softness once again restored.

Another soft valve, developed in its final form in 1913, was the Lieben-Reisz 'Gas Relay' (fig. 20). Like the Round valve, it employed an oxide coated filament and while being intended originally to be an amplifier of speech currents, it was successfully employed as a high frequency continuous wave oscillator by Alexander Meissner of the Telefunken Company in Germany, who on April 9th 1913 took out the world's first patent for using a valve in this way. The essential idea involved the coupling together of the input and output circuits to produce 'feed-back' whereby the small amount of energy from the anode circuit that was fed back to the input circuit caused it to oscillate. Later in June 1913, Meissner employed his feed-back circuit to produce carrier waves for the transmission of wireless telephony between Berlin and Nauen. The basic feed-back principle could also be used in simple receiving circuits, however the idea here was to use feed-back in a controlled way to obtain extra gain while stopping short of the actual point of oscillation. Feed-back was widely used in domestic valve wireless receivers during the 1920s in 'reaction' or 'regenerative' circuits and these too had their origin in 1913. On June 12th, C.S. Franklin took out a patent for a reaction circuit in which he employed a tuned grid and a tuned anode circuit, and in October, E. Armstrong patented his regenerative circuit which he had first demonstrated while still a student at Columbia University in America at the end of January.

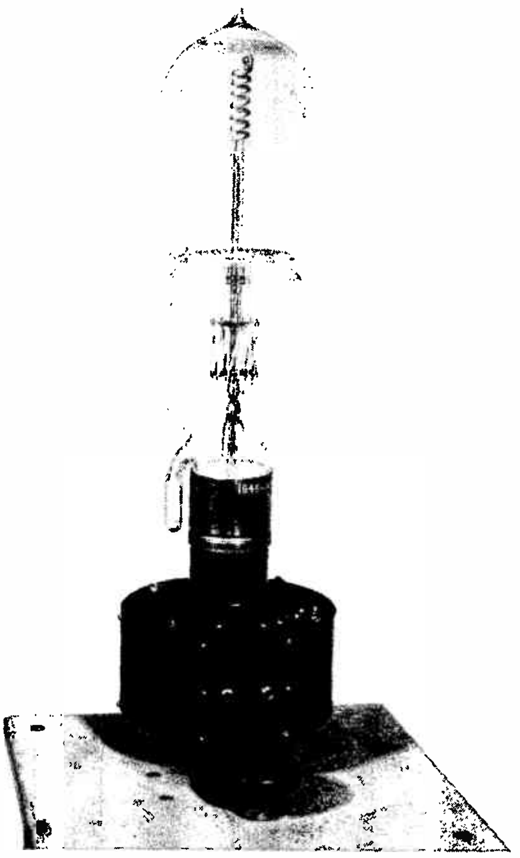


fig. 20. Lieben-Reisz 'Gas Relay' Valve, 1913. 11½ in. high x 4¾ in. dia. A small quantity of mercury amalgam was placed in the side tube, and this could be heated when necessary to produced a vapour which kept the pressure inside the valve constant.

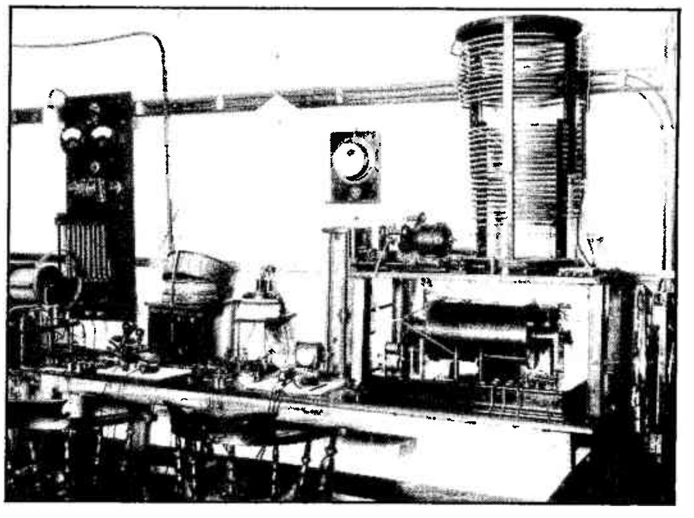


fig. 21. Claude Willcox's amateur wireless station, call-sign WUX, at 21 George Street, Warminster, Wiltshire. 1913. The transmitter used a gas quenched mercury break and a synchronised spark gap.

In the spring of 1913, a number of amateur wireless enthusiasts got together and formed the Derby Wireless Club, which was the first of many such organisations to be set up in Britain over the next ten years. Its formation reflected the growing public interest in wireless throughout the country and by now the number of experimental wireless licence holders was approaching 1,000, evidence of this being shown in A.W. Gamages' publication, *A Directory of Experimental Wireless Stations in the United Kingdom Licensed by the Postmaster General*. The directory's cover illustration showed station WUX (fig. 21). This was installed at 21 George Street, Warminster, and was operated by Claude Willcox who had been one of the very first wireless amateurs in the late 1890s (see 1898). In the directory were listed 405 transmitting stations together with their call-signs and details of the amateurs who operated them, and a description of 360 amateur receiving stations: among them was a station belonging to John Scott-Taggart (call-sign LUX) whose name was to become a household word amongst wireless-constructors during the 1920s and 1930s (see 1922 and 1932).

To the authorities, the number of licences already issued to experimenters seemed large, and concern was now shown that the situation might get out of hand if some new rules were not introduced. A new provision now laid down by the Post

Office stated that "licences to conduct experiments should only be issued to persons having the necessary qualifications". This went against Lord Stanley's original assurances a few years earlier when all the experimenter had to do was merely register, and with rumours circulating that the Post Office was drawing up rigorous legislation to clamp down on amateurs, wireless enthusiasts throughout the country began to realise the need for taking collective action. Also in May 1913, the Post Office had imposed a charge of £1.1s.0d on all new licences (whether for transmitting or for receiving), in the hope of dissuading those who were not really bona-fide experimenters from applying.

It was against this background of discontent that the London Wireless Club was formed on July 5th 1913 "to bring together all amateurs interested in wireless telegraphy and telephony". The founder members were Rene Klein, L. Francis Fogarty, A.P. Morgan and Leslie McMichael, who later went on to found his own wireless manufacturing company, L. McMichael Ltd.

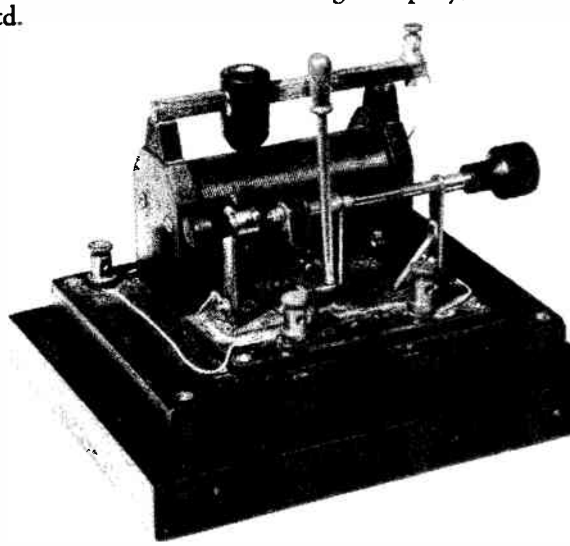


fig. 22 . Home-constructed crystal set with open cat's whisker/galena detector, tuning coil with slider, brass fittings, mahogany base. 5 in. x 6½ in. x 4¾ in. Typical of the amateur-built type of receiver of pre-war years.

The wireless world was still essentially one of sparks, of communication by Morse Code, just as it had been since the end of the 19th century. The technicalities of wireless telephony were such that it had not developed as rapidly as wireless telegraphy and few people had heard the human voice transmitted by wireless. Wireless telephony was very much in its embryo stage at this time and the London Wireless Club was one of the few bodies to have expressed any interest in it.

With its formation, the total number of wireless clubs around the country had now grown to six, and the honorary secretaries of three of them (the Derby, the Birmingham and the London) co-wrote a letter published in *The English Mechanic & World of Science* attacking the Post Office's licensing system and offering an alternative solution to the licence problem. They considered that the fee of £1.1s.0d was too much for the majority of amateurs to be able to afford, and was especially hard on those who were already carrying out extensive and costly experiments. They suggested that a fee of 5s.0d or perhaps 7s.6d would be more reasonable.

On July 25th 1913, the 3 honorary secretaries held a meeting with the Secretary of the Post Office when the question of the experimental wireless licence was discussed formally for the first time. However, little seems to have transpired from this meeting and the licence fee remained fixed at the original figure.

At its first General Meeting held at the City of Westminster School on September 23rd 1913, the London Wireless Club changed its name to the Wireless Society of London, for it was felt that the word 'club' conveyed a misleading impression. The Chairman of this first meeting was Frank Hope-Jones, the Managing Director of the Synchronome Company and designer of the Horophone crystal set (fig. 23). He was a very prominent member of the British Horological Society and had recently come into the public eye by the firm stand he took against the Post Office over another constricting piece of legislation which he described as a "preposterous proposal". This was that the Post Office was intending to levy a tax or royalty on those who desired to listen to the international service of time signals transmitted from the Eiffel Tower station. Although he was biassed to a certain extent by commercial interests, Hope-Jones did express generally held fears that following this legislation, the Post Office would take drastic steps to repress what it called the "irresponsible amateur".

By the time the Wireless Society of London held its second meeting on November 13th 1913, many prominent scientists and eminent men from the Institution of Electrical Engineers had joined its ranks and it had also been recognised by the British

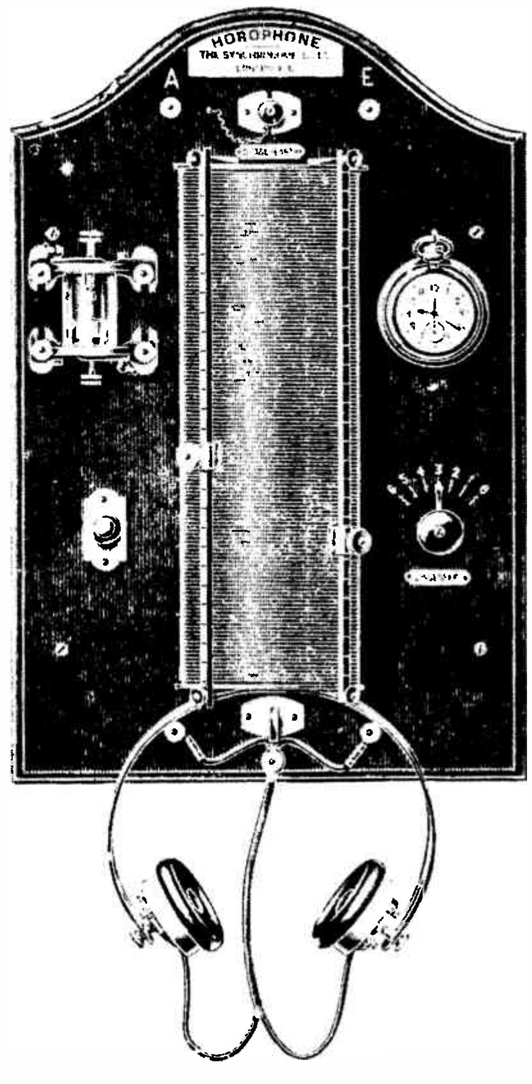


fig. 23 . The 'Horophone' crystal set manufactured by Synchronome Co. Ltd., London EC1. 1913. It was designed to receive time signals, weather reports and news in Morse Code from Paris, Norddeich and other high-power wireless telegraphy stations within a radius of about 800 miles. The receiver comprised a nickel-plated glass-enclosed cat's whisker/galena detector, a variable condenser and a double-sliding tuning coil assembled on a wall-mounted mahogany base 15 in. high.

Association. Although its main body was now swelled by professionals, the Wireless Society of London still represented the voice and opinion of the amateur wireless experimenter and during the immediate pre-war period, its activities were considered important enough to be regularly reported in nearly a dozen technical journals.

1914

As war approached, it was seen that little at this stage could be achieved with the Post Office negotiations. On August 1st, just a few days before Britain declared war on Germany, the activities of the various wireless clubs and societies around the country were curtailed when the Post Master General ordered all experimental wireless apparatus in use to be dismantled and all aerial wires taken down and removed from their masts. Amateurs were informed that they could expect visits from Post Office officials to check that this order had been carried out.

Under the terms of Regulation 22 of the *Defence of the Realm Consolidation Act, 1914*, dated November 28th, restrictions were introduced banning the manufacture, the sale, and the purchase of all wireless apparatus intended for the transmission or reception of wireless telegraphy except under special Government permit. These measures in effect put an end to most amateur wireless experiments for a long time, although, by what appears to have been an oversight by the Post Office, all amateur experimental licences remained in force throughout the duration of the war.

However, there were some amateurs who refused to abide by the Post Office's ruling and left their apparatus intact and kept their aerial wires visible for everyone to see. This had the result that the police began to receive reports from worried members of the public that there were "wireless spies" in their midst. Immediately after war had broken out, courts-martial were set up to put on trial anyone found in unauthorised possession of wireless apparatus. In one case, a keen member of the Birmingham Wireless Association was found guilty and sentenced to six months imprisonment for possessing a small portable transmitter at his home in Filey, Yorkshire. The severity of the sentence, particularly when it was made known that according to an expert Post Office witness, the transmitter was not capable of sending more than a mile, prompted many angry letters of protest to the Press. In the end, the sentence was reduced to two months, but only because the prisoner had already spent seven weeks in a cell awaiting trial.

In 1914, having been the subject of many tentative experiments and trials for a number of years, wireless telegraphy was beginning to be more widely used by the Military as a useful addition to visual and line signalling. At the beginning of the war, with the British Army on the move in France, cumbersome horse-drawn wagon and pack types of long-range wireless telegraphy sets were in use by the cavalry divisions and brigades, but with the coming of static trench warfare by the middle of October 1914 in which the opposing armies dug themselves in and were to face each other across no-man's-land for four years, the demand arose for efficient short-range equipment which would be more compact and portable and much less obtrusive. A huge network of telephone and telegraphy line communication had originally been laid down in the trenches but the enemy's barrage soon began to destroy it and wireless telegraphy (and later on in the war, wireless *telephony*) came into its own. An efficient organisation of trench wireless telegraphy grew up using 50 watt, 120 watt and 1.5 kW spark transmitters depending on the range required and it quickly became indispensable to the infantry, artillery and anti-aircraft gunners.

1915

In July 1915, more positive measures with regard to amateur wireless equipment were taken when the Post Master General announced that "in order to simplify the control of wireless apparatus and to avoid the inspection of private premises, all wireless apparatus (whether licensed or not), which is not required for public purposes shall be removed into Post Office custody for the period of the war, under the authority contained in the Defence of the Realm Act regulations".

As war progressed, the need for wireless operators, telegraphists and signallers became urgent and wireless amateurs were now called upon to fill many important posts in all three Services, joining the Wireless Sections as instructors, technicians and operators. For the thousands of men that these wireless amateurs of pre-war days trained, joining the Services during World War One gave them their first real experience of wireless, and for many that survived, this initial contact was to spark off a life-long fascination for the subject. Back in civilian life in the immediate post-war years, these men were to form the backbone of a growing body of enthusiastic wireless experimenters and, as the nucleus of the 'listening public', they gave great support and encouragement during the early and uncertain stages of British broadcasting.

THE DEVELOPMENT OF VALVES & TELEPHONY

Valves now began to be employed in Military receivers and transmitters and by 1917 they were in general use for wireless telephony communication. From a design patented on October 23rd 1915, the 'R' type high vacuum valve was first produced by the French Company, E.C. & A. Grammont of Lyon. These were designated 'TM Fotos' and the layout of their 4-pin 'B4' metal base was to become a standard design among British and European-made triodes until well into the post-war years. Because valves were vulnerable and were also the most expendable part of the circuit, they had to be easily removeable for replacement. For quite a few years following their introduction, they were usually mounted on the control panel by means of a 'socket' comprising four individual metal tubular contacts (one for each pin) protruding above, or sometimes below, the surface of the panel. From the early 1920s, one-piece moulded sockets with insulated metal contacts superseded the tubular contact type.

