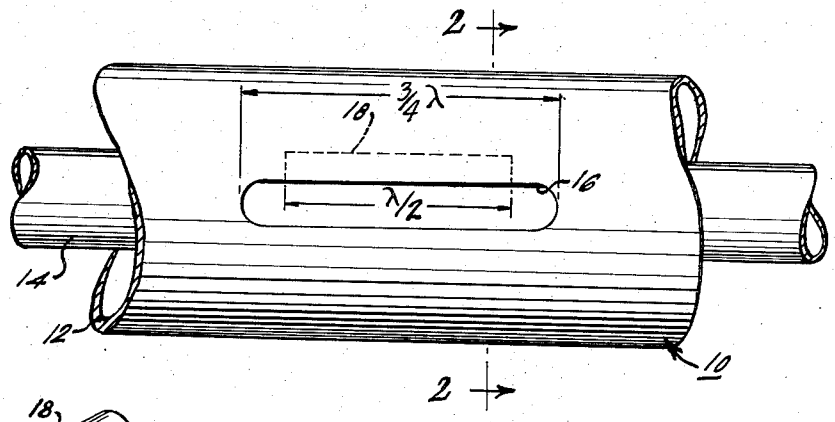
April 25, 1961 S. J. BAZAN 2,981,947

COUPLING DEVICE FOR SLOT ANTENNA

Filed Sept. 24, 1957

Fig. 1



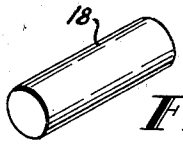


Fig. 3.

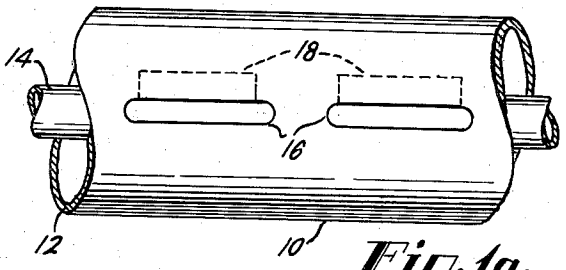


Fig. 1a.

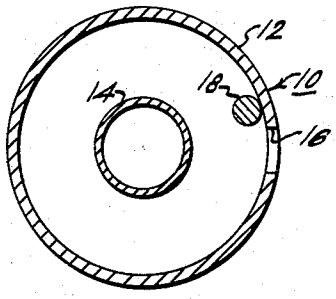


Fig. 2

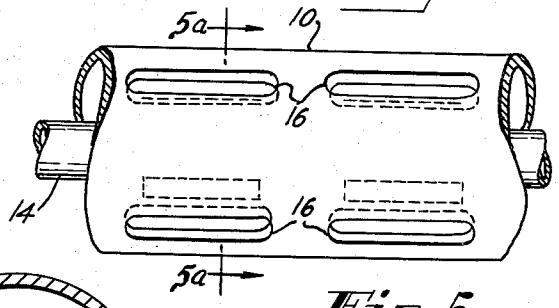


Fig. 5.

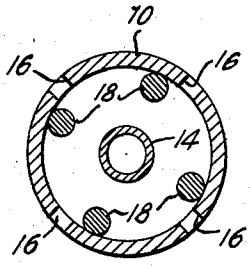


Fig. 5a.

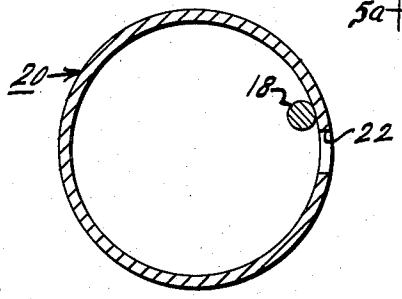


Fig. 4

INVENTOR.
STEVEN J. BAZAN
BY Charles H. Brown
ATTORNEY

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COUPLING DEVICE FOR SLOT ANTENNA

Steven J. Bazan, Philadelphia, Pa., assignor to Radio Corporation of America, a corporation of Delaware

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2 Claims. (Cl. 343—767)

The invention relates to a coupling device, and particularly to a coupling device for slot antennas or for slotted transmission lines.

