The Centennial of KDKA's Historic 1920 Broadcasts

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This article marks the centennial of KDKA's historic broadcasts of the U.S. presidential election results on November 2, 1920. The article identifies important parts of the Westinghouse Electric Manufacturing Company/KDKA story, and it includes discussions about Frank Conrad, Harry Davis, Donald Little, and some of the other key people responsible for building the station and Westinghouse's radio network. The authors compile key references for further research, trace the station's licensed operations, and provide descriptions of the historic transmitters, antennas, and studios used by KDKA and its related experimental stations, 8XK, 8ZZ, and others. The article also shares current photographs of the station from a private tour taken in 2017. The authors mention some of KDKA's claims of priority for "firsts" in radio broadcasting, but they do not take a position on those claims, since that debate lies outside the scope of this article. As KDKA's centennial celebrations approach, the authors hope to stimulate further research by sharing their findings and observations regarding the many achievements of this historic station.

Introduction

The year 2020 marks the centennial of the historic broadcasts of the U.S. presidential election results on November 2, 1920, by radio station KDKA. This date is commonly used to mark the beginning of the commercial radio broadcasting era. The stories of Frank Conrad, his experimental station 8XK, and KDKA's legendary accomplishments have been told in a variety of formats over the years.

In 2017, members of the Radio Club of America received a private tour of the current KDKA radio studios and KDKA's transmitter station, which continues to reside in its 1939 transmission facility. The authors' participation in that tour sparked our curiosity and led us to further inquiry. This article identifies important parts of the KDKA story, investigates and recounts aspects of that history, compiles key references for further research, and shares current photographs of the station.

Previous anniversaries garnered much fanfare (see Figs. 1 and 2). As KDKA's centennial celebrations approach, we understand that the Radio Club of America and members of the Antique Wireless Association will be participating in KDKA's month-long commemorative events in November 2020. Further information can be obtained from those organizations.



Fig. 1. KDKA 95th anniversary card. (Courtesy, KDKA)

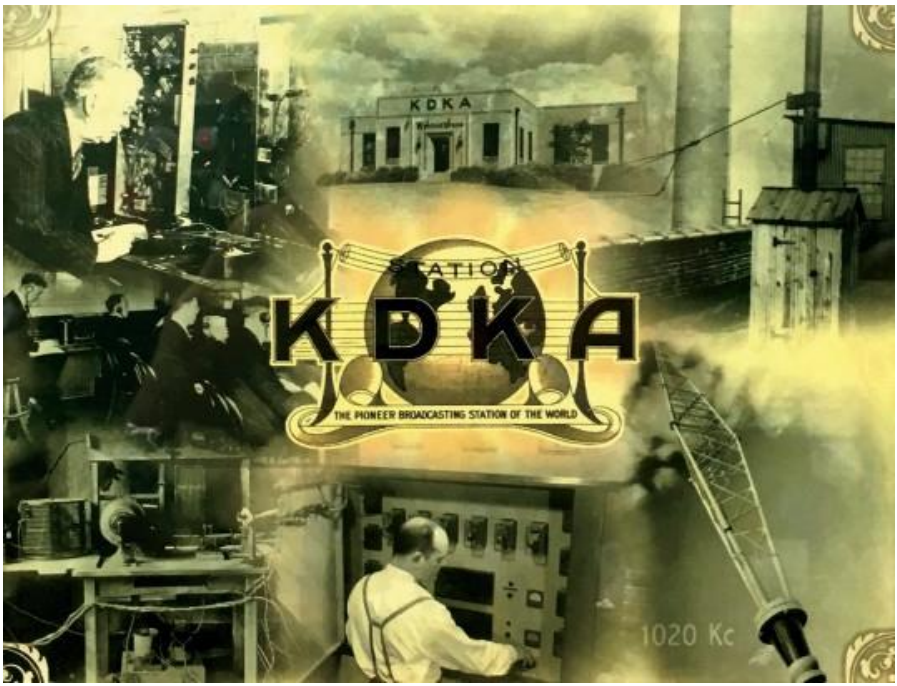


Fig. 2. Another example of a KDKA anniversary card. (Courtesy, KDKA)

Radio Pioneer Frank Conrad

Early Years [1]

Frank Conrad (1874–1941) is best known for his work developing radio technology at the Westinghouse Electrical and Manufacturing Company in East Pittsburgh, Pennsylvania, where he helped establish a foundation for commercial broadcasting (see Fig. 3). His efforts grew from an experimental radio station, 8XK, developed in the workshop he built in the second story of his garage, and aided in the establishment of Westinghouse's first broadcasting service over radio station KDKA.

Conrad was born in Pittsburgh in 1874, the son of a railroad mechanic and homemaker. Formal schooling ended after he completed the 7th grade. In 1890, he joined Westinghouse at age 16 and registered trains for ampere-hour meter maintenance. He developed reputations for his insatiable thirst for knowledge, work ethic, and incredible memory. In 1897, at age 23, he transferred to Westinghouse's Testing Department where he invented a circular-type watt-hour meter. Thirty years later, in 1937, approximately 30 million of these units remained in use. Westinghouse promoted him to General Engineer in 1904 and Assistant Chief Engineer in 1921. His work involved a wide range of areas, especially arc lighting, ignitions in automobiles, and then radio. He pioneered the development of metal case power rectifiers, and solved many difficult problems connected with the electrification of the New York, New Haven, and Hartford Railroad. He became a member of the American Institute of Electrical Engineers (AIEE) in 1902 and went on to receive more than 200 patents for a variety of electrical devices: 177 in the United States, 42 in the United Kingdom, and 9 in Germany.



Fig. 3. Frank Conrad. (Courtesy, IEEE History Center)

Conrad's interest in radio stemmed from a 1913 bet with a co-worker over whose watch was more accurate. Conrad won the bet after he secretly replaced his cheap watch's internal components with the mechanism from a more expensive and much more accurate watch.[2] Conrad then tested the watches, after which he began to question the accuracy of Western Union's telegraphed time signals. In 1916, he built a simple radio to receive the U.S. Naval Observatory's time signals, broadcast nightly by station NAA in Arlington, Virginia. Conrad next constructed a transmitter to communicate with his neighbor and other local amateur radio operators. He then installed a radio station on the top floor of his

two-story garage adjacent to his new home in Wilkinsburg, Pennsylvania.[3]

In July 1916, Conrad's amateur station received an "Experimental" license, with the call sign 8XK.[4] The station included a spark transmitter for Morse code transmissions. The "8" indicated the station was located in the 8th Radio Inspection District, and the "X" designated the station was operating under an Experimental license.

World War I

Following the United States' entry into World War I in April 1917, the U.S. Navy assumed control of the country's commercial radio stations, including approximately 60 maritime commerce stations. All civilian radio stations, including experimental stations like 8XK, were ordered to cease transmission and reception.[5] Conrad spent the war years at Westinghouse working on improvements to military radio equipment, including the U.S. Army Signal Corps SCR-69 transmitter and SCR-70 receiver used in airplanes. Conrad's work included development of a wind-driven electrical generator that was attached to an airplane's wing for powering airplane radio transmitters.[6] Westinghouse became the first supplier of combination radio telephone-telegraph receivers for the U.S. Navy. Its airborne electrical generator provided power for the first continuous over-water plane-to-shore transmission tests in May 1919 between Newfoundland and England.[7] Radio transmitters and receivers designed by Conrad were the only radio equipment to reach the front for use by the Allied Expeditionary Force in considerable quantities.[8]

Conrad's work encompassed radiotelephone transmissions (for voice and music, not simply Morse code), and incorporated vacuum tube transmitters. Despite the nationwide blackout for amateur radio transmissions, Conrad received authorization to operate an experimental radio transmitter from his home during the war with the call sign 3WE. He used this station to communicate with a second station located at the Westinghouse plant in East Pittsburgh.[9]

Radio Broadcasting Begins

The ban on operating civilian radio stations ended after the war, effective October 1, 1919. Conrad resumed his experiments using the 8XK call sign broadcasting from his home garage, including testing vacuum tube radiotelephone equipment,[10] although a formal license renewal was not issued to him until January 21, 1921. Nevertheless, beginning on the evening of October 17, 1919, Conrad began broadcasting selections from his personal collection of phonograph records as he undertook a series of test broadcasts.[11] He accepted specific requests to hear records from his growing audience. As the demand grew, he announced that instead of complying with individual requests, he would "broadcast" records for two hours each Wednesday and Saturday evening. KDKA claimed, "This is the first recorded use of the word broadcast to describe a radio service."[12] The debate over this claim is outside the scope of this article, but it can be contested.

For example, a January 1917 article in *Electrical Experimenter* outlined Lee De Forest's "broadcast" by "radio," using those words, of U.S. election returns via wireless telephony in November 1916 to 7,000 amateur radio operators who were notified in advance of the scheduled program.[13] See further comments below.

In any case, in response to his growing audience interest, Conrad adopted a semi-regular schedule of defined programming that was transmitted for all to hear. After exhausting his personal collection of records used to broadcast music, he borrowed records from a local Brunswick record shop in exchange for on-air acknowledgements.[14] These on-air acknowledgements constituted the early beginnings of on-air radio advertising. Conrad also ran a telephone line from the music room in his home to the transmitter in his garage, so performers, which included Conrad, could use the family piano.[15] These performances constituted the early origins of the on-air radio "studio," that is to say, a room used as a dedicated performance space whose sounds are broadcast by radio to a listening audience. (Again, the authors of this article have not verified these KDKA claims of providing the first on-air advertisements or first on-air studio.)

The *Pittsburgh Gazette-Times* reviewed Conrad's radio transmissions, and on December 26, 1919, the *New York Times* reported "Phonograph's Music Heard on Radio Phones." The *New York Times* estimated Conrad's audience to be approximately 400 owners of wireless sets. On June 26, 1920, Conrad broadcast a special concert for the patients at the Tuberculosis League Hospital.[16]

The Joseph Horne Department Store in Pittsburgh placed an advertisement in the *Pittsburgh Sun*, "Air Concert Picked Up By Radio," on September 29, 1920, that offered for sale crystal set radios to hear Conrad's broadcasts. Harry Davis, a vice president at Westinghouse, noticed the growing popularity of Conrad's broadcasts and arranged for Westinghouse to build a transmitter at the plant (see Fig. 4). The new Westinghouse station received licensing in October 1920, in time to broadcast results of the upcoming Harding-Cox Presidential Election results on November 2, 1920. (See further discussion below about the timing of the licenses issued to stations KDKA and 8ZZ.)[17]

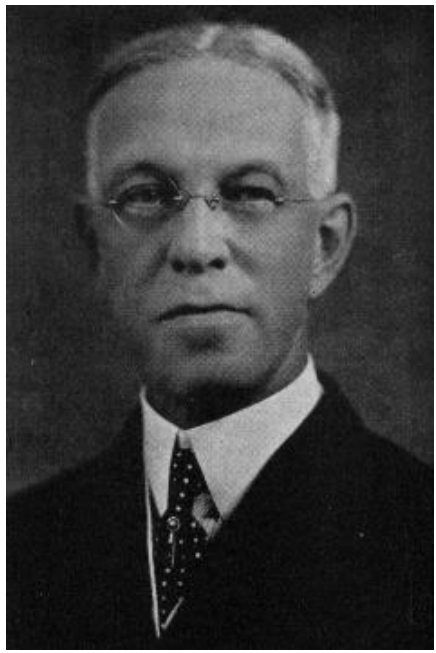


Fig. 4. Harry Davis. (*Wireless Age*, Apr. 1924)

Davis envisioned combining radio manufacturing with free radio programming. Listeners could purchase Westinghouse radios specifically to hear free programming provided by Westinghouse in their own homes, thereby creating a readymade market for both the radios and the broadcast programming. Davis had conceived the idea of commercial broadcasting. He invited Conrad to build a transmitter at the Westinghouse plant in Pittsburgh and developed the first formal guidelines for KDKA's broadcast programming.[18] As Davis later explained, "We had in our hands in this idea the instrument that would prove to be the greatest and most direct means of mass communication and mass education that had ever appeared."[19] Guy E. Tripp, Westinghouse's Chairman of the Board of Directors, would later state, "Mr. Davis was the only man in the Westinghouse Co. who had the vision of broadcasting and the courage to see it through," and many Davis obituaries would call him the real "father of broadcasting."[20]

Throughout, Conrad continued to conduct experimental radio work. In the summer of 1920, the American Radio Relay League (ARRL) and the U.S. Bureau of Standards began investigating the phenomenon of radio signal fading. Variations in signal strength were affecting long distance signals during nighttime operation. Conrad provided testing ideas, and station 8XK was one of the key stations participating in these tests.[21] In 1921, Conrad was named assistant chief engineer at Westinghouse and assumed responsibility for all of the company's radio-related activities.[22]

KDKA Facilities

KDKA's Early Transmitter Frequencies

In the early 1920s, many radio transmitters were rated from 100−150 watts, and approximately 15 were rated up to 1 kW watt with 5−6 rated up to 5 kW. By 1920, a wavelength of 360 meters (833.3 kHz) had been allocated by the U.S. government for public broadcasting, near the 600 meters (500 kHz) range used for international distress and experimental uses. By December 1921, a second wavelength of 485 meters (618.6 kHz) had been added for crop reports and weather forecasts. In spring 1922, a third wavelength was added at 400 meters (750 kHz) for Class B stations, which typically operated at 500−1,000 watts. In May 1923, frequencies were reassigned again. As a result, two classes of stations occupied frequencies of 500−1,350 kHz: Class A stations transmitting at less than 500 watts (550−800 kHz and 1,000−1,350 watts) and Class B stations using 500 watts or more (870−1,000 kHz), with some older stations still operating at 833.3 kHz. In a series of revisions in April 1927, August 1933, and March 1941, broadcasting allocations were further realigned and now permitted single channel station broadcasting on all frequencies between 550 kHz and 1,600 kHz. This allocation remained in place into the 1990s (see Fig. 5).[23]

The *History of American Broadcasting* website analyzed and summarized KDKA's frequency authorizations by the Federal Radio Commission (FRC) and its successor the Federal Communications Commission (FCC).[24]

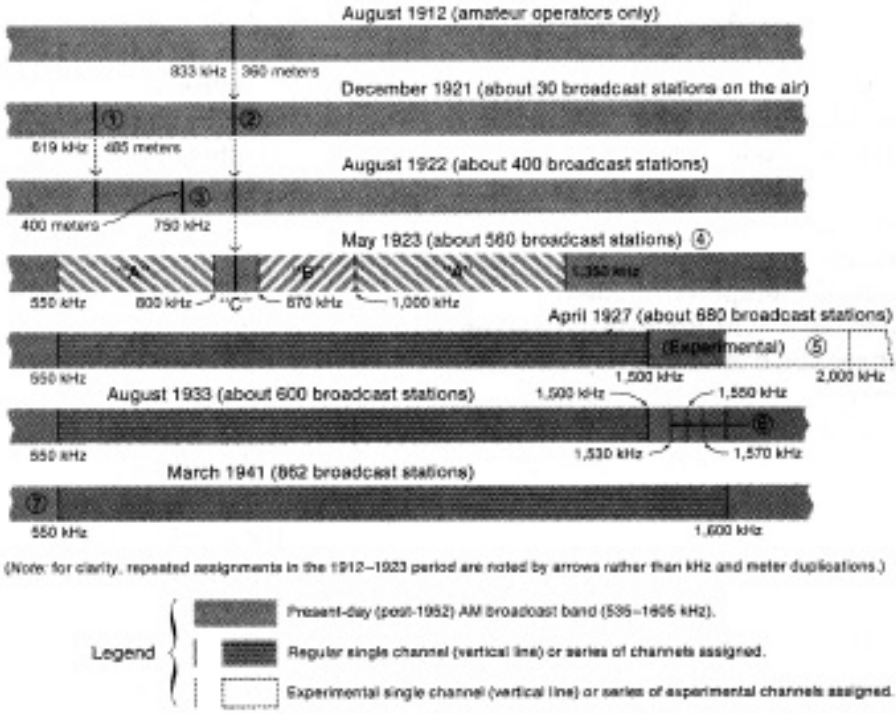


Fig. 5. Evolution of the standard broadcast band. (Sterling and Kittross, *Stay Tuned*, 2002, p. 95)

- KDKA made its submission to the FRC, dated October 16, 1920, on Form 761, "Applicant's Description of Apparatus." Form 761 specified that KDKA had two transmitters: a high frequency alternator (3,200 meter set), and a vacuum tube transmitter (500 meter set); both used for code transmissions, and it contained a note that the 500 meter set could also be set up for audio transmissions.
- The November 1, 1920 *Radio Service Bulletin* lists wavelengths of 3,200 meters (93.75 kHz) and 500 meters (600 kHz) for KDKA. At the same time, Westinghouse was assigned the use of 330 meters for its 8ZZ broadcasts, although the 8ZZ and initial KDKA broadcasts transmitted on 550 meters for the historic November 2, 1920 broadcast, as described below. Westinghouse reports that it transmitted on 330 meters until fall 1921, when Westinghouse's other stations (KDKA, WBZ, and WJZ) were all assigned to 360 meters at Westinghouse's request.*
- The initial license authorized the use of telephone apparatus on 600 meters with 200 watts on October 27, 1920. From October 5–23, 1922, KDKA

* "Listen, Local Wireless Fans," *Indiana Gazette*, Oct. 26, 1920, p. 1. "Test Give Proof Radio Can Carry Election News," *Pittsburgh Post Gazette*, Oct. 29, 1920, p. 16. "The Radio Amateur," *Pittsburgh Post Gazette*, Oct. 24, 1920, p. 50.

received authorization to operate on 400 and 485 meters with 600 watts. A series of license modifications in 1922–1923 permitted operations at 360 and 485 meters with 600 watts, 1 kW, and 1.6 kW. In addition, KDKA was granted use of 920 kHz at 500 watts to 10 kW that covered its three transmitters in August 1923. A temporary permit allowed experimental operations at 970 kHz and 50 kW, and KDKA was authorized to use 1.5 kW of power in 1925.

