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Stavis et al.

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[54] **MISSILE GUIDANCE SYSTEM**

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[21] Appl. No.: **87,491**

[52] **U.S. Cl.** **244/3.15,** 244/3.19

[51] **Int. Cl.** .. **F42b 15/02,** F42b 15/00, F42b 15/10

[58] **Field of Search** ..... 244/14, 14.3, 14.55, 3.15; 250/83.3 UV; 102/50; 343/7, 7.4

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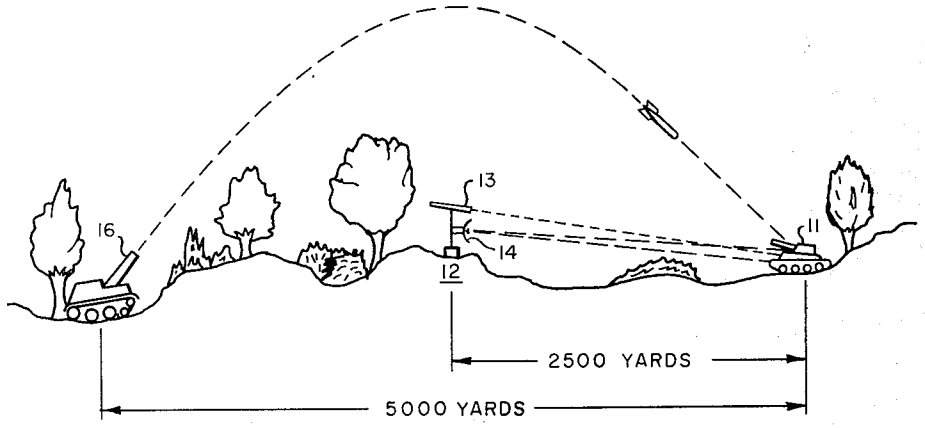
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Assistant Examiner—Thomas H. Webb
Attorney, Agent, or Firm—T. W. Kennedy

EXEMPLARY CLAIM

1. A missile guidance system comprising, a missile carrying a microwave receiver and beam antenna, means adapted to fire said missile in the general direction of a target, a stationary microwave transmitter irradiating said target and its vicinity by a single beam, means conically rotating said beam at a first rate about a line joining said transmitter and said target, the conical angle thereof being substantially equal to the beam angular width, means conically rotating the beam direction of said receiver antenna at a second rate whereby at a selected first range said receiver perceives and receives said irradiation reflection modulated at said second rate, means demodulating the received modulation to secure a signal having a frequency determined by said second rate and a phase relative to a datum line on said missile, means steering said missile coarsely toward said target in accordance with the phase of said signal, means in said receiver operative at a selected second range less than said first range for receiving said irradiation reflection and demodulating said first rate modulation thereof to form a second signal having a determinable phase, and means steering said missile in fine guidance mode toward said target in accordance with the phase of said second signal.

