

[54] **RATE TRANSMITTAL METHOD FOR
BEAMRIDER MISSILE GUIDANCE**

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[51] Int. Cl. **F41g 7/14, F42b 15/02, F42b 15/10**

[58] Field of Search **244/3.13**

[56] **References Cited**

UNITED STATES PATENTS

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Primary Examiner—Benjamin A. Borchelt

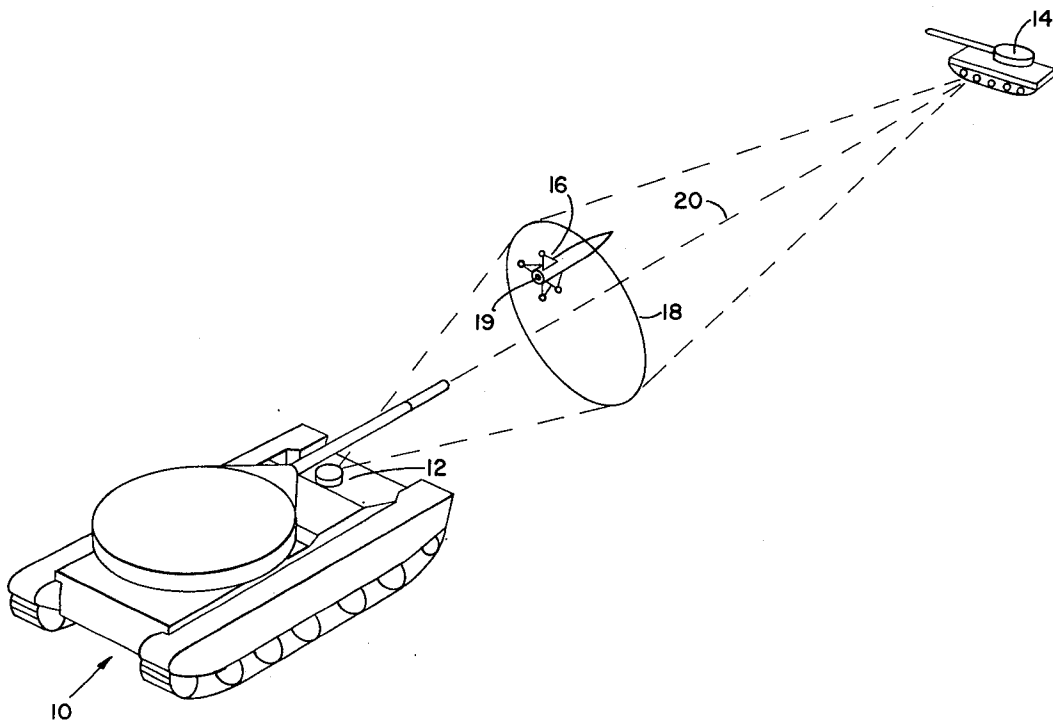
Assistant Examiner—Thomas H. Webb

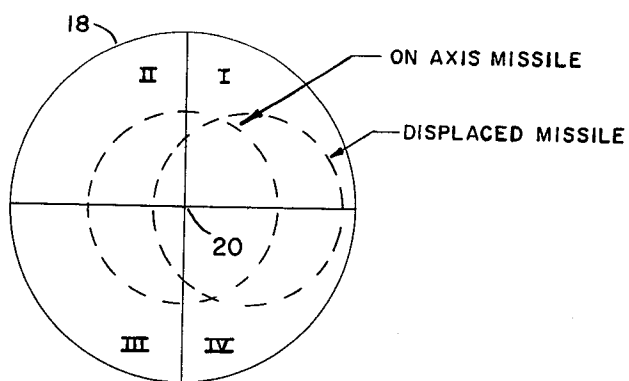
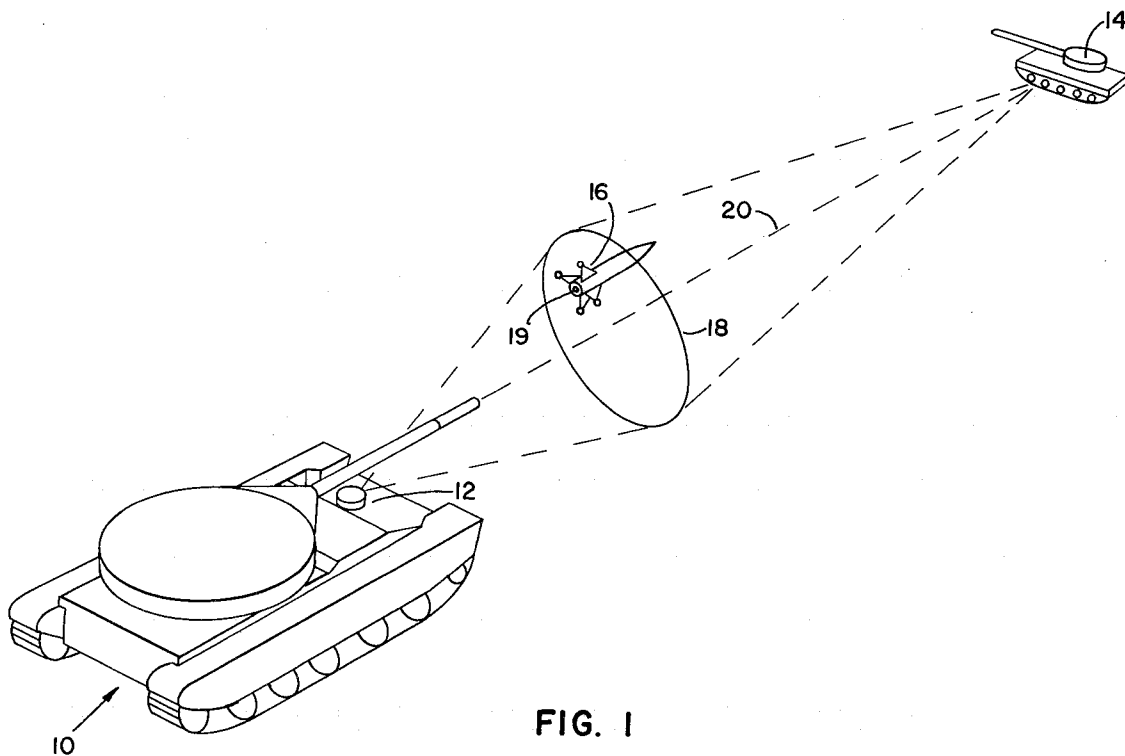
Attorney, Agent, or Firm—Edward J. Kelly; Herbert Berl; Jack W. Voight

[57] **ABSTRACT**

In beamrider guidance of a missile toward a target, tracking or error determination is accomplished on board the missile. Rate information obtained at the launch site must be transmitted to the missile if it is to be used in the guidance thereof. Rate information allows correction of the inherent lag of a missile behind the target line-of-sight. A method of electronically accomplishing the equivalent of an optical boresight shift allows the missile direction to be adjusted to compensate for the inherent lag of the missile as it moves toward the target.