- KDKA applied for additional allocations on April 1, 1927 (see Fig. 6). Licenses were issued in June 1927 permitting operations at 950 kHz and 30 kW as well as 50 kW. In 1928, Westinghouse also received experimental rights granted at 25 kW, and the main license was reallocated to 980 kHz at 50 kW.
- KDKA relocated its main transmitter in 1929. Subsequent FCC authorizations in 1930 and 1932 granted operations at 980 kHz and 25 kW then 50 kW. In 1941, operations were granted at 1,020 kHz and 50 kW.

In sum, at the time of the November 2, 1920 election broadcast, a KDKA license had been signed in October 1920, but Westinghouse had not received it yet. So, Westinghouse requested and was granted the temporary license 8ZZ to use for the broadcast. Westinghouse therefore announced both 8ZZ and KDKA call signs on-air.[25]

KDKA's Early Transmitters

QST described Conrad's station 8XK in detail in its September 1920 issue cover story (see Figs. 7 and 8). The tour was likely provided by Conrad himself, since

Card No. 1
Form 94

APPLICATION RECORD - BROADCASTING

Call Letters KDKA

Name Westinghouse Electric and Manufacturing Company

File No. Lic. #174	Dated	Application for BUREAU OF NAVIGATION RECORD-Dept. of Commerce	Action Nature	Action Date
174	10-16-20	New station-Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., requesting 500 meters, 200 watts, unlimited time.	Granted 600 m., unlim. time.	10-27-20 600 w.
174		Renewal of License	Granted 360 m.,	11-7-21 600 w., U
174	8-25-22	Renewal of License, requested 400 meters, 1 kilowatt.	Granted 400 & 485 m., 600 w. Cancelled (not desired)	10-5-22 10-23-22
174	10-26-22	Renewal of License, requesting 360 meters, 1.6 kilowatts.	Granted 360 & 485 m., 600 w.	11-1-22
174	1-9-23	Renewal of License, requesting 360 meters, 1.6 kilowatts.	Granted 360 & 485 m., 1KW.	1-12-23
174	3-17-23	Renewal of License, requesting 360 meters, 1.6 kilowatts.	Granted 360 & 485 m., 1.6 KW.	3-23-23

Fig. 6. U.S. Federal Radio Commission application record for station KDKA dated Apr. 1, 1927. (Courtesy, FCC)

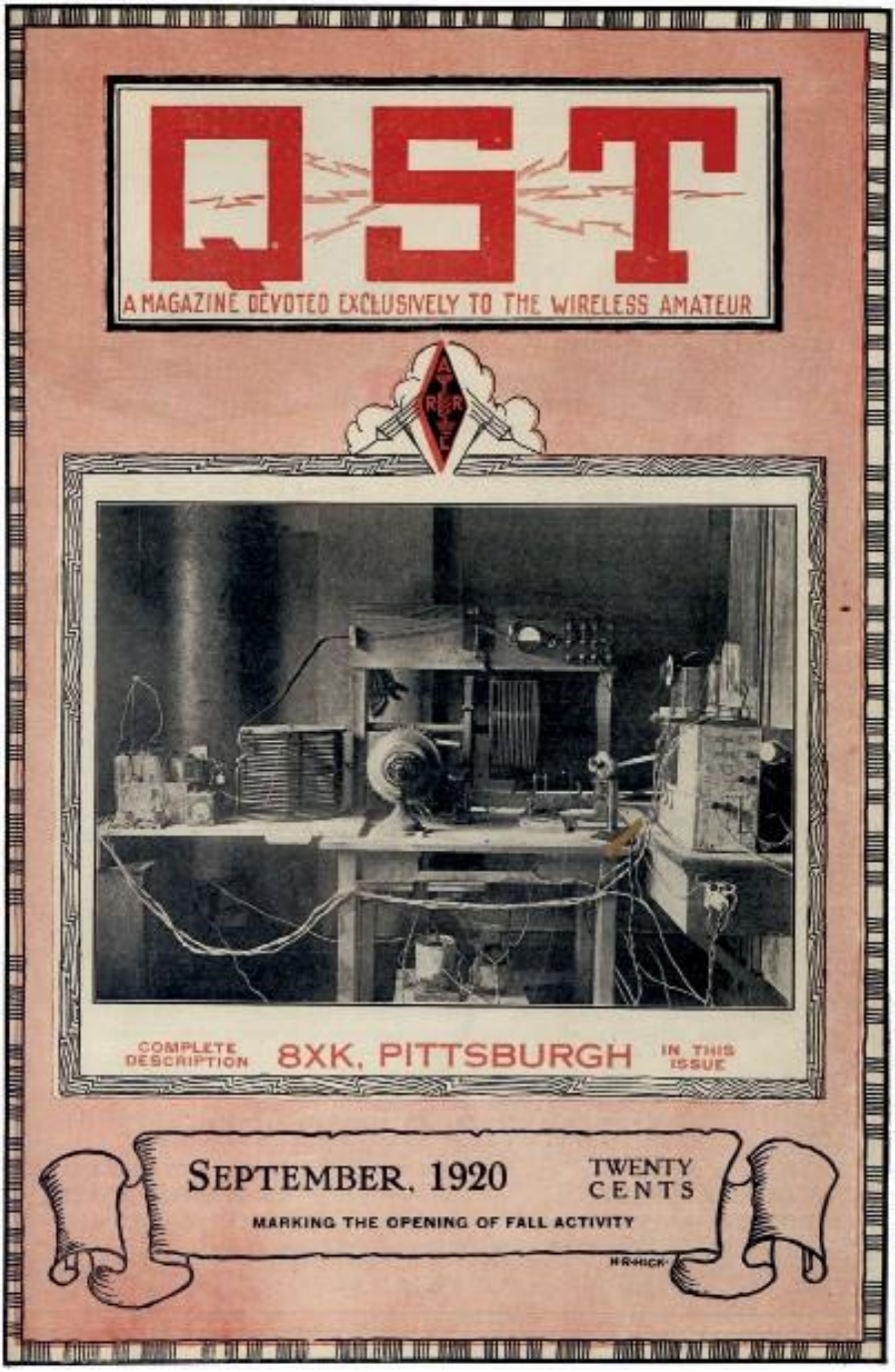


Fig. 7. Frank Conrad's garage station 8XK appeared on the cover of *QST*. (*QST*, Sept. 1920, p. 1)

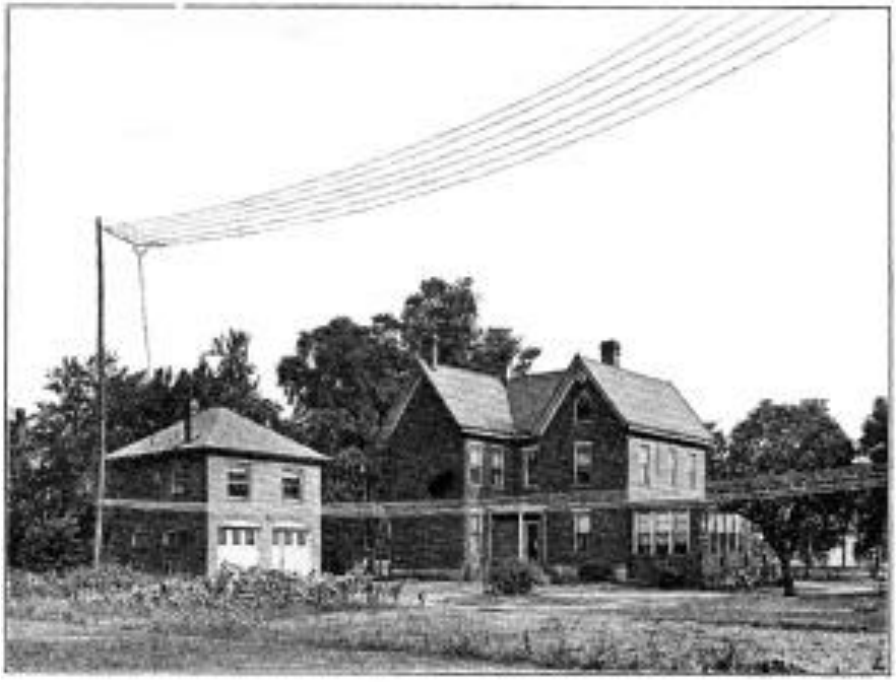


Fig. 8. Frank Conrad's house, garage, and antenna for station 8XK. (*QST*, Sept. 1920)

the station resided in his home garage. The radio telephone set at the right of Fig. 7 used two 50 watt power tubes, where the plate circuit was supplied by a 1,000 VDC generator, and a 5 watt tube that amplified the audio frequency of the usual direct current generator. The set included two vacuum tubes operating in parallel and directly coupled to the antenna inductance. A 700 cycle generator rated at 300 watts supplied the plate circuit, and was driven by a half horsepower induction motor. When adjusted to 250 meters for the Bureau of Standards/ARRL Fading Tests, the set delivered a current of 6.5 amperes to the antenna, with an output of 450 watts. The receiving equipment (not shown in Fig. 7) was typically used for ordinary shortwave reception and comprised a single circuit receiving tuner, which was used in connection with a detector and a two-stage amplifier. The antenna shown includes the counterpoise in place of a ground connection.[26]

Donald G. Little, the radio engineer who worked as Conrad's assistant at Westinghouse (see Fig. 9), provided the earliest formal descriptions of the transmitters at KDKA. He published a detailed explanation of the equipment used at KDKA in the September 1922 issue of *Radio*.[27] Conrad presented a paper about the station on January 2, 1924, at the convention of the Institute of Radio Engineers (IRE) held in New York City. He subsequently published this paper in the June 1924 issue of the



Fig. 9. Donald G. Little. (*Proc. IEEE*, June 1998)

Proceedings of the IRE.[28] Little first joined Westinghouse as a radio engineer after serving in the U.S. Army Signal Corps during World War I. At Westinghouse, he was assigned to serve as Conrad's assistant. At Conrad's direction, Little designed and modeled the 1920 KDKA transmitter. Little remained at Westinghouse until his retirement in 1958. He provided numerous firsthand accounts explaining KDKA's operations in articles published for a wide range of readers (see Appendix 1).[29]

In 1922, the KDKA transmitter operated a modulated oscillator of four 250 watt tubes (possibly UV-204 tubes) in parallel modulated by five similar tubes also in parallel. All tubes operated with approximately 2 kV on the plate from a motor-generator set. The radio frequency output was rated at 1 kW.[30] This circuit, the Meissner circuit, was being used in experimentation jointly performed with the Radio Laboratory of the Bureau of Standards and Western Electric Company regarding signal fading at various times of day for continuous wave broadcasts at 105 meters.[31]

By the time Little published his paper describing KDKA in 1924, the station had three complete transmitting sets. Metal water-cooled vacuum tubes acted as rectifiers, modulators, and oscillators. The four rectifier tubes and associated apparatus had a maximum rated output direct potential of 10 kV. Circulating water from a 100 gallon tank placed approximately 20 feet above kept them cool. The tubes used 20−50 gallons of water per hour depending on the power load and resulting heat. The station operated at 920 kHz using an inverted "L" transmitting antenna with a counterpoise (see below). Two outside telephone lines terminating at an operator's desk provided audio from a studio located at the *Pittsburgh Post* and another studio located at Westinghouse's East Pittsburgh plant. In 1923, KDKA's facilities were considered state of the art.[32]

Little and a manager at Westinghouse, R. L. Davis, jointly published an updated account of KDKA's operations in the August 1926 issue of the *Proceedings of the IRE* where they fully described KDKA's equipment as of 1926 that was used for both regular and shortwave broadcasting (see Figs. 10–15).[33] An interior photograph of KDKA's shortwave broadcasting station equipment appeared on the cover of the May 1928 issue of *QST*, but the magazine provided only

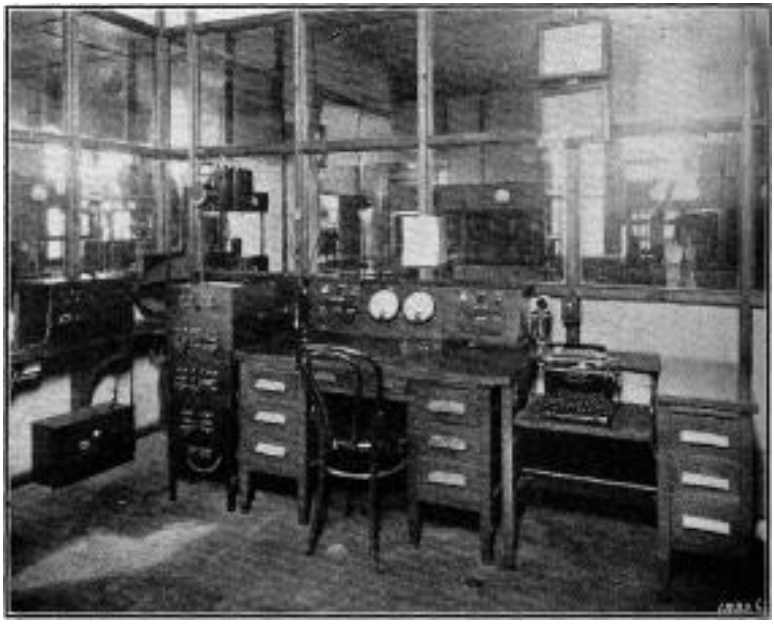


Fig. 10. View of control desk of KDKA's 1926 transmitter station located two miles from the East Springfield Works. (*Proc. IRE*, Vol. 14, Aug. 1926, p. 502)

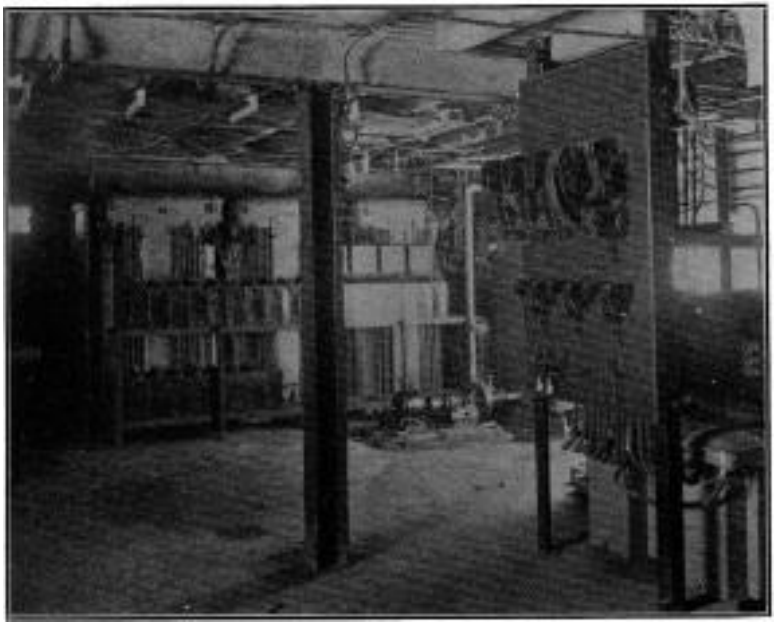


Fig. 11. View of KDKA's 1926 transmitter and filter control panel. (*Proc. IRE*, Vol. 14, Aug. 1926, p. 501)

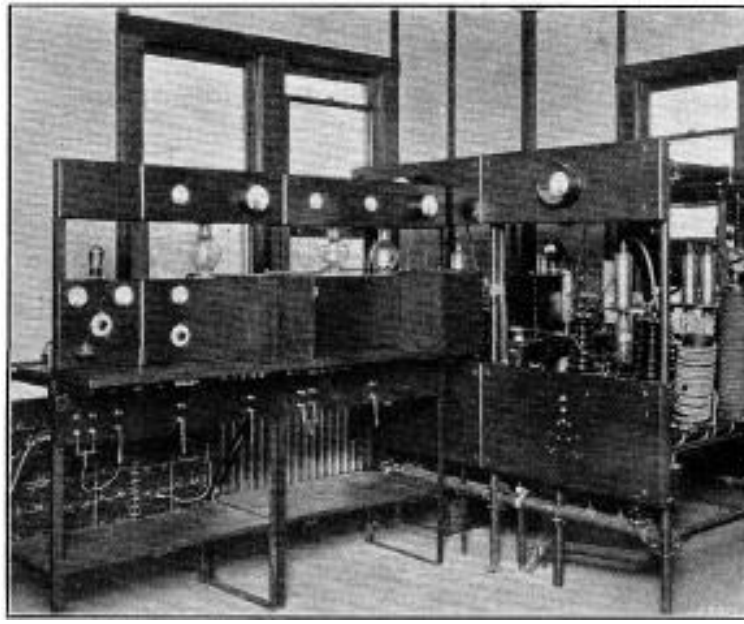


Fig. 12. View of KDKA's 1926 No. 1 Transmitter. (*Proc. IRE*, Vol. 14, Aug. 1926, p. 506)