In the summer of 1915, the first one-way spoken message from an aeroplane to a ground station was achieved by the experimental section of the R.F.C. at the Wireless School, Brooklands, under the guidance of C.E. Prince, but at this stage in development, no attempt was made at receiving ground-to-air communication. The wireless telephony transmitter used here, (fig. 24), employed a single 'Round' valve and could also be used for Morse Code by simply moving a plug. It had been adapted by Prince (later to be given the O.B.E.) from a ground set originally demonstrated by Marconi's in 1914. The aerial was loose-coupled to the valve circuit which oscillated continuously and a microphone was used to modulate this current by varying the resistance in the aerial/earth lead. The operating wavelength was about 300 metres and using a trailing-wire aerial of about 75 feet, the set achieved an air-to-ground range of about 20 miles for wireless telephony and about 60 miles for Morse.

During World War One then, the first serious scientific experiments were conducted in Britain into wireless telephony and the success of these was due in particular to the rapid development of the valve.

From America, the Atlantic Ocean had once again been crossed by wireless, but this time it had been the human voice that had been transmitted. In October 1915, the American Telephone & Telegraph Company working with the Western Electric Company managed to send speech from the American Navy station in Arlington, Virginia across to the Eiffel Tower station, some 3,500 miles to the east. Despite only a few faint words being heard, the world's first transatlantic wireless telephony transmission was heralded as a success. But at this stage, long-distance telephony equipment was far from perfected; the transmitter used on this historic occasion employed several hundred 15 watt valves, many of which kept burning out and had to be hurriedly replaced.

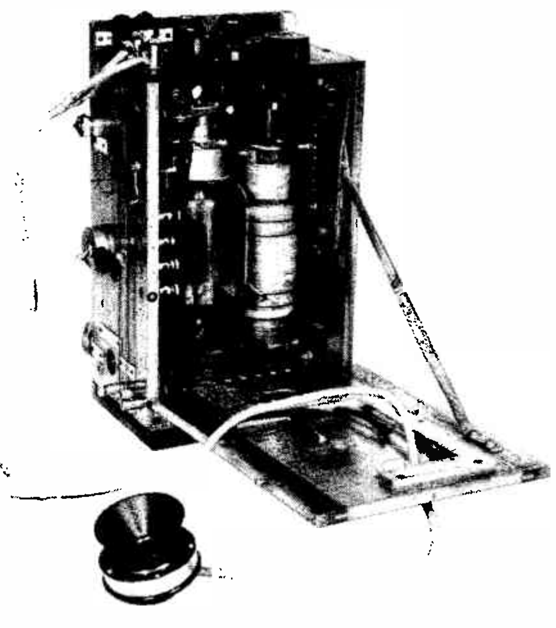


fig. 24 . 'Aircraft Telephony Transmitter'. 1915. A single valve set adapted by C.E. Prince from a 1914 ground set by Marconi's Wireless Telegraph Co. Ltd. Also fitted with Morse key. Solid teak case, ebonite panels, nickel-plated fittings, milliampermeter on front. 13¼ in. x 7¾ in. x 5¼ in. (closed).

1916

In 1916, while working for Marconi's, H.J. Round had developed the V24 high frequency valve principally for use in marine communications equipment and even twenty years later it was still being manufactured for replacement purposes. By 1916, Round had been put in control of seven Admiralty wireless direction-finding stations installed on the eastern coast of Britain and these soon played a decisive role in the war when on May 31st during the battle of Jutland they provided essential information on the movements of the German fleet. The Marconi International Marine Communication Company had secured the patents of the Bellini-Tosi direction-finding system in 1912, and this was much improved on during the war by Round.

WIRELESS IN THE TRENCHES

By the middle of the war, the high vacuum valve was being successfully developed as a detector and an amplifier, but its growing use by the Military did not immediately cause the crystal to become obsolete. In fact, one of the most well known and widely used wireless receivers of the First World War period was a crystal receiver, the Mark III Short Wave Tuner, which had a tuning range of between 100 and 700 metres. (Until towards the end of the 1920's, the term 'short-wave' generally stood for wavelengths below 700 metres and it was not until then that the term 'medium-wave' was substituted. See 1929). The Mark III Tuner was designed by Marconi's Wireless Telegraph Company Ltd. in 1915, and manufactured too by a number of other firms from 1916 including the W/T Factory, Robert W. Paul, Johnson & Phillips, and A.T.M. Co. (fig. 27). It was used by R.F.C. ground stations for the reception of Morse Code signals transmitted from aeroplanes flying above the battlefields of the Western Front. The pilots job was to direct the gunfire of artillery batteries on the ground via an R.F.C. wireless operator attached to each battery. With a clear view of the battle scene below, the pilots would transmit in Morse the coded position of the enemy using their Sterling No.1 spark transmitter of 1915 (fig. 25) and the message would be relayed on to the gunners who would then take the appropriate action.

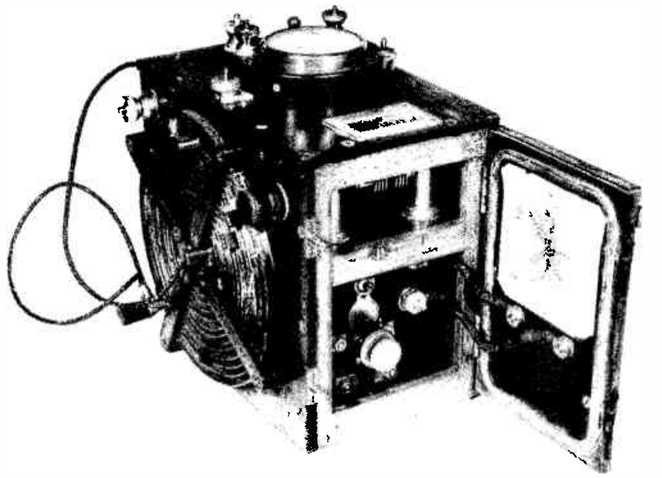


fig. 25 . Sterling 'W.T. Spark Transmitter, No.1', by W/T Factory, W.D., Soho. 1915. This transmitter was widely used in British spotter aircraft from 1916 in conjunction with the 'Mark III Short Wave Tuner' (fig. 27) for one-way air to ground wireless telegraphy communication. It was developed by Fl./Lieut. B. Binyon RNAS and the Sterling Telephone & Electric Company. During operation, the front door was closed and in conjunction with an enclosed Morse key (not shown), danger of igniting petrol vapour from the engine by the transmitter's spark was averted. Nickel-plated fittings, black ebonite panels, teak case. 7 in. x 8 in. x 5 in.

Very little has been published about the men who served as wireless operators in the trenches, upon whose skill and endurance depended the accurate shooting of the artillery and upon that, the saving of the lives of many thousands of British and Allied infantry, and whose ground jobs with the R.F.C. were commonly believed to be 'soft billets'. I am very grateful therefore to 1st Air Mechanic William Manns (fig. 26) for supplying me with much of the following first-hand information on the time he spent on the Western Front attached to the 1/1st Welsh Heavy Battery.

William Manns was born in London on August 20th 1896 and joined the Royal Flying Corps in October 1915. For his training he was initially sent to the Polytechnic Institute in Regent Street, London where he learnt Morse Code and elementary electricity and magnetism. In order to accommodate the large number of men studying there, the Polytechnic's swimming baths were emptied to house rows of tables and chairs so that up to 150 recruits could receive instruction at the same time. Most of the men were billeted at Olympia and Manns remembers that the march to Regent Street for breakfast every morning was the worst part of the day. Usually they had one session of Morse Code training in the morning with most of each afternoon being spent in darkness while they practiced with signalling lamps. Before tea there would be a lecture on magnetism followed by one on electricity at about six o'clock. Lunchtimes were spent doing physical exercises or aerial erection practice in Regents Park: they never did any route marches, the walk to breakfast every morning being "quite sufficient!".

fig. 26. 1st. Air Mechanic William T. Manns (sitting) with his assistant, 2nd. Air Mechanic R. Davidson. Zeggers-Cappel, August 1918.

In April 1916, Manns finished his training in London, having attained a Morse speed of 22 words per minute, and he then spent a fortnight at Test Hill, Weybridge which until then had been used as a race track. Here he got his first taste of the sort of operating conditions he was likely to encounter in France, albeit simulated. Test Hill was covered with dug-outs and places simulating the muddy terrain of the Western Front and with an RE8 observation aeroplane circling overhead, Manns put theory to practice, receiving signals and operating a Mark III Tuner for the first time.

In May, he went to the School For Wireless Operators at Farnborough which by this time had taken over from the Polytechnic as the main establishment for wireless tuition. The demand for, and the general recognition of the importance of wireless at the Front was marked by the fact that at the outbreak of the war only one Military aeroplane was equipped with a transmitter with less than a handful of wireless ground stations. By the time the Farnborough School had been established for a few months, there were 306 aeroplanes and 542 ground stations equipped with wireless, although at this stage of development the aeroplanes could only transmit and the ground stations could only receive.

At Farnborough, Manns was recruited for No.5 Squadron R.F.C. and was sent to join them at Dover. They then moved to Wye in Kent attached to the 20th Signals Regiment where part of his job was to fit the aeroplanes with Sterling spark transmitters and train the pilots to send Morse to a standard of 7 words per minute. During his stay in Wye, it was found that he could do shorthand and typing and so Manns was collared for an office job. He would have stayed in it permanently if he had not resisted strongly, for he did not want to be sent to France as a clerk. After a few days he was taken to the H.Q. of the 1/1st Welsh Heavy Battery T.A. Royal Garrison Artillery and rather unceremoniously left alone to find his own feet. For the next 18 bloody months he was to see intensive action with this battery on the Western Front (particularly while stationed at Ypres) but miraculously he came through it all without so much as a scratch and never thought for a moment that he would be killed, although sometimes while under particularly heavy shelling, he admitted to having "got the wind up".

On arrival at the H.Q. he was issued with the following equipment which being heavy and cumbersome had to be carried about by motor transport or, more usually, by horses:

1 mast: 8 sections of iron tube 3 inches in diameter to make a 30 ft. mast, halliard and top plug, top and bottom guy ropes, 6 pegs, 1 hammer and a 5 ft. picket; 1 aerial on a winch with an insulated lead-in wire; 1 spare aerial; 2 aerial insulators; 2 earth mats; 6 cloth ground strips, 24 ft. by 2 ft., and a Morse lamp for signalling to aeroplanes; 1 tool kit; message forms, carbon paper and pencil; cord; Mark III Tuner including 2 pairs of Browns headphones, calibration and instruction card, technical notes in the use of the wireless station, circuit diagrams, 4 'S' cells for the buzzer and potentiometer, copper gauze earth mat, perikon crystals (zincite and chalcopyrites), carborundum crystals (silicon carbide) and a spare set of crystals.

The technical notes issued to Manns with this equipment were expected to be rigorously adhered to but, as Manns says,

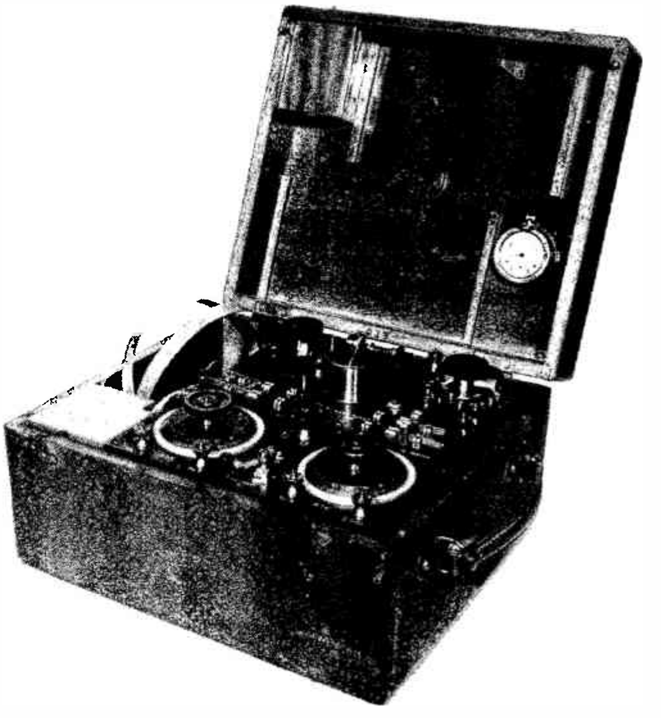


fig. 27. A.T.M. 'Mark III Short Wave Tuner', by Automatic Telephone Manufacturing Co. Ltd., London. 1916. A 'short-wave' crystal receiver for headphone use, covering the 100/700 metre wave range, used by R.F.C. ground stations in World War One. The panel houses Perikon and carborundum/steel detectors, a buzzer, and terminals for connecting the receiver to an auxiliary triode detector/amplifier. The lid contains a spare crystal compartment, a watch and a bracket for holding charts (charts missing in photograph). Solid mahogany case with polished interior, outside covered in black painted canvas. 8 in. x 14 in. x 12 in.

they were "wonderfully drawn up in an armchair in the safety of base camp and were often impossible to follow to the letter when under heavy shell fire in the battlefield". The 30 ft. aerial mast, with its 8 telescopic sections was extremely cumbersome to use and Manns says he "did not use that wretched thing whether there was a push on or not", he usually found a tree or other high place to fix his aerial instead.

Retrieving the copper earth mats, which he found easy enough to bury under the earth when setting up a station for the first time, proved an impossible task when moving location because the soil had by then become compressed into rock hard mud on top of them. Manns used to knock a nail in for the earth connection for subsequent stations and that worked just as well.

As a wireless operator receiving 4s.0d per day, Manns lived with the artillery gunners, sharing the same risks and hardships of trench warfare. Whenever possible, he operated near the map room so that the officer-of-the-day who had overall responsibility for communication could liaise with him. An observation aeroplane flying above the battlefield would direct the gunners towards the enemy targets by sending coded signals via Manns with his Mark III Tuner far below. The enemy's gun-smoke, giving away the position of its batteries, was known as a 'fleeting target', and would be clearly visible from the air as would be any enemy infantry or motor transport movement.

A wireless operator's work demanded continual alertness and close attention and more often than not was performed under heavy gunfire in a hastily constructed dug-out, rocking with the concussions of exploding shells which frequently put the aerial out of action, whereupon he was expected immediately to go outside and repair the damage, and this could mean going out more than a dozen times during one shoot. Through all this, he had to distinguish those signals coming from the particular aeroplane with which he was working from the numerous signals coming from other transmitters and a precise record had to be kept of the time and nature of each signal received and the result of the action taken by the gunners.

A careful check was being continually kept by the Central Wireless Station and each Squadron's H.Q. on whether the messages were being sent and received correctly. Only once was Manns' station reprimanded for inefficient reception, having receiving just 57 per cent of signals sent during one particular week, and that was the week when Manns was on leave.

At that time, ground wireless operators were also equipped with several strips of white cloth for use when signalling to the aeroplanes. Manns was supplied with a Mark III Tuner which could be used for reception purposes only. He did not have a transmitter to communicate to the aeroplane flying above but had to use either the cloth strips laid out on the ground in a coded pattern, or a Morse signalling lamp.

During a push, there was not time to build even the flimsiest shelter, the operator advanced with the gunners, rigged up his aerial and took cover in the nearest shell hole. In the long days of summer, Manns was sometimes on duty from 3am to 10pm with only a brief spell of relief when an artillery telephonist took over, and sometimes this was only for a few minutes. The telephonist however was not trained in wireless reception, and Manns had to give him enough instruction to enable him to get by. If there was a lull in the fighting, the battery used the time for calibrating and positioning their guns, with an aeroplane circling overhead directing the practice fire via the ground wireless operator.