An object of the invention is to provide an improved coupling device for use with a slot antenna.

Another object of the invention is to provide an improved coupling device for use with slotted transmission lines.

Another object of the invention is to provide an ultra-high frequency (UHF) antenna system capable of handling large amounts of power, for example, in the order of a plurality of megawatts of effective radiated power.

The coupling device is designed to be used with a hollow or coaxial transmission line having a slot in its wall, and provides improved means for coupling radio frequency energy between the interior of the transmission line and the surrounding space. Such a transmission line is frequently used as a slot antenna. Briefly, the coupling device comprises a cylindrically shaped rod-like metallic coupler fastened to the inner surface of the wall of the transmission line. The coupler is positioned adjacent one edge of the slot so that its long dimension is substantially parallel to that one edge. If the transmission line is to be used to radiate radio frequency energy to the surrounding space, the presence of the coupler disturbs the exciting field within the transmission line so as to provide a radiating field across the slot to the surrounding space. In a like manner, the coupler can be used to provide a field within the transmission line so that the transmission line can be used to receive radio frequency energy from the surrounding space. The length of the coupler is made to approach the length of the slot so that for a total amount of radiating field through or across the slot, excess disturbance to the exciting field is avoided.

The invention is explained in detail in connection with the accompanying drawing in which:

Figures 1 and 1*a* show longitudinal views of slotted coaxial transmission line radiators or antennas utilizing the invention;

Figure 2 shows a transverse cross-sectional view taken along the lines 2—2 in Figure 1;

Figure 3 shows a perspective view of the coupler shown in Figures 1, 1*a* and 2;

Figure 4 shows a transverse cross-sectional view of a slotted hollow transmission line radiator or antenna utilizing the invention, and

Figures 5 and 5*a* show modifications of the arrangement shown in Figures 1, 1*a* and 2.

In Figure 1, a slotted coaxial transmission line **10** comprises a hollow cylindrical outer conductor **12** and a concentric inner conductor **14** positioned within the outer conductor **12**. The dominant mode for the coaxial transmission line **10** is the TEM mode, and radio frequency energy propagated through the transmission line **10** has a transverse electric field in radial directions. An elongated or rectangularly shaped slot **16** is provided in the outer conductor **12**, and is positioned with its longer

edges substantially parallel to the longitudinal axis of the transmission line **10**. However, the slot **16** may be oriented in other positions, such as with its longer edges positioned at some angle with respect to the longitudinal axis of the transmission line **10**. In Fig. 1 the length of the slot **16** is indicated, illustratively, as being three quarters of a wave length longitudinally.

Practically no voltage will be developed across the slot **16** of the transmission line **10**, as described so far, in response to the presence of radio frequency energy in the TEM mode within the transmission line **10**. Consequently, no radio frequency energy will be coupled between the interior of the transmission line **10** and the surrounding space. However, in accordance with the invention, a voltage or radiating field may be developed across the slot **16** by means of an elongated, cylindrically shaped, metallic coupler **18**. Although the coupler **18** is shown having a circular cross-section, it may also have a polygonal or non-circular curved cross-section. The coupler **18** is located within the transmission line **10**, and is fastened to the inner surface of the outer conductor **12** adjacent one of the longer edges of the slot **16**. The coupler **18** is positioned so that its longitudinal axis is substantially parallel to the one edge of the slot **16**. The arrangement of the coupler **18** in the transmission line **10** is also shown in Figure 2. A perspective view of the coupler **18** is shown in Figure 3.

When radio frequency energy is propagated through the transmission line **10**, the coupler **18** creates a disturbance in the field of this radio frequency energy so that a voltage or radiating field appears across the slot **16**. It is preferred that the length of the coupler **18** be in the order of 50% to 100% of the length of the slot **16** so that the disturbance to be exciting field along the length of the transmission line **10** may be held to a minimum. In Fig. 1 the length of the member **18** is indicated, illustratively, as being one half wave length longitudinally. In other words, the coupler **18** extracts the total amount of radiating field across the slot **16** along a greater length from the feeding transmission line **10** than prior art devices, such as a probe, thus avoiding a point loading. The heavy energy concentration present at a point loading will not only result in a voltage breakdown and hence limited power rating but, in the case of a plurality of slots extending longitudinally along the transmission line **10**, will also cause unwanted disturbance in adjacent slots.

