July 20, 1965 R. G. LEFFELMAN ETAL 3,196,442

ANTENNA WITH SIDE LOBE ABSORBER MOUNTED ADJACENT THERETO

Filed Dec. 14, 1959

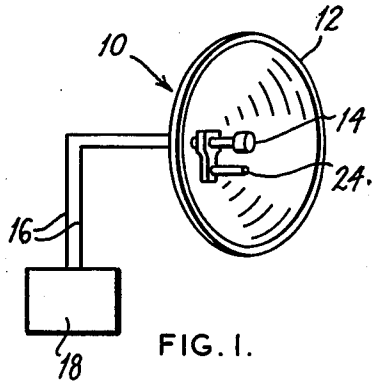


FIG. 1.

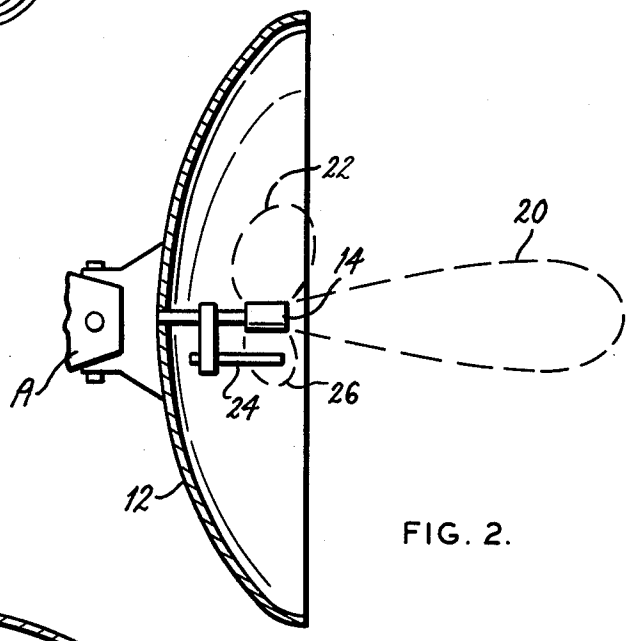
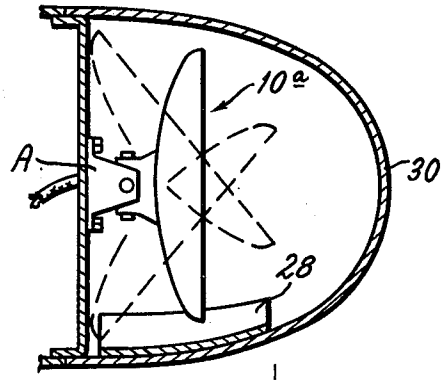


FIG. 2.



PRIOR ART

FIG. 3.

INVENTORS

RICHARD G. LEFFELMAN

JOHN TORRISI

BY Gravely, Lieder & Woodruff

ATTORNEYS

United States Patent Office 3,196,442 Patented July 20, 1965

3,196,442

ANTENNA WITH SIDE LOBE ABSORBER MOUNTED ADJACENT THERETO

Richard G. Leffelman, Overland, and John Torrisi, Florissant, Mo., assignors to McDonnell Aircraft Corporation, St. Louis, Mo., a corporation of Maryland

Filed Dec. 14, 1959, Ser. No. 859,255
4 Claims. (Cl. 343—765)

The present invention relates generally to devices for shaping the radiation pattern of an antenna and more particularly to radar antenna radiation pattern shaping means.

