THE Yankee Network, directed by its president, John Shepard, 3rd, embarked on a program of experimentation with frequency modulation in the Spring of 1937 which has been keenly, watched by the broadcasting art.

The completion of the new antenna at Yankee's 50,000-watt FM transmitter, W1XOJ, represents over two years of experimentation and FM broadcast operation. This station, located at Paxton, Mass., about 7 miles northwest of Worcester, operates from the Boston studio through an FM radio link.

Certain aspects of the results of this project are reported here together with something of the background of this enterprise.

When Major Edwin H. Armstrong disclosed his system of frequency modulation to the radio art in the Fall of 1935, he had in a sense revealed the creation of a new technological frontier, its extent unknown, with implications in the art of communications and broadcasting not yet fully understood.

To John Shepard, 3rd, already with many pioneering achievements to his credit, this new frontier was both a challenge and an opportunity. Believing that Major Armstrong's system of frequency modulation was destined to eventually supersede present broadcast methods, he inaugurated a program of FM development that ranks indisputably as broadcasting's outstanding project.

As part of a plan conceived in 1936 to bring FM to listeners throughout New England, authority was requested from the Federal Communications Commission in the Spring of 1937 to construct a 50-kw FM station in Massachusetts. Delays in securing a suitable site for the station held up construction for over a year, but in October, 1938, work was begun on Yankee's FM station atop Mt. Asnebumskit, in the town of Paxton, Mass.

When this project was planned, no 50-kw equipment had been built for the frequencies assigned to FM experimentation. Furthermore, no antenna system had been designed or constructed with radiating efficiency high enough to insure the desired performance.

Undeterred by the opinions of many that the ultra high frequencies could not serve areas beyond the optical horizon, and that a station located 45 to 60 miles from such cities as Boston, Providence, Springfield and Hartford could never render primary service in those cities, construction was started.

It was estimated at the outset that a transmitter of 50-kw capacity located near Worcester, Massachusetts, using an antenna with an equivalent power gain of five or more, would serve a residential and rural population to a distance of about 100 miles. Further, it was estimated that the large cities would receive sufficient field intensities to insure satisfactory service within 50 to 75 miles, depending on topographical conditions between the station and the area in question. Obviously, failure to render primary service in the large cities of Massachusetts would make the project a failure economically.

The writer described in an earlier issue of *FM Magazine* the technical equipment of W1XOJ and the FM relay station WOED that transmits the program from Boston to Paxton. Attention was called to the fact that operation at that time was with a temporary antenna, on account of the destruction of the original antenna in an unprecedented ice storm and hurricane on January 15th, 1940, and that a new antenna was nearing completion.

On January 15, 1941, the new antenna was put in operation. and reports far beyond the range calculated in accordance with FCC practice show that the performance fulfills all expectations.

It is no exaggeration to say that the broadcasting art has watched closely the developments at W1XOJ, and that there has been much speculation as to whether or not this station would attain the intended results. The answer can now be given.

Today, the fulfillment of all expectations is an accomplished fact, and John Shepard's FM Key Station is rendering coverage in ex- tent and quality exceeding that which was visualized at the outset, almost five years ago. Although W1XOJ's 50 kw and height above sea level 1,600 ft. are determining factors in the station's coverage, the antenna is no less important, as unless power can be radiated efficiently, it avails little.

Measurements of the field intensity from the new antenna indicate about a six-fold increase from the old array. It can only be con- cluded that although the old array was somewhat inefficient, the new antenna is developing very close to ideal efficieney.

Far exceeding in size, power, handling capacity, and efficiency any FM Broadcasting antenna in use, the new antenna at W1XOJ makes it without question the world's outstanding FM installation. It stands as a monument to the successful application of Major Armstrong's system of frequency modulation in the field of broadcasting.

