Oct. 15, 1968 J. J. KULIK 3,406,393

DUAL ANTENNA

Filed April 25, 1967 2 Sheets-Sheet 1

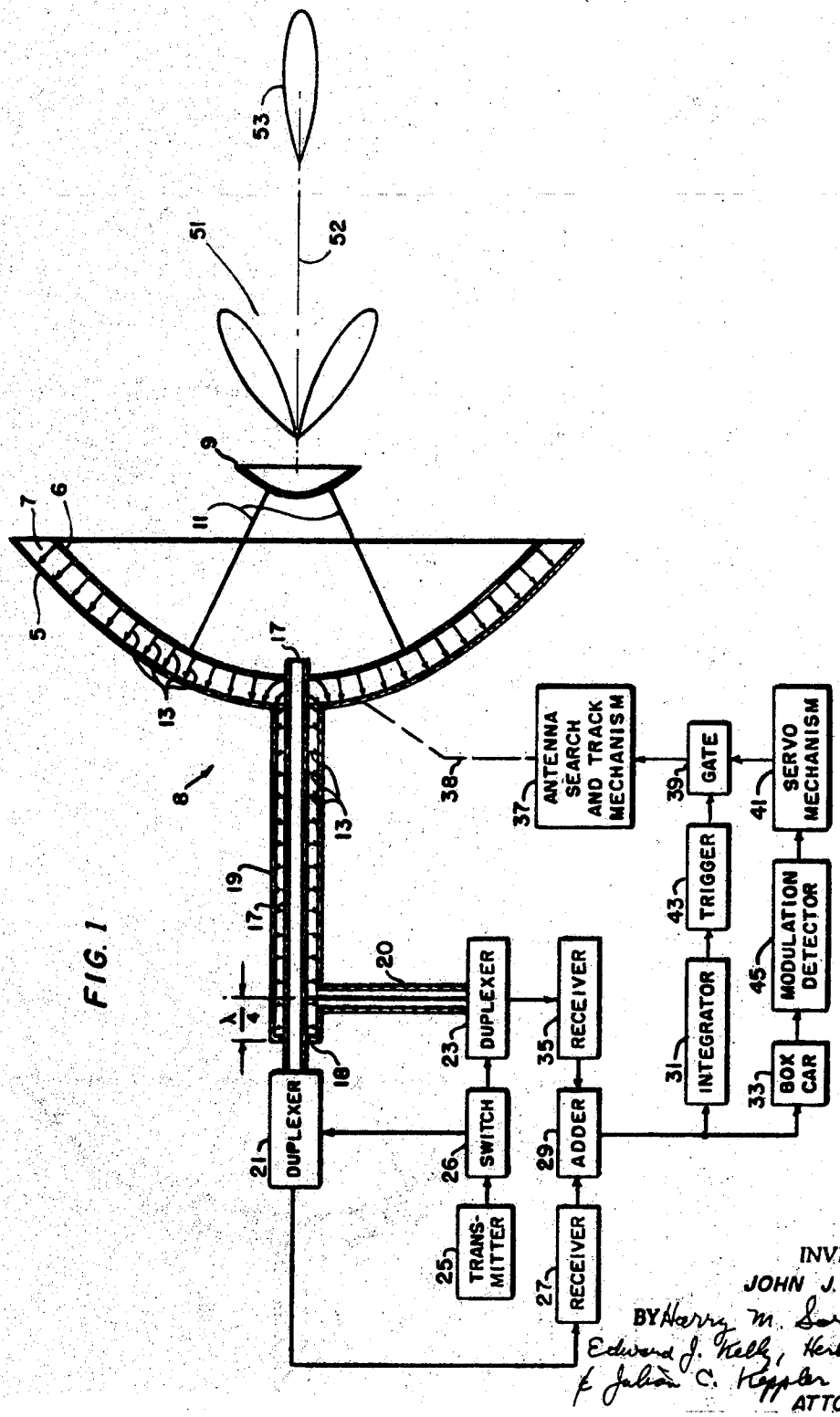


FIG. 1

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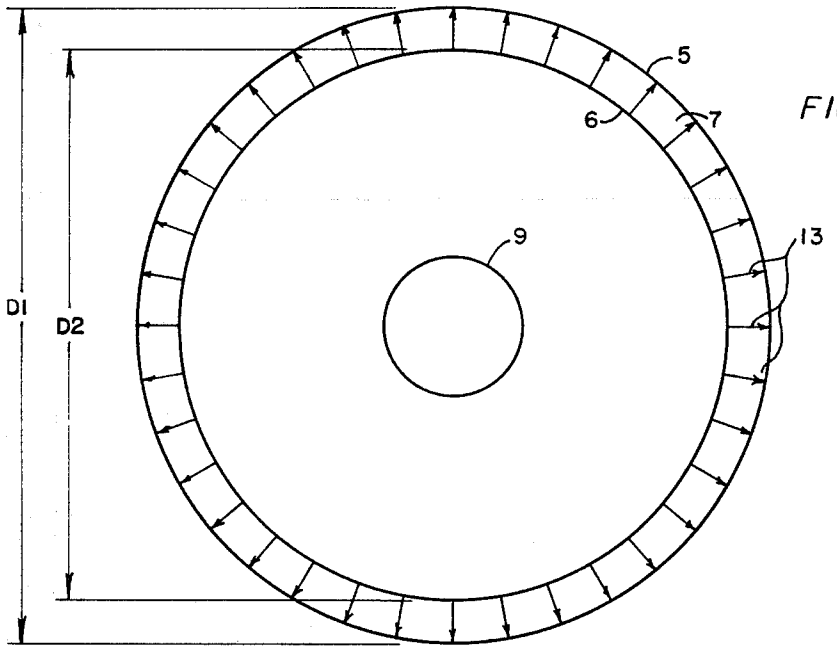
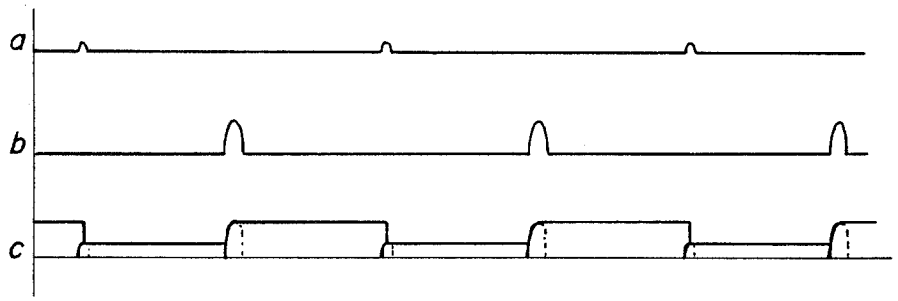


FIG. 2

FIG. 3



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United States Patent Office 3,406,393 Patented Oct. 15, 1968

3,406,393

DUAL ANTENNA

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Filed Apr. 25, 1967, Ser. No. 634,796
5 Claims. (Cl. 343—7.4)

ABSTRACT OF THE DISCLOSURE

A dual antenna is described comprising a pair of spaced and nested paraboloids. The inner paraboloid is fed in normal fashion to form a pencil beam. The annular slot formed by the peripheries of the paraboloids is fed from the vertex area to form a split lobe pattern with a null on the focal axis of the paraboloids. A circuit of a search and track radar utilizing this dual antenna is shown.

Specification

This invention relates to a dual antenna and more particularly to such an antenna comprising a pair of nested but spaced paraboloids with the forward paraboloid illuminated or fed in nomal fashion to produce a pencil type radiation pattern and the space between the paraboloids fed from the vertices thereof in such a manner as to cause radiation from the annular slot formed by the peripheries of the spaced paraboloids, thereby forming a radially symmetrical beam about the common boresight or focal axis of the paraboloids, with a null on the axis. Such a dual antenna is useful in search and track radars in that both search and track functions can be obtained from the single unitary structure.