In contrast to this, the coupler **18** of this invention, while extracting the same total amount of energy, but along a greater length, will cause much smaller overall disturbances which will practically die out before they reach the adjacent slots. The distributed loading, along the full length of the coupler will safeguard against a voltage breakdown or arcing and thus enable the invention to be used at a relatively high powers.

Figure 4 shows a transverse cross-sectional view of a hollow cylindrically shaped transmission line **20** utilizing the invention. The transmission line **20** is provided with an elongated slot **22** similar in shape to the slot **16** shown in Figures 1 and 2. A cylindrically shaped metallic coupler **18** is fastened to the inner surface of the wall of the transmission line **20** adjacent the slot **22**, and is positioned with its longitudinal axis substantially parallel to the one edge of the slot **22**. The operation of the transmission line shown in Figure 4 is similar to that of the coaxial transmission line **10** shown in Figures 1 and 2.

While the invention has been described in connection with hollow and coaxial cylindrically shaped transmission lines, the invention can also be used with other transmission lines, such as a slotted rectangular waveguide.

The coupling device of the invention is quite useful in connection with high frequency or ultra-high frequency

cylindrical slot antennas which are designed to radiate radio frequency energy through a plurality of slots. These slots may be positioned in various configurations around the circumference of the antenna as shown in Figure 5, and above one another in various arrays as shown in Figures 1*a* and 5. Figure 5*a* shows a transverse cross-sectional view of the arrangement of Figure 5, on the line 5*a*—5*b* of Figure 5. With a proper selection of coupler diameter and associated slot length, an independent amplitude control or an independent phase control of the radiated energy may be obtained. Some antennas may utilize one of the controls. However, in a more general case, the dimensions of the coupler and slot will provide interdependent amplitude and phase controls. If the antenna is provided with a plurality of slots along its length, different slots may be provided with different diameter and length couplers. Also, if a plurality of slots are provided at the same level in the antenna, different size and dimensioned couplers may be used with the different slots to shape the radiated pattern, so as to favor one direction over another. Thus, the invention can provide any desired amplitude and phase of the energy radiated from any of the slots. In addition, since the couplers provide a means for radiating energy from the exciting field over a greater length than previous devices, their power handling capacity is limited only to the extent of the power handling capacity of the transmission line itself.

An antenna comprising a coaxial transmission line having cylindrical inner and outer conductors was constructed in accordance with the invention with the following specifications:

Frequency: 629 megacycles
Outer conductor: 12.820 inches inside diameter
Inner conductor: 8.268 inches outside diameter
Slots: $\lambda/2$–$3\lambda/4$ long
Couplers: Solid aluminum, $\lambda/2$ long and 0.5–1.6 inches in diameter

This antenna had 66 layers of slots, and provided an effective radiated power of one megawatt when excited by a transmitter delivering a rated power of 25 kilowatts.

What is claimed is:

1. Apparatus for translating radio frequency energy through an elongated slot opening in the outer member of two coaxial members, said elongated slot having a length not to materially exceed $3\lambda/4$, said apparatus comprising an elongated conductive member fastened to the inner wall of said outer coaxial member at one side of the said elongated slot opening with one side of said member's long dimension substantially parallel to and substantially registered with said one side of said elongated slot, said conductive member having a length of the order of $\lambda/2$, where λ is the RF wave length.

2. Apparatus for translating radio frequency energy through an elongated slot opening in the outer member of two coaxial members, said members being capable of presenting a transverse electric field in radial directions upon excitation by radio frequency energy, said elongated slot having a length not to materially exceed $3\lambda/4$, said apparatus comprising an elongated conductive member positioned with respect to the inner wall of said outer coaxial member to cooperate with one side of the said elongated slot opening and with one side of said member's long dimension substantially parallel to and substantially registered with said one side of said elongated slot whereby to create a disturbance in said field so that a radiating field appears across said slot, said conductive member having a length of the order of $\lambda/2$, where λ is the RF wave length.

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