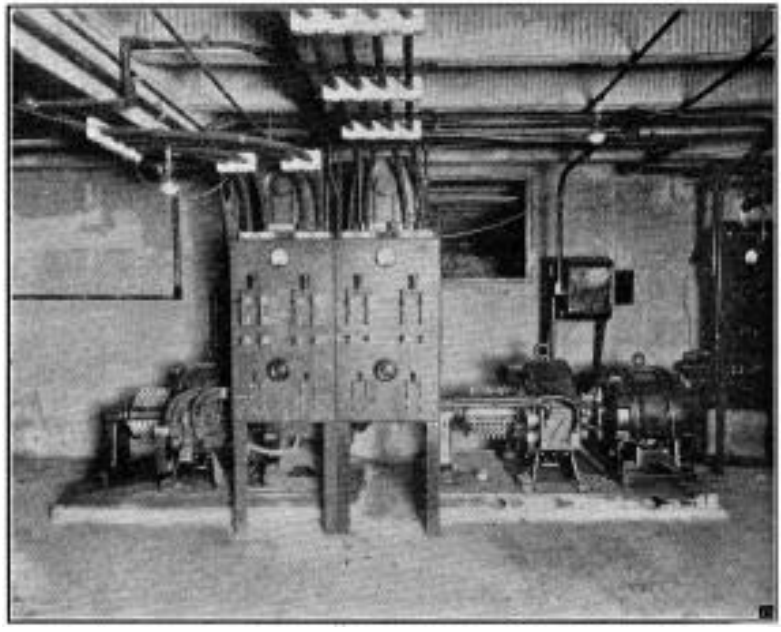


Fig. 13. View of KDKA's 1926 transmitter filament motor-generator sets. (*Proc. IRE*, Vol. 14, Aug. 1926, p. 486)

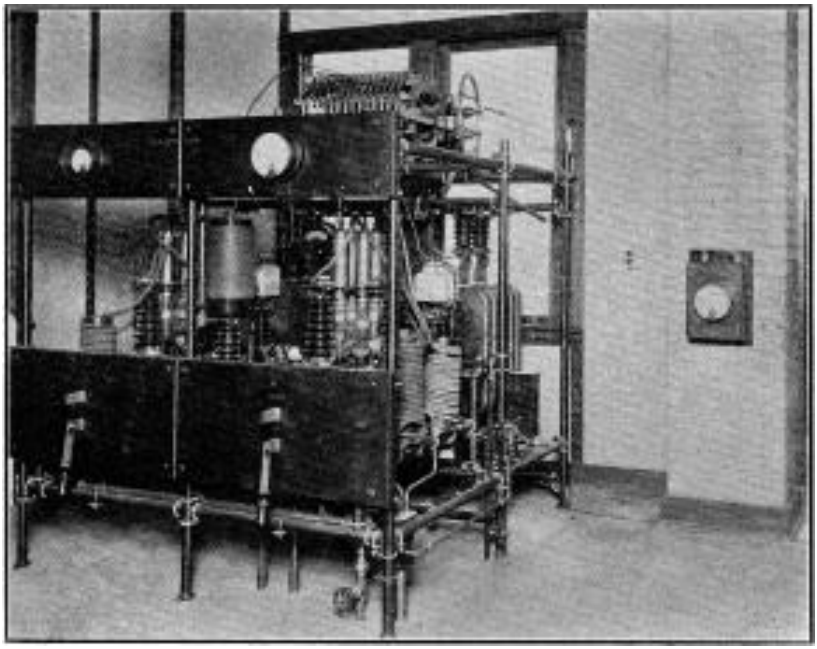


Fig. 14. View of KDKA's 1926 970 kHz oscillator frame. (*Proc. IRE*, Vol. 14, Aug. 1926, p. 485)

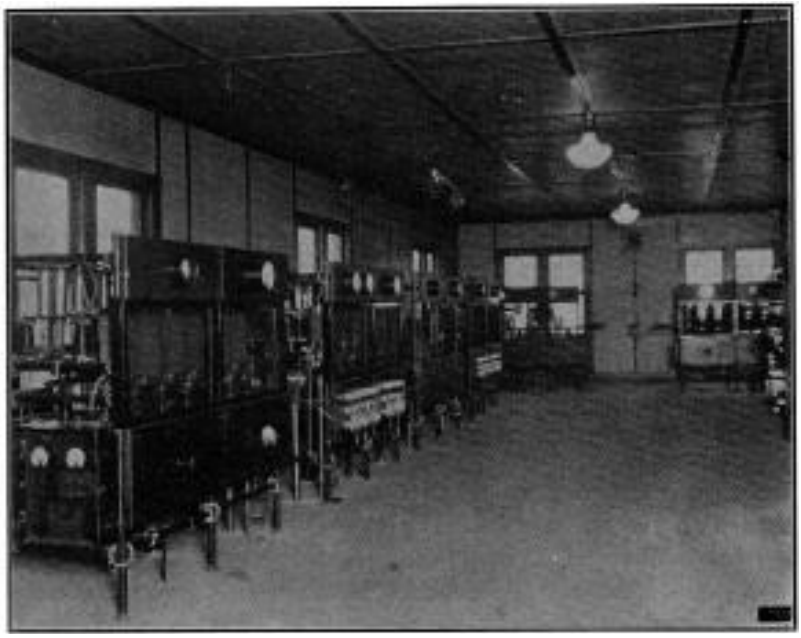


Fig. 15. General view of KDKA's 1926 transmitter apparatus room. (*Proc. IRE*, Vol. 14, Aug. 1926, p. 489)

limited information in a short descriptive paragraph about the station.[34]

KDKA's research into signal fading and signal strength eventually contributed towards its rationale for moving its transmitter and antenna tower in 1929. The FRC granted permits in July 1929. The following year, the FRC granted permits for KDKA to operate experimentally on 400 kW, the highest broadcasting power ever attempted up to that time.[35]

Thus, in 1929, KDKA moved its transmitter from East Pittsburgh to a 120 acre site at Saxonburg, Pennsylvania, 26 miles northeast of Pittsburgh. This time, R. L. Davis and another Westinghouse radio engineer, V. E. Trouant, published their description of KDKA's newest operations used in both regular and shortwave broadcasting in the June 1932 issue of the *Proceedings of the IRE* (see Figs. 16–18).[36]

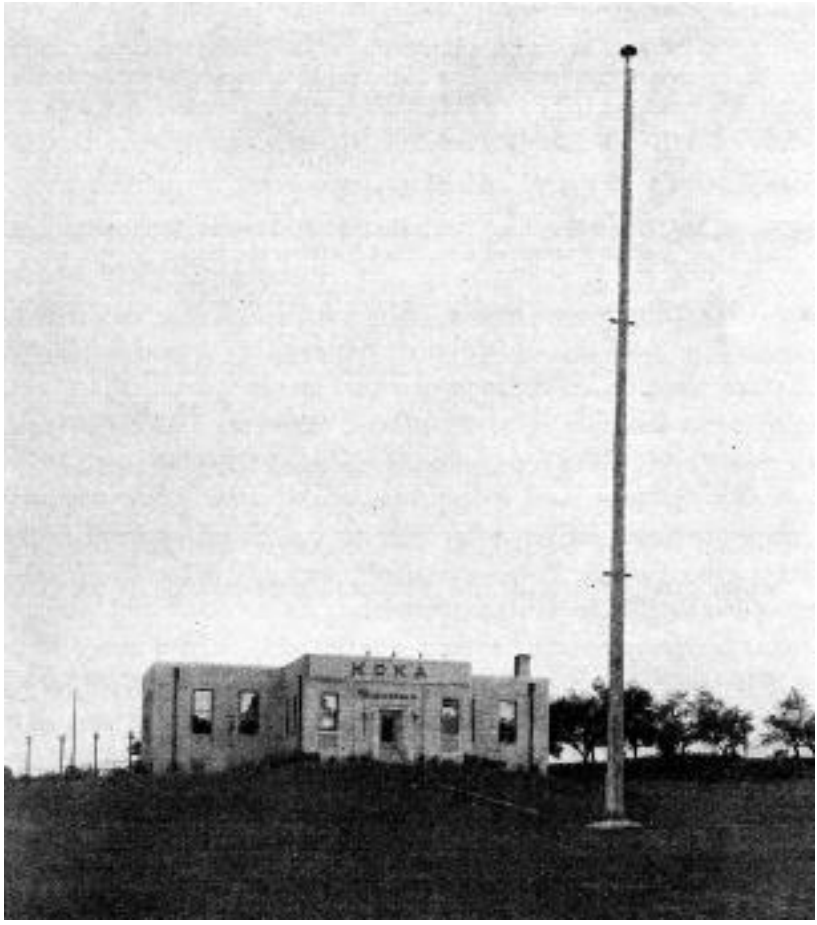


Fig. 16. View of Saxonburg transmitting station in 1932 showing transmitter building. (*Proc. IRE*, Vol. 20, June 1932, p. 922)

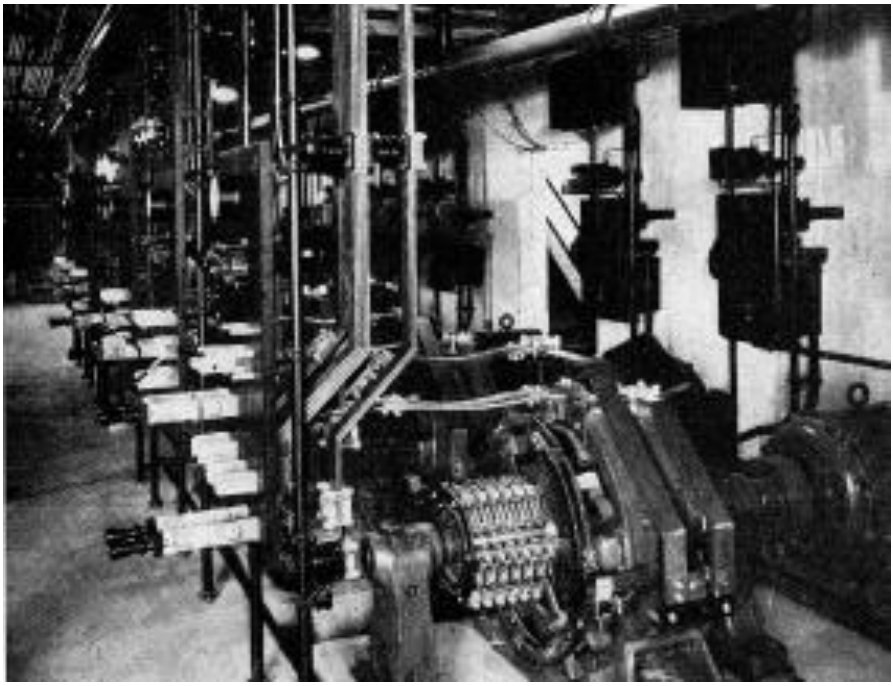


Fig. 17. View of Saxonburg transmitting station in 1932 showing 40 volt, 1,000 ampere filament motor generators. (*Proc. IRE*, Vol. 20 June 1932, p. 928)

- A 2,600 square foot brick building housed a new transmitter. The antenna sat at some distance away, over a pond, with eight 110 foot high wooden (not metal) poles to limit the signal absorption. The building housed all of the equipment except the rectifier transformers and filter chokes, which sat on a platform at the rear of the building. The wood antenna poles were spaced on a circuit more than 700 feet in diameter, each with a vertical down lead that was fed from a center point transmission line. The 130 acre site was at 1,300 feet elevation, 100 feet higher than KDKA's prior transmitter (see below).[37]
- KDKA incorporated six new 100 kW, seven foot tall, eight inch diameter, 60 pound, water-cooled, power supply tubes (AW-220 tubes) that each permitted KDKA to broadcast at 50 kW, half of the power capability. The new tubes, intended for the highest frequency power output, were cooled using soft water pumped to an outdoor cooling pool before being returned to the cooling coils and the tubes. The new tubes replaced the five smaller tubes in operation at the former transmitter. The new Saxonburg facility could produce 400 kW (see Fig. 19).[38]

Relocation of antenna tower to Allison Park in 1939 (see below) and

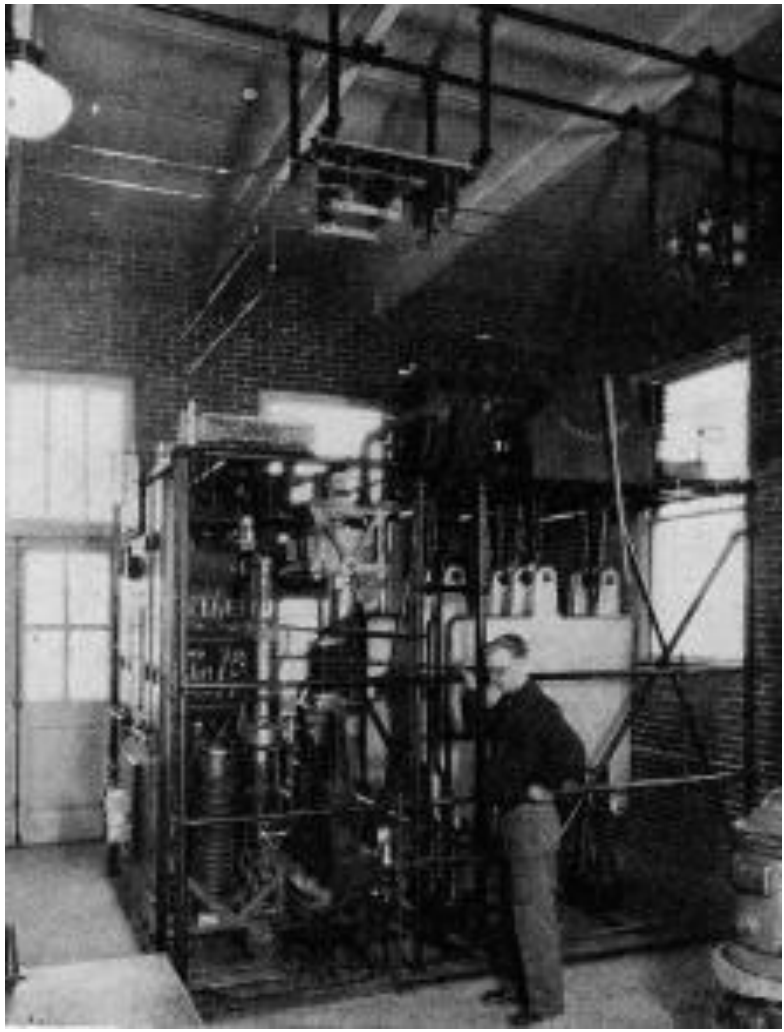


Fig. 18. View of Saxonburg transmitting station in 1932 showing AW-220 radio frequency output stage. (*Proc. IRE*, Vol. 20, June 1932, p. 929)

construction of a new transmitter building brought further changes to the transmitter itself:[39]

- The new transmitter building was revolutionary. For the first time, a transmitter station of this size was heated by the same air that was used to cool the giant transmitting tubes. There was no furnace in the building. Air ducts and fins circulated cool air about the tubes, and then recirculated the heated air throughout the building. Since the station was on the air 18 hours a day, electrical heating units inside the ventilating ducts were

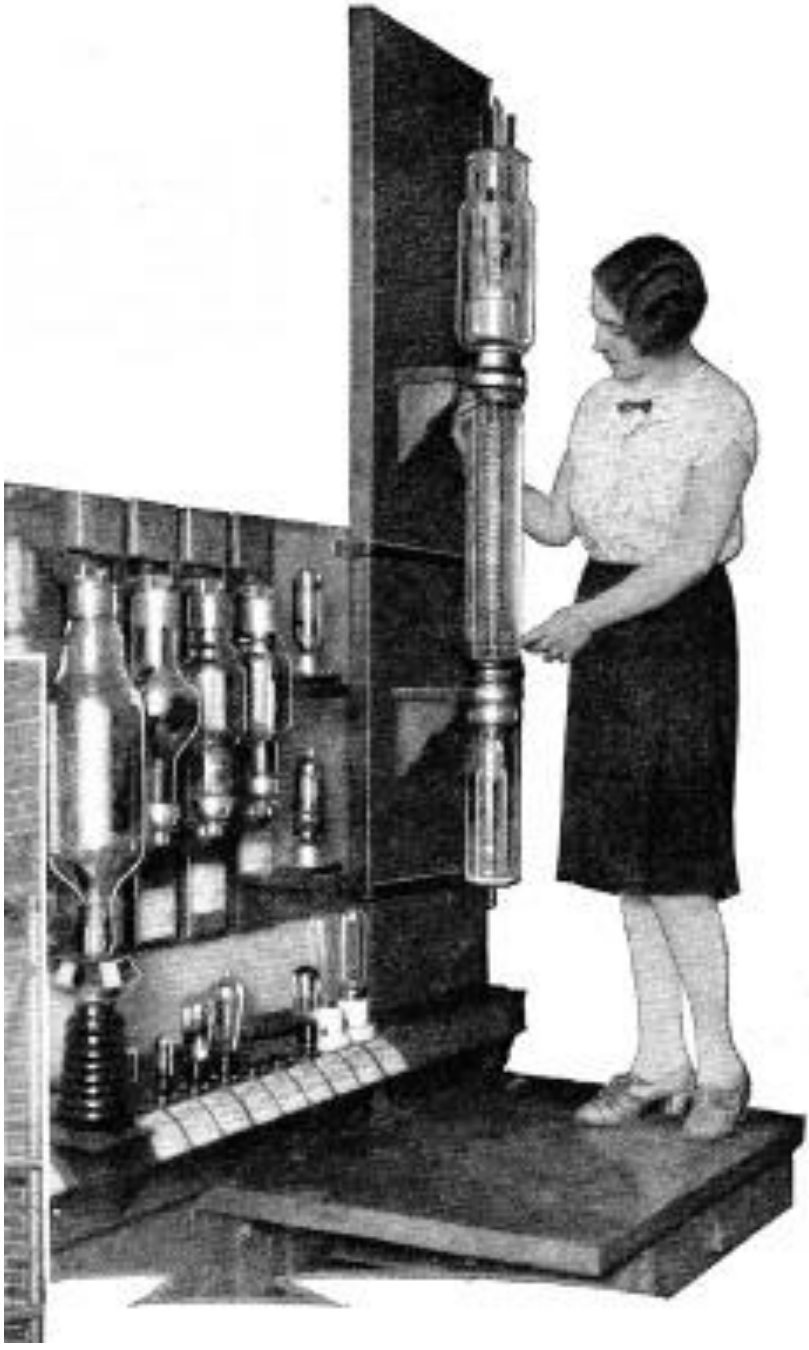


Fig. 19. Saxonburg transmitting station's AW-220 tube. (*Radio News*, Apr. 1931)

able to provide sufficient heat for the remaining hours.

