

BROADCAST ANTENNAS ON THE EMPIRE STATE BUILDING

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This is a description of how a multitude of FM and TV stations broadcast from the
"World's Most Unusual Antenna Site."

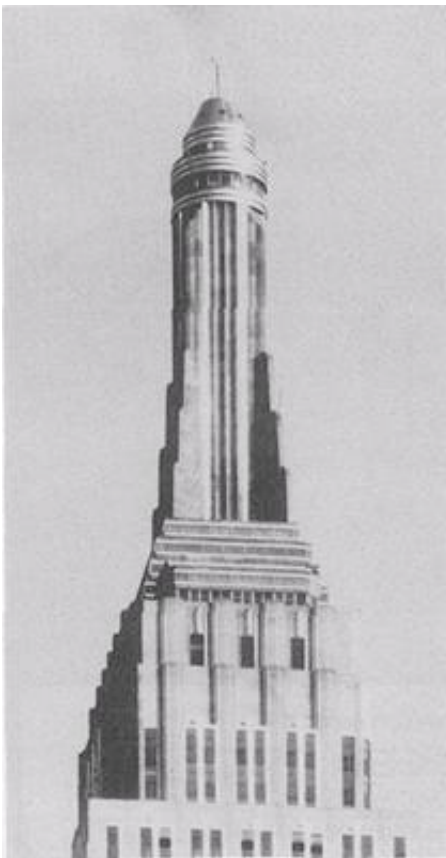


Fig. 1. 1931 Empire State TV antenna had separate visual, aural elements.

On May 1, 1931, construction was completed on what is still the world's tallest building—the Empire State Building in New York City. Less than eight months later, a television transmitting antenna had been erected atop the structure (a point originally designed as a mooring mast for dirigibles). During the ensuing 36 years, television and FM radio signals have continued to be transmitted from this location. Today, 22 stations share the site.

Early History

The original tenant at the pinnacle of the mooring mast (the topmost portion of the building) was the National Broadcasting Company. NBC began experimental television transmissions from the first Empire State antenna on December 22, 1931 (Fig. 1); Separate transmitters for visual and aural transmissions were used with the call letters W2XF and W2XK respectively.

These two transmitters were operated concurrently with another NBC television transmitter already located at the New Amsterdam theatre studio on 42nd Street. This earlier station carried the call letters W2XBS (later transferred to the Empire State transmitter) and operated on approximately 2 MHz with 60-line, mechanically scanned picture signals. The first experimental transmission from the Empire State Building were 120-line pictures using mechanical scanning of both film and live subjects.

(These are believed to be the first high-power, high-frequency transmissions received and monitored by means of the kinescope, or cathode-ray picture tube. At that time, the tubes had green fluorescent





Fig. 2. 1939-1946 antenna had separate visual (lower) , aural (upper) elements.

screens, since the white phosphor later used for black-and-white television had not yet been developed.) The Empire State tests, even though at a line rate twice that of the W2XBS 60-line tests indicated that greater resolution would be required for a satisfactory public television service.

In 1934, NBC, cooperating with Major Edwin H. Armstrong, provided the high-power VHF transmitting facilities for tests of frequency modulation. These test transmissions continued until late in 1935, when the facilities were required for a continuation of the NBC-RCA television held tests. A new antenna with horizontal polarization was installed in 1936, and new series of tests using 343 scanning lines per picture was initiated from Empire State. These tests used for the first time a fixed relationship between visual and aural carriers so that receivers could be designed with a single tuning control. The tests also marked the first use of the iconoscope camera.

By 1938, NBC had again remodeled its antenna on the building. The experimental station, then designated W2XBS, broadcast a picture with 441 scanning lines. Transmission was within the range of 45 to 50 MHz. with various picture-to-sound carrier spacings. A new NBC antenna was installed by February of 1939 (Fig, 2), and in January 1940 the company began regular FM operation from an antenna at the same site. (This station was W2XDG. operating on 42.6 MHz.)

