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TARGET-SEEKING HEAD FOR GUIDED MISSILE

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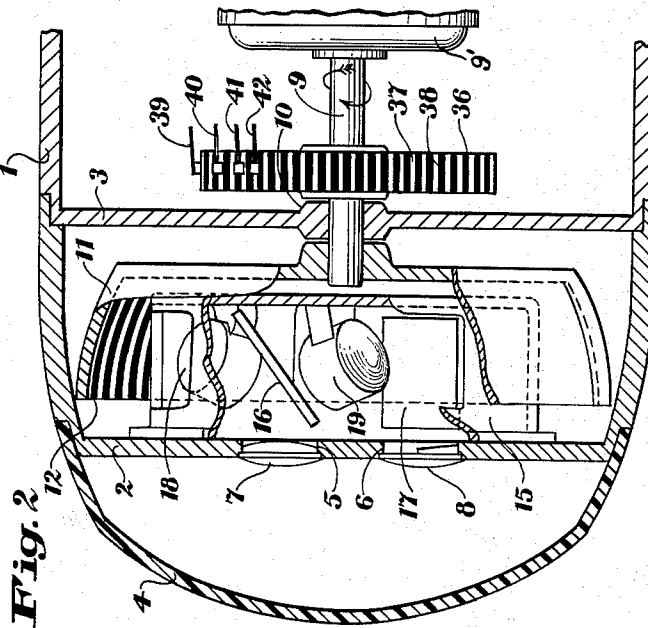


Fig. 2

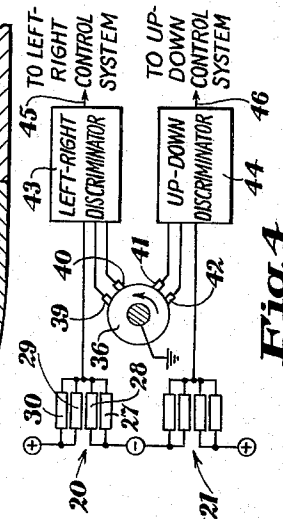


Fig. 4

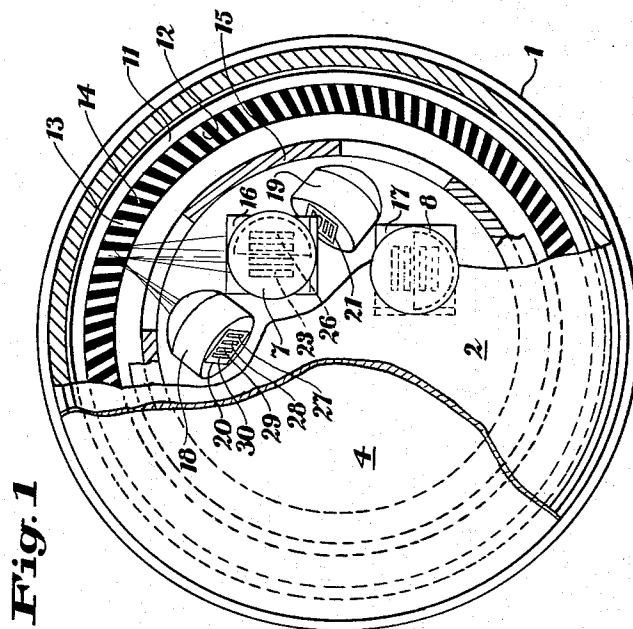


Fig. 1

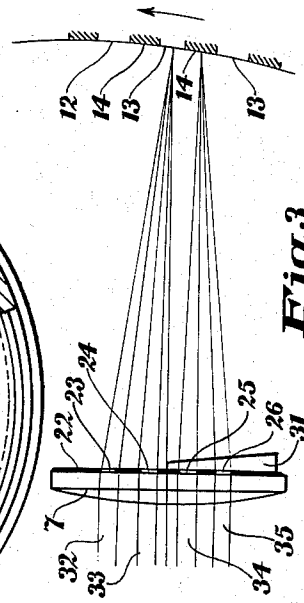


Fig. 3

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TARGET-SEEKING HEAD FOR GUIDED MISSILE

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ors, by mesne assignments, to the United States of
America as represented by the Secretary of the Navy
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2 Claims. (Cl. 250-203)

This invention relates to a target-seeking head for guided missiles which is particularly well adapted for generating guidance signals derived from infrared or other radiant energy emanating from a target whereby to direct the missile into a collision course with the target. Like many guidance systems for this same general purpose, it is a two coordinate system utilizing a separate set of target-sensing elements for each of two rectangularly related coordinate planes which, for ease of description will be termed the left-right and up-down planes.