- The new transmitter was intended to send out both the standard broadcasts of KDKA as well as shortwave programs over the Westinghouse International station WPIT and experimental noise-free shortwave programs from a "pick-a-back" aerial that was eventually mounted at the top of the main tower.
- KDKA's programs continued to originate from the Grant Building studios in Pittsburgh that were conveyed to Allison Park over special high quality telephone lines at an input power of one sixty-millionth of a watt, which were then rebroadcast at 50 kW.
- The new KDKA transmitter had a new master control system, which provided a duplicate set of controls for each of three transmitter units. This enabled one operator in a glass enclosed room to simultaneously supervise the programs carried by all three transmitters. The station also had a push button relay shift device that prevented broadcast interruptions caused by burned out tubes by bringing a spare tube into service automatically when one of the six regular tubes became inoperative. At the press of a button, the inoperative tube could be selected and cut out of the circuit, allowing the reserve tube to go into action without loss of station time or danger to transmitter employees.

The Antennas

Conrad employed an inverted "L" antenna at his garage station 8XK that was used in conjunction with a counterpoise in place of a ground connection (see Fig. 8). The flat top of the antenna had six wires, two feet apart, 105 feet long, and 50 feet high. The arrangement permitted operation at shortwave length without the use of a series condenser. It had resistance of 8 ohms at 250 meters.[40]

The original antenna for the 1920 broadcasts from Building K at the Westinghouse plant in East Pittsburgh comprised six wires 190 feet in length on 20 foot spreaders. The antenna sat 210 feet above the ground, supported by the building's smokestack at one end and a 100 foot pipe mast on the nine story building at the other end (see Fig. 20). A counterpoise, which duplicated the antenna and replicated a ground connection, was located 110 feet beneath the antenna. This brought the counterpoise about 15 feet below the transmitting set. The high frequency resistance of the antenna system at 360 meters wavelength was approximately 12 ohms, and was mostly radiation resistance. The antenna current was 6.5 amperes at 500 watts, and 9 amperes at 1 kW.[41]

Conrad's initial shortwave broadcasts in 1921 transmitted from a simple vertical pole mounted on the flat roof of Westinghouse's Building K. A number of continuous copper strips were fastened to the pole's surface in order to eliminate high resistance joints in the pole. These strips carried out over the roof at the foot of the pole, forming an extended ground. Conrad replaced this antenna with a vertical L type antenna and a counterpoise to overcome frequent unanticipated frequency shifts



Fig. 20. KDKA's 1920 antenna on Building K in East Pittsburgh. (Courtesy Heinz History Center, Image 20170320-hpichswp-0042)

(see Fig. 21).[42] Conrad designed new versions of oil condensers to handle the high amperages, new inductance coils, and made other circuit and equipment modifications, which successfully raised the upper frequency limits to 3.8 MHz (79 meters) (see Fig. 22).[43]

By 1929, KDKA's shortwave broadcasts reached around the world. The shortwave transmitter occupied the same building as the longwave transmitter that produced signals at 360 meters. The shortwave transmitters operated on 62.50 and 25.40 meters (see Fig. 23).

In April 1933, KDKA used an aerial suspended by a blimp in experiments performed at Saxonburg to help reduce signal fading and to extend the range of the broadcasts by using a 25 foot long, 10 foot diameter, blimp at 1,500 feet altitude to lift 500 feet of antenna wire (see Fig. 24).[44]

On October 30, 1937, KDKA celebrated its 17th anniversary by dedicating a new 718 foot vertical antenna at Saxonburg. The first antenna installed at 644 feet fell earlier in October. Designs for the new, even taller 1938 antenna included additional wire cabling and forged steel turnbuckles to strengthen the tower's ability to withstand strains and loads up to 100,000 pounds each.[45]

KDKA relocated the antenna in 1939 to the highest point in Allegheny County at Allison Park, only eight miles from Pittsburgh, when it also moved

the transmitter. The 718 foot tall Truscon antenna located 1,400 feet from the transmitter gave KDKA primary broadcasting service over an area 10 times greater than previous operations.

- KDKA placed a circle of eight 90 foot antennas surrounding the 718 foot vertical antenna to suppress interfering radio waves. These 90 foot antennas radiated "skywaves" in opposite directions so that they nullified the effect of the skywaves emitted from the main antenna and extended the fading zone.
- The 60 ton structure of the main

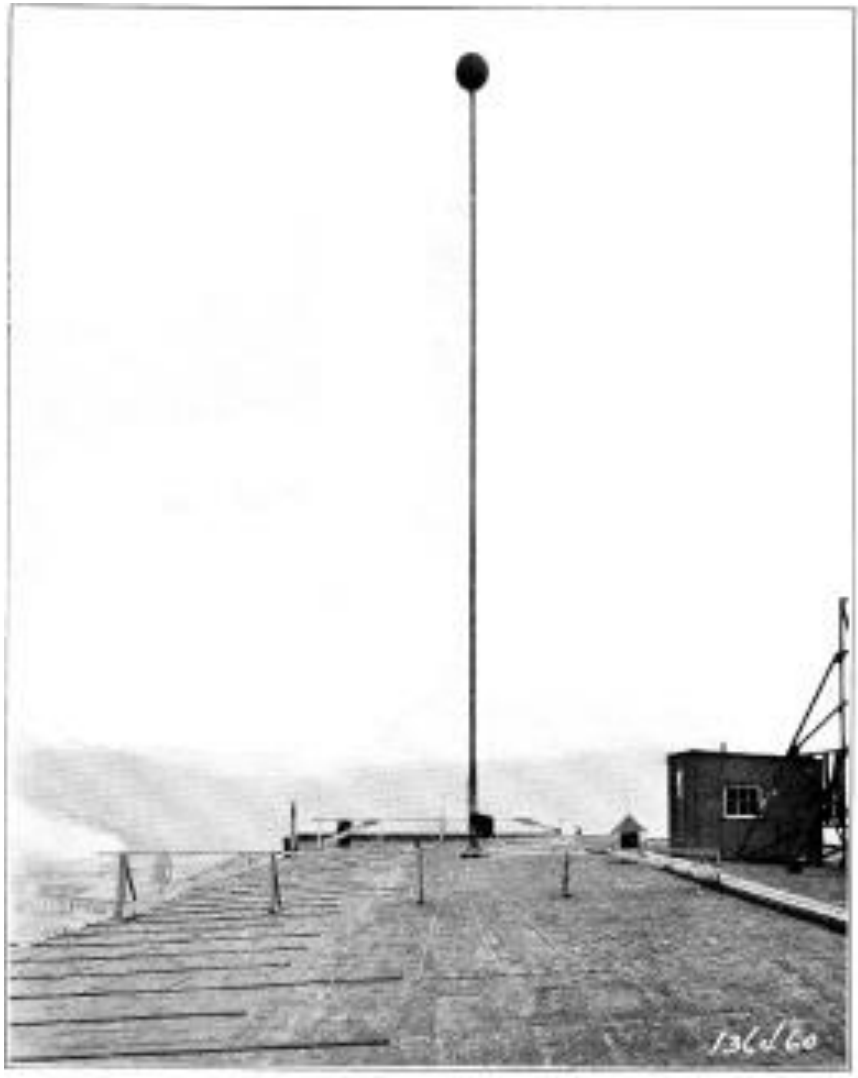


Fig. 21. KDKA's 1921 shortwave antenna on Building K. (*Proc. IRE*, Vol. 12, Dec. 1924, p. 726)

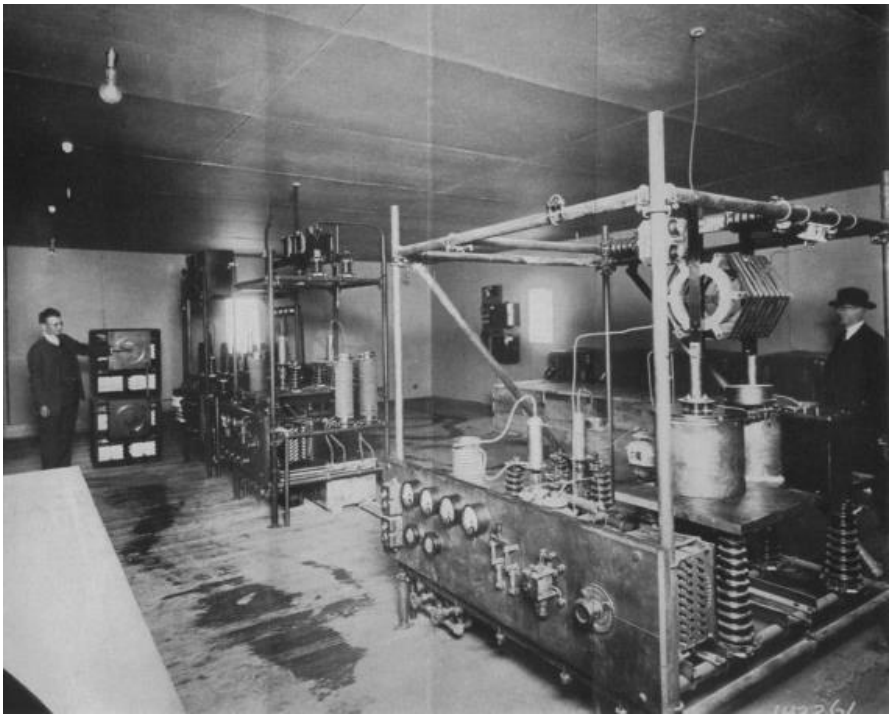


Fig. 22. KDKA's 1921 transmitter unit including rectifiers, modulator, and oscillator. (*Proc. IRE*, Vol. 12, Dec. 1924, plate after p. 732)

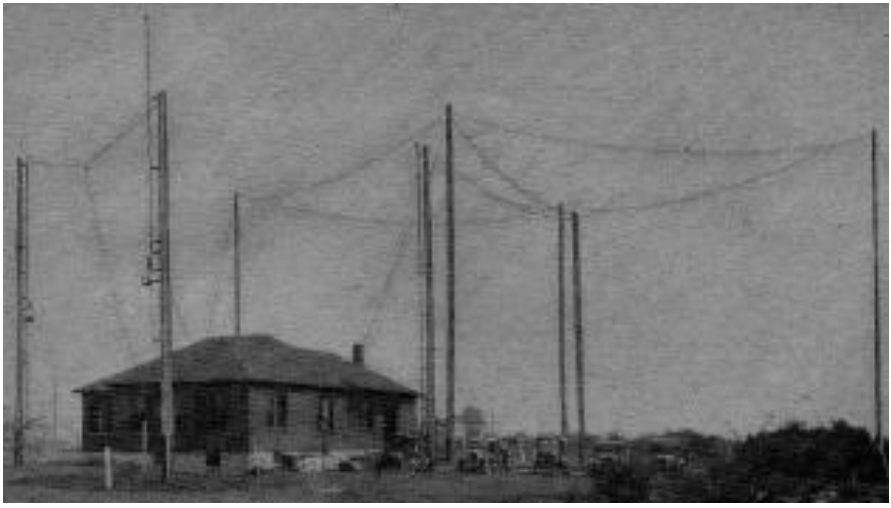


Fig. 23. KDKA's Saxonburg transmitting station circa 1929 with shortwave antennas shown at the left. (*Radio News*, Feb. 1929)



Fig. 24. KDKA blimp used to lift antenna aerial, circa 1933. (Courtesy KDKA)

antenna comprised 32 three-cornered, welded steel sections each five feet wide, sitting on a 10 foot wide concrete pier. The tower rested in the ball and socket joint of a single large porcelain insulator strong enough to support the additional 20 ton load added by the pull of the guy wires. At 336 feet of height, the antenna was electrically broken by three insulators. The conductivity of the ground was improved by burying 50 miles of copper wire radiating out for 700 feet at one degree apart.[46]

- Cross-arm aerials were also superimposed on the main tower for high frequency transmission, but those broadcasts were limited to 35 miles radius from the tower. The new tower eventually assumed all shortwave broadcasts made over station WPIT (formerly W8XK), which were still operating from Saxonburg in 1939 (see Figs. 25 and 26).[47]

The antenna tower, at 718 feet, was the tallest welded structure in the world and weighed 60 tons.[48] It was also the tallest structure in the United States, rising 1,900 feet above sea level. The American Bridge Company manufactured the carbon steel, and a team of nine men erected it in 72 hours. Its top 60 foot aviation beacon and lightning rod were level with the roof of the Radio City Building in New York City. Known for its efficiency, it had the strongest signal within its range of any other antenna.



Fig. 25. View from afar showing KDKA's Allison Park antenna in 1939. (*Broadcasting*, Nov. 1, 1939, p. 17)



Fig. 26. View from bottom up showing KDKA's Allison Park antenna in 1938. (*Radio News*, Jan. 1938, p. 393)

It broadcast at a constant 50 kW, the most powerful wattage allowed on the AM airwaves.[49]

Over the years, the main tower was painted with several layers of orange and white paint so that it would not present a hazard to aircraft. It also was equipped with a 36 inch rotating aviation beacon placed atop a 60 foot cap tower. In 1994, the tower was replaced for structural reasons. The replacement tower that still stands today is also made of carbon steel and resembles the original tower; however, it is equipped with the latest electrical and mechanical technology. The current transmitter and its identical backup system have been online since 1980.[50]

KDKA opened its FM tower in 1948, operating at 92.9 MHz, and transmitted on low band frequency of 47.5 MHz.[51] The dual band transition period ended at midnight on January 8, 1949, at which time all low band transmitters had to be shut down, thereby making obsolete 395,000 original FM receivers that had been previously sold and purchased under the original specification of the FM frequency band.[52]

Station Identification

Conrad received experimental license 8XK in 1916. He also used station 2WE at the Westinghouse plant in East Pittsburgh and 2WM at his home in Wilkinsburg. By 1919, he was using 8XK for most broadcasting tests. Conrad's experimental station 8XK provided some voice and music broadcasts by October 1919. Other experimental stations and amateurs occasionally broadcast phonograph music as well, even as early as 1906 (Reginald Fessenden), 1907 (Lee De Forest), and 1909 (Charles "Doc" Herrold). Nonetheless, Conrad is often credited with triggering or inspiring a critical chain of events that helped create the broadcasting industry. (Note, it is outside the scope of this article to fully explore the validity of various claims of who was "first" in radio broadcasting.)[53]

Evidence from an oral interview of Conrad taken by George Clark circa 1940 indicates that Conrad broadcast "radio concerts" earlier than October 1919 using his special wartime license before he could have been reassigned the 8XK license after the war, possibly as early as April 15, 1919. These broadcasts occurred well before the U.S. ban on radio reception was lifted, and possibly much earlier during experimental testing.[54]

On November 2, 1920, Conrad operated 8XK from his home as a backup for KDKA, which had authorization to operate under a special temporary amateur call sign 8ZZ in case the license for KDKA did not arrive in time. Donald Little remained at KDKA serving as the announcer and monitoring the 100 watt transmitter.[55] Conrad later recalled in the Clark interview that call sign 8ZZ and KDKA were used interchangeably and that he had also participated as an announcer.[56]

Arthur Goodnow, the retired Director of Transmitter Engineering for Westinghouse, analyzed government records and reports about KDKA's licensing history. KDKA began as a Land Radio Station, Class Limited Commercial under

a license issued on Oct. 27, 1920, by the Bureau of Navigation of the U.S. Department of Commerce.