In February 1918, Manns was joined by 2nd Air Mechanic R. Davidson who, sent out as his assistant, provided a welcome division of the work. Happily, both Manns and Davidson survived the war, but during the first four years of hostilities there was a yearly average of over 400 casualties amongst R.F.C. wireless operators, and this rose to nearly 500 during the months from May to November 1918. It was not a large number in itself, but compared to the numbers on the establishment, it represented a very large percentage: unusually large for a 'soft billet'.

After the war, many Mark III Tuners appeared on the surplus market and must have provided hundreds of people with their first taste of listening-in both before and after official broadcasting from the B.B.C. began in November 1922.

1917

With the war giving impetus to wireless research, Military wireless equipment continued to be developed and several notable transmitters and receivers were introduced including the Telephone Wireless Aircraft, Mk.II (fig. 28), the Aircraft Receiver Mk.III (fig. 29), the Mk.II Front Receiver (fig. 30) and the C.W. Mk.III Transmitter (fig. 31).

In April, the Mark III Amplifier became available and this was produced specifically for use with the Mark III Tuner. It was designed by the British Signals Experimental Establishment and employed two valves, the White soft valve and a de Forest Audion, but few of these amplifiers ever found their way to the Front.

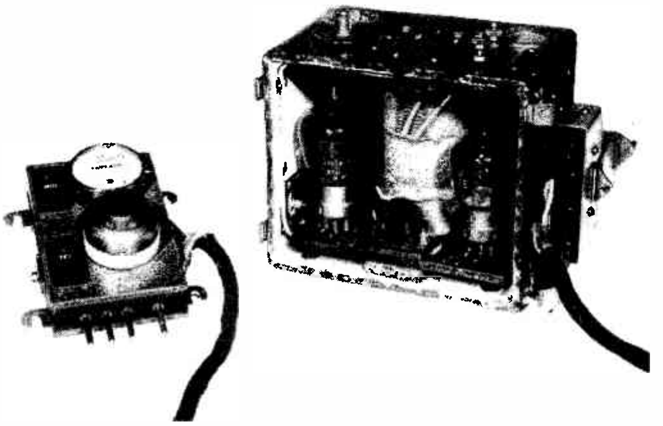


fig. 28. Right: 'Telephone Wireless Aircraft, Mk.II', by General Electric Co., U.S.A. 1917. A 2-valve 20 watt telephony transmitter, fitted as standard in British aircraft towards the end of the war. Wood case covered in grey-painted cloth. 7 in. x 8 in. x 6 in. Left: A remote ON/OFF control with terminals for microphone, headphones and earth wires, (plugs into right hand side of transmitter).

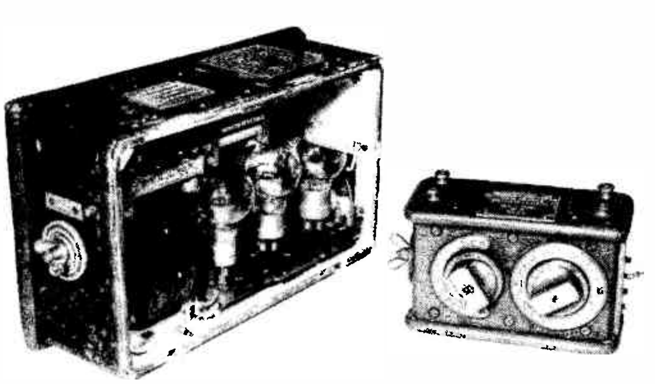


fig. 29. Left: 'Aircraft Receiver Mk.III', by Automatic Telephone Manufacturing Co. Ltd., London. 1917. A 3-valve receiver widely used in British aircraft in the latter stages of the war in conjunction with the General Electric Mk.II telephony transmitter (fig. 28). Wood case covered in black-painted cloth. (Receiver illustrated date-stamped "1918". Front of case removed to show components). 7 ½ in. x 12½ in. x 5 in. Right: Matching remote control unit, 'Tuner Aircraft Mk.III', by W/T Factory, W.D., Soho. 1917. 4 in. x 6 ½ in. x 3 in.

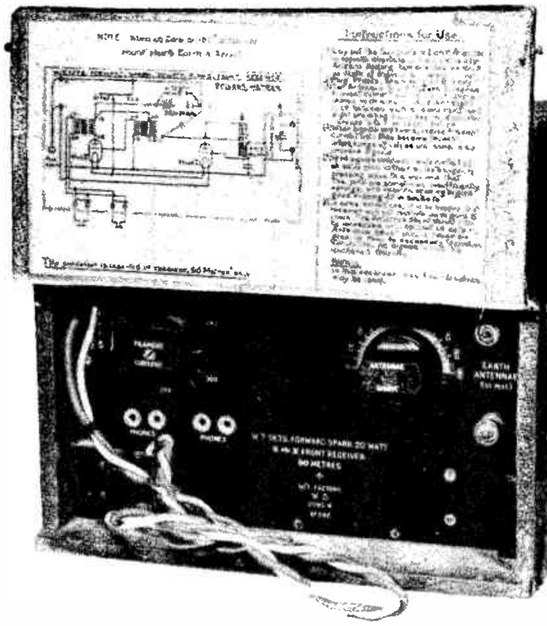


fig. 30 . 'Mk.II Front Receiver', by W/T Factory, W.D., Soho. 1917. A 20 watt spark receiver, employing two 'R' valves: an oscillating detector and an LF amplifier. Tunes to 80 or 65 metres. Wood case covered in black-painted cloth. 10 in. x 18 in. x 6 in.

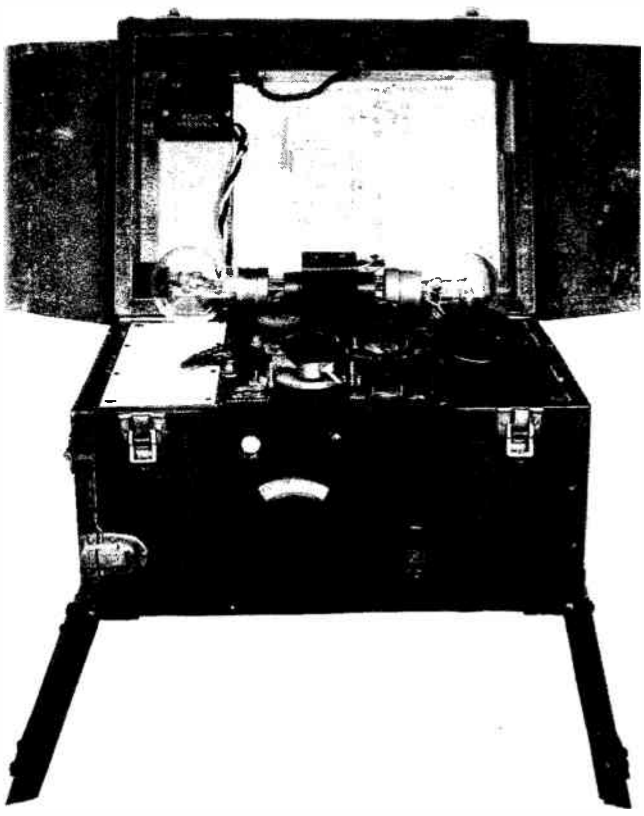


fig. 31 . 'C.W. Mk.III Transmitter'. 1917. A 2-valve portable transmitter operating between 500/2000 metres. Ebonite panel, wood case covered in black-painted cloth. 13½ in. x 12½ in. x 9½ in. (including stand).

In the R.F.C., continuous-wave valve transmitters were brought into general use and immediately increased the ground-to-air and the air-to-ground range, and by the following year some 600 aircraft and 1,000 R.F.C. ground stations were using wireless communications equipment.

1918

During the year, the General Electric Company released the Osram R2A which was one of the very last 'soft' valves to be produced in this country (fig. 32).

In May 1918, the Dutch lightbulb manufacturers Philips introduced their first valve in Holland: the '1 Deezet' (1DZ), named after Dr. Hanso Idzerda. Idzerda was an electrical engineer who had set up business in 1914 to manufacture wireless apparatus and it was he who managed to persuade Philips (until then solely manufacturers of lightbulbs) to begin producing wireless valves. In 1919, the transmitting station in the Hague belonging to Idzerda's company, call-sign PCGG, began broadcasting a series of concerts which soon became compulsive listening-in for thousands of people in Britain and on the Continent (see 1919).

The First World War was now drawing to a close. For four years the opposing armies had viewed one another across the narrow belt of no-man's-land which separated their front lines, but in the summer of 1918 the great Allied break-through began with a French attack in July and a British attack in August led by 450 tanks, and within a few months the Germans had surrendered.

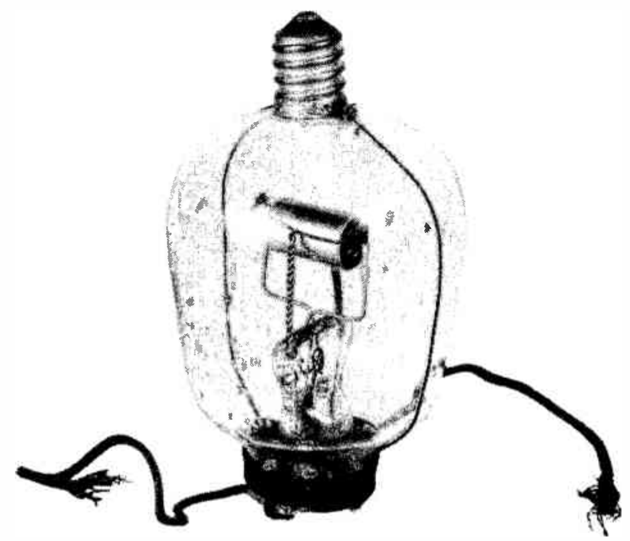


fig. 32 . Osram R2A, by the General Electric Company, London. 1918. A 'soft' valve filled with helium, mainly used in British Naval installations during the last year of the war. 1.1 amps, 3.3 volts, 28/38 anode volts. Brass screw-thread fitting. 3¼ in. high. Its appearance marked the final development of the 'soft' valve in England.

1919

Several months after the Armistice, the first relaxation of official restrictions on wireless occurred. In a letter to manufacturers of electrical apparatus dated March 24th 1919, the Secretary of the Post Office announced that restrictions were now lifted on the sale of certain component parts including spark coils and headphones. This was on condition that the purchaser gave a written undertaking that the experimental apparatus in which the parts were to be used would not be employed for wireless work unless written permission had first been obtained from the Post Master General. In the next month, the Post Office began issuing special licences to clockmakers for the reception of time-signals, but the applicant had to prove that the licence was only going to be used in conjunction with his business before it was granted.

On July 5th 1919, all pre-war licences were cancelled but the Post Office did not start to replace these until October 21st 1919 when, under pressure from the wireless societies and clubs, they announced that informal authority could now be granted for the use of receivers only and amateurs could reclaim their wireless apparatus confiscated by the Post Office during the war. Accompanying this relaxation in restrictions, the Experimenter's Licence (for reception only) was introduced at 10s.0d per annum. Applicants for this new licence had to be of British nationality and had to produce a birth certificate to that effect. They were first required to submit a description of the apparatus they proposed to install, and if they sought to use thermionic valves, a diagram had to be sent showing the circuit layout. If any applicant wanted to buy complete factory-built apparatus (the manufacture of which was still controlled by official permit), he was required to give full particulars of the equipment and the name and address of the firm from whom he bought it. There were restrictions too on the size of the aerial used, the length being limited to 100 feet for a single stranded wire and 140 feet for a double or multi-stranded wire.

A week after the Experimenter's Licence was introduced, the Wireless Society of London held its first post-war Annual General Meeting at the Institution of Civil Engineers at Westminster on October 28th. Many societies and clubs were very keen to resume their activities soon after the war had ended, and in the audience that evening were some two hundred amateurs and their guests from as far away as Plymouth and Derby, providing further evidence of the growing national interest in wireless.

On show at the meeting were a few pieces of equipment made by Society members but the display mostly comprised factory-made wireless apparatus of the official type with Military C.W. and telephony receivers forming a major part of the exhibition. There was a lot of interest in valves made by the Edison Swan Electric Company and a valve display showing an 'R' valve in various stages of production which was described by John Scott-Taggart. British Thomson-Houston Co. Ltd. showed valves from the U.S., Germany and France, and there were various exhibits from Marconi's Wireless Telegraph Company including a Type 55 7-valve amplifier, direction-finding apparatus for ships, and pieces of captured German equipment such as trench spark sets and valves. The exhibition gave many their first chance of examining such apparatus at close quarters, and although a private affair, it was the first wireless exhibition ever to be held in Britain.

But with only a licence for receiving having been granted to the amateurs, there was not much for them to listen to apart from the international time-signals or Morse Code from official Government or Military stations. But on November 6th 1919, the situation took a definite turn for the better when the world's first pre-announced wireless telephony broadcast was transmitted from station PCGG in the Hague, Holland. The station had been set up by Hanso Idzerda and was owned by his company, Nederlandsche Radio Industry, who were designers and manufacturers of wireless equipment. Idzerda thought that he could use the transmitter for increasing the popularity of wireless broadcasting in Holland, stimulate the need for wireless receivers and so promote his commercial business: an idea which was fundamental too in the setting up of the British Broadcasting Company three years later. The day before, Idzerda had published details of the first of his forthcoming 'Soiree-Musicales' in the *Nieuwe Rotterdamsche Courant* and although of an irregular nature at first, the programmes, consisting of speech and music transmitted on 1,150 metres long-wave, were well received not only by the Dutch, but by hundreds of listeners in England too who soon began calling them the 'Dutch concerts'.

In November 1919, a Post Office announcement that new transmitting licences would shortly be introduced caused great excitement among the amateurs but again they had to wait, until August 1st 1920.

Immediately after the war, Marconi's began concentrating their research efforts in high-power wireless telephony transmission and soon commercial 250 watt, 1.5 kW, 3kW and 6kW sets were being manufactured. In 1919, they built an experimental 2.5 kW telephony transmitter at Ballybunion in Ireland under the direction of H.J. Round. Although it utilised only three main valves whose power was a fraction of that used by the Arlington transmitter in 1915, they succeeded in transmitting the voice of Marconi Engineer W.T. Ditcham to a receiving station at Louisbourg, Nova Scotia. The wavelength used was 3,800 metres and Ditcham's was the first European voice to be sent across the Atlantic by wireless. Spurred on by these excellent results, Marconi's then decided to build a 6 kW wireless telephony transmitter at their Chelmsford works to test long-distance transmissions on long-waves and this came into use in January 1920.

1920

On January 29th, the Wireless Society of London held its second private wireless exhibition. There were far fewer pieces of equipment of a Military or professional nature on show, and the accent now was on 'domestic' wireless for amateur home use. The exhibits included a Wireless Pocket-Book (a miniature crystal set designed by Capt. H. de A. Donisthorpe and manufactured by R.M. Radio Ltd. in the form of a pocket-book and claiming a range of 300/3,000 metres), a Gamage's Polaris Miniwaver, Mediwaver and Maxiwaver single-valve unit set capable of tuning between 450/30,000 metres (fig. 34), a Model No.2 valve detector unit by A.W. Knight and valve units and various components by F.L. Mitchell & Co. Ltd. Also shown at the exhibition was one of the very first domestic portable valve receivers: a 2-valve set for headphone use designed by R.C. Clinker and made by B.T.H. at Rugby (fig. 33).

