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Continuation-in-part of application Ser. No.
660,744, Aug. 15, 1967, now abandoned.

[54] **TRANSMITTING ANTENNA FOR AUDIO**
INDUCTION COMMUNICATION SYSTEM
15 Claims, 6 Drawing Figs.

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343/787, 343/873
 [51] Int. Cl. **H01g 7/06,**
H01g 1/40, H04g 5/00
 [50] Field of Search **179/82;**
343/787, 788, 873

[56]

References Cited

UNITED STATES PATENTS

2,478,313	8/1949	Peterson.....	250/33
2,769,170	10/1956	Clogston	343/907
2,853,557	9/1958	Lehman et al.	179/82
2,863,147	12/1958	Berlin.....	343/787
3,111,669	11/1963	Walsh.....	343/100
3,372,395	3/1968	Kline	343/787

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ABSTRACT: A transmitting antenna in an audio induction communication system consists of a core of silicon grain oriented steel made of laminations bonded to one another, a shrink fitted plastic insulating sleeve, and a coil of magnet wire wound on the sleeve, all of which are received in a nonmagnetic plastic shell filled with cured silicon rubber as a potting agent.

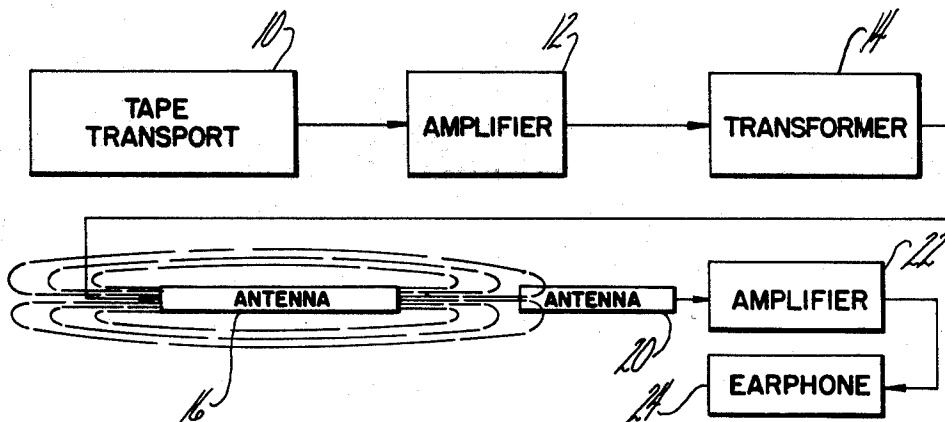


FIG. 1

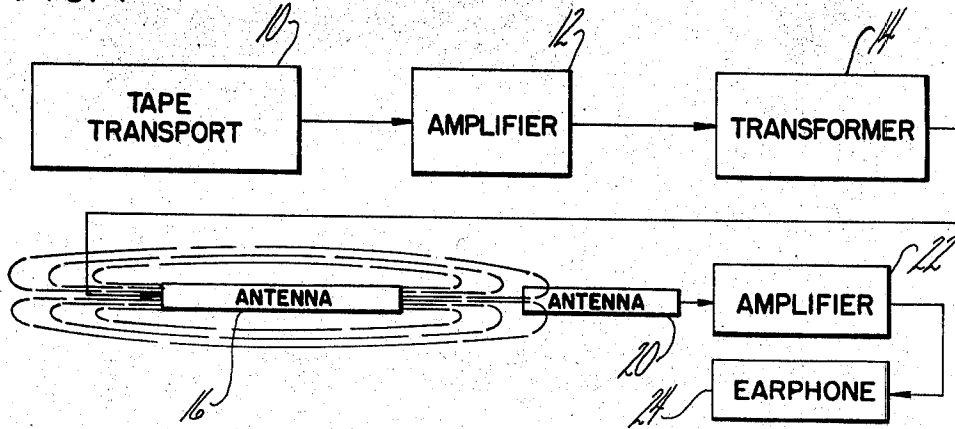


FIG. 2

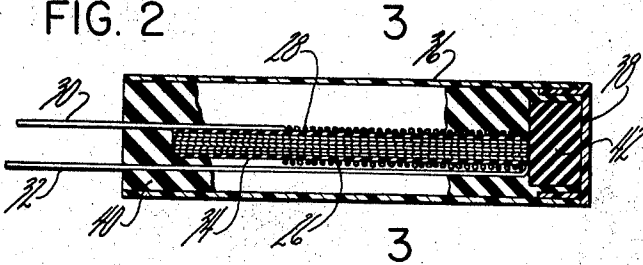


FIG. 3

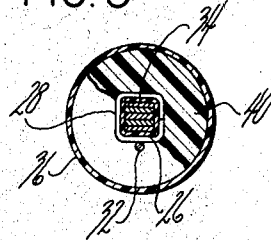


FIG. 5

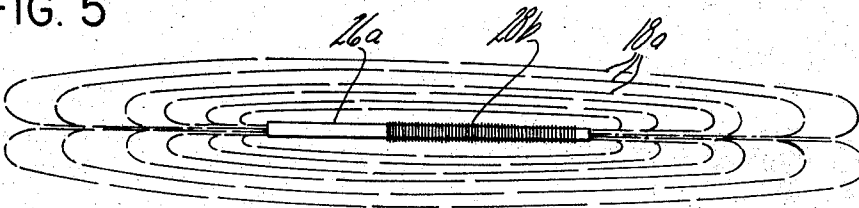


FIG. 6

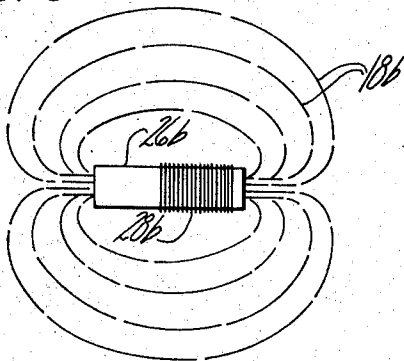
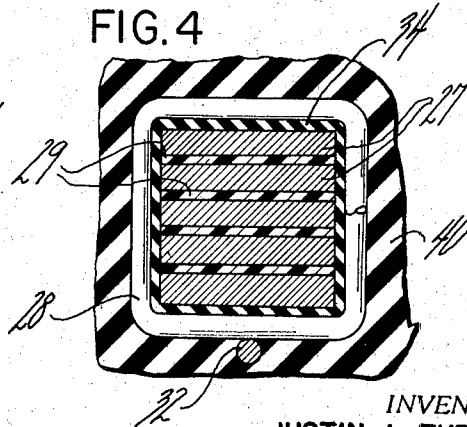


FIG. 4



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TRANSMITTING ANTENNA FOR AUDIO INDUCTION COMMUNICATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of presently pending application Ser. No. 660,744 filed Aug. 15, 1967 and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to wireless communication systems of the type wherein audio frequency messages are transmitted through space by a magnetic field the intensity of which is varied at such audio frequency, and deals more particularly with an improved transmitting antenna and associated components for establishing the magnetic field.

In the past, various different systems have been proposed for providing wireless communication by a magnetic field the strength of which varies in accordance with an audio signal so that a coil located in such field has induced therein a signal which may be converted to audible sound by merely amplifying it and applying it to an earphone, loudspeaker or other similar electromechanical transducer. Such systems are limited to communication over relatively short distances, because of the nature of the magnetic field, and are, therefore, generally proposed for use within relatively small areas such as the rooms of a museum where the system may be used to supply messages concerning various exhibits or displays to visitors carrying suitable receivers. One major drawback of prior audio induction communication systems, however, particularly with regard to usage in museums and the like, has been the problem of crosstalk between two or more simultaneously broadcast messages due to the magnetic field of one message interfering with the magnetic field of another message. In an audio induction communication system transmitting two or more messages simultaneously the field associated with each message must occupy its own exclusive space without overlap or interference from the field of another message. Otherwise, a receiver located in the zone of overlap will tend to pick up both messages. Transmitting antennas in the past have generally been in the form of relatively large loops of wire, often extending around the periphery of a room, and to avoid overlap and interference it has usually been necessary to locate the field of one program at a great distance from the field of another program. In museums, for example, it has generally been necessary to allot only one magnetic field or message to each room.