Various means have been devised in the past to eliminate or at least to reduce antenna radiation in a particular direction. The known means have included radiation absorbing devices which are mounted adjacent to the antenna to absorb radiation in a chosen direction. In the known constructions the radiation absorbing material has been fixedly attached to an immovable object adjacent to the antenna such as a radome but has not been satisfactory for use with moving antenna structures such as the antenna structures employed with radar gear because movement of the antenna changes the relative position of the absorbing material with respect to the antenna and thereby changes the direction of maximum radiation absorption relative to the radiation pattern. If the antenna is moved through a large enough angle the main antenna beam may actually be directed at the absorbing material and be undesirably attenuated while the (undesirable) side radiation which it is intended to absorb is unaffected. Another major problem of known radiation absorbing elements has been their inability to withstand intense radiation resulting in a functional breakdown when located in a strong electromagnetic field. These and other disadvantages of the known devices are overcome by the present devices which comprises an antenna structure having a feed element or radiator, a reflector located adjacent to said radiator, and means mounted on the antenna structure for attenuating radiation therefrom in a chosen direction relative to the antenna.

It is a principal object of the present invention therefore to provide means for reducing antenna radiation in a chosen direction, such as the extreme side lobes of the radiation pattern so that the effective radiation is concentrated as desired.

Another object is to uniformly reduce antenna radiation in a chosen direction relative to the antenna regardless of the direction in which the antenna is facing.

Another object is to maintain a constant relationship between a main antenna radiation beam and a secondary or side lobe.

Another object is to provide an inexpensive, lightweight and compact device capable of absorbing antenna radiation, which device is capable of withstanding large amounts of radiation without breaking down and which can be installed on new or existing antenna structures with minimum effort.

Another object is to provide a radiation absorbing device for antennae which reduces radiation therefrom in a chosen direction without reducing, distorting or bending the radiation in other directions.

Another object is to provide a radiation absorbing device which can be mounted on antenna structures and moved therewith.

Still another object is to increase the accuracy of radar antennae and the like by maintaining a constant fixed relationship between the magnitude of the principal radiation lobe and the side lobes.

These and other objects and advantages of the present invention will become apparent after considering the following detailed specification in conjunction with the accompanying drawing.

In the drawings:

FIG. 1 is a perspective view of an antenna structure having pattern shaping means constructed according to the preferred teachings of this invention;

FIG. 2 is a cross-sectional elevational view on an enlarged scale taken along the center line of the antenna of FIG. 1 and showing in phantom outline a typical attenuated radiation pattern therefor; and

FIG. 3 is a cross-sectional view of an antenna mounted in a radome for movement about different axes and relative to a radiation absorbing means which is illustrative of prior art examples.

Referring to the drawing more particularly by reference numbers, the number **10** refers to an antenna structure constructed according to a preferred teaching of the present invention. The antenna **10** has a parabolic reflector or shield **12**, a radiator **14** mounted centrally adjacent the concave side of the reflector **12**, and suitable leads **16** connecting the radiator **14** to a radar set **18** or similar radiation transmitting or receiving device. The reflector **12** is movably carried on a universally pivoting device A.

When energy is fed to the radiator **14** from the radar set **18** it is radiated therefrom in a pattern, as in FIG. 2, the characteristics of which depend upon the characteristics of the antenna components including the radiator and the reflector, the characteristics of the signal itself, and also the characteristics of the surrounding structures and their location relative to the antenna. For example, the forward lobe **20** emitted by the radiator **14** has a plurality of secondary or side lobes which are conveniently shown as envelope **22** and **26** in which the secondary and all side beams are lumped together. In the more generalized situation there will be a number of such side lobes, but for the sake of this invention these side lobes are dealt with as one general side lobe, which forms the envelope of all side lobes.

In order to reduce the magnitude of the side lobe in a given direction or portion of the annular envelope, depicted in FIG. 2, a stick **24** of radiation absorbing material is mounted adjacent to the radiator **14** as shown in FIGS. 1 and 2. Any suitable radiation absorbing material can be used for this purpose provided it can withstand the intensity of the radiation without breaking down. Heretofore, the absorber material **28** of FIG. 3 has consisted of a section of foam rubber with graphite therein and having a ply of aluminum foil on one surface. This is generally referred to as harp material and may have other material components. A greatly more effective material which has been found particularly desirable because of its electromagnetic absorption characteristics is ferrite. Ferrite is an amorphous substance, usually although not necessarily, an iron compound having magnetic characteristics. When a rod of ferrite is mounted as described, the radiation in the unwanted direction is absorbed and the radiation pattern from the antenna is modified from a pattern having approximately equal side lobe radiation in a band about the radiator **14** to that shown in FIG. 2. In the example of FIG. 2, the radiator **14** has the generally cylindrical shape illustrated with the outer free end defining an imaginary plane just within the rim opening of the reflector, and the stick has its free end at or to the rear of the imaginary plane for the radiator. The pattern of radiation when the stick **24** is used consists of the main beam **20** which is substantially unchanged, and a side lobe **22** which is modified from a uniform annular band by having its intensity greatly reduced in the direction of the stick **24**, as at **26**. The shape of the side lobe **22** is unchanged in the upper and sidewise

