THE OMNIGUIDE ANTENNA; AN OMNIDIRECTIONAL WAVEGUIDE ARRAY FOR UHF-TV BROADCASTING

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Summary

The Omniguide antenna is a new type of high-gain antenna developed for UHF-TV broadcasting. Waveguide components are employed in the design instead of coaxial line elements to increase the power-handling capacity. Separate picture and sound inputs are provided which are decoupled independent of frequency, thus eliminating the need for a frequency-selective combining filter. A reflection-absorbing circuit increases the picture input bandwidth.

General Principles of Operation

Basically, the antenna consists of a circular waveguide assembly which converts the energy flowing inside to a radiating, cylindrical current sheet on its outer surface. The circular waveguide permits propagation of the picture and sound energy as decoupled, symmetrical modes of transmission. In addition, the large diameter of circular waveguide required for this purpose provides a very high power-handling capacity.

The two required propagation modes are launched in the circular waveguide by a diplexer joining the two separate input lines from the picture and sound transmitters to the circular waveguide base.

A number of smaller waveguides containing spaced slots as radiators are grouped around the circular waveguide to function as the radiating, cylindrical surface as well as the distribution system supplying power from the circular waveguide to the individual slot radiators. Because of the large over-all diameter, eight surrounding waveguides are used to obtain a circular radiation pattern in the azimuth plane.

Description

A diagram of the Omniguide antenna for UHF-TV channel No. 72 (818 mc-824 mc) is shown in Fig. 1. In this design the mechanical construction was simplified by altering the circular waveguide to an octagonal form and changing the outer rectangular waveguides to a trapezoidal shape. Each of the trapezoidal waveguides contain a longitudinal ridge which lowers the cut-off frequency sufficiently to permit propagation of the dominant mode.

A column of spaced, vertical slots as horizontally polarized radiators are cut in the outer surfaces of each of the eight ridge waveguides. The coupling of the slots to the waveguide is controlled by the relative offset positioning of the slots with respect to the center line of the ridge waveguide. The number and spacing of the slots are designed to produce the highly directive elevation pattern required for high power gain.

Each ridge waveguide is energized at its center by probe excitation from the octagonal waveguide, (section C-C), and is terminated at the ends with shorting plungers at sections A-A and E-E.

The signal from the picture transmitter is fed into the lower end of the octagonal waveguide as a linearly polarized TE_{11} wave from a shunt-connected rectangular waveguide (section F-F). Progressing upward, the wave arrives at a quarter-wave plate or circularizer section. This circularizer consists of two parallel metal fins attached to the inner wall of the octagonal waveguide and lying in a plane making a 45° angle with the direction of polarization of the incoming wave (section D-D). The incoming wave may be separated into two linearly polarized waves with equal amplitude and phase, one polarized in the plane through the fins and one perpendicular to this plane. These two components propagate with different phase velocities due to the capacitive loading of the fins. With a proper length of the fins, the two components will be in time quadrature as they leave the fin section. Due to the field configuration of the TE_{11} wave, the components add to produce a circularly polarized wave.

This wave continues to the voltage probes and energizes the ridge waveguides at their centers with equal power and progressive phasing, resulting in essentially omnidirectional radiation in the azimuth plane.

In a reversed procedure, any reflected wave from the radiators is reconverted by the circularizer to a linearly polarized wave polarized at right angles with respect to the picture input wave. The reflected wave is thus decoupled from the picture input line and is transferred by the diplexer to an absorbing resistor (section G-G).

The impedance seen by the picture input line is therefore independent of the impedance properties of the radiating system. This means a considerable improvement in the picture input bandwidth, secured at a very small sacrifice of picture power being dissipated in the absorbing resistor.

The signal from the sound transmitter, injected through the diplexer base, excites the second higher, or TM_{01}, mode in the octagonal waveguide. The circularizer has only a transformer effect on this mode. Continuing upward, the sound wave energizes the eight ridge waveguides with equal power and equal phase, which also produces essentially omnidirectional radiation in the azimuth plane.

