UNITED STATES RADIO DEVELOPMENT*

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Before taking up the radio development of the United States as a whole, some of the more notable instances of Pacific Coast development will be cited. The Pacific Coast is particularly noteworthy for early construction *combined* with *lasting* construction.

The first *permanent* Commercial Public Service radio station in the United States, using U. S. built apparatus, was constructed at Avalon, Santa Catalina Island, California in the spring of 1902.

At the same time this station became the first *permanent* station in the United States to adopt exclusively the telephone method of reception.

The first *permanent* radio trans-oceanic service from United States soil was established between California, near San Francisco, and Honolulu in 1912. Also these were the first stations permanently to use the constant amplitude type of transmitters.

The first Permanent, Commercial, Overland, Public Service, Radio Stations using Constant Amplitude transmitters in the United States were established by the Federal Telegraph Company, between San Francisco and Los Angeles in 1911.

At an early date the Army constructed stations at Nome and St. Michaels, which, from 1904 on, became known for the comparative reliability with which they rendered radio service between these points.

We may now take up radio development in the United States as a whole. In numerical results given in this paper, only

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* A paper delivered before a joint meeting of the American Institute of Electrical Engineers and The Institute of Radio Engineers at the Panama Pacific Convention, San Francisco, September 17, 1915. This paper is based on Government records as found by the writer, and on the writer's notes and recollection. The records and notes are too voluminous to include in a paper of this kind; for example, about 3,000 sheets were used to classify and enumerate the radio transmitters.

Government stations and stations established for commercial purposes have been included because it was found that the number of experimental stations, their date of use and the apparatus used, was indefinite, extremely complicated, and required lengthy explanation.

Considering Chart 1 marked United States "Wireless" Telegraph Development (transmitters):

This chart shows the total number of transmitters and the total number of each class of transmitters for each year from 1899 to 1915, together with manufacturers of these transmitters and operating organizations.

PLAIN ANTENNA TRANSMITTERS (P. A. Class) shown in black includes the type of transmitters wherein the antenna was connected to one side and the ground to the other side of the spark gap of an induction coil.

TUNED COUPLED CIRCUIT TRANSMITTERS (C. T. Class) shown in heavy diagonal lines, includes, for example, the transmitters where an antenna in series with an inductance was tuned to the same frequency, and inductively coupled to a circuit containing a plain spark gap in series with an inductance and leyden jars. United Wireless Telegraph Company transmitters were commonly of this type.

IMPULSE EXCITATION TRANSMITTERS (I. E. Class) shown in lighter diagonal lines, includes, for example, the quenched gap type of apparatus. The Telefunken Company transmitters were commonly of this type.

CONSTANT AMPLITUDE TRANSMITTERS (C. A. Class) shown in white, includes transmitters which produce constant amplitude alternating current in the antenna. Federal Telegraph Company arc transmitters, and radio frequency alternators are included under this class.

With the exception of the number of stations equipped with the different classes of transmitters and the names of Companies, the points in this chart are contained in a general way in Chart 2 and its discussion.

CURVE *R* at the top is intended to indicate the approximate maximum distances used for public or government service each year from 1899 to 1915 referred to the numerals at the left reading from 0 to 4,000 and marked "Range in Miles." (1 mile = 1.6 km.)

CURVES *T*, *S*, *L*, *V*, and *G* are intended to indicate the number of stations each year from 1899 to 1915 referred to the

