H.W.Dickow

The Arc vs the Spark

A new era in wireless communication came with the advent of the Arc as a generator of electric oscillations. And although the majority of the membership of the Society of Wireless Pioneers is composed of "spark gappers," there are nevertheless a great number of pioneer brass-pounders whose activities were devoted partially or exclusively to communication by means of the Arc.

Here is a comprehensive history of the Arc, and the evolution of those who engaged in its design and manufacture from 1903 until it, like the spark, fell victim to the vacuum tube.

Please Space
I will write on my machine
B.

H.W.Dickow

Chronology of the Poulsen Arc and the Founding of Federal Tel., Mackay and I.T.T.

The first indication that wireless telegraphy by means of the spark transmitter would eventually be replaced by some other more satisfactory and economical system,was the introduction of the Poulsen Arc. This revolutionary device was invented in 1903 by the Danish scientist Valdemar Poulsen, although the original experimental work on the arc was done by Elihu Thompson in 1892. Thompson, like Heinrich Hertz, did not forsee the potential of his experiments, and it remained for Poulsen to do with the arc what Marconi had done with the spark.

Poulsen owes some of his success to William Duddell, who substituted carbon electrodes for those of metal as used in the wireless spark gap. By immersing his arc in hydrogen gas, Poulsen was able to produce higher frequencies than otherwise and greater amounts of power were likewise generated. The frequencies thus provided were practical for the transmission of radio signals.

Poulsen's invention first became known in the United States in 1908. During this same year, a Stanford University graduate, C.F.Elwell, whose thesis was devoted to the design of an electric furnace, known as The Induction Furnace, and whose purpose was the reduction of iron ore, was offered a position with the McCarty Wireless Telephone Co. by the Henshaw Brothers of their Oakland, California, banking firm, to research the McCarty patents and the system generally. Elwell accepted the offer. During this same year he purchased the necessary equipment and materials to build a McCarty Wireless telephone, and on August 29, 1908, the project was completed and subjected to public demonstartion. Although it proved satisfactory in its ability to transmit the human voice, as had been proved by the McCarty brothers in 1902, its range was very limited.

Lack of public interest in the invention resulted in its abandonment by Elwell and he immediatedly turned his attention to the sensational discovery of the Poulsen Arc.

The following year, 1909, Elwell entered into negotiations with Poulsen to buy the arc patents for use in the United States. He appealed to the Henshaw Brothers for financial support, but without success. Elwell went to Denmark in May, 1909, at his own expense, to begotiate directly with Poulsen and his collaborator, Dr. P.O.Pederson. Reluctantly, Poulsen demonstrated his system of wireless telephony to Elwell. Amazingly the voice was transmitted successfully over a distance of 10 miles. The following day, Elwell heard wireless telegraph signals at 200 words per minute, between Danish stations at Lyngby and Esbjerg, 180 miles apart. Elwell was astonished and immiediately offered to buy the Poulsen patent.

Poulsen was willing to sell the rights to his invention for use in the United States; his asking price was $450,000. Elwell agreed, and sealed the bargain with a token payment of $1,000 in cash. He additionally agreed to buy two Poulsen transmitters, one of which was rated at 12-kw and the other at 5-kw, for $6,000.00 Elwell hurried back to the United States and upon his arrival in New York he called upon Fortune Ryan and other Wall Street financiers. He was rebuffed by one and all.

Elwell returned to Denmark during the summer of 1909 and purchased a small Poulsen Arc rated at 100 watts. It consisted of a small hollow cube formed by two sides or marble and with the remaining two sides, as well as its top and bottom, made of brass. The anode was mounted in the center of one of the marble slabs, the cathode in the center of the other slab. Thus the marble served as an insulator to the electrodes. It operated on 110 volts direct current, with an output of approximately one ampere.

It was this arc that Elwell took with him to Palo Alto, California, the first Poulsen Arc ever to arrive in America. With his arc, Elwell was able to transmit clear radiotelephone signals from North Palo Alto to South Palo Alto, a distance of one mile. Thus, in 1909, the Poulsen Wireless Telephone and Telegraph Company, direct predecessor of Federal Telegraph Co., was formed as a California corporation. Its presiding officer was David Satrr Jordan, who headed Stanford University. Jordan got the new company under way with his initial investment of $500.00.

During the early months of 1910, two Poulsen transmitters arrived in New York and the newly formed cmpany was required to pay an import duty of $4,500.00 before the equipment could be shipped to Palo Alto. Furthermore, it was essential that several Danish engineers would be on hand to install the new apparatus. Three engineers were sent to Palo Alto: Peter L. Jensen (later of loudspeaker fame), F. Albertus, and C.L.Schou. Jensen became a member of the Poulsen team a year earlier, as did Edwin S. Pridham, who later became associated with Jensen in the development of the dynamic speaker.

