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2,894,231

SIGNAL COUPLING DEVICE

Original Filed Dec. 1, 1953

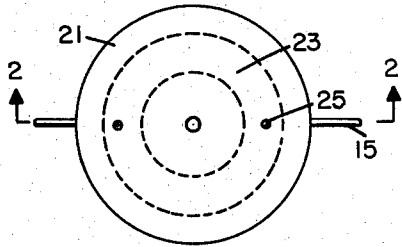


FIG. 1

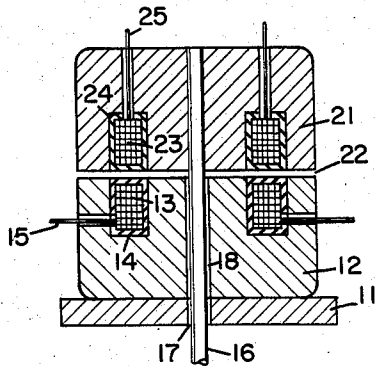


FIG. 2

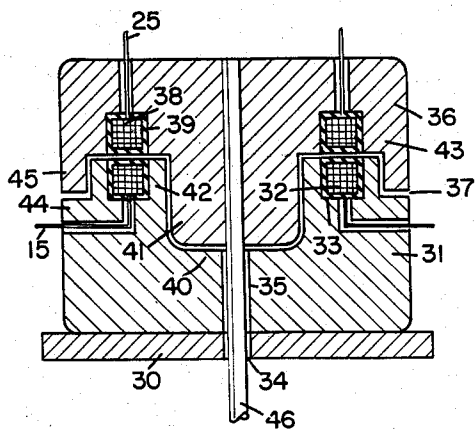


FIG. 3

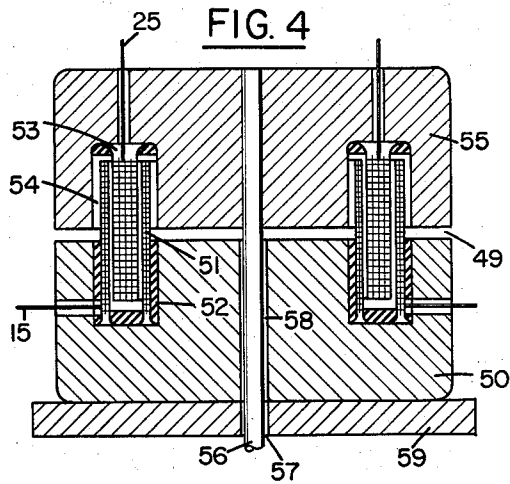


FIG. 4

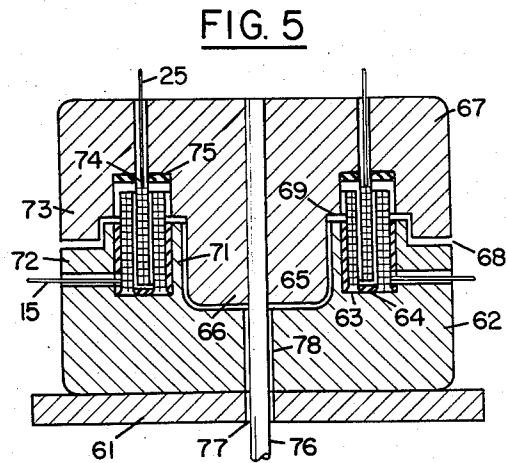


FIG. 5

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2,894,231

SIGNAL COUPLING DEVICE

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Original application December 1, 1953, Serial No. 395,630. Divided and this application March 29, 1956, Serial No. 577,433

1 Claim. (Cl. 336—83)

This invention relates to signal coupling devices and more particularly to devices for coupling an electrical signal between rotating and stationary apparatus.

This application is a division of now abandoned application Serial No. 395,630, filed December 1, 1953, in the name of Maxwell R. Krasno for Signal Coupling Device.

In many electrical signaling installations such as underwater sound locating apparatus, the signal generating units are mounted upon a stationary base, but the signal transmitting and receiving units are rotationally mounted. It is necessary to couple the electrical signals from the stationary to the rotating units with a minimum of noise and distortion. In the past, slip rings have been used, but the noise introduced by the rubbing of the stationary brushes upon the rotating rings was often of the same order of magnitude as the reflected signals, and difficulty was encountered in distinguishing between the signal and the noise.

The word "stationary" in this application refers to the relationship of the elements with respect to their supporting structure which may be a ship or the like.

It is an object of this invention to provide a new and improved device for coupling electrical signals between stationary and rotating apparatus.

It is another object of this invention to provide a new and improved device for coupling electrical signals between stationary and rotating apparatus, which device introduces substantially no noise into the signals.