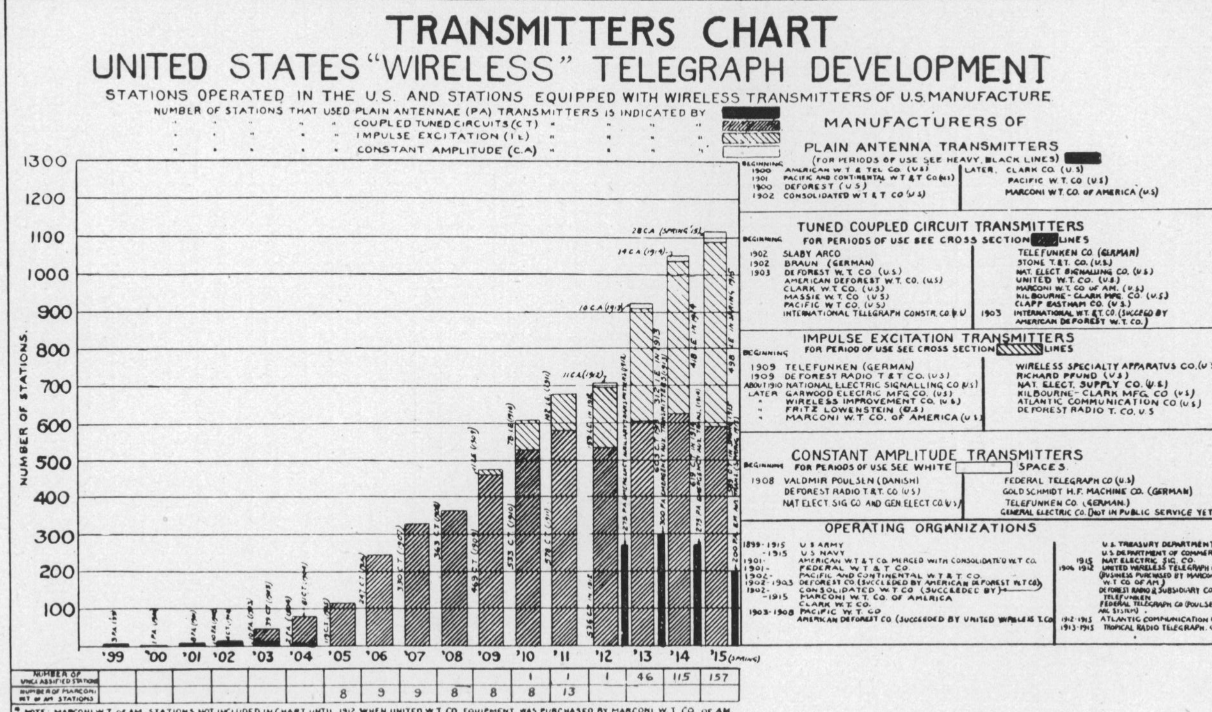
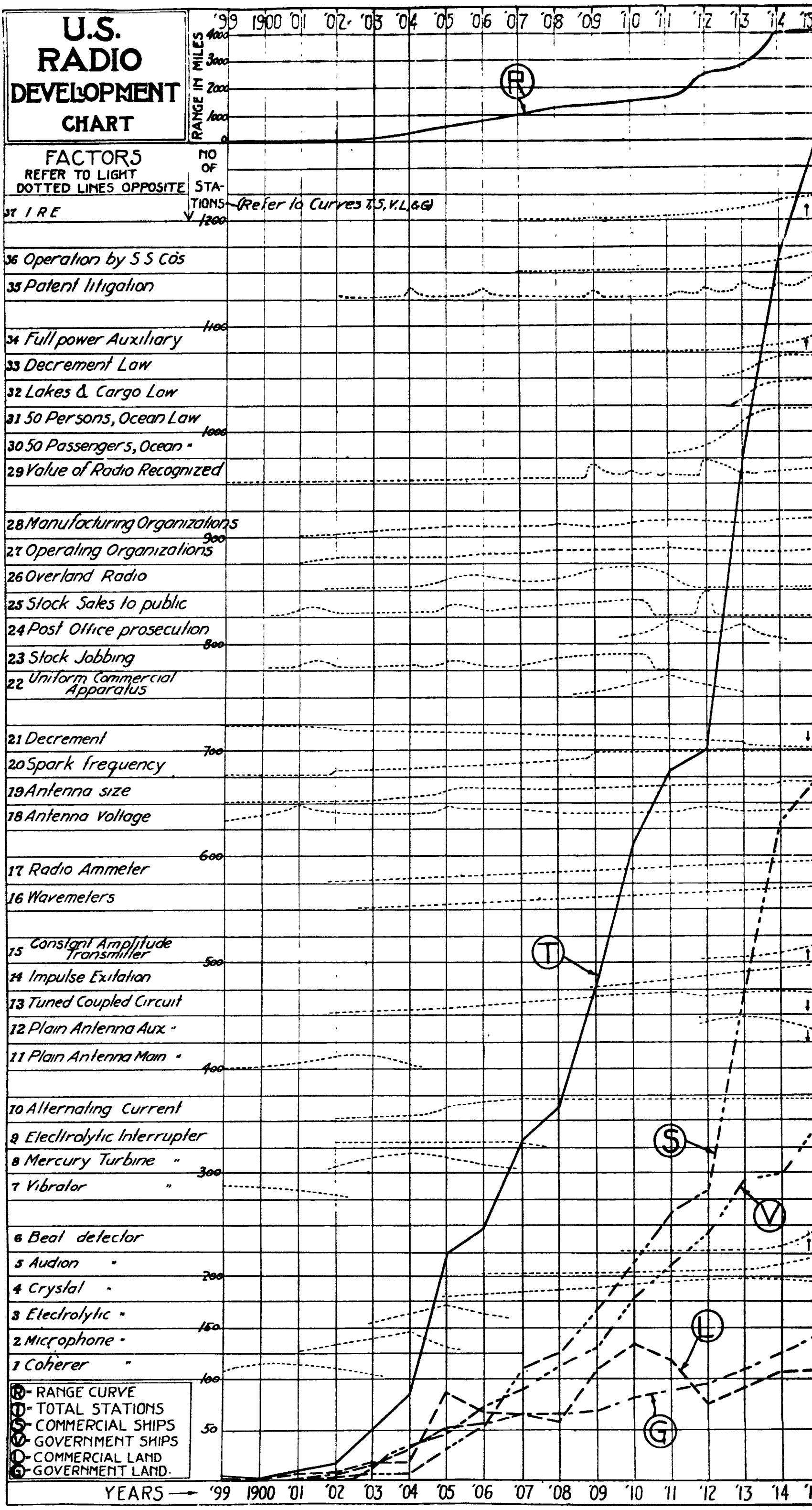