directions but is substantially attenuated in the downward direction. In actual tests it has been found that the reduction in radiation in the downward direction is very substantial using a ferrite stick, and that the effect on the main beam **20** even when the radiation is relatively high is negligible.

A particular application where the present device has been found useful is in connection with the radar systems employed on airplanes. In such devices not only is it important to properly modify the radiation pattern in given directions but it is also important that the size and weight of the equipment be kept at a minimum. These requirements are all obtained using a ferrite stick constructed and installed as described herein. During a typical tracking operation, for example, using an airplane radar set, the radar antenna main beam is directed to a remote target. The main beam thus directed, is reflected from the target and picked up by the same antenna. At the same time energy is also being radiated in the form of side lobes, and part of the side lobe energy is radiated downwardly and reflected from the earth's surface. The reflected energy received from the target area, and from the earth's surface as a result of the side lobe energy, is fed to the radar set and its presence made known in the form of images on a radar scope. The radar scope is usually calibrated in azimuth and range.

The pictorial representations on the scope appear as a line which is referred to as the "altitude line" and which extends across the face of the scope as if it were a target at a range corresponding to the aircraft altitude, and as a target or bright spot. As the aircraft closes on the target, the range to the target decreases and the target must pass through the altitude line. It is important to proper tracking that the intensity of the power reflected from the target and received by the radar antenna be of much higher magnitude than the power the antenna receives which has been reflected from the earth. This difference in intensity will insure that the radar remains locked on the target as the target passes through the altitude line. In this regard it should be noted that the power due to noise and earth reflections is due in large part to the strength of the side lobe reflections. If the reflected energy due to the side lobes is large, the power which contributes to the altitude line will be large and it will be more difficult for the tracking radar to distinguish between the altitude line and target and "lock on" may be lost as the target passes through the altitude line. When this condition exists it becomes difficult if not impossible to successfully track.

As previously noted, to insure satisfactory tracking, the power received from the target signal must be appreciably greater than the power received from the earth's signal. The ratio of the power received from the earth and the power received from the target depends on the reflecting areas of the reflecting bodies and the gain of the antenna when power is received from a particular direction. The ratio of the observed area of the earth to the observed target area is a factor which cannot be controlled. Therefore, in order to have an appreciably stronger signal from the target than from the earth, some means must be devised to reduce the amount of energy radiated in and received from the side lobes without reducing the energy directed by the main beam at the target.

By using a ferrite rod **24** mounted adjacent to the lower side of the radiator (FIG. 2) the desirable reduction in downward radiation is effected. The same effect is obtained with the harp material **28** in FIG. 3, however, in the past, attempts to solve this problem have been unsuccessful because they have not made provisions taking into account the movement of the antenna as it follows the target. For example, as illustrated in FIG. 3, the radiation absorbing material **28** is mounted in a fixed position relative to the antenna **10***a* mounted on the universally pivoting device A within the radome **30** of an airplane. The antenna **10***a* works satisfactorily during level flight

but not otherwise because during certain flight attitudes the antenna **10***a* will actually be looking through the absorbing material **28** or else looking away from the absorbing material, as indicated in the broken line positions.

