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Kreinheder

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[54] MONOPULSE SWITCHING SYSTEM

[75] Inventor: **Donald E. Kreinheder**, Los Angeles, Calif.

[73] Assignee: **Hughes Aircraft Company**, Culver City, Calif.

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[52] **U.S. Cl.** .....**343/16 M**, 343/7.4

[51] **Int. Cl.**.....**G01s 9/22**

[58] **Field of Search** .....343/7.4, 11, 16, 16 M

[56] **References Cited**

UNITED STATES PATENTS

2,464,822	3/1949	Mallett	343/16
2,594,317	4/1952	Lancar	343/7.4
2,597,862	5/1952	Greig	343/17.1
2,759,154	8/1956	Smith	343/7.4

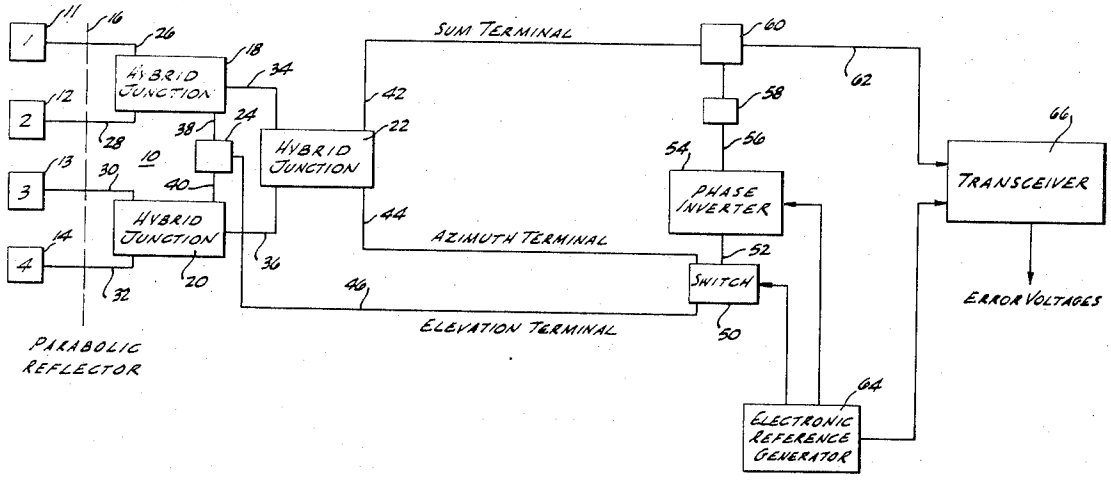
Primary Examiner—Malcolm F. Hubler

Attorney—James K. Haskell and Earnest F. Oberheim

EXEMPLARY CLAIM

6. An electronic lobe switching system for locating a target in space comprising: a simultaneous lobing antenna including four symmetrically positioned radiators defining the corners of a square, and a plurality of intercoupled hybrid junctions having four input terminals, a sum output terminal, an azimuth output terminal and an elevation output terminal, each of said radiators being coupled to one of said input terminals and adapted to excite a microwave signal therein representative of a microwave signal received from said target, said plurality of hybrid junctions being adapted to develop a sum signal in said sum terminal, an azimuth signal in said azimuth terminal and an elevation signal in said elevation terminal representative of the range, the azimuth and the elevation of said target respectively; a receiver responsive to a microwave error signal and a reference signal and adapted to develop demodulated error voltages representative of the azimuth and elevation of said target; and a switching circuit responsive to said sum signal, said azimuth signal and said elevation signal and coupling and said simultaneous lobing antenna to said receiver, said switching circuit being adapted to develop said microwave error signal and including a microwave two-channel switch, a microwave phase inverter, adder means, and an electronic reference generator for developing said reference signal and first and second control signals, said switch being coupled to said phase inverter and to said generator and responsive to said first control signal for sequentially applying either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being coupled to said generator and being responsive to said second control signal for sequentially introducing a 180° phase shift to the sequentially applied azimuth or elevation signal, and adder means coupling said phase inverter to said sum terminal and being adapted to mix the sequentially phase-inverted signal from said phase inverter and said sum signal to develop said microwave error signal.