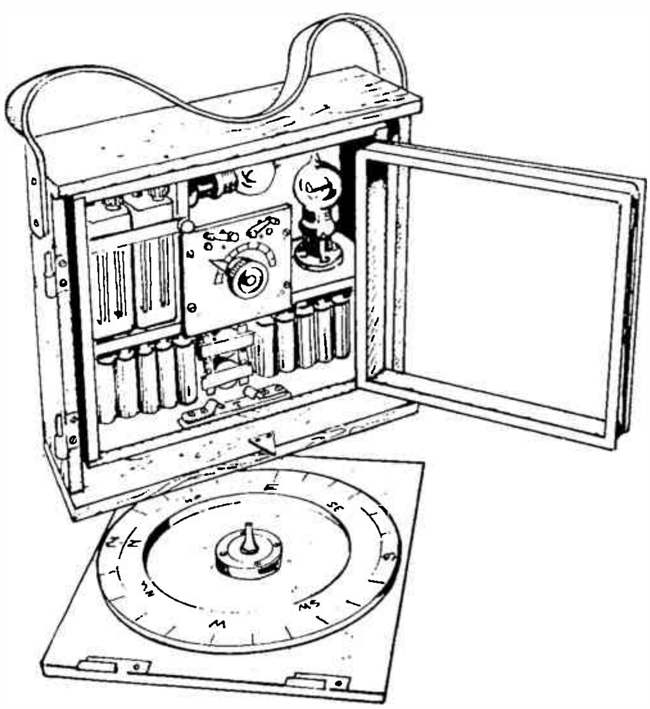


fig. 33. A 2-valve battery portable for headphone use, made by British Thomson-Houston Co. Ltd. Spring 1920. (des: R.C. Clinker). This very early domestic portable was designed to receive Press news, time signals and meteorological reports sent out from long-wave transmitting stations, and had a standard tuning range of 1,500/15,000 metres, extendable down to 400 metres. The receiver, together with all the necessary HT and LT batteries, was housed in a 13 in. x 14 in. x 5 in. oak case which had a removeable hinged front door, on the back of which was a printed compass scale. When required for use, the door was lifted from its hinges and laid flat on a table and the scale lined up along the meridian by means of a compass. The set was then positioned onto the pivot screwed in the centre of the door and swung around so that the pointer at the bottom of the cabinet indicated the bearing of the station required. This was then roughly tuned in by means of a variometer, and to obtain fine tuning, the hinged square-wound 'retroactive' coil (right) was swung out to the required position. (Drawing: Norman Jackson).

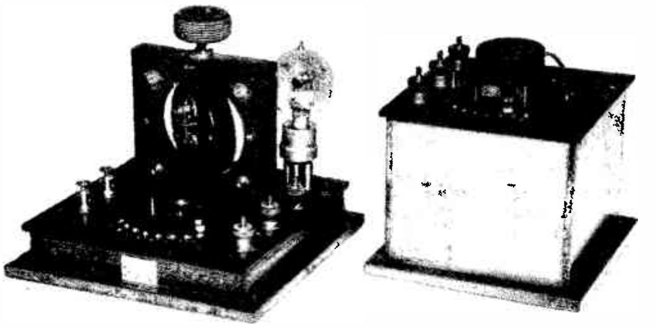


fig. 34 . Left: Gamage's 'Polaris Mediwaver', by A.W. Gamage Ltd., Holborn, London EC. 1919. (des: H. Powell Rees). A 1-valve battery receiver for headphone use, tuning between 750/3,300 metres. Mahogany case 8 in. x 8¼ in. x 8¼ in. Right: An add-on unit, the 'Polaris Miniwaver', was used to lower the combined wave range of the two units to between 400/700m. (In 1920, a third unit, the 'Polaris Maxiwaver', was introduced to extend the combined wave range to as high as 30,000 metres).

On February 23rd 1920, the power of the Chelmsford transmitter was increased to 15 kW and a regular service now began which consisted of two daily half-hour programmes of news, talks and music organised by G.W. White, an assistant to Round and Ditcham. These unofficial broadcasts were transmitted on 2,800 metres long-wave and since this was the same wavelength as that used by the Poldhu Station, a large number of wireless operators at sea were able to pick them up on their ships' receivers. Many amateurs too were listening-in around the country, and most of those who had previously bought or made apparatus for receiving the 2,600 metre time-signals from the Eiffel Tower transmitter also found that their receivers could tune to the Chelmsford wavelength. The programmes were a great success and they gave many their first chance of hearing broadcasts radiating from an English transmitter. The excitement of the Chelmsford broadcasts and the anticipation of future broadcasting developments, encouraged a national demand for wireless apparatus and during 1920, a domestic Wireless Industry began to be established based on the idea of manufacturing receivers specifically for home entertainment, and not for any Military or professional use.

In the immediate post-war years, the future of wireless communication was thought to lie with the *long* waveband, especially as there were already many well established official long-wave stations transmitting in this country and in Europe. Many receivers, like the Gamages Polaris unit set referred to above, were even brought out covering wavelengths as high as 30,000 metres, in order "to provide for future contingencies". Many who tuned-in were doing so on surplus Military wireless equipment left over from the war and now sold by the Disposal Board War Office, and some unwary amateurs were caught out by unscrupulous dealers offloading inefficient, obsolete or totally unsuitable equipment. Much of it had originally been designed for receiving the 'short' (medium) waveband only, and the circuits therefore had to be modified to receive the long waveband. Around this time, articles giving details of the necessary circuit changes often appeared in the Press and one, published in *Wireless World*, gave details of how to modify the Mark III Tuner and left little more than a dozen of the original parts intact, and that included the wooden case! The Mark III Short Wave Tuner also appeared as a commercial 1-valve long-wave receiver when in 1920, W.R.H. Tingey bought up a parcel of them and used many parts, including the case, to produce the Tingey Valve Tuner No.22 (fig. 35). Here again, the manufacturers had an eye to what they considered to be future broadcasting developments and provided this receiver with a circuit capable of tuning up to 30,000 metres.

However, when national broadcasting began from the British Broadcasting Company in November 1922, the *medium* waveband was chosen, and together with sets only capable of receiving long-waves, military surplus receivers like the Mark III Tuner which had been designed for the medium waveband but had then been changed soon after the war to cover the long waveband, had to be re-converted to receive the shorter 'Broadcast Band' (350 to 425 metres).

fig. 35 . Tingey 'Valve Tuner No.22', by W.R.H. Tingey, London EC. 1920. A 1-valve battery receiver for headphone use, tuning between 800/30,000 metres. Made using parts from surplus 'Mark III Short Wave Tuners' (fig. 27). Canvas-covered mahogany case, 8 in. x 14 in. x 12 in.

The event which really put the idea of using wireless as a broadcast entertainment firmly on the map occurred on June 15th 1920. Sponsored by the *Daily Mail* for a reported figure of £1,000, the Australian soprano, Nellie Melba (fig. 36), sang a concert from the Chelmsford works which was heard by listeners all over the British Isles and many countries abroad, and led to Marconi's receiving thousands of letters and telegrams of praise. One newspaper reported, "Punctually at 7.15pm the words of Home Sweet Home swam into the receivers. Those who heard it might have been in an audience in the Albert Hall."

As well as in England, the concert was heard in Paris, Rome, Warsaw, Madrid, Berlin, Stockholm and Tabriz in Persia. But although dramatic and momentous at the time, the Melba concert did little to speed up the establishment of a national broadcasting system in Britain and several problems were to occur before the British Broadcasting Company was set up.

fig. 36 . The Australian soprano, Nellie Melba, on the night of her famous broadcast from Marconi's Chelmsford works in New Street. June 15th 1920. Clutching her handbag, (which surely is far too small to accommodate the £1,000 performance fee?), she is singing into an improvised Peel Connor carbon granule microphone manufactured by the General Electric Company. The makeshift cone was hastily made by H.J. Round from an old cigar box and was autographed by Melba after her broadcast.

Meanwhile, the public continued to listen-in with interest to the broadcasts from Chelmsford, which in the last week of July enabled the passenger liner *Victorian* to establish a long-distance telephony record for a ship at sea. Having been equipped by the Marconi International Marine Communication Company with an experimental 3 kW two-way wireless telephony transmitter, the *Victorian*, sailing from England *en route* for Canada, had first established telephonic communication with Chelmsford on July 21st 1920 when she was some 600 miles distant. The following day, she was able to entertain her passengers with concerts and Press Association news bulletins transmitted from Chelmsford and picked up on her telephony receiver. The programmes were relayed to passengers through a Brown H1 loud-speaker drive unit connected to a phonograph horn set up in the first-class passenger lounge. On the following days, the Chelmsford concert was again received until on July 26th, it was heard for the last time when the *Victorian* was over 2,100 miles away, establishing a new record. The *Victorian* also broadcast her own daily and nightly programmes of wireless telephony concerts comprising records played on a gramophone and she received many Morse Code requests for encores from ships scattered about the North Atlantic over a radius of nearly 800 miles.

On August 1st 1920, new experimental transmitting licences were introduced (the first one was issued to the Radio Communication Company at Slough, call-sign 2AA), and the 1,000 metre wavelength was allotted to amateurs for the transmission of wireless telephony with the maximum power restricted to 10 watts. In the same month, further experimental broadcasts of news items were conducted by the Press Association and to receive them, multi 'R' valve sets using frame aerials were installed in newspaper offices at Newcastle, Preston, Sheffield and Belfast. The frame aerial, a long length of wire wound around a square wooden frame usually a few feet across, was not as efficient as an outdoor aerial but was used where space outside was limited.

A new source of telephony now became available for amateurs to tune-in to. In 1919, Croydon Aerodrome had become Britain's main civil airport and during 1920 was supplied by Marconi's with a two-way telephony transmitting station and a Bellini-Tosi direction-finder sited 3 miles away at Mitcham. This was remotely controlled from the Croydon control tower, and by tuning to 900 metres, amateurs could listen-in to conversations with aeroplanes in flight as they made the journey to and from Paris.

Across the Atlantic in November, the Westinghouse Electric & Manufacturing Company in Pittsburg, Pennsylvania, transmitted the returns of President Harding's election by wireless telephony, thus beginning the advent of broadcasting in the United States. The public had been prepared for this by announcements in the newspapers and many thousands of amateur experimenters were therefore ready with their receivers and managed to obtain the news long before the papers had time to publish the results. The success of this first national broadcast encouraged Westinghouse to organise and maintain a daily service from its Pittsburg station, call-sign KDKA, which became the pioneering broadcast station in the United States.

But in England, things now took a turn for the worse when on November 23rd, the Post Master General, Albert Illingworth, informed the House of Commons that permission to broadcast from Marconi's Chelmsford works was being withdrawn owing to "the considerable interference with other stations", in particular with the Post Office's new arc transmitting station at Leafield near Oxford, which was then being used for telegram, Press and Foreign Office Morse transmissions to Cairo, India and America on 12,200 metres. The irony of this was that Leafield itself was a greater source of interference, owing to the harmonics generated by the arc system (see 1922).

1921

On September 21st, due to the lapse of Regulation 22 of the *Defence of the Realm Consolidation Act, 1914*, wireless apparatus could now be freely manufactured, sold and purchased without permit or restriction, although an Experimenter's Licence would still be necessary for those wishing to install a wireless receiver. An arrangement was made however for 'toy' sets to be used without a licence, providing that such apparatus had been approved by the Post Master General and had been stamped or marked to that effect before sale. (Toy sets were defined as "receiving or transmitting apparatus of the Hertzian oscillator type, not intended for connection to earth or to any aerial other than small rods and with a range not exceeding 50 yards").

By the winter of 1921, the Dutch concerts were in serious trouble, and it looked as though these were going to cease altogether owing to financial difficulties. But an appeal was made in the September 3rd 1921 issue of *Wireless World* by W.W. Burnham, Managing Director of the wireless manufacturers Burnham & Co. (later Burndept Ltd.), and sufficient funds came in to enable PCGG to continue broadcasting. Comments were also raised in the appeal that it was abominable that no British station, such as the one at Chelmsford, was allowed to transmit a short concert or a brief news bulletin even once a week while in America, broadcasting was well under way. Even the time-signal broadcasts from the Eiffel Tower station were now being livened up with speech and music.

As a minor concession, Marconi's were then granted permission for transmitting calibration signals from Chelmsford for half an hour a week, but the English amateur was justifiably feeling rather snubbed by the Post Office and thought that his contribution to radio science was often going unseen and unheard. Despite various important successes, including the first reception of transatlantic short-wave (200 metres) transmissions by the English amateur W.F. Burne (call-sign 2KW) of Sale, Cheshire on December 8th 1921, and the amateurs' considerable technical contribution during World War One, to many, the Post Office still exhibited a "deplorable attitude".

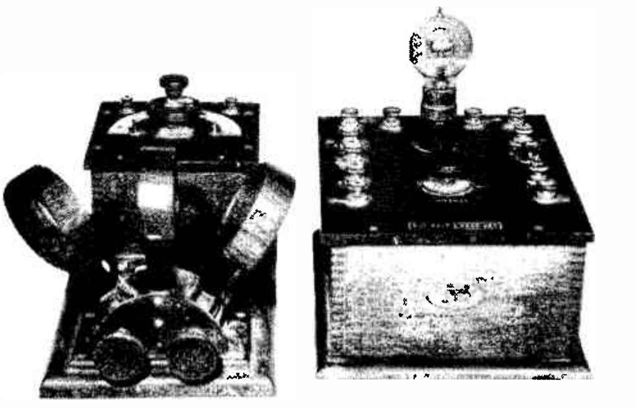


fig. 37 . 'Burndept 1', a two-unit set for headphone use manufactured by Burnham & Co., Deptford, London SE. 1921 (des: Frank Phillips). Left: A tuner unit with three loose-coupled plug-in coils, and a variable condenser housed in a walnut case with an ebonite control panel. Mounted on a walnut base, 7 in. x 7 in. x 13½ in. Right: A 1-valve amplifier unit with an ebonite control panel and walnut case, 5 in. x 8 in. x 10 in. One of Burnham & Co.'s first valve sets, which no doubt would have received the Dutch Concerts that the firm's Managing Director, W.W. Burnham, raised funds to save.

Since the spring, negotiations had been going on between the Post Office and the Wireless Society of London (now representing the majority of wireless societies and clubs around the country), with a view to establishing weekly high-power calibration transmissions, wireless telegraphy and, more especially, wireless telephony. This led to a petition being presented to the Post Master General, F.G. Kellaway on December 29th 1921, pleading the amateur's case:

"We, the undersigned, on behalf of the Wireless Society of London, and of most of the other societies of the country, representing in the aggregate a large number of citizens interested in wireless telegraphy, ask you to be good enough to give consideration to our views as follows:

"We wish to express our thanks for the courtesy and consideration which the authorities have always shown to the amateur radiotelegraphists of this country, and to state that we fully realise the difficulties that are inherent to the carrying on of wireless operations in a small and crowded country such as our own where the stringent regulations are obviously necessary to prevent undue interference.

"We also wish to express our satisfaction at the permission recently given to the Marconi Company to send special calibration signals from Chelmsford for the benefit of our members for a period of half an hour every week.

"We desire, however, to express our regret that wireless telephony has not been included in this arrangement and to say that we hope that this restriction may be reconsidered, either with reduced power, or perhaps on a short wavelength of 200 or 300 metres, so as not to cause interference. We would point out that it is telephony in which the majority of our members are chiefly interested at the present time, this being the most recent achievement in wireless, and that in which, for moderate distances at all events, improvements such as avoidance of distortion and the production of really articulate loud speakers and such like, are most required. It is therefore primarily to serve the scientific purpose of improving the receiving arrangements that we desire to have telephony included. We would, however call attention to the following general consideration, which in our opinion, should not be overlooked by the authorities in dealing with this question.

"It should be remembered that wireless telegraphy was, in the first instance, originated and has since been largely developed, by men who, at any rate to begin with, were not even electrical engineers or electricians, and still less qualified telegraphists. Many of these, when they began experimenting, were in this particular line pure amateurs, though no doubt some of them gradually attained to professional proficiency. New inventions and important improvements are still being made by this class of person and the more numerous they are the more chance there is for good and useful work to be done. In this connection it is noteworthy that it is entirely due to amateurs that all records have recently been broken by the successful transmission and reception of signals across the Atlantic on 200 metre waves. To attract such workers in the first instance and to keep them interested, it is necessary to make the occupation interesting and even entertaining; hence the need for wireless telephonic speech and even music. Furthermore the requirements of the large number of such amateur users have led to the establishment of numerous factories for the manufacture of wireless instruments and apparatus, where skilled engineers and workmen are employed and many experiments are carried out and where quite important improvements in instruments and methods are constantly being effected. Were it not for the demands of numerous amateurs, such manufacturing concerns would not exist and advance in the art would be checked. There is also the advantage, in the case of any future wars, of the existence of a number of persons skilled in wireless.