5 Claims, 7 Drawing Figures



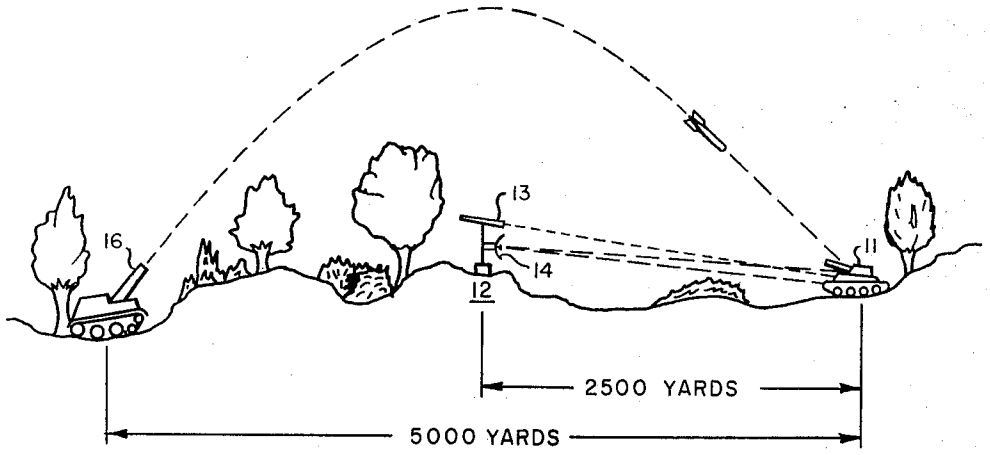


Fig. 1

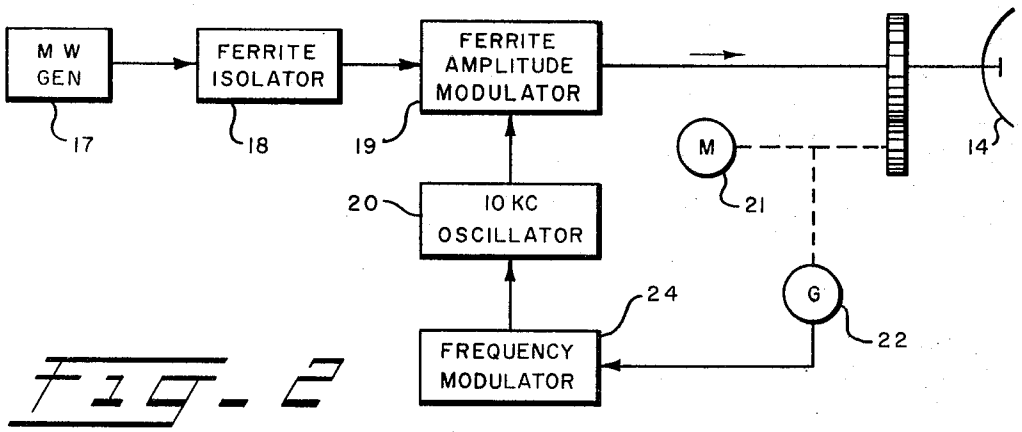


Fig. 2

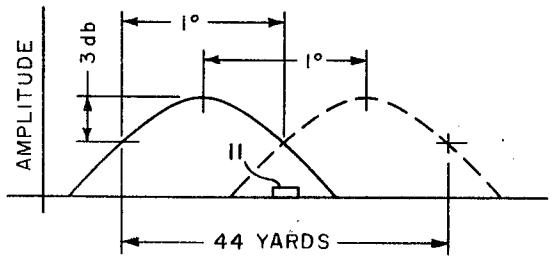


Fig. 3

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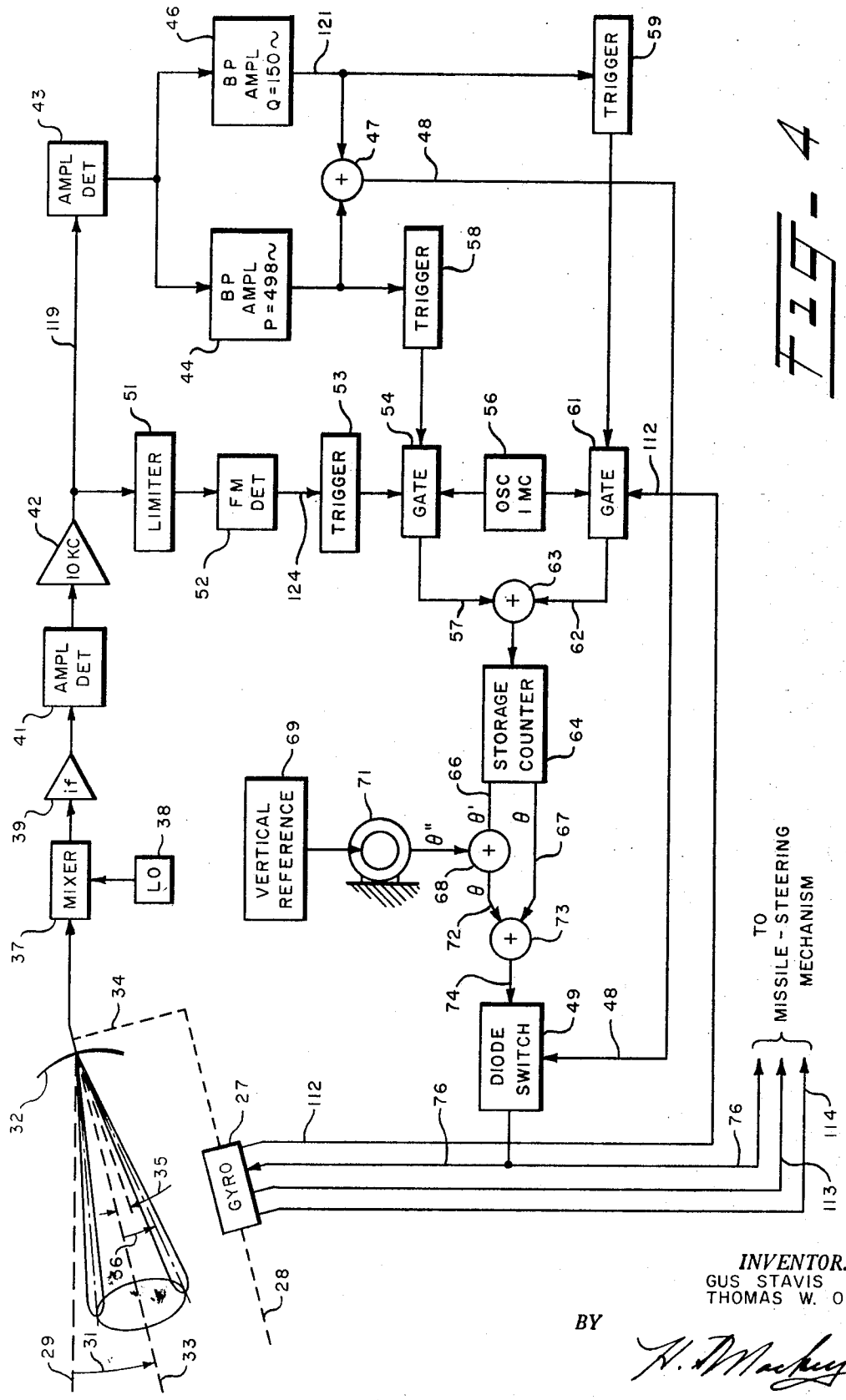