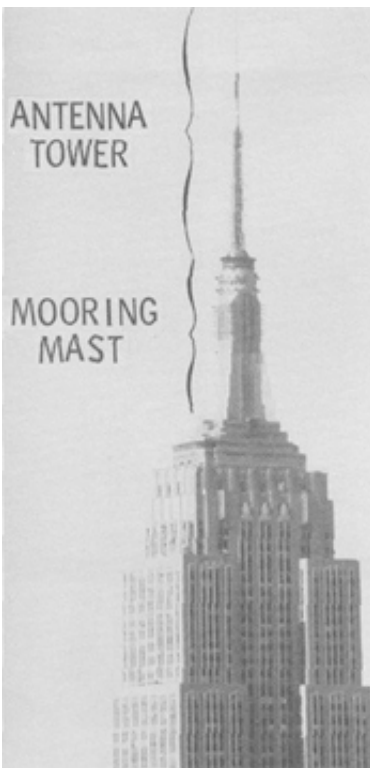


Fig. 3. Empire State

Shortly thereafter, the first National Television System Committee began work to recommend a TV system and standards to the **FCC**. The present system of 525 lines was adopted by the Commission early in 1941, and operating licenses were soon issued. On July 1, 1941, NBC began operation of a commercial television station-WNBT (now WNBC-TV) started its transmissions on channel 1 (50-56 MHz.) from the antenna atop Empire State.

During the years of World War II, further experimentation advanced the television art. In 1946, NBC installed still another new antenna at the top of the building. This one transmitted the visual and aural signals of WNBT (which had begun operation on its present assignment of channel 4 on May 9, 1946). It also radiated the signal of the NBC FM station (now WNBC-FM) and experimental television signals on 288 MHz.

In 1941, there were two commercial TV stations in New York City. In 1944, a third took the air. By the end of 1948, six stations were operating in the metropolitan area. and in 1949, a seventh began broadcasting. Each transmitted from a different site — a situation that presented problems to both broadcasters and their audiences. Each station had to bear the expense of its own tower, or lease

Building today is shared by 22 FM and TV stations.

space on a tall building in Manhattan. TV viewers had the problem of rotating the antenna when they switched channels. To solve these problems, a project began to take form in 1949 which contemplated using the Empire State Building as the antenna location for several New York, City television stations.

Multi-station Site

Work began in 1950 on the multiple TV/FM antenna installation. Many engineers were involved in the research, design, testing, and construction of the multiple array. Among them were Dr. Frank G. Kear (Kear and Kennedy), John B. Dearing and Herman F. Gihring (RCA), and O. B. Hanson and Raymond F. Guy (NBC).

Prior to initial construction of this new antenna structure, the American Broadcasting Company had moved its transmitter to the Empire State Building and utilized an antenna at the top of the NBC supporting mast. Later in the year, during construction of the multiple-antenna structure, ABC's WJZ-TV (now WABC-TV) used an interim antenna mounted atop the mooring mast but tilted 15 °. from vertical. The NBC station did the same, for mutual isolation.

By December 1951, work was completed on the multiple-antenna installation. It was designed and built so that each of the five television and three FM stations could employ the maximum radiation permitted by the FCC. As shown in Fig. 3. the tower becomes progressively narrower as its height increases. This construction was dictated by the principles of good mechanical design. Since the wavelength and consequently element size, decreases with increasing frequency. the antennas were generally arranged for increasing frequency with increasing height. The NBC antenna was an exception to this rule for two reasons: As original tenant at Empire State, NBC had prior rights to position on the tower, Also. since NBC chose a superturnstile antenna, it had to be on top, the slim steel pole would not support additional antennas above it.

In addition to handling the signals of five television stations, the tower was designed to radiate transmissions from three FM stations. The NBC FM transmitter output was triplexed into the NBC TV antenna, The ABC and CBS FM signals were diplexed into a single set of dipoles installed within the CBS TV antenna near the bottom of the tower.

