Nov. 24, 1953 G. LEY ET AL 2,660,722

RADIO SCANNING SYSTEM

Filed July 22, 1950

Fig.1.

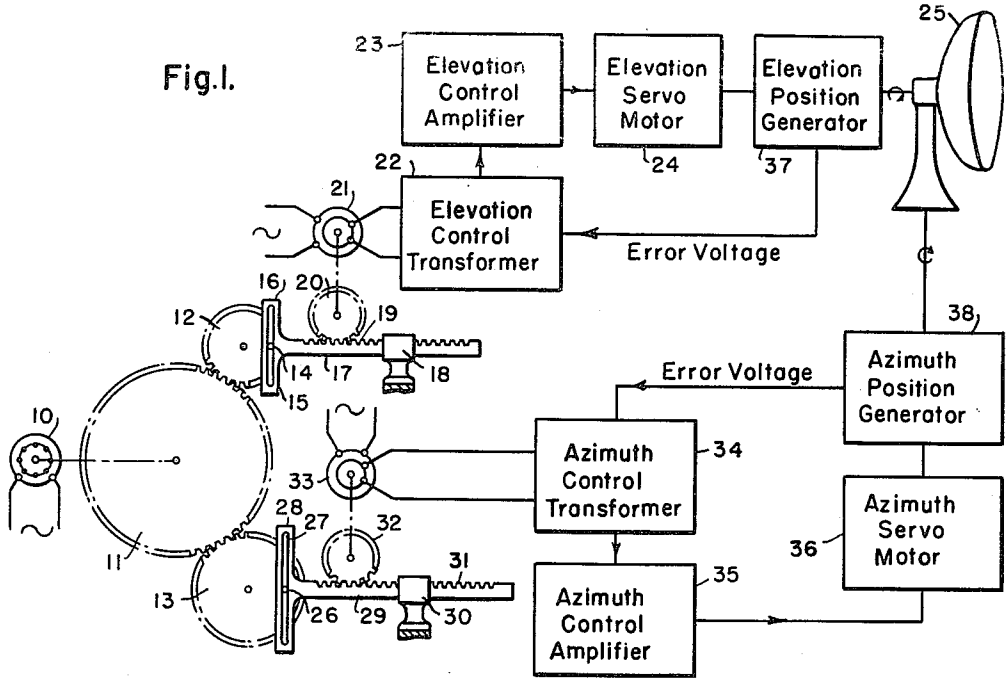


Fig.2.

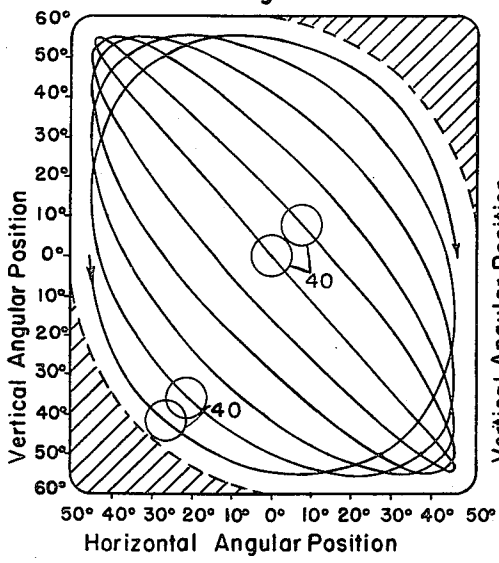
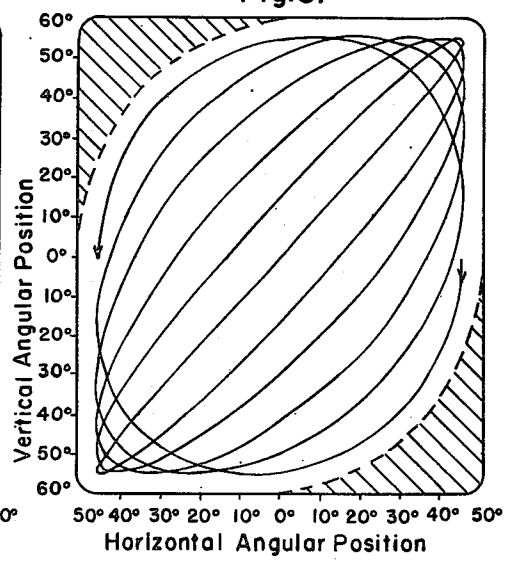


Fig.3.