FIG. 4

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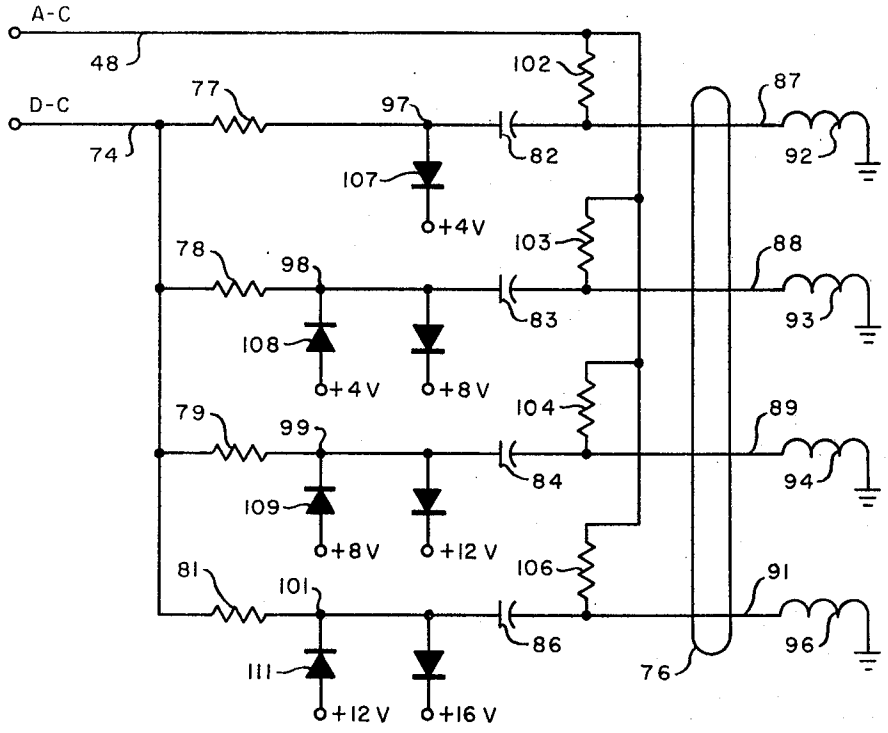


Fig. 5

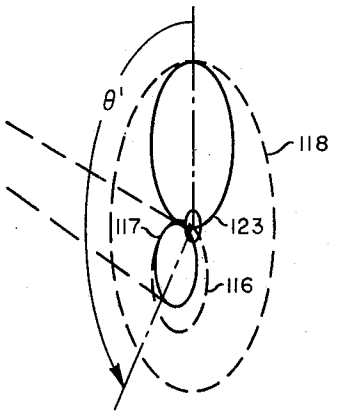


Fig. 7

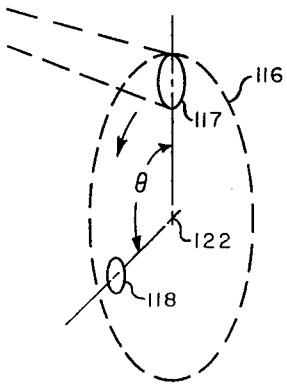


Fig. 6

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MISSILE GUIDANCE SYSTEM

The invention herein described was made in the course of or under a contract, or subcontract thereunder, with the Department of the Army.

This invention relates to radar guidance systems and particularly to semi-active radar systems applied to the guidance of missiles.

The problem of accurate ground-to-ground missile guidance involves more than mere aiming at launch when no target misses are permitted. In this case, terminal guidance is required and a target-seeking principle is desirable. When a radio or radar target seeker is employed it should be proof against countermeasures which, for example, would make the radar reflectivity of the target indistinguishable from that of its background. For tactical use against mobile targets it is practically necessary for the guidance system to have pinpoint accuracy and to have such reliability as to hit its target on the first shot in every case.

The present invention meets these requirements and, in addition, is insensitive to ground clutter and other interfering effects reducing the effectiveness of low altitude radars. The invention employs a radar transmitter on the ground at the missile firing point or at an advanced post. It also employs a radar receiver in the missile. Both the transmitter and receiver employ single-beam antennas, and both antenna beams are conically rotated or scanned, but at different rates.

In a typical situation, a target tank is dug into the forward slope of a hillside and is so concealed that its radar reflectivity is indistinguishable from that of its background. A missile firing battery faces the target at a range of 5,000 yards. An observation post at 2,500-yard range has a clear view of the target and is connected by a channel of signal communication with the firing battery. The observation post radar transmitter is connected to a sighting device, which may be an optical or infrared telescopic sight, so that the radar transmitting pointing direction is at all times that of the sighting device.

In operation, the sighting device is aimed at a selected vulnerable point of the target and the transmitter is turned on. Its beam irradiates the target and surroundings with a beam having 1° angle and turning conically at a rate, P, so that its axis describes a circle at the target, which is centered at the aiming point. At a signal the missile is fired toward the target. Its radar receiver receives the radar energy reflected from the target and its background, but at long ranges perceives this reflecting area as a point source. The rotated receiving antenna scans the target vicinity at a rate, Q, and, perceiving the radar reflections during a part of each antenna revolution, observes the received phase and from it the deflection of the line of sight, from missile to target, from the missile axis, and generates a signal representing the deflection. At a selected range, say 1,800 yards, missile control elements including a gyroscope are activated. The received deflection signal is then employed to guide the missile toward its target. This is termed coarse guidance operation.