The general object of this invention, therefore, is to provide an improved means for establishing the varying magnetic field of an audio induction communication system and whereby such field may be controlled so as to allow a number of fields or messages to be placed close to one another without undue overlap or interference from one another, thereby permitting a number of fields or messages to be used at once in a single room or other small area.

BRIEF DESCRIPTION OF THE INVENTION

The invention resides primarily in the construction of a transmitting antenna used in combination with an audio signal source and amplifier of an audio induction communication system. The antenna is a coil of magnet wire wound on a core of magnetic material which is preferably made up of silicon grain oriented steel laminations bonded to one another and surrounded by a shrink fitted plastic insulating sleeve. This unit is potted in liquid silicon rubber which is cast into a non-magnetic container or shell and held under vacuum for a number of hours during curing to eliminate all voids between the convolutions and layers of the wire and the core to prevent chattering and hum as a result of wire vibration. The bonding of the core laminations to one another also eliminates noise arising from vibration of the laminations relative to one another.

The length and cross-sectional shape of the core, and the power supplied to the coil, control the shape of the magnetic

field projected from the antenna. The length of the core in general determines the length of the field axially of the core and the cross-sectional shape determines the width of the field radially of the core. The power supplied to the antenna controls both the width and length of the field. Accordingly, by properly selecting the length and cross-sectional shape of the antenna and the power supplied thereto, the shape of the space occupied by the field projected therefrom may be relatively accurately controlled so as to place the field in a given desired location, thereby making it possible to arrange a number of different fields in a small area so as to not interfere with one another.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating an audio induction communication system of the type with which this invention is concerned.

FIG. 2 is a longitudinal sectional view taken through the transmitting antenna of FIG. 1.

FIG. 3 is a transverse sectional view taken on the line 3-3 of FIG. 2.

FIG. 4 is a view showing a portion of FIG. 3 in an enlarged scale and with the spacing between the core laminations exaggerated to reveal the bonding agent used in the core.

FIG. 5 is a diagram illustrating the nature of the field produced by an antenna such as that of FIG. 2 having a relatively large length in comparison to its cross-sectional area.

FIG. 6 is a diagram generally illustrating the nature of the field produced by an antenna such as that of FIG. 2 having a relatively short length in comparison to its cross-sectional area.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning to the drawing, and first referring to FIG. 1, this FIG. shows in block diagram form an audio induction communication system utilizing a transmitting antenna of the type with which this invention is concerned. The illustrated system includes an audio signal source in the form of a magnetic tape transport or recorder 10. The audio signal output of the tape transport is transmitted to an associated power amplifier 12 which produces an amplified audio frequency signal on its output line. The output signal of the amplifier 12 is in turn transmitted to a matching transformer 14 having a transmitting antenna 16 connected to the output terminals thereof. In a typical museum installation, for example, the tape transport 10 and amplifier 12 may be located at a distribution center and be only one of many such transport and amplifier pairs used to provide a large number of messages transmitted simultaneously to different areas of the museum. The matching transformer 14 is preferably located close to the exhibit or display with which the transmitting antenna 16 is associated, and it preferably includes a number of different taps of different impedance, such as 2, 4, 6 and 8 ohm taps, to allow the antenna 16 to be any one of a number of corresponding input impedances. The antenna 16, as explained in more detail hereinafter, produces a magnetic field which varies in strength in accordance with its audio input signal and which passes from one end of the antenna to the other as indicated by the flux lines 18.

