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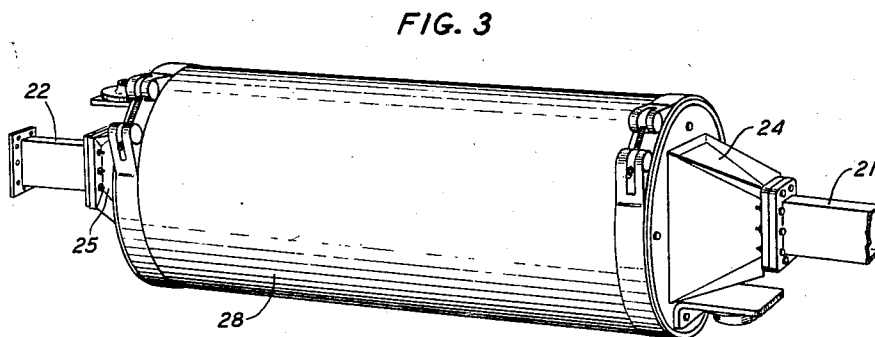
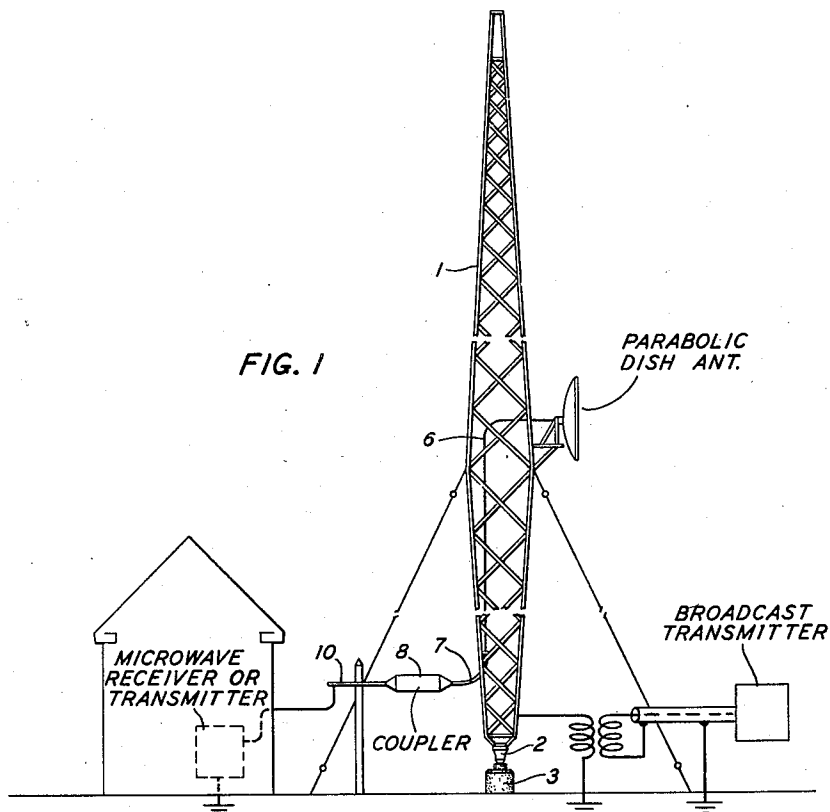
W. C. BABCOCK ET AL

