April 14, 1959 G. V. MORRIS 2,882,527

ANTENNA STRUCTURE

Filed Aug. 5, 1953

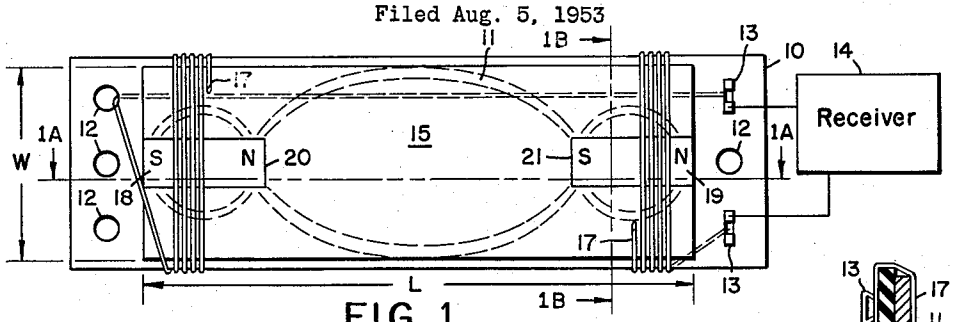


FIG. 1



FIG. 1A

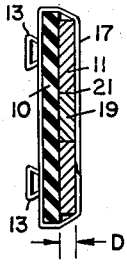


FIG. 1B

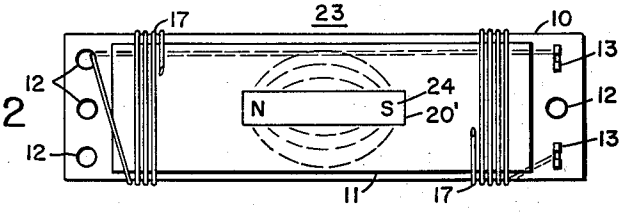


FIG. 2

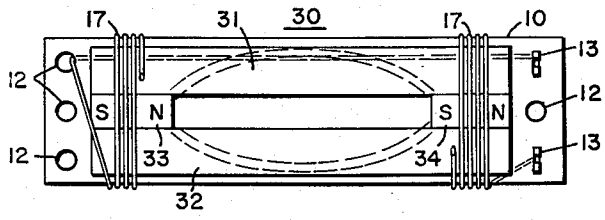


FIG. 3

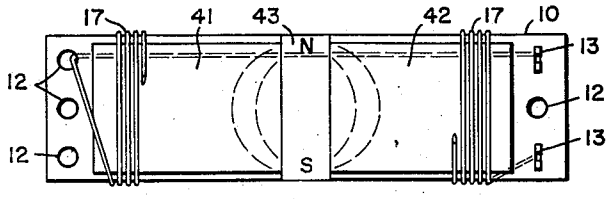


FIG. 4

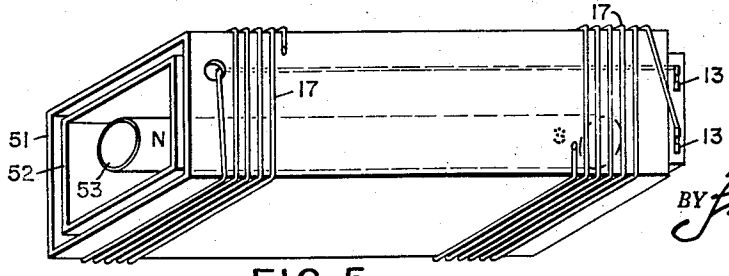


FIG. 5

GEORGE V. MORRIS
INVENTOR.

BY Francis W. Crotty

HIS ATTORNEY.

United States Patent Office

2,882,527

Patented Apr. 14, 1959

2,882,527

ANTENNA STRUCTURE

George V. Morris, Chicago, Ill., assignor to Zenith Radio Corporation, a corporation of Delaware

Application August 5, 1953, Serial No. 372,443

2 Claims. (Cl. 343—788)

This invention relates to a new and improved antenna structure for use with a wave-signal receiver operable over a range of frequencies; this antenna structure has been found to have particular application to radio receivers of the portable type and tunable over the broadcast band of frequencies which extends from about 540 to 1,600 kilocycles per second and will be described in that connection.