It is thus an object of the invention to provide a novel and useful dual parabolic antenna, each antenna thereof having a different radiation pattern.

A further object of the invention is to provide an antenna structure capable of radiating or receiving simultaneously two signals with different radiation patterns.

These and other objects and advantages of the present invention will become apparent from the following detailed description and drawing in which:

FIGURE 1 is a combination pictorial drawing of an illustrative embodiment of the dual antenna of the present invention and a block diagram of the radar circuitry with which the antenna may be used.

FIGURE 2 is a view of the antenna of FIGURE 1 looking into the aperture thereof and,

FIGURE 3 is a series of waveforms illustrating the operation of the circuitry of FIGURE 1.

In FIGURE 1, the dual antenna **8** therein is formed by nesting two spaced paraboloids or dishes **5** and **6**. The forward or inner paraboloid **6** functions as a conventional parabolic antenna and in the present example is shown as a Cassegrainian type with a sub-reflector **9** within the aperture thereof, supported by struts **11**. The sub-reflector is illuminated by the energy emitted from the open-ended round waveguide **17** which projects through the vertices of both paraboloids and is conductively connected to the inner paraboloid **6**. The parabolic portion of the antenna is fed from first duplexer **21**, which is connected to the opposite end of round waveguide **17**. The outer surface of waveguide **17** forms the inner conductor of a coaxial line **19** which feeds the annular slot defined by the space **7** between the two nested paraboloids. The coaxial line is terminated at its end remote from the paraboloids in a short circuit **18**. One quarter wavelength away from this short a second coaxial line **20**, mounted at right angles to the line **19**, has its center conductor connected to the outer surface of waveguide **17** and its outer conductor connected to the outer conductor of the line **19**. Thus, a microwave signal

launched down line **20** from the second duplexer **23** will excite the TEM mode in the line **19**. The arrows **13** illustrate the electric vectors in the line **19** and in the annular slot antenna. As seen in FIGURE 2, the vectors within the slot are all radially symmetrical about the center of the antenna aperture or focal axis and therefore will give rise to a radially symmetrical radiation pattern with a null on the axis. This pattern is illustrated in a single plane by the diagram **51** of FIGURE 1. The actual three dimensional pattern is a figure of revolution obtained by rotating the pattern **51** about the boresight or null axis **52**. The radiation pattern of the forward or inner paraboloid is shown at **53**.

As seen in FIGURE 2 the diameter D2 of the forwarded paraboloid **6** is made less than the diameter D1 of the rear paraboloid **5** and this difference in diameters controls the annular slot width. If the two paraboloids have the same curvature at corresponding points the distance between them will be uniform at each point. This is the case illustrated in the drawings. It may be desirable in certain applications to provide a spacing which flares or diverges from the vertex toward the periphery. This will result in a wider annular slot. Such a structure can be accomplished by making the focal length of the rear paraboloid greater than that of the forward paraboloid. Also, in FIGURE 1 the peripheries of the two paraboloids are shown lying in the same plane, a vertical plane if the boresight axis **52** is directed horizontally. Here again this feature is not essential to the practice of the invention and the paraboloid peripheries may lie in different, but parallel planes.