WITNESSES:

E. A. McElskey.

R. G. Brodahl

INVENTORS

Gordon Ley and

Charles H. Jones.

BY

F. E. Browder

ATTORNEY

Patented Nov. 24, 1953

2,660,722

UNITED STATES PATENT OFFICE

2,660,722

RADIO SCANNING SYSTEM

Gordon Ley and Charles H. Jones, Pittsburgh, Pa., assignors, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application July 22, 1950, Serial No. 175,404

6 Claims. (Cl. 343—100)

1

This invention relates to directional scanning antennas for use in radar systems.

In some radar systems, the scanning antennas are required to search rectangular areas. In the past this has been accomplished by starting at the upper left-hand corner and sweeping horizontally across, and by then stepping down and sweeping horizontally back, this being repeated until the entire area is swept. This method requires limit switches for reversing the horizontal and vertical drive motors.

According to this invention, a scanning antenna is moved vertically up and down periodically to substantially follow a sine wave or triangular wave of position as a function of time, while at the same time it is moved horizontally back and forth periodically to substantially follow a sine wave or triangular wave of position as a function of time, at a higher or a lower frequency. This results in the scan beam tracing the pattern of a Lissajous figure while it sweeps a rectangular area at a faster rate than the prior parallel sweeps, and without the previously required limit switches. Another feature of this invention is that the scanning traces overlap over most of the area searched.

An object of this invention is to increase the rate of search of a rectangular area by a scanning antenna.

Another object of the invention is to simplify scanning antennas used for searching rectangular areas.

Another object of the invention is to more thoroughly search a rectangular area with a scanning antenna.

Another object of the invention is to search an area with a scanning beam which forms a Lissajous figure.

The invention will now be described with reference to the drawing, of which:

Figure 1 is a simplified diagrammatic view of one embodiment of this invention;

Fig. 2 is a graph illustrating the first half of a search pattern provided by the apparatus of Fig. 1, and

Fig. 3 is a graph illustrating the second half of the search pattern.

Referring now to Fig. 1 of the drawing, the constant speed, electric motor 10 rotates the gear 11 of relatively large diameter which is meshed with the gears 12 and 13 of relatively small diameter, the gear 13 having, however, a larger diameter than the gear 12.

The gear 12 has adjacent its perimeter, the pin 14 in the slot 15 in the crosshead 16. The

2

crosshead 16 has attached thereto the arm 17 which is slidable horizontally in the fixed support 18, and which has the gear teeth 19 on its upper surface. The teeth 19 are meshed with the gear 20 which drives the elevation Selsyn generator 21.

The generator 21 is connected through the control transformer 22 and the elevation control amplifier 23 to the elevation servo-motor 24 which is connected through the elevation position generator 37 to the vertical drive of the scanning antenna 25. Error voltages from the generator 37 are fed back to the transformer 22 as is usual.

The gear 13 has adjacent its perimeter, the pin 26 in the slot 27 of the crosshead 28. The crosshead 28 has attached thereto the arm 29 which is slidable horizontally in the fixed support 30, and which has the gear teeth 31 on its upper surface. The teeth 31 are meshed with the gear 32 which drives the azimuth Selsyn generator 33.

The generator 33 is connected through the azimuth control transformer 34, azimuth control amplifier 35 to the azimuth servo-motor 36 which is connected through the azimuth position generator 38 to the horizontal drive of the antenna 25. Error voltages from the generator 38 are fed back in the usual manner to the transformer 34.

In operation, as the gears 12 and 13 are rotated by the gear 11, the motions of the pins 14 and 26 in the slots of the crossheads 16 and 28 respectively, cause the arms 17 and 29 to reciprocate horizontally in sine waves of acceleration as a function of time. This causes the gears 20 and 32 of the generators 21 and 23 respectively, to rotate back and forth, and to deliver sine wave voltages to the control transformers 22 and 34 respectively.

The voltage from the generator 21 is supplied through the transformer 22 and the amplifier 23 to the servo-motor 24 which moves the antenna vertically up and down in a sine wave of acceleration as a function of time, similar to that imparted to the generator 21.