Upon closer approach, for example, at a range of 500 yards, the receiving system of the missile, now aimed generally at the reflecting area, perceives the ring pattern caused by the transmitter beam rotation at P revolutions per second. This actuates suitable circuits in the missile to cause it to seek the center of the ring pattern.

It thus homes on a target spot which may be as small as 1 yard in diameter. This is termed fine guidance operation.

An object of this invention is to provide a semi-active radar system for terminal guidance of a missile to a target.

Another object of this invention is to provide a ground radar transmitter and a receiver carried on a missile for homing the missile on a target which cannot be distinguished by radar from its background.

Another object of this invention is to provide an extremely accurate missile guidance system for complete reliability in causing a hit by the first missile fired.

A further understanding of this invention may be secured from the detailed description and drawings, in which:

FIG. **1** depicts a terrain profile showing a typical situation employing this invention.

FIG. **2** is a block schematic drawing of the microwave transmitter at the observation post.

FIG. **3** is a graph showing the distribution of transmitted irradiation at the target.

FIG. **4** is a block schematic drawing of the microwave receiver in the missile.

FIG. **5** is a schematic diagram of the diode switch.

FIG. **6** is an oblique drawing showing the pattern in the vicinity of the target as scanned by the receiver at a range of 1,500 yards.

FIG. **7** is an oblique drawing showing the target pattern as scanned by the receiver at a range of 200 yards.

Referring now to FIG. **1**, a target **11** consists of an enemy installation such as a tank which, by camouflage, has a radar reflectivity indistinguishable from its hillside background. The target is, however, perceivable from an observation post **12** by a sighting device which may be, for example, either an ocular telescope or infrared telescope **13.** The sighting device is secured to a microwave narrow-beam transmitting antenna **14** so that both are adjusted together to point in the target direction. A communication channel is set up between the observation post and a missile launcher **16.**

The missile launcher **16** is positioned at a range of 5,000 yards from target so that the missile can be fired toward the target. The accuracy need be only enough to insure that at a distance of 1,800 yards between missile and target a cone of 30° angle generated at the missile will include the target.

The construction of the missile includes means to maintain its axis approximately parallel to its line of flight and means, such as movable vanes or adjustable steering jets, to steer it toward the target under control of electrical signals. These elements are outside of the scope of this invention.

A microwave transmitter, FIG. **2,** is positioned at the observation post. It contains a microwave continuous-wave generator, **17,** which, through a ferrite isolator **18** and ferrite amplitude modulator **19** feeds the transmitting antenna **14.**

The antenna **14** emits a narrow beam of radiation having an angular width between 3 db points of 1°. This beam is rotated or scanned so that its axis sweeps a cone with an included angle of 1° having its apex at the transmitter. Thus the axial center line of this 1° cone, accurately aimed at a vulnerable point of the target, continuously transmits microwave energy which is 3 db below the beam axis energy. The beam is rotated at a

rate of 498 revolutions per second by a motor **21** but any other of several methods of beam scanning may be used instead.

Associated with the rotating beam is generator **22** emitting a 498 cps alternating waveform in which the phase progressively changes throughout one cycle of the beam rotation. This alternating waveform is sawtooth, but alternatively may be sinusoidal or of any other form satisfying the above requirement. This waveform is applied through a frequency modulator **24** to modulate the frequency of a 10 kcps oscillator **26.** The frequency excursion of the modulation may be whatever is desired. As an example, it is here chosen to be 255 cps, so that the oscillator **26** is modulated to emit a signal having a frequency varying between 9,745 cps and 10,255 cps.

This modulated 10 kcps signal is applied as modulating frequency to the modulator **19,** where it amplitude modulates the microwave energy before its application to the antenna.

In the operation of the microwave transmitter, a beam of microwave energy is rotated around the center of the target to form an irradiation pattern, as shown in FIG. **3.** The pattern laid on the target has a diameter of 44 yards at this range, and the accuracy of application is limited only by the accuracy of aiming. The center of the pattern can easily be positioned within a 3-foot circle on the target.

The microwave receiver carried by the missile is shown schematically in FIG. **4.** A gyroscope **27** is carried in two gimbal rings borne by the missile frame, so that when these rings are unlocked, the gyroscope rotor axis **28** has freedom to depart from alignment with the missle axis **29** by any amount up to 8°. This gimbal angle is shown as angle **31** in FIG. **4.** A microwave dish antenna **32** is fixed to the gyroscope rotor so that as the rotor rotates, the antenna must rotate at the same speed. The identity of the antenna rotational axis **33** with the rotor axis **28** is indicated by the dashed line **34.** Thus the gyroscope has two distinct funtions: its gyroscopic inertia serves as an important part of the missile steering function, and the rotor, in rotating, rotates the antenna.