- The license authorized 500 and 3200 meter transmission and also "300 and 600 meters to be used as required in regulations 42 and 44," which meant KDKA was authorized to use 300 meters as a working wave and 600 meters as a calling and distress wave in the maritime service. Power levels were set at 2 kW for radio telegraphy and 200 W for radiotelephony. The KDKA license never mentioned broadcasting, but KDKA operated the historic November 2, 1920, broadcast of U.S. election results on 550 meters.
- On November 7, 1921, KDKA's license was modified to include broadcasting on "360 meters to be used exclusively for broadcasting."
- The first station in the United States to receive an authorization specifically stating, in so many words, that the license was intended for radio "broadcasting" was actually Westinghouse's second broadcast station WBZ in Springfield, Massachusetts, which received its authorization on September 21, 1921.[57] Although KDKA was not the only station to broadcast election night returns on November 2, 1920 (for example, 9XM/WHA in Madison, Wisconsin, broadcast the results using wireless telegraphy), KDKA claims to be the first station to broadcast regularly scheduled programming, and claims to be the first to engage in "broadcasting" as that term is commonly used today. KDKA is often acknowledged as the oldest station still in continuous operation.[58]
- Following the opening of WBZ, Westinghouse opened WJZ in Newark, New Jersey, and KYW in Chicago, Illinois, in October and November 1921, respectively.[59]

As Conrad's interest in shortwave broadcast experiments grew during 1921–1922, KDKA installed and operated experimental shortwave station 8XS on the rooftop of Westinghouse's Building K. Beginning July 19, 1923, KDKA began regular nightly 4.5 hour shortwave broadcasts that were soon received across the world.[60] In July 1924, the shortwave transmitters were upgraded and relocated to nearby Forest Hills, Pennsylvania. Conrad's historic call sign 8XK was transferred to the KDKA shortwave transmitter at about this same time.[61] By 1927, KDKA shortwave broadcasts on 8XK could be heard most nights at 4.760 MHz.[62] Call sign 8XS was returned to the Federal Radio Commission in 1925.[63]

In November 1927, the FRC held a Washington conference attended by 79 nations and many non-voting organizations. A major accomplishment included the adoption of frequency allocations for most of the broadcast spectrum. It also established that experimental stations would carry country/region prefix in their call signs; i.e., a "W" prefix was added to U.S. experimental station "X" call signs east of the Mississippi River to match the newly agreed-upon international labeling system. Thus, KDKA's experimental station 8XK became

W8XK effective October 1, 1928, in the United States and January 1, 1929, internationally.[64]

A number of other call signs are associated with KDKA. Call sign 8XAU dated from 1924 for use at Westinghouse, which was subsumed into 8XK within the year. Westinghouse used 8XAV for television experiments in the 1920s. Both Westinghouse and the University of Pittsburgh held 8XI during World War I, and it appears to have been a forerunner of 8XK. In 1937, Westinghouse received call sign 8XKA for ultra-shortwave band experiments.[65]

In subsequent years, frequency locations and broadcasting schedules were revised numerous times. Call signs for a number of experimental stations also changed effective September 1, 1939, including W8XK, which became WPIT.[66]

Finally, on the corporate side, Westinghouse formed its broadcasting company in the 1920s, known as Westinghouse Radio Stations, Inc., which it subsequently renamed as Westinghouse Broadcasting Company (WBC) in 1954. WBC adopted the "Group W" moniker on May 20, 1963. WBC operated a self-contained entity within the Westinghouse corporate structure. WBC maintained its headquarters in New York City, even though Pittsburgh remained the parent company's headquarters. WBC operated KDKA. In 1943, WBC stations became affiliates of NBC's Red Network. WBC eventually built sister stations for FM operations, i.e. KDKA-FM, and for television operations, i.e. KDKA-TV. Today, CBS owns and operates KDKA-TV, and Entercom owns KDKA-AM, while KDKA-FM is owned by Steel City Media.[67]

KDKA's Studios

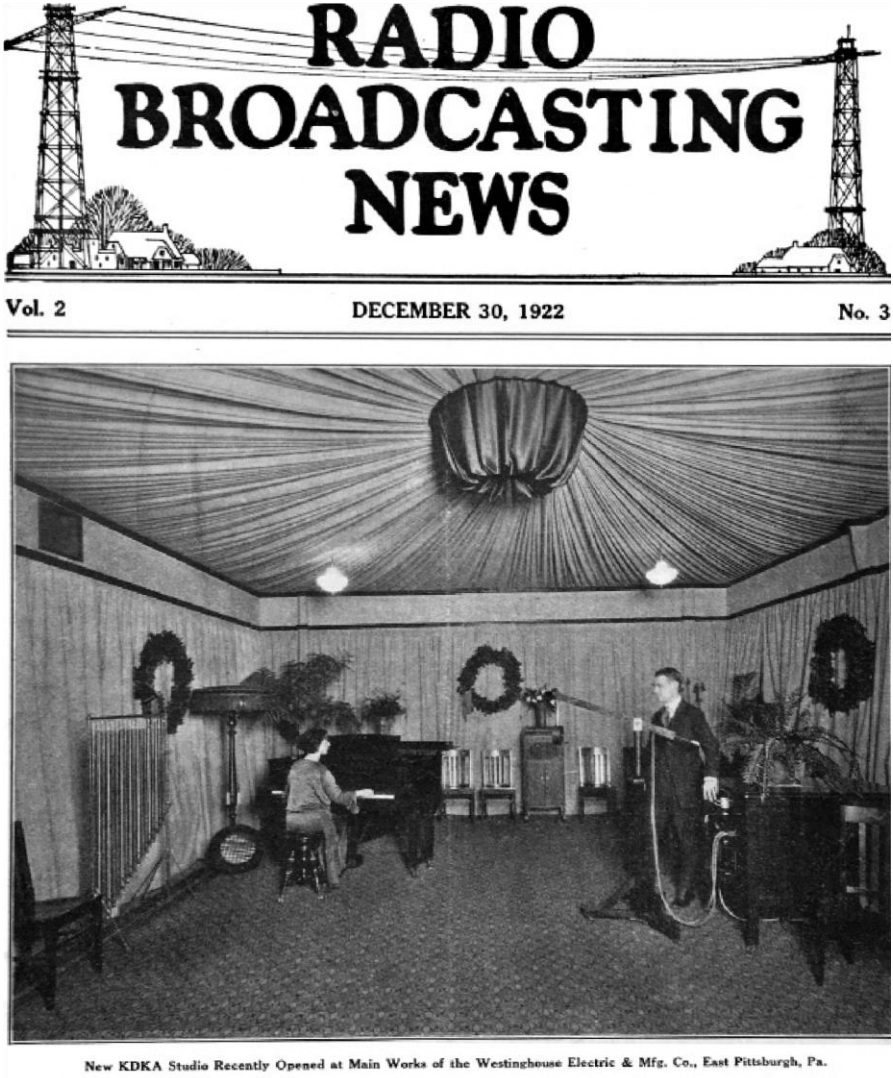
For its first six months, KDKA operated without a studio. All programs originated either as phonograph records played on turntables in the tiny transmitter penthouse atop Building K or from churches, theaters, hotels, or other remote points that were relayed back to the transmitter. In May 1921, KDKA added live band and orchestras to the programming.[68]

KDKA broadcast its first studio programs from a ninth floor auditorium at the plant, but the microphones picked up excessive sound resonance in the room. So, engineers erected a tent draped with burlap (originally termed "monk's cloth") and a single-room shack on the roof next to the transmitter-penthouse. The single room accommodated transmitting equipment, a turntable for records, and KDKA's first broadcast staff. The performers worked outdoors under the tent. The rooftop tent/studio worked reasonably well all summer that year until the weather worsened and the tent blew down in a storm. Engineers further developed the use of burlap drapes and acoustical boards after constructing an indoor studio the following October in Building K.[69] As part of ongoing facility upgrades, a new studio went into operation in December 1922 (see Fig. 27).[70]

KDKA opened an auxiliary studio in Pittsburgh's Old Post Building for the convenience of speakers who did not want to travel to East Pittsburgh. The station eventually moved into the ground floor of the Fort Pitt Hotel,

occupying two rooms and a bathroom, which housed the control equipment. In January 1929, KDKA opened new studio facilities at the William Penn Hotel.[71]

The following June, KDKA relocated its master control facilities to the hotel.[72] In November 1934, on KDKA's 14th anniversary, KDKA inaugurated new studios in downtown Pittsburgh's Grant Building on the third floor.[73] The studio included a master control room that relayed the radio signals to the main transmitter site at Saxonburg, location of the 50 kW transmitter (see Figs. 28–30).


RADIO BROADCASTING NEWS

Vol. 2 DECEMBER 30, 1922 No. 3

New KDKA Studio Recently Opened at Main Works of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Fig. 27. Cover of *Radio Broadcasting News* showing new KDKA studio at Building K in December 1922. (*Radio Broadcasting News*, Dec. 30, 1922, p. 1)

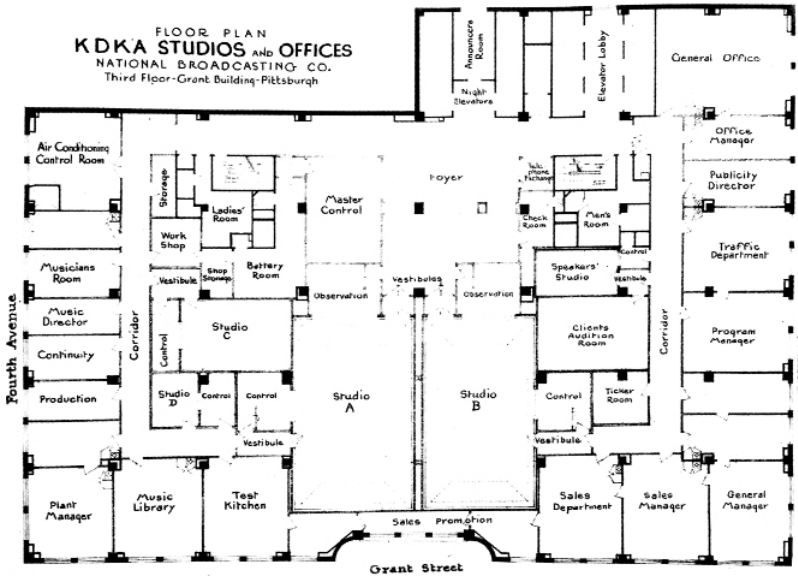


Fig. 28. Floor plan for KDKA studios in the Grant Building circa 1934. (Courtesy Broadcast Pioneers Library)



Fig. 29. Control room at KDKA studios in the Grant Building circa 1937. (Courtesy Broadcast Pioneers Library)

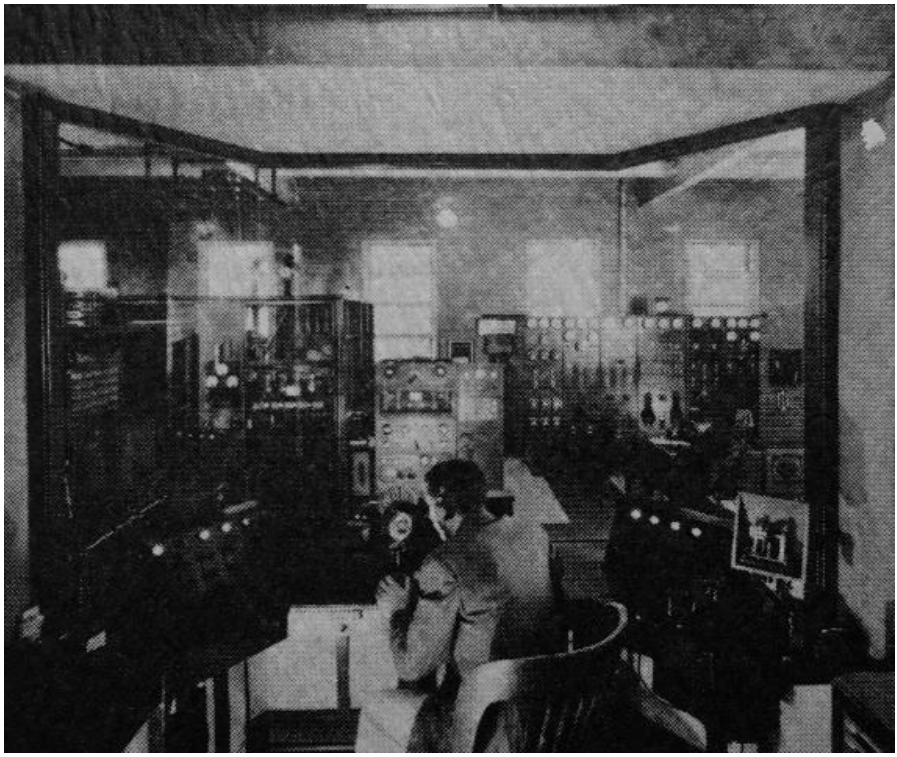


Fig. 30. Transmitter control room at Saxonburg circa 1937. (Courtesy KDKA)

Twelve years later, in May 1956, KDKA relocated the radio studios to 1 Gateway Center, joining KDKA-TV, where they remained until 2010. That year, KDKA-AM relocated to CBS's combined radio facility on Holiday Drive in nearby Green Tree, Pennsylvania. KDKA continues to transmit from the Allison Park facility today. Meanwhile, KDKA-TV continued its studio operations at Gateway Center, where it remains today.[74]

KDKA's First Decade

Frank Conrad's initial experiments focused on 100 meter shortwave broadcasting between KDKA and amateurs living in the Pittsburgh area. In 1922, Conrad successfully demonstrated shortwave radio reception while at an International Radio Conference held in London where the audience heard broadcasts from station 8XK.[75] Based on these and other successful experiments and demonstrations, Westinghouse installed a second receiving and broadcasting station, KDPM, in Cleveland, Ohio. Two years later, in 1923, Westinghouse opened station KFKX at Hastings, Nebraska, and claimed it to be the world's first repeating station. It was specifically located near the geographic center of the United States. Westinghouse did not consider KFKX to be an experimental station

since much of its design was copied from KDKA's existing technology and systems. Going forward, much of KDKA's research efforts centered on shortwave transmitting and reception. Experiments involved determining the precise carrier wave frequencies that would give the maximum constant strength of signal, especially during high listenership broadcast hours. KDKA maintained a 100 meter shortwave transmitter antenna, only 35 feet long, atop Building K in East Pittsburgh (see Fig. 31).[76]

Recognizing the success of KDKA's shortwave broadcasts from Pittsburgh and the establishment of KFKX as a

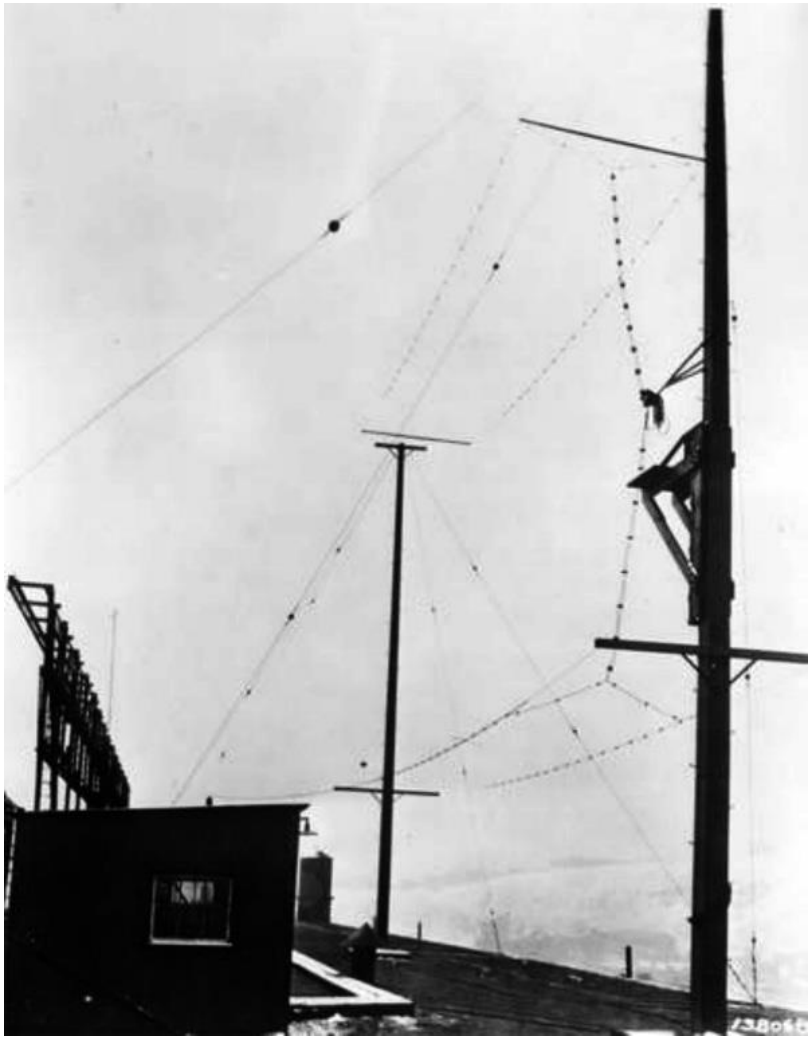


Fig. 31. KDKA's 100 meter shortwave antenna on Building K. (Courtesy Heinz History Center, Image 20170320-hpichswp-0059)

repeating station, the newly formed British Broadcasting Company (BBC) established a private high frequency receiver in Manchester, England, to perform tests of its own with KDKA and KFKX. This led to the BBC's own shortwave broadcasts by December 29, 1923, that were linked to KDKA. On December 31, 1923, Davis broadcast a New Year greeting speech to the people of Great Britain.[77]

Over subsequent years, Westinghouse expanded its operations at KDKA, as told in numerous firsthand accounts (see Appendix 1) and in other publications. It also opened and operated a number of other radio stations and built the Westinghouse network of radio stations (see Appendix 2).

In its first decade, KDKA achieved a string of successes and received national and international attention from those accomplishments. For example, a brief survey of just the *New York Times* reporting for the general public:[78]

- December 21, 1923 – "Boy In Belfast Picks Up KDKA" – Noted that a Belfast schoolboy in Ireland received a radio concert broadcast by KDKA showing the international reach and distances achieved in reception of the station.
- February 10, 1924 – "Mountains Cause KDKA's Music to Swing And Fade" – Explained research into KDKA's broadcast reception at different times of day and night and at many signal locations "all over the dial" and the development of a filter circuit or "wave trap" placed between the antenna and ground.
- March 16, 1924 – "Sextet of Stations Broadcast Over A Span of 7,000 Miles" – Explained how KDKA intercepted and relayed shortwave broadcasts originating from New York City's Aeolian Hall on WJZ to California and England; KDKA combined telegraph, telephone, and radio operations and multiple amplification/rebroadcast of the received radio signals (known as a remote control broadcasting system) involving six stations that covered 1.5 million square miles (see Fig. 32).
- April 20, 1924 – "Pittsburgh Programs Relayed To England on Short Waves" – Described British reception of American programs broadcast from Pittsburgh on shortwave.
- March 29, 1925 – "Transmitter On A Truck Relays Programs To KDKA" – Described mobile radio operations with portable shortwave transmitters.

