DEPARTMENT OF COMMERCE

RADIO SERVICE BULLETIN

ISSUED MONTHLY BY RADIO DIVISION

Washington, December 31, 1927—No. 129

CONTENTS

ABBREVIATIONS

The necessary corrections to the List of Radio Stations of the United States and to the International List of Radiotelegraph Stations, appearing in this bulletin under the heading "Alterations and corrections," are published after the stations affected in the following order:

Name = Name of station.
Loc. = Geographical location. O=west longitude. N=north latitude. S=south latitude.
Call = Call letters assigned.
System = Radio system used and sparks per second.
Range = Normal range in nautical miles.
W. l. = Wave lengths assigned: Normal wave lengths in italics.
Service = Nature of service maintained:
FX=Point-to-point (fixed service).
PG=General public.
PR=Limited public.
RC=Radio compass.
AB=Aviation beacon.
B=Beacon.
P=Private.
O=Government business exlusively.
Hours = Hours of operation:
N=Continuous service.
X=No regular hours.
F. T. Co. = Federal Telegraph Co.
I. R. T. Co. = Intercity Radio Telegraph Co.
I. W. T. C. = Independent Wireless Telegraph Co.
K. & C. = Kilbourne & Clark Manufacturing Co.
M. R. T. Co. = Mackay Radio and Telegraph Co.
R. C. A. = Radio Corporation of America.
T. R. T. Co. = Tropical Radio Telegraph Co.
U. R. Corp. = Universal Radio Corp.
W. S. A. Co. = Wireless Specialty Apparatus Co.
C. w. = Continuous wave.
I. c. w. = Interrupted continuous wave.
Kc. = Kilocycles.
Fy. = Frequency.
A. c. = Alternating current.
V. t. = Vacuum tube.
U. S. L. = Applies only to the list of Commercial and Government Radio Stations of the United States.

NEW STATIONS

Commercial land stations, alphabetically, by names of stations

[Additions to the List of Radio Stations of the United States, edition of June 30, 1927, and to the International List of Radiotelegraph Stations published by the Berne bureau]

Station	Call signal	Wave length	Service	Hours	Station controlled by—
San Pedro Calif.[1]	KMY	51.09	FX	X	State of California, Division of Fish and Game.

[1] System, composite v. t. telegraph.

Commercial ship stations, alphabetically, by names of vessels

[Additions to the List of Radio Stations of the United States, edition of June 30, 1927, and to the International List of Radiotelegraph Stations published by the Berne bureau]

Name of vessel	Call signal	Rates	Service	Hours	Owner of vessel	Station controlled by—
Albacore[1]	WQBM	.....	P	X	State of California, Division of Fish and Game.	Owner of vessel.
Captain William	WQBK	.....	P	X	Wilmington Transportation Co.	Do.
Dixie	KGGQ	8	PG	X	Southern Pacific Co.	
H. C. Cadmus[2]	WQBL	8	PG	X	New Orleans Coal & Bisso Towboat Co.	I. W. T. Co.
International	KITQ	8	PG	X	International Packing Co.	Do.
Malibu	WQBN	.....	.....	.....	.....	

[1] Range, 150; system, composite v. t. telegraph: w. l., 53.6.
[2] System, W. S. A. Co., 1,000; w. l., 600, 706, 800.

Commercial land and ship stations, alphabetically, by call signals

[b, ship station; c, land station]

Call signal	Name of station		Call signal	Name of station	
KGGQ	Dixie	b	WQBL	H. C. Cadmus	b
KITQ	International	b	WQBM	Albacore	b
KMY	San Pedro, Calif.	c	WQBN	Malibu	b
WQBK	Captain William	b			

Government land stations, alphabetically, by names of stations

[Additions to the List of Radio Stations of the United States, edition of June 30, 1927, and to the International List of Radiotelegraph Stations published by the Berne bureau]

Station	Call signal	Wave length	Service	Hours	Station controlled by—
Blue Canyon, Calif.	KWZ	.....	FX	X	Bureau of Lighthouses.
Burley, Idaho	KNV	.....	FX	X	Do.
Strevell, Idaho	KME	.....	FX	X	Do.

Government land and ship stations, alphabetically, by call signals

[c, land station]

Call signal	Name of station		Call signal	Name of station	
KME	Strevell, Idaho	c	KWZ	Blue Canyon, Calif.	c
KNV	Burley, Idaho	c			

Special land stations, alphabetically, by names of stations

[Additions to the List of Radio Stations of the United States, edition of June 30, 1927]

Station	Call signal	Wave length (meters)	Frequency (kilocycles)	Power (watts)	Station controlled by—
California: Oakland.	6XN	10-40	30,000-7,500	10,000	General Electric Co.
Pennsylvania: Oil City	8XBD	293.9	1,020	1,000	Petroleum Telephone Co.
Philadelphia	3XS	Variable under 175.	Variable over 1,713.	1 100	Gleason W. Kenrick, Moore School of Electrical Engineering.

1 Also 1 k. w. spark.

Special land stations, grouped by districts

Call signal	District and station	Call signal	District and station
3XS	Third district: Philadelphia, Pa.	8XBD	Eighth district: Oil City, Pa.
6XS	Sixth district: Oakland, Calif.		

ALTERATIONS AND CORRECTIONS

COMMERCIAL LAND STATIONS

[Alterations and corrections to be made to the List of Radio Stations of the United States, edition of June 30, 1927, and to the International List of Radiotelegraph Stations, published by the Berne bureau]

MARTINSVILLE, ILL.—Strike out all particulars.
ROCKY POINT, N. Y. (WHR-WEHR).—W. l., 31.86 in lieu of 31.96.
ROCKY POINT, N. Y. (WPE-WEPE).—W. l., 21.66 in lieu of 21.63.

COMMERCIAL SHIP STATIONS, ALPHABETICALLY, BY NAMES OF VESSELS

[Alterations and corrections to be made to the List of Radio Stations of the United States, edition of June 30, 1927, and to the International List of Radiotelegraph Stations, published by the Berne bureau]

BELLBUCKLE.—Station controlled by R. C. A. (U. S. L.).
BESSEMER.—Station controlled by R. C. A. (U. S. L.).
BIRD CITY.—Station controlled by I. W. T. Co.
BRANT.—Station controlled by I. W. T. Co.
BROOKS-SCANLON.—W. l., *600*, 706; station controlled by owner of vessel.
BUFFALO BRIDGE.—Station controlled by I. W. T. Co. (U. S. L.).
CALIFORNIA.—Owner of vessel, American Line S. S. Corp.
CASPER.—Station controlled by I. W. T. Co.
CHASE.—Station controlled by I. W. T. Co. (U. S. L.).
CUTTYSARK.—Station controlled by I. W. T. Co. (U. S. L.).
HERON.—Owner of vessel, Portland Trawling Co.; station controlled by I. W. T. Co.
LA PERLA.—Range, 200; system, W. S. A. Co. spark, 1,000 and R. C. A. v. t. telegraph; w. l., *600*, 706, 750, 800, 1,800, 1,900, 2,000, 2,100, 2,400.
MERCER.—Station controlled by I. W. T. Co. (U. S. L.).
MOUNT EVANS.—Station controlled by R. C. A. (U. S. L.).
NARBO.—Station controlled by I. W. T. Co. (U. S. L.).
NORMAN BRIDGE.—Range, 150; w. l., add 900.
OCEANUS.—Owner of vessel, Donaldson Brown.
OSCAR D. BENNETT.—Range, 200.
O. T. WARING.—Range, 200; system, R. C. A. spark, 1,000 and v. t. telegraph; w. l., *600*, 706, 800, 900, 1,800, 1,900, 2,000, 2,100, 2,400.
PASTORES.—Range, 200; w. l., add 2,400.
PUEBLO.—Range, 200; system, R. C. A. v. t. telegraph; w. l., *600*, 706, 750, 800, 900; rates, 8 cents per word.
RICHMOND.—Range, 100-200; system, K. & C., spark, 1,000 and composite v. t. telegraph; w. l., 34.78, *600*.