The antenna is fixed to the rotor by means of a hinge joint, so that although they always rotate together, the antenna dish axis can depart from the rotor axis by an angle having a minimum fixed at 1.4° and a maximum limited to 7½°. This angle is shown as angle **35** in FIG. **4.** Thus, as the rotor rotates, the antenna axis sweeps out a cone having an angle which is between 2.8° and 15°, with the cone axis coincident with the rotor axis.

The microwave antenna **32** is tuned to receive the frequency of transmission of the transmitter shown in FIG. **2.** The receiving energy pattern of antenna **32** constitutes a single beam having a width between 3 db points of 4°. Since the microwave feed component is fixed to the rotor and in line with its axis and the antenna dish reflector is hinged relative to the rotor axis, the beam axis angle relative to the rotor axis is double the antenna hinge angle, with limits 2.8° and 15°, as shown in FIG. **4** at **36.**

The electrical signal received from the antenna **32** is applied to a mixer **37,** where it is mixed with the output of a local oscillator **38** differing in frequency from the microwave carrier frequency by 30 mcps, the amount of the intermediate amplification frequency. The mixer output is applied to an intermediate frequency amplifier **39** having a 10 mcps transmission band centered at 30 mcps. The width of this transmission band permits some variations in the frequency of the local oscillator **38** and of the generator **17,** FIG. **2.**

The IF output is amplitude detected by detector **41,** recovering the 10 kcps average amplitude modulation, which is amplified in the amplifier **42.**

The 10 kcps average amplitude modulation is again amplitude detected by detector **43.** The outputs are amplified and separated by two bandpass amplifiers **44** and **45** having transmission band centers of 498 cps and 150 cps respectively. The outputs are added in an adding circuit **47,** the output of which is applied through conductor **48** to a diode switch **49.**

The output of 10 kcps amplifier **42** is also amplitude limited in a limiter **51,** then frequency demodulated in FM detector **52.** The resulting 498 cps frequency is applied to a trigger circuit **53,** where a pulse is generated at each cycle at a selected phase. This pulse train is applied to a gate circuit **54.** An independently oscillating generator **56** oscillates at 1 mcps. Its output is also applied to gate **54,** with the gate output imposed on conductor **57.**

The output of amplifier **44** is additionally applied to a trigger circuit **58** which emits a trigger pulse once each cycle at a selected phase. The output of trigger circuit **58** is applied to the gate circuit **54.** The output of amplifier **46** is additionally applied to a trigger circuit **59** which emits a trigger pulse once each cycle at a selected phase. The output of trigger circuit **59** is applied to gate circuit **61.**

Gate circuit **61** is similar to gate **54,** and imposes its output on condutor **62.** These gates are of the digital type, allowing transmission of the signal of oscillator **56** to the output between start and stop trigger pulse inputs. A design for such a gate is given in Pulse and Digital Techniques, by Millman and Taub, FIG. 14.21, Page 445.

The outputs of gates **61** and **54** imposed on conductors **62** and **57** are applied to an adding circuit **63,** and their sum is applied to a storage counter **64.** This counter is described in the Millman and Taub Publication, supra, on Page 351, and its circuit is shown in FIG. 11.28.

In the operation of this counter, an input at 1 mcps is started and stopped, for example, by gate **54,** at two selected phases within one cycle of the 498 cps input, and a direct-current output is emitted by the storage counter on conductor **66** representing by its magnitude the angular difference between the two selected phases. At the end of each cycle of the 498 cps input, the counter is restored to begin a new output amplitude in the next cycle. When the input is from the 150 cps filter through gate **61,** the output of the storage counter **64** is at conductor **67.**

The storage counter output is applied through conductor **66** to a summing circuit **68,** where the output is added to the output of a vertical reference **69,** its relation to the missile attitude being indicated by the symbol **71.** The summing circuit **68** performs algebraic addition of direct-current components, the algebraic sum being imposed on conductor **72.** This sum is added in adding circuit **73** to the signal in conductor **67.**

The sum output of adding circuit **73** in conductor **74** is applied to diode switch **49.** This switch emits a signal in cable **76** at a time during each revolution of the gyro-

scope **27** controlled by the signal in conductor **74** and having an amplitude controlled by the signal in conductor **48.** Cable **76** is also connected to the missile steering mechanism.

A circuit for the diode switch **49** is shown in FIG. **5.** The conductor **74** is connected through four resistors **77, 78, 79** and **81** and four capacitors **82, 83, 84** and **86** to the cable **76** containing the four conductors **87, 88, 89** and **91.** This cable **76** containing four conductors is connected to the gyroscope **27.** In the gyroscope four precessing coils **92, 93, 94** and **96** are distributed at 90° intervals around its gimbal suspension, and each coil is connected for excitation from a respective one of the four conductors **87, 88, 89** and **91.**

The four junctions **97, 98, 99** and **101** between the resistors and capacitors are connected to limiting diodes and limiting potentials of 4, 8, 12 and 16 volts so arranged that coil **92** is excited only when the potential applied from conductor **74** is between 0 and +4 volts, coil **93** is excited only when the potential is between 4 and 8 volts, coil **94** only when potential is between 8 and 12 volts and coil **96** only when potential is between 12 and 16 volts. Conductor **48** is connected through four resistors **102, 103, 104** and **106** to the four coils respectively.