"The education value of wireless should not be overlooked. Just as the advent of the motor car has undoubtedly done more to disseminate a knowledge of mechanics throughout the population than all the millions of money spent annually on technical education, so also the practice of wireless is teaching thousands the principles of electrical science and of physics, and this without any expense to the State.

"That the French authorities recognise the force of these considerations is evidenced by the transmissions of speech and music that have already commenced under Government auspices from the Eiffel Tower. It is understood that it is intended to make these a regular feature like the time signals and meteorological reports and it will be somewhat lamentable if England, where Wireless Telegraphy originated and whose Greenwich time is the time of the world, but who sends out no wireless time signals, should again fall behind other countries by reason of failure to move with events.

We are,
Your obedient servants."

Here, the petition was signed by the Committee of the Wireless Society of London and representatives of some 65 other Societies and Clubs affiliated with it.

THE BROADCASTING YEARS

1 The 1920s

1922

THE WRITTLE STATION, 2MT

Having carefully considered the petition presented to him by the Committee of the Wireless Society of London only a few weeks before, the Post Master General announced on January 25th 1922 that he had authorised Marconi's Wireless Telegraph Co. Ltd. to arrange a short weekly programme of wireless telephony and Morse calibration signals for the benefit of the several thousand amateur wireless experimenters around the country who were eagerly waiting for something interesting to listen to. The service would be provided by Marconi's subsidiary, the Marconi Scientific Instrument Co. Ltd., from an experimental station housed in a wooden hut in the Essex village of Writtle, a few miles from Chelmsford and would have the call-sign 2MT ("TWO-EMMA-TOC"). This company had been set up by Marconi's on November 1st 1919 to repair and bring up to date all obsolete apparatus belonging to Marconi's and to manufacture and sell amateur telegraphic and telephonic equipment under licence. During the first week of January 1922, they had exhibited components, valves, batteries and receiver units including a complete set of six, at the Model Engineer Exhibition held at the Horticultural Hall in London. Also at the exhibition were stands from six other wireless manufacturers who displayed domestic wireless equipment designed solely for "amateur use in the home". The other exhibits were by G.Z. Auckland & Sons, a selection of components for the amateur to build "a domestic wireless installation"; Bower & Co., components and French 'R' valves; Burnham & Co., their Ultra-Five receiver and honeycomb tuning coils, together with the actual transmitter used to broadcast the Dutch concerts from the Hague; Economic Electric Co., various pieces of electrical and wireless apparatus; A.W. Gamage, components and unit receivers, and F.O. Read & Co., HF and LF amplifiers and other wireless apparatus. Leslie McMichael also had a stand at the exhibition, but showed almost exclusively ex-Government apparatus from the Disposal Board War Office including Townsend wavemeters, Mark III Tuners, condensers and valves.

The Writtle station began its regular Tuesday night broadcasts on February 14th at 7pm. From 7pm to 7.25pm, three five minute sections of C.W. Morse were transmitted on 1,000 metres long-wave (the same wavelength allocated to amateur transmitters) with a power of 1 kW, 500 watts and 250 watts respectively. This was followed at 7.35pm by an opening concert of songs by Robert Howe and records played on a Cliftophone gramophone, transmitted on the relatively long wavelength of 700 metres with a power of 250 watts. The wireless telephony transmissions were strictly limited to a maximum of half an hour per week and like the Morse transmissions were divided into sections. Between each section was a break during which the Writtle station closed down for a couple of minutes so that the announcers could maintain a listening watch on 2MT's wavelength for any important Government messages or "S.O.S." calls. For the benefit of wireless enthusiasts who wanted to try to tune-in to the test broadcasts, *Wireless World* had, a week before, published full details of the opening programme. Excellent reception was reported by those living within about a 15 mile radius of Writtle who were able to pick up the broadcasts on simple crystal sets while as far north as Forfar in Scotland, loud-speaker reception was obtained on a 5-valve set although signal fading was quite marked. Another, more serious problem encountered by many of those tuning-in on valve receivers was interference, and this was especially experienced by amateurs living on the English Channel coast who were often prevented from receiving 2MT because of jamming from ship and coastal-based Naval wireless installations. Around the London area, the first three items of the opening concert were heard quite clearly, although after that, harmonic interference from the Post Office's arc transmitter at Leafield on 12,200 metres entirely wiped them out.

Interference continued to be a problem and so a few months later, on Tuesday May 30th, 2MT's 700 metre wavelength was changed to 400 metres medium-wave and the rather dreary section of Morse calibration signals on 1,000 metres long-wave was dropped altogether, with the wireless telephony section opening the programme at its new time of 8pm. 2MT's new medium wavelength meant that the circuit designs of long-wave only receivers had to be modified in order for Writtle to be received. This change would be necessary anyway as plans had been announced by the P.M.G. earlier in the month proposing the establishment of a national domestic broadcasting service which would employ a number of wireless telephony transmitting stations using allocations between 350 and 425 metres on the medium waveband: soon to become popularly known as the 'Broadcast Band'.

Until the Writtle station closed down on January 17th 1923, the 'ether' around the Essex area was filled with "first class amusement", which included on October 17th, the first ever wireless play: a short scene from Cyrano de Bergerac directed by a Miss Agnes Travers.

The station's Director and Chief Announcer was Captain Peter Pendleton Eckersley. An R.F.C. Wireless Equipment Officer during the war, he later joined the Experimental Section of the Marconi Company's Aircraft Department and went on to become the B.B.C's Chief Engineer. It was largely due to Eckersley's boyish enthusiasm and imaginative personality that these Tuesday evening programmes became compulsive listening-in and although the Writtle station operated for less than a year, it was a tremendous success and helped to convince many, including the Post Office, that broadcasting as an entertainment had great public benefit and, as a new art, had very definitely arrived.

THE BRITISH BROADCASTING COMPANY

Shortly after Writtle went on the air in January, the Post Office granted Marconi's a licence for the installation of a 100 watt wireless telephony broadcasting station at their Head Office at Marconi House in the Strand, London. Its call-sign was to be 2LO.

The transmitter and a single 20 ft. x 20 ft. studio were housed on the top floor of Marconi House in what used to be an old cinema theatre, and from here the first experimental tests began at 9.25pm on the night of Thursday May 11th with the opening message, "Hullo C.Q. 2LO calling. Please stand by." There then followed a rather ambitious outside broadcast of a boxing match between Carpentier and Lewis at Olympia in West London. The commentary was relayed live by telephone by *Daily Mail* reporters at the ringside and was sent out via the transmitter at Marconi House on 360 metres. However, there was not very much to describe as Carpentier won after only

A.J.S. 4-valve battery receiver, 1923, with an S.G. Brown Model H1 horn loudspeaker.

one minute of the first round, although the general opinion afterwards was that the broadcast had been a great success, brief as it was. 2LO was not alone in broadcasting the fight as the Radio Communication Company at Slough (call-sign 2AA) had their own commentator, Jack Dempsey, at the other end of a telephone line at Olympia.

Initially, subsequent test broadcasts from 2LO were restricted by the Post Office to hour-long studio programmes of speech, sent out in the late morning or late afternoon to a limited reception area around London. Like Writtle, periods of a few minutes silence were included which had the advantage of allowing the engineers time to smooth out any technical problems which might have (and usually had!) occurred. The station's Chief Announcer was Arthur Burrows, who in mid-November, when 2LO was inaugurated as the first station of the British Broadcasting Company, became its Director of Programmes. He was soon to become one of the famous Wireless Uncles: 'Uncle Arthur' to the thousands of children listening to him on Children's Hour every evening.

On May 18th, the first of a series of meetings was held between the Post Office and the representatives of firms interested in the Post Master General's proposed broadcasting plan, with the idea of forming a *single* licensed broadcasting company rather than having many firms operating their own separate stations, each under a different licence. In America, where controls were non-existent, the situation had become chaotic with a very large number of stations transmitting on a narrow band of wavelengths, and the Post Office naturally sought to prevent a similar situation arising in Britain. Also, any licence granted to such a joint company would only be for two years, thereby giving the Post Office the safeguard of being able to review the entire situation after a limited period. The geography of the British Isles played an important part too in this decision. Given that each station was to be of a certain power and range, it was thought impossible to operate more than eight transmitters in mainland Britain without causing interference between them.

From mid-summer, more variety was introduced into the broadcasts from 2LO with programmes of concerts and musical evenings now permitted. The original power of around 100 watts was raised to 1.5 kW and the reception range of the transmissions greatly extended to encompass many more of the 11,000 amateur 'listeners-in' who had already been issued with Experimenter's Licences.

In September, from the 2nd to the 8th, the International Radio Exhibition took place at the Central Hall, Westminster. This was the first exhibition open to the public solely devoted to wireless and was supported by over 40 British and foreign manufacturers showing complete receivers, components and accessories. At the end of the month, from September 30th to October 7th, the first All British Wireless Exhibition was held at the Horticultural Hall, London SW1. Supported by 52 British wireless manufacturers, it was then the most representative trade gathering ever to be held in Britain and was aimed primarily at the requirements of experimenters and amateur listeners-in. The general public flocked to the Hall, not to make a critical examination of the apparatus on show, but to witness the new phenomenon of broadcasting itself.

Among the exhibits on show were the first three sets from Marconi's made specifically for domestic and not for Government, marine or other official use. They were the Marconiphone V2 2-valve receiver (fig. 60), the Marconiphone Crystal A crystal set (fig. 64) and its smaller version, the Marconiphone Crystal Junior (fig. 68). 'Marconiphone' was the trade name used until the end of December 1923 by Marconi's on all their broadcast receivers produced for the domestic market. The Marconiphone Company Limited was set up on December 29th 1923 and within a couple of days all the business in connection with the sale and distribution of Marconiphone receivers and accessories together with the Marconiphone trade name had been transferred to them (see 1923).

The original chassis of the V2, the Crystal A and the Crystal Junior were not in fact made by Marconi's but by the firm of Plessey, who up to that time, using two rooms in shared premises in Holloway, had specialised in the manufacture of tools and jigs. Early in 1922, Marconi's had been looking for firms to manufacture domestic wireless sets under contract, and in July, Plessey won an order from them for 5,500 crystal sets and 5,000 V2 valve receivers. It was worth £30,000 and transformed Plessey overnight, establishing them in the forefront of the emerging Wireless Industry, enabling them to quickly expand and, within twelve months, to move to a large permanent factory site of their own at Ilford.

On October 18th, the British Broadcasting Company was at last formed. It comprised 300 British manufacturers and dealers in wireless receivers and accessories headed by the so-called 'Big Six': British Thomson-Houston Co. Ltd., the General Electric Co. Ltd., Marconi's Wireless Telegraph Co. Ltd., Metropolitan-Vickers Electrical Co. Ltd., the Radio Communication Co. Ltd., and the Western Electric Co. Ltd. It was registered on December 15th 1922 and although its licence was not issued until January 18th 1923 it was retrospective and gave permission to broadcast for an initial period of two years as from November 1st 1922, two weeks before the actual inauguration of broadcasting.

The B.B.C. was a limited liability company licensed under the Wireless Telegraphy Acts to conduct a broadcasting service "to the reasonable satisfaction of the Postmaster General". It was constituted with a capital of £100,000, of which £60,000 was contributed in equal parts by the six main wireless manufacturing firms who each had representation on the Board of Governors. John C.W. Reith was appointed as General Manager of the Company, and in October 1923 joined the Board as Managing Director. The Chairman received an annual remuneration of £500, and each of the Governors received £200 -all payments free of income tax! Smaller firms were represented by Sir William Bull (Director of Siemens) and Walter W. Burnham (Managing Director of Burndept) and the remaining 40,000 £1 shares (limited to 10,000 to any one applicant) were made available to any bona-fide British manufacturer wishing to join the Company, whether it was a long-established firm with impressive factory premises or one of the growing number of 'back-room' concerns with just a few employees. Each shareholder had to pay an initial goodwill deposit of £50, although this clause was subsequently abolished on October 1st 1923. Dividends were limited to 7.5 per cent and revenue was derived both from a half share of the 10s.0d Broadcast Licence introduced on November 1st 1922 and from royalties levied on certain wireless equipment sold to the public.

And so, on Tuesday November 14th, the British Broadcasting Company first began broadcasting from their single studio on the top floor of Marconi House in the Strand. The London station retained its call-sign 2LO, and with the programmes being beamed on 361 metres from a cage aerial perched high on the roof, listeners in London and the Home Counties were soon tuning-in to the first evening's entertainment: two copyright news bulletins each of about a thousand words, and two weather reports, put out at 6pm and at 9pm. The announcer was the station's Director of Programmes, Arthur Burrows, and at the start of each programme he informed listeners-in that he would read the 'messages' through twice, first quickly and second slowly, asking them to write in and say which pace they considered better. With the official programmes over, he then began a little informal talk by saying, "You know, this broadcasting is going to be jolly good fun!"

Both the news and the weather reports soon became important features of the B.B.C.'s daily programme. An agreement was reached with four British Press agencies (Reuter's, the Press Association, the Central News and the Exchange Telegraph Company), for them to supply a daily summary of the world's news, and the Meteorological Department of the Air Ministry agreed to supply the B.B.C. with two weather reports every night.

THE B.B.C.'S BROADCASTING POLICY

The B.B.C.'s broadcasting policy was primarily one of public service rather than of pure commercial interest, and headed by Reith, it strove for political independence and impartiality. The Company began by serving the most densely populated areas in each main part of the country first, to gauge the popularity of broadcasting and to test for future requirements. Compared to later broadcasting developments, the B.B.C. was, in 1922, using very low power transmitters and while the basic predicted range of reception had been calculated at about 100 miles, it was soon found in practice that the real limit of 'quality' reception was about 35 miles with a simple valve receiver and headphones, and only about 12 miles with a crystal set. Greater distances were obtainable at night and in special circumstances of weather and terrain, and for those rich enough to be able to afford multi-valve receivers, reception range was increased to well over 100 miles. Curious freaks of reception did occur of course: readable signals from 2LO were reported to have been received in the Shetland Isles on a 1-valve set, while nearly 200 miles away from London, reception was claimed on a crystal set at Bridlington, Yorkshire.

On Wednesday November 15th, the day after the opening of the first station, the B.B.C.'s second and third stations began broadcasting to listeners in the Midlands. They were Birmingham (call-sign 5IT) on 420 metres, owned by the Western Electric Company, and Manchester (call-sign 2ZY) on 384 metres, owned by Metropolitan-Vickers Electrical Company, each transmitting programmes of concerts and news from about 6pm to 10pm.

Both these companies had strong American connections and like Marconi's had been experimenting with wireless telephony for some time. The Metropolitan-Vickers Electrical Company had earlier in the year been given a licence to begin experimental broadcasts from their station in Manchester, having pooled their patents with those of the Radio Communication Company, who themselves were then operating an experimental broadcasting station from their works in Slough.

Earlier in October, the Western Electric Company, which was part of the Bell Telephone Group of America, had set up a 500 watt transmitting station (call-sign 2WP) in Norfolk Street, London. Later that month, the component parts of 2WP were transferred to Birmingham and installed in the works of the General Electric Company and given a new call-sign, 5IT.

At 6.30pm on December 23rd, the B.B.C.'s new station at Newcastle (call-sign 5NO) opened with an experimental transmission of concert music on 400 metres. By the close of 1922, the B.B.C. had four of its proposed eight main stations in operation, all transmitting within the Broadcast Band to an audience of nearly 36,000 listeners tuning-in on factory-made Broadcast Licence receivers, together with many thousands of amateur experimenters with home-constructed sets.

THE BROADCAST LICENCE

To legally tune to the B.B.C.'s programmes, listeners-in had first to purchase a licence; either the Experimenter's Licence for those building their own equipment at home, or the Broadcast Licence for the less technically minded who wanted a factory-made, 'ready-to-receive' set.