SAGAPORACK.—Station controlled by I. W. T. Co. (U. S. L.).
SAMUEL L. FULLER.—Range, 200; w. l., *600*, 706, 750, 800, 900.
SOUTHSEAS.—W. l., *600*, 706, 800; rates, 8 cents per word.
STEEL CHEMIST.—Range, 150; w. l., *715*, 800, 875; rates, Great Lakes service, 4 cents per word.
STEEL ELECTRICIAN.—Range, 150; w. l., *715*, 800, 875; rates, Great Lakes service, 4 cents per word.
STEELMOTOR.—W. l., *715*, 875; rates, Great Lakes service, 4 cents per word.
STELLA LYKES.—System, Navy-Marconi, 1,000; rates, 8 cents per word.
STELLARIS.—System, Navy-R. C. A., 1,000; w. l., *715*, 875.
TEAL.—Station controlled by I. W. T. Co.
WEST CRESSEY.—Range, 300; system, Navy-Marconi, 1,000; w. l., *600*, 706, 800.
WEST ERRAL.—System, Navy-W. S. A. Co., 1,000.
WESTMORELAND.—System, Navy-Lowenstein, 1,000; rates, 8 cents per word.
W. H. LIBBY.—Correct call signal, KDMP (U. S. L.).
WILLIAM C. ATWATER (WTOU).—Station controlled by I. W. T. Co.
WILLIAM H. DOHENY.—Range, 200.
W. L. CONNELLY.—Range, 200.
YARMOUTH.—Range, 50-800.

COMMERCIAL LAND AND SHIP STATIONS, ALPHABETICALLY, BY CALL SIGNALS

Strike out all particulars following the call signal, WHY.

BROADCASTING STATIONS, BY CALL SIGNALS

[Alterations and corrections to be made to the List of Radio Stations of the United States, edition of June 30, 1927]

KFJB (MARSHALLTOWN, IOWA).—Power, 250 day, 100 night.
KFKX (HASTINGS, NEBR.).—Changed to Chicago, Ill., 508 Michigan Ave.
KFNF (SHENANDOAH, IOWA).—Power, 2,000 watts day only; w. l., 461.3, fy. kc., 650.
KFUR (OGDEN, UTAH).—Changed to Farmington, Utah—near; power, 500.
KLZ (DENVER, COLO.).—Power, 1,000 day, 750 night.
KRAC (SHREVEPORT, LA.).—Address, 504 Wall St.
KSOO (SIOUX FALLS, S. DAK.).—Power, 500 day, 250 night.
KXRO (SEATTLE, WASH.).—Changed to Aberdeen, Wash.
WAAF (CHICAGO, ILL.).—Owner of station, Drovers Journal Publishing Co.; w. l., 389.4, fy. kc., 770. Portable.
WALK (BETHAYRES, PA.).—Station permanently located at Willow Grove, Pa.
WARS (BROOKLYN, N. Y.).—Call signal changed to WSGH.
WBMS (UNION CITY, N. J.).—Owner of station, WBMS Broadcasting Corporation.
WBNY (NEW YORK, N. Y.).—Power, 500.
WBRS (BROOKLYN, N. Y.).—Consolidated with WCDA, Cliffside, N. J.
WCDA (CLIFFSIDE, N. J.).—Combined with WBRS, Brooklyn, N. Y.; transmitter at Cliffside; both call signals to be used.
WIBX (UTICA, N. Y.).—Power, 300 day, 150 night.
WICC (BRIDGEPORT, CONN.).—Changed to Easton, Conn.
WJBB (TAMPA, FLA.).—Changed to Sarasota, Fla., Grier Park; w. l., 238, fy. kc., 1,260.
WKEN (BUFFALO, N. Y.).—Changed to Amherst, N. Y.
WMAK (LOCKPORT, N. Y.).—Changed to Tonawanda, N. Y.; owner of station, WMAK Broadcast Station.
WOR (KEARNY, N. J.).—Power, 3,500.
WOS (JEFFERSON CITY, MO.).—W. l., 422.3, fy. kc., 710.
WRHF (WASHINGTON, D. C.).—Owner of station, American Broadcasting Co.
WSBT (SOUTH BEND, IND.).—W. l., 399.8, fy. kc., 750.
WSVS (BUFFALO, N. Y.).—W. l., 204, fy. kc., 1,470.
WTAZ (LAMBERTVILLE, N. J.).—Changed to Richmond, Va.; owner of station, W. Reynolds, jr., and T. J. McGuire.
WTHS (ATLANTA, GA.).—W. l., 227.1, fy. kc., 1,320.
Strike out all particulars of the following-named stations: KGEU (Lowes

GOVERNMENT LAND STATIONS, ALPHABETICALLY, BY NAMES OF STATIONS

[Alterations and corrections to be made to the List of Radio Stations of the United States, edition of June 30, 1927, and to the International List of Radiotelegraph Stations, published by the Berne Bureau]

FORT RODMAN, MASS.—Range, 100; system, U. S. Army v. t. telegraph.

MISCELLANEOUS

VESSELS EQUIPPED WITH A RADIOCOMPASS

[Additions to the list of commercial vessels published in the list of Commercial and Government Radio Stations of the United States, edition June 30, 1927]

Name	Call signal [1]	Owner
Pioneer	KIG	Standard Shipping Co.
Samuel H. Squire	----------	Forest City S. S. Co.

[1] Vessels which do not have a call signal are not equipped with apparatus for communication.

CHANGES IN RADIOBEACON STATIONS

Vineyard Sound Lightship, Mass.—New beacon established. Will transmit every 180 seconds; groups of 1 dot and 2 dashes for 60 seconds, silent 120 seconds, thus:

. — — . — — etc. (60 seconds) Silent. (120 seconds)

Operated on a wave length of 1,000 meters, continuously during thick or foggy weather, and daily in clear weather from 4.30 to 5 and 10.30 to 11 a. m. and p. m., seventy-fifth meridian time.

Location: 71° 00′ 00″ W., 41° 22′ 47″ N.

Cape St. Elias Light Station, Alaska.—Beacon established. Will transmit every 180 seconds; groups of 4 dashes for 60 seconds, silent 120 seconds, thus:

— — — — — — — — etc. (60 seconds) Silent. (120 seconds)

Operated on a wave length of 1,000 meters, continuously during thick or foggy weather and daily in clear weather from 2 to 2.30 and 8 to 8.30 a. m. and p. m., one hundred and thirty-fifth meridian time.

Location: 144° 36′ 18″ W., 59° 47′ 48″ N.

EXPERIMENTAL RADIOBEACON ESTABLISHED AT CAP FERRET LIGHTHOUSE, FRANCE

[Admiralty Notice to Mariners No. 2114, 1927, London]

An experimental beacon established at the lighthouse, located in approximately 1° 15′ W., 44° 39′ N., will transmit on 1,000 meters four groups of signals every 10 minutes, each group consisting of the following signals:

. . — . . . — . . . — . (10 seconds) — — — — — — — — etc. (30 seconds)

. . — . . . — . . . — . (10 seconds) Silent. (10 seconds)

The signals will be transmitted, commencing at the 10th, 20th, 30th, 40th, 50th, and 60th minutes of each hour.

RADIOBEACON ESTABLISHED AT BAR LIGHT VESSEL, LIVERPOOL BAY, ENGLAND

[Admiralty Notice to Mariners No. 2112, 1927, London]

During thick or foggy weather the beacon transmits signals on 1,000 meters, I. c. w. for one minute every four minutes, continuously as follows: The call signal GGM (— — . — — . — —) at the rate of 15 words per minute, repeated

duration; the Morse letters GGM, once (the entire transmission of these signals to take exactly 60 seconds); a silent period of 3 minutes.