TRANSMITTERS CHART
UNITED STATES "WIRELESS" TELEGRAPH DEVELOPMENT
STATIONS OPERATED IN THE U.S. AND STATIONS EQUIPPED WITH WIRELESS TRANSMITTERS OF U.S. MANUFACTURE
NUMBER OF STATIONS THAT USED PLAIN ANTENNAE (PA) TRANSMITTERS IS INDICATED BY
COUPLED TUNED CIRCUITS (CT)
IMPULSE EXCITATION (IE)
CONSTANT AMPLITUDE (C.A)
NUMBER OF STATIONS.
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
'99
'00
'01
'02
'03
'04
'05
'06
'07
'08
'09
'10
'11
'12
'13
'14
'15 (SPRING)
NUMBER OF UNCLASSIFIED STATIONS
NUMBER OF MARCONI W.T. OF AM. STATIONS
* NOTE: MARCONI W.T. OF AM. STATIONS NOT INCLUDED IN CHART UNTIL 1912 WHEN UNITED W.T. CO. EQUIPMENT WAS PURCHASED BY MARCONI W.T. CO. OF AM.
MANUFACTURERS OF
PLAIN ANTENNA TRANSMITTERS
(FOR PERIODS OF USE SEE HEAVY BLACK LINES)
BEGINNING
1900 AMERICAN W.T. & TEL. CO. (U.S.)
1901 PACIFIC AND CONTINENTAL W.T. & T. CO. (U.S.)
1900 DEFOREST (U.S.)
1902 CONSOLIDATED W.T. & T. CO. (U.S.)
LATER, CLARK CO. (U.S.)
PACIFIC W.T. CO. (U.S.)
MARCONI W.T. CO. OF AMERICA (U.S.)
TUNED COUPLED CIRCUIT TRANSMITTERS
FOR PERIODS OF USE SEE CROSS SECTION LINES
BEGINNING
1902 SLABY ARCO
1902 BRAUN (GERMAN)
1903 DE FOREST W.T. CO. (U.S.)
AMERICAN DEFOREST W.T. CO. (U.S.)
CLARK W.T. CO. (U.S.)
MASSIE W.T. CO. (U.S.)
PACIFIC W.T. CO. (U.S.)
INTERNATIONAL TELEGRAPH CONSTR. CO. (U.S.)
TELEFUNKEN CO. (GERMAN)
STONE T. & T. CO. (U.S.)
NAT. ELECT. SIGNALLING CO. (U.S.)
UNITED W.T. CO. (U.S.)
MARCONI W.T. CO. OF AM. (U.S.)
KILBOURNE-CLARK MFG. CO. (U.S.)
CLAPP EASTHAM CO. (U.S.)
1903 INTERNATIONAL W.T. & T. CO. (SUCCEED BY AMERICAN DEFOREST W.T. CO.)
IMPULSE EXCITATION TRANSMITTERS
FOR PERIOD OF USE SEE CROSS SECTION LINES
BEGINNING
1909 TELEFUNKEN (GERMAN)
1909 DE FOREST RADIO T. & T. CO. (U.S.)
ABOUT 1910 NATIONAL ELECTRIC SIGNALLING CO. (U.S.)
LATER GARWOOD ELECTRIC MFG. CO. (U.S.)
WIRELESS IMPROVEMENT CO. (U.S.)
FRITZ LOWENSTEIN (U.S.)
MARCONI W.T. CO. OF AMERICA (U.S.)
WIRELESS SPECIALTY APPARATUS CO. (U.S.)
RICHARD PFUND (U.S.)
NAT. ELECT. SUPPLY CO. (U.S.)
KILBOURNE-CLARK MFG. CO. (U.S.)
ATLANTIC COMMUNICATION CO. (U.S.)
DEFOREST RADIO T. CO. U.S.
CONSTANT AMPLITUDE TRANSMITTERS
FOR PERIODS OF USE SEE WHITE SPACES.
BEGINNING
1908 VALDMIR POULSEN (DANISH)
DEFOREST RADIO T. & T. CO. (U.S.)
NAT. ELECT. SIG. CO. AND GEN. ELECT. CO. (U.S.)
FEDERAL TELEGRAPH CO. (U.S.)
GOLDSCHMIDT H.F. MACHINE CO. (GERMAN)
TELEFUNKEN CO. (GERMAN)
GENERAL ELECTRIC CO. (NOT IN PUBLIC SERVICE YET)
OPERATING ORGANIZATIONS
1899-1915 U.S. ARMY
-1915 U.S. NAVY
1901- AMERICAN W.T. & T. CO. MERGED WITH CONSOLIDATED W.T. CO.
1901- FEDERAL W.T. & T. CO.
1902- PACIFIC AND CONTINENTAL W.T. & T. CO.
1902-1903 DEFOREST CO. (SUCCEEDED BY AMERICAN DEFOREST W.T. CO.)
1902- CONSOLIDATED W.T. CO. (SUCCEEDED BY)
-1915 MARCONI W.T. CO. OF AMERICA
CLARK W.T. CO.
1903-1908 PACIFIC W.T. CO.
AMERICAN DEFOREST CO. (SUCCEEDED BY UNITED WIRELESS T. CO.)
U.S. TREASURY DEPARTMENT
U.S. DEPARTMENT OF COMMERCE
1915 NAT. ELECTRIC SIG. CO.
1906-1912 UNITED WIRELESS TELEGRAPH CO. (BUSINESS PURCHASED BY MARCONI W.T. CO. OF AM.)
DEFOREST RADIO & SUBSIDIARY COS.
TELEFUNKEN
FEDERAL TELEGRAPH CO. (POULSEN ARC SYSTEM)
1912-1915 ATLANTIC COMMUNICATION CO.
1913-1915 TROPICAL RADIO TELEGRAPH CO.