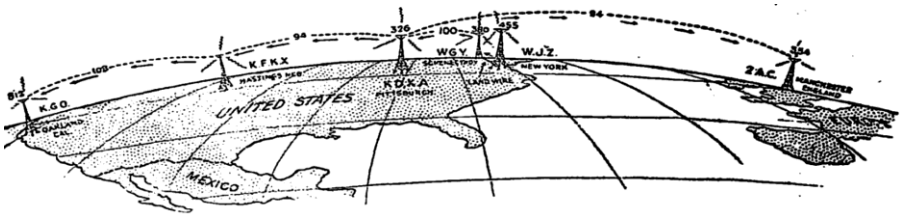


Fig. 32. KDKA's international broadcasting system. (*New York Times*, Mar. 16, 1924)

- October 5, 1924 – "Short Waves To Link 62 Banquets" – Described how 10,000 diners met simultaneously in America and England to hear a President Coolidge address from the White House through KDKA (see Fig. 33).
- April 20, 1925 – "Australia Hears KDKA" – Described the experimental rebroadcast of KDKA signals in Sydney, 9,000 miles distant.
- June 7, 1925 – "Low Aerial On Hill Radiates Further And Waves Fade Less" – Explained hilltop broadcasting versus high-tower valley broadcasting tests of received signal strength and the theory of fading.
- May 14, 1927 – "Devise New System of Broadcasting" – Explained how 1,900 stations could operate simultaneously on KDKA's new 500 Hz signal separation system, which vastly improved station selectivity.
- November 29, 1927 – "Test Short Waves To Attune Stations" – Explained how KDKA and KYW of Chicago tested synchronized chain broadcasting that permits single channel use of a single radio wave for broadcasts without interference.
- January 6, 1929 – "KDKA Program Reaches Top and Bottom of World" – Described the Christmas broadcast to the Admiral Byrd Expedition at the South Pole and the Canadian outpost near the North Pole, world record transmissions traversing more than 11,000 miles.
- January 9, 1929 – "Radio to Byrd Improves" – Described further test broadcasts to the Admiral Byrd Expedition at the South Pole.
- January 22, 1929 – "Dual Broadcasting System Invented By Pioneer at KDKA" – Described the Conrad patents permitting one microphone to

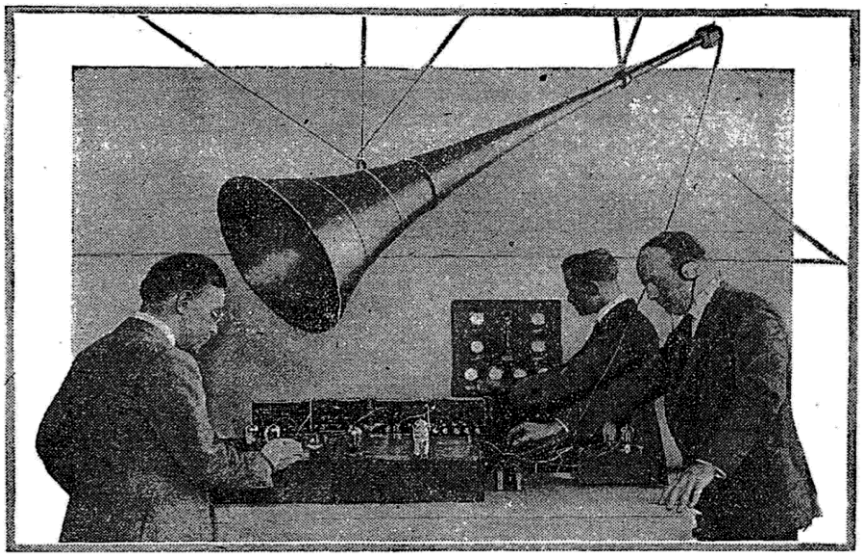


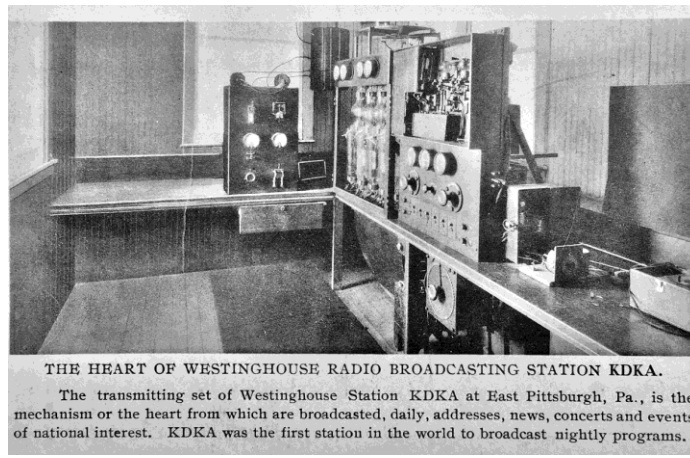
Fig. 33. Shortwave receivers installed at 62 banquets by KDKA. (*New York Times*, Oct. 5, 1924)

serve two transmitters simultaneously that was used for both 316 meter and shortwave broadcasts.

- February 24, 1929 – "KDK A Rebroadcasts Big Ben Time Signal" – Explained the international experiments to rebroadcast Chelmsford, England's 5SW shortwave broadcasts at midnight London time or 7 p.m. in New York.
- September 5, 1929 – "New Distance Record Set By Radio Program" – Described the KDKA report of the German blimp the *Graf Zeppelin*'s arrival in Lakehurst, New Jersey, as heard by Admiral Byrd's ship at New Zealand, 9,000 miles distant.

The decade would not have been complete without obtaining the full recognition of the ARRL. In January 1925, ARRL held a Tri-State Convention in Pittsburgh and included a special tour of KDKA to see the 63 meter transmitter.[79] ARRL returned in June 1927 for its Atlantic Division Convention. This time, Bell Telephone Company and Westinghouse teamed up to provide tours of the telephone exchange and the station facilities at KDKA.[80] The IRE held their 20th anniversary convention in Pittsburgh in August 1932 at the Wil- liam Penn Hotel, once the location of KDKA's earliest radio studios. Again, exhibits and programs featured KDKA as a major attraction. Bus tours brought participants to see KDKA's current and historic locations at the Westinghouse plant and the Saxonburg transmitter station.[81]

Throughout, 8XK, W8XK, and KDKA issued confirmations and other correspondence with listeners from the general public and amateur radio followers. Beginning the night of the initial November 1920 broadcast, KDKA announced a familiar request to the radio audience, "Will anyone hearing this broadcast communicate with us, we are anxious to know how far the broadcast is reaching and how it is being received."[82] Written contacts were made by sending post cards, station letters, and amateur radio QSL card mailings to verify radio contacts and signal strengths (see Figs. 34–37).



THE HEART OF WESTINGHOUSE RADIO BROADCASTING STATION KDKA.

The transmitting set of Westinghouse Station KDKA at East Pittsburgh, Pa., is the mechanism or the heart from which are broadcasted, daily, addresses, news, concerts and events of national interest. KDKA was the first station in the world to broadcast nightly programs.

Fig. 34. Reception verification card with interior view: 1922 KDKA post card. (Authors' collection)

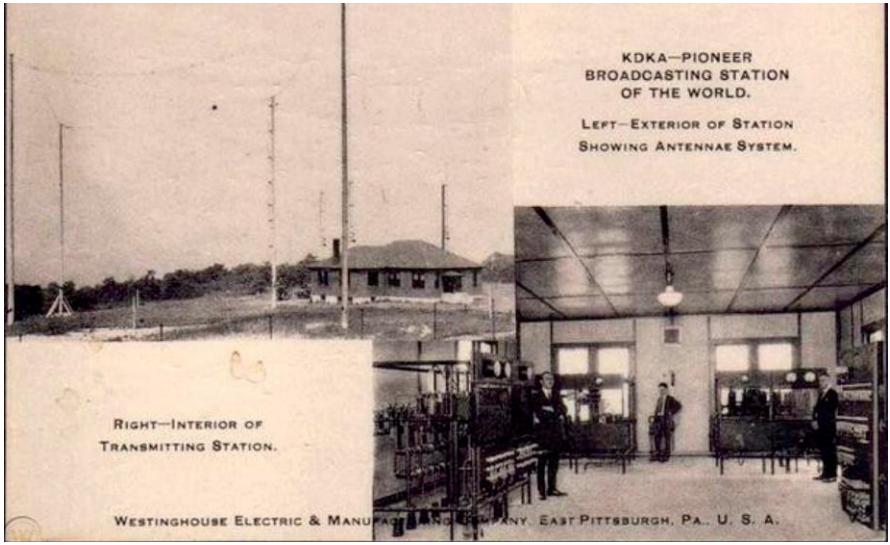


Fig. 35. Reception verification card showing antennas and interior of building: 1928 KDKA QSL card. (K8CX Collection)

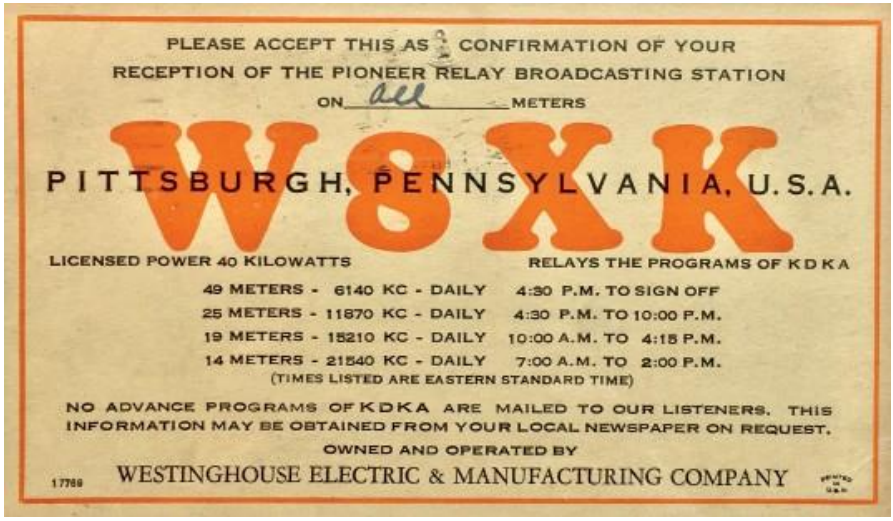


Fig. 36. Reception verification card: 1929 W8XK QSL. (Authors' collection)



Fig. 37. Reception verification card showing antenna views: 1969 KDKA QSL. (Flickr)

Frank Conrad's Later Years[83]

Conrad continued doing groundbreaking radio research throughout his life. He investigated transmitter harmonics, the unwanted additional radio signals produced at higher frequencies than a station's normal transmission frequency. He unexpectedly found that harmonics could be heard farther than the primary signal in some instances. This work initially led Westinghouse to evaluate the commercial potential of shortwave transmissions. In 1924, Conrad showed Radio Corporation of America's (RCA) then vice president and general manager, David Sarnoff, that low-powered shortwave signals from East Pittsburgh could be received in London using a simple receiver with a curtain rod as an antenna. This matched the results obtained, at a small fraction of the cost, from RCA's method for transatlantic radio using the massive longwave Alexanderson alternator transmitters at RCA Radio Central located on Long Island. RCA's transmitters produced signals that were sent and received using horizontal antennas with lengths measured in kilometers.[84]

Conrad's last license for 8XK expired November 3, 1924. Westinghouse redesignated the call sign of a different experimental station in East Pittsburgh from 8XAU to 8XK in December 1924. Thus, the historic 8XK call sign continued to be heard worldwide as part of Westinghouse's shortwave transmission tests.[85]

In 1928, Conrad demonstrated a movie film-to-television converter at Westinghouse, and he also researched narrowband FM transmissions.[86] Conrad retired from Westinghouse in 1940. He

suffered a heart attack the following year on November 6, 1941, while driving to his winter home in Miami, Florida. He died there on December 10, 1941.[87]

Conrad shared his research publicly from the start. He provided a description of his home garage station 8XK to *QST* in its cover story for the September 1920 issue. He presented a comprehensive description to the Radio Club of America in a presentation entitled "Description of Radio Station 8XK" in September 1921.[88] These were followed by numerous other firsthand descriptions of station 8XK and KDKA over the years (see Appendix 1).

Conrad became widely acclaimed as a father of radio broadcasting. He was featured in the cover story of the June 1930 issue of *Radio-Craft* as one of the "Men Who Made Radio" (see Fig. 38). He served on the Advisory Technical

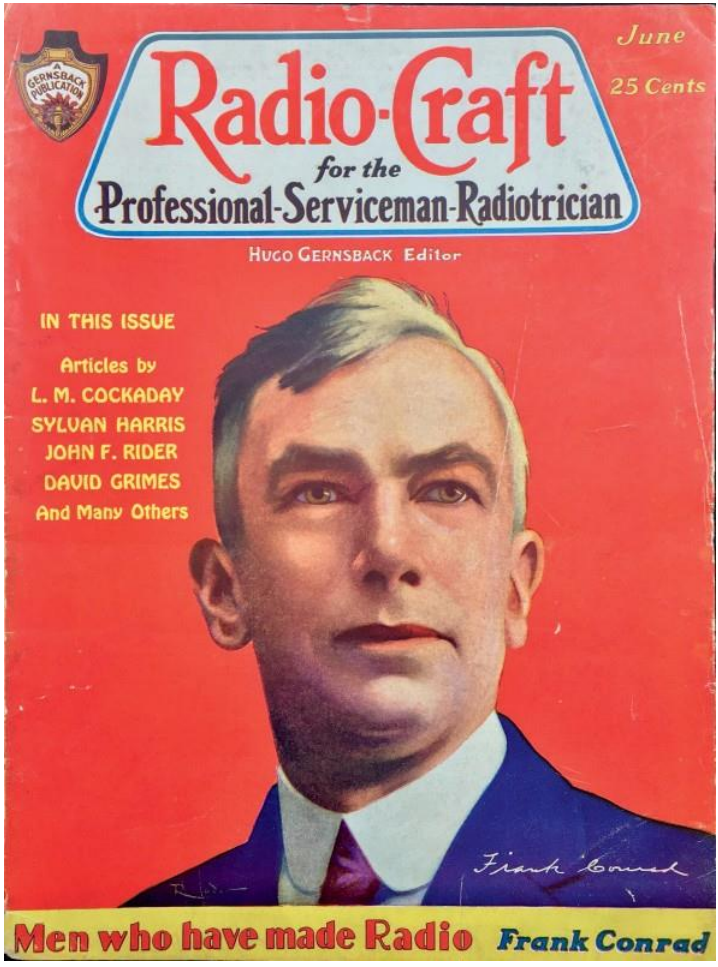


Fig. 38. Frank Conrad on the cover of *Radio-Craft*. (*Radio-Craft*, June 1930)

Committee of the ARRL in 1923, as reflected in the issues of *QST* published that year. He was very active in the AIEE and the IRE, the predecessor organizations to the Institute of Electrical and Electronics Engineers (IEEE), where he published numerous articles about his research.

Starting as a self-made man with a seventh grade education, in 1928, Conrad received an honorary Doctor of Science degree from the University of Pittsburgh in recognition of his many contributions. He received numerous awards for his work, including:[89]

- Liebmann Award (1925) from the IRE for his research on high-frequency radio receivers and shortwave transmission.
- Fellow, IRE (1927).
- Vice President, AIEE (1927) and Chair of the Committee on Admissions (1927).
- Edison Medal (1930) from the AIEE for his contributions to radio broadcasting and shortwave radio transmission.
- Scott Medal (1933) from the city of Philadelphia for inventions that improved the comfort, welfare, and happiness of humankind.
- Lamme Medal (1936) from the AIEE for pioneering and basic developments in the fields of electric metering and protective services.
- Fellow, AIEE (1937).
- Gold Medal (1940) from the American Institute of the City of New York.
- Member of the Society of Automotive Engineers.
- Member of the American Association for the Advancement of Science.
- IEEE Electrical Engineering Hall of Fame (2007).

Legacies and Commemorations

The First Broadcasting Station?

KDKA gained recognition as an early commercial broadcaster as the strength of its signal grew and as it reached more listeners over a wider geographic area. Its reputation stemmed, in part, from its commitment to providing regularly scheduled programming and publishing its programming schedules, which were widely disseminated in newspapers. Westinghouse supported the broadcasts by developing low-cost easily operated radio receivers that became widely available to the public, thereby expanding the radio experience from the more technical amateur to the much broader general public.

KDKA is not the world's oldest radio station. Instead, KDKA considers itself "the pioneer broadcasting station of the world" and "world's first broadcasting station."[90] As Davis later explained, by design and intent, Westinghouse and KDKA "endeavored to render a real public service, with regularity, presenting well-planned, high-grade, interesting, and timely advertised programs."[91] Note, KDKA's claims pertain to a nuanced view of the word "broadcasting" that includes programming management and public announcements of that programming. It lies outside the scope of this article to verify or debate those claims. Other authors have surveyed these issues and reached their own conclusions.[92]

KDKA quickly claimed a long list of accomplishments. KDKA's promotional literature and its management claim to have achieved many firsts (note, verification of these claims is outside the scope of this article):[93]

- First commercial broadcasting studio.
- First church service.
- First broadcast from a hotel.
- Herbert Hoover's first radio address.
- First presidential inaugural address (President Harding).
- First broadcast from a theater.
- First symphonic music played on the air.
- First sports broadcast (boxing match between Johnny Ray and Johnny Dundee).
- First heavyweight boxing match broadcast (Jack Dempsey knockout of Georges Carpentier).
- First broadcast of a tennis match.
- First regular government farm reports.
- First radio newsroom (linked to the *Pittsburgh Post*).
- First full time professional radio announcer and sportscaster (Harold Arlin).
- First radio broadcast of comedian (Will Rogers).
- First baseball game broadcast (Pittsburgh Pirates beat the Philadelphia Phillies).