During clear weather the Morse letters GGM are transmitted for one minute, at 0, 4, 8, 28, 32, and 38 minutes past each clock hour.

Location: Long. 3° 19′ 45″ W., lat. 53° 32′ 13″ N.

The station should be considered as experimental for a period of three months, during which time the signals may be subject to temporary interruption.

HUMBER, ENGLAND, COAST STATION MOVED, RADIOCOMPASS AND NAVIGATIONAL WARNING SERVICES ESTABLISHED

[Admiralty Notice to Mariners No. 2135, 1927, London]

This station has been moved from Grimsby docks entrance to Trusthorpe, about 16 miles south-eastward of Spurn Point, in longitude 0° 16′ 34″ E., latitude 53° 19′ 43″ N. It will retain the name Humber, and, in addition to giving the usual facilities for commercial service, will also be available as a radiocompass station on completion of calibration tests.

Navigational warnings will be transmitted to every vessel approaching or leaving the River Humber. They will not be broadcast.

REGULATIONS GOVERNING THE OPERATION OF TRANSMITTERS BY VESSELS ANCHORED IN PERUVIAN PORTS

On October 31, 1927, the Peruvian Government established the following rules of procedure in order to prevent interference:

Wireless communication between ship stations and coast stations is strictly prohibited when said ships are anchored in Callao Bay.

When ships are anchored in other Peruvian ports, communication with coast stations can be carried out but only through the nearest coast station and with the minimum power.

When ships are anchored in Peruvian ports wireless communication with other ship stations is prohibited, except to attend to or transmit the international distress signal, SOS.

If transmission by a ship at anchor causes interference with other wireless communication, such ship station must immediately cease transmission if so requested by the coast station that is being interfered with.

RADIO-MEDICAL CONSULTATION SERVICE ESTABLISHED IN BELGIUM

A radio-medical consultation service has been established in Belgium for the use of ships at sea, and operates at all hours of the day and night.

Radiograms relating to this service should be transmitted to the Anvers-Radio station, call signal OSA, and should be addressed as follows: Radio Medical Anvers-Radio.

The prefix SVH should be used to assure their priority over all other communication, except those relating to a distress (SOS) call.

The radio medical should be signed by the captain and contain as the first part of the text the type of medicine chest which is at the disposal of the vessel as "Belgian chest," "English chest," etc. The military hospital at Anvers which is called upon to give consultations possesses the nomenclatures of medicines and accessories contained in the regular chests in the merchant marine of the different countries: Australia, Belgium, Denmark, United States, Spain, France, Norway, Netherlands, United Kingdom of Great Britain, Ireland, and Sweden. In order that the consulting doctor can render account of the resources which are at the disposal of a vessel, it is important that the radiogram requesting a consultation give the necessary information to this effect.

The radio-medical telegram should describe in a concise manner but clear and complete all the symptoms bearing on the patient and those perceived by him. In every case he will mention the age and sex of the subject, the date of the accident or beginning of the sickness, the temperature, the pulse, general condition, location of sickness. In case of a special sickness, the coloring of the tongue should be described, the manner of breathing, of vomiting, of urine, of motion. Information should also be given as to whether the patient has been previously hurt or sick with affections from "hot countries" or if he has recently touched ports suspected to be contaminated by exotic or infectious diseases. In case of supposed fracture, state if there is deformation of the limb, swelling

The radio medical should be made out in the French or Flemish language and in case of absolute necessity in the English language; the reply will be made out in the language used in requesting advice, in so far as the French and Flemish languages are concerned; in case the English language is used an immediate reply can not be guaranteed in this language. In case of urgency, the reply can be made immediately in French, confirming it later in English.

The radio-medical consultation service (requests and replies) is entirely gratuitous.

SPECIAL CALL SIGNALS ASSIGNED FOR USE IN TRAINING NAVAL RESERVES

Call signal NRRD has been assigned for use of the master control station of the fourth naval district, located at 328 South Eighth Street, Darby, Pa.; and call NRRZ has been assigned for use at the alternate control station of the ninth naval district, located at 224 Sheridan Road, Winnetka, Ill.

EXTENSION OF BROADCASTING STATION LICENSES

General Order No. 21, December 1, 1927, by Federal Radio Commission.—All existing broadcasting licenses and renewals are hereby extended until and will terminate on January 31, 1928.

All broadcasting stations will make application for new license not later than January 15, 1928. Application forms will be mailed to all existing stations about January 1, 1928.

AMENDED REGULATIONS GOVERNING THE ISSUANCE OF RADIO OPERATORS' LICENSES

The following regulations should be added to the regulations published in Radio Service Bulletin No. 124, July 31, 1927:

Paragraph 7, subparagraph 4.—Renewals or new licenses may be issued a reasonable length of time previous to the expiration of existing licenses, but must bear the exact date of issue, which must correspond with the date on the back of Form 756 forwarded to the radio division.

Operators who fail to apply for renewal of their licenses on or prior to the date of expiration must be reexamined. If, because of circumstances over which the applicant has no control, an operator is unable to apply for renewal of license on or prior to the date of expiration, an affidavit may be submitted to the radio division through the supervisor of radio or examining officer, attesting to the facts, which will be considered by the radio division, which will advise the supervisor of radio or examining officer in regard to the issue of a renewal of the license without reexamininations.

Service records must be completed and signed only by masters, employers, or the duly authorized agents of either.

Any improper alteration of the service record or the forgery of masters' or employers' signature constitutes a violation of the regulations, and the operator may suffer suspension of license for a period not exceeding one year, at the discretion of the Secretary of Commerce.

OBITUARY

This office deeply regrets the recent death of Hon. Henri L. Etienne, director of the international bureau of the telegraphic bureau during the past several years, having succeeded the late Col. E. Frey. Mr. Etienne died suddenly on board ship while returning to Switzerland after the close of the International Radiotelegraphic Conference in Washington where he was in charge of the affairs of the international bureau.

A METHOD OF USING FRACTIONAL HARMONICS OF QUARTZ CRYSTALS

[By J. H. Burton, jr., radio inspector, Baltimore]

Additional points for drawing calibration curves of wave meters may be obtained by the use of what is termed fractional harmonics, these harmonics falling between the fundamental harmonics of crystal oscillators as is indicated by the following example. The quartz oscillator being used in conjunction with an auxiliary generator, the telephone being connected to the auxiliary generator.

Using a quartz plate with a fundamental frequency of 90 kilocycles, the sixth and seventh harmonics which are easily located will be 540 and 630 kilocycles,

the auxiliary generator several other beat notes which are somewhat weaker than the sixth and seventh harmonics. Approximately midway between the sixth and seventh harmonics a fairly strong beat note will be noted, this is the result of the second harmonic of the auxiliary generator beating with the thirteenth harmonic of the crystal which is 1,170 kilocycles. Since the second harmonic of the auxiliary generator is beating with the thirteenth harmonic of the crystal, the frequency of the auxiliary generator will be one-half of this harmonic and may be expressed as follows:

$$\frac{13}{2}=\frac{1170}{2}=585 \text{ kilocycles}$$

at which setting a calibration point for the frequency curve of the wave may be obtained after the auxiliary generator is adjusted to zero beat.

It will also be noted that between this point and the point where the sixth harmonic is found another but still weaker beat note may be heard, this will be the result of the third harmonic of the auxiliary generator beating with the nineteenth harmonic of the crystal. In other words, the fundamental of the generator will equal one-third of the nineteenth harmonic of the crystal expressed as follows:

$$\frac{19}{3}=\frac{1710}{3}=570 \text{ kilocycles.}$$

A point for the calibration curve at this frequency may be made as usual.

