Sept. 24, 1957 A. A. HEMPHILL ET AL 2,807,802

MAGNETIC ANTENNA WITH LOW LEAKAGE INDUCTANCE

Filed March 22, 1954

FIG. 1

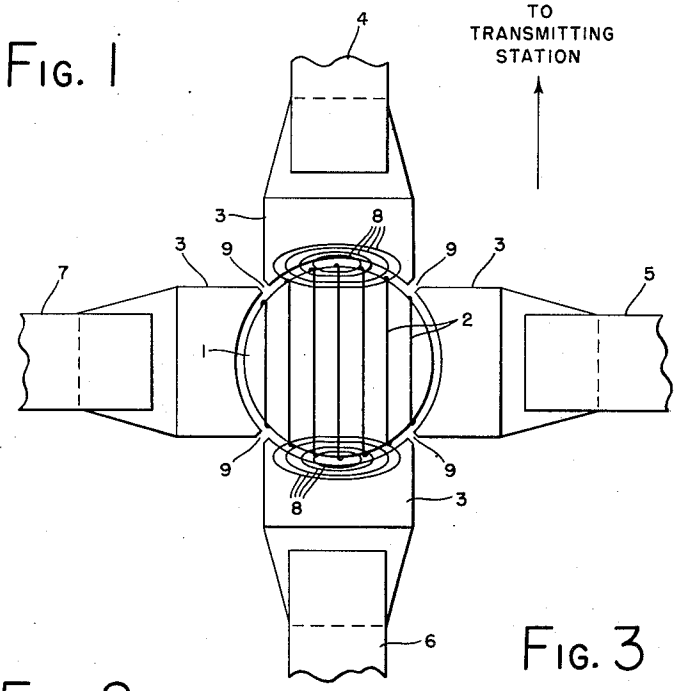


FIG. 2

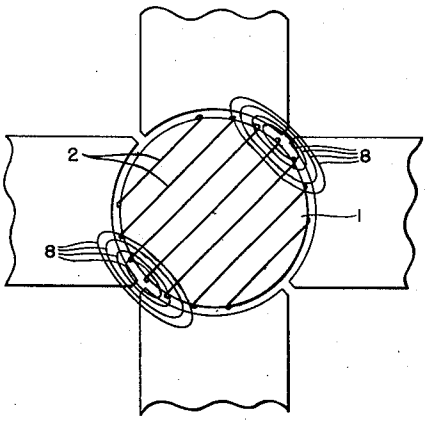
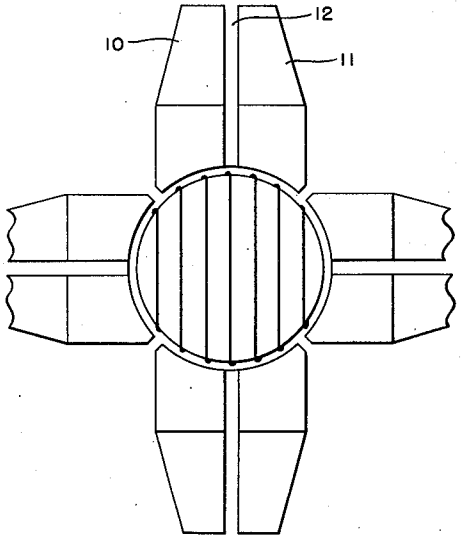


FIG. 3



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MAGNETIC ANTENNA WITH LOW LEAKAGE INDUCTANCE

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3 Claims. (Cl. 343—788)

This invention relates to magnetic antennas and more particularly to means for reducing the inductance of the pickup coil of such an antenna due to the presence of leakage flux paths linking the coil.

This invention has particular application to magnetic antennas arranged for the derivation of directional indications, such for example, as those disclosed in U. S. patent applications, Serial No. 264,717 for "Magnetic Antenna System," filed January 2, 1952, by Alfred A. Hemphill, and Serial No. 417,612 for "Means for Reducing Leakage Inductance in Magnetic Antennas" by Alfred A. Hemphill and John M. Tewksbury, filed March 22, 1954.