8 Claims, 4 Drawing Figures



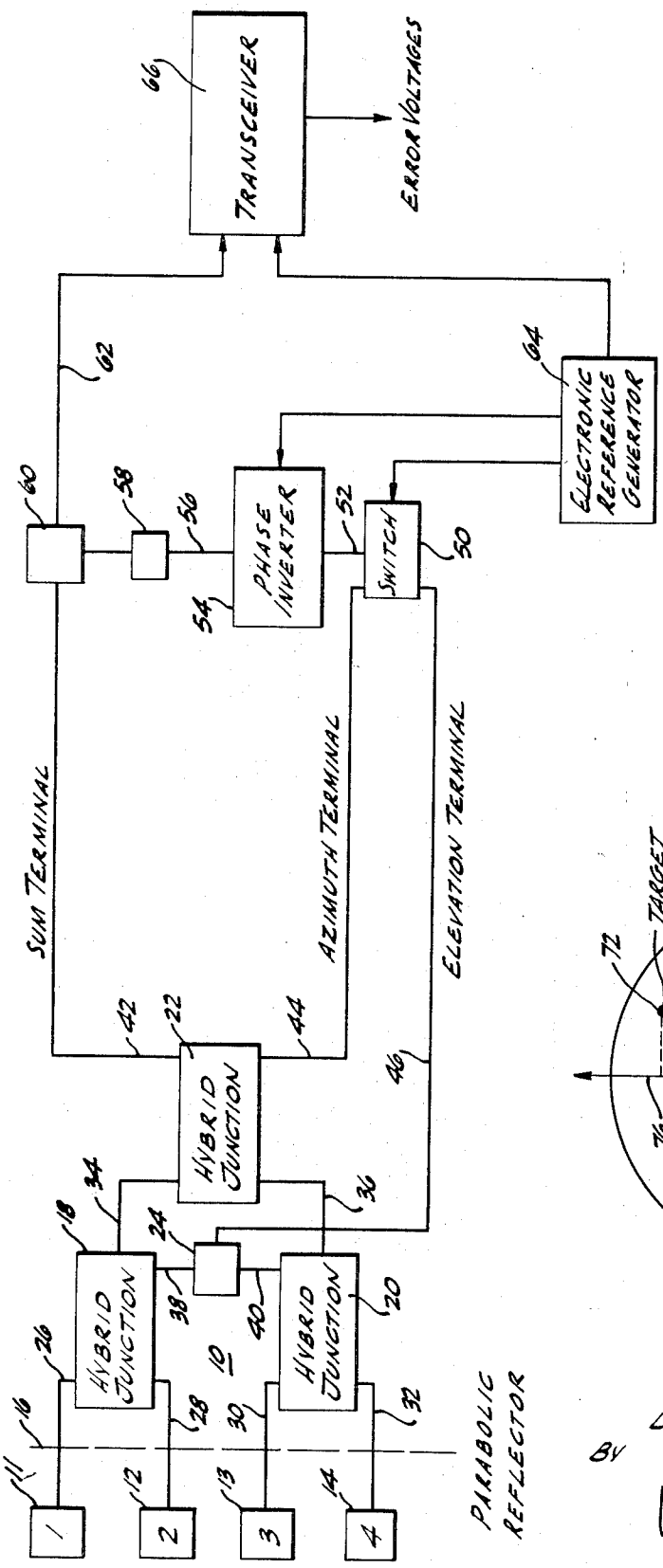


FIG. 1.

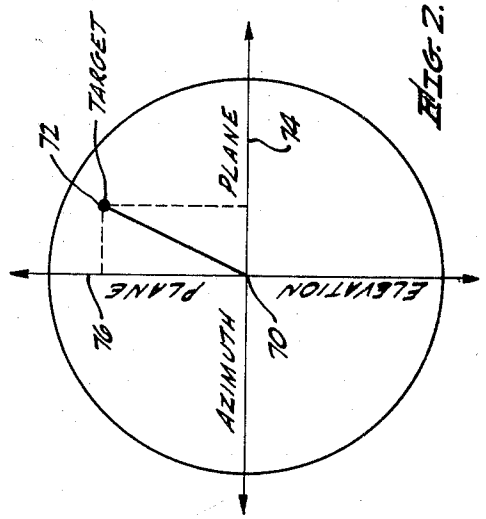


FIG. 2.

INVENTOR.
DONALD E. KREINHEDER,
BY
Harvey J. Lanshurst
AGENT

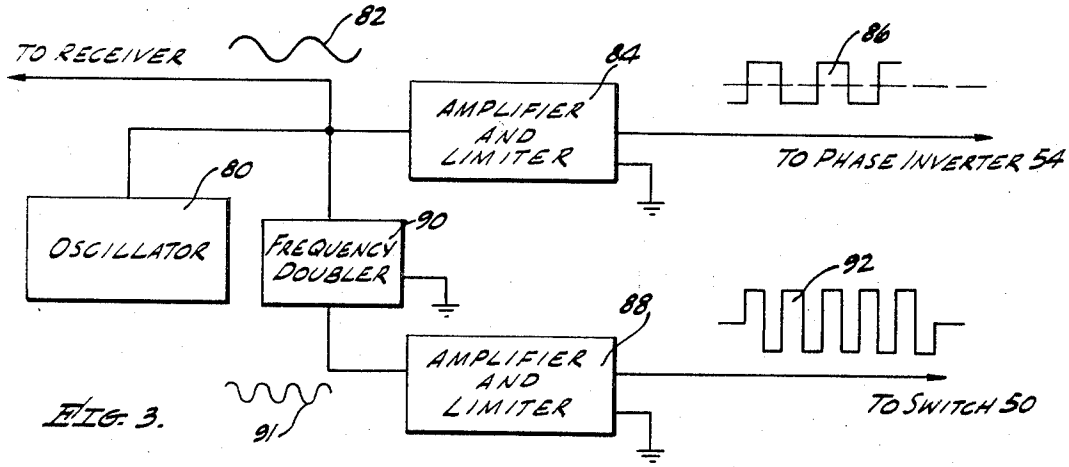


FIG. 3.