While it is not the purpose of this article to go into a detailed technical discussion of the new antenna, some facts may be appropriately included at this time. There are forty separate elements in the antenna array, mounted on a 100-ft. steel mast, forming what is commonly known as a 10-bay turnstile. The 100-ft. mast is supported 150 ft. above the ground on a fabricated steel structure. Forty 7/8-in. lines with 3/8-in. inner conductors connect the elements of the array to the coupling and phasing equipment which is located m the building under the tower.

From the 50-kw amplifier, power is transmitted to the coupling house by means of a pair of concentric lines 4 ins. in diameter, with 2-in. inner conductors. These lines are run underground, protected by 18-in. split drain tile. The interior of the coupling house has the impedance matching and phasing networks. The 4-in. lines from the station enter the building through the floor. Just above the floor, one half of the power enters a power dividing unit, the second unit is fed thru through a section of horizontal line one-quarter wave length long and feeds a second unit. In this manner a satisfactory impedance match is obtained between the 4-in. main lines and the 7/8-in. lines feeding the elements directly.

Long cabinets on the walls on each side of the building enclose the connections between the jumpers from the matching and phasing sections, and the end of the lines running through the roof to the elements on the mast. These latter are sealed and gas under a pressure of a few pounds is maintained to prevent condensation of moisture. The jumpers are open, and are kept dry by maintaining the interior of the building warm and dry with an oil heater . The building is 15 by 28 ft. and is of substantial construction to prevent damage from falling ice.

This type of construction was adopted after giving consideration to all factors, the outstanding of which are:

Capacity to handle 50-kw
Radiating Efficiency
Flexibility Mechanical Strength

Experience has now shown that this array will handle 50-kw comfortably, and is not affected by heavy ice accumulations. The structure is designed to carry ice accumulation 8 ins. thick, and to withstand a wind velocity of 150 miles per hour while loaded with ice. The radiating efficiency is excellent, and although it has not been accurately determined, the writer believes it will be found to be about 90% of the theoretical maximum possible. The division of power to the elements is obtained by circuits readily changed in the coupling house and not by the physical dimensions of the elements and their relative positions on the mast. The station frequency may, therefore, be changed to any part of the assigned band, and the antenna adjusted to operate with the same efficiency without structural changes. This is a very important characteristic in view of the newness of this method of broadcasting, and the probability of frequency shifts among stations in the future.

The total cost of the antenna is about $35,000, including the main transmission line and coupling house. With previous expenditures already made in building, equipment, road, power lines and land, the total investment in the station is about $200,000. This is believed quite reasonable in consideration of the service area attained and the inhospitable location of the station.

Now that accomplishment is not a matter of speculation, what can be said concerning the coverage from this station? In an article written for the *Broadcasting Year Book of 1940*, the writer stated that, based upon experience with 2 kw of power and estimated antenna performance, *"There is no question that with the 50-kw amplifier now being installed, virtually interference-free service will cover all the area within a radius of 75 miles from W1XOJ, and the same service will be obtained in residential and rural areas for a distance of 100 miles and more in favorable locations."* It is gratifying to find that this prediction has been fullfiled in the demonstrated perforrnance of the new antenna. The prediction made a year ago is a conservative statement of today's accomplishment. If there has been doubt among the broadcasters regarding the area that can be serviced by a high powered FM station, the performance of W1XOJ should dispel all rnisgivings.

The record of FM pioneering has been written and in it W1XOJ, Paxton, stands out as the accomplishment of a daring undertaking and a present day manifestation of the pioneering spirit of New England enterprise. Reports of noisefree reception are coming in from points far beyond the 50 microvolt contour. Perfect reception is being obtained from W1XOJ in the business center of Hartford, for example. A letter from Stonington, Me., 300 miles distant, reports FM reception far superior to any AM station that can be heard there. Dealers in the business districts of Boston, New Bedford, and Providence, where local noise is extremely strong, are now demonstrating perfect reception in their stores from W1XOJ. This has, naturally, given a great impetus to the sale of FM-AM receivers.

FM/March, 1941. Paul deMars, V.P. in charge of engineering/Yankee Network.