The diode switch operates as follows. When the signal on conductor **74** is between 0 and +4 volts, diode **107** is nonconducting but diodes **108, 109** and **111** are conducting, shorting conductors **88, 89** and **91** to ground for alternating inputs. Meanwhile, alternating potential at either 498 cps or 150 cps is applied from conductor **48,** its potential amplitude representing the amount of pointing error and hence the amount of correction of gyroscope pointing direction needed. This signal is applied only to coil **92,** precessing the gyroscope in the quadrant controlled by that coil with a force proportional to the amount of existing pointing error. Similarly, voltages between 4 and 8 volts impress the amplitude signal on coil **93** only, the other coils being grounded, each through its capacitor and diodes, for alternating current.

It is to be noted that the signals on conductor **74** are unidirectional pulse signals having the coarse guidance operation rate of 150 cps or the fine guidance operation rate of 498 cps, and are always at the same rate as the alternating signals in conductor **48.**

A pulse signal is taken from the gyroscope **27** at the same selected phase in each revolution thereof and applied to gate **61** through conductor **112.**

The gyroscope **27** output conductor **113** carries a signal emitted by the gyroscope components representing the angular rate of movement of the gyroscope axis **28** toward the line of sight, which is the line between the missile and the target. The gyroscope output conductor **114** carries yaw and pitch damping signals. The conductors **76, 113** and **114** control the missile direction of flight through vanes or direction jets on the missile but these control devices are outside of the scope of this invention. They are employed in proportional navigation of the missile as described in the book Guidance, by Arthur S. Locke, on Pages 475–478.

The operation of the missile is divided into the ballistic phase and the guided or homing phase. The ballistic phase refers to the missile flight between launch and range of 1,800 yards from the target. The guided or homing phase refers to the last 1,800 yards of its flight terminated by impact on the target. The missile is preset at firing so that, during the ballistic phase, its gyroscope does not rotate and its gimbal rings are locked. Thus the antenna cone rotational axis **33** and rotor axis **28** are coincident with the missile axis **29.**

The antenna hinge bearings which hinge it to the gyroscope rotor are locked at their maximum angle, so that the antenna is canted or hinged with its reflector dish axis at the maximum mechanical angle **35** of 7½° to the rotor axis.

The operation of the receiver during the guided or homing phase, in the last 1,800 yards of its flight, can be divided into two modes or kinds of operation, the search mode and the locked-on mode. When locked on to the target echo signals and electrical signals are consequently being received, these signals are of two kinds or degrees of fineness, resulting in coarse guidance operation and fine guidance operation. These modes and operations merge into one another to some extent but for clarity they are described in the above order.

At 1,800 yards, operation is converted from the ballistic phase to the guided or homing phase by several actions which may be nearly or quite simultaneous, or partly overlapping, but which are described in the closely consecutive order in which they may occur.

First, a spring in the missile is released by a timing mechanism. This spring now spins the gyroscope rotor and accelerates it to a speed of 150 rps in one-half second, when the spring frees itself from the rotor, which thereafter coasts, spinning itself and the antenna at or near this speed. Since the gimbal rings are locked at 0°, the antenna axis, canted at 7½°, describes a cone of 15° angle. The microwave path as reflected by the antenna reflector is such that the mechanical angle is doubled as before stated, and the lobe of antenna microwave reception therefore describes a cone of 30°. The antenna has been held at the maximum 7½° axis cant angle by a latch, which next is released and a spring urging the antenna axis toward the rotor axis is thereby permitted to move the antenna. Since the antenna is now rotating with the rotor while the antenna axis is moving toward the rotor axis, the combination causes the lobe of antenna reception to spiral inward from a diameter of 30° to a diameter of 5.6°, which is four times the minimum cant angle of 1.4°, at which angle further antenna hinge motion is stopped by a pin.

The third and last timed action is to release the gyroscope gimbal rings, permitting precession to occur and permitting the corrective action of the gyroscopic momentum to be applied through circuits and mechanisms to the missile steering vanes or jets, so that the missile axis is thereby brought into line with the rotor axis and so maintained. These circuits and mechanisms are outside of the scope of this invention.

In operation in the search mode, coincident with the inwardly spiralling scan which begins at 1,800-yard range, the irradiated area at and near the target with a diameter of about 44 yards is perceived by the missile receiver as a mere point of reradiation somewhere within its 30° diameter field. The transmitter scan modulation at 498 cps is not perceived. FIG. **6** illustrates this situation at a selected instant. The scanning area **116** has a diameter of 30°, equal to 770 yards at 1,500 yards range. The 4° receiving beam area is indicated at **117,** and is spiralling inward from the circle **116** at 150 cps. Let it be assumed that the reradiation area is at **118.** As the received beam area **117** sweeps past **118** the receiver receives a pulse of microwave energy hav-

ing an average modulation frequency of 10 kcps. After demodulation this 10 kcps signal is found in conductor **119**, FIG. **4**. After demodulation in detector **43** and amplification by the bandpass amplifier **46**, the signal is converted to a signal having a frequency of 150 cps in conductor **121**.