The 10s.0d Broadcast Licence had been introduced along with the B.B.C.'s royalty scheme on November 1st, two weeks before the inception of broadcasting. Although there were no restrictions as to the qualifications, experience or experimental objectives of the applicants, its terms did stipulate that the holder was only allowed to receive B.B.C. broadcasts on British-made equipment which had been manufactured by a member of the B.B.C. and registered and approved by the Post Office. All such equipment could be readily identified by a circular 'BBC/PMG' stamp of approval (see Appendix, fig. 907a) placed either on the cabinet or the panel of the receiver together with an engraved G.P.O. registration number. The stamp however, did not signify any guarantee of the quality of the receiver bearing it.

While the B.B.C. had not actually begun to broadcast until November 14th, this licensing measure was brought into force in advance with the aim of protecting the infant British Wireless Industry from foreign competition, as membership of the B.B.C. was open only to bona-fide British wireless manufacturers. As a contribution towards the expense involved in the erection and maintenance of suitable transmitting stations and studios and the maintenance of regular programmes, the B.B.C. was to receive a moderate royalty on all British factory-built BBC/PMG-stamped receivers, amplifiers and certain accessories sold to the listening public together with a 50 per cent share of the revenue from the Broadcast Licence.

Problems soon arose however, and continued to grow throughout the early part of 1923, as there was an unexpected and overwhelming public interest in the very much cheaper home-constructed type of receiver, whether assembled from odd components and work box 'bits and pieces' or from a commercially-made boxed kit of parts. Both the B.B.C. and the Post Office had miscalculated the appeal of home-construction and soon after official broadcasting began new home-constructors in their thousands applied for the 10s.0d Experimenter's Licence which gave them the legal right to build home-constructed sets which the Broadcast Licence did not. Armed with an Experimenter's Licence, listeners could also legally use non BBC/PMG-stamped factory-made receivers of either domestic or foreign origin. One British company, the Peto Scott Co. Ltd., even sold G.P.O.-registered receivers either with or without the stamp. Their 2-valve Broadcast Major cost an extra 35s.0d in royalties if sold stamped for use with the Broadcast Licence, although listeners could buy it un-stamped at the normal price if they had an Experimenter's Licence, thereby making quite a saving for themselves but otherwise depriving the B.B.C. of its royalty. The B.B.C. therefore were receiving no royalties on sales of un-stamped apparatus or kits of parts (commercially manufactured receivers in kit form were exempt from royalty payment), and no revenue either from the Experimenter's Licence.

In December 1922, in order to curb the rush for Experimenter's Licences, the Post Office re-defined the original terms of that licence by stipulating that it would be granted only for genuine home-made apparatus to bona-fide experimenters who actually *made* their own components. Mr J.W. Wissenden, Head of the Wireless Licence Department of the Post Office defined the term 'home-made' as follows: "Any set which does not contain bought parts such as transformers, inductances, condensers etc., built at home from raw materials by the amateur wireless experimenter constitutes a home-made set. Any major parts of the apparatus that have to be bought for the set (such as valves) have to be stamped with the B.B.C. stamp and therefore have to be of British manufacture. 'Home-made' does not mean sets that have been bought in a kit of parts or made up of wholly manufactured parts which only need a screwdriver or a pair of pliers to assemble them." Therefore, from December 1922, applicants for the

Experimenter's Licence were scrutinised with a lot more attention and an inevitable backlog soon built-up during the early part of 1923.

As well as the BBC/PMG stamp, all sets for use with the Broadcast Licence also bore a G.P.O. registration number, signifying that the circuitry of the set had been tested and passed by the Engineer-In-Chief at the Wireless Section of the General Post Office (North) London as conforming to the technical requirements laid down to prevent interference from oscillation. Before beginning production, a manufacturer had to submit an example of his receiver for testing and if found satisfactory, a registration number would be allotted to it and the set sealed, labelled and returned. All sets in the production run could then bear a BBC/PMG stamp and that particular G.P.O. registration number as long as they were identical to the sealed and registered set, which had to remain sealed and readily available at the factory in case of official inspection. (Post Office officials also had the authority to select sets from the production line and compare them with the standard model they had previously approved).

In December, *Popular Wireless Weekly* sent a reporter down to the Post Office's Wireless Section to see how the registration and approval systems were working. Half a dozen sets were lined up when he arrived and a vast amount of brown wrapping paper and packing provided evidence of how many sets had been there before. He tackled one of the department's officials with the question "Pretty busy?" and received the reply, "This broadcast business is a blessed nuisance!" "And," wrote the reporter, "what more satisfactory indication of the prosperity of the wireless trade could be desired?".

Valve receivers were of the 'tuned radio frequency' ('TRF') type, (also known as the 'straight' type) and used general purpose 'R' valves which could be used either as HF amplifiers, detectors or LF amplifiers. The ubiquitous 'R' valve (fig. 38), with its characteristic bulbous shape and 'top-pip' evacuation seal (a pinch of glass formed at the top of the valve during the air evacuation process in manufacture and common to practically all valves until 1925) dominated the domestic receiver market until towards the mid-1920s. It employed a 'pure' tungsten filament (a tiny trace of thoria was added to improve tensile strength) which required a high temperature to give the necessary electron emission (c.1,050 deg. C. - c.1,200 deg. C.). This consumed a large current from the accumulator and gave rise to the valve's characteristic feature of glowing like an electric light bulb when in use. For this reason it was known familiarly as a 'bright-emitter' and some frivolous people, on occasions when they weren't using their receivers for listening-in, instead merely connected the filaments to the accumulator and turned up the rheostats high enough to provide light to read by or even to light the room. *Wireless World* thought that this practice was extremely foolish and ought to be discouraged at all costs for it considerably shortened the valves' lives. With receivers of this period designed with valves mounted externally on the control panel, the valves' incandescence could prove rather trying on the eyes. To combat this, a device costing 8d placed on the market by a Mr R.F. Gordon of Weymouth provided one remedy. Rather similar in appearance and construction to a well-known family planning product, it consisted of a sleeve of black rubberised material which was rolled snuggly over the valve, and being opaque, effectively shielded the listeners' eyes from the glowing filament. On the upper end of the sleeve was a protective protrusion which prevented the valve's top-pip of glass from damage if accidentally knocked.

In practice the 'R' valve was usually very unstable particularly when used as a HF amplifier due to a small but troublesome anode-grid capacity which could very easily be made to produce excessive feed-back and distortion. To obtain

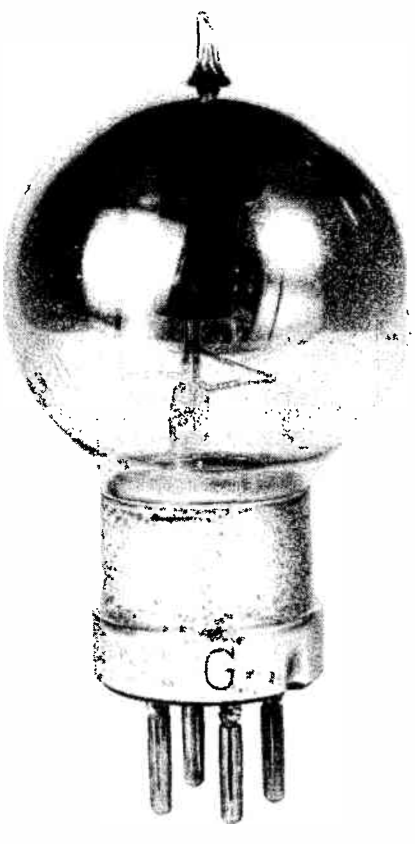


fig. 38 . 'R' Valve (actual size), by British Thomson-Houston Co. Ltd. Late 1922. A bright-emitter with a nickel-plated base. 4 ¼ in. high. Etched with the BBC/PMG stamp.

a degree of volume, the long-standing favoured method was to employ an adjustable reaction circuit in which part of the amplified energy from the anode of the valve in the aerial circuit was fed back by means of a swinging reaction coil to its grid and therefore further amplified. (The method of 'swinging coil reaction' was very popular until it was displaced by 'capacity controlled reaction' in 1927). The amount of reaction amplification was determined by adjusting the variable reaction control mounted on the panel which would sometimes be labelled 'VOLUME', although with the B.B.C.'s transmitters using very low power and with the relative inefficiency of receiving valves in general, there certainly wasn't much volume to control. Adjustable aerial circuit reaction generally gave better results than other types of circuit but was prone to cause severe oscillations in the receiver's aerial with only the smallest overuse of the reaction control knob by an unsuspecting or novice listener-in. This oscillation would then be radiated locally causing 'howling wails' to be heard in the headphones and loud-speakers of neighbouring receivers tuned-in to the same station for perhaps several miles around, possibly completely drowning out the programme being listened to.

Before the inauguration of the B.B.C., the use of adjustable aerial circuit reaction was universal but under the Broadcast Licence regulations, the use of adjustable reaction in the aerial circuit of all BBC/PMG-stamped valve sets was banned, although fixed reaction could be used in this stage if it was incapable of causing oscillation. Adjustable reaction could be used in a subsequent stage so long as it was not coupled to the aerial tuning circuit. The Post Office therefore only passed manufactured sets which did not oscillate but to produce an efficient receiver under these conditions was extremely difficult. Much to the annoyance of many long established and reputable firms, the home-constructor was virtually given a free hand as to the type of circuit he chose to build and any such amateur-built receiver, no matter how crude, inefficient or liable to cause interference, could cheerfully be used with the Experimenter's Licence without being subject to any kind of Post Office test or approval. Most of these sets had adjustable aerial circuit reaction and therefore most of the problems encountered with oscillation lay squarely with the home-constructor's set. Although the Experimenter's Licence stipulated that home-made sets must not be allowed to cause oscillation, the sheer number of home-constructors made it difficult for Post Office officials to carry out checks. Mr. W.W. Burnham of Burndept Ltd., voiced the opinion that experienced firms such as his were being treated by the Post Office as "schoolboys" by being compelled to submit their sets and this general discontent continued until reaction testing was abolished altogether in October 1923.

Reaction circuit interference from "inexpert amateurs" was very common during the early years of the British Broadcasting Company and was still something of a menace when the Company became a Corporation in 1927. Common too were the sometimes desperate appeals broadcast to listeners-in to control their sets and a black list of defaulting areas was often read out over the air in the hope of "shaming the delinquents". But soon, vast improvements to high frequency amplification with the wide adoption of Neutrodyne circuits in 1925 and the introduction of the screened-grid valve in 1927, led to the development of highly stable TRF receivers which became universal until the mid-1930s when they were finally ousted by the mains superhets.

Local interference from amateur transmitters was also very noticable within a few weeks of the inauguration of the British Broadcasting Company and their owners were politely requested not to carry out experiments during the broadcasting hours, 5pm to 11pm. The B.B.C. hoped to provide such high grade programmes that all amateurs would be listening-in instead of experimenting during the hours when the broadcasting stations were in operation.

LISTENING-IN

Two basic types of factory-built receiver were available to the public for listening-in to the B.B.C.: the crystal set and the battery-driven valve receiver. There were no plug-in mains receivers at this time and it would be another few years before the first commercial 'mains' wireless receivers began to appear (see 1925).

Crystal Sets

Crystal sets were in general designed for short-range reception of their local medium-wave broadcasting station, and could be used satisfactorily up to about 12 miles from the transmitter. They were by far the most popular type of receiver, due mainly to their sheer simplicity in use, relative cheapness and compact size: most were housed in a small polished wooden box-like cabinet, little bigger than a biscuit tin (fig. 39). They employed a mineral crystal (usually galena) in delicate contact with a tiny coil of wire known as a 'cat's whisker' to detect the transmitted high-frequency currents which were then converted into audio-frequency currents enabling the broadcast programmes to be heard through a pair of headphones. It was not a question of simply turning the set on, for the listener-in first had to carefully search the crystal with his cat's whisker in order to find a spot sensitive enough to produce a good signal in his headphones, (a process called "tickling the cat's whisker"), and this could take some considerable time. Care had to be taken too, once a good contact had been found, not to jog the detector (which was usually protected from dust by being enclosed in a glass tube) as the cat's whisker/crystal arrangement was easily upset: 'permanent detectors', which required no adjustment, were employed by some manufacturers but were never very widely used.

fig. 39. Gecophone Model No.1 Type BC 1002, by General Electric Co. Ltd. 1922. BBC/PMG Stamp, GPO Reg.No.102. Crystal set for headphone use, glass-enclosed cat's whisker/galena detector (open detector version also known), provision for plug-in coils, variometer tuning, ebonite control, nickel-plated fittings, mahogany box with lift-up lid. 6 ¼ in. x 9 in. x 6 in. (closed). £5.10s.0d.

fig. 40 . Exploring the crystal with the cat's whisker in order to get a good signal could prove a time consuming task, leading in some cases to the point of frustration.

For tuning purposes, either a variometer or a cylindrical inductance coil with a slider or tappings was used - the variable condenser (then the 'straight-line capacity type' with semi-circular metal vanes) was at this time quite an expensive component and although fairly common in valve receivers, it was not usually employed to any appreciable extent in crystal sets until 1923 when cheaper examples appeared. While most crystal sets covered the medium-wave Broadcast Band only, a few were provided with interchangeable plug-in or slot-in tuning coils which enabled their basic tuning range to be extended. This was useful for those within reception range who might enjoy listening-in to the ground-to-air conversations from Croydon Aerodrome on 900 metres, or who wished to set their watches or clocks by the Paris time-signals on 2,600 metres.

In the main, the crystal set was for the solitary listener-in even though it was possible to connect up another pair of headphones without too much loss of signal strength. Family listening was generally ruled out as, without the aid of amplification, the output was not strong enough to drive a horn loud-speaker; but it was a fairly common practice to place the headphones in a china fruit bowl or pudding basin which seemed to amplify the signals a little, especially if everyone huddled around.

Unlike valve receivers, crystal sets worked without batteries as all the necessary power came directly from the energy of the transmitted waves picked up by the outdoor receiving aerial. (There were a few rare exceptions to this, with crystal sets using a carborundum crystal and a steel contact, where a small cell of about 1.5 volts was needed to polarize the crystal in order to get it to function properly, fig. 64). The most common form of outdoor receiving aerial was the horizontally mounted 'L' type: a large, cumbersome affair, strung up on poles or fixed to a tree in the garden with the down lead-in wire to the set positioned at one end giving the whole aerial its characteristic 'L' shape. The Broadcast Licence permitted the use of up to 100 ft. of aerial wire and for maximum signal strength this had to be carefully positioned so that it was in a direct line with the nearest broadcasting station.

Given that the crystal set's reception range was not very great, then with a large outdoor aerial, plus a good earth connection and a pair of headphones, plenty of entertainment could be enjoyed for the investment of an average week's wages. As *Popular Wireless Weekly* reported, listening-in soon became "Britain's most favourite hobby - afforded by everyone!"

Valve Receivers

In comparison to crystal sets, battery-driven valve receivers were very expensive. They were capable of greater receiving ranges but were larger and more complicated and generally looked as though they would be far more suitable on a science laboratory bench than in the domestic surroundings of the home. Some, *Wireless World* thought, were of "fearsome appearance" (fig. 41) with their ebonite control panels festooned with an imposing array of protruding bright-emitter valves, plug-in tuning coils for various wave-ranges, knobs, switches and dials. The panels themselves were characteristically either sloping (fig. 65), horizontal (fig. 53) or vertical (fig. 41). Receivers employing from one to as many as eight or more valves were available on the market, and listeners tended to go for the cheaper and basic models like the comparatively short-range 2-valve (DET/LF) receivers rather than the more specialised long-range multi-valve sets which were not very economic due to the heavy filament current consumption and the initial cost of each valve. Valves were not generally included in the price of the receiver and like the other accessories such as batteries, earth wire and an aerial system, they had to be purchased separately.