The present invention overcomes these disadvantages by mounting the ferrite rod **24**, or the absorbing material **28** adjacent to the radiator itself on the antenna so that it moves with the antenna and not relative thereto. Obviously, therefore, regardless of the attitude of the airplane or the direction in which the antenna is facing, the antenna never faces into or away from the absorbing material. The purpose of applicant's device then is to absorb or redirect the side lobe power that otherwise would be radiated toward the earth or some other body so that the reflected energy received by the main lobe will always be substantially greater than the energy received from the side lobes.

In a particular test it was discovered that a ferrite rod 7 inches long and .250 inch in diameter reduced side lobe radiation by at least 4 decibels in the downward direction, and at the same time produced no significant attenuation, distortion, or bending in the azimuth plane of the main beam. This indicates that the ferrite rod produced no deterioration of the main or target beam but effect substantial reduction in the downward side lobe radiation.

Temperature test also indicated that the ferrite rod would not break down even under extreme operation conditions. Tests have also been conducted satisfactorily over land and over water.

While the present invention has been described in connection with a specific application and in a specific antenna construction, it is obvious that it can also be used with many other antenna structures and for many other applications without departing from the spirit and scope of the invention. Furthermore, many changes, alterations and modifications of the present device as well as other uses and applications will be apparent to those skilled in the art. All such changes, alterations, modifications and uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention which is limited only by the claims which follow.

What is claimed is:

1. In an antenna having a reflector shield and a radiator mounted forwardly thereof in the direction of principal radiation and capable of radiating a forward radiation lobe and a side lobe, the improvement comprising a member constructed substantially entirely of ferrite material mounted laterally adjacent to the radiator on one side thereof and spaced forwardly of said shield in position to absorb side lobe radiations from the radiator substantially only in the direction of said ferrite member.

2. Means for changing the radiation pattern of an antenna comprising an antenna having a parabolic reflector shield, a radiator mounted adjacent to said shield in the direction of principal radiation therefrom, means connected to said radiator for energizing said radiator to generate a signal therefrom having a forward radiation lobe and at least one side lobe, and a radiation shaping member mounted on said antenna spaced forwardly of said shield and adjacent to the side of said radiator in the path of said radiation side lobe, said member being constructed of a ferrite substance capable of reducing by absorption the side lobe radiation in the direction thereof.

3. In a directional antenna having a reflective shield and a radiator member mounted thereon adjacent to and forwardly of said shield, said radiator member being capable of radiating a main forward energy beam and side lobe energy in a direction angularly related to the forward beam, the improvement comprising a radiation absorbing element mounted on the antenna adjacent to a side of said radiator and spaced forwardly of the shield in the path of the side lobe energy, said element being constructed substantially entirely of an amorphous substance having magnetic characteristics capable of absorbing side lobe radiations from the radiator substantially only in the direction thereof, and means for angularly moving said antenna

without changing the relative positions of said shield, said radiator and said radiation absorbing element.

4. In a target seeking radar antenna, means for attenuating disturbing radiations and reflections comprising a movable reflector which projects radiations and receives reflections from frontal areas, a radiator-receiver element mounted on and positioned ahead of said reflector in position to project and receive frontal radiations and reflections including a principal forward energy beam and side lobe radiations and reflections, and absorber means positioned ahead of the reflector in the path of said side lobe radiations and reflections, said absorbing means including an element constructed substantially entirely of ferromagnetic material capable of absorbing side lobe radiations and reflections in the direction thereof without producing any substantial effect on the radiations and reflections of the principal forward beam.

References Cited by the Examiner

UNITED STATES PATENTS

2,597,313	5/52	Gardner	343—840
2,750,497	6/56	Stott	343—788
2,808,586	10/57	Chrlich et al.	343—838
2,923,934	2/60	Halpern	343—18
2,926,349	2/60	Jensen	343—840
2,982,962	5/61	Kendall et al.	343—840
2,998,602	8/61	Cacheris	343—782 X

HERMAN KARL SAALBACH, *Primary Examiner.*

GEORGE N. WESTBY, ELI LIEBERMAN, *Examiners.*