The tap transport 10, or other audio signal source, amplifier 12, transformer 14 and antenna 16 constitute the transmitting portion of the communication system. The receiving portion of the system comprises a receiving antenna 20, an audio amplifier 22 and an earphone 24, or other similar electromechanical transducer, for converting the electrical signals from the amplifier 22 into sound. The complete receiving unit may be in the form of a relatively small package worn or carried by a person visiting the museum or other area within which the communication system is located and as the person moves to a point within the field produced by the transmitting antenna 16 the field induces an audio signal in the receiving

antenna 20 which is amplified by the audio amplifier 22 and converted to sound by the earphone 24. The receiving antenna 20 may take various different forms and in general constitutes a coil or loop of wire.

FIGS. 2 and 3 show in detail the construction of the transmitting antenna 16 of the FIG. 1 system. As mentioned, previous audio induction communication systems have generally utilized transmitting antennas in the form of relatively large loops of wire creating relatively large magnetic fields, in terms of the space occupied thereby, and most often these antennas have surrounded the perimeter of the room or other area within which the transmitted message is to be heard. In contrast to this, the antenna 16 of this invention is designed to produce a relatively small magnetic field of a readily controlled shape and size. This antenna comprises a core 26 of magnetic material surrounded by a coil 28 of wire having two leads 30 and 32 for connection to the transformer 14 or other output device. The core 26 is in the nature of a relatively straight bar of substantially uniform cross section throughout its length. It may be made in various different ways and of various different materials but preferably is rectangular in cross section and consists of a plurality of laminations of silicon grain oriented steel with each lamination extending the full length of the core and having its grain oriented so as to be generally parallel to the longitudinal axis of the core. Due to the varying nature of the field produced by the antenna, it tends to set up varying magnetic forces between the laminations of the core, and unless the laminations are held tightly to one another, they will tend to vibrate and produce an objectionable audible noise in the form of chatter, hum or an actual low volume reproduction of the transmitted message. In some instances, a sheath, such as the sheath 34 hereinafter described, may be sufficient to prevent vibration of the core laminations. Preferably, however, and as shown best in FIG. 4, the laminations are bonded to one another by a bonding agent interposed between each pair of laminations.

In FIG. 4, the laminations of the core 26 are shown at 27, 27 and the layers of bonding agent between each pair of adjacent laminations are indicated at 29, 29. Various different bonding agents and methods of application and curing may be used. In the presently preferred case, however, an epoxy resin, referred to as "C-7 Epoxy Resin" sold by Armstrong Products Co., Inc. of Warsaw, Indiana is used in combination with an activator sold by the same company and referred to as "H-20 Activator." The resin and the activator are mixed by weight in the ratio of 29 parts activator per 100 parts of resin, or by volume in the ratio of 1 part activator to 3 parts resin, and the mixture is then applied at room temperature to the laminations by painting it onto the laminations with a brush. The laminations are then stacked on one another to form the desired size core and are placed in a jig which applies a constant pressure between the top and bottom laminations tending to squeeze the laminations together. The jig and the laminations are then placed in an oven or other suitable heating device and heated to approximately 160° F. during a curing period of at least 1 hour. The heating of the core during the curing process not only speeds up the cure, but also renders the bonding agent more viscous so that it tends to flow out from between the laminations, to spread itself evenly and to fill up voids, leaving only a very thin layer of bonding agent between each pair of laminations in the fully cured core. Before the laminations are painted with the bonding agent, they are, of course, cleaned thoroughly to remove scale and dirt as by dipping in a suitable acid bath. After the finished core is cured, excess bonding agent is removed therefrom before the insulating sheath, if any, is applied and the wire of the coil 28 wrapped therearound.