In June of 1951, WNBT began transmissions from its antenna on the tower. In August, WPIX (channel 11) and what is now WABC-TV (channel 7) started using their facilities on the structure, WABD (now WNEW-TV. channel 5) joined the other stations in October, and WCBS-TV (channel 2) was operating from its new facilities by December. The ABC and CBS FM stations began operating from their common antenna in March of 1952.

With five of the then existing seven New York metropolitan area TV stations transmitting from the Empire State Building, the trend soon reached the other two. In 1952, WATV (now WNBT. channel 13), began transmitting from an antenna mounted on the mooring mast of the building. An additional installation was made during 1953, and in, December WOR-TV (channel 9) began transmission from an antenna at the top of the mooring mast, just below the multiple-antenna lower. Sister station WOR-FM followed in 1956, utilizing an antenna just below the base of the multiple-antenna tower. In 1958, WNEW-FM began operation from an antenna within the WNEW-TV array.

When, in 1961, the FCC planned a test of UHF television in a metropolitan area. the Empire State

Building was chosen as the antenna site. For the first (and so far only) time in its history, the Commission itself became a broadcast licensee. WUHF started transmitting November 1, 1961 from an antenna located on the four corners of the tower, beside the WCBS-TV array, near the tower base. The station (on channel 31) was later donated to the City of New York and became WNYC-TV.

By 1965 a ninth TV station had come on the air in the New York 'area—WNJU-TV (channel 47) licensed to Linden, N. J. It began transmitting May 16, 1965 from an antenna on the mooring mast of the building.

Combined FM Operations

By the fall of 1959, nearly 20 FM stations were operating in New York City. With five stations already transmitting from Empire State and six others expressing an interest in using facilities on the building, the possibility of a commonly shared FM antenna arose. Rather than simply tack on antennas one by one, it seemed advantageous to investigate the possibility of a master antenna. The Empire State Building Co. asked Dr. Kear for an opinion on the possibility of a master FM antenna. He recommended a feasibility study which was undertaken by Alford Manufacturing Co. Dr. Kear and his associates then began design, in conjunction with the testing and construction of several scale models by Fred Abel, Andrew Alford, Harold H. Leach, and Nelson R. Powers, all of Alford Manufacturing Co.

In March of 1965, three New York FM stations agreed to lease space on the proposed master FM antenna, shortly thereafter, construction of the array was begun by Alford Manufacturing. As can be seen in Fig. 4 and the other photos, space on the mooring mast was limited. The best available location seemed to be the stainless-steel bands surrounding the 102nd-floor observation deck. Through [the use of a scale model, various combinations of 8, 12, and 16 dipoles were tried, until tests proved 16 to be the optimum number for each bay. This configuration provided the required circularity in the horizontal plane together with a VSWR of less than 1.10 to 1 from 90 to 108 MHz and less than 1.20 to 1 from 88 to 90 MHz. One of the dipoles is seen in Fig. 5.

Dual polarization was incorporated into the antenna by orienting each dipole 45° away from the horizontal. Each dipole is fed 22.5° out of phase with respect to its neighbors; this arrangement was found to give satisfactory patterns and a low standing-wave ratio. The dipoles are arranged into groups of four, each group being fed by one element of a four-way fork. Each bay contains 16 dipoles, and there are 2 bays, A transfer panel allows feeding both bays, or either bay in case of an emergency

Each station is connected to the antenna through a multiplexer which offers a high degree of attenuation to all frequencies except that of the input station. All multiplexers are connected in a line and beyond the last station is an extra, unmultiplexed input. If any station's multiplexer should be put out of service, that transmitter may be coupled to the last input for emergency operation. Normal isolation from transmitter to transmitter varies from 26 to 55 dB. The antenna will accommodate 17 stations of up to 10 KW.

On December 9, 1965, WQXR-FM became the first station to begin transmitting from the master FM antenna. During 1966, seven more stations installed transmitters in the building and used the master array: January, WHOM-FM; February, WLIB-FM and WOR-FM;

March, WBAI and WNCN; September, WNYC-FM and WPIX-FM, On February 1, 1967 WRFM became the ninth station to transmit from the master FM antenna.