It is well known in the art that so long as the line of sight from a missile to a given target remains at a constant angle with the axis of motion of the missile, the latter will be on a true collision course with the target. On the other hand any shift in the angle of the line of sight indicates that the missile is off course in one direction or another, the direction and rate of shift of the sighting angle being indicative of the corrective control action necessary to bring the missile back into its desired collision course.

It is therefore an object of this invention to provide a target-seeking head for sensing the direction and extent of shift in the line of sight from a missile to a target and which is capable of producing output signals, useable for control purposes, indicative of this shift.

It is a further object of this invention to provide such a target-seeking head wherein a scanning element is caused to sweep at a constant linear rate across an image of the target field, the scanning element being arranged to alternately interrupt and then pass radiant energy emanating from the target.

It is a further object of this invention to provide such a target-seeking head wherein, for each coordinate plane, means are provided for directing energy emanating from said target along two similar but separate paths onto separate detectors, and wherein a modulating scanner is caused to sweep across both of said paths at a constant linear rate, the energy in each of said paths being brought into focus at the plane of said scanner to form a pair of target images so spaced relative to one another that the energy striking the detectors will be modulated at a frequency indicative of the dynamic relationship of the line of sight to the missile axis and the modulations at the detectors will be 180° out of phase with one another, the detectors being so connected together that each serves as a load for the other during alternate half cycles whereby the combined output signals derived therefrom will be of substantially twice the peak-to-peak amplitude obtainable from a single detector under similar conditions.

Further objects of the invention will become apparent from the following description and claims were considered in the light of the accompanying drawing wherein:

FIG. 1 is a front view of a missile incorporating our invention, parts being broken away better to show the internal construction;

FIG. 2 is a fragmentary longitudinal sectional view through the forward portion of the missile;

FIG. 3 is a partially diagrammatic representation of a portion of the optical system used in our invention; and

FIG. 4 is a block diagram of a system which may be utilized with our invention for converting the informa-

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tion derived from the target-seeking head to a form useable for control of the missile.

Our invention is shown as being applied to a missile 1 which may be provided with a pair of bulkheads 2 and 3 in the forward portion thereof. The missile is provided with a nose unit 4 formed of a suitable material which is transparent to the particular type of radiant energy which is to be utilized for guidance. Mounted in a pair of openings 5 and 6 in the bulkhead 2 are a pair of objective lenses 7 and 8 which will be described in more detail herebelow. Carried by a rotary driven shaft 9 journaled in suitable bearings 10 in bulkhead 3 in a scanning drum 11, the periphery of which is in the form of a portion of a sphere. The inner surface 12 of this scanning drum is coated with an energy reflecting material so as to produce a series of alternately arranged reflecting strips 13 separated by non-reflecting portions 14. Shaft 9 is adapted to be driven at a constant speed, as by a suitable motor 9', which, with the shaft, constitutes means for rotating the scanning drum 11 at a constant angular rate. Mounted axially rearwardly of the objective lenses 7 and 8 as by a suitable bracket structure 15, are a pair of plane mirrors 16 and 17, so oriented as to reflect rays of energy passing through the lenses 7 and 8 onto the inner surface 12 of the scanning drum 11. The focal lengths of lenses 7 and 8 are such that rays emanating from a distant object will be brought into substantial focus at the inner surface 12 of the drum, those rays impinging at any particular instant upon a strip of reflecting material 13 being redirected thereby toward one of the two collecting lenses 18 or 19, to the rear faces of which are secured energy sensitive detectors 20 and 21, respectively.