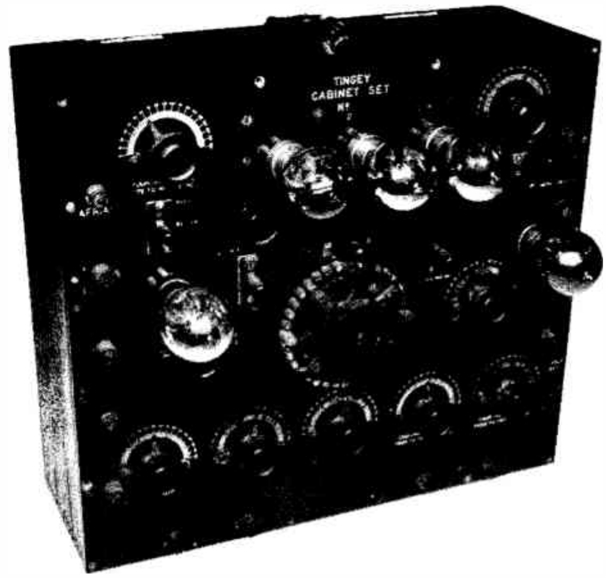


fig. 41 . 'Cabinet Set', by W.R.H. Tingey. Early 1922. A 5-valve receiver with 3 or 5 valve switching, covering 175 to 28,000 metres in 7 stages, ebonite control panel, ebonised wood case. 16 in. x 18 in. x 7 in. Typical of the "fearsome" type of valve receiver described by *Wireless World*, with its scientific-looking panel bristling with controls.

Valve receivers were of the 'permanently installed' type, and it was not practical to move them once they had been wired-up via panel terminals to the aerial, earth, HT and LT batteries and headphones or, if capable of driving one, a horn loud-speaker. The whole assortment, with trailing wires and accessories spreading out around the receiver, constituted the 'wireless *set*' in its original meaning. If space for an outside aerial system was limited, for example in the case of a flat-dweller, a small indoor directional frame aerial, mounted on a stand or fitting into the top of the receiver's cabinet, was usually found to be adequate for local station reception, although the actual amount of energy it picked up was small.

A good low resistance earth connection was thought essential and there were several methods of obtaining it. The most elaborate was to bury a fan-shaped system of wires under the entire length of the aerial, or the listener could purchase a specially produced copper earth mat which was buried deep in the ground preferably in a damp part of the garden: a 7lb. biscuit tin or an old copper saucepan could give similar results. Most listeners though used a copper tube driven into the earth which they frequently watered. Wiring the receiver's earth terminal to an outside water pipe or an interior gas pipe were other favoured and perhaps more convenient methods, but with the latter, leaded joints in the pipe offered a high resistance which made the connections inefficient. To protect both the receiver and the home from lightning, (an outdoor aerial was an excellent lightning conductor), a throw-over switch was usually employed which disconnected the aerial from the receiver and connected it to the earth wire and thereby directly to earth. But there were apparent hazards with connecting the aerial system directly to a gas pipe being used as the earth which most wireless magazines and books were at pains to point out.

At this time, valve receivers in general were designed for headphone use, although some of the more powerful multi-valve models and those which were used with a separate valve amplifier were capable of driving a horn loud-speaker (a 2-valve DET/LF receiver could also drive a horn loud-speaker if used very close to a transmitter). Loud-speakers with metal, wood or ebonite horns were only being produced in small numbers, and these were usually straight-necked or curved-necked. A few of the more 'modern' swan-necked variety were only just beginning to appear but by the following year these had become the dominant design. Most horns were made of metal (spun aluminium or copper), and these had the annoying property of vibrating at certain specific frequencies especially during passages of loud orchestral music. Some were finished in a crystalline paint which helped to overcome the problem but horns made of ebonite, like those made of wood, were thought of as being comparatively non-resonant.

The sound, intensified by the horn, was reproduced from a drive unit housed in the base of the loud-speaker and the vast majority of these used a magnet system which was very similar to that found in headphones, only with a somewhat larger soft-iron diaphragm. Arrangements were made, via a 'sensitivity control', for altering the distance between the diaphragm and the pole pieces of the magnet so that the drive unit could be adjusted according to the power output of the receiver, a feature which in some cases was used in headphones such as the Brown Type 'A'. Sensitivity controls were also used in moving-iron cone loud-speakers following their introduction in the mid-1920s. During the late autumn of 1922, the first energised moving-coil horn loud-speaker, the Magnavox R2B, was introduced into Britain from America by the Sterling Telephone & Electric Company and this was certainly the most sophisticated horn loud-speaker then on the market (fig.820). In 1926, moving-coil *cone* loud-speakers were introduced which within a few years superseded all other types and became the standard approach to loud-speaker design.

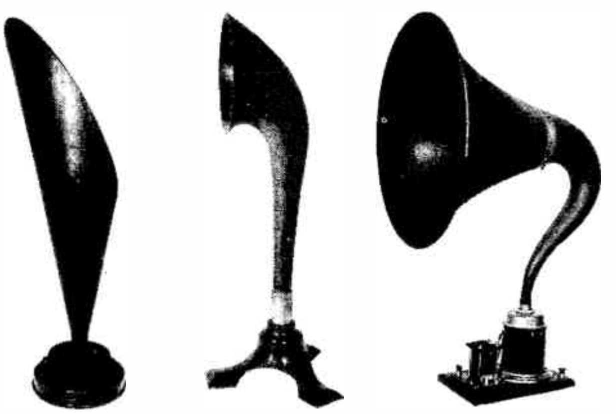


fig. 42 . Straight-necked, curved-necked and swan-necked horn loud-speakers of 1922.

In 1922, wireless receivers, accessories and components were generally bought from the relatively few specialised wireless and electrical retailers established in the cities and towns within the service area of the four B.B.C. stations, or they could be obtained by mail order direct from the manufacturer. (Valves were not generally sent through the post owing to the risk of breakage and were usually purchased locally). Quite unrelated establishments such as cycle shops, newsagents, tobacconists and chemists also sold wireless sets but within a few years, as broadcasting encompassed practically the whole of Britain, a network of specialist wireless retailers was established around the country and the wireless shop, usually with its backroom service engineering department providing repair, battery charging and valve testing facilities, became as common a sight in the High Street as the butchers' or the bakers', and was probably more frequented by men than any other shop in town.

The wireless retailer was the last link in the chain of marketing and his shop was soon to become the showroom of Britain's fastest growing industry, supplying an ever enthusiastic listening public with the latest receivers, headphones, loud-speakers, batteries, components and valves.

In 1922, valves were generally of the 4 volt bright-emitter type and to supply filament current, 6 volt accumulators were required. Known as 'low tension' ('LT') batteries, these comprised three series-connected 2 volt lead-acid cells housed in thick glass containers (fig. 43). Accumulators were very heavy and needed frequent re-charging (the charge lasted from 2 to 3 weeks with average use), and while most battery set users had to put up with the inconvenience of lugging their accumulators down to the nearest wireless retailer or garage who could provide this service, home-charging units had become available during the summer for use in homes connected to a DC mains supply. In September, the Hart Accumulator Company of London inaugurated a motorised re-charging service for the convenience of their customers in outlying districts which was soon to be copied by other battery firms and garages around the country. For 6d a time, the used accumulator would be collected and swapped for a re-charged one, the customer of course having initially to purchase an extra accumulator. Valve receivers also required a 'high tension' ('HT') battery to supply the valves with anode voltage (fig. 44). These were mostly non re-chargeable and would last about 3 to 4 months.

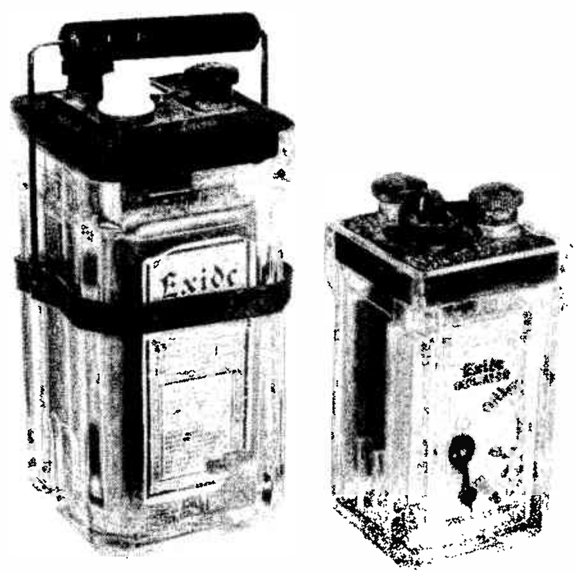


fig. 43 . Lead-acid accumulators, also known as 'LT' (low tension), 'secondary', 'storage' or 'wet' batteries, were re-chargeable 2 volt batteries of varying current capacity, consisting of a thick glass container in which two sets of lead plates were fitted. The plates were made up of lead grids filled with paste: a mixture of red lead, litharge and sulphuric acid for the positive plate, and a mixture of litharge and sulphuric acid for the negative plate, (the sulphuric acid in both mixtures was allowed to dry out before the cell was assembled). The plates, separated by hard wood or ebonite separators, were immersed in an electrolyte comprising a solution of pure sulphuric acid diluted with distilled water to the required specific gravity. Accumulators provided the filament current for the valves and would last about two to three weeks before they needed re-charging, depending upon the number and the type of valves used and the time spent 'listening-in'. In 1922, a 3-cell 6v accumulator of 40 ampere-hour capacity complete in a 7¼ in. x 10 in. x 5½ in. wooden carrying crate cost around £2.10s.0d, and the re-charging service, which usually took about 24 hours, cost around 6d. From the mid-1920s, 'unspillable' accumulators with a 'jelly' electrolyte and accumulators housed in lighter weight 'unbreakable' celluloid containers became popular for use with battery portable receivers. The LT batteries in the photograph date from the late 1920s.

In November at the Olympia Motor Show, Marconi's and Daimler carried out experiments intending to exploit the commercial possibilities of car radio. An experimental receiver was mounted adjacent to the back seat of a limousine to pick up programmes sent from a temporary Marconi transmitter (call-sign 2BP) set up in Olympia for the duration of the show.

However, little came of these experiments and the development programme was subsequently dropped. Over the next ten years, there were various private experiments with car radios (see 1927) but they remained little more than a novelty until the introduction of the first commercially manufactured model in 1932 (see 1932).

In 1922, a few valve sets began to be housed in neat upright wooden cabinets with a battery compartment below and double doors above which were kept closed when not in use to hide the control panel. Known as 'smoker's cabinet sets' because of their resemblance to this article, they became popular with several manufacturers and were the first real attempts to make the wireless fit in with domestic furnishings (fig. 56).

Completely 'all-enclosed' sets with both batteries and a horn loud-speaker contained within the cabinet were rare. One of these, by Wates Bros., was the Cabinet Set which was built into a writing bureau, and Anode Wireless & Scientific Instruments Ltd. offered a Table Model (literally!) with the receiver and all its accessories housed neatly within a rectangular mahogany table so as to "harmonise with the other furniture in the room".

'Unit sets' were very much in evidence too, both in factory-built and home-constructed form (fig. 65). Any number of separate add-on units (e.g. a detector or LF stage) could be purchased as and when required and linked by standard terminal connections to be assembled into anything from a simple crystal set to a multi-valve receiver depending upon the budget or the requirements of the listener-in.

A new type of circuit introduced at about this time was the reflex circuit in which one of the valves served the double purpose of acting simultaneously as an HF and an LF amplifier (fig. 60, Marconiphone Model V2).

Home-construction grew increasingly popular, for with a minimum of technical knowledge, building a receiver on the kitchen table offered a cheaper and to many, a more rewarding way of listening-in, especially if the set worked after it had all been wired together! For the even more technically minded, making some components by hand was comparatively straight forward although there were many sources of cheap ready-made components available to save both time and trouble. There were also many books on the subject and one of the most well known names in this field was that of John Scott-Taggart. A keen experimenter since before the First World War (see 1913), Scott-Taggart founded The Radio Press in 1922 which concentrated on books and magazines (notably *Modern Wireless* and *The Wireless Constructor*) published with the home-constructor's market in mind. He was a prolific writer, with innumerable wireless books and magazine articles to his credit, and amongst wireless collectors, is perhaps best known for his famous series of circuits which bear his initials 'ST' (see 1932).

The problems over the Experimenter's Licence had given the green light to some foreign component manufacturers, who took full advantage of the situation and began to flood Britain with cheap stock. There were plenty of ex-Government components around to experiment with too, as well as surplus World War One wireless receivers, much of it suitable for medium-wave reception. At least one of these receivers, the 1916 Mark III Tuner, was given its own G.P.O. registration number (Reg.No.237) when it emerged in December 1922 in a slightly modified guise as the McMichael Radiomac Crystal Mark III crystal set. This version covered "the entire broadcasting and shipping range, 150/1200 metres" and was described in McMichael's advertisements as "Brand New!", which was probably an accurate statement since the bulk of Mark III Tuners released onto the market straight from Government stores were unissued and had never seen active service.

fig.44 . High tension ('HT') batteries, which were also known as 'primary' batteries, were necessary to provide the valves with anode voltage, and comprised a large number of series-connected 1½ volt dry cells usually arranged neatly in a strong cardboard box and well sealed in with paraffin wax or pitch to form a single unit. Depending on the valves and the type of receiver used, HT batteries in sizes from 45 volts to as much as 180 volts were available, and these were provided with tappings taken from groups of cells at regular intervals so that variations in voltage could be obtained as desired. While being non re-chargeable, a good quality HT battery could, with average use, last for about three to four months and in 1922, one of 60 volts in a 3½ in. x 9 in. x 2¾ in. container cost around £1.0s.0d. HT batteries were sometimes made up of series-connected accumulators, but these were usually used only by listeners who were in a position to do their own re-charging or had a regular collection and re-charging service. The HT batteries in the photograph date from the 1930s.

With valve sets, a good percentage were capable of being adapted to tune outside the medium-wave Broadcast Band by means of interchangeable plug-in coils and this meant from below 200 metres to above 20,000 metres, encompassing both wireless telephony and Morse transmissions. With some models, tuning could be a highly complex process as there were several controls which had to be adjusted and balanced up correctly. The use of a wavemeter to measure the wavelengths of stations in order to calibrate the dials, was useful (fig.179, a later example).

While tuning in both crystal sets and valve receivers was comparatively 'coarse', there was at least one early use of an auxiliary vernier condenser to obtain finer tuning (fig. 62). This was a small unit, comprising one moving and two fixed metal vanes, connected in the circuit of the main tuning variometer making possible fine adjustments in steps of about a tenth of a degree. Although this component first appeared in a crystal set it was not long before vernier condensers were adopted in some valve receivers too and from 1925 they became generally available (see 1925).

As a more accurate indication of station tuning, some listeners-in with valve receivers employed a milliammeter placed in series with the positive HT battery lead and the anode of the output valve, which gave a visual indication of the signals received. The needle would deflect to a maximum point when the required station was fully tuned in, and an accurate reading of the strength of the signal received could then be taken. Visual tuning indicators of this type were occasionally included on the panel of some commercially manufactured valve receivers during the 1920s, but with the advent of automatic volume control and the need for far greater tuning accuracy in the 1930s, various types of visual tuning indicators became widely adopted (see 1932). Another meter sometimes seen on the panels of sets of the 1920s was the ammeter, which was used for measuring filament current.

In general though, the only visual guide to tuning in 1922 was by the two types of dial then in common use. Both had been used in military equipment during World War One and had influenced the design of domestic wireless equipment after. The first type was a rotating, circular dial in Bakelite or ebonite, with white 0-180 degree engraving on the bevelled edge of the dial itself (sometimes 0-100 degrees) and a fixed datum line engraved on the panel so that the reading was always in the most convenient position for the eye (fig. 56). Once broadcasting got under way in November 1922, this latter type of dial was universally adopted and continued practically unmodified for several more years.

The second type of dial was a rotating control knob with an attached pointer to indicate the settings on a semi-circular degree-marked Ivorine scale screwed onto the panel (fig. 53). Less commonly, these scales were also transfer printed or engraved directly onto the panel. Similar, smaller controls were also used to indicate the filament current of bright-emitter valves. Although bright-emitters were universally employed in wireless receivers of this period, they were recognised as being relatively inefficient, for they gave only a tiny power output while their filaments could consume nearly 3 watts. But about this time, interest began to be shown in a new improved class of valve known as the 'dull-emitter', the first commercial example of which, the LT1, had been produced by the M-O. Valve Company in March 1921. The dull-emitter employed a non-incandescent filament made of tungsten coated with thoria which gave the same necessary electron emission as the bright-emitter while operating at a very much cooler temperature (c.600 deg. C. - c.750 deg. C.). It therefore had a very much lower current consumption and required a smaller filament voltage (c.0.8v - 3v).