Another beat note may be heard at a point between the last setting of the auxiliary generator and the point where the sixth harmonic is found, this will be due to the fourth harmonic of the auxiliary generator beating with the twenty-fifth harmonic of the crystal and may be expressed as follows:

$$\frac{25}{4}=\frac{2250}{4}=562.5 \text{ kilocycles.}$$

As this beat note is very weak, it may be more easily determined by the use of the two-step audio-frequency amplifier connected to the auxiliary generator.

Points may be also obtained at the twentieth harmonic of the crystal with the third harmonic of the generator as

$$\frac{20}{3}=\frac{1800}{3}=600 \text{ kilocycles}$$

and the twenty-seventh harmonic of the crystal is the fourth harmonic of the generator as

$$\frac{27}{4}=\frac{2430}{4}=607.5 \text{ kilocycles.}$$

Points between other fundamental frequencies may likewise be determined. However, as the frequency is increased, the higher harmonics become weaker and it is ordinarily not possible to readily make use of higher than approximately the twenty-fifth harmonic unless audio-frequency amplification is used. For instance between the seventh and eighth harmonics may be found the

$$\frac{15}{2}=\frac{22}{3}=\frac{23}{3} \text{ harmonics.}$$

Should there be any question as to which harmonic is being heterodyned, it may be identified by reference to the curve plotted between known harmonics.

The calibration curve should be plotted using a hard pencil on a large sheet of cross-section paper, allowing 10 kilocycles to the inch for the abscissa and 10° on the small vernier dial of the wave meter to equal 1 inch for the ordinate.

It is essential that wave meters be checked against the crystal frequently in order that errors due to temperature changes, etc., may be corrected.

IMPORTANT EVENTS IN RADIO—PEAKS IN THE WAVES OF WIRELESS PROGRESS

1827. Savary found that a steel needle could be magnetized by the discharge from a Leyden jar.

1831. Faraday discovered electromagnetic induction between two entirely

1837. The first patent for an electric telegraph was taken out by Cooke and Wheatstone (London) and by Morse (United States).

1838. Steinhell discovered the use of the earth return.

1840. Henry first produced high-frequency electric oscillations and pointed out that the discharge of a condenser is oscillatory.

1842. Morse made wireless experiments by electric conduction through water.

1843. Lindsay suggested that if it were possible to provide stations not more than 20 miles apart all the way across the Atlantic there would be no need of laying a cable.

1845. Lindsay made experiments in transmitting messages across the River Tay by means of electricity or magnetism without submerging wires, using the water as a conductor.

1849. Wilkins revived the same suggestions for wireless telegraphy.

Doctor O'Shaughnessy succeeded in passing intelligible signals without metallic conduction across a river 4,200 feet wide.

1862. Heyworth patented a method of conveying electric signals without the intervention of any continuous artificial conductor.

1867. Maxwell read a paper before the Royal Society in which he laid down the theory of electromagnetism, which he developed more fully in 1873 in his great treatise on electricity and magnetism. He predicted the existence of the electric waves that are now used in wireless telegraphy.

1870. Von Bezold discovered that oscillations set up by a condenser discharge in a conductor give rise to interference phenomena.

1872. Highton made various experiments across the River Thames with Morse's method.

1879. Hughes discovered the phenomena on which depend the action of coherer. The coherer was later used practically by Marconi.

1880. Trowbridge found that signaling might be carried on over considerable distances by electric conduction through the earth or water between places not metallically connected.

1882. Bell's experiments with Trowbridge method on the Potomac River resulted in the detection of signals at a distance of 1½ miles.

Professor Dolbear was awarded a United States patent in March, 1882, for wireless apparatus in connection with which he made the statement that "electrical communication, using this apparatus, might be established between points certainly more than one-half mile apart, but how much farther I can not say." It appeared that Professor Dolbear made an approach to the method that was, subsequently in the hands of Marconi, to be crowned with success.

1883. Fitzgerald suggested a method of producing electromagnetic waves in space by the discharge of a conductor.

1885. Edison, assisted by Gilliland, Phelps, and Smith, worked out a system of communication between railway stations and moving trains by means of induction and without the use of conducting wires. Edison took out only one patent on long-distance telegraphy without wires. The application was filed May 23, 1885, at the time he was working on induction telegraphy, but the patent (No. 465971) was not issued until December 29, 1891. In 1903 it was purchased from him by the Marconi Wireless Telegraph Co.

Preece made experiments at Newcastle-on-Tyne which showed that in two completely insulated circuits of square form, each side being 440 yards, placed a quarter of a mile apart, telephonic speech was conveyed from one to the other by induction.

1886. Dolbear patented a plan for establishing wireless communication by means of two insulated elevated plates, but there is no evidence that the method proposed by him did, or could, effect the transmission of signals between stations separated by any distance.

1887. Hertz showed that electromagnetic waves are in complete accordance with the waves of light and heat, and founded the theory upon which all modern radio signaling devices are based.

Heaviside established communication by telephonic speech between the surface of the earth and the subterranean galleries of the Broomhill Collieries, 350 feet deep, by laying above and below ground two complete metallic circuits, each about 2¼ miles in length, and parallel to each other.

1889. Thompson suggested that electric waves were particularly suitable for the transmission of signals through fogs and material objects.

1891. Trowbridge suggested that by means of magnetic induction between two separate and completely insulated circuits communication could be effected between distances.

1892. Preece adopted a method which united both conduction and induction as the means of affecting one circuit by the current in another. In this way he established communication between two points on the Bristol Channel and at Lochness in Scotland.

Stevenson, of the Northern Lighthouse Board, Edinburgh, advocated the use of an inductive system for communication between the mainland and isolated lighthouses.

Branly devised an appliance for detecting electromagnetic waves, which was known as a coherer.

1894. Rathenau experimented with a conductive system of wireless telegraphy and signaled through 3 miles of water.

1895. Smith established communication by conduction with the lighthouse on the Fastnet.

Marconi's investigations led him to the conclusion that Hertzian waves could be used for telegraphing without wires.

1896. Marconi lodged his application for the first British patent for wireless telegraphy. He conducted experiments in communicating over a distance of 1¾ miles successfully.

The first demonstration of directional wireless using reflectors was given in England. Experiments were conducted to determine the relative speed of propagation of light waves and the electric vibrations which actuated a receiver at a distance of 1½ miles between reflectors.

1897. March: Marconi demonstrated communication being established over a distance of 4 miles.

March 17: Balloons were first used for the suspension of wireless aerials.

July 10–18: Marconi maintained communication between the shore and a ship at sea distances up to 10 miles.

September and October: Apparatus was erected at Bath, England, and signals received from Salisbury, 34 miles distant.

November 1: First Marconi station erected at the Needles, Alum Bay, Isle of Wight. Experiments were conducted covering a range of 14½ miles.

December 6: Signals transmitted from shore to a ship at sea, 18 miles distant.

December 7: First floating wireless station was completed.

1898. June 3: The first paid radiogram was transmitted from the Needles (Isle of Wight) station.

July 20–22: Events of the Kingstown regatta in Dublin reported by wireless for Dublin newspaper from steamer *Flying Huntress*.

1899. April 22: The first French gunboat was fitted with wireless telegraph apparatus at Boulogne.

The American battleships *New York* and *Porter* were equipped with radio apparatus.

July: During the naval maneuvers three British warships equipped with Marconi apparatus interchanged messages at distances up to 74 nautical miles (about 85 land miles).

The international yacht races which took place in September and October were reported by wireless telegraphy for the New York Herald. At the conclusion of the races series of trials were made between the United States cruiser *New York* and the battleship *Massachusetts*, signals being exchanged between the vessels at distances up to 36 miles. On the return journey from America Marconi fitted the steamship *St. Paul* with his apparatus, and on November 15 established communication with the Needles station when 36 miles away. Reports of the progress of the war in South Africa were telegraphed to the vessel and published in a leaflet entitled "The Transatlantic Times," printed on board.