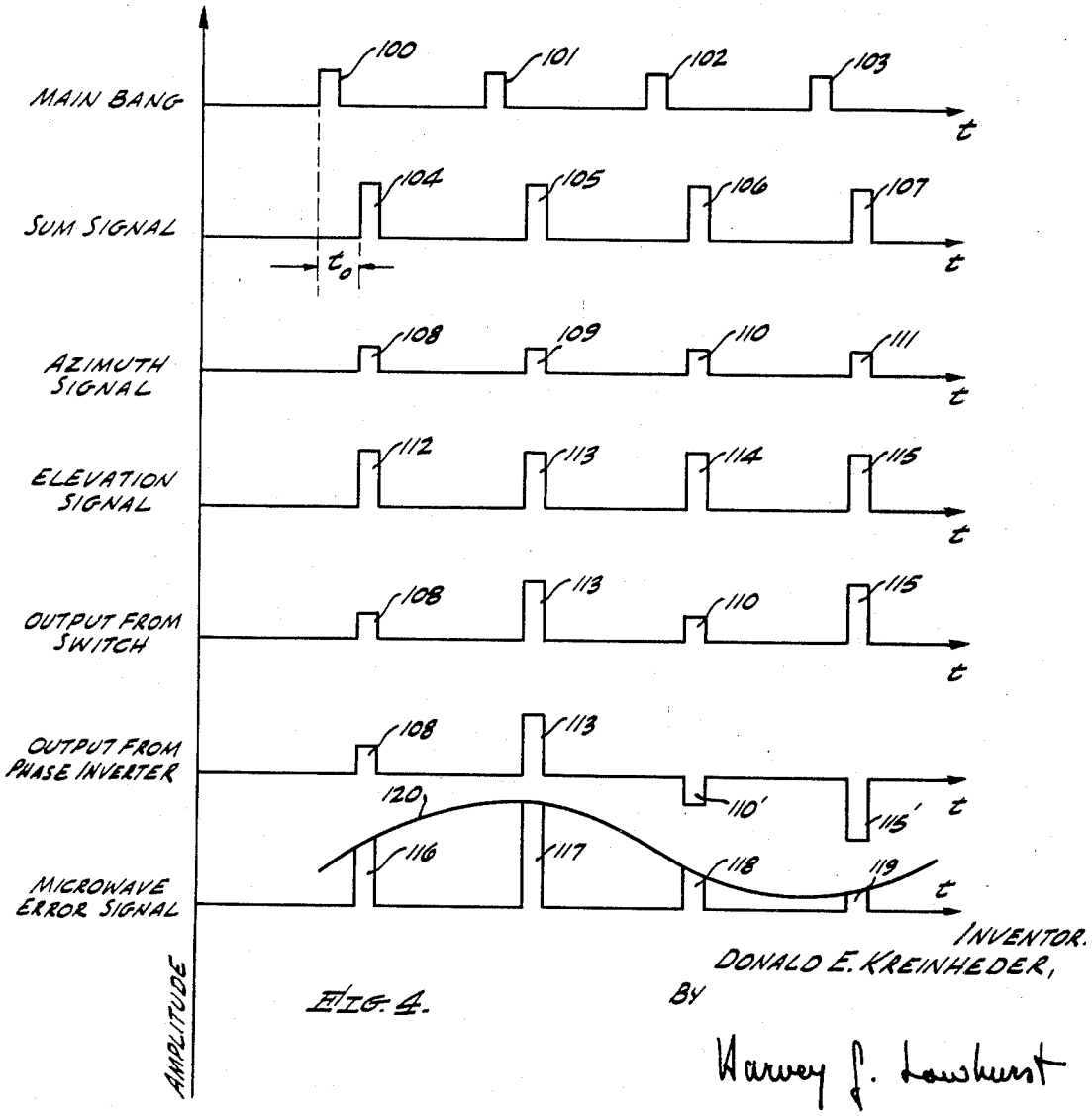


FIG. 4.

INVENTOR.
DONALD E. KREINHEDER,
BY
Harvey J. Lawhurst
AGENT.

MONOPULSE SWITCHING SYSTEM

This invention relates to tracking systems, and more particularly, to an electronic lobe switching means for and a method of intercoupling a simultaneous lobing antenna and a single channel microwave receiver to provide a wave energy tracking system.

Simultaneous lobing systems of the prior art for tracking a target utilize a single stationary wave energy beam for illuminating the target which, upon reflection, provides an echo signal from which the desired position information of the target may be abstracted. The antenna of such a system, which is designated as a simultaneous lobing antenna includes four symmetrically spaced radiator elements which are equally excited by the transmitter of the system to provide the illuminating beam. These four radiator elements are also coupled to the receivers of the system and are excited by the echo signal to provide information of the target location. The four signals developed by the four radiators are mixed in a phase and amplitude sensitive hybrid junction means, usually comprising three or four hybrid junctions to develop simultaneous lobing antenna output signals designated as the sum signal, azimuth signal, and the elevation signal.