The first Poulsen stations were built in Stockton, California, and at Sacramento, some 49 miles apart. Two 180-ft. masts were erected at each site. These poles had to be towed by a Sacramento River boat. A powerful wireless spark station had previously been in operation in Sacramento and its operators made a concerted effort to break-up the Poulsen arc transmissions by creating heavy interference. Federal radio laws, outlawing such practices, were not yet in effect.

The financial coffers of the embryonic Poulsen company were enriched by funds provided by Richard E. O'Connor, who later headed the Magnavox Company.

On February 19,1910, the Stockton and Sacramento Poulsen stations were officially opened by David Starr Jordan, and a public stock offering was announced. One of the highlights of the offering was an announcement that a large number of arc stations could be operated simultaneously without interfering with one another, an achievement impossible with wireless spark transmission.

Also during 1910, the Poulsen Company began the manufacture of its own arc transmitters in a small house ans shed in the residential area of Palo Alto. In this same shed, Dr. Lee deForest discovered the audion amplifier and vacuum-tube oscillator.

During July, 1910, Poulsen Wireless built its large "Beach Station" on San Francisco's ocean front near the Great Highway, where a 12-kw arc transmitter was installed. The 300-ft. wooden lattice-work towers, supported by cables from the original San Francisco cable car transportation company, served to hold these towers in position. The towers were painted white. They presented an awesome spectacle to the residents of the city. The original building in which the equipment was housed was later sold to D.B.McGown for $1200.00 when deactivation of the station was completed. McGown, then with the Police Radio System of the city, converted the building into an apartment house, which stands fully occupied to this day.

Another Poulsen Wireless station was built in Los Angeles, 340 air miles from San Francisco, and a heavy volume of traffic began to flow between the two points.

In January, 1911, The Poulsen Wireless Telephone and Telegraph Company was reorganized with its official title reduced to Poulsen Wireless Corporation. Beach Thompson became president. Although the volume of paid message traffic on opening day of the new circuit amounted to only $5.00, it soon grew rapidly.

The following year (1912) Federal Te;egraph Co. arc stations were built in Medford, Oregon; Phoenix, Arizona; Seattle, Washington; El Paso, Texas; Kansas City, Kansas; Fort Worth, Texas, and Chicago, Illinois. Eventually, 14 stations were competing with the wire services, with consistent wireless communication over distances of 500 miles during daylight and 1,000 miles at night. A Federal Arc station was built during this same year at Heeia Point, Oahu, for Hawaiian traffic with San Francisco, 2400 miles distant, although the distance was covered only during the hours of darkness. This station handled a minimum of 1,500 words of press daily at a rate of 16 cents a word, versus thirty-five cents by trans-Pacific cable.

At the time of completion of the Los Angeles station, Poulsen in Denmark was paid $500,000 in cash and bonds in the reorganized Poulsen Wireless Corporation. The payment was made in January, 1911. However, prior to this date, the Federal Telegraph Company was organized for the sole purpose of avoiding high taxation in the event that business transacted with States fell into such a category. Upon completion of capitalization of Federal Telegraph Company, Beach Thompson died and George A. Pope succeeded him.

In 1912, Federal Telegraph Co. sent the first self-contained 3-stage audio amplifier to Washingtom, D.C., in order to demonstrate it to the U.S.Navt. At the same time, the company requested the Navy's permission to demonstrate the Federal Arc. The Navy had just completed its 100-kw spark station at Arlington, Virginia, which required three years to build; after prolonged tests of all types of spark systems then available, the Navy decided to adopt the 100-kw Fessenden transmitter, although Federal had previously established conclusively that its 2400-mile circuit between the Hawaiin Islands and the San Francisco Beach Station was a complete success.

The U.S.Navy consented to the installation of a 30-kw Federal Arc to be operated in competition with its elaborate 100-kw spark transmitter, and on December 8,1912, communication was established between Arlington and the Federal's South San Francisco station. This was considered a phenomenal feat by the Navy officials because they failed to contact Mare Island with their 100-kw spark transmitter. The following night a record was broken when the Federal Arc covered a distance of 4,500 miles between Arlington and Heeia on the Island of Oahu, a few miles out of Honolulu.

The Navy's Dr. Austin then tested the Federal Arc signals at Colon, Canal Zone, with significant results. Messages were received through the heavy static when the spark failed to get through. The many wireless spark pioneers who sailed on ships which cruised in the static-infested areas of Panama will be quick to realize the tremendous importance of this achievement.