As best shown in FIG. 3 the rear surfaces of the lenses 7 and 8 are painted or coated as shown at 22 so as to provide four elongated entrance pupils or apertures 23-26. Each of the detectors 20-21 also comprises four detector elements 27-30 of similar shape, the collector lenses being so designed in conjunction with the remainder of the optical system that they effectively image the entrance pupils individually onto the corresponding detector elements. Thus, with this arrangement, rays passing through aperture 23 of lens 7 and which are reflected by the drum 11 onto collector lens 18 will impinge upon detector element 27, while those passing through aperture 26 will similarly impinge upon detector element 30, etc.

Each of the objective lenses 7, 8 is likewise provided on its rear surface with a wedge prism 31 which covers two of the apertures 25 and 26 and is arranged to deflect the bundles of rays 34 and 35 passing therethrough so that they will be focused on the drum surface 12 at a point spaced one half of the pitch distance between adjacent reflecting strips 13 from the point at which bundles of rays 32-33 emanating from the same source and passing through apertures 23 and 24 will impinge upon said drum surface. By pitch distance is meant the angular distance along the periphery of the drum between corresponding points on any two adjacent strips 13. Thus, at any particular instant, the bundles of rays 32-33 passing through apertures 23-24 will fall on a reflecting strip 13 as indicated in FIG. 3 while at this same instant, the rays 34-35 from the same source and passing through apertures 25-26 will impinge upon the adjacent non-reflecting strip 14 of the drum. Thus, at this instant, the bundles of rays 32 and 33 will be reflected by the strip 13 onto the corresponding detectors 27-28 while the rays 34-35 will not be reflected and the corresponding detectors 29-30 will be unilluminated. However, an instant later, when the drum has rotated an amount corresponding to one-half the spacing between adjacent reflecting strips 13, rays 34 and 35 will be reflected onto the corresponding detectors 29 and 30 while detectors

27 and 28 will be unilluminated. Thus, the two pairs of detector elements making up each of the detectors 20—21 will be alternately illuminated at a frequency depending upon the rate of revolution of the scanning drum 11 and the number of sets of reflecting and non-reflecting strips 13 and 14. Where the line of sight to the target from the missile remains at a fixed angle relative to the longitudinal axis of the missile, the images of the target will remain at fixed points on the periphery of the drum 11 and the resulting output pulses from the detectors 20 and 21 will therefore occur at a predetermined frequency which will hereinafter be termed the normal scanning frequency. However, if the line of sight to the target is shifting relative to the longitudinal axis of the missile the images of the target will likewise be shifting. Any component of movement of these images which is parallel to the peripheral movement of the drum at that particular location will result in either an increase or decrease, as the case may be, in the frequency of the output signals from the detectors 20 or 21. Therefore, by comparing the frequency of the signals occurring at the outputs of these detectors with the normal scanning frequency a signal indicative of the relative direction and rate of shift of the line of sight relative to the missile axis may be obtained which may be utilized to initiate appropriate control corrections.

While many different arrangements could obviously be utilized for obtaining such correction signals a system such as is described and claimed in the copending application of Edward O. Dixon and Stephen M. MacNeille, Serial No. 722,620, filed concurrently herewith, is particularly well adapted for this purpose.

To facilitate the conversion of the output from the detectors 20, 21 into such useable control signals, a commutator 36 may be mounted on shaft 9 for rotation therewith, the commutator being provided with alternately arranged conducting and insulating segments 38 corresponding in number to the number of reflecting and non-reflecting strips 13 and 14 on the drum 11. Suitable brushes, diagrammatically indicated at 39—42, contacting the periphery of the commutator may serve as sources of the normal scanning frequency useable for such signal conversion. Thus, as is diagrammatically indicated in FIG. 4, the output of detector 20 is applied to a left-right discriminator 43 controlled by commutator brushes 39 and 40 while the output from detector 21 is fed to a similar up-down discriminator 44 controlled by the brushes 41, 42. For a detailed description of these discriminators reference should be made to the above-mentioned copending application Serial No. 722,620. Suffice it to say that each of these discriminators is so arranged as to produce at its output 45 or 46 a control signal indicative of both the relative direction and extent of difference between the associated detector output and the normal scanning frequency. This output may therefore be directly utilized to control both the direction and degree of corrective control action to be taken.