Fig. 4 "Yagi" arrays are for Ch 13

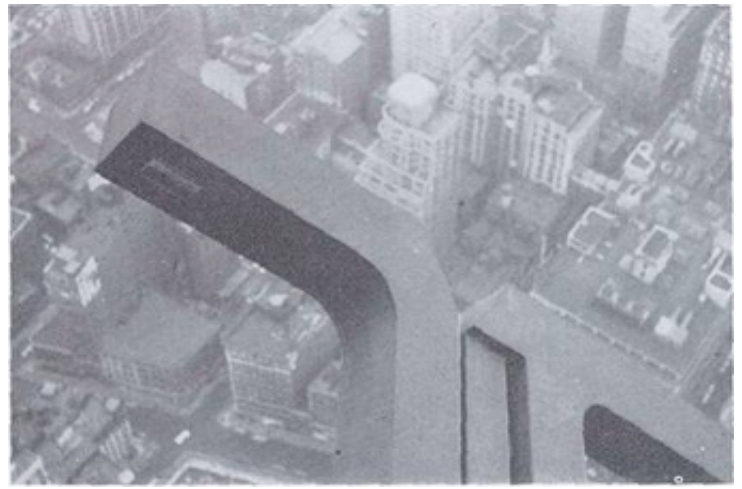


Fig. 5 One element of the master FM antenna seen from window on 102nd floor.

GROUND IN FEET

1472

1967 Facilities

Today the Empire State Building occupies a unique position in the broadcast industry. It furnishes leased vertical space of 317 feet for the antennas of 22 stations. Between the 80th and 85th floors arc housed 35 separate broadcast transmitters with a combined total RF output power of over 400 KW. The Empire state Building Co. owns the master FM antenna and leases it to individual FM stations — perhaps the only such situation in the world. The company also has responsibility for general maintenance of the tower.

The tower is provided with a code beacon, and there is obstruction lighting at three lower levels. The mooring-mast section of the building is illuminated by flood-lights. FCC rules with respect to tower painting are waived in favor of tower lighting 24 hours per day.

Stations currently transmitting from the building are listed below in order of their position from the top of the tower (Fig. 6).

WNBC-TV (ch. 4): 25.7 KW visual, 5.13 KW aural at 1445 ft. WNBC (FM) (97.1 MHz): 1.1 KW at 1445 ft. WNBC visual, aural, and FM signals are triplexed into a single 4-bay superturnstile antenna 56 ft in length.

WPIX (TV) (ch.11): 100 KW visual, 20 KW aural at 1400 ft, using a zigzag antenna 23 ft in length. (Also auxiliary antenna at 1325 ft level.)

WABC-TV (ch. 7);110 KW visual, 11 KW aural at 1380 ft. using a Z-type antenna 25 ft in length.

WNEW-FM (102.7 MHz): 4.1 KW horizontal, 4.1 KW vertical at 1360 ft, A special single-bay antenna is used. It consists of 4 horizontal dipoles on the tower faces, and 4 vertical dipoles on the corners. All dipoles are positioned between the upper two bays of the WNEW-TV array.

WNEW-TV (ch. 5): 37.1 KW visual, 5.5 KW aural at 1330 ft, A five-bay antenna 56 ft in length is employed. The upper two bays are used as an auxiliary antenna, while the lower three bays are used as the main antenna.

Fig. 6 A detailed view of the upper portion of the Empire State Building showing locations of transmitting antennas.

WPIX (TV): This station also has a main antenna at 1400 ft.

WCBS-TV (ch. 2); 42 KW visual, 8.32 KW aural at 1300 ft. A five-bay antenna 65 ft in length is used. The upper three bays are for visual, and the lower two bays for aural transmission.

WNYC-TV (ch. 31); 890 KW visual, 89 KW aural at 1290 ft. A special antenna, utilizing vertical slots in a collinear traveling wave array 40 ft in length is in service. There are 24 slots, or bays, in each element.