2,639,371

WAVE-GUIDE ISOLATION COUPLING SYSTEM

Filed Jan. 25, 1950

2 Sheets-Sheet 1



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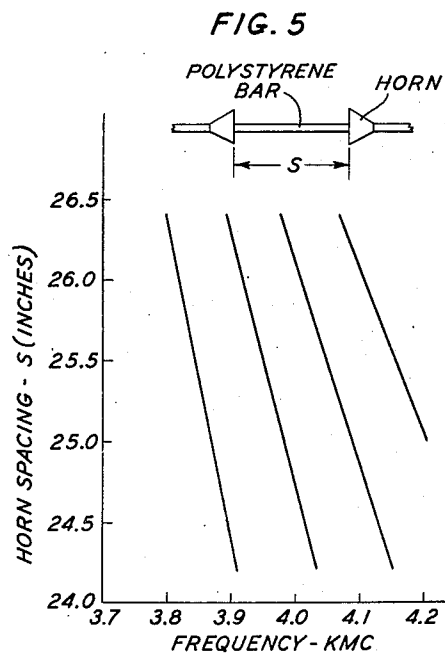
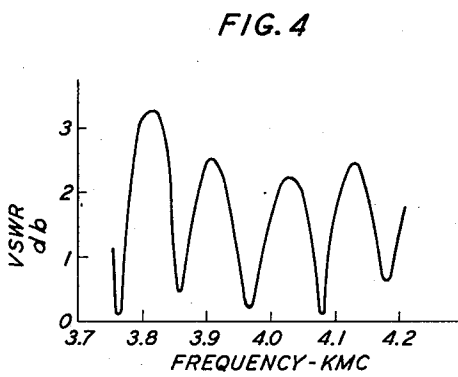
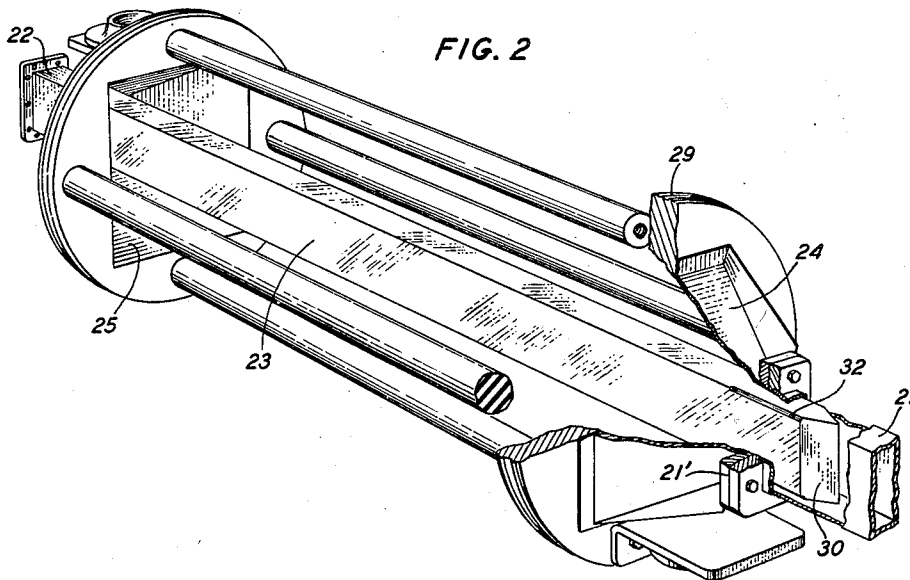
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WAVE-GUIDE ISOLATION COUPLING SYSTEM

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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WAVE-GUIDE ISOLATION COUPLING
SYSTEM

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4 Claims. (Cl. 250—17)

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This invention relates to antenna systems for electromagnetic waves whose frequencies lie in different portions of the frequency spectrum.

In point-to-point microwave transmission systems, it is the practice, because of the limitation to substantially line-of-sight transmission, to mount the microwave antennae at a considerable height above ground, individual towers being erected for this purpose when necessary.

Throughout the country, there are mast- or tower-type antennae used for radio broadcasting, and often it would be advantageous if these could be used to provide the necessary elevated support for microwave antennae. Many of these tower-type antennae, however, have insulated bases and are operated with a high radio-frequency potential to ground. A hollow-pipe wave guide extending down the tower from a microwave antenna to a microwave transmitter or receiver on the ground would, in such case, short-circuit the tower inasmuch as the radio-frequency power would flow over the exterior of the wave guide to ground.

An object of the present invention is to enable such an insulated tower-type broadcast antenna to be used as a support for a microwave antenna and its associated wave-guide transmission line.

A related object is to obviate the necessity for high voltage insulation of the wave guide from the tower and to enable the wave guide to be conductively secured throughout its length to the tower.

A feature of the invention is a microwave "isolation coupler" interposed in the wave guide near the base of the tower, the coupler providing a substantially continuous low-pass path for the transmission of microwaves to or from the microwave antenna and introducing in the external circuit provided by the exterior of the wave guide an open circuit or gap that cannot be bridged by the high power, broadcast frequency currents.

The nature of the present invention will appear more fully in consideration of the following description of a preferred embodiment of the invention, reference being made also to the appended drawings, in which:

Fig. 1 shows an embodiment of the invention in which an insulated broadcast tower-type antenna supports a microwave antenna and hollow wave-guide feeder therefor;

Fig. 2 shows in partial section a wave-guide isolation coupler in accordance with the invention;

Fig. 3 shows the wave-guide isolation coupler with attached neoprene cover; and

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Figs. 4 and 5 are curve diagrams showing the characteristics of the isolation coupler.

Referring to Fig. 1, 1 designates an insulated tower antenna erected to a suitable elevation, for example, 400 to 500 feet above the ground. The antenna tower 1, which is insulated from the ground by an insulator 2 and concrete base 3, is used for radio broadcasting and is fed from a radio-frequency high power transmitter by a coaxial transmission line and transformer coupling, as disclosed by the United States Patent 2,140,174, issued December 13, 1938, to P. H. Smith. In one exemplary installation, the radio broadcast frequency was 1150 kilocycles.