1900. February 18: The first German commercial wireless station was opened on Borkum Island.

February 28: The first German liner fitted with wireless apparatus communicated with Borkum Island over a range of 60 miles.

November 2: The first wireless land station in Belgium was finished at Lapanne.

Between 1900 and 1905 Doctor De Forest was granted numerous patents in the United States and other countries for inventions connected with wireless telegraphy.

1901. January 1: The bark *Medora* was reported by wireless as waterlogged

January 19: The *Princesse Clementine* ran ashore, and news of the accident was telegraphed to Ostend by wireless.

February 11: Communication was established between Niton Station, Isle of Wight, and the Lizard station, a distance of 196 miles.

March 1: A public wireless telegraph service was inaugurated between the five principal islands of the Hawaiian group, viz, Oahu, Kauai, Molaki, Maui, and Hawaii.

October 15: The first fan aerials were erected for experiments between Poldhu and Newfoundland.

December 12: The letter "S" was received by Marconi from Poldhu, England, at St. Johns, Newfoundland, a distance of 1,800 miles.

Prof. R. A. Fessenden applied for United States patent on September 28 for "Improvements in apparatus for the wireless transmission of electromagnetic wave, said improvements relating more especially to the transmission and reproduction of words or other audible signals." It appears that in connection with this apparatus there was contemplated the use of an alternating-current generator having a frequency of 50,000 cycles per second. Professor Fessenden was granted a number of United States patents between 1899 and 1905 covering devices used in connection with radiotelegraphy.

1901–1904. During this period Dr. John Stone was granted more than 70 United States patents covering radiotelegraphy.

1901–1905. More than 40 United States patents were granted to Harry Shoemaker covering certain apparatus used for radio communication.

1902. February: Steamship *Philadelphia*, American Line, received messages a distance of 1,551¼ statute miles and received Morse signals up to a distance of 2,099 statute miles from Poldhu station, Cornwall, England.

June 25: The first moving wire magnetic detector actuated by clockwork was installed on the Italian cruiser *Carlo Alberto*.

July 14–16: Marconi received messages from Poldhu on the Italian cruiser *Carlo Alberto*, lying at Cape Skagen, a distance of 800 miles; and at Kronstadt, 1,600 miles.

December: On the 17th the first wireless message was transmitted across the Atlantic. On the 18th wireless messages were dispatched from Cape Breton station to King Edward VII.

1903. January 19: President Roosevelt sent a trans-Atlantic radiogram to King Edward via Cape Cod and Poldhu stations.

March 30: First transoceanic radiogram was published in the London Times.

August 4: First International Radiotelegraphic Conference was held at Berlin.

Poulsen patented the improved arc oscillation generator, using a hydrocarbon atmosphere and a magnetic field.

1904. January 20: The first press message was transmitted across the Atlantic.

August 15: The wireless telegraph act of Great Britain was passed.

November 16: Dr. J. Ambrose Fleming took out his original patent No. 24850 for thermionic valves.

1905. In October of this year erection of Clifden, Ireland, high-power radio station was commenced.

1906. Doctor De Forest was granted a patent on January 18 for a vacuum rectifier, commercially known as the audion.

Second International Radiotelegraphic Convention was held at Berlin, and a convention was signed by a majority of the principal countries of the world.

Dunwoody discovered the rectifying properties of carborundum crystals and Pickard discovered the similar properties of silicon crystals. These discoveries formed the basis of the widely used crystal detectors.

1907. October 17: Trans-Atlantic stations at Clifden and Glace Bay were opened for limited public service.

1908. February 3: Trans-Atlantic radio stations were opened to the general public for the transmission of messages between the United Kingdom and the principal towns in Canada.

In carrying out his invention Professor Fessenden constructed a high-frequency alternator with an output of 2.5 kilowatts at 225 volts and with a frequency of 70,000 cycles per second. Later Professor Fessenden reported successful wireless telephonic communication between his station located at Brant Rock, Mass., and Washington, D. C., a distance of about 600 miles.

1909. The steamship *Republic*, after colliding with the steamship *Florida* off the coast of the United States on January 23, succeeded in calling assistance by

1910. The steamship *Principessa Mafalda* received messages from Clifden at a distance of 4,000 miles by day and 6,735 miles by night. On April 23 the Marconi trans-Atlantic (Europe-America) service was opened.

June 24: Act approved by the United States Government requiring radio equipment and operators on certain passenger-carrying vessels.

1911. July 1: Radio service organized in Department of Commerce and Labor to enforce the act of June 24, 1910.

1912. F. A. Kolster, of the Bureau of Standards, invented and developed the Kolster decremeter, which is used to make direct measurements of wave length and logarithmic decrement. This instrument has been used by the radio service of the Department of Commerce since it was invented.

Early in the year the American Marconi Co., absorbed the United Wireless Co., of the United States.

In February the Marconi Co. procured the patents of Bellini and Tosi, including those for the wireless direction finder.

On February 9 the Australian Commonwealth station was opened.

On April 15 the steamship *Titanic*, on her maiden voyage, struck an iceberg and sank, but owing to the prompt wireless call for assistance the lives of more than 700 of her passengers were saved.

The International Radiotelegraphic Conference opened in London on June 4 and approved important regulations to have uniformity of practice in wireless telegraph services. On July 5 the International Radiotelegraphic Convention was signed at London.

July 23: Act approved by the United States Government extending act of June 24, 1910, to cover cargo vessels and requiring auxiliary source of power, efficient communication between the radio room and the bridge, and two or more skilled radio operators in charge of the apparatus on certain passenger-carrying vessels.

August 13: Act approved by the United States Government licensing radio operators and transmitting stations.

1913. F. A. Kolster submitted to the Government a paper pointing out the advantages of certain applications of radio signaling for use at lighthouses, lightships, and life-saving stations, especially in time of fog.

During this year the Governments of France and the United States experimented between the Eiffel Tower station and Washington by wireless to procure data for comparing the velocity of electromagnetic waves with that of light.

In June a wireless telegraph bill was presented to the Ottawa Parliament and passed under the title "Radiotelegraph act of Canada."

On October 11 the *Volturno* was burned in mid-Atlantic, and in response to the wireless appeal 10 vessels came to the rescue, 521 lives being saved.

November 12: Safety at Sea Conference held in London. At this conference the use of radio received appropriate consideration.

On November 24 the first practical trials with wireless apparatus on trains were made on a train belonging to the Delaware, Lackawanna & Western Railroad.

The station at Macquerie Island was the means of keeping Doctor Mauson, the Australian explorer, in touch with the outer world. Radio dispatches were published in a small journal which was established, called the Adelie Blizzard.

November 24. The first practical trials with wireless apparatus on trains were made, messages having been received and transmitted on board trains.

1914. Experiments in wireless telephony were carried out between several vessels lying at anchor five-eighths of a mile apart, ordinary receivers being used with success. The wireless-telephone experiments were continued between two warships on the high seas, and the reception was consistently good over a distance of 18½ miles. Successful wireless-telephone communications were effected later, using only very limited energy, between vessels on the high seas 44 miles apart. These experiments were repeated where land intervened between the communicating vessels, and in this case again excellent results were obtained. On this day radiotelephonic communication was constantly maintained for 12 hours.

On April 15, at Godalming, a memorial was unveiled to the memory of Jack Philips, chief radio operator of the ill-fated *Titanic*, who died at his post when the vessel foundered in mid-Atlantic on the 15th of April, 1912.

A new departure in the application of radiotelegraphy to the safety of life at sea was the equipment of the motor lifeboats of the steamship *Aquitania* with radio apparatus.