The circuitry of FIGURE 1 and the waveforms of FIGURE 3 show how the dual antenna **8** may be used as part of a search and track radar system. In such a system, the radar is first operated in the search mode, usually employing a pencil type beam as shown at **53** in FIGURE 1. When a target is thus detected, the system is switched over to the tracking mode in which the antenna continually tracks the moving target by means of a servo system. The circuitry of FIGURE 1 includes a pulse modulated microwave transmitter **25**, the output of which is alternately applied to first and second duplexers **21** and **23** by means of switch **26**. Thus the transmitter pulses are alternated between the two duplexers and hence the slot and parabolic antennas are energized by altenate transmitter pulses. Target echoes from the parabolic antenna are applied to first receiver **27** via first duplexer **21** and echoes from the slot antenna to the second receiver **35** via the second duplexer **23**. The demodulated video target pulse trains of the two receivers are combined in adder **29**. The adder output is applied to integrator **31**, the output of which operates trigger **43**, which may be of the Schmitt type which will produce an output if the integrator output exceeds a certain threshold voltage and no output if the integrator output falls below the threshold. The trigger circuit output is applied to the control input of transmission gate **39**. The adder output is also applied to boxcar circuit **33**. This circuit holds the peak amplitude of each video pulse applied thereto until the next pulse arrives, at which time the process is repeated. The modulation detector senses the maximum amplitude of the alternating component of the boxcar circuit output and controls the servomechanism **41** in accordance therewith. The servomechanism output is applied to the antenna search and track mechanism through gate **39**. The operation of the system is as follows: The mechanism **37** controls the antenna movement via mechanical connection **38**. In the search mode this mechanism systematically scans an area of space for targets. If a target is picked up in the beam of either antenna, the resulting target echoes will build up the voltage on integrator **31** to such an extent that trigger **43** will be

operated, thereby closing normally open gate **39** and switching the system into the tracking mode. The antenna movement will thereafter be controlled by the servomechanism **41**. It will be assumed that after the opening of gate **39** the target is somewhat offset from the boresight axis **52** but within the beams of both antennas. In this condition both antennas will receive target echoes, but those of the receiver **27** will be larger than those of the receiver **35** since in the vicinity of the boresight axis, the response or gain of the parabolic antenna is higher than that of the slot antenna. Since the adder interleaves the two receiver video pulse trains in time, the boxcar output will be alternately high and low. This situation is illustrated in FIGURE 3. The waveform *a* therein illustrates the output of the slot antenna receiver **35** and the waveform *b* the output of the parabolic antenna receiver **27**. The waveform *c* is the output of the boxcar circuit. Under the control of the circuit **41**, the antenna will be moved by trial and error until the modulation of the boxcar circuit is a maximum. This will occur when the target is on the boresight axis, since the parabolic antenna output is a maximum there and the slot antenna output zero. The servomechanism then moves the antenna in such a direction as to maintain this condition.

While a specific embodiment of the invention has been shown and described, obvious modifications can be made thereto without departing from the spirit of the invention. For example, instead of the Cassegrainian type feed, the parabolic antenna may be fed from a horn at the focus thereof, the horn being an extension of the feed waveguide. Accordingly, the invention should be limited only by the scope of the appended claims.

What is claimed is:

1. A dual antenna comprising a pair of spaced paraboloids, one of said paraboloids being nested inside of the other paraboloid, the focal axis of the paraboloids being collinear, said one of said paraboloids being fed in normal fashion, resulting in a parabolic antenna with a pencil beam, and means to feed the annular slot formed by the peripheries of said paraboloids in such a manner as to form a radially symmetrical beam about said focal axis with a null on said axis.

2. The dual antenna of claim **1** wherein said one of said paraboloids is fed by means of a hollow waveguide which projects through the vertices of both paraboloids from the rear and is conductively connected to said one of said paraboloids, and said annular slot is fed by means of a coaxial line which communicates with the space between said paraboloids, the inner conductor of said coaxial line being the outer surface of said hollow waveguide.

3. The dual antenna of claim **1** wherein said hollow waveguide has a circular cross-section.

4. The structure of claim **1**, further including a radar transmitter, means to alternately apply the output of said transmitter to said parabolic antenna and to said slot antenna, and means responsive to the amplitudes of target echoes received by said parabolic and slot antennas to move said structure in such direction that the boresight axis of said paraboloids remains fixed on the source of said target echoes.

5. A dual microwave antenna comprising a pair of nested and spaced paraboloids, means to feed the inner paraboloid from tthe focal area thereof to form a pencil beam, and means to feed the annular slot defined by the peripheries of said nested and spaced paraboloids in such a manner as to form a split-lobed beam with a null on the focal or boresight axis of said paraboloids.

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