An antenna 5 for microwaves, namely, a paraboloidal dish, or the like, is supported on a horizontal platform connected to tower antenna 1 approximately half-way above the ground. The paraboloidal antenna 5, which may be of the type disclosed in the United States Patent No. 2,422,184, issued June 17, 1947, to C. C. Cutler, is connected to a feeder line comprising a vertical section of wave guide 6 (1.5 x 3.0 inches in cross section), a 90-degree wave guide bend 7, an isolation coupler 8, and a horizontal section of wave guide 10 connected to either a microwave transmitter, or a receiver. The latter may be of the type disclosed in an article by J. F. Wentz and K. D. Smith entitled "A new microwave television system" in the Trans. A. I. E. E., volume 66, pages 465 through 470, 1947, adapted for microwave radio relay use. The vertical section of wave guide 6 is fastened to the tower 1 by bolts or other fastening means, while the horizontal section is supported at an elevation of nine feet from the ground.

Fig. 2 shows the isolation coupler in full detail excepting for the cover.

The coupler 8 comprises two hollow rectangular wave-guide sections 21, 22 separated by a three-foot gap, which is bridged by a rectangular polystyrene bar 23 about 40 inches in length, extending a few inches into the proximate ends of each wave guide 21, 22. These proximate ends of wave guides 21, 22 are terminated by pyramidal horns 24, 25 facing each other for beaming microwaves therebetween along the surface of and into the dielectric bar 23. The horns 24, 25 are spaced apart mechanically and electrically insulated from each other by four rods 26, formed of phenol fibre.

The length of polystyrene bar 23, or, more particularly, the gap length, is somewhat greater than the height of the base insulator 2 to prevent flash-over from the energized tower antenna

1 to ground and to preclude the introduction of excessively low reactance paths to ground at the radio broadcasting frequencies.

A cylindrical protective cover 28 of neoprene is clamped to the circular grooved edges 29 of the horns to act as a gas-tight seal for the inert gas flowing through the wave-guide feeder and to prevent rain and dust from infiltrating thereinto, as illustrated in Fig. 3.

The polystyrene bar 23 is provided with tapered terminals 30, for matching the impedance thereof to that of the wave guides 21, 22. The corners of the bar, where the tapered ends protrude into the wave guides, are slightly chamfered at 32 for permitting the flow of nitrogen or other inert gas under pressure into the wave-guide system. The cross-sectional dimensions of the bar 23 permit its ends to fit snugly into wave guides 21, 22.

A dielectric bar 23 connecting two open-ended wave guides 21, 22 will concentrate and transmit microwave energy between the guides and across the gap. In the transmission through the bridging polystyrene bar, however, some of the energy may tend to travel along the exterior surface of the bar and may tend to escape into space or be reflected when it encounters the impedance discontinuity present where the wave guide ends, namely at 21', 22'. The pyramidal horns 24, 25, which terminate the wave guides 21, 22, capture this energy and direct it back into wave-guide sections and also overcome to a considerable extent the aforementioned impedance discontinuity.

The insertion loss of the polystyrene isolation coupler 8 is low, ranging from 0.3 to 0.5 decibel in the microwave band from 3.75 to 4.25 kilomegacycles. Low loss is an essential characteristic and low dielectric constant is a desirable characteristic of the isolation coupler, particularly for simplifying the impedance-matching problem.

As shown in Fig. 4, the voltage standing wave ratio over this microwave band ranges from a minimum of 0.1 decibel to a maximum of 3.2 decibels in cyclic fashion, adjacent minima being about 110 megacycles apart. This cyclic variation of voltage standing wave ratio with frequency depicted in Fig. 4 is attributable to the vector addition of reflections originating at each end of the isolation coupler and caused by:

1. The junction between wave guide and horn;
2. The transition from the end points of the polystyrene bar into the hollow guide space;
3. Aperture of the horn.

The isolation coupler is suitable for broad-band operation over a frequency band 0.4 to 0.5 kilomegacycle wide centered around 4 kilomegacycles, where a standing wave ratio of about 2 to 3 decibels is permissible.

The exact frequencies at which minimum standing wave ratios are found are critically dependent upon the dimensions of the parts of the coupler. With proper dimensions of horns and polystyrene bar, it is possible to obtain a V. S. W. R. minimum of 0.2 decibel at 3970 megacycles. A typical set of dimensions utilized for achieving this result comprised a bar 39 $\frac{3}{8}$ inches long, 1 $\frac{1}{4}$ inches wide, tapered over a length of 1 $\frac{1}{8}$ inches at its ends. The height of the horn was 5 inches, and the rectangular mouth thereof was 6 $\frac{3}{8}$ inches by 5 $\frac{3}{4}$ inches, while the horn's circular base has a diameter of 5 $\frac{3}{4}$ inches.