High-powered transoceanic stations were completed at Carnarvon, Wales, Belmar, Honolulu, and San Francisco during the autumn of 1914. The Honolulu

Most of these stations made use of the latest developments in the art, using undamped and long waves as produced by the Poulsen arc and the radiofrequency alternator.

On October 6 E. H. Armstrong was issued a patent covering the regenerative circuit also known as the feed-back and the self-heterodyne circuit.

1915. During this year F. A. Kolster, of the Bureau of Standards, developed a radiocompass said to be more effective than that which was being used.

On February 20 the Panama-Pacific Exhibition at San Francisco was officially opened by President Wilson at Washington, through the medium of wireless telegraphy.

On May 12, in Battery Park, New York City, the mayor unveiled the monument in memory of wireless operators who had lost their lives at the post of duty.

On July 27 wireless communication between the United States and Japan was effected. Two terminal stations were located at San Francisco and Funabashi, near Tokyo, and the messages were relayed through Honolulu.

On July 28 the American Telephone & Telegraph Co., working in conjunction with the Western Electric Co., succeeded in telephoning the wireless across the American Continent from Arlington to Hawaii, a distance of nearly 5,000 miles.

On October 26 the wireless telephone experiments were continued, communication being effected across the Atlantic from Arlington to the Eiffel Tower, Paris.

During this year ship service was greatly improved through the installation of new equipment, embodying features of great practical value, by various operating companies. Efficient emergency radio transmitters came into wider use, owing considerably to the efforts of the radio service of the Department of Commerce and its refusal to pass inefficient equipment. Such installations, considered as essential, are safeguards to shippers and the seagoing public.

1916. During the course of a severe blizzard in the United States during February wireless telegraphy was extensively used for train dispatching, as the telegraph wires were down.

The determination of the difference in longitude between Paris and Washington with the aid of radio which had been in progress since October, 1913, was completed during May, the result, expressed in terms of time, being 5 hours 17 minutes 35.67 seconds, and has a probable accuracy of the order of 0.01 second.

The initiation of the newly established trans-Pacific wireless service between the United States and Japan was celebrated on November 5 by an interchange of messages between the Mikado and President Wilson.

1917. June 2 marked the "coming of age" of wireless telegraphy in England; that is, that 21 years had elapsed since the registration of patent 12039 in 1896.

1918. The trend of progress toward continuous-wave communication as distinct from that by damped waves was very marked during this year, a particular impetus being given by the continued development of the electron tube as an efficient receiver and generator of undamped oscillations. Steady improvement was also evident in the arc form of generator which was installed in many new high-power stations.

Wireless telephony also progressed to a marked extent, particularly in the direction of reliability and increase of range, due mainly to the development of valve generators and receivers.

In the equipment of aircraft with wireless great progress was made, both in radiotelegraphy and radiotelephony.

In April a high-power station was opened at Stavanger, Norway, for the use of the Norwegian Government. The station communicates with the United States.

In the Argentine the erection of a station destined for direct communication with the North American continent was commenced in the vicinity of Buenos Aires.

The extension in the application of wireless telegraphy to merchant vessels continued, and at the close of the year some 2,500 to 3,000 vessels of the British Merchant Marine carried installations.

On July 31 the United States Government took over all wireless land stations in the United States, with the exception of certain high-power stations, which remained under the control of commercial companies.

On September 22 messages transmitted from Carnarvon were received in Sydney, 12,000 miles away. Cable confirmations of these messages were sent forward at the same time, but were received some hours later than the corresponding radiotelegrams.

At the end of the year a high-power station, erected by the United States Government, was opened at Croix d'Hins, near Bordeaux.

1919. The successful trans-Atlantic flights of Alcock and Brown, of the Ameri-

attention upon the application of radio for aviation purposes and its great value for aerial navigation.

In February a Spanish decree was issued to the effect that all sailing vessels of 500 tons or over and carrying 50 or more passengers must be equipped with wireless apparatus.

On June 30, 1919, there were 2,312 ship stations of the United States, having increased from 1,478 on June 30, 1918. At this time new ship stations were increasing at the rate of 100 a month. This increase was due to the great number of vessels built during the war period.

The temporary war measures relative to the installation of wireless telegraph apparatus on all merchant vessels of 1,600 tons or over under the British flag was made permanent by a bill passed by the British Parliament.

During the year the Radio Corporation took over the radio interests of the American Marconi Co.

The war-time ban on private and experimental wireless stations was removed.

1920. The steady development of continuous-wave wireless work was continued during the year and some further progress made in the commercial application of tube apparatus.

On January 14 a law was passed in Greece making the carrying of wireless apparatus obligatory on all Greek merchant ships of 1,600 tons gross and over, or having 50 or more persons aboard, including crew.

On January 25 a new high-power station was opened at Monte Grande, Argentina, call letters LPZ.

Amateur radio work in this and other countries progressed steadily during the year with the gradual removal of war-time restrictions.

Bordeaux, France, high-power station opened.

1921. Experiments were carried out in France with successful results in the application of Baudot and similar high-speed telegraph apparatus to radio work.

The progress made in amateur and experimental wireless is exemplified by the attempts made in February and December of this year to effect communication on short-wave lengths between the wireless amateurs of the United States and Great Britain. The first attempt was unsuccessful, but during the second test signals from many American amateur stations were heard both by British radio amateurs and by the representative of the American Radio Relay League who was sent over for the tests. The signals were also heard in Holland.

The American Radio Relay League held its first annual convention in Chicago, August 30-September 3, at which many thousands of amateurs of the United States were present.

The first licenses for broadcasting stations were issued in September of this year.

New York radio central station opened on Long Island.

1922. During this year broadcasting stations increased rapidly in keeping with the great interest taken in the art.

First Annual Radio Conference held in Washington, D. C., February 27.

On June 7 E. H. Armstrong read a paper before the Institute of Radio Engineers on some recent developments by him of regenerative circuits. Professor Armstrong was granted a patent for the superregenerative circuit.

Experiments in radiotelephony from ship to shore were conducted during this year. In tests from the steamship *America* it was proved possible to communicate with land telephone stations more than 400 miles distant from the ship.

1923. On March 2 E. A. Hazeltine, of Stevens Institute of Technology, presented a paper before the Radio Club of America on tuned radio-frequency amplification with neutralization of capacity coupling. Professor Hazeltine was granted a patent for the nonradiating neutrodyne receiver.

On March 4 the Cleveland, Ohio (KDPM), station of the Westinghouse Electric & Manufacturing Co. successfully repeated short waves from the East Pittsburgh, Pa. (KDKA), station for the first time in history.

Second Annual Radio Conference held in Washington, D. C., March 20.

The Marconi Co. made a tender, which was accepted, for the erection of a transmitting station in Australia of a power of 1,000 kilowatts with 20 steel masts, 800 feet high. Corresponding stations were to be provided in England and Canada. The receiving arrangements would permit simultaneous reception from five stations.

The construction of a large radio station in a valley between the Herzogstand and the Stein, two of the foothills in the Bavarian Alps, was undertaken. The aerial will be suspended by wire cables stretched between the tops of the two

The increase in traffic on some of the large liners of the Atlantic route led to the installation of apparatus for high-speed automatic transmission and reception on several lines.

Successful tests on wireless-controlled airplanes were carried out at the Etampes Aerodrome in France. Flights were made without a pilot. Flights were also made with a pilot using a gyroscopic stabilizer and special steering motors which could be controlled from the ground.

The International Commission for Aerial Navigation agreed, as a general principle, that all aircraft engaged in public transport must carry radio apparatus.

The General Electric Co. developed a tube capable of delivering 20 kilowatts of high-frequency energy to an aerial. Using six of these tubes in parallel with 15,000 volts on the anode, a current of 310 amperes in an Alexanderson multiple tuned aerial was obtained. A tube of the magnetron type was developed by the same company, capable of giving 1,000 kilowatts at 20,000 cycles with an efficiency of 70 per cent.