CHART 1



UNITED STATES RADIO DEVELOPMENT CHART 2

Numerals at the top and bottom of this chart indicate years numerals at the left reading from 0 to 1,200 and under the heading "Number of Stations."

These curves, particularly in latter years, lag somewhat because it frequently happened that the existence of stations was not recorded or was unknown to the writer until the following calendar year. Data for 1915 was brought up to about June 1.

CURVE *T*—Total number of radio stations in the United States. (Government and commercial)

CURVE *S*—Number of commercial ship stations

CURVE *L*— " " " land "

CURVE *V*— " " Government ship "

CURVE *G*— " " " land "

Under the heading of "Factors" at the left on chart 2 is a list of subjects, numbered on the extreme left. The lighter dotted curves extending across the chart in the single narrow spaces opposite these subjects are intended to indicate approximately the rising, falling, peaks, and depression in the history of these subjects or factors.

1. COHERER. This form of detector was used in the Navy stations in 1899. Apparently coherers of English Marconi Company and Navy make were used. Owing to its insensitiveness and uncertainty of action, the coherer was almost entirely discarded in the United States by 1903 as indicated by the light dotted line opposite "Coherer" on the Chart. Changing from the coherer was one of the greatest steps, not only by virtue of increased sensitiveness and reliability, but by leading to detectors more capable of utilizing long wave trains thereby making it easier to construct more powerful transmitters.

2. MICROPHONE. This is intended to include the class of detectors which superseded and took the place of the coherer. As a rule, they consisted of a contact between steel and carbon, or steel and aluminum; however, the detectors as used at Avalon and Whites Point, California, consisted of the contact between steel and an oxide of iron (and thus may have had more of the qualities of the crystal detectors). The microphone was abandoned largely because of its lack of stability.

THE TELEPHONE RECEIVER

The arrival of the microphone marks the arrival of the lasting telephone method of reception, a revolutionary and comparatively large step in radio advancement.

3. ELECTROLYTIC. This detector succeeded, and took the place of the microphone. At its best it was very sensitive but atmospherics destroyed its extreme sensitiveness and the acid used in it damaged other things. A court decision tending to give Mr. Fessenden and his associates a patent monopoly on this form of detector apparently hastened its disapproval and disappearance.

4. CRYSTAL. This detector succeeded and took the place of the electrolytic partly because it was cheaper and more stable and partly because the United Wireless Telegraph Company, the commercial company having the greatest number of stations at that time, controlled the use of the carborundum detector.

Also, the Government became active in the use of silicon and perikon (zincite and chalcopyrite). Galena and various combinations with zincite came into use. These crystal detectors have been used in greater number than any other since about 1907.

5. AUDION. This form of detector was used to some extent as early as 1906, but apparently in very small numbers until about 1912 when the amateurs became active in its use, and within the last year or more it has been used to some extent by the Government.

The TIKKER detector, not shown in the Chart, was mainly used in 1912 and 1913 for receiving constant amplitude waves.

6. BEAT detector. This form of detector consists, in part, of a radio frequency, constant amplitude generator supplying a radio frequency differing from the frequency of the incoming, constant amplitude signals by such an amount as will produce audible beats. This appeared some time ago, to a very limited extent, in what was called the "heterodyne," wherein an arc produced the local radio frequency.

Within the last year or more, detectors, of which the audion is one type, have been arranged to act as detectors and local generators. This comparatively simple form of beat detector is taking the place of the tikker and increasing in number with the increase in use of constant amplitude transmitters.

The pliotron and other detectors and oscillators are increasing in numbers with the audion, particularly for beat reception.

These successive detectors, and the telephone method of reception, together with the subsequent improvements in telephone receivers and tuner circuits, have obviously contributed to radio service and to the rise of the range curve *R*, shown at the top of the chart.