The relative amplitudes and phases of the waves excited in the radiators by the echo signal are proportional to the angular position of the target in a plane perpendicular to the axis of symmetry of the four radiator elements. By comparing the relative amplitudes and phases of the waves in the four radiators with one another, two space quadrature difference signals designated herein as the azimuth signal and the elevation signal may be developed which give the angular position of the target in terms of rectangular coordinates.

In practice, this position information is utilized to maintain the symmetry axis in coincidence with the line of sight in much the same manner as used in conical scan tracking techniques by using a feedback system including a torquer system to move and constantly maintain the antenna axis in coincidence with the line of sight.

In a monopulse system, which most commonly employs a simultaneous lobing antenna and which, for the purpose of this specification, is defined as a system capable of providing complete position data upon transmission of a single pulse, the three output signals received from the simultaneous lobing antenna are fed to three different microwave receivers for demodulation. The output of each receiver is combined and its phase detected to obtain complete position information.

The desirable major characteristics of a tracking system are complete absence of moving parts in the antenna, electrical simplicity of the receiver system and ability to provide complete positional target information in a short time interval. The conventional monopulse tracking system hereabove described requires three microwave receivers which introduce great electrical complexity and require additional space in an otherwise desirable tracking system.

It is therefore an object of this invention to provide a wave energy tracking system incorporating the advantages of the monopulse tracking system while at the same time requiring but a single microwave receiver.

It is a further object of this invention to provide a wave energy tracking system which provides complete position information of a target by means of four consecutive pulses and which requires but a single microwave receiver.

It is a still further object of this invention to provide a new method for tracking targets in space incorporating simultaneous lobing antenna techniques and electronically intermixing the antenna output signals to develop a single microwave error signal.

It is a still further object of this invention to provide a method of tracking targets in space which is simple and reliable in operations and which substantially decreases the complexity attendant in conventional monopulse tracking systems.

In accordance with one embodiment of this invention a conventional simultaneous lobing antenna is utilized which provides three output signals respectively designated as sum, azimuth, and elevation output signals. Instead of providing a microwave receiver for each of these output signals the output signals themselves are combined to provide a single microwave error signal. The intermixing of the signals is undertaken in much the same way as a carrier is modulated by information. More particularly, the sum signal furnishes a convenient pulsed carrier and the azimuth signal and the elevation signal are selectively added to or subtracted from the sum signal. This selective combination takes place in accordance with a predetermined scheme such as may be provided by a programming unit.

The sum signal, after having impressed upon it the azimuth and the elevation signals, is designated as the microwave error signal. Them microwave error signal which includes complete position information of the target is then demodulated in a single receiver. A reference signal from the programming unit is then utilized for detecting the phase of the demodulated microwave error signal in accordance with the prior modulation. Upon phase detecting, error voltages representative of the azimuth and the elevation of the target are obtained.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

FIG. 1 is a schematic block diagram of the wave energy tracking system in accordance with this invention;

FIG. 2 is an illustrative diagram showing the geometrical position of a target with respect to the simultaneous lobing planes;

FIG. 3 is a schematic block diagram of an embodiment of the electronic reference generator included in the system of FIG. 1; and

FIG. 4 is an illustrative diagram showing the correspondence between designated signals on a time-amplitude basis.

Referring now to the drawings wherein like reference characters designate like parts and particularly to FIG. 1 there is shown schematically a conventional simultaneous lobing antenna **10** coupled to a switching circuit which switching circuit is an important factor of this invention. The simultaneous lobing antenna **10** includes four radiators **11**, **12**, **13** and **14** which are symmetrically positioned within a parabolic reflector schematically indicated by a dotted line **16** and usually occupy the corners of a square. The simultaneous lobing antenna **10** also includes a hybrid junction means made up of three hybrid junctions **18**, **20** and **22** and a T-junction **24**. It is self evident to those skilled in the art that a fourth hybrid junction may be substituted for the T-junction wherein the difference branch arm is terminated in a matched load.

The pair of radiators **11** and **12** are directly coupled to the symmetry branch arms **26** and **28** of hybrid junction **18** and the pair of radiators **13** and **14** are coupled to the symmetry branch arms **30** and **32** of hybrid junction **20**. The radiators **11** – **14** may be dipoles, waveguide horns, or slots. The sum branch arm **34** of hybrid junction **18** and the sum branch arm **36** of hybrid junction **20** are each coupled to a different symmetry branch arm of hybrid junction **24**. The difference branch arm **38** of hybrid junction **18** and difference branch arm **40** of hybrid junction **20** are each coupled to a different terminal of the T-junction **24**. In this manner, the hybrid junction means is adapted to provide vector addition and subtraction of the wave energy excited by the radiators between all radiators taken in pairs.

The simultaneous lobing antenna **10** has three output terminals which are respectively designated as the sum output terminal **42**, the azimuth output terminal **44** and the elevation output terminal **46** and which are respectively the sum and difference branch arm of hybrid junction **22** and the leg of the T-junction **24**.