At any desired frequency, one may choose horn

spacings corresponding to a minimum S. W. R., as shown in Fig. 5.

It should be understood that other dielectrics, which show low loss in the microwave range, may be used in the isolation coupler, for example, quartz, methyl methacrylate resin, glass, mica bonded glass, or the like.

It should also be understood that for narrow-band operation, dielectric bars of low loss and high dielectric constant may be utilized, such as rutile, barium titanate, strontium titanate, and the like.

It should also be understood that the paraboloidal microwave antenna shown is merely exemplary and that other types, such as microwave horns, slotted wave guides, arrays of dipoles, metallic lens antennae, or the like, may be substituted therefor without departing from the spirit of the invention.

The polystyrene bar may be cylindrical, hexagonal, octagonal, or the like in shape, and it may be reduced in cross section without departing from the spirit of the invention.

What is claimed is:

1. In combination, a hollow-pipe wave guide pressurized by an inert gas and transmitting therethrough microwaves, said guide having a gap intermediate its ends, a low-loss dielectric bar bridging said gap, said bar having impedance-matching gas-to-dielectric transition sections of substantially reduced cross-sectional dimensions at each end thereof, the portions of said bar extending into said pressurized wave guides being of slightly reduced peripheral dimensions relative to the enclosing wave guides to permit passage of gas around the ends of said bar, opposed inwardly extending conductive horns secured to the ends of said wave guide on either side of said gap to concentrate the microwaves and supplement said dielectric bar in their transmission from one section of conductive wave guide to the other, and a gastight cover of non-conducting material secured to the outer periphery of said horns and sealing said gap therewithin to facilitate the transmission of the pressurized gas across the gap.

2. In combination, a high power radio frequency transmitter, a radiating antenna tower coupled thereto and insulated from ground at its base, an elevated microwave antenna supported on said tower, microwave equipment spaced from said tower, a conductive hollow pipe wave guide extending between said microwave antenna and equipment for the propagation of microwaves therebetween, said wave guide being conductively secured to said antenna tower substantially throughout its length between said base and said microwave antenna, said wave guide having a non-conductive gap therein adjacent said base, and a low-loss dielectric bar extending across said gap and into the ends of the wave guide on both sides of said gap to bridge said gap for the transmission of microwaves and the prevention of flashover from the high voltage antenna tower along said wave guide to ground.

3. In combination, a high voltage radio frequency broadcasting tower, a broadcast transmitter coupled to said tower, insulating means supporting the base of said tower a predetermined height above ground, microwave equipment spaced from said tower, an electrical conductor connecting said microwave equipment to ground, an elevated microwave antenna mounted on said tower, a conductive hollow pipe wave guide extending between said microwave anten-

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na and equipment for the propagation of microwaves therebetween, said wave guide being conductively secured to said tower substantially throughout its length between said base and said microwave antenna, said wave guide having a non-conductive gap therein at a location between said microwave equipment and the base of said tower, and a low-loss dielectric bar extending across said gap to the ends of the wave guide on both sides of said gap to bridge said gap for the transmission of microwaves, the length of said non-conductive gap and the distance of said wave guide above ground between said gap and the tower base both being greater than said predetermined height, whereby flashover from said high voltage tower to ground through said wave guide or said gap is prevented.

4. In combination, a high power radio frequency transmitter, a radiating antenna tower coupled thereto and insulated from ground at its base, an elevated microwave antenna supported on said tower, microwave equipment spaced from said tower, a pressurized conductive hollow pipe wave guide extending between said microwave antenna and equipment for the propagation of microwaves therebetween, said wave guide being conductively secured to said antenna tower substantially throughout its length between said base and said microwave antenna, said wave guide having a non-conductive gap therein adjacent said base, a low-loss dielectric bar extending across said gap and into the ends of the wave guide on both sides of said gap to bridge said gap for the transmission of microwaves and the prevention of flashover from the high voltage antenna tower through the microwave equip-

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ment to ground, the portions of said dielectric bar which extend into said wave guides being slightly reduced in cross section relative to the enclosing wave guides, to permit the passage of pressurized gas, opposed inwardly extending conductive horns secured to the ends of said wave guide on either side of said gap to concentrate the microwaves and supplement said dielectric bar in its transmission of microwaves from one section of conductive wave guide to the other, and a gastight cover of non-conductive material secured to the outer periphery of said horns and sealing said gap therewithin to facilitate the transmission of the pressurized gas across the gap.

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