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SLOT ANTENNA HAVING SHORT RADIATING SLOTS AND LONG NONRADIATING DISTRIBUTED CAPACITANCE TUNING SLOT

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Fig_1_

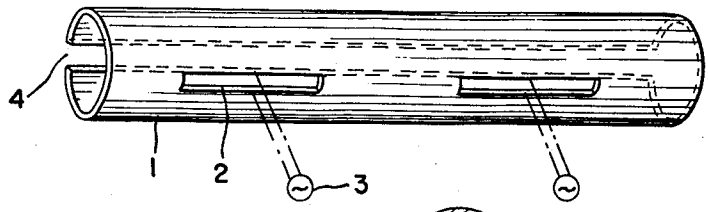


Fig_2_

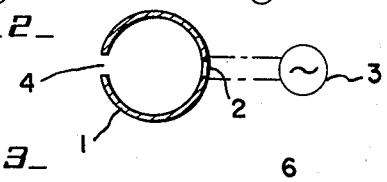


Fig_3_

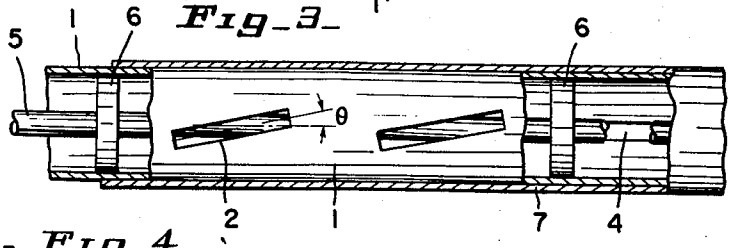


Fig_4_

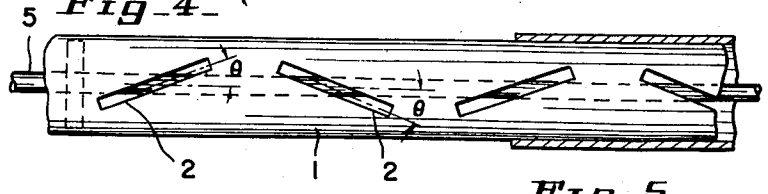


Fig_5_

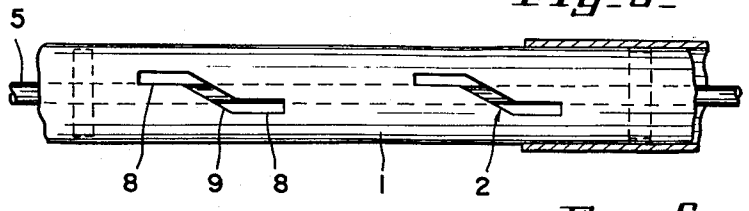


Fig_7_

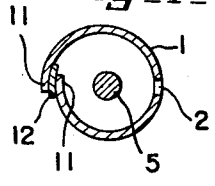


Fig_8_

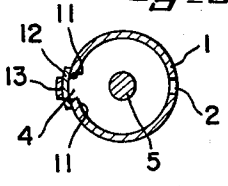
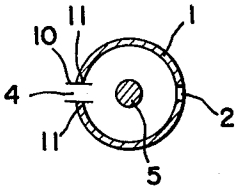


Fig_6_



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SLOT ANTENNA HAVING SHORT RADIATING SLOTS AND LONG NONRADIATING DISTRIBUTED CAPACITANCE TUNING SLOT

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6 Claims. (Cl. 343—770)

The present invention relates to a slot antenna which comprises a tubular conductor for radiating from its side surface electromagnetic wave.

In general, in wireless communication with a moving station such as automobile, train, etc., when the station passes through a valley, tunnel, etc., the electromagnetic wave is interrupted and cannot arrive at the station, thereby interrupting the communication. In such a case, therefore, it is necessary to provide the valley, tunnel, etc. with such a guided line or lines to be coupled with the antenna of the moving station as will transmit the electromagnetic wave to continue the communication.

For such purpose, use has been made of two parallel conductors or a leakage coaxial system which comprises a coaxial cable having an outer conductor which is provided in its longitudinal direction with a continuous slot. It is impossible, however, to efficiently radiate the electromagnetic wave in a direction at right angles with the line since such system is influenced by other objects such as line supporters or tunnel wall near by, which fact results in an increase of the transmission loss of the line.