The azimuth terminal **44** and the elevation terminal **46** are both coupled to a two-channel microwave switch **50**, the operation of which is controlled by a first control signal. In contradistinction to microwave signals, the control signal is an electrical signal whose frequency is in the range of 10 to 10,000 cycles per second. The switch **50** operates like a single-pole, double-throw switch and in accordance with the control signal impresses either the signal from the elevation terminal **46** or the signal from the azimuth terminal **44**, but not both, to the output terminal **52**. Such microwave switches are well known in the art. By way of example, a ferrite microwave switch is described in detail in, High Speed Ferrite Microwave Switches, by George S. Uebele, published in the IRE Convention Record, **1957** National Convention, Part 1, Pages 227–234.

The output terminal **52** of the switch **50** is coupled to a phase inverter **54**, the operation of which is likewise controlled by a second control signal. This second control signal is similar in character to the first control signal but has a frequency which differs therefrom as will be explained in detail below. The function of the phase inverter **54** is to permit propagation of the signal from the switch **52** therethrough either, with or without subjecting the signal to a 180° phase shift as determined by the second control signal.

The output terminal **56** of the phase inverter **54** is coupled to the sum terminal **42** by means of an intercoupling network **60** which may be a vestigial Y-junction well known to those skilled in the art. A microwave gas discharge device **58** which may be a conventional TR tube is provided in the leg of the Y-junction **60** which upon being fired will prevent microwave energy traversing junction **60** from passing to the phase inverter **54**.

An electronic reference generator **64** which provides the first and the second control signal is coupled to the switch **50** and the phase inverter **52** as shown. The electronic reference generator also provides a reference signal which, as will be explained later, is used in the process of phase detecting the error voltages.

The combination of the two-channel switch **50**, the phase inverter **54**, the intercoupling network **60** and the electronic reference generator **64** is referred to as the switching circuit which intercouples the simultaneous lobing antenna **10** with a microwave transceiver **66**. The transceiver **66** is a conventional microwave receiver and transmitter combination such as is used with conical scan wave energy tracking systems. The switching circuit has a single microwave output terminal **62** which is coupled to the receiver **66** and a single electrical output for a reference signal which is coupled to the phase detector portion of the receiver **66**.

FIG. **2** shows the position of an assumed target **72** and its associated geometry when sighting along the symmetry axis **70** extending through the plane of the paper of the simultaneous lobing antenna **10**. The target **72** is located above the azimuth plane **74** and to the right of the elevation plane **76**. For the assumed target position the azimuth error of the target is approximately twice as large as the elevation error. It is further assumed that the radiators which occupy positions on lines making a **45** degree angle with the two planes **74** and **76** are so spaced that both the azimuth signal and the elevation signal are positive. The designation of a signal as positive denotes that the phase thereof is the same as the phase of the sum signal. In other words, the quadrant in which target **72** is located provides positive or in-phase error pulses for both the azimuth and the elevation signal.

The electronic reference generator **64** of FIG. **1** is shown in greater detail in FIG. **3** and includes as its basic component a master oscillator **80**. The oscillator **80** provides a sinusoidal output signal **82** which, as will be explained later on, is impressed on the receiver **66** for the purpose of phase detection. The oscillator **80** is also coupled to an amplifier and limiter **84** which converts the sinusoidal output signal **82** into a square wave **86** having the fundamental frequency of the oscillator **80**. The square wave **86** is the second control signal and is applied to the phase inverter **54** of FIG. **1** to control the operation of the phase inverter **54**.

The oscillator is also coupled to another amplifier and limiter **88** through a frequency doubler **90**. The frequency doubler **90** doubles the frequency of the sinusoidal output signal **82** to provide sine wave **91**. The amplifier and limiter **88** converts the sine wave **91** into a second square wave **92** having a fundamental frequency of twice that of the fundamental frequency of the oscillator **80**. The square wave **92** is the first control signal and is impressed on the switch **50** of FIG. **1** to control the single-pole double-throw switch.

The operation of the wave energy tracking system of this invention will now be explained with the aid of FIG. 4. A transmitter incorporated in the receiver **66** supplies pulsed microwave energy commonly referred to as the main bang or the main transmitted pulse to output terminal **62** of the switching circuit of FIG. 1. The main bang passes through the Y-junction **60** and fires the gas discharge device **58** thereby creating a short circuit at that coupling junction. If the gas discharge device is a conventional TR tube its location will be an integer number of half wavelengths from the junction point. The main bang then passes to the sum branch arm **42** of hybrid junction **22** wherein it is equally divided into two portions and transmitted by the associated symmetry branch arms thereof to the sum branch **34** and **36** of hybrid junctions **18** and **20** respectively. Hybrid junctions **18** and **20** further divide the main bang into equal portions and deliver one quarter of the wave energy of the main bang to each of the radiators **11**, **12**, **13** and **14**. The radiators so excited illuminate the target by generating a single beam whose axis is coincident with the axis of symmetry of the system. Actually the radiators give rise to four separate beams but for the purpose of discussing the illumination of the target the four beams may be considered as a single illuminating beam. FIG. **4** shows four successive main bang pulses, **100**, **101**, **102** and **103**.

