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Evers-Euterneck

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[54] CONSTANT BEARING COURSE HOMING MISSILE

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[51] Int. Cl. F41g 7/00, F41g 9/00, F41g 11/00
[58] Field of Search ..... 244/3.15, 317; 343/5.5 MM

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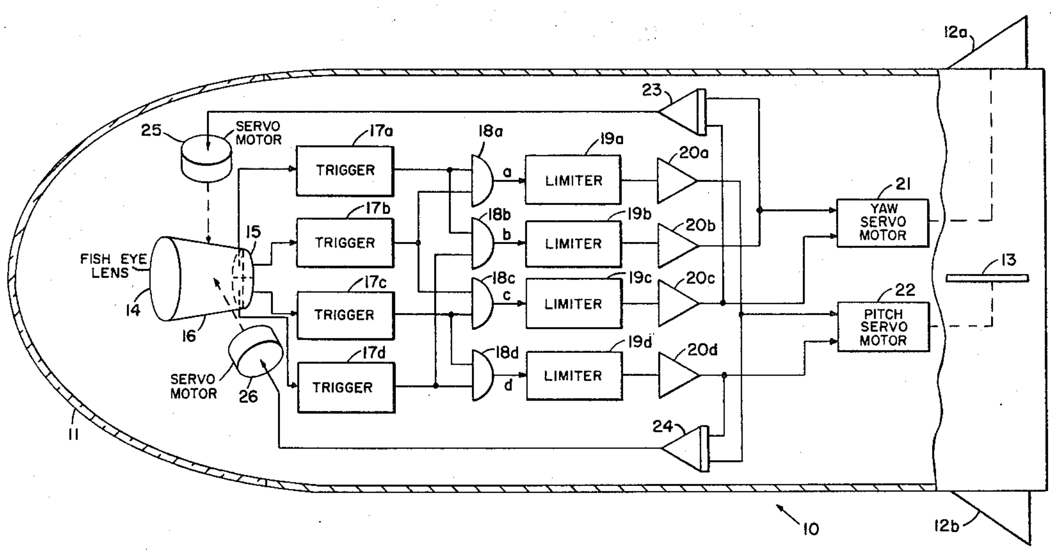
[57] ABSTRACT

A passive or semiactive homing missile using an optical sensor. The sensor includes a wide-angle lens and a quadrature detector. When a moving target is acquired, signals are generated to turn the missile toward the target. These signals are integrated and are used to turn the sensor to lead the target. The missile will eventually settle on a constant bearing (collision) course with the target. If the target makes changes in speed or direction, the missile will change direction to re-establish a collision course to the target.