Westinghouse Radio

Westinghouse arrived as a relative latecomer to radio manufacturing. Notwithstanding its government contracts in World War I to produce military airplane radios, it did not join the "radio group" until 1920. In May 1920, Westinghouse acquired the International Radio Telegraph Company, successor to Fessenden's National Electric Signaling Company, and in November of that year it acquired Armstrong's regeneration circuit patent and superheterodyne patent application. Davis's recognition of the potential for broadcasting and the KDKA license in November 1920 suddenly put Westinghouse into the radio business. Within weeks, Westinghouse secured the Armstrong patent transfer and put nameplates on its initial production run of new RA/DA radio sets.[94]

Conrad, with assistance from Little, designed forerunners to the Westinghouse RA and DA sets in 1919 for wireless telegraphic communication between Westinghouse's facilities at Newark, New Jersey, and Cleveland, Ohio. They tested them in April and May 1920. The RA patents were issued in July 1920, but no clear concept yet existed to manufacture the sets for the public. Within six months, these would become the first radio receivers manufactured and sold to the public specifically for broadcast radio reception.[95]

In November 1920, both stations 8XK and KDKA used the sets as receivers to monitor their broadcasts and for intra-company receptions. The sets appear in the well-known photographs of KDKA's first station (i.e., see the center of the photo in Fig. 39), and they were distributed among some local amateurs and friends of Westinghouse officers.[96]

The first production run with nameplates dated Nov. 30, 1920, consisted of

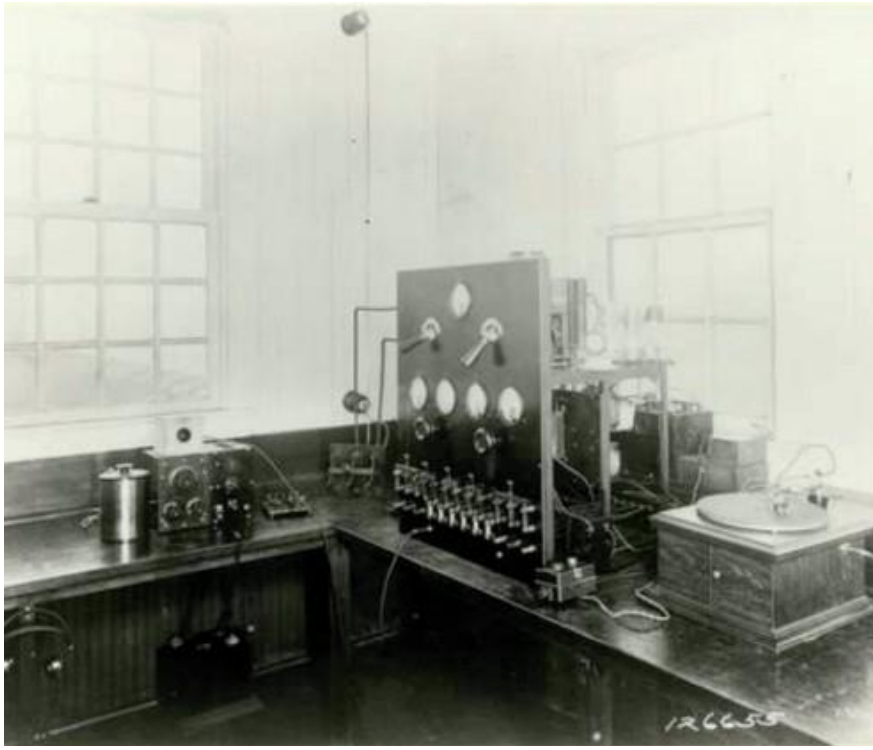


Fig. 39. KDKA's November 1920 station with an early version of the RA/DA receiver set on the table left of center and the transmitter right of center. (Courtesy, Heinz History Center, Image 20170320-hpichswp-0043).

approximately 1,700 RA and DA units. Advertising placed in *QST*, *Wireless Age*, and other magazines notified the public of their availability. In 1921, Westinghouse made approximately 80,000 units. The last production run in 1922 totaled approximately 63,000 units. Westinghouse combined many RA/DA sets into a single case and sold them as RC units. Thus, within the 18 months from June 1921 to January 1923, Westinghouse designed and produced three variants of the RA/DA individual units and the combined RC units, plus a range of other new radio models, and brought to market approximately 145,000 total radios (15% RA/DA and 85% RC).[97]

Westinghouse further conceived of a way for groups to listen to the radio by developing the Vocarola loudspeaker. Although some other commercial loudspeakers existed by the early 1920s, Conrad later described in the Clark interview how he was inspired by an automobile speaker horn to connect a telephone reproducer for driving the horn to project the sounds of radio reception to listeners. This led to the development of a simple home radio loudspeaker, sold by Westinghouse as the Vocarola. This

enabled a room of people, not just one listener using headphones, to hear the radio programming.[98]

In a span of just a few years, Westinghouse moved into producing commercial crystal detectors, crystal radios, one-tube radios, and various combination sets, all springing from its new concept of the radio listeners' marketplace. Westinghouse successfully designed a simple radio receiver for the general public, and Westinghouse correctly anticipated the demand for broadcast receivers.

Westinghouse also organized a marketing approach. Westinghouse began issuing a magazine dated January 1, 1922, subsequent to the November 2, 1921 first anniversary of KDKA's 1920 broadcast. The new magazine, *Radio Broadcasting News,* was distributed to 2,000 newspapers to announce KDKA's programs. The information prompted the listening audience to seek the programming that in turn necessitated purchasing radios made by Westinghouse and other manufacturers. *Radio Broadcasting News* was one of the first regular publications announcing radio station programming.[99]

Westinghouse soon entered cross-licensing agreements with RCA and General Electric in June 1921 and quickly dominated the manufacturing of broadcast receivers marketed by RCA in the early years of the broadcast era.[100] Within five months of KDKA's November 1920 broadcast, an estimated 600,000 people possessed radio receiving sets, compared to only 50,000 the previous year.[101] By the end of 1922, more than 500 radio stations were operating, and by 1927,710 stations were broadcasting.[102] The total number of radio broadcasting listeners in 1927 was estimated at 40 million, and the industry had grown from $2 million in annual revenues in 1920 to $500 million, all due to broadcasting.[103]

Legacies

KDKA's historic broadcast was hardly mentioned in newspapers and magazines during 1920. "The sensation in the public press created by this marvelous demonstration of wireless telephony"[104] would not begin to be recognized outside of Pittsburgh until May 1921 (*QST* and *Scientific American*) and July 1921 (*Literary Digest*).[105] Yet, the legacies of KDKA and its predecessor 8XK are celebrated today. David Sarnoff, RCA's legendary president, proclaimed Frank Conrad to be "a man respected and admired throughout the electrical and radio industries, a benefactor of humanity and my friend."[106] Conrad and Westinghouse's stations, along with other experimental stations and early broadcasters, transformed radio from an amateur technologist's hobby to a broad, easily accessible, national pastime. Radio converted from the use of small crystal radios and personal transmitters issuing point-to-point communications into a voice driven medium cast upon the airwaves for all to listen.

But Conrad was a technology developer, not a company president. When radio pioneer Guglielmo Marconi died, all the radio stations in the world broadcast a two-minute silence. When Conrad died at age 67 in 1941, there was no such fanfare.[107]

Celebrations and Historic Markers

The 100th anniversary of KDKA's broadcast of the Harding-Cox election returns occurs in November 2020. Numerous museum exhibits, plans for activities and events, and commemorative radio operations are contemplated as we write this article. Both the Radio Club of America and members of the Antique Wireless Association will be participating in KDKA's centennial celebrations. Numerous previous milestones have also been celebrated.

In 1964, KDKA received the fourth annual Broadcast Pioneers "Mike" Award for its "enlightened management, inventive, entertaining and informative programming, and responsible, rigorous community involvement."[108] In the 1960s, WBC produced commemorative Zippo cigarette lighters celebrating the accomplishments of the broadcasting company (see Fig. 40).

In 1970, Westinghouse prepared a retrospective on the history of radio broadcasting to honor the 50th anniversary of KDKA broadcasting the 1920 election returns. Years earlier, Conrad was interviewed by Westinghouse about how KDKA began. His live interview is now available online.[109] KDKA promoted major celebrations of the anniversary, published a booklet about its history (*It Started Hear*), issued commemorative keepsakes, and held special events (see Figs. 41 and 42).

KDKA celebrated its 75th anniversary in 1995. The previous summer, in June 1994, after six decades of service in Allison Park, the 1939 KDKA radio tower was replaced. The 1994 replacement tower continues operating today.

- Since 1946, KDKA worked with the Old Newsboys charity organization on an annual campaign to raise



Fig. 40. Westinghouse Broadcasting Company Zippo lighter, mid-1960s. (Authors' collection)



Fig. 41. KDKA 50th anniversary coaster. (Authors' collection)



Fig. 42. KDKA 50th anniversary pewter plate. (Authors' collection)



Fig. 43. KDKA 75th anniversary commemorative segments of the 1939 transmitter tower. (Authors' collection)

money for children whose families could not afford health care. In the late 1960s, KDKA established its own fund drive for the Children's Hospital of Pittsburgh's Free Care Fund, highlighted by holiday broadcasts from department store windows. As the antenna tower came down in 1994, KDKA collaborated with the hospital to sell pieces of the original tower at $20 each for the benefit of the Free Care Fund.

- Cross-section segments of KDKA's 1939 antenna tower now survive in 4,000 Lucite keepsake commemoratives of the station's 75th anniversary as staff awards, advertising pieces, and public souvenirs, each complete with the original orange colored paint (see Fig. 43).[110]

Efforts to preserve Conrad's two-story garage date to 1987 when it was scheduled for demolition. Recognizing the importance of the building, the city of Wilkinsburg halted the demolition and searched for options. In 2001, the National Museum of Broadcasting carefully dismantled Conrad's garage and placed it into storage. However, the house was demolished. The telephone pole, which held Conrad's antenna, was reportedly cut up and pieces were given as desk sets when the house was demolished.[111] The museum hopes it will rebuild the garage someday as part of a complete broadcasting museum to be constructed in Pittsburgh.[112] The site of Conrad's house and garage later became a Wendy's restaurant.[113]

In 2010, KDKA celebrated its 90th anniversary. The National Association of Broadcasters featured the station's history at its Philadelphia show. The show featured highlights of the tower and broadcast stations.

Numerous sites around Pittsburgh include historic markers that celebrate Westinghouse's and Pittsburgh's ties to

Conrad, 8XK, and KDKA. Two markers in particular are of note.

On November 2, 1957, the 37th anniversary of KDKA's first broadcast, a historical marker was dedicated at the site of Dr. Conrad's former home in Wilkinsburg. It was subsequently removed in 2014 to a nearby location in Wilkinsburg. Unfortunately, the claims made on the historical marker can be disputed due, in part, to the very loose and overly broad wording. For example, what is meant by "radio broadcasting?" Also, what defines the "first scheduled broadcast?" Others have also asserted claims to these achievements as mentioned elsewhere in this article. The marker reads:[114]

BIRTHPLACE OF RADIO BROADCASTING

Here radio broadcasting was born. At this location, Dr. Frank Conrad, Westinghouse Engineer and Scientist, conducted experimental broadcasts which led to the establishment of KDKA and modern radio broadcasting, and to the world's first scheduled Broadcast, November 2, 1920.

On June 1, 1994, the IEEE installed an IEEE Milestone marker. But, some of the claims made in this plaque are contradicted by the historical record. For example, as explained in this article, KDKA transmitted on 500 meters, not 360 meters. Nevertheless, the marker states:

WESTINGHOUSE RADIO STATION KDKA

Westinghouse Radio Station KDKA was a world pioneer of commercial radio broadcasting. Transmitting with a power of 100 watts on a wavelength of 360 meters, KDKA began scheduled programming with the Harding-Cox Presidential election returns on November 2, 1920. A shed, housing studio and transmitter, was atop the K Building of the Westinghouse East Pittsburgh works. Conceived by C.P. Davis, broadcasting as a public service evolved from Frank Conrad's weekly experimental broadcasts over his amateur radio station 8XK, attracting many regular listeners who had wireless receiving sets.

KDKA's Current Transmitter Station[115]

Although the original KDKA transmitter towers on the roof of Westinghouse's East Pittsburgh plant no longer stand, a number of KDKA's antenna and station relics still exist. For example, the Heinz History Center in Pittsburgh exhibits the KDKA transmitter used in November 1920. On loan from the Smithsonian Institution National Museum of American History, it contains original parts within the reassembled replica. The Smithsonian collection also includes a microphone from the 1920 station.

The Saxonburg site remained in use for shortwave, operating under the W8XK call sign, until the end of World War II, and was eventually donated to the nuclear physics program at the Carnegie

Institute of Technology (now Carnegie Mellon) for the construction of a cyclotron. After the cyclotron was dismantled in the 1970s, the Saxonburg site became home to the high-tech firm II-VI Corporation, which remains there today.

Westinghouse's Building K in East Pittsburgh was demolished to make way for a new industrial park in the first decade of the 21st century. The Gateway Building in downtown Pittsburgh, which once housed KDKA radio and television studios, remains standing. In 2010, KDKA radio studios relocated to the CBS radio headquarters in nearby Green Tree.

In November 2017, on the 97th anniversary, the Radio Club of America was given a private tour of KDKA's radio studios in Green Tree and its transmitter at Allison Park. The following text and photographs offer views of KDKA's current operations from that tour. The working studios and offices in Green Tree contain numerous displays of KDKA's historical photos and documentation and many of the station's awards (see Figs. 44–46). The KDKA transmitter facility in Allison Park remains in use today, although the 1939 equipment has been replaced by modern digital systems. The original transmitter building still contains much of the now idle 1939 Westinghouse equipment.

When entering the main transmitter building from the front door, one can view the mammoth Westinghouse HG50 transmitter, complete with its original control console, on the entire left side of the room (see Figs. 47–49). The transmitter duplicated two other



Fig. 44. KDKA's Green Tree studios in 2017 showing awards. (Authors' photo)



Fig. 45. KDKA's Green Tree studios in 2017 showing control room. (Authors' photo)

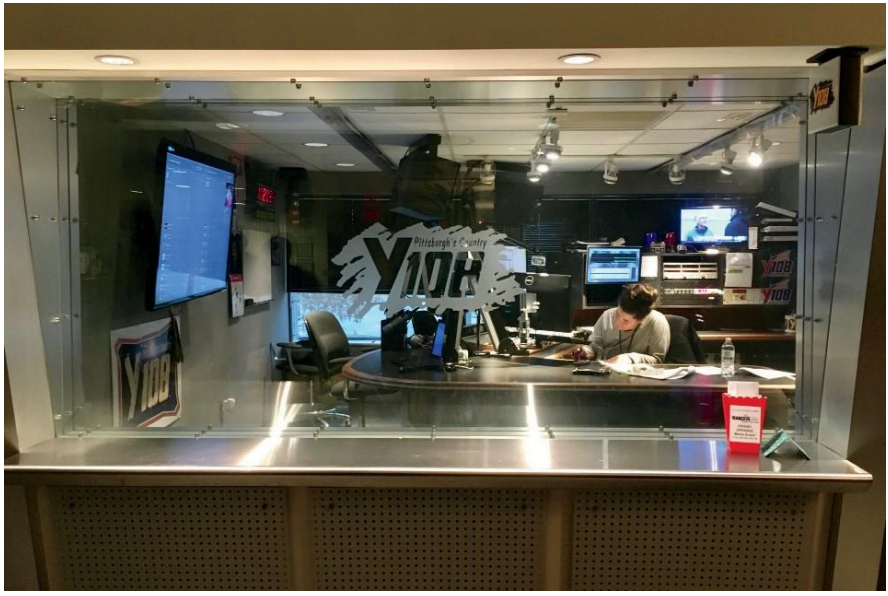


Fig. 46. KDKA's Green Tree studios in 2017 showing control room from outside the windows. (Authors' photo)



Fig. 47. KDKA's 1939 HG50 transmitter showing cut-off switches. (Authors' photo)



Fig. 48. KDKA's 1939 HG50 transmitter showing control panel. (Authors' photo)



Fig. 49. KDKA's 1939 HG50 transmitter showing rectifier tubes. (Authors' photo)

Westinghouse stations from the same era, WBZ in Boston and KYW in Philadelphia. This transmitter was actually designed for 100 kW. KDKA's application for 500 kW, filed in 1936, was dismissed at Westinghouse's request in 1938. KDKA installed replacement Gates MW50 transmitters in the 1970s in the same room on the opposite wall. The Gates MW50 was the most advanced 50 kW medium wave transmitter in the world used for AM broadcasting.

KDKA replaced the Gates MW50 transmitters with three Harris DX50 transmitters in the early 1990s that reside along the wall adjacent to the HG50s. The DX50 transmitters hold a reputation for reliability that stem from their complete solid-state design. The DX50 now has digital controls that reside on the same wall. KDKA's HG50 transmitter was used for the last time on the night the Pittsburgh Pirates won the 1979 World Series.

An engineering shop sits behind the main transmitter room where the transmitter panel sections can be accessed from their rear entry doors. The original antenna cut-off connections are visible above the shop desk (see Fig. 50 and 51).