All of the detector steps were markedly useful in radio development, but those recent steps of which the audion and pliotron are types (with their three-fold abilities, as detectors, generators and amplifiers), stand out as particularly useful. And the possibility of tuning to group frequency adds encouragement to the thought of better selectivity for the future.

7. The VIBRATOR INTERRUPTER used first as a means of breaking the primary current in the induction coil, because of its unreliability, small current carrying capacity, and slow operation was abandoned quite early by most United States users; the chief exception being the American Marconi Company, which brought it back into use in considerable quantity in 1912 in connection with the auxiliary 10-inch coil supplied by them and indicated under Factor 12. However, it has again been condemned and is passing out.

8. The MERCURY TURBINE INTERRUPTER replaced the vibrator to some extent. This interrupter was capable of giving a much higher interruption rate per second and to some extent was more reliable; however, the mercury required frequent cleaning and was somewhat expensive and injurious.

At the Avalon and Whites Point, California Stations, in 1902, rotating commutators were used. These were more reliable and gave higher interruption frequency than the vibrator.

9. The ELECTROLYTIC INTERRUPTER came with the mercury turbine interrupter, as a part of German made apparatus, supplied to the U. S. Navy in 1902. It, too, produced higher interruption frequency, but varied in action and became less satisfactory as its temperature increased and the acid used was injurious.

10. Early in 1903, Dr. de Forest brought an *alternating current generator and transformer* to the Navy Department at Annapolis. This was the beginning of the marked advancement in power and reliability at the transmitter. And the alternating current has lasted up to the present time.

The mercury turbine and electrolytic helped to increase the range and service, while the alternating current contributed to a greater and more lasting extent.

11. The PLAIN ANTENNA TRANSMITTER was used by the United States Navy as early as 1899 at the Atlantic Highlands near New York and on vessels. At this time, it appeared with the vibrator interrupter and coherer detector.
12. The PLAIN ANTENNA TRANSMITTER as an auxiliary was brought back by the American Marconi Company in 1912. The plain antenna transmitter was the characteristic transmitter of Marconi Companies.
13. The TUNED COUPLED-CIRCUIT TRANSMITTERS made by the Slaby-Arco Company of Germany were used by the United States Navy at Annapolis and on vessels in the Fall of 1902. Tuned coupled circuit transmitters later became the characteristic transmitters of the de Forest and United Wireless Telegraph Companies.
14. The IMPULSE EXCITATION TRANSMITTERS made by the Telefunken Company of Germany and by Dr. Seibt of Germany (then with the de Forest Radio Telephone and Telegraph Company) were put in use almost simultaneously in 1909. The Telefunken transmitters were used shortly thereafter by the Navy and Army. Later the quenched gap transmitters became known as the characteristic transmitter of the Telefunken Company.
15. CONSTANT AMPLITUDE TRANSMITTERS of the arc type were used in commercial radio Service in 1912, and have become known as the characteristic transmitters of the Federal Telegraph Company. The Goldschmidt alternator type came into service at Tuckerton in 1914, and the frequency-changing transformer type came into service at Sayville in 1915.

Before 1912, constant amplitude generators were built and experimented with in an endeavor to obtain serviceable machines, and for calibrating purposes.

The RADIO TELEPHONE has been experimented with in varying amount since about 1907, but up to the middle of this year it apparently has never been sufficiently marked in its usefulness to remain in Government or commercial use. Apparently the main reasons have been: 1: inability to construct a telephone transmitter (e. g. microphone) which would reliably modulate sufficient energy; and 2: difficulty in obtaining constant amplitude current at short wave lengths or satisfactory spark frequency above audibility. The pliotron and similar devices may serve in solving these difficulties.

The word "radio" came into marked use in place of "wireless" in 1907, and was officially adopted by The Institute of Radio Engineers in 1911 and shortly thereafter by the United States Government.

16. WAVE METERS of German make were used by the Navy Department early in 1903, and stations were adjusted to prescribed wave lengths with increasing accuracy up to the present. Also, Navy records made about that time or shortly after show resonance curves. The wave meter was used in the United Wireless Company in 1907 and increased in use, until in 1910, practically all the United Wireless (the then largest commercial company) stations were adjusted by using the wavemeter.

17. RADIO AMMETERS came with the German apparatus to Annapolis in 1902 and the Navy has used such ammeters in increasing numbers since that time. Commercial organizations were slower to adopt these however. Within the last two years radio ammeters have been used in noticeably increasing numbers in commercial stations.

18. ANTENNA VOLTAGE increased from time to time up to the insulation limits as attempts were made, with different transmitters, to increase the power. The point of breakdown was quickly reached with the plain antenna transmitters, and this was one of the several objectionable features of the plain antenna transmitter. It may be that the insulation broke down more quickly with this type of transmitter because the antenna potential to ground remained high (before the spark discharge took place) for a greater length of time than where coupled circuits were used. For example, assuming that a coupled transmitter produced only alternating currents in the antenna and the potential rose from zero to a maximum and returned to zero again in one millionth of a second, while with the induction coil connected in the plain antenna circuit, the potential possibly increased from zero to a greater maximum for about one-tenth of a second before the discharge took place, the antenna insulation was subjected to higher potential for longer intervals.