Antenna structures for portable wave-signal receivers must of necessity be of relatively small size and must be economical to manufacture. Usually such antennas comprise a coil of wire acting as the inductive element of a tunable resonant circuit which may be tuned over a desired frequency band. In their early manufacture, air-core coils were employed but they have been found to be undesirable because of their cost and bulk resulting from the large number of turns required to achieve adequate inductive reactance for use as radio antennas. In order to overcome these difficulties subsequent antenna coils have employed cores of a ferrite material to increase the effective inductance per turn and also to improve the Q, or quality factor (defined as the ratio of reactance to resistance) of the antenna. Such improvements achieve a significant reduction in the physical size and in the cost of radio receiving antennas and as a result have found wide application in the radio receiver art.

While the use of ferrite cores has proven successful in reducing the manufacturing cost of antennas for portable radio receivers, such antennas are, nevertheless, subject to certain inherent adverse characteristics. It has been found for example that the frequency response of a ferrite-core antenna is unstable in the presence of stray external magnetic fields, particularly when the structure is affected by mechanical shock or temperature variations as often occur during its normal use. The stray external fields may be of natural origin, as the earth's magnetic field, or may be attributable to other components of the receiver itself, as speaker coils or coupling transformers.

It is an object of the present invention, therefore, to provide a new and improved antenna structure which reduces the instability in frequency response in the presence of stray magnetic fields.

It is an additional object of the present invention to improve the stability of the receiving antenna by reducing the adverse effects resulting from mechanical shock or temperature variations.

It is a corollary object of this invention to provide an improved antenna structure for mounting inside the cabinet of a wave-signal receiver and occupying a minimum amount of space.

In accordance with the invention, an antenna structure for use with a wave-signal receiver operable over a

range of frequencies comprises an open ended core which includes at least two high permeability ferromagnetic plates spaced at a distance one from another. A permanent magnet is mounted in contiguous relationship with the ferromagnetic plates for biasing the core to a region of substantially constant incremental permeability, while a helical coil comprising a plurality of turns of conductive wire, electrically insulated with respect to each other, is tightly wound peripherally around the core and encompasses at least a portion of the biasing flux from the magnet.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals indicate like elements and in which:

Figure 1 is a side view of an embodiment of the antenna structure coupled to a wave-signal receiver according to the invention;

Figure 1A is a sectional view taken along line 1A—1A of Figure 1;

Figure 1B is a sectional view taken along line 1B—1B of Figure 1; and

Figures 2–5, inclusive, individually represent additional embodiments of the present invention.

In the preferred embodiment of Figure 1, the antenna structure comprises a mounting plate **10** of insulating material such as chip board or a plastic to provide a suitable mechanical support for a ferrite plate **11** which is relatively brittle. The combination of mounting plate **10** and ferrite plate **11** constitutes a composite core structure **15**. For greater mechanical strength ferrite plate **11** may be affixed to support member **10** through the use of a suitable adhesive substance, as for example, glue or cement, although the compressing action of an encompassing helical coil, hereinafter described in greater detail, may be sufficient for this purpose. In the preferred embodiment the length L and width W of the core assembly **15** are preferably approximately four times as great as the thickness D although in certain applications it has been found that the ratio of length L or width W to thickness D may be about 10 to 1.