In order to obviate the above disadvantage a tubular conductor is provided on its side surface with a number of slots of suitable width and length arranged in a longitudinal direction and separated one from another with a desired interval, and the slots are brought into resonance condition in order to radiate the electromagnetic wave from the tube wall. In this case, if the diameter of the tubular conductor becomes extremely small as compared with the wave length, the feeding impedance at the slots becomes too high to efficiently radiate the electromagnetic wave. In other words, since it is necessary to satisfy a condition of $D/\lambda>0.12$ (where D is the diameter of the tube and λ is the wave length), the diameter of the tube has to be large enough to decrease the feeding impedance. But, the use of the tubular conductor having a diameter greater than that necessary for the electromagnetic wave transmission is extremely uneconomical.

The object of the invention is to obviate the above disadvantage and provide a slot antenna which comprises a tubular conductor that radiates from its side surface electromagnetic wave most efficiently even though the diameter of the conductor becomes smaller than $\frac{1}{10}$ of the wave length.

For a better understanding of the invention, reference is made to the accompanying drawings, of which—

FIG. 1 is a perspective view of a slot antenna embodying the invention;

FIG. 2 is its cross-sectional view;

FIG. 3 is a partial sectional view of a coaxial cable embodying the invention;

FIGS. 4 and 5 show modified embodiments of a coaxial cable in accordance with the invention; and

FIGS. 6, 7 and 8 are cross-sectional views of modified slit parts of the coaxial cable according to the invention.

In FIG. 1, 1 designates a tubular conductor which is provided on its one side surface with a number of

slots of about ½ of the wave length of the electromagnetic wave to be transmitted, which are separated one from another with an interval equal to about one wave length in a longitudinal direction. Each slot is connected to a power source 3 to supply a high frequency voltage and excited to radiate the electromagnetic wave in the conventional manner. In accordance with the invention, the tubular conductor 1 is provided at the opposite side with a longitudinal slit 4 which is sufficiently long as compared with the slot 2. The slit 4 provides, in case of a current flowing circumferentially along the tube 1, a circuit having capacitance such as a distributed constant connected in parallel, so that the antenna is brought into a resonance condition even though there exists a relation of $D/\lambda<0.12$ (where D is the diameter of the tube and λ is the wave length of the electromagnetic wave to be transmitted). Thus, the feeding impedance of the slot 2 is decreased and it is possible to efficiently radiate the electromagnetic wave.

FIG. 3 shows a coaxial cable embodying the invention having an outer tubular conductor 1 and a central conductor 5. The tubular conductor 1 is provided on its one side with a number of slots 2 and on the opposite side with a longitudinal slit 4 in the same manner as shown in FIG. 1. The central conductor 5 is supported in the outer tubular conductor 1 by means of insulating discs 6. 7 shows an outer protective sheath. In this embodiment, the slots 2 are inclined at an angle $\theta°$ with respect to the longitudinal axis. Thus, the slots 2 interrupt a current flowing through the tubular conductor 1 in the axial direction, so that a potential difference is produced across each side edge of the slot 2, which results in radiation in transverse direction of the electromagnetic wave without any coupling element at the slot. The inclination of the slot 2 may suitably be selected within a range of $0°\sim\pm90°$ according to the energy of electromagnetic wave to be radiated, but it is generally selected within a range of from 2° to 60°. In the embodiments shown in FIGS. 1 and 2, the length of slot 2 is usually made equal to about ½ of the wave length of electromagnetic wave, but it is not necessarily limited to such value, and may be selected at any length shorter than the wave length. The interval between adjacent slots 2 may be determined in accordance with the electromagnetic energy to be transmitted. In the case shown in FIG. 1, such interval may be made equal to about one to several wave lengths, while in the case shown in FIG. 2 such interval may be made odd multiple of the ¼ wave length. These intervals are not required to be equal to each other. One of the intervals may be made equal to two wave lengths, while the next interval to 1¼ wave length and the other intervals may be made equal to one wave length. The length of the slit 4 should be selected much longer than the length of the slot 2 on the opposite side. For example, the length of the slit 4 may be made 1.5~2.0 times that of the slot 2. If the interval between the slots 2 is made from 1 to several times the ¼ wave length, then the slit 4 may be made to cover the total length of the tube.