The position of the top octagonal shorting plate and its central probe (section B-B) are provided as separate matching adjustments for the two modes.

Another variation of the Omniguide antenna construction consists of adding a coaxial inner conductor to the central, octagonal waveguide. This inner conductor has relatively little effect on the picture mode. The sound energy, however, is fed upward as a TEM mode instead of the TM_{01} mode. Although somewhat more complicated mechanically, the addition of the inner conductor considerably increases the frequency band over which the central octagonal waveguide can be operated with three independent modes.

The photograph of Fig. 2 shows the completed antenna supported on its side for testing. The entire structure was fabricated from formed aluminum alloy sections spot-welded together. A thin-wall, cylindrical covering of fiberglass material is provided for weather protection. The array weighs approximately 750 pounds, is 20 inches in diameter, and 26 feet high with the lower 6 feet being utilized for feeding and mounting.

High mechanical strength and low weight are secured by the relatively large diameter and the cellular form of construction. A single basic structure may be operated over a wide frequency range by the use of replaceable slotted panels.

Measurements

Experimental measurements showed that the azimuth patterns were circular within ± 0.5 db and that the nominal power gain with respect to a half-wave dipole was 13.6 db. Approximately 40 db of isolation was obtained between the separate picture and sound inputs. Adequate bandwidth for both the picture and sound inputs was obtained with less than 0.01 db power loss in the reflection-absorbing resistor.

Although the maximum power-handling capacity of the antenna is not known, tests with the limited available power on certain critical components of the system proved that they would safely carry at least the combined power from a 27.5 kw (peak) picture transmitter and a 13.75 kw sound transmitter.

Experimental measurements at higher power levels were not possible due to the lack of a higher power transmitter. However, an analysis of the various elements indicate that this is a very conservative figure, and that the antenna will handle much higher powers.

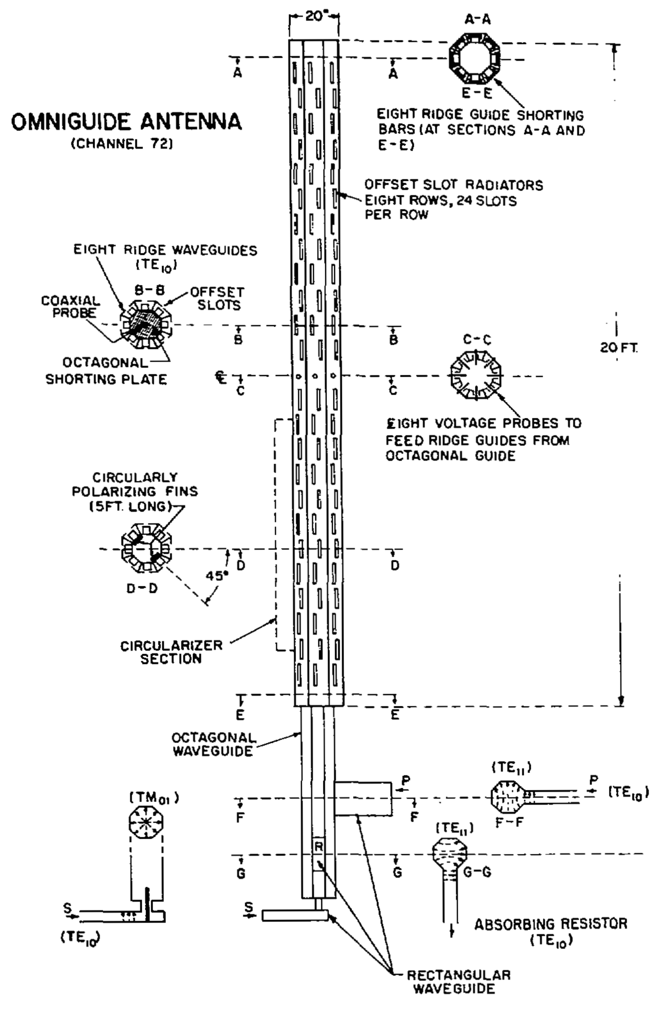

Fig. 1
Diagram of the Omniguide antenna.