19. ANTENNA SIZE. At first the vertical dimension of the

antenna was increased because it was recognized quite early that the sending range increased with the height of the antenna.

Later it was recognized that more power could be put in an antenna without breaking down the insulation by adding horizontal wires to the vertical antenna, and more power meant greater range.

Still later the antenna size was also increased to obtain natural periods more nearly equal to the longer transmitting wave lengths desired. An exception was the recent (since 1912) decrease in horizontal length of some shipboard antenna, to bring down the natural period so that the legal requirements for 300 meter waves could be met, as prescribed by the International Radio Conference.

In each step of development of the transmitter the size of the antenna was as a rule increased.

The plain vertical antenna grew from less than 100 feet (30 m.) to over 100 feet in height.

With the tuned coupled circuits at land stations in 1905, the height increased to over 200 feet (60 m.), and the horizontal dimensions were increased by fanning the wires and by increasing the number of masts. On shipboard, wider spreaders and more wires were used, increasing the capacity and *decreasing* the *resistance.*

With the impulse exitation transmitters, the height on land increased to 400 feet (120 m.) or more and the spread became greater; for example, in 1912, Sayville with its antenna, about 500 feet high and covering an area of about 4,000,000 square feet. With the constant amplitude transmitter came still larger antennas, for example, Tuckerton in 1914, with its antenna 850 feet (250 m.) high and covering an area of about 7,000,000 square feet.

An increase in height of about 10 to 1 occurred between 1899 and 1915, and a large increase in area with consequent capacity increase of about 25 to 1.

For future high power stations, right of ways may be obtained along roads or waterways and long antenna erected on high towers in one or more directions from the transmitter.

The single vertical wire antenna probably gave rise to the term "open circuit" while its use as plain antenna helped to stamp radio frequency circuits as "oscillating circuits." Apparently the term "open circuit" is passing with increased horizontal dimensions of antenna as also is "oscillating" with the advent of constant amplitude transmitters.

20. Spark Frequency increased from about 30 to 1,000 sparks per second during the period from 1899 to 1909. At Catalina, in 1902, about 70 sparks per second were used. In 1903, the 60 cycle alternating current brought the spark frequency to 120 or more per second. By 1905, apparently, spark frequencies as high as 500 per second were used. In 1909, spark frequencies of 1,000 per second and higher were used, particularly with quenched gap transmitters.

21. Decrement. The decrements of the alternating currents in the antenna have materially decreased since 1899.

Apparently, with practically all the steps in radio development tending to produce longer ranges and greater continuity of radio service, the effective power radiated increased with, and largely because of, the decrease in decrement. Or, probably, it may be said that the trend of transmitter development has been to increase the power and the size of the antenna and to produce single, radio frequency, constant amplitude (zero decrement) alternating current in the antenna.

22. Uniform Commercial Apparatus. The era of standardization from the standpoint of having apparatus of fixed type was between about 1908 and 1912, with the peak equipment consisted of a power switchboard, motor generator of uniformity in apparatus at about 1910. The uniform (delivering 60 cycle A. C. and about 1 K. W.), open core transformer, rack with 12 jars, muffled open gap in a helix (direct coupled), two coil direct-coupled tuner, carborundum receiver, telephones, and flat top antenna (loop connected). This uniformity kept down first cost and maintenance, but it prevented material improvement, because improvement meant violation of uniformity and consequent raising of maintenance cost and because other vessels would want the same improvement thus resulting in the scrapping of apparatus without indication of sufficient compensation.

23. Stock Jobbing. The exaggeration of radio matters in connection with the sale of "wireless" stocks of doubtful or practically no value was, as a rule, more or less associated with the operating commercial radio companies, from 1900 to 1911. As early as 1901, one company circulated printed matter and letters emphasizing the increase in telephone and telegraph stations and the great increase in selling price of telephone stocks and implying that the radio telegraph and telephone were ready to take the place of wire telegraph

and telephone. This company and subsidiary companies sold or attempted to sell stock. The same general process with amplifications continued to 1911 being promoted by several groups of people and under many names.

This stock jobbing influenced radio development in many ways; and whether or not this method was good, bad, or avoidable it certainly was an effective factor.

To sell stock required the showing of assets and activity. Patents and stations were considered as assets and activity. A patent was usually cheaper than a station which probably accounts for many radio patents.

Stations which were unprofitable from the standpoint of tolls or rental were established and maintained for and by the sale of stock.

Many steamship companies apparently only equipped their vessels with radio some years ago because it cost them little or nothing. By virtue of stock jobbing, the ocean-going public received more radio service and protection some years ago than it probably would have otherwise received, and the science and art were developed thereby. In the main, the general public paid the expenses without return of dividends or principle. It will be noted that curve L (land stations) drops at the beginning of the discontinuance of stock jobbing in 1910 and for similar reason the commercial ship stations, curve S changed direction in 1912.

