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 rate 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.
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 telescopc 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 transmitted 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, an ocular telescope or infrared telescope 13. The sighting device is secured to the 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 through 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 missile 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 functions: 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 7/2°. 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 kcfs average amplitude modulation, which is amplified in the amplifier 42.

The 10 kcfs 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 kcfs 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 conductor 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 +44 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 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 473-478.

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 pre-set 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 7°6' 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 7°6', 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 7°6' 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 rereadation 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 rereadiation 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 of beams is received by the receiver. 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 direct 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 59 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 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 and locks to 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 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 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.