The basement contains vaults where the rectifiers and power transformer for the 1939 transmitter once sat. Today, the basement is used for storage and contains interesting relics from the old KDKA,



Fig. 50. Display behind KDKA's 1939 HG50 transmitter: (l) 4CX35000 tube used in the MW50 transmitter, (r) mica transmitting capacitor, (front) other meters and (sides) induction coils. (Authors' photo)



Fig. 51. The 50 kW antenna feed located above the bench. (Authors' photo)



Fig. 52. Basement view of condenser cages. (Authors' photo)

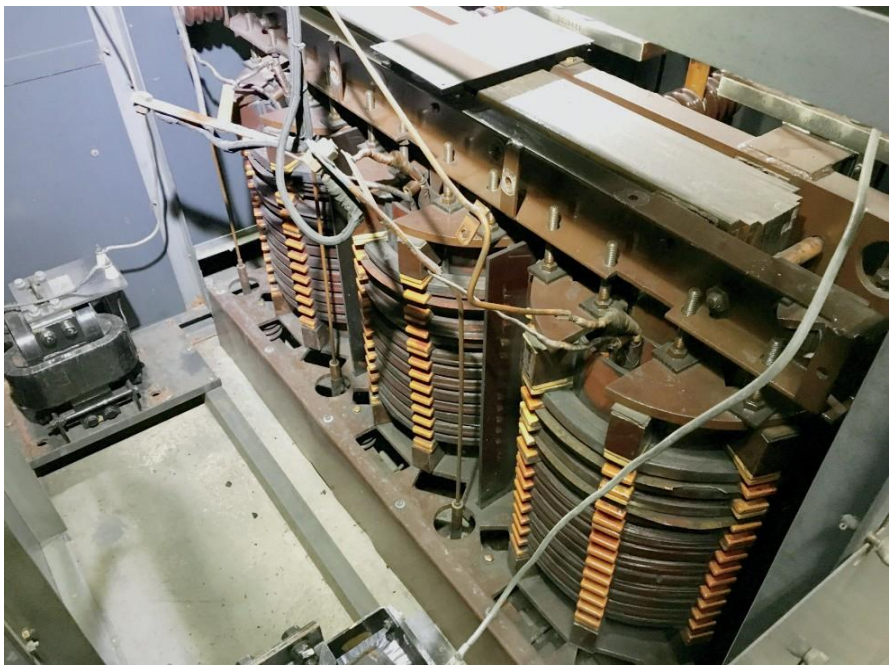


Fig. 53. Basement view of Westcox rectifier. (Authors' photo)

including stacks of 78 RPM transcription disks and phonograph records from the 1920s–1940s. The high voltage generators, caged condensers, and air ducting used to cool the transmitter circuits are all visible (see Figs. 52–54).

Garages on the north and south sides of the building are used for storage today. A separate building houses satellite receivers and microwave uplinks for both KDKA-AM and KDKA-FM as well as KDKA-TV with microwave links back to the studios.

The main tower resides in a large clearing across from the transmitter building (see Figs. 55 and 56). The current tower dates from 1995, and, like its 1939 predecessor, is sectionalized and is 718 feet tall, approximately equivalent to a seventy-story building height. The design was intended to reduce adjacent channel interference to sister stations WBZ and WINS. Bases from the 1939 tower can still be seen today. The shortwave towers are located adjacent to the transmitter building (see Fig. 57).



Fig. 54. Basement view of induction regulator. (Authors' photo)



Fig. 55. KDKA's Allison Park main antenna tower circa 2017. (Authors' photo)



Fig. 56. Antenna tower masthead discharger in display room. (Authors' photo)



Fig. 57. KDKA's Allison Park shortwave towers and transmitter building circa 2017. (Authors' photo)

APPENDIX 1. Important Firsthand Descriptions of 8XK and KDKA

1920: Likely F. Conrad: "8XK, Pittsburgh, PA" [*QST*, Sept. 1920, p. 32]

1921: F. Conrad: "Description of Radio Station 8XK" [*Radio Club of America*, Sept. 1921]

1922: D. G. Little: "Radio Equipment at KDKA" [*Radio*, Sept. 1922, p. 29]

1924: D. G. Little and F. Falknor: "Radio Station KFKX" [*The Electric Journal*, Jan. 1924, p. 25]

1924: D. G. Little: "KDKA: The Radio Telephone Broadcasting Station of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pennsylvania" [*Proceedings of the IRE*, Vol. 12, No. 3, June 1924, p. 255]

1924: F. Conrad: "Short-wave Radio Broadcasting" [*Proceedings of the IRE*, Vol. 12, No. 6, Dec. 1924, p. 723]

1926: D. G. Little, R. L. Davis: "KDKA" [*Proceedings of the IRE*, Vol. 14, No. 4, Aug. 1926, p. 479]

1928: H. P. Davis: "The Early History of Broadcasting in the United States" [In *The Radio Industry: The Story and Its Development As Told by Leaders of the Industry to the Students of the Graduate School of Business Administration George F. Baker Foundation Harvard University*, (A. W. Shaw Company, Chicago & New York) 1928, p. 189]

1931: R. L. Davis: "Power Equipment at New KDKA Station" [*Transactions of the AIEE*, Vol. 31, No. 3, Sept. 1931, p. 942]

1932: R. L. Davis, V. E. Trouant: "Westinghouse Radio Station at Saxonburg, Pa." [*Proceedings of the IRE*, Vol. 20, No. 6, June 1932, p. 921]

1938: F. Conrad: "Reminiscences of Old-Timers–Dr. Frank Conrad" [*Radio-Craft*, Mar. 1938, p. 557]

1940: F. Conrad: "The Story of Short Waves" [*Science*, Vol. 91, No. 2354, Feb. 9, 1940, p. 131]

1940: F. Conrad, W. W. Rogers: "The Story of Conrad and Station KDKA" (as dictated to H. G. Clark) [*George H. Clark Radioana Collection 1880–1950*, Smithsonian Institution National Museum of American History, SRM 4 1559, circa 1940]

1951: D. G. Little: "Reminiscences" [*Unpublished, Oral History Collection*, Columbia University, New York, 1951]

1955: D. G. Little: "Dr. Conrad Founds KDKA" [*American Heritage*, Aug. 1955, p. 71]

APPENDIX 2. Early Westinghouse Network AM Radio Stations

This appendix contains a list of the early Westinghouse AM network stations, the years of operation, how Westinghouse acquired them, and their ultimate disposition. Numerous ownership and licensing transfers were involved. These tables summarize only the major Westinghouse network stations for illustrative purposes, and omit experimental stations such as 8XK, 8ZZ, W8XK. Table 1 lists the initial network stations and Table 2 lists other network stations before 1940. (Source: Wikipedia and FCC filings.)

Table 1. Initial network stations.

Station	Location	Westinghouse-Owned Dates	Acquisition by Westinghouse	Disposition by Westinghouse
KDKA	Pittsburgh, PA	1920–1995	New Construction	Transferred to CBS when Westinghouse acquired CBS
WJZ	Newark, NJ	1921–1923	New Construction	Became responsibility of RCA and then joined NBC Blue Network
KYW	Chicago, IL	1921–1934	New Construction	Moved to Philadelphia and became affiliated with NBC Blue Network
WBZ	Springfield, MA	1921–1962	New Construction	Moved to Boston 1931 and merged with WBZA; transmitter closed in 1962
WBZA	Boston, MA	1924–1995	New Construction	Transferred to CBS when Westinghouse acquired CBS

Table 2. Other network stations before 1940.

Station	Location	Westinghouse-Owned Dates	Acquisition by Westinghouse	Disposition by Westinghouse
KDPM	Cleveland, OH	1923–1926	New Construction	Relay and shortwave station, closed
KFKX	Hastings, NE	1923–1928	New Construction	Relay and shortwave station, merged with KYW
WGL	Ft. Wayne, IN	1936–1945	Acquired from Fred Zieg family	Sold to the Farnsworth Television and Radio Corporation
WOWO	Ft. Wayne, IN	1936–1982	Acquired from Fred Zieg family	Sold to Wayne Broadcasting Corporation

APPENDIX 3. KDKA and Frank Conrad Mile Markers

Photographs of selected mile markers identifying the places where important events occurred in the life of both KDKA and Frank Conrad are shown in Figs. 58–61.

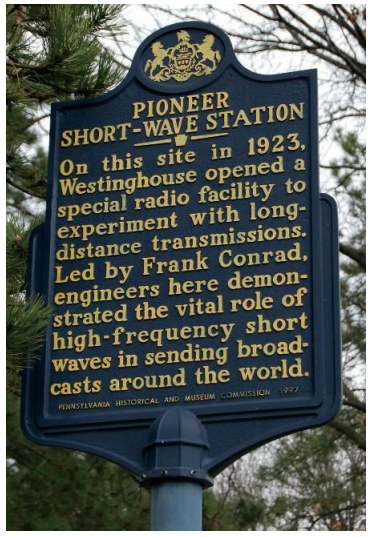


Fig. 58. Historical marker celebrating KDKA: Pioneer short-wave station. (Courtesy Pennsylvania Historical and Museum Commission, IEEE)

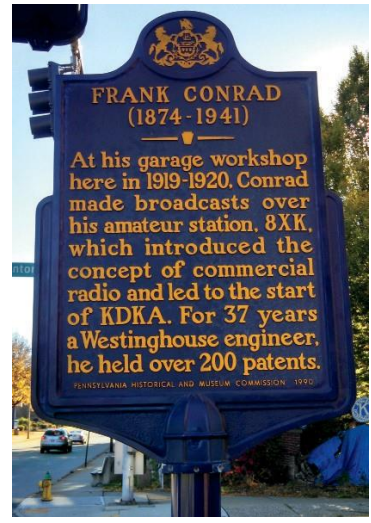


Fig. 59. Historical marker celebrating KDKA: Frank Conrad's garage. (Courtesy Pennsylvania Historical and Museum Commission, IEEE)



Fig. 60. Historical marker celebrating KDKA: Radio station KDKA. (Courtesy Pennsylvania Historical and Museum Commission, IEEE)

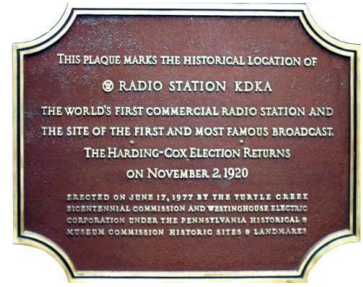


Fig. 61. Historical plaque celebrating KDKA: IEEE plaque marking the historical location of radio station KDKA. (Courtesy Pennsylvania Historical and Museum Commission, IEEE)

Endnotes

1. "Who's Who in Amateur Wireless," *QST*, Feb. 1921, p. 39; "Radio–Trick Watch: First Radio Broadcasting Followed Founder's Time Wager in Pittsburgh," *Literary Digest*, Mar. 13, 1937, p. 19; D. W. Kraeuter, "A Bibliography of Frank Conrad," (3rd ed., 2007) National Museum of Broadcasting, http://www.nmbpgh.org/cbib/conradbibl.htm; "Personalities in Industry: Frank Conrad," *Scientific American*, Vol. 157, No. 5, Nov. 1937, p. 259; E. Barnouw, *A Tower in Babel: A History of Broadcasting in the United States to 1933*, (Oxford University Press, New York, 1966) pp. 64–74 citing D. G. Little, *Reminiscences,* Unpublished, (Columbia University Oral History Collection, New York, 1951); "Correspondence Regarding H. P. Davis' Nomination of Frank Conrad for the Lamme Medal," dated Oct. 13, 1928, IEEE Archive, https://ethw.org/w/images/3/35/Conrad_-_correspondence_regarding_lamme_medal.pdf.
2. "Radio Pioneer's Bet A Trick, Widow Says," *Pittsburgh Press*, Sept. 7, 1957, p. 2.
3. "Frank Conrad: Sleepless Genius," National Museum of Broadcasting, http://www.nmbpgh.org/conrad_project/historical_background/conrad.htm.
4. "New Stations: Special Land Stations," *Radio Service Bulletin*, Aug. 1, 1916, p. 3.
5. Barnouw, 1966, pp. 39–41, 61.
6. D. G. Little, "Dr. Conrad Founds KDKA," *American Heritage*, Aug. 1955, p. 71; "Electrical Engineering Hall of Fame: Frank Conrad," *Proceedings of the IEEE*, Vol. 95, No. 6, June 2007, p. 1378.
7. *It Started Hear: The History of KDKA Radio and Broadcasting*, KDKA booklet, 1970, p. 3; https://www.americanradiohistory.com/Archive-Station-Albums/It-Started-Hear-KDKA.pdf.
8. "Men Who Have Made Radio–Frank Conrad," *Radio-Craft*, June 1930, p. 631.
9. G. Gray, "Signing Off on the First Ten Years," *World's Work*, Dec. 1930, p. 46; E. Wenaas, *Radiola: The Golden Age of RCA 1919–1929*, (Sonoran, Chandler, AZ, 2007) pp. 68–71 and p. 124, Note 12.
10. Experimental License number 236½, call sign 8XK, covering Jan. 21, 1920–Jan. 20, 1921. Conrad may have received informal authorization to operate pending the license reissuance. *QST* reported that radio Inspectors were authorized to permit radio operators to resume transmissions using their official call without waiting for receipt of the actual license ("Getting Your Licenses," *QST*, Nov. 1919, p. 12).
11. C. E. Urban, "The Radio Amateur–Wireless Telephone Here," *Pittsburgh Gazette Times*, Oct. 26, 1919, Sixth Section, p. 13.
12. *It Started Hear*, 1970, p. 4.
13. "Election Returns Flashed by Radio to 7,000 Amateurs," *Electrical Experimenter*, Vol. IV, Whole No. 45, No. 9, Jan. 1917, p. 650.
14. Gray, 1930, p. 47.
15. C. E. Urban, "The Radio Amateur," *Pittsburgh Gazette Times*, May 2, 1920, 6th Section, p. 4; Barnouw, 1966, p. 67; Little, 1951.
16. C. E. Urban, "The Radio Amateur," *Pittsburgh Gazette Times*, July 4, 1920, 2nd Section, p. 5.
17. "Electrical Engineering Hall of Fame: Frank Conrad," June 2007, p. 1378.
18. H. P. Davis, "The Early History of Broadcasting in the United States," *The Radio Industry The Story and Its Development As Told by Leaders of the Industry to the Students of the Graduate School of Business Administration George F. Baker Foundation Harvard University*, (A. W. Shaw Company, Chicago & New York, 1928) pp. 189–225.
19. G. Archer, *History of Radio to 1926*, (The American Historical Society, Inc., New York, 1938) p. 201; Davis, 1928, pp. 189–225.
20. A. Balk, *The Rise of Radio From Marconi Through The Golden Age*, (McFarland & Co., Jefferson, NC, 2006) pp. 34–39; Davis, 1928, pp. 189–225.
21. S. Kruse, "The Bureau of Standards–ARRL Tests of Short Wave Signal Fading," *QST*, Part I: Nov. 1920, p. 5 and Part II: Dec. 1920, p. 13.
22. "Electrical Engineering Hall of Fame: Frank Conrad," June 2007, p. 1378.
23. C. H. Sterling and J. M. Kittross, *Stay Tuned: A Concise History of American Broadcasting*, 2nd ed., (Wadsworth Publishing, Belmont, CA, 1990) pp. 83–89; for a more comprehensive discussion, see also M. R. Bensman, *The Beginning of Broadcast Regulation in the Twentieth Century*, (McFarland & Co., Jefferson, NC, 2000).
24. "History of KDKA, Pittsburgh," History of American Broadcasting website, http://jeff560.tripod.com/kdka.html citing FCC microfiche files on KDKA as transcribed by Xen Scott and G. Douglas, *The Early Days of Radio Broadcasting*, (McFarland & Co., 2001); see also Bensman, 2000, pp. 75, 130–131, 181.
25. Ibid.

26. "8XK, Pittsburgh, PA," *QST*, Sept. 1920, p. 32.
27. D. G. Little, "Radio Equipment at KDKA," *Radio*, Vol. IV, No. 9, Sept. 1922, pp. 29–31, 90–94.
28. D. G. Little, "KDKA: The Radio Telephone Broadcasting Station of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pennsylvania," *Proceedings of the IRE*, Vol. 12, No. 3, June 1924, pp. 255–276.
29. M. A. Simaan, "An Introduction to D. G. Little's 1924 Classic Paper 'KDKA,'" *Proceedings of the IRE*, Vol. 86, No. 6, June 1998, p. 1273; Little, Aug. 1955, pp. 71–73.
30. "KDKA 1922," *Old Timer's Bulletin*, Antique Wireless Association, Vol. 11, No. 1, June 1970, p. 17.
31. S. R. Winters, "100-Meter C.W. Transmission," *Radio News*, Nov. 1923, p. 530.
32. Simaan, June 1998, p. 1273; Little, June 1924, p. 255.
33. D. G. Little and R. L. Davis, "KDKA," *Proceedings of the IRE*, Vol. 14, No. 4, Aug. 1926, p. 479.
34. "The Short-wave Broadcasting Station at KDKA, East Pittsburgh," *QST*, May 1928, cover and p. 43.
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About the Authors

David and Julia Bart reside in the Chicago area. Together, they have published numerous articles on telegraph, radio, and broadcasting history.

David has a BA and MBA from the University of Chicago. He is the Senior Director of the Forensics Practice for the Great Lakes Region of RSM US LLP. He has published widely in his field and authored professional standards involving corporate finance and commercial litigation. David is a Director and Life

Member of the Antique Wireless Association, and a former co-editor of the *AWA Review*. He is a Fellow, Life Member, and Director of the Radio Club of America, and serves as the Editorial Director of the *Proceedings of the Radio Club of America.* David is also Vice President of the Museum of Broadcast Communications in Chicago and Treasurer of the IEEE Historical Committee. He has received numerous awards for his historical research, publications, and exhibit development. He is the former President of the Antique Radio Club of Illinois.

Julia received her BA from the University of Chicago and MA from Concordia University, Chicago. She teaches elementary school with specialties in Reading and English Language Learning (ELL) instruction. Julia is a former associate editor of the *AWA Review* and an advisor to the Antique Wireless Association. She is a former officer of the Antique Radio Club of Illinois, editor of its publications, and an advisor to the board of directors. She has co-authored many peer-reviewed articles for the AWA, RCA, and IEEE, and works closely with David on their collecting interests.



David and Julia B