Initially costing more than an 'R' valve, early thoriated tungsten dull-emitters were too expensive for most listeners-in. But from 1923 with the introduction of the first standard ranges and the lowering of prices, they gradually became popular and soon superseded bright-emitter types, their heyday being from 1925 to about 1927 when they in turn began to be displaced by barium oxide coated types (see 1927).

1923

On May 1st 1923, the British Broadcasting Company moved its 2LO studio to new premises a few hundred yards away at the Institution of Electrical Engineers' building in Savoy Hill, while the original transmitter and aerial were kept in position at the top of Marconi House with a Post Office line connecting the two buildings. This move permitted the gradual construction of several additional studios at Savoy Hill and by the time these had been superseded by the new purpose-built Broadcasting House in May 1932, nine studios were completed, the largest of which (the concert hall) measured 45 ft. x 26 ft.

The first phase of the B.B.C.'s mainland broadcasting scheme was completed on October 17th with the opening of the eighth main station at Bournemouth (call-sign 6BM) on 385 metres. Cardiff (call-sign 5WA) on 353 metres had opened on February 13th, Glasgow (call-sign 5SC) on 415 metres on March 6th and Aberdeen (call-sign 2BD) on 495 metres on October 10th (the Broadcast Band had been extended in October 1923 following recommendations of the Sykes Committee: see THE LICENCE PROBLEM, below).

Each of the eight main stations produced its own separate programme from its own studio which meant that some eight complete programmes had to be produced every night. This proved very expensive and it soon became clear that if broadcasting became very popular and was allowed to expand, it would be essential to increase the potential number of listeners without increasing the number of separate programmes. This led to the establishment of eleven relay stations around the country by the end of 1924, each with a transmitter output of about 120 watts serving their immediate local area for a radius of about 5 miles.

The first relay station, Sheffield (call-sign 6FL) on 303 metres, was opened on November 16th. The relay station scheme was one of the recommendations of the Sykes Committee following its investigation into broadcasting. The relay stations were to provide a few of their own productions but mainly a simultaneous broadcast programme fed by Post Office telephone lines from London, Glasgow or Cardiff: their own programme costs were therefore very much lower than in the case of the B.B.C.'s main stations.

By the mid-1930s, most of the B.B.C.'s stations were interconnected by long-distance underground cables specially designed for the purpose of simultaneous broadcasting, but when this method was first introduced (Glasgow did the first official 'SB' in the winter of 1923) ordinary Post Office telephone lines were used. By connecting the various broadcasting stations together it was possible for all, or a combination of those stations, to broadcast one single programme simultaneously.

LISTENING-IN

In the winter of 1923, just a year after broadcasting began, there were over 500,000 licensed receivers grouped around the eight main stations and one relay of the British Broadcasting Company. Unless you happened to live close to one of these stations, the type of receiver you could afford to buy did limit your listening. It would be a bad investment to purchase a cheap crystal set if you lived a hundred miles or so away from a transmitter, for the receiving range of this type of set was very limited. Of course, if money was no object, you could buy a long-range multi-valve set and be assured of hearing *something* entertaining practically anywhere in Britain, and there was often the possibility of picking up some really long-distance stations from Europe or even America, especially during long winter evenings when conditions were more favourable.

Fig. 45 . The chance of getting America or other distant stations often kept the really keen listener-in up till the early hours of the morning.

In January there had been a large increase in the purchase price of many valve receivers due to the introduction of the Marconi A1 Licence. A royalty was payable to Marconi's at the rate of 12s.6d per valve holder on receivers covered by Marconi patents and made by member firms of the British Broadcasting Company. (The 'Big Six', under the A2 Licence, paid only 7s.6d per valve holder). During the Marconi Company's existence, it had probably done more original research than any other firm, and this had resulted in an accumulation of patent rights made out in the names of various employees of the firm. Added to this were numerous other patents which had been purchased outright from other companies. Since practically every type of valve set made for broadcast reception was likely to involve the use of various circuits patented by Marconi's, it was usual for manufacturers to work under their patent licences.

In March, Plessey left London and moved to large factory premises at Ilford, Essex and from here it was to grow into one of Britain's foremost manufacturers and suppliers of unbranded chassis, loud-speakers and components to the Wireless Industry. (By 1950, it was the largest manufacturer of radio components in the Commonwealth). On December 29th 1923, the Marconiphone Company Limited was set up by Marconi's to take over from them the responsibility of the sale and distribution of domestic broadcast receivers and accessories and Plessey continued to make Marconiphone receivers for them until 1926. By then, Marconi's had acquired their own domestic wireless manufacturing company, Sterling Telephone & Electric Co. Ltd., who had a factory at Dagenham, Essex, shared office buildings with Marconiphone at Tottenham Court Road and with whom Marconi's had already established a mutual trading relationship. From 1926, orders continued to be received by Plessey from many other wireless companies and soon Plessey branched out into additional fields of production which led to a long association with the Post Office and the Ministry of Defence.

By 1923, the public were getting more used to having the wireless in their homes and as well as hours of entertainment of all kinds, it was providing special services of news, "S.O.S." messages and communiques and weather forecasts, although to some, wireless was still regarded with suspicion. A dealer who ran a battery charging service round the Exmoor farms in his district in the early 1920s recalled a remark made by a farmer's wife whose husband was off hay-making. "He'd better be careful," the dealer told her, "the *wireless* speaks of rain!" "Where did 'ee 'ear that?" she demanded. "Why, on Mrs P.'s set up at Higher House." he replied. The woman sniffed the air disdainfully. "Don'ee take no notice of what that wireless tells 'ee," she said, "'tis only a cheap ol' set!"

The wireless was a distraction and as 'Ariel' reported in the January 20th 1923 issue of *Popular Wireless Weekly*, "the craze for wireless is spreading more rapidly than ever. People are indeed going wireless mad and are forgetting their work. One business man has complained to Marconi House that wireless has been responsible for his wife neglecting her household duties. 'At half-past five each evening,' he wrote, 'instead of my wife preparing the evening meal, she sits down to listen-in'. Perhaps before long, we shall hear of wireless divorces."

On September 28th, the first issue of *The Radio Times* was brought out by the B.B.C. and within a few days over 250,000 copies had been sold. Unlike other publications on wireless, this "Bradshaw of Broadcasting" as the B.B.C.'s Director of Programmes Arthur Burrows described it, did not deal specifically with the technical aspect of the subject but took as its main theme the popular entertainment side of broadcasting, and backed this up by including full programme details of all the B.B.C. stations for the coming week together with news of the Company's activities. Since the inauguration of the B.B.C.'s first station in November 1922, listeners had been able to obtain programme times and details from information published in newspapers and in various wireless magazines such as *Popular Wireless Weekly*. But by early 1923, some newspapers began to fear the competition that this new medium of broadcasting was apparently presenting. This led them to hold a one day boycott of the B.B.C.'s programme listing in February as a protest. However, this incident backfired on them for it was enough to convince the B.B.C. (and Reith in particular) that the Company should bring out its own independent weekly publication and no longer rely solely on the Press for informing listeners of the details of the B.B.C.'s programmes.

In general, the approximate receiving range using headphones of the various types of factory-built receiver available in 1923 was as follows: Crystal sets (12 miles), 1-valve sets (25/30 miles), 1-valve/crystal sets (45 miles), 2-valve sets, HF/DET (50/80 miles), 3-valve sets, HF/DET/LF (80/120 miles), and 4-valve sets, 2 HF/DET/LF (120/250 miles).

One problem encountered by those equipped with moderate-range valve receivers and living close to their local broadcasting station, was the interference from it. Even though only nine B.B.C. stations occupied the Broadcast Band on the medium-wave, some of their wavelengths were relatively close together, and often when attempting to tune into a more distant station on a wavelength similar to that of their local station, listeners-in would hear both signals together. As a device for eliminating the station causing interference, 'wave-traps' became available for the first time in commercial form. They comprised a unit made up of a coil connected in parallel with a variable condenser, and this was placed between the aerial lead-in wire and the aerial terminal of the set. The unwanted station could then be tuned out by adjusting the variable condenser in the wave-trap although this tended to cause the desired station to diminish in signal strength and meant that the wave-trap usually had to be adjusted again when other stations were required. (With the inauguration of the B.B.C.'s Regional Scheme in the early 1930s, wave-traps were once more back in favour and were employed to combat interference problems encountered particularly by listeners using older types of receiver. See 1930).

THE LICENCE PROBLEM

By the end of April 1923, some 260 British wireless manufacturers had become members of the British Broadcasting Company and the number of various different models of receiver given a G.P.O. registration number had reached 1,450 with some 80,000 BBC/PMG-stamped sets in operation. This figure included all classes of equipment, from crystal sets (still by far the greatest number), valve/crystal sets, 1,2 and 3-valve sets and multi-valve sets and amplifiers. Of the valve sets, those with a 3-valve HF/DET/LF type of circuit were the standard product of many of the top manufacturers and were usually chosen by those prepared to pay a good price for a good quality receiver, while the 2-valve DET/LF type were very popular with the general listening public since they permitted the use of a loud-speaker within short-range of a transmitter.

But there was increasing competition from the home-construction market which threatened the section of the British Wireless Industry which produced ready-made sets and which only now was beginning to grow and to establish itself. The licence problem grew worse, and because the Post Office was looking more closely at new applicants for the Experimenter's Licence, a huge backlog built up during the spring and summer of 1923. Every week more interest continued to be shown in home-construction and a great deal of attention was now being paid by component manufacturers to the design and production of component parts from which the wireless experimenter could build his own wireless apparatus in his own home without too much skill. Kit-receivers, a packaged set of parts complete with a cabinet, were also becoming widely available (fig. 89) and most wireless magazines carried regular articles on circuits and also published plans and blueprints to aid home-construction. In May, details of the new Neutrodyne circuit from America were first published in *Wireless World* who tried to encourage home-constructors to build it since it was a very selective circuit with an HF stage free from causing oscillation interference (see also 1925).

As news of the Post Office backlog spread, more and more home-constructors, either deterred from applying for a licence or just fed up with the long wait, (or even those who had been refused a licence), simply carried on listening-in without a licence of any kind. This serious situation then led to a Parliamentary Committee of Enquiry under the Chairmanship of Sir Frederick Sykes (the Sykes Committee) being assembled in April to help unravel the licence tangle and to review broadcasting as a whole.

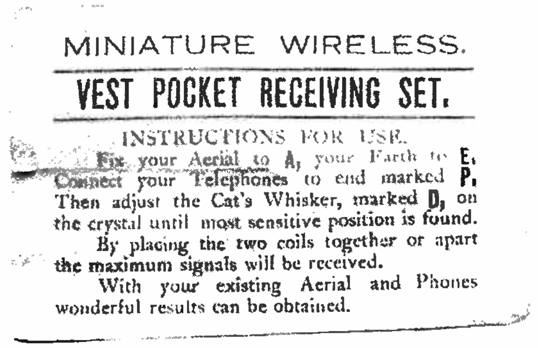
Far from being critical of the B.B.C., the Sykes Committee's report, published on October 1st 1923, recommended the extension of the B.B.C.'s licence to broadcast until December 31st 1926, the immediate establishment of various relay stations around the country to further enlarge the broadcasting service and an extension of the present Broadcast Band to cover 300 to 500 metres but excluding 440 metres to 460 metres. (The reason for this exclusion was that the 450 metre wavelength was being used by direction-finding stations, and enough clearance either side of this had to be given to ensure freedom from interference). To substantially reduce the B.B.C.'s partial dependence on the Wireless Industry, the Sykes Committee recommended the abolition of royalties on sets sold by its member firms, and an increase in the B.B.C.'s share of the Broadcast Licence revenue from 50 to 75 per cent.

With regard to the licence problem, the Committee recommended the introduction of a single form of licence. However, this was not introduced until January 1st 1925 (see 1925) when protection of British manufacturers against foreign competitors ceased. At the time of the Committee's report, it was estimated by the Post Office that there were in the region of 200,000 unlicensed receivers in illegal use throughout the country, and so, on October 4th, two new licences were introduced as a counter-measure. They were the Constructor's Licence at 15s.0d for those wishing to construct their apparatus at home using British-made components only, and the Interim Licence also at 15s.0d introduced as an amnesty for all those listening-in on unlicensed equipment which included home-constructed sets made with foreign components and factory-built sets not bearing the BBC/PMG stamp or a registration number. These measures had the desired effect as licence figures for the end of October reveal: Broadcast Licences (128,000), Experimenter's Licences (59,000), Constructor's Licences (29,000) and Interim Licences (200,000).

fig. 46 . Square wires and sloping panels - members of the Hounslow Wireless Society passing a winter's evening in November 1923. Home-construction was very popular, for it offered a cheap alternative to expensive factory-made receivers and was often more of a challenge to the science-minded 'amateur' armed with his 15s.0d Constructor's Licence.

At the beginning of October, the Post Office's requirements for broadcast receivers were revised and out of consideration for manufacturers who were very seriously handicapped by the difficulties experienced in having to design receivers capable of non-oscillation, the testing of sets with regard to reaction circuits was abolished with the consequent appearance of Post Office approved receivers with adjustable aerial circuit reaction. Receivers for use under the Broadcast Licence still continued to be approved and stamped, but were now merely tested to see if they were capable of receiving the B.B.C. stations on both a long and a short aerial. While *The Wireless Trader* had given a full account of these test revisions in their November 1923 issue, the facts did not become generally known outside the trade until January 1924, when *Wireless World*, alarmed by the increase in interference naturally brought about by these sets, published a critical account of the Post Office and wondered why the public had not been informed. With the changes, it was inevitable that there should be a great rise in oscillation interference particularly as so many new listeners-in who bought these sets were completely ignorant of the technicalities of wireless. Seeing the BBC/PMG stamp of approval displayed on their receiver they naturally assumed that it was exactly the same as all the other non-oscillating receivers that had gone before and were often blissfully unaware of the problems they were causing.

On the same day as the Post Office's test revisions (October 1st), as a first step towards total abolition, the B.B.C. greatly reduced the royalty payable upon the purchase of factory-built BBC/PMG-stamped apparatus and abolished it entirely on valves, headphones and loud-speakers. Crystal sets benefited well from this for royalties on them dropped from 7s.6d to just 1s.0d and listeners found that those crystal sets which before had only been available in kit form (fig.100), and so had avoided the royalty dues, could now be purchased ready-made for only a shilling extra.



MINIATURE WIRELESS.

VEST POCKET RECEIVING SET.

INSTRUCTIONS FOR USE.

Fix your Aerial to A, your Earth to E, Connect your Telephones to end marked P, Then adjust the Cat's Whisker, marked D, on the crystal until most sensitive position is found.

By placing the two coils together or apart the maximum signals will be received.

With your existing Aerial and Phones wonderful results can be obtained.

fig. 47 . Crystal sets came in a variety of shapes and sizes. This unusual miniature receiver, built into an ordinary Bryant & May's matchbox, was provisionally patented by W.J. Hunt and was first shown at a trade exhibition of toys and novelties at the Royal Agricultural Hall in London in July 1923. It was known as the 'Vest Pocket Receiving Set', and was made with only a very short production run by Radiax Ltd. of London W1. The circuit comprises a primative loose-coupled arrangement, made up of two cotton-covered wire coils (the exposed end of one forming a cat's whisker), a galena crystal and boot eyelets for aerial, earth and headphone connections. The detector and coils are extremely difficult to adjust being so small and unstable. Box, ¾ in. x 2¼ in. x 1½ in. Price 2s.6d.
A 'de-luxe' version (for the same price) is known which came with an imitation lizard skin wrap-around label bearing the legend "Miniature Wireless Marvel" in gold lettering together with the distributor's name and address, "Agents - Samuels Ltd., 84 Strand, WC2". Neither version bore a BBC/PMG Stamp nor a G.P.O. registration number.