It is a further object of this invention to provide a new and improved device for coupling electrical signals between rotating and stationary apparatus, which device contains no rubbing electrical conductors.

A still further object of this invention is to provide a new and improved device for coupling electrical signals between stationary and rotating apparatus, which device utilizes magnetic fields as the coupling medium.

Other objects and advantages of the invention will hereinafter become more fully apparent from the following description of the annexed drawings, which illustrate a preferred embodiment, and wherein:

Fig. 1 is a plan view of the coupling device of this invention;

Fig. 2 is a sectional view on line 2—2 of the device shown in Fig. 1;

Fig. 3 is a sectional view of a modification of the device shown in Fig. 1;

Fig. 4 is a sectional view of another modification of the device shown in Fig. 1; and

Fig. 5 is a sectional view of a further modification of the device shown in Fig. 1.

Identical elements in the various figures of the drawings are identified by identical reference numerals.

Referring to the drawings in detail, and more particularly to Fig. 1 and Fig. 2, the reference numeral 11 designates a stationary base or support upon which is mounted a cylinder 12 of magnetic material such as soft iron. An annular coil 13 coaxial with the cylinder 12

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is mounted within an annular groove 14 and has two leads 15 extending outward from the cylinder 12 for connection to other apparatus.

A shaft 16, adapted to be rotated by a source of power (not shown), extends through an opening 17 in the base 11 and through an axial opening 18 in the cylinder 12. A second cylinder 21 also of magnetic material is mounted upon the shaft 16 to be rotated thereby and is separated from the cylinder 12 by an air gap 22. An annular coil 23 is mounted within a coaxial groove 24 in the cylinder 21 and has leads 25 extending through the cylinder 21 for connection to other apparatus. The coils 13 and 23 are fixed in position in their respective grooves 14 and 24 by surrounding masses of insulating material such as a synthetic resin. The cylinders 12 and 21, the shaft 16, and the coils 13 and 23 are all coaxial.

In operation, signals to be coupled between rotating apparatus and stationary apparatus are fed into one of the two coils 13 or 23. The signal current flowing through the coil establishes a magnetic field which varies in the same manner as the current flow through the coil. The coils 13 and 23 have a common magnetic path which includes portions of the cylinders 12 and 21 and the air gap 22. The magnetic flux established by the signal current in one of the coils induces in the other coil a signal voltage which has the same wave form as the original signal, and since the two coils 13 and 23 are coaxial and annular in form, the rotation of the coil 23 with respect to the coil 13 has no effect upon the signal. Thus, a signal is coupled between stationary and rotating apparatus with substantially no additional noise introduced therein.

Fig. 3 shows a modification of the invention, which modification reduces the effect of varying spacing between the cylinders. A stationary cylinder 31 of a material having a low magnetic reluctance such as soft iron is mounted upon a stationary base 30 and has a groove 33 in which is mounted an annular coil 32. A shaft 46 extends through an opening 34 in the base 30 and through an axial opening 35 in the cylinder 31 and is adapted to be rotated by a source of rotating power (not shown). A second cylinder 36, also of a material having a low magnetic reluctance such as soft iron, is mounted upon the shaft 46, to be rotated thereby, and is separated from the cylinder 31 by an air gap 37. An annular coil 38 is mounted in a groove 39 in the cylinder 36 coaxial with the shaft 46.

The adjacent surfaces of the two cylinders 31 and 36 are shaped so that the air gap 37, seen in cross section, follows a path in which the air gap 37 is purposely lengthened to diminish its contribution to the total magnetic path, and a large part of this air gap 37 is made parallel to the axis of rotation and is not appreciably affected by relative axial motion of the two cylinders 31 and 36. The cylinder 31 has a cylindrical depression 40 surrounding the shaft 46, and is spaced from a mating cylindrical projection 41 of the cylinder 36 by the air gap 37. A projection 42 surrounding the depression 40 in the cylinder 31 is also cylindrical in form and is spaced from a mating depression 43 in the cylinder 36. The coil 32 is mounted in its groove 33 in the projection 42 of the cylinder 31, and the coil 38, arranged to be opposite the coil 32, is mounted in a groove 39 in the base of the depression 43. The cylinder 31 has a depression 44 around its periphery and is spaced from a projection 45 of the cylinder 36.

The modification shown in Fig. 3 operates similarly to that of Figs. 1 and 2. As in the device of Figs. 1 and 2, a signal current is introduced into one of the coils 32 or 38 and establishes a magnetic field which varies as the current in the coil. This magnetic field induces a voltage in the unenergized coil, which voltage also varies as the

original signal. The configuration of the opposing faces of the cylinders 31 and 36, having depressions and projections such that they define a tortuous path for the air gap 37, has the effect of minimizing the compensating changes in the air gap 37 for a displacement of one of the cylinders 31 or 36 from the other cylinder. Thus, if the cylinder 36 were mounted such that there were end play and it would vary in distance from the cylinder 31, the sides of the facing projections 42 and 41 and depressions 43 and 40 of the two cylinders 31 and 36 remain spaced a constant distance from each other, and along these portions the air gap would not vary in width.