3 Claims, 2 Drawing Figures



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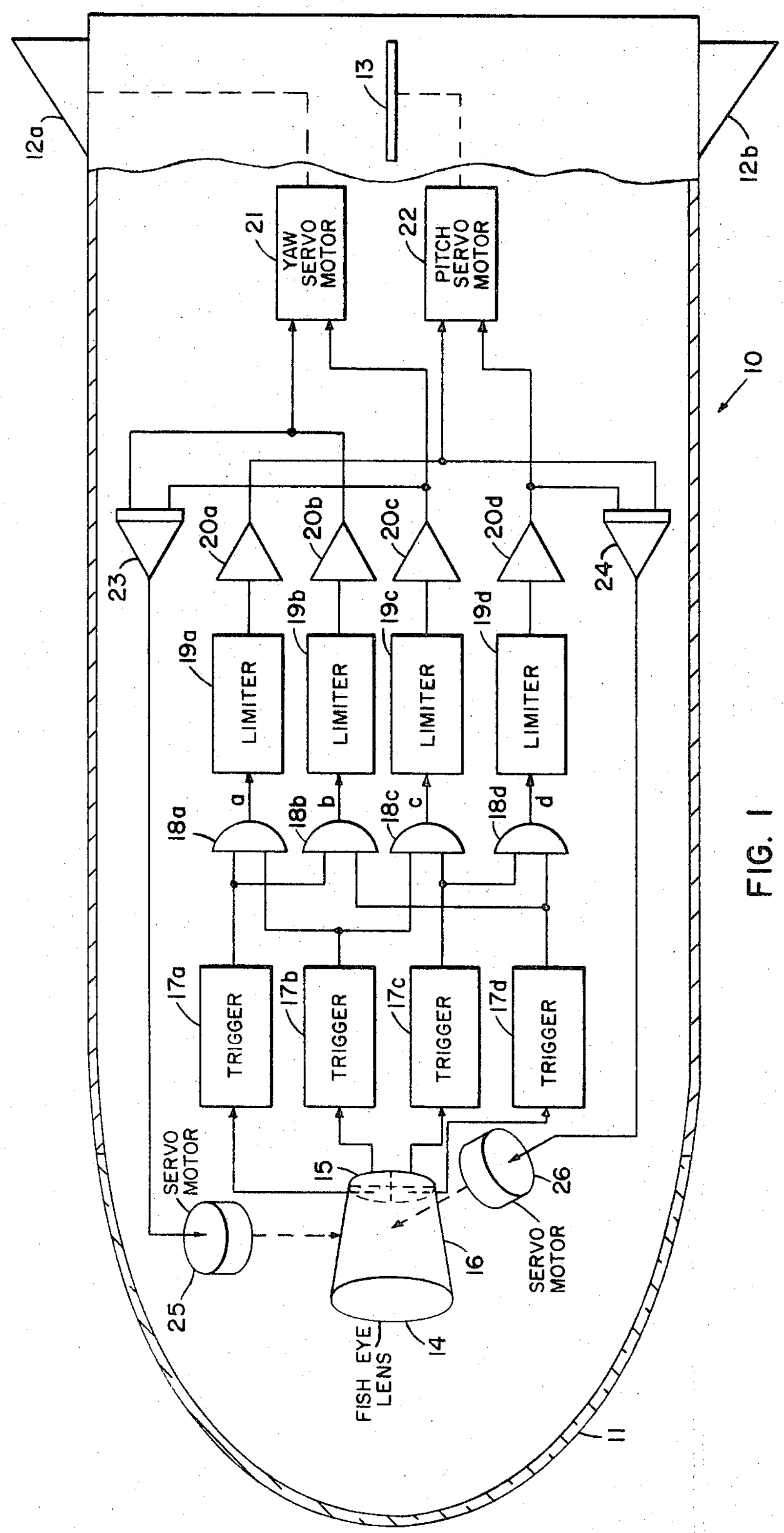