The target reflects a portion of the illuminated wave energy which reflected wave again excites the radiators **11**, **12**, **13** and **14**. If the target is located at a point not lying on the symmetry axis of the antenna system such as the assumed target **72** in FIG. **2**, the excitations of the individual radiators will be out of phase. In fact, this phase difference in the excitation of the individual radiators provides the positional information of the location of the target.

The wave energy excited by means of the radiators **11** and **12** within the symmetry branch arms of the hybrid junctions **18** are vectorially added and subtracted therewithin so that the sum terminal **34** and the difference terminal **38** provide the respective vector sum and the vector difference. Similarly, the wave energy excited by means of the radiators **13** and **14** within the symmetry branch arms of the hybrid junction **20** are vectorially added and subtracted therewithin so that the sum terminal **36** and the difference terminal **40** provide respectively the vector sum and the vector difference.

The vector sums, respectively, of radiators **11** and **12** and radiators **13** and **14** are further vectorially added and subtracted in hybrid junction **22** from which is derived the vector sum of radiators **11** to **14** to provide the sum signal in sum terminal **42** and the vector difference providing the azimuth signal in azimuth terminal **44**. In a similar fashion, the T-junction **24** provides the sum of the phase difference between radiators **11** and **12** and radiators **13** and **14**, which sum gives rise to the elevation signal in the elevation terminal **46**.

FIG. **4** shows four consecutive pulses **104**, **105**, **106** and **107** of the sum signal. The time displacement t_0 between the pulse **100** of the main bang and the pulse **104** of the sum signal provides an indication of the range of the target, t_0 being the time it takes the wave energy to travel twice the distance from the simultaneous lobing antenna to the target.

The azimuth signal shown in FIG. **4** comprises the pulses **108**, **109**, **110** and **111**. The relative magnitude of the pulses is a direct indication of the azimuth angle of the target. The elevation signal also shown in FIG. **4** is designated by pulses **112**, **113**, **114** and **115**. The relative amplitude of the elevation pulse **112** is approximately twice the amplitude of the azimuth pulses **108** which is an indication that the elevation angle is twice as great as the azimuth angle. These relative magnitudes are in accord with the position of the target **72** in FIG. **2**.

The above three signals, namely the sum, azimuth and elevation signals are the output signals of the conventional simultaneous lobing antenna. Mixing of these signals is accomplished by the switching circuit of this invention which, by combining these signals, derives a single microwave signal.

The fundamental frequency of the master oscillator **80** of the electronic reference generator of FIG. **3** is one-quarter of the pulse repetition rate of the transmitter incorporated into transceiver **66** which originates the main bang. Hence, there are four main bang pulses to one cycle of the oscillator **80**.

The microwave switch **50** of FIG. **1** is actuated by the control signal **92** of FIG. **3** having a frequency twice that of the oscillator. Since the switch is brought to the same position every second pulse, the switch will alternately pass an azimuth signal pulse and an elevation signal pulse to the phase inverter. This is illustrated diagrammatically in FIG. **4** where the output from the switch consists of azimuth signal pulse **108** followed by elevation signal pulse **113** which again is followed by azimuth signal pulse **110** and elevation signal pulse **115**.

The pulse inverter **54** of FIG. **1** is actuated by the square wave signal **86** of FIG. **3** which has the same frequency as the oscillator and which will actuate the phase shifter twice during each oscillator cycle. In other words, the phase inverter **54** will let two pulse signals pass through without changing the phase and thereafter invert the phase of the next two pulses. In accordance with the designation of the term positive or in-phase, the inverted phase pulse will be negative. This can be seen diagrammatically in FIG. **4** where pulse **108** and pulse **113** from the switch **50** are permitted to pass freely through the phase inverter whereas pulse **110'** and **115'** have suffered a 180° phase shift with respect to the pulses from the switch **50**.

The output of the phase inverter is then combined with the sum signal in the Y-junction **60**. The result of this combination is shown diagrammatically in FIG. **4** where pulse **116** is a combination or addition of pulse **104** and **108**, pulse **117** is a combination of pulse **105** and **113**, pulse **118** is a combination of pulse **106** and **110'**, and pulse **119** is a combination of pulse **107** and **115'**. The pulses **116**, **117**, **118** and **119** provide the single microwave error signal having an envelope **120** which is the error envelope from which error voltages representative of the azimuth and elevation may be obtained by conventional demodulation taking place within the transceiver **66**.

More particularly, the microwave error signal of FIG. **4** whose envelope **120** has the same frequency as the reference signal **82** of FIG. **3** is applied to the standard microwave receiver incorporated into transceiver

66 which has a mixing stage, an IF stage, and which demodulates the microwave error signal to abstract therefrom the envelope 120. Thereafter, the envelope 120 is phase detected by means of the reference signal 82 by standard conical scan tracking methods as are well known to those skilled in the art.