Great progress was made during the year in the development of vacuum tubes.

Short-wave lengths were used to greater advantage than heretofore.

The McMillan expedition to the polar regions had radio for their only means of direct communication. Using low power and short-wave lengths, their vessel, *Bowdoin*, communicated with several stations in the United States while they were frozen in thousands of miles away. Broadcasting concerts from United States stations were heard during the long dark nights of the Arctic Zone.

During the year foreign countries became interested in radiotelephone broadcasting.

Broadcasting in the United States heard in England. British stations also heard in the United States.

On December 31 East Pittsburgh, Pa. (KDKA), transmitted a program to Great Britain on a short wave.

1924. In January radio was used in the region of the Great Lakes during a blizzard for dispatching trains.

The high-power station at Monte-Grande, Argentina, was opened in January for direct communication with New York, Paris, and Berlin. The service will be extended to Great Britain when a corresponding transmitting station is available. The power of the station is 800 kilowatts, the aerial being carried on 10 masts, each 690 feet high. The receiving station is at Villa Eliza, 30 kilometers from Buenos Aires, the actual control being effected from a central office in Buenos Aires.

On February 5 a radio program broadcasted in the United States from the East Pittsburgh, Pa. (KDKA), station of the Westinghouse Electric & Manufacturing Co. was received and rebroadcast in England for the benefit of English stations.

On February 23 a concert broadcast by the same station and relayed from London, England, was heard clearly in Calcutta, India.

In July an agreement was concluded between the British Government and the Marconi Wireless Telegraph Co. (Ltd.) for the construction of a wireless station on the beam system, capable of communicating with Canada and of being extended to India, South Africa, and Australia, the transmitting station to have an input of at least 20 kilowatts and the receiving station to have an aerial designed to focus the received waves within an angle of 30°.

The short-wave direction system of radiotelegraphy and the results obtained in tests made on it were described in a lecture before the Royal Society of Arts, in July, by Senatore Marconi.

During the period from August 5 to September 24 the East Pittsburgh, Pa. (KDKA), station maintained communication with the ship *Arctic* while on its expedition to the Arctic regions. Upon the ship's return it was reported that messages sent on short waves by the East Pittsburgh station were received at Cape Sabine within 11° of the North Pole. This is the farthest north radio messages have been received.

Third National Radio Conference held in Washington, D. C., October 6.

On October 11 signals from the East Pittsburgh station were successfully repeated from a station in Cape Town, Africa.

An expedition from the United States, under the leadership of Hamilton Rice, which will explore the Amazon and Orinoco Rivers in Brazil and Venezuela, in the interest of geographical sciences in general, will have radio as their only means of communication.

Roger Babson, economist, estimates that during this year the American people will spend approximately $350,000,000 for radio equipment. Sales of radio

A wireless lighthouse has been set up on an island in the Firth of Forth, Scotland. Wireless waves are concentrated by reflectors into a beam which can be sent 100 miles, giving ships their position in a fog.

1925. Considerable progress was made during 1925 in working with short waves. Several transoceanic stations are working foreign stations at great distances on wave lengths varying from 22 to 103 meters.

In an experiment between the Hastings (Nebr.) station and the East Pittsburgh (Pa.) station the Westinghouse Electric & Manufacturing Co. demonstrated that a 64-meter wave could be picked up, and by placing it on a short transmission line to the transmitting station, increasing the strength of the signals to their original power or greater, if necessary, the amplified wave could be transmitted onward. This experiment shows that repeater stations can be constructed in different parts of the world and be fairly certain of transmitting a strong signal.

A number of short-wave transmissions were made by East Pittsburgh (KDKA) transmitting to South Africa and Australia.

Amateur operators by their interest have made considerable achievements in the development of short waves.

During July programs were broadcast to the American naval fleet in Australian waters.

Radiocompass (direction finder) came into greater use on board vessels. Over 100 American vessels are equipped.

The Lighthouse Service, Department of Commerce, established several new radio fog signal stations on all coasts of the United States.

The practical use of the telephone and radio for the transmission of photographs was more clearly demonstrated during the year.

As a means of eliminating interference, the transmitters of high-powered broadcasting stations were moved to the outlying districts of several large cities, the studios remaining in the cities.

Broadcasting programs from airplanes was done in a few instances.

The General Electric Co., the Radio Corporation of America, and the Westinghouse Electric & Manufacturing Co. conducted experiments in broadcasting, using as high as 50 kilowatts.

The Department of Commerce placed in commission a "radio test car" which is equipped with an assortment of radio instruments used in conducting tests and investigations.

The Fourth National Radio Conference was held in Washington, D. C., November 9, 1925.

The Radio Corporation of America began the operation of a high-powered broadcasting station at Bound Brook, N. J., for transmission of programs to Europe. This station is equipped so as to use as high as 50 kilowatts.

One of the large electrical companies conducted experiments to determine the characteristics and peculiarities inherent in the piezo crystals. Several stations are now using this quartz crystal to maintain a constant frequency which eliminates to a great extent the "beat notes" resulting from two stations heterodyning at an audio-frequency. The radio-inspection service of this department has been supplied with these crystals to insure accuracy in frequency or wave-length measurements.

1926. During this year directional or beam transmission developed to a point where it may now be considered as practical for commercial usage.

The use of quartz plates for maintaining constant frequency or radio transmitters advanced considerably during the year.

Successful radiotelephone experiments were conducted between New York and London. This service will be used commercially in the near future.

With the development of transmitting pictures by radio it is now practical to transmit weather maps to vessels at sea.

Considerable progress was made in the perfection of receiving sets. The single-dial receiver came into greater use for reception of programs from broadcasting stations.

A committee representing the departments of the United States Government directly concerned studied our radio problems and prepared proposals for consideration by the International Radiotelegraph Conference which is contemplated being held in Washington during 1927.

Commercial pictoradiogram services are now in operation between New York and London and between San Francisco and Hawaii.

The use of the radio compass (direction finder) on shipboard increased materi-

equipped. A very large number of naval vessels are also equipped with this apparatus.

On July 8 the Attorney General of the United States rendered a decision to the effect that the Secretary of Commerce has no jurisdiction as to the wave length, with the exception of the band between 600 and 1,600 meters reserved for Government stations, or the power used by commercial stations, including broadcasting stations.

The joint resolution of Congress approved December 8 requires the applicant for a radio-station license to waive any right or any claims of right against the United States to any wave length or to the use of the ether in radio transmission because of previous license to use the same or because of the use thereof.

Since July the number of broadcasting stations increased 155, making the total number licensed on December 31, 571. A large number of the stations in this class increased their power and changed their wave lengths during this period.

Radiotelephone was used for the first time in directing the filming of a naval scene, off the coast of California, for a photoplay.

During the year successful development of a wireless system for controlling fog signals from unattended lighthouses and beacons marked a great advance on the automatic or semiautomatic systems for starting and stopping acetylene fog-signal gun by wireless impulses.

Successful experiments of synchronizing two or more stations in order that simultaneous operation on the same wave length without interference may be accomplished were conducted by the Westinghouse Electric & Manufacturing Co. during the year.

1927. Transatlantic radiophone service opened to the public on January 7.

Radio act of 1927 passed February 23.

On April 7 the experimental radio station of the Bell Telephone laboratory at Whippany, N. J. (3XN), was successfully used in a public demonstration of television; the facial expression and voice of Secretary of Commerce Hoover could be seen and heard in New York distinctly and at the same time.

Radio was used in connection with the floods in the Mississippi Valley during the spring and New England during the fall, when other means of communication were inoperative or inaccessible. Several amateur stations rendered valuable aid.

Radio was used by the airplane *America* on June 29 for the first time by an airplane in crossing the Atlantic Ocean from the United States to France.

International Radio Telegraph Conference held at Washington, D. C. October 4 to November 25.