3 Claims, 4 Drawing Figures





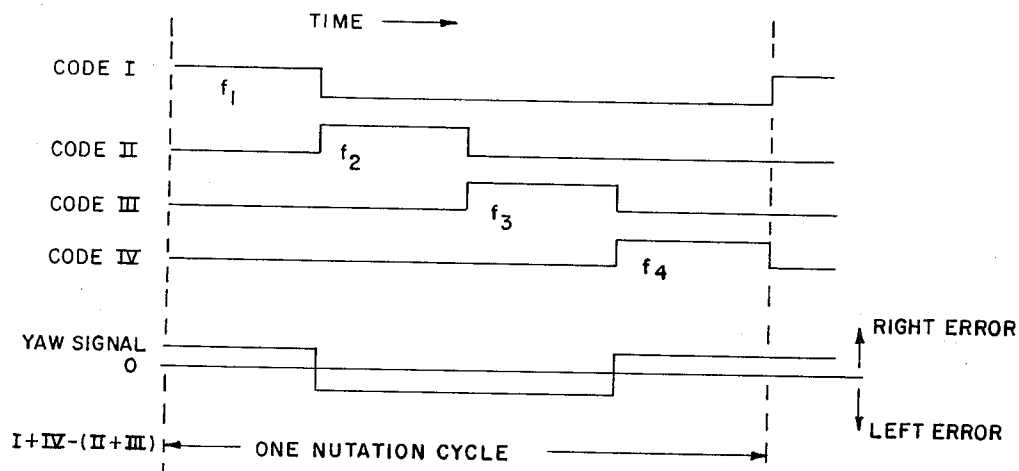


FIG. 3

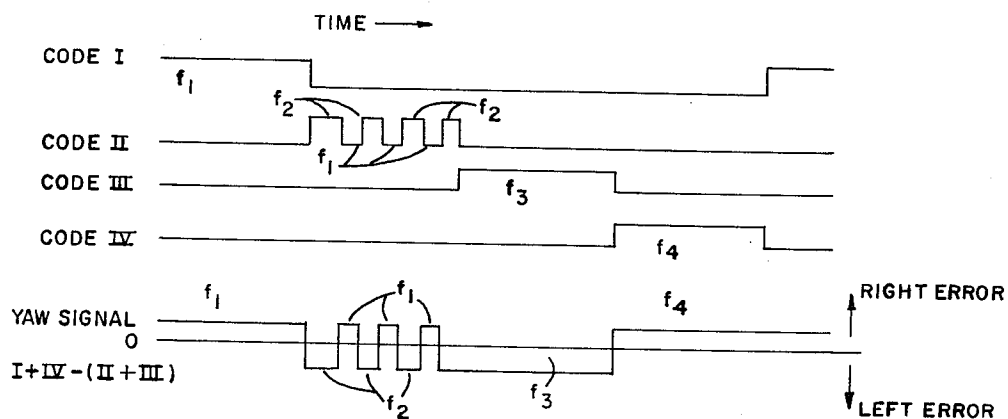


FIG. 4

RATE TRANSMITTAL METHOD FOR BEAMRIDER MISSILE GUIDANCE

BACKGROUND OF THE INVENTION

Beamrider guidance is a method of guidance whereby a missile is enabled to determine its own relative position in a transmitted beam, due to spatial encoding of that beam. The missile generates guidance commands to correct missile flight path toward the center of the transmitted beam. A gunner then points the beam at a target, and the missile follows the beam to target impact. Since the missile generates its correctional commands internally there is no requirement for correctional or tracking guidance from an external source.

However, the line-of-sight rate resulting from a moving target or a moving transmitter causes a missile guidance error. This guidance error is defined as "lag" of the missile behind the changing line-of-sight of the transmitted beam. Since this changing line-of-sight may be measured at the transmitter as an angular rate, it can be used to reduce the missile guidance error caused by line-of-sight rate. Since guidance commands are generated on board the missile, any rate information must either be transmitted directly to the missile, or be used to alter the boresight of the transmitter to compensate for predicted missile lag. Rate transmission requires either a separate transmission link or a multiplexing method. Mechanical or optical boresight shift mechanisms are not capable of providing the ± 0.1 milliradian accuracy required.

A beamrider missile guidance method and apparatus are disclosed in patent application Ser. No. 275,014, filed July 25, 1972 by Miller et al. Miller et al. disclose an improved beamrider missile guidance system wherein an observer at a launch site visually locates a target. A line-of-sight to the target is established through a telescopic sight. An optical transmitter, boresighted to the telescope, directs optical energy toward the target. Transmitted optical energy is spatially encoded to allow on board missile sensors to respond to missile deviation from the observer's line-of-sight to the target. Error information generated in the missile allows automatic missile correctional commands for returning the missile to the line-of-sight.

SUMMARY OF THE INVENTION

In a beamrider missile guidance system a moving target is tracked by visual line-of-sight from the target tracking station or launch site. The missile is launched substantially along the line-of-sight axis to the target. Rate transmission for beamrider guidance is encoded into the existing guidance information with the same code or frequencies already present in the beam. The transmitted beam, formed of individually modulated beam segments, has one or more segments modified by alternately modulating the segment with the modulation rate of an adjoining segment. This alternate modulation of adjoining segments provides electronic adjustment of the optical boresight so that the beam null is leading the target by an amount equivalent to the inherent missile lag, the missile trajectory is effectively corrected to place the missile directly on target. Thus, missile trajectory is corrected at the tracking station without transmitting any additional signals in the beam.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an embodiment of the beamrider guidance system.

FIG. 2 is a static cross-section of a four-quadrant beam having four codes or frequencies for respective quadrants.

FIG. 3 is a diagram of the signal resulting on the missile for on-axis conditions without rate encoding.

FIG. 4 is a signal diagram resulting on the missile for on-axis conditions with rate encoding included.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIG. 1 discloses an optical beamrider system. A target tracking station 10 directs an optical beam from a source 12 toward a target 14. Source 12 is boresighted to follow telescopic tracking of the target by an observer or gunner at the tracking station. A missile 16 is launched into the path of beam 18 toward the target. An optical receiver 19 on the missile's aft end responds to the spatially encoded light beam 18 for directing the missile toward the center of the beam. The beam center is the line-of-sight axis 20 between target tracking station 10 and target 14.

