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(54) **Panoramic locating apparatus**

(57) Movement within a scene is detected by scanning the scene in elevation and azimuth, 6,4,3, imaging each part of the scene onto two detector rows 12, 13 which are staggered with respect to one another in the azimuthal direction and which have an identical number of detector elements, delaying the output of the detector rows 12 which detects first of all a specific instantaneously-depicted picture detail and comparing it with the non-delayed output of the second detector row 13. A difference signal which is different from zero then indicates movement within the field of vision of the panoramic locating apparatus. The angular position of the moving object can be obtained by measuring the angle of elevation and angle of azimuth of the optical axis 6 at the instant of the recognition of the moving object.

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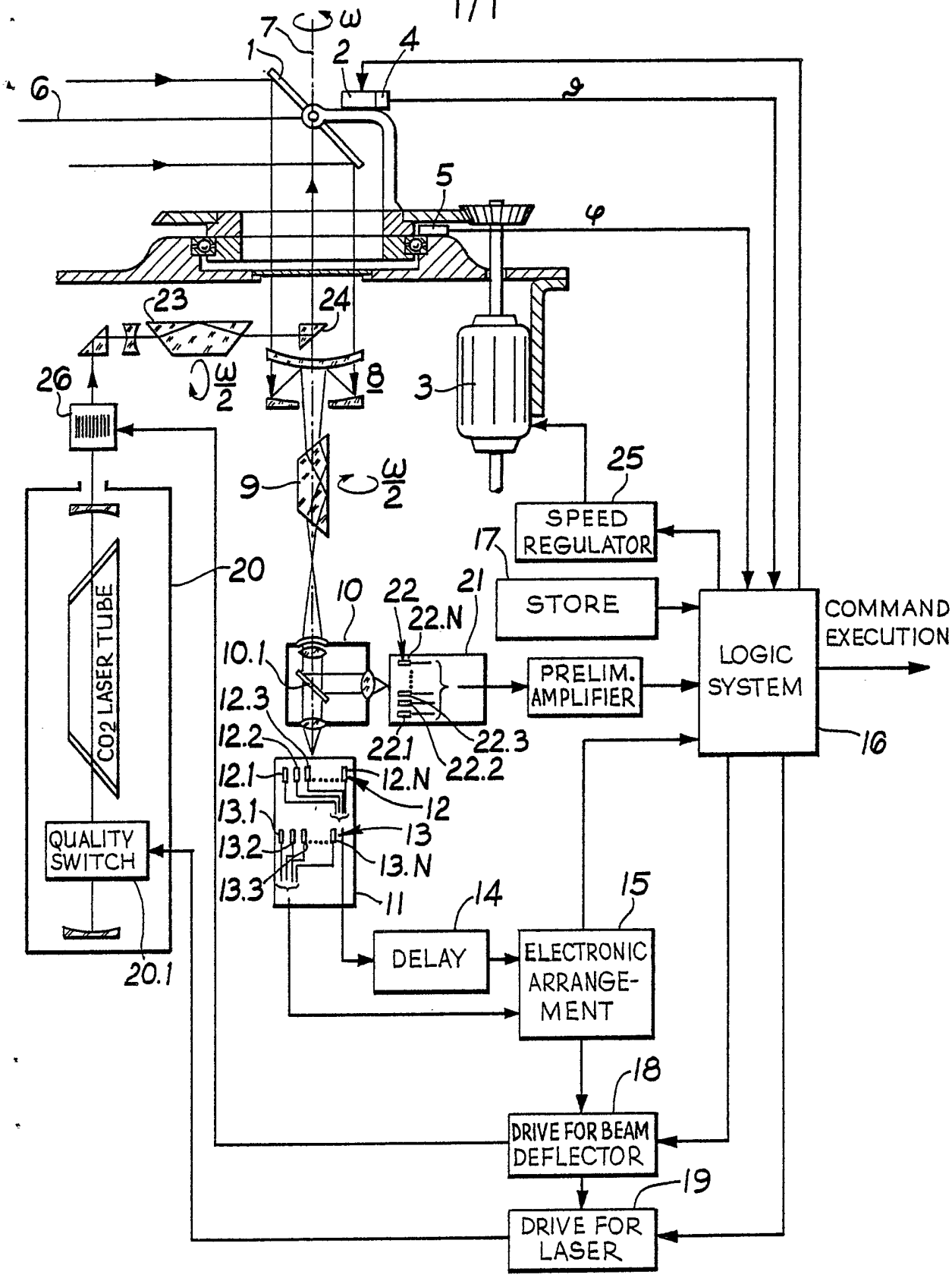
The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.


ω
7
1
2
4
6
9
5
φ
23
24
ω/2
8
3
26
9
ω/2
25
SPEED REGULATOR
17
STORE
20
10
22
22.N
21
10.1
12.3
PRELIM. AMPLIFIER
LOGIC SYSTEM
COMMAND EXECUTION
16
12.2
12.1
12.N
12
13.1
13
13.2
13.N
13.3
11
22.1
22.3
22.2
CO2 LASER TUBE
QUALITY SWITCH
20.1
14
15
DELAY
ELECTRONIC ARRANGE-MENT
18
DRIVE FOR BEAM DEFLECTOR
19
DRIVE FOR LASER

SPECIFICATION

Panoramic locating apparatus

This invention relates to panoramic locating apparatus, for locating the position of a moving object, comprising a mechanism for varying the apparatus's object-sided optical axis in elevation and with a constant angular velocity in azimuth arrangements for determining the angle of elevation and azimuth of the optical axis, a receiving optical system and a radiation-sensitive detector which is arranged in the receiving optical system's focal plane.