Ferrite plate **11** is composed of a ferromagnetic crystal structure, such as ferrite, Fe_3O_4. Other suitable compositions may be derived from ferrite by replacing the ferrous ions by one or more metal ions to produce compounds such as manganese ferrite, Fe_2O_3MnO, cobalt ferrite Fe_2O_3CoO, nickel ferrite, Fe_2O_3NiO, copper ferrite, Fe_2O_3CuO, magnesium ferrite, Fe_2O_3MgO, zinc ferrite, Fe_2O_3ZnO, or cadmium ferrite, Fe_2O_3CdO. The ferrite material is usually prepared by a sintering process well known in the ceramic industry. For example, component metal oxide is mixed, ground, usually sintered and ground again, finally compressed into the desired shape with the necessary binders and sintered at high temperatures. The sintering process results in the production of a brittle cubic close-packed structure of ions with a small volume percentage of voids. Small apertures **12** are drilled into mounting plate **10** to provide a practical means for mounting the composite structure inside the cabinet of a radio receiver.

Recesses **20** and **21** are provided in ferrite plate **11** to receive bar magnets **18** and **19** which are oriented so that the north-seeking pole of magnet **18** and the south-seeking pole of magnet **19** face internally toward the cen-

ter of ferrite plate **11**. The dashed lines entering and leaving permanent magnets **18** and **19** are indicative of the lines of flux in the external magnetic field. The ferromagnetic material of which permanent magnets **18** and **19** is composed preferably consists of a crystal structure of a ferromagnetic oxide of barium, $BaFe_{12}O_{19}$, although other materials which have been found equally applicable for use as permanent magnetic material include magnetoplumbite, $PbFe_{12}O_{19}$ or ferromagnetic oxide of strontium, $SrFe_{12}O_{19}$. However, from an economic standpoint the barium compound has been chosen for the commercial application of the illustrated antenna structure.

A helical coil **17** consisting of a plurality of turns of conductive wire, electrically insulated from each other, is tightly wound around the structure composed of mounting element **10**, ferrite plate **11**, and permanent magnets **18** and **19**. The terminal leads of the helical coil are soldered to terminal lugs **13** for conveniently coupling the antenna structure to a receiver **14**. Receiver **14** comprises any well-known receiver tunable over the band of frequencies in the broadcast range and for this reason is not considered in any further detail.

Cross-sectional views 1A and 1B shows the core assembly **15** encompassed by helical coil **17** which is tightly wound around this assembly. Helical coil **17** as shown in Figure 1B binds together ferrite core **11** and supporting member **10** to form a compact antenna structure.

The high permeability of ferrite core **11** permits its effective use as an integral part of the antenna structure, since this characteristic increases the Q and the inductive reactance of coil **17** to a more practical value than that which is attainable with an air core coil of comparable physical size. The permanent magnetic material, in the preferred embodiment a ferromagnetic oxide of barium, $BaFe_{12}O_{19}$, has a relatively large coercive force, approximately 2,000–3,200 oerstads which makes it particularly desirable as a source of permanent magnetic flux. The high remanent magnetization, in the order of 2,100 gauss, of the permanent magnetic material allows its use as a practical means for establishing a stable uni-directional biasing magnetic flux. It has been discovered that a permanent magnet made of sintered oxide of iron and barium may be subjected to a high demagnetizing field and still recover almost all of its original magnetization. It is this characteristic which gives rise to the particular effectiveness of this compound in the present application. The term "uni-directional biasing magnetic flux" as used in this instance may be defined as a magnetic field in which the lines of magnetic flux flow uninterruptedly in the same direction and from a north-seeking pole to a south-seeking pole in the external field and in the opposite direction internally in the magnetic material, thus forming a closed magnetic circuit.

The high resistivity inherent in the crystal structure of the sintered ferrite material of both plate **11** and permanent magnets **18** and **19** effectively inhibits losses which are ordinarily attributed to eddy currents and thus the power losses are kept at a feasible minimum at the frequencies of operation for which this device is intended.