FIG. 2 discloses the cross-sectional beam pattern of a static beam. Separate beams I, II, III and IV are brought together in quadrants to form the single beam 18. These beam segments are coded to distinguish respective quadrants. The four-quadrant beam is nutated in space with a nutation radius equal to approximately one-half the beam radius. The missile detector 19 then sees, sequentially, the four codes (frequencies) of the four quadrants, with a duty factor that is dependent on missile location within the beam. This duty factor provides measurement of missile position error in the beam.

Typical of ideal conditions a missile is shown in dotted lines centered on axis for the four-quadrant beam of FIG. 2. As the beam is nutated, the missile will sequentially receive the codes of quadrant I, II, III and IV with equal duration of each quadrant (as also shown in FIG. 3). If, however, the missile is displaced to the right of the center the relative duration of codes I and IV will be increased and the durations of codes II and III will be decreased. The missile error signal is determined from these relative durations. However crossing motion by the target or tracker results in a consistently displaced missile which is continuously seeking alignment. Missile displacement to the right as shown in FIG. 2 is caused by a right to left crossing target and the resulting line-of-sight rate. Correction of this lag with lead adjustment is accomplished by a shift of the boresight to the left. The boresight shift is equal to the expected missile lag as determined by the angular line-of-sight rate measured at the beam transmitter.

FIG. 3 shows the signal resulting on the missile for the on-axis condition. Left to right missile position in the beam is given by the relative duration of the quadrants on the missile sensor 19. Thus, $(I + IV) - (II + III)$ provides the yaw signal where positive is right error and negative is left error in the figure. If these durations are equal, the average yaw error is zero. Referring now to FIG. 4, the signal in quadrant II is modified to be an alternating code frequency f_1 (code I) for a short time, and code II or frequency f_2 for a short time. This pro-

duces, for an on-axis missile, the yaw signal of FIG. 4. A positive or right error has been indicated, since the average yaw signal is positive. Thus, the boresight axis has shifted. By making the boresight axis shift approximately equal to the error caused by the line-of-sight rate, correction for this error is accomplished. Missile electronics respond to the signals received by detector 19, sensing the relative time duration of respective pulses and combining these signals to activate correctional guidance. Thus the missile is directed to lead a target by the equivalent amount of lag caused by the line-of-sight rate, thereby placing the missile directly on axis with the actual target. Reversal of the intermodulation, f_2 into quadrant I, would be used for lead in the opposite direction.

Quadrants III and IV can also be used for boresight shifting, in order to make the shift in yaw independent of missile pitch errors. Codes I, II, III and IV may easily comprise separate frequencies f_1 , f_2 , f_3 , and f_4 , allowing simplified detection of time duration signals.

Although a particular embodiment and form of this invention has been illustrated, it is readily apparent that various modifications and embodiments of the invention may be made by those skilled in the art without departing from the scope and spirit of the foregoing disclosure. For example, since all four quadrants can be intermodulated, other biases can be corrected for. Thus, a gravity bias can be programmed to provide missile lift as a function of expected missile velocity (time), and wind velocity can be measured and corrected for if desired. Accordingly, the scope of the invention should be limited only by the claims appended hereto.

We claim:

1. In a beamrider missile guidance system wherein a

target is tracked by visual line-of-sight from a tracking station and the missile is directed toward said target substantially along the line-of-sight axis, a method of transmitting rate information within the beam path and comprising the steps of:

directing optical energy from said target tracking station along the line-of-sight to the target,

spatially encoding said optical energy for providing a plurality of individually modulated optical frequency beams,

forming said individually modulated beams into a single beam of adjoining segments, and

modifying at least one of said beam segments by alternately modulating the beam segment with the modulation rate of an adjoining segment.

2. In a beamrider missile guidance system a method of transmitting rate information within the beam path as set forth in claim 1 and further comprising the steps of:

forming said beam segments into a quadrant,

nutating said beam for sequentially sweeping a portion of respective quadrants across the missile directed toward said target, and

alternately modulating said modified beam segment with a portion of said adjoining segment signal modulation which portion is equal in magnitude to missile lag.

3. In a beamrider missile guidance system a method of transmitting rate information within the beam path as set forth in claim 2 and further comprising the step of: detecting by said missile the duration of respective quadrant modulation rates during nutation for the further step of controlling the error correction of the missile trajectory toward said target.

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