FIG. 1

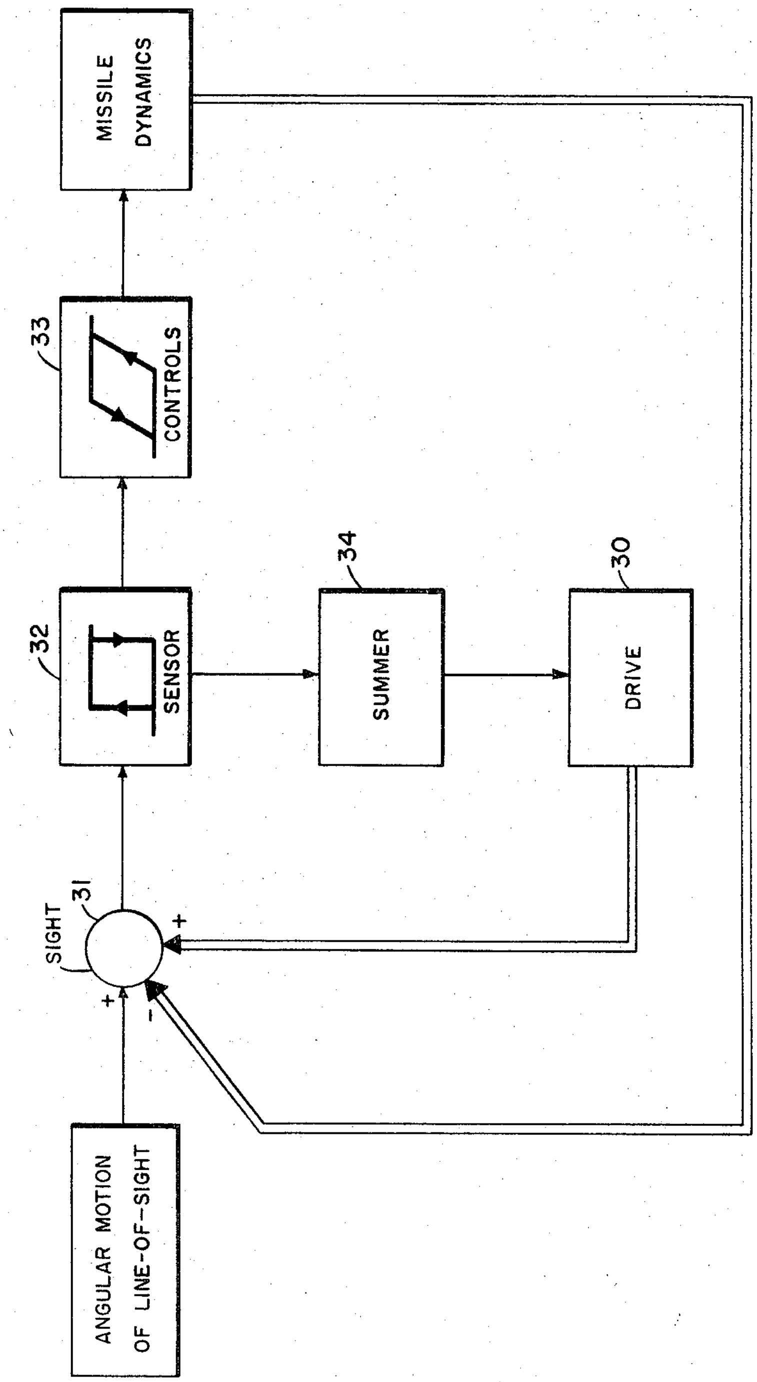
MISSILE DYNAMICS
33
CONTROLS
32
SENSOR
34
SUMMER
30
DRIVE
SIGHT
31
+
+
-
ANGULAR MOTION OF LINE-OF-SIGHT

FIG. 2

CONSTANT BEARING COURSE HOMING MISSILE

BACKGROUND OF THE INVENTION

Various types of homing missiles are known in the art. These include those using active, semiactive, and passive homing. Regardless of the type, these missiles usually engage a target with a pure pursuit course. Any other type of course normally requires a complex guidance computer on board the missile. As is well known, the pure pursuit course has greater time-of-flight to target than a collision course and requires high turn rates not required by a collision course. It is thus advantageous to have ones missile fly a collision course, if practical. The instant invention makes such a thing practical, with a relatively simple system.

SUMMARY OF THE INVENTION

The invention is a homing missile capable of taking a collision course to a moving target. The missile acquires the target with a wide-angle optical sensor, either semiactively or passively, and turns toward the target. The signals to the control surfaces of the missile are summed, and the summed signals cause the sensor to point to a position leading the target. The missile will eventually settle on a constant bearing (collision) course to the target.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of the invention.

FIG. 2 is a schematic diagram of a control loop of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, one sees missile **10** having a transparent nose **11** and control fins **12** and **13**. It should be understood that fins **12** and **13** are each half of a pair of fins, with the drawing not showing the other half of **13**, but showing both **12***a* and **12***b*. Naturally, the missile includes the usual rocket engine and warhead (both not shown). It is assumed in the invention that the missile travels with no roll at a constant speed until target engagement. The missile may be launched by a booster engine and maintained in speed by a sustainer engine, in the well known manner. Until a target is sighted, the missile may cruise under control of an autopilot. When a target is sighted, the instant invention begins to work.