The wire from which the coil 28 is made is preferably magnet wire, that is wire having a thin coating of insulating resin or the like, and is preferably insulated from the core 26 by a sheath 34 of insulating material surrounding the core and located between the core and the coil 28. The insulating sheath is not, however, necessary in all instances and may in

some cases be eliminated. On the other hand, in cases where the core 26 is made from laminations which are not bonded to one another, the sheath 34 may be used to aid in holding the laminations tightly to one another to reduce or eliminate vibrations of the laminations. The sheath 34 may consist of a tape or web of insulating material tightly wrapped around core, but preferably it consists of a heat shrinkable tube of polyvinylchloride which is shrink fitted onto the core so as to tightly grip the core and hold the laminations firmly in place relative to one another.

The subassembly made up of the core 26 and coil 28, together with the insulating sheath 34, if any, forms the basic electrical and magnetic parts of the transmitting antenna, but it has been found that when an antenna consisting merely of such subassembly is energized by a relatively high power audio signal, as required to produce the desired field, the convolution of the coil and other associated parts external of the core tend to vibrate relative to one another and to the core and produce a hum, chatter or other noise which is often sufficiently loud as to be unacceptable. To eliminate this source of noise, the coil and core subassembly is, according to the more detailed aspects of this invention, potted in a material which completely fills the otherwise empty spaces between the individual coil convolutions and other parts of the subassembly so as to restrain the wire and other parts against vibration and to dampen any vibrations which do occur.

As to the potting of the coil and core subassembly, the antenna 16 of FIGS. 2 and 3 includes an outer shell of nonmagnetic material comprised of a cylindrical plastic tube 36 closed at one end by a plastic end cap or plug 38. The core and coil subassembly is located within the shell and the intervening space is filled with a potting material 40. Various different potting materials may be used but at present the preferred material is a room temperature vulcanizing silicon rubber requiring a curing agent, such as sold by the General Electric Company, Silicone Products Department, Waterford, New York, under the designation RTV-11. In FIGS. 2 and 3 part of the potting material has been broken away to show more clearly the other parts of the antenna, but it should be understood that this material completely fills all of the otherwise empty space within the shell. In addition to eliminating the noise which would otherwise be present, the potting of the core and coil subassembly in a shell provides the finished antenna with a simple neat appearing capsule shape which is easily handled, and it also protects the coil of the antenna against damage during shipment and placement.

In the process of potting the core and coil subassembly, an empty shell is placed in an upright position with its open end uppermost. A small piece 42 of cured silicon rubber or other similar material is then placed in the bottom of the shell, and the coil and core assembly is then inserted and centered relative to the shell. The potting material, which is made by mixing a liquid base material with a liquid curing agent, is then poured in liquid form into the shell until it is filled. To assure that all of the spaces between the convolutions of the wire and other parts of the subassembly are filled with the potting agent, its curing is preferably performed under vacuum, the vacuum typically being maintained for a minimum of about 6 hours. After the curing of the potting agent the antenna is in its completed form, and in this form the insert 42 located at the bottom or front end of the shell serves to hold the adjacent end of the core 26 away from the end cap 38 so as to prevent chattering as a result of the core engaging and vibrating against the end cap.

FIGS. 5 and 6 show in general the manner in which the shape of the core controls the shape of the associated magnetic field. In these figures the shell and potting material of the antenna have been omitted for clarity. FIG. 5 shows an antenna having a relatively long core 26a in comparison to its cross-sectional shape. As shown by the associated flux lines 18a, 18a the field produced by such an antenna tends to be relatively long and thin with the field extending a relatively long distance from either end of the core. In the antenna of FIG. 6, the core

26b is relatively short in comparison to its cross-sectional size and when using an antenna of this general shape the field, as shown by the flux lines 18b, 18b tends to have a relatively short and thick shape. Therefore, by varying the length and/or cross-sectional size of the antenna core its field may be varied so as to have a shape generally similar to that of FIG. 5, generally similar to that of FIG. 6, or some intermediate shape.