Dr. Austin additionally found that the Federal Receiver provided from 2.8 to 4.6 times as much energy as the standard Navy IP76 receiver. Thereupon the U.S. Navy ordered a 100-kw arc for Darien, Panama Canal Zone. It was installed in 1913, thus making the U.S. Navy the first in the world to adopt continuous wave transmission. An additional Navy purchase was a 350-kw arc transmitter for Pearl Harbor and Cavite, P.I. Then a smaller station of 200-kw for San Diego,California. The distance from Cavite to San Diego is 7,800 miles, which was spanned successfully by the Federal Arc.

Arc signals could not be received on the conventional receivers designed for spark reception, unless and until a special device were installed to operate in conjunction with the crystal detector sets. This device was known as a "Ticker" - or "Tikker."

The original ticker-detector, brought to the United States from Denmark with the first Arc, was a costly gold-wire type vibrator. An amateur radio experimenter, C.V.Logwood, who later became an associate od Dr. Lee de Forest, devised a simple, inexpensive tickerby merely roughening the surface of a pulley removed from a $1.25 toy electric motor and arranged a small piece of steel wire in such a manner that it bore upon the roughened groove of the pulley. The result was a "ticker" which produced stronger and better sounding signals than the expensive original device. Logwood's invention was made in 1911. In 1912 he developed a cascade amplifier by connecting three Federal PN audion detectors in cascade, each supplied by current from separate plate and filament batteries. This was the first application of the audion, or three-element vacuum tube as an amplifier.

Reverting to 1910, Dr. Lee DeForest discovered his audion detector, oscillator, and amplifier in the Poulsen Wireless shed in Palo Alto, as was previously noted, and in July, 1911, he was made head of Federal Telegraph Company's research laboratory in Palo Alto, His radiotelephone company in San Francisco was a failure, as a consequence of which his equipment was purchased by Federal and de Forest was made a member of its laboratory staff, The first manufacturer of the deForest audion was MacCandles of New York, while subsequent audions were manufactured by an independent firm in Oakland, California.

In October, 1912, deForest took his audion amplifier to New York and demonstrated it to the officials of American Tel. & Tel. Co. During the early part of 1913, A.T.T. bought the wireless telephone rights to the amplifier from deForest and later it purchased the telegraph rights. But in subsequent ligitation, is was decided that Federal Telegraph Co. was to retain the shop rights because the development work was done in its Palo Alto laboratories. Thus did Federal retain

the shop rights in the basic deForest patents.

In 1914, Federal Telegraph Co. entered the marine radio field by inaugurating a ship-to-shore service and manufacturing the equipment for installation on shipboard. It then grew to 200 employees at its Palo Alto plant.

Following the U.S. entry into World War 1, the U.S. Navy ordered two 1000-kw Federal Arc converters for installation at Bordeaux, France. The station was completed in 1920 and the arcs remained in use until 1936, when the station was converted to vacuum tube transmission.

In 1917, Federal Telegraph Co. inaugurated duplex radio circuits between Los Angeles and San Francisco to handle its rapidly growing traffic load. The "break-in" system, by means of which transmissions could be interrupted by the receiving operator at will when errors occurred or for any other reason, proved to be a noteworthy contribytion to the rapid dispatch of traffic.

When the U.S. entered World War 1, the Navy Department, for security purposes, took possession of all Federal Telegraph stations. The Government paid Federal $1,600,000 in Liberty Bonds for the radio stations and virtually all of the company's domestic patents. The company nevertheless retained possesssion and control of its Palo Alto manufacturing plant, and all of its engineering units and foreign rights. Upon cessation of hostilities the Government restored to Federal all of its patent rights.

During 1921, Federal Telegraph entered into a contract with the Chinese Government for the construction of high-power radio stations at Shanghai, Harbin, Canton, and Peking, with 1000-kw and 60-kw arcs at Shanghai, 200-kw at Harbin, and 60-kw at Peking and Canton. Japanese opposition prevented completion of this contract. The huge castings for the arcs were then stored in the Federal factory until

the China contract was negotiated, when actual assembly was done on them. These giant magnetic-field pieces were stored at Palo Alto for a number of years while developments destined to have an important effect on World War II were taking place at the University of California in Berkeley where Dr. Ernest O. Lawrence was at work om his first Cyclotron. In due time he was presented with the magnetic-field pieces by Federal, free of cost.