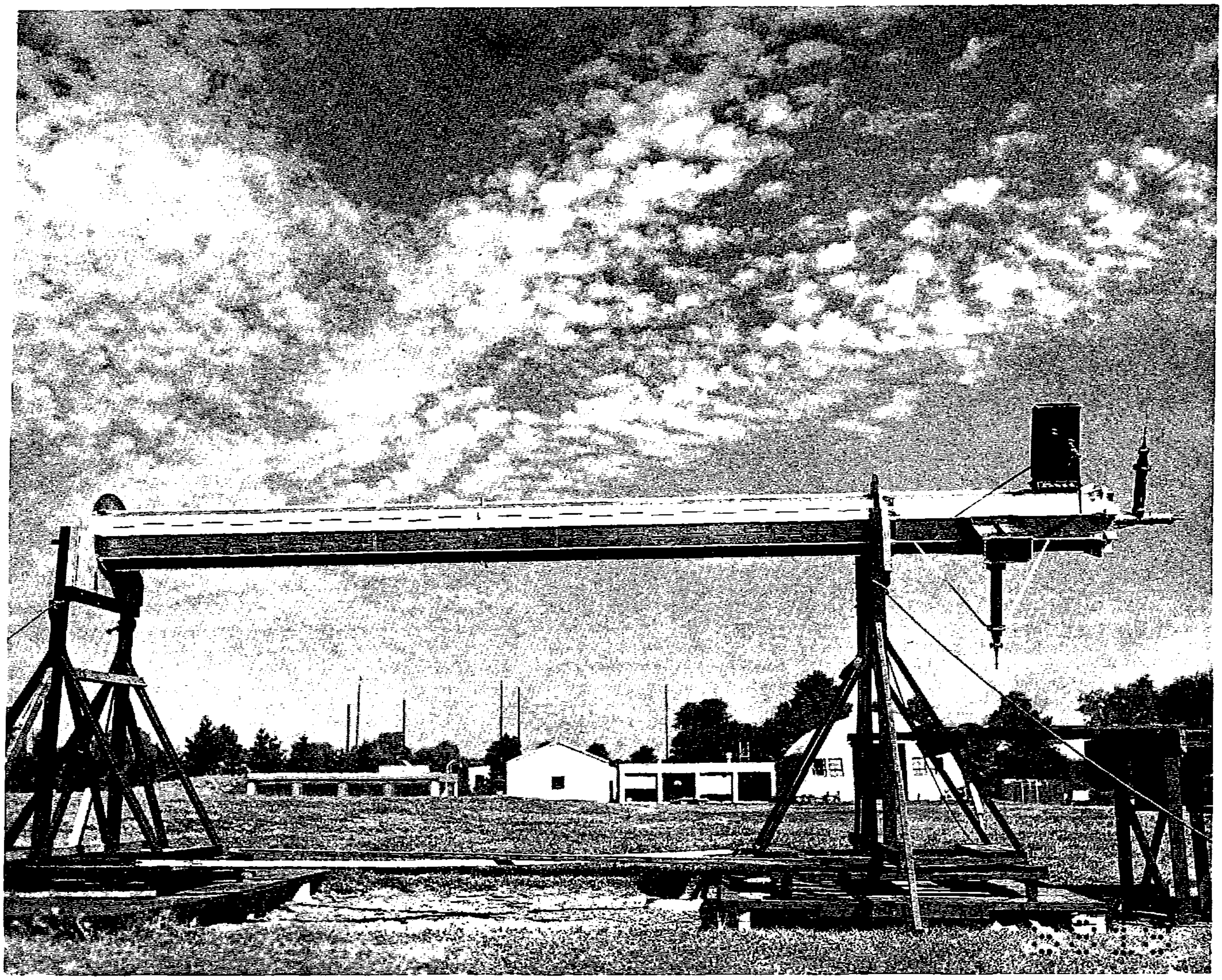

Fig. 2
General view of the Omniguide antenna without the cylindrical, fiberglass covering.