Since 1911, the laws requiring and regulating radio have probably been the chief factors in fixing the number of ship and shore stations.

24. Post Office Prosecution. This result of stock jobbing reached its most active stage in 1910 and 1911, or about ten years after the stock jobbing started. About ten men were sent to the penitentiary and two or more were fined. These were later-day stock jobbers, the earlier stock jobbers had been out of radio long enough to be forgotten or to be protected by the statute of limitations before the continued and growing complaint from the public became effective. While the charges and convictions were specified under several counts and certain specific instances were brought up for proof, it possibly may be summed up by saying these men were punished for getting money from widows and poor people by flagrant misrepresentation about radio thru the United States mails.

25. Stock Sales to the public by stock jobbing methods were largely stopped in 1910 and 1911 by the Post Office prosecution; but, oddly enough, probably the greatest sale of radio stocks in the United States history occurred in 1912, when apparently about $6,000,000 changed hands in the sale of Marconi Wireless Telegraph Company of America stocks. The Marconi Company had raised its capitalization for taking over the United Wireless Company. Marconi stock was put on the market following the publicity attached to the Post Office prosecution and then the Titanic sank, further emphasizing radio. The result was old Marconi stocks went up in price from about $12 to $360 per share on the curb market and the new issue was sold.

Apparently some of the results of this new sale of stock to the public were to produce high power stations for trans-oceanic work, increase patent litigation, raise rentals to steamship companies, cause steamship companies to own and operate radio equipments, with some development of steamship apparatus by the Marconi Company.

26. Overland Radio was attempted in competition with the wire lines at one time or another in a majority of the states of the United States. In many cases the gross receipts were not sufficient to pay for the coal used in heating the stations. A large percentage of these stations were said to have been erected for stock jobbing purposes.

As a rule the overland stations were unable to handle business satisfactorily during the season of summer atmospheric disturbances, and the stations interfered with each other. In addition to this, they were competing with minor portions of two or three long established wire lines that were equipped to render service to nearly any point in the United States and to a great many points thruout the world, and the public was in the habit of using the wire lines. The result was practically universal abandonment of overland radio stations.

27. Operating Organizations have apparently varied from about 5 in 1902 to 10 at the present time, marked in earlier days by small short-lived companies, later by larger longer-lived companies with the more recent addition of operation by steamship companies.

28. Manufacturing Organizations. For a time, manufacturing companies were usually operating companies, but with the continued demand of the Navy and Army for

radio apparatus of U. S. manufacture and for improved apparatus, companies other than operating companies were formed to manufacture, and to meet this demand.

29. VALUE OF RADIO RECOGNIZED. In the earlier history except when convinced by a stock salesman, the public as a whole apparently regarded radio as more or less of a scientific toy which had possibilities but was not particularly useful; and because of stock jobbing, radio people, as a class, bore a somewhat bad reputation, both as to morals and ability.

The sinking of the "Republic" and the use of radio caused the public to recognize that it was of value, and its subsequent use (as, for example, on the S. S. "Ohio," and lastly, with the "Titanic") made such an impression that Congress passed laws requiring and controlling radio.

It may be said that from 1899 to 1911, the period characterized by stock jobbing, was the ERA OF DEVELOPMENT OF DEMAND FOR RADIO SERVICE, and with the coming of the Radio Laws and the stopping of stock jobbing in 1911 began the ERA OF FIXED MINIMUM DEMAND FOR RADIO SERVICE.

30. 50 PASSENGER, OCEAN LAW.

The first law passed, which became effective in July, 1911, required *ocean-going* vessels carrying *passengers* and carrying 50 or more persons, including passengers and crew, for a distance of 200 miles from United States ports to have a radio operator and apparatus capable of working 100 miles (160 km.). Additional stations principally on ships, were required, which offset somewhat the decrease in stations due to the closing of stock jobbing stations.

50 PERSONS LAW

In October, 1912, a revised law became effective for 50 persons which added one more operator and an emergency auxiliary source of power for the radio transmitter on ocean-going passenger ships; and later in 1913 on cargo and passenger carrying ships on the Great Lakes and on ocean cargo ships.

As will be noted in curve *S*, by the time all of these laws became effective the number of ship stations was approximately twice that of 1911 when the first law began to be effective.

In addition, these laws covering vessels carrying 50 persons required two licensed operators and an auxiliary source of power which increased the number of operators on commercial ships to about four times that of 1911 and brought in the plain antenna auxiliary set and later the full power auxiliary set.

The licensing of the operators by examinations raised the technical training of the operators as a class.

The requirement for continual service and operative apparatus has improved the apparatus and provided far better radio protection for occasions of distress on vessels.

33. The DECREMENT LAW, or portion of the law, effective in 1912 with regulations, was made to prevent interference and for that reason required certain wave lengths and licenses for various classes of stations, all of which stations were required to use a decrement of less than 0.2.