In 1921, Dr. Frederick A. Kolster teamed-up with Federal as chief research engineer. Form 1912 to 1921 he served as radio specialist at the U.S. Bureau of Standards and was chief of the radio section which he organized. Then he invented the Kolster Decremeter, an instrument for determining the wavelength and logarithmic decrement of radio transmission. In 1913 the first Kolster Radio Beacons were installed on the Ambrose and Fire Island Lightships and the Sea Girt lighthouse on the New Jersey coast. In 1921 he perfected unidirectional and bidirectional methods of direction finding, a significant improvement over earlier types. This work was accomplished in Palo Alto where he served as Federal's cheif research engineer.

A year earlier, in 1920, under the presidency of R.P.Schwerin, the capital stock liability of the Poulsen Company was liquidated by exchanging Federal Co. stock for Poulsen, This produced a new capitalization of $2,500,000. By eliminating the former Poulsen Wireless corporation, the Federal Telegraph Co. became the sole operating and controlling company. In 1925, Federal entered the field of manufacturing and selling broadcast receivers which had been designed by Kolster. The new receiving sets were sold as Kolster Radios. Federal then moved its broadcast receiver manufacturing operations to the Brandes (headset) plant in Newark, New Jersey, and a merger with Brandes, based on an exchange of stock, was arranged. The new company formed, named Federal-Brandes,Inc., operated as a holding company for the Federal Telegraph Co.

In 1928, Dr. Kolster began a series of experiments with directional antennas employing short waves in the region of three meters. Tests were made between Palo Alto and Honolulu (over 2,000 miles). Federal was soon to take the lead in creating for the Mackay System a point-to-point short-wave radio network utilizing radio tubes and transmitters of its own design and manufacture, as well as directional antennas of superior efficiency.

On March 21,1928, the entire Mackay System was merged with International Telephone and Telegraph Corporation. Control of All-American Cables had been acquired in 1927.

International Tel. & Tel. had entered the manufacturing field in 1925 with the purchase of the International Westerb Electric Co., the name of which was subsequently changed to International Standard Electric Corporation, now the world-wide sales and manufacturing subsidiary of I.T. & T. Extension of its telephone operating and manufacturing activities in Latin America, Europe, and Asia came in the ensuing years, Parallel development took place in the field of international communication by cable and radio.

During 1928, the name Federal Brandes in the U.S.A. was changed to the Kolster Radio Corporation.

In 1930, sales of radio sets became so unstable as a result of the Great Depression that it was decided to discontinue the manufacture of Kolster radios in the U.S.A. and to concentrate on the manufacture of vacuum tubes, radio trabsnitters, and navigational equipment.

Federal Telegraph of Palo Alto was moved to Newark, New Jersey during the summer months of 1931, where it still continues many of its operations. During this period, its business consisted

primarily in the manufacture of marine radio equipment for the Marine Division of Mackay Radio and Telegraph Company, as well as the design and manufacture of vacuum tubes for high-power radio transmitters and a line of smaller tubes for the receivers used by Mackay in point-to-point communication under its own jurisdiction.

In 1932, a number of 1-kw vacuum tube transmitters were designed and constructed for the China Electric Co.

Mackay's expanding communications network in 1934 required the manufacture of a quantity of 50-kw vacuum tube radiotelegraph transmitters for use in its stations abroad, as well as in the U.S.A. Apparatus was also manufactured for All-American Cables and the Postal Telegraph Company.

In 1934, development began on the first of a line of water-cooled tubes for broadcast services, and in 1936 Federal developed a complete shipboard radio unit for installation in the 500 ships of the Maritime Commission for its National Defense Program. A large share of the Liberty Ships and Victory cargo vessels were equipped by Federal.

During 1937, Federal produced a prototype of the "Walkie-Talkie" for the Signal Corps of the U.S. Army, as well as a long line of other special equipment for the U.S. Government.

The International Telephone and Telegraph Corporation, having brought its aerial navigation and selenium rectifier developments to this country in 1937, undertook to organize the International Telephone Development Company the following year.

In 1939, with the outbreak of hostilities in Europe, I.Y. & T. found it necessary to establish a manufacturing unit in the U.S. for the purpose of supplying its Western Hemisphere subsidiaries. A new factory was built in Newark, New Jersey, known as International Telephone and Radio Manufacturing Corporation, which absorbed the

International Telephone Development Company. The new company acquired control of the Federal Telegraph Company in June, 1941, and the two corporations thereafter operated as separate I.T.T. associates until October 1942 when they were merged into Federal Telephone & Radio Corporation.

A Research and Development Division was opened in 1941 at 67 Broad Street, New York City, to develop Radar, D.F., aerial navigation and communication systems. Field stations were later set up at Great River, Long Island, Haslett, New Jersey, and Rye Lake Airport in New York.