In antennas of this type, using elongated collector bars of high permeability arranged radially about a coil wound on a highly permeable rotatable core, as the coil is rotated past the pole pieces the leakage flux through pole pieces of collector bars which are in positions of minimum pickup increases the inductance of the coil. When these flux paths pass through only one pole piece the inductance of the coil is increased to a greater extent than when the flux paths include portions of more than one pole piece and the air gap between them. This differing inductance affects the pickup, introducing distortion into the directional indication and tending to mask the null indication. When the antenna is being used for reception, without reference to the indication of direction, the effect of the leakage flux to reduce the pickup is still undesirable.

It is an object of this invention to provide a means for effectively reducing the leakage inductance and the variation thereof occurring under the above circumstances.

It is a further object of the invention to provide this reduction by means which is inexpensive and simple.

It is another object of the invention to provide means of this type which does not introduce significant errors into the system.

These and other objects and advantages of the invention may be realized by providing for each collector bar two pole pieces rather than one, the two pieces having the same configuration as though a single pole piece symmetrical about a vertical plane of symmetry had been divided along that plane into two equal portions.

In the drawing:

Fig. 1 is a plan view of a magnetic antenna system showing the linkage of leakage flux with the coil of the rotor and the pole pieces, under a certain set of conditions;

Fig. 2 is a plan view of the antenna of Fig. 1 with the rotor rotated to a different position, showing the linkage of the leakage flux under this changed set of conditions; and

Fig. 3 is a plan view of a magnetic antenna embodying the invention.

Referring now more particularly to the drawing, there is shown in Fig. 1 a magnetic antenna comprising a centrally located rotor, made up of a disk-shaped core **1** of highly permeable material, having wound about it a

pickup coil **2**. Positioned symmetrically about the rotor are a plurality of pole pieces **3** also formed of highly permeable material. The faces of these pole pieces which lie adjacent to the rotor are arcuate in form, the curvature being concentric with that of the lateral periphery of the rotor. Air gaps **9** separate adjacent pole pieces.

Associated with each of the pole pieces is a respective collector bar **4**, **5**, **6** or **7** extending radially from the center of the rotor. These bars are constructed of highly permeable material. The inner ends of the bars are arranged in overlapping relationship with the outer ends of the pole pieces with which they are associated, so that parallel surfaces of the bar and its associated pole piece are either in contacting relationship or in very close proximity to each other, thus providing a path of low reluctance passing through the bar and its pole piece.

In the use of an antenna arrangement such as is illustrated in Fig. 1, for direction finding, the rotor is rotated with respect to the collector bars to find a position of minimum signal pickup, or the so-called null point of the signal, which defines the direction of the transmitting station. In positions other than this the rotor will pick up a signal which will gradually increase in intensity as the rotor is turned from the null position until it passes through a broad region of substantially maximum signal, about 90° from the null position. Upon continued rotation the signal will decrease until another null point is reached, at substantially 180° from the first.

While the above description of the operation of the antenna indicates the presence of a sharp null point in the sensitivity pattern thereof, there is present in practice an effect which tends to obscure the null and to produce a distorted output.

In the illustration of Fig. 1, let it be assumed that the collector bar **4** is pointed in the direction of the transmitting station, as indicated by the arrow accompanying the figure. The flux set up in the collector bars by the magnetic field of the wave advancing from the station will be a maximum through bars **5** and **7** and a minimum through bars **4** and **6**. With the orientation of the core and coils shown, the flux passing through the rotor should cause a maximum current flow through the coil and hence, a maximum pickup.

However, there will be a certain amount of leakage flux, as indicated by the closed lines **8**, flowing through the core **1** and the pole pieces **3** associated with collector bars **4** and **6**. This flux will increase the inductance of the coil. The change of inductance in the coil will impair the match between the coil and the tuned circuit (not shown) normally coupled to the coil in such systems for applying the signal to the remainder of the system. This impairment of the coupling will reduce the maximum pickup of the system, tending to obscure the null by rendering its sides less steep. The change in inductance also results in the detuning of the above mentioned tuned circuit, causing bearing error because of the non-symmetry of the two slopes of the null.

It should be noted that in the orientation shown in Fig. 1 and described above the lines of leakage flux **8** do not traverse any of the air gaps **9** between the pole pieces so that the paths are of a low reluctance nature.