The gyroscope **27** emits a pulse at a reference angle of rotation relative to the missile frame which is, for example, termed 0° in FIG. **6**. This pulse is applied through conductor **112** to gate **61**, opening it and causing 1 mcps energy from oscillator **56** to flow into counter **64**. The energy in conductor **121** is applied to the trigger generator **59** to generate a trigger which is representative of the angular position θ of the irradiated target area **118**, FIG. **6**, in the circle **116** swept by the received beam. This trigger is applied to close gate **61**, stopping the flow of 1 mcps energy to the storage counter. The output, then, of the storage counter in conductor **67** is a direct voltage pulse having an amplitude proportional to the angle, θ, FIG. **6**, representing the angle of the target in the received field relative to a datum line on the missile.

The voltage proportional to θ in conductor **67**, FIG. **4**, is applied through the summing circuit **73** and conductor **74** to the diode switch **49**, where is produces a signal in conductor **76** determining, through gyroscope **27**, which one of the four quadrant steering elements is energized, the amplitude signal in conductor **48** determining the amplitude of the steering effort.

Thus the missile is steered toward the target. In FIG. **6**, the center **122** of the circle is thereby moved toward the target area **118** while the 15° radius of the circle **116** is reduced toward 2.8°. By the time the spiralling-in of the antenna lobe has been completed the target has been acquired, the target spot **118** remains within the received are **117** and the receiver is in the locked-on mode, with coarse guidance operation.

As the missile approaches a range of 500 yards from the target, the detail of the pattern laid down by the transmitter begins to be perceived. The transmitted pattern modulated at 498 cps and the received pattern modulated at 150 cps are about the same size at the target. At closer approach the 150 cps modulation decreases toward zero while the 498 cps modulation begins to dominate. This 498 cps modulation of the 10 kcps carrier has an amplitude nature for a reason similar to that which was shown by the scanning diagram of FIG. **6** for 150 cps. The 498 cps signal also has a frequency modulation nature since the 10 kcps average frequency is moved between 9,945 cps and 10,255 cps at a rate of 498 cps.

Accordingly, energy at 498 cps is amplitude detected at **43**, FIG. **4**, and amplified at **44** to generate a trigger each cycle in trigger circuit **58**. This trigger has a phase representing the phase of the transmitted signal relative to a datum direction, such as directly upward, when perceived most strongly by the narrow received beam. This is shown in FIG. **7**, in which the received beam **117** is scanned in a tight circle **116** and the transmitted beam **123**, rotating at a rate of 498 cps in a large circle **118**, is perceived at maximum strength once in each of its revolutions. The trigger signal from circuit **58** is used to close gate **54**.

The frequency-modulated signal in conductor **119** is limited at **51** and demodulated at **52** to produce a 498 cps signal in conductor **124**. This generates a pulse in trigger circuit **53** at a phase marking a selected datum direction in the transmitter scanning circle, here selected as the "up" direction. This trigger is used to open gate **54**.

Thus gate **54** is conductive for the angle of transmitter rotation from directly upward to the direction of the receiving pattern, or θ' in FIG. **7**.

The signal is transmitted to the storage counter **64**, producing a direct current output signal representative thereof in conductor **66**.

Since the missile will generally be rotating, a signal must be produced representing the angle between the datum line on the missile, previously referred to, and the upward direction. This signal is generated by employing the vertical reference **69** and generating a signal in component **71** representing at any instant the changing angle between the vertical direction and the missile datum line direction. This signal, θ'', is added in the adding circuit **68** to θ' to form θ in conductor **72**. This signal is applied to adding circuit **73**, where it is used as before described.

What is claimed is:

1. A missile guidance system comprising, a missile carrying a microwave receiver and beam antenna, means adapted to fire said missile in the general direction of a target, a stationary microwave transmitter irradiating said target and its vicinity by a single beam, means conically rotating said beam at a first rate about a line joining said transmitter and said target, the conical angle thereof being substantially equal to the beam angular width, means conically rotating the beam direction of said receiver antenna at a second rate whereby at a selected first range said receiver perceives and receives said irradiation reflection modulated at said second rate, means demodulating the received modulation to secure a signal having a frequency determined by said second rate and a phase relative to a datum line on said missile, means steering said missile coarsely toward said target in accordance with the phase of said signal, means in said receiver operative at a selected second range less than said first range for receiving said irradiation reflection and demodulating said first rate modulation thereof to form a second signal having a determinable phase, and means steering said missile in fine guidance mode toward said target in accordance with the phase of said second signal.