FIG. 4 shows another embodiment of the coaxial tubular conductor wherein the slots 2 are alternately sloped in opposite directions for the angle of $+\theta$ and $-\theta$ with the longitudinal axis. In this case, the interval between adjacent slots 2 is made odd multiple of the ½ wave length of the electromagnetic wave to be transmitted. Thus, the electromagnetic wave can be radiated outwards from the slots in a similar manner to that in the case of FIG. 3.

FIG. 5 shows a further embodiment wherein the slots 2 consists of two portions 8 parallel with the longitudinal axis of the tube connected by an intermediate inclined portion 9. A number of such slots 2 are formed on one side

of the conductor **1** at a suitable interval, while the slit **4** is formed on the opposite side in the same manner as in the cases of FIGS. 1 to 4.

FIGS. 6 to 8 represent modifications of the slit **4** each edge of which is capacitively coupled in order to decrease the feeding impedance at the slots. In case of FIG. 6, a metal plate **10** is attached to each edge **11** of the slit **4** in parallel, then the electrostatic capacity is increased. In case of FIG. 7, edges **11** are overlapped one upon another and a dielectric piece **12** is inserted between the overlapping edges **11**. In the embodiment shown in FIG. 8, a metal strip **13** is attached to the edges **11** of the slit **4** with a spacer **12** made of dielectric material. In any case, the electrostatic capacity at the slit is increased and the feeding impedance at the slots is decreased, which results in an increase of the radiation energy of the electromagnetic wave even though the diameter of the tubular conductor is small.

As above mentioned, the invention provides a slot antenna comprising a tubular conductor which is provided on its one side with short slots and on the opposite side with a long longitudinal slit, and has advantages that the feeding impedance at the slots can be decreased even if the diameter of the tubular conductor is made smaller than $\frac{1}{10}$ the wave length of the electromagnetic wave to be transmitted, thereby efficiently radiating the electromagnetic wave, contrary to the conventional slot antenna provided with slots alone. The invention has a particularly noteworthy advantage in that when it is applied to the outer conductor of a conventional coaxial cable used as the guided line in a tunnel, a valley, etc. where the electric wave cannot reach, UHF and VHF communications with a moving station can be effected with highly efficient results.

What we claim is:

1. A slot antenna which comprises a tubular conductor, a number of slots formed on one side of the conductor and separated with a desired interval, each of said slots having a length shorter than the wave length of the electromagnetic wave to be transmitted and a slit formed on the opposite side of the tubular conductor in a longitudinal direction and having a length longer than that of the slot.

2. A slot antenna which comprises a coaxial conductor through the outer tubular conductor, a number of slots

formed on one side of said tubular conductor and separated with a desired interval, each of said slots having a length shorter than the wave length of the electromagnetic wave to be transmitted and a slit formed on the opposite side of the conductor in the longitudinal direction and having a length longer than that of the slot.

3. A slot antenna which comprises a tubular conductor, a number of slots formed on one side of the conductor and inclined at an angle with a longitudinal axis and separated with a desired interval, each of said slots having a length shorter than the wave length of the electromagnetic wave to be transmitted and a slit formed on the opposite side of the conductor in the longitudinal direction and having a length longer than that of the slot.

4. A slot antenna which comprises a tubular conductor, a number of slots formed on one side of the conductor, each inclined with a longitudinal axis alternately at angles $+\theta$ and $-\theta$ and separated with an interval which is about odd multiple of $\frac{1}{2}$ wave length of the electromagnetic wave to be transmitted, each of said slots having a length shorter than the wave length of the electromagnetic wave to be transmitted and a slit formed on the opposite side of the conductor and having a length longer than that of the slot.

5. A slot antenna which comprises a tubular conductor, a number of slots formed on one side of the conductor and each consisting of portions in parallel with a longitudinal direction and a sloped portion interconnecting said parallel portions and separated with a desired interval, each of said slots having a length shorter than the wave length of the electromagnetic wave to be transmitted an a slit formed on the opposite side of the conductor in the longitudinal direction and having a length longer than that of the slot.

6. A slot antenna which comprises a tubular conductor, a number of slots formed on one side of the conductor and separated with a desired interval, each of said slots having a length shorter than the wave length of the electromagnetic wave to be transmitted and a slit formed on the opposite side of the conductor and having a length longer than that of the slot, each edge of said slit being capacitively coupled.

No references cited.