In this application, the external field of the closed magnetic circuit is concentrated in the ferrite plate to improve the stability of the tuned circuit in the presence of stray magnetic fields. Since the inductance of coil **17** varies directly with the permeability of the ferrite plate which it encompasses, the frequency response of the resonant antenna circuit, which in turn depends upon the inductive reactance of the antenna coil, also varies with permeability. According to the Domain theory of magnetization, a nonmagnetized ferromagnetic substance is considered to be composed of a multitude of minute magnets, randomly displayed throughout the substance; but when the ferromagnetic material is subjected to a magnetizing force, the minute magnets orient themselves in

accordance with the field pattern of the magnetizing force. This phenomenon of orientation is more pronounced if the ferromagnetic material is heated or shocked mechanically in the presence of the magnetizing force. Consequently, an unmagnetized ferrite antenna core is particularly vulnerable to permeability variations during the normal use of a radio receiver of the portable type because of the influence of stray magnetic fields on the core. The present invention provides means for establishing in the ferrite core a permanent uni-directional biasing magnetic flux to minimize the adverse effects of such stray magnetic fields. Because the ferrite core is subjected to a large biasing magnetic flux, the percentage change in its permeability due to ordinary external magnetic fields is held to a minimum, resulting in stabilization of the inductance of the antenna coil. In this manner fluctuations in the frequency response of the antenna circuit are effectively inhibited.

The embodiment of Figure 2 is similar to that of Figure 1 except that in this case a single permanent magnet **24** is disposed within a recess **20'** in the center of the ferrite core and the field of magnetic flux is concentrated to a greater extent at the center of the antenna structure.

In the embodiment of Figure 3 two ferrite plates **31** and **32** are affixed to base member **10**, being spaced laterally to permit the positioning of two bar magnets **33** and **34** therebetween at both extremities of base assembly **30**. In this arrangement as in Figure 1 the opposite poles of the two magnets face internally to concentrate the uni-directional biasing magnetic flux in the ferrite plates.

The arrangement of the invention illustrated in Figure 4 also utilizes two ferrite plates **41** and **42** disposed longitudinally on mounting base **10** with a permanent magnet **43** in contiguous relationship between these two ferrite plates.

Figure 5 illustrates a further embodiment of the invention in which a plurality of ferrite plates **51** of rectangular cross section are arranged to define a channel circumscribing an internal mounting structure **52** of dielectric material. Further, a permanent magnet **53** extends axially throughout the length of this composite core structure.

In short, the receiving characteristics of the new and improved antenna structures described herein are stabilized through the use of a uni-directional biasing magnetic flux established in the ferrite core through the use of at least one permanent magnet, also of ferrite material. In this way a compact antenna structure is achieved which is relatively free from adverse frequency drift caused by unwarranted temperature variations or mechanical vibrations in the presence of stray magnetic fields.

While particular embodiments of the invention have been shown and described, modifications may be made and it is intended in the appended claims to cover all such modifications as may fall within the true spirit and scope of the invention.

I claim:

1. An antenna structure for use in conjunction with a wave-signal receiver operable over a range of frequencies, said antenna structure comprising: an open-ended core including at least two high permeability ferromagnetic plates spaced at a distance one from another; each of said plates having three characteristic dimensions of which one is materially smaller than the other two; means including at least one permanent magnet placed in contacting relationship between said ferromagnetic plates for biasing said core to a region of substantially constant incremental permeability; and a helical coil comprising a plurality of turns of conductive wire, electrically insulated with respect to each other, tightly wound peripherally around said core and encompassing at least a portion of the biasing flux from said magnet.

2. An antenna structure for use in conjunction with a wave-signal receiver operable over a range of frequencies, said antenna structure comprising: an open-ended core including two high permeability ferromagnetic plates

spaced apart longitudinally; means including at least one permanent magnet mounted in contiguous relationship with said ferromagnetic plates for biasing said core to a region of substantially constant incremental permeability; and a helical coil comprising a plurality of turns of conductive wire, electrically insulated with respect to each other, tightly wound peripherally around said core and encompassing at least a portion of the biasing flux from said magnet.

References Cited in the file of this patent

UNITED STATES PATENTS

2,503,155	Harvey et al.	Apr. 4, 1950
2,581,348	Bailey	Jan. 8, 1952
2,624,004	Polydoroff	Dec. 30, 1952
2,645,746	Bruijning	July 14, 1953
2,730,681	Went et al.	Jan. 10, 1956