On October 18, 1941, a few months before the U.S. entered into World War II, a new 50-kw main transmitter and a 5-kw emergency transmitter for WABC, key station of the Columbia Broadcasting System, and new WCBS, were completed. From December 7, 1941, to the end of hostilities, it operated on a continuous 24-hour schedule, and in 1942 CBS inaugurated its new international short-wave broadcast service, built by Federal. During this aame year, Federal also built two 200-kw short-wave broadcast transmitters which were put into operation on the West Coast in 1945 for beaming programs to the Pacicic area and the Orient. Federal devoted its entire effort exclusive to the war effort during the period of hostilities.

One of the World's Most Important Developments

Classified as one of the most important developments of the war, and one of its best-kept secrets, Federal's High-Frequency Onstantaneous Direction Finder, known as the "Huff Duff", was responsible for the defeat of the German submarine wolf-pack operations in the Atlantic, thereby contributing greatly to the defeat of Hitler's attempt to blockade Britain. Federal was awarded the Navy "E" for Excellence on April 20, 1943; a second star was added on Dec. 2,1944, and a third on April 11, 1945.

A new site for Federal's manufacturing facilities was purchased in February, ~~19~~ 1943; it was a 120-acre plot formerly known as the Yountakah Country Club in Huntley and Clifton, New Jersey; here the expanded laboratories of Federal were likewise located. The first of the new buildings was dedicated on October 3, 1945, and the complex was wholly completed two years later.

Soon afeter V-J Day, on September 27, 1945, Federal Telegraph gave a demonstration of Pulse-Time Modulation. For the first time, with its/~~PTM,~~ "PTM," two-dozen simultaneous two-way conversations were were carried over an 80-mile microwave relay circuit at 1300 megacycles. All conversations were transmitted on a single carrier frequency. Only one transmitter and receiver were employed at each terminal for all conversations.

The first high-definition, ultra-high-frequency, full-color television transmitter was installed by Federal in the Chrysler Building, New York City, for the Columbia Broadcasting System ~~in~~ during January, 1946. During the following October, Federal demonstrated the features of its own new aerial and traffic control system for coordinated planning, global in scope, of radio aids to aerial navigation. Then followed the development of an 8-element square-loop antenna for FM stations, giving an effective power gain of 9.

Turning back the pages of Federal's history, it is seen that in 1927 the Company signed a 21-year contract with the Postal Telegraph-Commercial Cables group which comprised the Mackay System. By the terms of this contract, the Federal Telegraph Company agreed to devote its patents, manufacturing and engineering facilities, to supplying the Mackay companies with whatever they needed to begin a land and ocean radio service on a parity with existing competition. As a step towards aiding Mackay in the immediate inauguration of a readio service, Federal ~~x~~ sold outright to that company its Pacific

Coast point-to-point radio communications system, comprising the entire operating communication interests of the original Federal Telegraph Company. Under these arrangements the Federal Telegraph Company became purely a manufacturing and engineering company engaged in the design and supply of electrical equipment to the Postal Telegraph- Commercial Cable companies and their subsidiaries - later augmented by the Mackay Radio & Telegraph Company which was organized to take over the Federal Telegraph's Pacific Coast radio stations.

By 1927, as the vacuum tube as a generator of continuous waves was fast replacing all other systems, the Palo Alto plant of Federal was then equipped to manufacture its own vacuum tubes. In the same year, the company also obtained the services and rights to patents of F.S. McCullough, one of the pioneer bacuum tube engineers in America for the development of this phase of the company's business.

The source material for this chronological report of the Arc is from the files of the Magnavox Company, then of Oakland, California, with whom Peter L. Jensen became associated prior to the establishment of his own loudspeaker manufacturing business, and furthermore, directly from the offices of International Tel. Tel. & Tel. Co. of New York City, from whom all of the material relative to Federal, Mackay, and I.T.T. was received.

HWD.

missed
I need here.

H. W. DICKOW
Publisher
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October 23,1970

Dear Bill:

Somehow, I must have neglected to send you this complete chapter on the Poulsen Arc, Mackay, Federal, and I.T.T. which evolved therefrom. I found this MSS in my desk drawer, so hasten to send it to you. It is a very comprehensive account of the arc and I am sending you both the original and the carbon copies, so that you can use one for PORTS O' CALL, if you see fit. In my original TALES OF THE WIRELESS PIONEERS I am sure I have some data on the ARC, but mighty little on Mackay,Federal and ITT, so it may be wise to substitute the attached in its place.

I have had a very bad week, Bill, and I must close this note with a hurried 73/88 to you and Ruth. And please give my very best to Frank, Earle, Dick, and the gang.

Dick