The invention includes a wide-angle lens (fisheye) together with a matrix sensor such as quadrature detector **15** in nose **11** of the missile. Lens **14** and detector **15** are supported by frame **16**. The outputs from the four quadrants of detector **15** feed respective triggers **17***a*–**17***d*. These triggers block signals from **15** below some threshold level. The outputs of **17***a*–17d feed inputs of respective AND gates **18***a*–**18***d*. The output signals *a, b, c, d* from **18***a*–**18***d* may respectively be indicative of a target above or below the longitudinal axis to the missile, and port and starboard of the axis. These outputs *a–d* are applied to respective limiters **19***a*–**19***d* to give a constant value to any output from gates **18***a*–**18***d*. These constant outputs are amplified to higher levels in amplifiers **20***a*–**20***d*, with respective amplified outputs applied to servo motors **21** and **22**. The signal treatment used results in a "bangbang" control system. Thus far, a missile capable of pure pursuit has been described, inasmuch as lens **14** and detector **15** have not been described as movable. There are three alternatives at this point: 1) **14** and **15** can be fixed (strapped-down) to the missile body and not movable with respect to the body, 2) **14** and **15** and missile body **10** can be controlled to track the target, and 3) **14** and **15** can be controlled to track the target and the missile controlled to lead the target. The first two of these alternatives are used in the art and usually involve pure pursuit courses to the target. The instant invention uses alternative 3) and is thereby able to fly a collision course with the target. This is accomplished by feeding the signals applied to motors **21** and **22** to respective summers **23** and **24**. If the signals from **20***a*–**20***d* are derived from target radiation (passive), they will be rectangular waves, **23** and **24** will be integrators, and **23** and **24** will provide triangular output waves to respective servo motors **25** and **26**. These motors are at a right angle to each other and are attached between the missile body and housing **16** in order that **16** may be rotated in a direction to lead the target. If the target is illuminated by a pulsed laser or the like for semiactive homing, **15** will receive pulses and **23** and **24** will be accumulators.

FIG. 2 shows the simplified control loop for one axis of rotation (pitch or yaw) for the inventive missile. As can be seen, the angular motion of the line-of-sight, and motion from the sensor drive **30** (equivalent to servo motor **25** or **26**) are effectively added, as schematically suggested by summing point **31**, and the motions resulting from missile movement are subtracted in this point, with the sum-difference affecting the output of **32** (**32** corresponds to **14, 15,** and **16** of FIG. 1). The output of **32** affects controls **33** to cause rotation of the missile about an axis (pitch or yaw). Box **33** corresponds approximately to ones of elements **17–22** and **12** or **13** of FIG. 1. The control signals for drive **30** are derived in summer **34**, which corresponds to element **23** or **24** in FIG. 1. The sensor and control may have hysterysis curves as shown in the boxes.

Operation of the invention should be readily understood, in view of the drawings and of the detailed description above. One may fairly assume that the missile has been launched, has dropped its booster, has roll stabilized, and is cruising at constant speed on its sustainer engine. When its sensor detects a target, the missile, because of its bang-bang controls, executes a coarse maneuver toward the target, then starts a fine oscillation about the line-of-sight to the target. The signals used to execute the maneuvers are summed and asymetries from the bang-bang dwell times cause net output signals, which output signals are used to rotate the sensor contrary to the rotation of the line-of-sight in space. The turning velocity of the sensor with respect to the missile axes must be in accordance with the inequality

$$\omega_{missile}{}^{max.} > \omega_{sensor} > \omega_{line\ of\ sight}$$

where ω is angular velocity. The bang-bang controls gradually establish symmetrical limit cycles and the average sum in the summer becomes 0. If the target tries evasive maneuvers, the missile automatically readjusts for a collision course.

While a specific embodiment of the invention has been shown and described, other embodiments should be obvious to one skilled in the art. For example, the triggers **17** and limiters **19** could be combined; or the limiters might be inserted between AND gates **18** and the triggers. Amplifiers **20** might be inserted between

15 and the triggers, between the triggers and the AND gates, or between the AND gates and the limiters. Servo motors **21, 22, 25,** and **26** may have substituted therefor pneumatic or hydralic activators. Although specifically described as usable against moving targets, the inventive missile would obviously be usable against fixed targets.

I claim:

1. A homing missile having an elongated body with a longitudinal axis and yaw and pitch control means and including: optical sensor means including a wide-angle lens and a matrix detector and means for supporting said lens and detector; a first set of respective oper-

ators for said control means; logic means connected to said detector for providing output control signals as inputs to said operators; a pair of summers having inputs connected to the inputs of said operators and each having an output; and a second set of respective operators attached between said body and said means for supporting and having inputs connected to said outputs of said summer.

2. The missile as defined in claim **1** wherein said summers are integrators.

3. The missile as defined in claim **1** wherein said summers are accumulators.

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