There has been described a method and a means of utilizing a conventional simultaneous lobing antenna and combining the output of this antenna in such a way as to obtain a single microwave error signal which has modulated upon it information representative of the azimuth, the elevation and the range of the target. The switching means used in deriving the microwave error signal employs a microwave switch and a microwave phase inverter both of which are only required to handle very small amounts of wave energy power and which therefore can be very efficiently operated. The advantages which the wave energy tracking system of this invention provide are the use of a simultaneous lobing antenna system having no moving parts and therefore greater mechanical simplicity and a single microwave receiver as used in conical scanning techniques with a resultant saving of weight and space.

What is claimed as new is:

1. In an electronic lobe switching system for locating a target in space and including a monopulse antenna having three output terminals which provide respectively a sum signal, an azimuth signal and an elevation signal, a receiver responsive to a microwave error signal and a reference signal and adapted to develop corresponding demodulated error voltages therefrom, and a switching circuit responsive to said sum signal, said azimuth signal and said elevation signal and adapted to develop therefrom said microwave error signal, said switching circuit coupling said monopulse antenna to said receiver and comprising: a phase inverter; a microwave two-channel switch coupled to said phase inverter and responsive to a first control signal to selectively apply either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being responsive to a second control signal to selectively impart a 180° phase shift to the selectively applied azimuth or elevation signal; and adder means coupled to said phase inverter and responsive to said sum signal and the selectively phase-inverted signal derived from said phase inverter and adapted to develop said microwave error signal therefrom.

2. In an electronic lobe switching system for locating a target in space and including a monopulse antenna having three output terminals which provide respectively a sum signal, an azimuth signal and an elevation signal, a receiver responsive to a microwave error signal and a reference signal and adapted to develop corresponding demodulated error voltages therefrom, and a switching circuit responsive to said sum signal, said azimuth signal and said elevation signal and adapted to develop therefrom said microwave error signal, said switching circuit coupling said monopulse antenna to said receiver and comprising: a phase inverter; an electronic reference generator adapted to develop said reference signal, a first control signal and a second control signal; a microwave two-channel switch coupled to said phase inverter and to said generator and responsive to said first control signal to selectively apply either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being coupled to said generator and being responsive to said second control signal to sequentially impart a 180 degree phase shift to the selectively applied azimuth or elevation signal; and adder means coupled to said phase inverter and responsive to said sum signal and the sequentially phase-inverted signal derived from said phase inverter and adapted to develop said microwave error signal therefrom.

3. An electronic lobe switching system for locating a target in space comprising: a simultaneous lobing antenna including four symmetrically positioned radiators defining the corners of a square, and hybrid junction means having four input terminals, a sum output terminal, an azimuth output terminal and an elevation output terminal, each of said radiators being coupled to one of said input terminals and adapted to excite a microwave signal therein representative of a microwave signal received from said target, said hybrid junction means being adapted to develop a sum signal in said sum terminal, an azimuth signal in said azimuth terminal and an elevation signal in said elevation terminal representative of the range, the azimuth and the elevation of said target respectively; a receiver responsive to a microwave error signal and a reference signal and adapted to develop demodulated error voltages representative of the azimuth and elevation of said target; and a switching circuit coupling said simultaneous lobing antenna to said receiver, said switching circuit including a phase inverter; a microwave two-channel switch coupled to said phase inverter and responsive to a first control signal to selectively apply either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being responsive to a second control signal to selectively impart a 180° phase shift to the selectively applied azimuth or elevation signal, and adder means coupled to said phase inverter and responsive to said sum signal and the selectively phase-inverted signal derived from said phase inverter and adapted to develop said microwave error signal therefrom.

4. An electronic lobe switching system for locating a target in space comprising: a simultaneous lobing antenna including four symmetrically positioned radiators defining the corners of a square, and hybrid junction means having four input terminals, a sum output terminal, an azimuth output terminal and an elevation output terminal, each of said radiators being coupled to one of said input terminals and adapted to excite a microwave signal therein representative of a microwave signal received from said target, said hybrid junction means being adapted to develop a sum signal in said sum terminal, an azimuth signal in said azimuth terminal and an elevation signal in said elevation terminal representative of the range, the azimuth and the elevation of said target respectively; a receiver responsive to a microwave error signal and a reference signal and adapted to develop demodulated error voltages representative of the azimuth and elevation of said target; and a switching circuit coupling said simultaneous lobing antenna to said receiver, said switching circuit including a phase inverter, an electronic reference generator adapted to develop said reference signal, a first control signal and a second control signal, a microwave two-channel switch coupled to said phase

inverter and to said generator and responsive to said first control signal to sequentially apply either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being coupled to said generator and being responsive to said second control signal to sequentially impart a 180 degree phase shift to the sequentially applied azimuth or elevation signal, and adder means coupled to said phase inverter and responsive to said sum signal and the sequentially phase-inverted signal derived from said phase inverter and adapted to develop said microwave error signal therefrom.