34. FULL POWER AUXILIARY. This is an auxiliary source of power capable of furnishing sufficient power to operate the main radio transmitter for four hours or more. Two such installations were made early in 1911 by the United Wireless on the Lamport and Holt line. When the law requiring auxiliary sources of power went into effect, ten inch induction coils with small storage battery were put on by the Marconi Company, thereby providing less power for distress purposes than was provided for ordinary business. In 1913, the United Fruit Company installed large Edison storage batteries to furnish full power for their main transmitters and for emergency deck lights, and since then other steamship companies have been making somewhat similar installations.

35. PATENT LITIGATION. In August, 1902, the Marconi Wireless Telegraph Company of America brought suit against the de Forest Wireless Telegraph Company on the Marconi reissue patent number 11,913. Nearly three years later, in April, 1905, Judge Townsend held that claims 3 and 5 of the Marconi patent were infringed and granted an injunction and accounting on those claims, but said that claim 1 was too broad and claims 8, 10, and 24 were not infringed. However, in April, 1905, the de Forest Wireless Telegraph Company was a company of the past, and the decision practically only served to make others wary of claims 3 and 5. So that, altho the Marconi Company sued the American de Forest Wireless Telegraph Company in March, 1906 on claim 3 of this patent, the American de Forest Wireless Telegraph Company was using the loop antenna, and Judge Townsend rendered a decision in April, 1907, holding that the showing

made did not warrant the granting of an injunction. The chief result of this litigation which started in 1902 and ended in 1907, was the loop antenna, excepting, of course, that a considerable sum of money was probably expended. Taking into account all the radio litigation up to the present, probably the main features have been the expenditure of money and the time between the starting of the case and the final decision. This litigation effected the development of radio in a number of ways.

Beginning with 1902, one or more suits have been before the courts each year.

The decision in favor of the Marconi Company, plaintiffs, in 1905 resulted in the loop antenna which was successfully defended later.

The decision in favor of Fessenden and his associates, plaintiffs, in 1906 on the electrolytic detector, helped bring crystal detectors into use.

The decision in favor of the Marconi Company, plaintiff, in 1914, against the National Electric Signaling Company, and the National Electric Signaling Company suits against the Marconi Company apparently brought about the working agreement between these companies.

Seven suits filed in 1914 were the greatest number filed in one year.

Of approximately 27 suits filed from 1902 to the present time, apparently only seven have shown permanent status in favor of the plaintiff.

Of these, two were rendered ineffective by the defendant subsequently using other apparatus, two produced a working agreement, one was in connection with the selling out of the defendant, and the other two partially restricted two companies but are still being fought.

About eight suits are pending trial or decision.

Apparently United States radio patent litigation has been unprofitable for both the defendants and plaintiffs.

The time elapsed between filing the suit and the decision has varied from one month to four years and averaged about one and one half years.

36. Operation By Steamship Companies. That is, wherein the steamship companies rent or buy their apparatus, handle the traffic accounts, control their operators the same as the other members of their crews, etc. Among the first to do this was the United Fruit Company. Recently this

method of operation has increased quite rapidly, particularly on the Pacific Coast.

In the early days the stock jobbing operating companies rented the operators, apparatus, and traffic service for from $62.50 per month *down* to *nothing* per month. The steamship companies were not required to have it, and they were *not responsible* for it. Then, to the steamship company it was largely a *cheap* novelty which might be useful.

But with the departure of the low rent stock jobbing method, and the coming of some patent decisions and combinations in attempted patent monopoly, and the enforcement of radio laws, conditions have changed. Now, to the steamship company, it is more expensive and usually it is a *necessity* and a *responsibility*.

It has become a matter of question whether the steamship company cannot operate radio as cheaply as to rent its operation, and since it is now a *necessity* and a *responsibility*, the natural question is, why should not radio apparatus be in the same business system as other parts of the ship's equipment, the operator the same as any other member of the crew, and the traffic accounts the same as other traffic pertaining to ships? The result is that additional lines own and control the radio on their vessels.

37. THE INSTITUTE OF RADIO ENGINEERS. The Institute of Radio Engineers, formed by the combining of the Society of Wireless Telegraph Engineers and the Wireless Institute, was developed in the former organizations, principally by the persistent efforts of a few individuals. Practically, its early development was mainly characterized by the persistence of a few persons in meeting, reading, and discussing radio papers, regardless of attendance. Later, gradually, and still later, more rapidly, others became interested and active until now The Institute of Radio Engineers is an international, influential, educational organization, occupying a class by itself, and is worthy of classification as an effective factor in radio development.*

SUMMARY: The history of radio development in the United States is considered in great detail. Transmitters, detectors, antennas, a number of detailed parts of radio apparatus, and various branches of radio communication are classified, and their progress studied. Such topics as standardization, financial procedure, litigation, radio laws, and their consequences are treated fully.

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*In this connection, it is a pleasure to inform the readers of the PROCEEDINGS that it is largely thru the loyal and continued efforts of Mr. Marriott that the originally very restricted membership of the Institute now runs into the thousands.—EDITOR.