Assume now that the rotor is rotated in a clockwise direction through an angle of 45° as indicated in Fig. 2. Now it will be seen that the lines of leakage flux **8** traverse one of the air gaps **9**. As a consequence, the reluctance of their paths will be increased, with an accompanying decrease in the inductance of the coil **2** and a corresponding improvement in the coupling between the coil and the tuned circuit of the system coupled thereto.

As the rotor is rotated, the inductance of the coil continues to follow this pattern, falling when the leakage flux

paths pass through an air gap and rising when the paths do not include such a gap. The undulating pattern of distortion which is applied to the pattern of response as a result serves to obscure and displace the null indication and to lower the amplitude of the maximum pickup. The latter defect is particularly objectionable when the system is being used for communication purposes.

In accordance with the instant invention the defect described above is reduced to such an extent as to be unobjectionable by a construction such as illustrated in Fig. 3, in which, instead of the unitary pole piece 3 provided for each collector bar in the system of Fig. 1, there is provided a pair of pole pieces 10 and 11, lying side-by-side and separated by a uniform air gap 12. These pole pieces are of a structure similar to that which would result if one of the pole pieces 3 were split into two parts along its vertical plane of symmetry and those parts moved apart to provide the air gap 12 therebetween.

The effect of the construction illustrated in Fig. 3 is to provide an additional air gap in the center of each pole piece 3, so that when the lines of leakage flux are positioned as shown in Fig. 1 their paths will include an air gap and their reluctance will be increased to substantially the same value as the paths for the orientation of Fig. 2. The peaks of the distortion pattern are thus removed and the pattern as a whole made more uniform. The undulations which remain in the pattern are small enough so that the error remaining is of a value low enough to be unobjectionable. Care should be maintained to insure that the pole pieces 10 and 11 are as nearly identical as possible, since any departure from identity will introduce distortion into the output. The amount of this distortion is small, but with care it can be completely eliminated.

What is claimed is:

1. A magnetic antenna comprising a rotor including a pickup coil wound upon a rotatable highly permeable core; a plurality of collector bars formed of highly permeable material symmetrically disposed about said rotor, said bars extending radially from the center of said core and lying in a common plane, and a pair of pole pieces formed of highly permeable material disposed between each of said collector bars and said rotor and in abutting relationship with said bar, whereby an air gap exists between said bar and said pole pieces, said pole pieces of said pair presenting substantially equal reluctances to the flow of magnetic flux between said rotor and said bar, said pole pieces of said pair being symmetrical with respect to the plane normal to said common plane and containing the longitudinal axis of said bar.

2. A magnetic antenna comprising a rotor including a pickup coil wound upon a rotatable, highly permeable core; a plurality of collector bars formed of highly permeable material symmetrically disposed about said rotor, said bars extending radially from the center of said core and lying in a common plane, and a pair of pole pieces formed of highly permeable material disposed between each of said collector bars and said rotor and in abutting relationship with said bar, whereby an air gap exists between said bar and said pole pieces, said pole pieces of said pair presenting substantially equal reluctances to the flow of magnetic flux between said rotor and said bar, said pole pieces of said pair being completely separated by an air gap of uniform cross-section and being symmetrical with respect to a plane normal to said common plane and containing the longitudinal axis of said bar.

3. A magnetic antenna comprising a rotor including a pickup coil wound upon a rotatable, highly permeable core; a plurality of collector bars formed of highly permeable material symmetrically disposed about said rotor, said bars extending radially from the center of said core and lying in a common plane, and a pair of pole pieces formed of highly permeable material disposed between each of said collector bars and said rotor and in abutting relationship with said bar, whereby an air gap exists between said bar and said pole pieces, said pole pieces of said pair presenting substantially equal reluctances to the flow of magnetic flux between said rotor and said bar, said pole pieces of said pair being completely separated by an air gap of uniform cross-section and being symmetrical with respect to a plane normal to said common plane and containing the longitudinal axis of said bar, each pole piece of said pair being spaced from one of the pole pieces of an adjacent pair by an air gap having substantially the same reluctance as the said air gap separating the pole pieces of said pair.

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