5. An electronic lobe switching system for locating a target in space comprising: a simultaneous lobing antenna including four symmetrically positioned radiators defining the corners of a square, and a plurality of intercoupled hybrid junctions having four input terminals, a sum output terminal, an azimuth output terminal and an elevation output terminal, each of said radiators being coupled to one of said input terminals and adapted to excite a microwave signal therein representative of a microwave signal received from said target, said plurality of hybrid junctions being adapted to develop a sum signal in said sum terminal, an azimuth signal in said azimuth terminal and an elevation signal in said elevation terminal representative of the range, the azimuth and the elevation of said target respectively; a receiver responsive to a microwave error signal and a reference signal and adapted to develop demodulated error voltages representative of the azimuth and elevation of said target; and a switching circuit responsive to said sum signal, said azimuth signal and said elevation signal and coupling said simultaneous lobing antenna to said receiver, said switching circuit being adapted to develop said microwave error signal and including a microwave two-channel switch, a microwave phase inverter, and adder means, said switch being coupled to said phase inverter and responsive to a first control signal for sequentially applying either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being responsive to a second control signal for sequentially introducing a 180° phase shift to the sequentially applied azimuth or elevation signal, and adder means coupling said phase inverter to said sum terminal and being adapted to mix the sequentially phase-inverted signal from said phase inverter and said sum signal to develop said microwave error signal.

6. An electronic lobe switching system for locating a target in space comprising: a simultaneous lobing antenna including four symmetrically positioned radiators defining the corners of a square, and a plurality of intercoupled hybrid junctions having four input terminals, a sum output terminal, an azimuth output terminal and an elevation output terminal, each of said radiators being coupled to one of said input terminals and adapted to excite a microwave signal therein representative of a microwave signal received from said target, said plurality of hybrid junctions being adapted to develop a sum signal in said sum terminal, an azimuth signal in said azimuth terminal and an elevation signal in said elevation terminal representative of the range, the azimuth and the elevation of said target respectively; a receiver responsive to a microwave error signal and a reference signal and adapted to develop demodulated error voltages representative of the azimuth and elevation of said target; and a switching circuit responsive to said sum signal, said azimuth signal and said elevation signal and coupling said simultaneous lobing antenna to said receiver, said switching circuit being adapted to develop said microwave error signal and including a microwave two-channel switch, a microwave phase inverter, adder means, and an electronic reference generator for developing said reference signal and first and second control signals, said switch being coupled to said phase inverter and to said generator and responsive to said first control signal for sequentially applying either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being coupled to said generator and being responsive to said second control signal for sequentially introducing a 180° phase shift to the sequentially applied azimuth or elevation signal, and adder means coupling said phase inverter to said sum terminal and being adapted to mix the sequentially phase-inverted signal from said phase inverter and said sum signal to develop said microwave error signal.

7. An electronic lobe switching system for locating a target in space comprising: a simultaneous lobing antenna including four symmetrically positioned radiators defining the corners of a square, and a plurality of intercoupled hybrid junctions having four input terminals, a sum output terminal, an azimuth output terminal and an elevation output terminal, each of said radiators being coupled to one of said input terminals and adapted to excite a microwave signal therein representative of a microwave signal received from said target, said plurality of hybrid junctions being adapted to develop a sum signal in said sum terminal, an azimuth signal in said azimuth terminal and an elevation signal in said elevation terminal representative of the range, the azimuth and the elevation of said target respectively; and a switching circuit responsive to said sum signal, said azimuth signal and said elevation signal coupled to said simultaneous lobing antenna, said switching circuit being adapted to develop a microwave error signal and including a microwave two-channel switch, a microwave phase inverter and adder means, said switch being coupled to said phase inverter and responsive to a first control signal for sequentially applying either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being responsive to a second control signal for sequentially introducing a 180° phase shift to the sequentially applied azimuth or elevation signal, and adder means coupling said phase inverter to said sum terminal and being adapted to mix the sequentially phase-inverted signal from said phase inverter and said sum signal to develop said microwave error signal.

8. An electronic lobe switching system for locating a target in space comprising: a simultaneous lobing antenna including four symmetrically positioned radiators defining the corners of a square, and a plurality of intercoupled hybrid junctions having four input terminals, a sum output terminal, an azimuth output terminal and an elevation output terminal, each of said radiators being coupled to one of said input terminals and adapted to excite a microwave signal therein representative of a microwave signal received from said target, said plurality of hybrid junctions being adapted

to develop a sum signal in said sum terminal, an azimuth signal in said azimuth terminal and an elevation signal in said elevation terminal representative of the range, the azimuth and the elevation of said target respectively; and a switching circuit responsive to said sum signal, said azimuth signal and said elevation signal coupled to said simultaneous lobing antenna, said switching circuit being adapted to develop a microwave error signal and including a microwave two-channel switch, a microwave phase inverter, adder means, and an electronic reference generator for developing a reference signal and first and second control signals, said switch being coupled to said phase inverter and to said generator and responsive to said first control signal for sequentially applying either said azimuth signal or said elevation signal to said phase inverter, said phase inverter being coupled to said generator and being responsive to said second control signal for sequentially introducing a **180** degree phase shift to the sequentially applied azimuth or elevation signal, and adder means coupling said phase inverter to said sum terminal and adapted to mix the sequentially phase-inverted signal from said phase inverter and said sum signal to develop said microwave error signal.

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