As is also indicated diagrammatically in FIG. 4 the pairs of detector elements 27—28 and 29—30 which together constitute the detector 20 or 21 are so connected together that each pair serves as the load resistor for the other pair during alternate half cycles. As a result of these connections and the fact that the pairs of detector elements are alternately illuminated during each scanning cycle, the output of the detector 20 will be of substantially twice the peak-to-peak amplitude which would be obtained with a single detector or pair of detectors and a conventional load resistor. The individual detectors 27—28 and 29—30 of each pair may be connected either in parallel with one another as indicated in FIG. 4 or in series depending upon the impedance of the detector input stage of the associated discriminator.

Operation of the invention is believed to have been made obvious from the preceding description. Rays of

energy from a target passing through the apertures 23—26 of the objectives 7 or 8 will be alternately reflected by the reflecting strips 13 of the scanning drum 11 onto the corresponding detector elements 27—30. The resulting pulsating outputs from these detectors will be applied to the corresponding discriminator, compared with the normal scanning frequency derived from the commutator brushes and converted into a form suitable for corrective control purposes.

From the above description it is believed apparent that we have disclosed a target-seeking scanning head for a missile which is of relatively simple construction and which is well adapted to the desired purpose. Obviously, the materials utilized in the optical components of the system will depend upon the particular type of radiant energy which is to be detected by the head and materials suitable for light or infrared or other types of radiation are well known to those skilled in the art. Obviously, many variations in the specific arrangement of the parts as disclosed herein may be made without departing from the principles of the invention. While we have shown four apertures and four detector elements associated with the scanning system for each coordinate plane, the number of such elements may obviously be varied without departing from the general mode of operation described above. Moreover, while the "push-pull" type of operation resulting from the incorporation of the wedge prisms 31 is highly useful in that an output from the detector may be obtained of relatively large amplitude, it is likewise obvious that this particular feature may be eliminated, if desired, without departing from the scope and spirit of the invention. Moreover, as has previously been indicated, while the arrangement has been disclosed as being particularly well adapted for use in conjunction with discriminators of the type described in the companion application of Dixon and MacNeille Serial No. 722,620 it will be equally obvious to those skilled in the art that other types of discriminators may be substituted without invention and that many other changes may be made without departing from the spirit and scope of the invention as defined by the appended claims.

In the specific embodiment disclosed, to avoid unnecessary confusion, the line of flight of the missile has been assumed to be coincident with the longitudinal axis of the missile and the seeker head has therefore been shown as rigidly mounted on the missile. As is well known in the art, in an actual missile the seeker head would normally be carried on a gyro stabilized assembly within the missile so that pitch or yaw motions of the missile would not produce false guidance information. The principles of the invention are obviously equally applicable to such an arrangement and the term missile axis as used herein is intended to mean the actual line of flight of the missile whether it be coincident with the longitudinal axis of the missile itself or to a gyro-stabilized reference axis within the missile.

We claim:

1. A target seeking head for generating signals indicative of the dynamic relationship, in a given coordinate plane, of the line of sight from the head to a target to a predetermined reference axis through said head, comprising a pair of energy responsive detectors, means forming a pair of apertures, and means for directing energy emanating from said target and passing through said apertures along separate paths respectively to said detectors, scanning means including a plurality of uniformly spaced energy modulating elements mounted for movement transversely across said paths and means for moving said scanning means at a constant rate whereby said elements cyclically sweep across each of said paths to correspondingly modulate the energy reaching said detectors, said energy directing means including energy focusing means in each path arranged to form an image of said target at the point in each path which is traversed

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by said modulating elements of said scanning means, said images being spaced laterally from one another in the direction of movement of said modulating elements a distance equal to an odd multiple of one half the pitch distance between successive modulating elements, said energy directing means being so arranged relative to said scanning means that any shifting of said line of sight relative to said reference axis in said coordinate plane will produce a corresponding shifting of both of said target images in the same direction along the path of movement of said modulating elements whereby the modulations of the energy reaching said detectors will be 180°

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out of phase and at a frequency indicative of the dynamic relationship of said line of sight to said reference axis in said coordinate plane.

2. A target seeking head as in claim 1 wherein said energy directing means includes an objective lens common to both paths for forming said images and wherein a wedge prism is positioned adjacent one of said apertures to relatively deflect the energy passing through said lens and said one aperture whereby to produce the desired separation of said images.

No references cited.