2. A missile guidance system comprising, a missile carrying a microwave receiver and beam antenna, means adapted to fire said missile toward a target with a polar error of less than 15° measured at a selected first range during flight, a stationary microwave transmitter irradiating said target and its vicinity by a single narrow beam, means conically rotating said narrow beam at a first rate about a line joining said transmitter and target, the conical rotation angle being substantially equal to said narrow beam width, means conically rotating said receiver antenna beam at a second rate about a line joining said missile and a point at or near said target, said receiver antenna beam conical rotation angle being approximately 30° at said selected first range, means reducing said receiver antenna beam conical rotation angle to an angle approximately equal to the receiver antenna beam width, said reduction occurring during a search and acquisition phase of operation, said receiver during the search and acquisition phase acquiring and receiving the reflection of said target irradiation to form a signal modulated at said second rate, means demodulating said signal to form a second

signal having a phase relative to a datum line on said missile, means for generating a course correction signal the value of which is dependent on said relative phase, means steering said missile coarsely toward said target in accordance with said course correction signal, means in said receiver operative at a selected second range less than said first range for receiving said irradiation reflection and demodulating said first rate modulation thereof to form a third signal having a frequency determined by said first rate and a phase which is determined by its relation to a datum phase, and means steering said missile in a fine guidance phase toward the target in accordance with the third signal phase.

3. A missile guidance system comprising, a missile carrying a microwave receiver and beam antenna, means adapted to fire said missile toward a target with a polar error of less than 15° measured at a selected first range during flight, a stationary microwave transmitter irradiating said target and its vicinity by a single narrow beam amplitude modulated at a selected rate, means conically rotating said narrow beam at a first rotation rate about a line joining said transmitter and target, the conical rotation angle being substantially equal to said narrow beam width, means frequency modulating said selected rate at said first rotation rate at a selected phase, means conically rotating said receiver antenna beam at a second rotation rate about a line joining said missile and a point at or near said target, said receiver antenna beam conical rotation angle being initially of the order of 30° at said selected first range, means starting at said selected first range spirally scanning said receiver beam inward to reduce the cone of rotation angle to substantial equality with the receiver antenna beam width and substantially greater than said transmitter narrow beam width, said spiral scan constituting the search mode of operation, whereby said receiver during the search mode acquires and locks to a signal derived from the target echo of said transmitter radiations terminating the search mode and commencing the lock-on mode, means adapted to secure a coarse signal having said second rate for coarse guidance of said missile, and means operative at a selected second range less than said first range adapted to secure a fine signal having said first rate for fine guidance of said missile.

4. A missile guidance system comprising, a missile carrying a receiver and antenna, means adapted to fire said missile in the general direction of a target, a stationary transmitter for irradiating said target by a single amplitude modulated microwave beam, said amplitude modulation being frequency modulated, means for conically rotating said microwave beam about a rotation axis at a first rate, the conical angle being substantially equal to the beam angular width, means conically rotating the receiving axis of said antenna at a second rate, the conical angle thereof being approximately equal to the received beam angular width, means for acquiring a signal by said receiver from the reflections at said target of said irradiating microwave beam, a demodulator in said receiver deriving a signal having the rate of said amplitude modulation, a second demodulator operative at a first range demodulating said last named signal to secure a coarse steering signal having a frequency equal to said second rate and a phase representing the direction of steering error relative to a datum point on said missile, gate and switch means adapted to apply the amplitude and phase of said coarse steering signal to generate a coarse correction signal the amplitude and phase of which are dependent on the amplitude and phase of said coarse steering signal, a vertical reference in said receiving means operative at a second selected range less than said first range for receiving said irradiation reflection and demodulating said frequency modulation at said first rate to form a fine steering signal having phase representing direction of steering error and amplitude representing amount of steering error, said gate and switch means being adapted to apply said fine steering signal to generate a fine correction signal the amplitude and phase of which are dependent on said vertical reference signal and on the amplitude and phase of said fine steering signal.

5. A missile guidance system comprising, a missile carrying a microwave receiver and beam antenna, means adapted to fire said missile toward a target with a polar error of less than 15° measured at a selected first range during flight, a stationary microwave transmitter irradiating said target and its vicinity by a single narrow beam amplitude modulated at a selected rate, means conically rotating said narrow beam at a first rotation rate about a line joining said transmitter and target, the conical rotation angle being substantially equal to said narrow beam width, means frequency modulating said transmitter beam at said first rotation rate and at a selected phase, means conically rotating said receiver antenna beam at a second rotation rate about a line joining said missile and a point at or near said target, said receiver antenna beam conical rotation angle being initially of the order of 30° at said selected first range, means starting at said selected first range spirally scanning said receiver antenna beam inward to reduce the cone of rotation angle to substantial equality with the receiver antenna beam width and substantially greater than said transmitter narrow beam width, said spiral scan constituting the search mode of operation, whereby said receiver during the search mode acquires a signal derived from the target echo of said transmitter radiations, a demodulator in said receiver deriving a signal having said selected rate of amplitude modulation, a second demodulator demodulating said last-named signal to secure a coarse steering signal having a frequency equal to said second rotation rate and a phase representing the direction of steering error relative to a datum point on said missile, gate and switch means adapted to apply the amplitude and phase of said coarse steering signal to generate a coarse correction signal the amplitude and phase of which are dependent on the amplitude and phase of said coarse steering signal, a vertical reference in said receiver, and means in said receiver operative at a selected second range less than said first range for receiving said irradiation reflection and demodulating said frequency modulation at the first rotation rate to form a fine steering signal having phase representing direction of steering error and amplitude representing amount of steering error, said gate and switch means being adapted to apply said fine steering signal to generate a fine correction signal the amplitude and phase of which are dependent on said vertical reference signal and on the amplitude and phase of said fine steering signal.

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