Also, by varying the power supplied to the antenna the size of the field may also be controlled. That is, as the power to the antenna is increased the field projected therefrom tends to increase in size, and as the power is decreased the field tends to decrease in size, such increases and decreases occurring along both the length and the width of the field so as to maintain the general field shape dictated by the core shape. The power which the antenna can properly handle is dependent upon its impedance which may be in turn varied by varying the number of turns in the coil 28. In FIGS. 2, 3 and 4, the coil 28 has been shown to consist of a single layer of turns but where necessary to provide the proper desired impedance two or more layers of turns may be used in the coil 28.

Although the preferred embodiment of the invention has been described above, it should be understood that various changes may be made from the construction disclosed, and that the drawing and description are not to be construed as defining or limiting the scope of the invention, the claims which follow being relied upon for that purpose.

I claim:

1. A means for establishing a magnetic field the frequency of which varies in direct correspondence with that of a given audio frequency input signal in an audio induction communication system wherein intelligence is transmitted solely by such magnetic field, said means comprising a source of an audio frequency input signal an audio frequency power amplifier for amplifying said audio frequency input signal from said source, and an antenna connected with the output of said power amplifier so that the signal supplied thereto is an amplified version of said audio frequency input signal, said antenna comprising a coil of wire wound on a core of magnetic material.

2. The combination defined in claim 1 further characterized by said core of magnetic material being made up of a plurality of laminations of silicon grain oriented steel.

3. The combination defined in claim 2 further characterized by said laminations being bonded to one another by a layer of bonding agent between each pair of adjacent laminations.

4. The combination defined in claim 1 further characterized by said core of magnetic material being a substantially straight bar of substantially uniform cross section throughout its length.

5. The combination defined in claim 4 further characterized by said antenna further including a sheath of electrical insulating material surrounding said core between said core and said coil.

6. The combination defined in claim 4 further characterized

by said antenna further comprising a quantity of nonmagnetic potting material surrounding said coil and core and filling the spaces otherwise existing between the convolutions of said coil.

7. A transmitting antenna for a communication system wherein intelligence is transmitted solely by a magnetic field varied at an audio frequency corresponding directly with the frequency of an audible input signal, said antenna comprising a core of magnetic material and a coil of wire wound on said core, and a body of potting material surrounding said coil and filling the spaces otherwise existing between the convolutions thereof.

8. A transmitting antenna as defined in claim 7 further characterized by said potting agent consisting of a silicon rubber compound.

9. A transmitting antenna as defined in claim 7 further characterized by said core of magnetic material being a substantially straight bar of substantially uniform cross section throughout its length.

10. A transmitting antenna as defined in claim 9 further characterized by said core of magnetic material being made up of a plurality of laminations of silicon grain oriented steel with each of said laminations extending along the full length of said core and having its grain oriented so as to be generally parallel to the longitudinal axis of said core.

11. A transmitting antenna as defined in claim 9 further characterized by said core of magnetic material being made up of a plurality of laminations of magnetic material bonded to one another by a layer of bonding agent between each pair of adjacent laminations.

12. A transmitting antenna as defined in claim 9 further characterized by said core of magnetic material being made up of a plurality of laminations of magnetic material, and a tubular sheath of plastic electrical insulating material tightly surrounding said core between said core and said coil.

13. A transmitting antenna as defined in claim 7 further characterized by said coil and core being received in a tubular nonmagnetic shell, and said potting material filling the space between said coil and core and said shell.

14. A transmitting antenna as defined in claim 13 further characterized by said potting material consisting of silicon rubber.

15. A transmitting antenna as defined in claim 7 further characterized by said core of magnetic material being in the nature of a substantially straight bar of a substantially uniform cross section throughout its length and made up of a plurality of laminations of silicon grain oriented steel each of which laminations extends along the full length of said core and has its grain oriented so as to be generally parallel to the longitudinal axis of said core, said laminations being bonded to one another by a layer of bonding agent between each pair of adjacent laminations, said coil and core being received in a tubular nonmagnetic shell, and said potting material filling the entire space between said coil and core and said shell.