WABC-FM (95.5 MHz); 1.5 KW at 1270 ft., (101.1 MHz): 1.5 KW at 1270 ft,

WABC-FM and WCBS-FM are duplexed into a single-bay antenna consisting of four horizontal dipoles mounted on the tower faces between the two lower bays of the WCBS-TV array.

WABC-TV and WNBC-TV: These stations have auxiliary antennas at the 1250-ft level (the very top of the mooring mast).

1391

1365

1319

1250

1207

1155

80th FLOOR

OBSERVATION DECK

102nd FLOOR

OBSERVATION DECK

WNBC-FM

WABC-FM

WABC-TV

WABC-TV

WABC-TV

WABC-TV

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WABC-TV

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WCBS-TV

WOR-FM: An auxiliary antenna is located just below the base of the TV tower.

WOR-TV(ch. 9): 155 KW visual, 31 KW aural at 1240 ft. A special 2-bay antenna 8 ft in length is in use. Each bay consists of 24 dipoles equally spaced around the top of the mooring mast, approximately 35 ft in diameter.

Master FM Antenna: Each of the two bays consists of 16 dipoles equally spaced around the mooring mast above and below the 102nd-floor observation deck. Height is 1220 ft. Stations now using the array:

WBAI (FM) (99.5 MHz): 5.4 KW horizontal, 3.8 KW vertical

WHOM (FM) (92.3 MHz): 5.4 KW horizontal, 3.8 KW vertical

WLIB (FM) (107.5 MHz): 2.0 KW horizontal, 1.45 KW vertical

WNCN (FM) (104.3 MHz): 5.4 KW 3.5 KW vertical

WNYC (FM) (93.9 MHz); 5.3 KW horizontal, 3.7 KW vertical

WOR (FM) (98.7 MHz): 5.4 KW horizontal, 3.8 KW vertical

WPIX (FM) (101.9 MHz): 5.4 KW horizontal. 3.8 KW vertical

WQXR (FM) (96.3 MHz): 5.4 KW horizontal. 3,8 KW vertical

WRFM (FM) (105.1 MHz): 5.2 KW horizontal, 3.7 KW vertical

WNDT (TV) (ch. 13): 178 KW visual, 34.7 KW aural at 1180 ft. A stacked 6-bay Yagi, 27.5 ft in length, is employed.

WNJU-TV (ch. 47): 234 KW visual, 46.8 KW aural at 1180 ft. In use is a special 4-bay vertical-slot antenna 52 ft in length. The antenna consists of two sections which are mounted on the north and south faces of the mooring mast.

The Future

Some time ago, a feasibility study was conducted by a consulting engineering firm for the Empire State Building Co. This study showed that the mooring mast could hold several more UHF antennas. Currently a CP is held by WTVE (ch. 41). licensed to Patterson, N. J., which proposes another antenna on the building. Another FM station is considering using the master FM antenna. Also, WABC-FM, WCBS-FM. and WNDT plan to install new antennas during the summer of 1967.

The world's most unusual antenna site may not exist much longer. Recently, the Port of New York Authority has been planning the construction of twin 110-story skyscrapers in Lower Manhattan. Independent studies by Alford Manufacturing Co, and Jansky and Bailey have shown that the proposed towers would cause ghosting to some viewers watching some of the TV stations presently on the Empire State Building. Several solutions to the program have been advanced, one being to relocate antennas from Empire State to the new. taller structures (to be known as the World Trade Center).

Whatever the future of the Empire State Building antenna site. it remains a monument to the ability

of broadcast engineers and stations to cooperate for their mutual welfare and for the public benefit.

Acknowledgements

The author wishes to thank the various engineers of the stations, networks, and companies mentioned for their assistance in preparing this report. He is especially grateful to Thomas J. Buzalski of NBC. John F. Garrety of the Empire State Building Co., Dr. Frank G. Kear of Kear and Kennedy, Harold H. Leach of Alford Manufacturing Co., and Robert M. Morris, formerly of ABC and NBC.

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