Fig. 4 shows a modification having a different configuration of the coils, which configuration improves coupling between the coils. A coil 51 in the form of two spaced concentric rings is mounted in a groove 52 in a cylinder 50. A coil 53 in the form of a single annulus, which is positioned in the space between the two concentric rings of the coil 51, is mounted in a groove 54 in a cylinder 55. The coil 53 extends into the groove 52 in the cylinder 50, and the two rings of the coil 51 extend into the groove 54 of the cylinder 55, thus providing a more intimate coupling between the two coils than is provided by either of the modifications shown in Figs. 1, 2, or 3. The cylinder 50 is mounted upon a base 59 and the cylinder 55 is secured to a shaft 56 which passes through an opening 57 in the base 59 and an axial opening 58 in the cylinder 50 and is adapted to be rotated by a source of power (not shown).

The device of Fig. 4 operates the same as the device shown in Figs. 1 and 2. A signal current is introduced into one of the coils 52 or 53 and the magnetic flux established by the current flowing through the energized coil induces a voltage, having the same waveform as the original current, in the other coil. The additional lengths of the coils 52 and 53 and the positioning of the coil 53 between the two portions of the coil 52 provides improved coupling for higher induced signal strengths in the induced winding.

Fig. 5 shows a modification which incorporates the changes of both Figs. 3 and 4. A cylinder 62 of magnetic material is mounted on a base 61 and has a cylindrical depression 65 adjacent a shaft 76, which shaft passes through an axial opening 78 in the cylinder 62. A projection 71 in which is an annular groove 64 containing a coil 63 in the form of two diametrically spaced rings surrounds the depression 65. A cylinder 67 of a magnetic material is mounted for rotation upon the shaft 76 and is spaced from the cylinder 62 by an air gap 68. The cylinder 67 has a projection 66 and a depression 69 in mating relation with the depression 65 and the projection 71 respectively of the cylinder 62. A coil 74 in the form of a single ring is mounted in a groove 75 in the base of the depression 69 and is positioned between the two rings of the coil 63. The coils 63 and 74 are of sufficient length to extend into the grooves 75 and 64 respectively.

The operation of the device shown in Fig. 5 is similar to the operation of the afore-described modifications. A signal current is caused to flow in one of the two coils 63 or 74 and the magnetic field established by the signal current induces in the other coil a voltage which has the same waveform as the original signal current. The shape and arrangement of the coils 63 and 74 provide improved coupling over the device of Figs. 1 and 2 and the mating projections 71 and 73 and the de-

pressions 69 and 72 reduce the effect of end motion of the cylinder 62 to a minimum.

In each of the above described modifications, it is contemplated that the rotationally mounted cylinder be connected mechanically as well as electrically to the rotating signal apparatus with which it is to be used and that the stationary cylinder be mounted stationarily with respect to the rotating signal apparatus. The magnetic material of the cylinders may be laminated in a manner well known in the art to reduce eddy current losses. The described modifications are intended for the coupling of signals of frequencies which are sufficiently low that iron cylinders may be used without undue hysteresis loss. If, however, it is desired to couple signals of radio frequencies, the cylinders may be formed of non-magnetic materials, and of non-conductors, such as synthetic resins, wood, ceramics, or powdered iron material.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

What is claimed is:

A magnetic coupling comprising a horizontal support, a rotatable shaft having an upper end portion extending through an aperture in said support, an upper cylindrical magnetic core member having an axial passageway therein fixedly received by the upper end portion of the shaft for rotation therewith and positioning the core member with its lower face providing a space with the support, a lower stationary cylindrical magnetic core member having an axial passageway therein and freely mounted about the shaft, said lower core member reposing on said support and having its upper face disposed in slightly spaced relation with the lower face of the upper core member to permit independent rotation of the upper core member, a first annular channel communicating through the lower face of the upper core member and coaxial with the shaft, a second annular channel communicating through the upper face of the lower core member coaxial with the shaft and vertically aligned with the first annular channel, a pair of spaced annular coils secured in one of said channels and extending into the other channel, a cooperating annular coil secured in the other of said channels and extending between said pair of spaced annular coils in spaced relation with each of said coils to provide an air gap therewith, each of said spaced coils and said cooperating coil being of substantially the length of the combined depths of both said channels to provide substantial magnetic surface coupling area between the coils, electrical connections extending from said coils in the one channel and through the supporting core member and an electrical connection extending from said cooperating coil and through its supporting core member.

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