The voltage from the generator 33 is supplied through the transformer 34 and the amplifier 35 to the servo-motor 36 which moves the antenna back and forth horizontally in a sine wave of acceleration as a function of time, similar to that imparted to the generator 33.

The ratio of the pitch diameters of the azimuth and elevation gears 13 and 12 should be the same as the scanning ratio, typically 10:9 or 15:14, etc.

The ratio of the diameter of the azimuth gear

13 to that of the elevation gear 12 should be such that the elevation gear is driven at a speed about 10% higher than that of the azimuth gear. This phase displacement causes the scanning beam 40 to rotate and to form a Lissajous figure as illustrated by Figs. 2 and 3, the arrows on the scanning traces illustrating the direction of rotation.

The result will be a sweep such as is illustrated by Fig. 2, followed by a sweep such as that illustrated by Fig. 3, after which the sweep of Fig. 2 will be repeated, etc.

The unsearched area in two of the corners of Fig. 2 is seen to be searched by the sweep of Fig. 3, and the unsearched area in two of the corners of Fig. 3 is seen to be searched by the following sweep of Fig. 2.

This Lissajous type sweep covers the same area in 11.5 seconds that the conventional parallel sweeps covers in 12.6 seconds.

Figs. 2 and 3 assume that the antenna has a 10° beam, and 10° between half-power points. They also assume a maximum allowance acceleration of 425° per second squared, and a maximum allowable velocity of 150° per second.

As illustrated by Figs. 2 and 3, the scanning spots 40 overlap except at the very center of the area where they are tangent. With parallel and spiral searches the traces are tangent over the entire area.

Square waves of acceleration as a function of time can be used instead of the illustrated sine waves with little effect on the form of the sweep illustrated by Figs. 2 and 3, and would result in about a 10% saving in time.

While the Lissajous type of search is particularly suited for scanning rectangular areas, its simplicity of generation shows it has advantages over the conventional spiral search method as well as over the conventional parallel search method.

We claim as our invention:

1. An antenna system comprising a directional antenna, first motor means having a rotor for cyclically moving said antenna alternatey in opposite directions at one frequency, and second motor means having a rotor for cyclically moving said antenna alternately in opposite directions different from said first-mentioned directions, and at a frequency different from said one frequency, and control means for effecting the rotation of said rotors at respectively predetermined frequencies.

2. An antenna system comprising a directional antenna, means including a first motor having a rotor for cyclically moving said antenna vertically up and down at one frequency, and means

including a second motor having a rotor for cyclically moving said antenna horizontally back and forth at a frequency different from said one frequency such that a substantially Lissajous figure is formed.

3. An antenna system comprising a directional antenna, means including an elevation servo-motor for moving said antenna vertically up and down, means including an azimuth servo-motor for moving said antenna horizontally back and forth, an elevation Selsyn generator having a rotor and connected to said elevation servo-motor, an azimuth Selsyn generator having a rotor and connected to said azimuth servo-motor, and means for cyclically rotating the rotors of said generators in opposite directions at different frequencies.

4. An antenna system comprising a directional antenna, means including an elevation motor having a rotor for moving said antenna vertically up and down, means including an azimuth motor having a rotor for moving said antenna horizontally back and forth, and means for cyclically rotating the rotors of said motors in opposite directions at different frequencies.

5. An antenna system comprising a directional antenna, means including a first motor having a rotor and adapted for moving said antenna in opposite directions, means including a second motor having a rotor and adapted for moving said antenna in opposite directions different from said first-mentioned directions, and means for cyclically rotating the rotors of said motors in opposite directions at different frequencies.

6. An antenna system comprising a directional antenna, means including a first servo-motor for moving said antenna in opposite directions, means including a second servo-motor for moving said antenna in opposite directions different from said first-mentioned directions, a first Selsyn generator having a rotor and being connected to said first servo-motor, a second Selsyn generator having a rotor and connected to said second servo-motor, and means for cyclically rotating the rotors of said generators in opposite directions at different frequencies.

GORDON LEY.
CHARLES H. JONES.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,231,929	Lyman	Feb. 18, 1941
2,410,666	Leck	Nov. 5, 1946
2,410,831	Maybarduk et al.	Nov. 12, 1946
2,526,314	Alexanderson et al.	Oct. 17, 1950