Receiving vacuum tubes with filaments heated from alternating current gained in popularity.

Chain broadcast programs greatly increased during the year.

Beam transmission on short waves increased considerably during the year; at the present time there are about 15 stations of this class in operation throughout the world.

Radio was a vital factor in the saving of an exceedingly large number of lives at sea.

As a result of experiments conducted during the past two years on methods of synchronization broadcasting stations WBZ at Springfield, Mass., and WBZA at Boston, Mass., owned by the Westinghouse Electric & Manufacturing Co., are now being regularly operated simultaneously in absolute synchronism, the wave length of the transmitter at the Boston station being automatically controlled by the Springfield transmitter so that any variation at Springfield will create a similar variation at Boston, assuring absolute synchronism at all times during the operation of these stations.

Experiments are now being conducted for the synchronization of two or more transmitters by radio control instead of by wire as in the case of the two stations referred to.

The U. S. S. *Kittery*, experimenting with a radio compass during hurricane weather, found that the intensity of static may be useful in detecting and locating storms at a considerable distance.

The experimental station of the General Electric Co. at Schenectady, N. Y., call signal 2XAG, in experiments used a vacuum tube of 100,000 watts power.

The Department of Commerce began the installation of directional radio-beacons for use in aviation. Two-way communication experiments between plane and ground carried on with considerable success.

STANDARD FREQUENCY STATIONS

As a result of measurements by the Bureau of Standards upon the transmitted waves of a limited number of low-frequency radio-transmitting stations, data are given in each month's RADIO SERVICE BULLETIN on such of these stations as have been found to maintain a sufficiently constant frequency to be useful as standards. There may be many other stations not measured in the bureau's laboratory which maintain their frequencies just as constant as the stations listed below. There is, of course, no actual guaranty that those stations will maintain the constancy shown, but the data indicate the high degree of confidence that can be placed in them. Broadcasting stations suitable for use as frequency standards are listed in the "Constant frequency broadcast stations."

The transmitted frequencies from the standard frequency stations can be utilized for calibrating frequency meters and other apparatus by the procedure given in Bureau of Standards Letter Circular No. 171, which may be obtained by a person having actual use for it upon application to the Bureau of Standards, Department of Commerce, Washington, D. C.

Station	Owner	Location	Assigned frequency	Period covered by measurements	Number of times measured	Deviations from assigned frequencies noted in measurements	
						Average	Greatest since Nov. 25, 1927
			Kilocycles	*Months*		*Per cent*	*Per cent*
NSS	United States Navy	Annapolis, Md.	17.60	19	80	0.14	0.23
WCI[1]	Radio Corporation of America,	Tuckerton, N. J.	18.00	33	123	.14	.11
WSS	....do	Rocky Point, N. Y.	18.00	16	52	.15	.22
WII	....do	New Brunswick, N. J.	21.80	30	159	.10	.23
NAA	United States Navy	Arlington, Va.	112.00	26	117	.18	.30

[1] Was formerly 17.05 kilocycles. Only 5 of the measurements reported have been made since the frequency was changed.

CONSTANT FREQUENCY BROADCAST STATIONS

The transmitted waves from these stations should be of value to the public as frequency standards because of their constancy and close adherence to their licensed values. The Bureau of Standards makes occasional measurements of the frequencies of these stations. Each station employs a special device for controlling or checking the frequency, the calibration of the device being in agreement with the bureau's frequency standards. The most satisfactory special devices are automatic piezo control, piezo oscillator, or piezo resonator. Until recently a device known as a frequency indicator, Bureau of Standards type B, has been considered a satisfactory instrument for maintaining a broadcasting station on its assigned frequency. On account of the greater accuracy now required of stations, the use of such a device will not hereafter be sufficient to qualify a station for addition to the list. Stations not included in this list which use a piezo-electric device are invited to communicate with the Bureau of Standards requesting a copy of Letter Circular 214, Requirements of Constant

Station	Owner	Location	Frequency	Wave length	Apparatus for frequency regulation
			Kilocycles	*Meters*	
WTIC	Travelers Insurance Co....	Hartford, Conn.....	560	535.4	Piezo oscillator.
WOW	Woodmen of the World Life Insurance Association.	Omaha, Nebr.....	590	508.2	Do.
WEAF	National Broadcasting Co.	New York, N. Y....	610	491.5	Special frequency standards.
WRC	Radio Corporation of America.	Washington, D. C..	640	468.5	Do.
WMAQ	Chicago Daily News.....	Chicago, Ill.....	670	447.5	Frequency indicator, type B, and piezo oscillator.
WCCO	Washburn-Crosby Co.....	St. Paul-Minneapolis, Minn.	740	405.2	Piezo oscillator.
WTAM WEAR	Willard Storage Battery Co.	Cleveland, Ohio....	750	399.8	Do.
WBBM	Atlas Investment Co.....	Chicago, Ill.....	770	389.4	Do.
KGO	General Electric Co.....	Oakland, Calif.....	780	384.4	Do.
KTHS	Arlington Hotel.....	Hot Springs, Ark...	780	384.4	Do.
WGY	General Electric Co.....	Schenectady, N. Y..	790	379.5	Special frequency standard.
WJJD	Loyal Order of Moose.....	Mooseheart, Ill.....	820	365.6	Piezo oscillator.
WLS	Sears, Roebuck & Co.....	Crete, Ill.....	870	344.6	Do.
WKAQ	Radio Corporation of Porto Rico.	San Juan, P. R.....	880	340.7	Frequency indicator, type B.
WBZ	Westinghouse Electric & Manufacturing Co.	Springfield, Mass...	900	333.1	Special frequency standard.
KOA	General Electric Co.....	Denver, Colo.....	920	325.9	Piezo oscillator.
KDKA	Westinghouse Electric & Manufacturing Co.	East Pittsburgh, Pa.	920	325.6	Piezo oscillator and piezo control.
KFAB	Nebraska Buick Auto Co.	Lincoln, Nebr.....	970	309.1	Piezo oscillator.
WBAL	Consolidated Gas, Electric Light & Power Co.	Glen Morris, (Baltimore), Md.	1,050	285.5	Do.
WEAO	Ohio State University....	Columbus, Ohio....	1,060	282.8	Do.
WBAA	Purdue University.....	West Lafayette, Ind.	1,100	272.6	Do.
KFIZ	Fond du Lac Commonwealth Reporter.	Fond du Lac, Wis...	1,120	267.7	Frequency indicator, type B.
WHK	Radio Air Service Corporation.	Cleveland, Ohio....	1,130	265.3	Piezo oscillator.
WMBI	Moody Bible Institute of Chicago.	Chicago, Ill.....	1,140	263.0	Do.
WEBJ	Third Avenue Railway Co.	New York, N. Y....	1,170	256.3	Do.
KWUC	Western Union College....	Le Mars, Iowa.....	1,200	249.8	Do.
WJAY	Cleveland Radio Broadcasting Corporation.	Cleveland, Ohio....	1,220	227.1	Do.
KFVS	Hirsch Battery & Radio Co.	Cape Girardeau, Mo.	1,340	223.7	Frequency indicator, type B.

REFERENCES TO CURRENT RADIO LITERATURE

This is a monthly list of references prepared by the radio laboratory of the Bureau of Standards and is intended to cover the more important papers of interest to professional radio engineers which have recently appeared in periodicals, books, etc. The number at the left of each reference classifies the reference by subject, in accordance with the scheme presented in A Decimal Classification of Radio Subjects—An Extension of the Dewey System, Bureau of Standards Circular No. 138, a copy of which may be obtained for 10 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C. The various articles listed below are not obtainable from the Bureau of Stand-

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R113.5 Wilcox, U. V. Radio reception dependent on solar radiation. Science & Invention, **15**, p. 825; January, 1928.

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