The automatic detection of objects exclusively in motion is possible principally with the aid of correlation methods (see Applied Optics *18*, 3307, 1979). In the case of such correlation methods, video signals of a complete individual picture picked up by scanning the overall field of vision are read into an electronic store and subsequently compared with the video signals of the next individual picture. Different video signals in one and the same picture point then indicate a moving object within the overall field of vision.

A disadvantage of such a correlation method is that individual complete pictures have to be stored electronically and then compared with one another. This is a relatively time-consuming method since with panoramic searchers scarcely more than two revolutions per second can be achieved. In other words two complete individual picture are only available after about a second.

It is therefore an object of the present invention to provide panoramic locating apparatus for locating the position of a moving object, which is considerably faster in reaction than the above-mentioned correlation method.

With this object in view the present invention provides panoramic locating apparatus for locating moving objects, comprising a mechansim for varying the apparatus's object side optical axis in elevation and with constant angular velocity in azimuth arrangements for determining the angle of elevation and azimuth of the optical axis, a receiving optical system and a radiation-sensitive detector which is arranged in the optical receiving system's focal plane characterised in that the detector consists of two rows of detectors arranged staggered with regard to one another in the azimuthal direction, each with the same number of detector elements, a first of the detector rows engaged firstly by a specific momentaneously-represented image area has a signal delaying mechanism 14, and that the detector elements are connected to a mechanism for forming difference signals from the delayed signals of the first detector row and the signals of a second of the detector rows.

With the panoramic locating apparatus in accordance with the invention, an individual picture point from the overall field of vision is picked up twice, shortly in succession. Advantageously, the signal given off by a detector element of the first detector row is stored in a known manner, for example, by a digital processes or by means of a delay line, until a corresponding detector element of the second detector row has also scanned the same picture point. Corresponding video signals from both detector rows are then compared, for example, by means of difference amplifiers. A difference video signal difference from zero indicates a mechanical movement, namely the tangential component thereof. The exact angular position of the moving object results from the values obtained for the angle of elevation and azimuth at the instant of recognition of the moving object, these values being measured for example by means of angle indicators on the adjusting mechanism for varying the optical axis. A further precise measurement of the angle of elevation results by determining which detector element from the detector row has indicated the movement.

Preferably, the apparatus is also provided with a laser range finder apparatus as claimed in claim 1, characterised by the provision of a laser range-finder comprising a transmitting and receiving arrangement which is coaxial to the object-side optical axis of the apparatus, in which respect arranged in the path of an emitted laser radiation beam is a beam deflector arrangement for deflecting the laser beam in the elevation direction, which beam deflector arrangement is controllable with the aid of the difference signals obtained. This makes possible the measurement of the distance to the moving object. The additional alignment of the laser beam in the elevation direction by means of a beam deflector makes possible, in this respect, the use of relatively closely bunched laser beams having high energy density.

The invention will be described further, by way of example, with reference to the accompanying drawing which illustrates schematically a preferred embodiment of the apparatus of the invention.

The preferred embodiment of the panoramic locating apparatus of the invention as shown in the drawing comprises a movably-mounted mirror 1, which is adjustable in height and laterally by means of drives 2 and 3. Angle indicators 4 and 5 indicate the respective angle of elevation or azimuth respectively of object-side optical axis 6. The azimuthal movement of the mirror is effected at a constant angular velocity ω about axis 7. Radiation detected by the mirror 1 is passed onto a radiation-sensitive detector 11 by way of an optical receiving system 8, an inverting prism 9 rotating at half the angular velocity $\omega/_2$ and a beam divider 10. The detector 11 has two detector rows 12 and 13, built up respectively from N elements (where N = 1, 2 3... etc) arranged side-by-side relative to one another in the azimuthal direction. Each detector row 12, 13 has as its function the detection of an image over a narrow vertical image area. The detector rows 12, 13 are so aligned that a picture point which encounters, for example, detector element 12.1 is passed, upon an azimuthal rotation of the mirror 1, onto a corresponding detector element 13.1 of the second detector row 13.

To ascertain the movement process within the field of vision covered by the mirror 1, video signals of the detector elements 12.1 12.2.....12.N of the detector row 12 are scanned electronically at short intervals of time and are stored or delayed for a time until the same picture detail has been picked up also

by the detector row 13 and video signal thereof has been scanned. The time delayed signals of the detector elements 12.1 12.2 ... 12.N of the first detector row 12 are compared with the corresponding signals of the detector elements 13.1, 13.2 ... 13.N of the second detector row 13, in a suitable electronic arrangement 15 which has, for example, N difference amplifiers.

If the signals of two corresponding detector elements differ from one another, then the difference signal thereof is fed to a logic system 16 and checked there once more by means of fixed decision criteria from a corresponding store 17. In this way, interesting speed ranges of detected objects and disturbances or several movement procedures within an instantaneously-scanned picture detail are selected. Where a target is recognised as a moving object, the instantaneous angular position δ, ψ of the optical axis 6 is stored, in which respect the angle of elevation can be ascertained more closely by determining which pair of detector elements has indicated the movement.

An angular resolution which can be achieved with the detector rows which are obtainable nowadays results from the following example:

Two identical detector rows for the reception of heat radiation consists of 100 detector elements each, which are arranged perpendicularly side-by-side in the picture plane. Thus an overall field of vision of 360° x 6° is intended to be scanned, so that the angular extent of the instantaneous vertical field of vision amounts to around 1 mrad.

In military applications of panoramic locating apparatus operating, for example, in the infra-red range, not only the angular position of the moving object has to be known, but also the range of the moving object. This is particularly necessary to determine the actual speed of the object, which can enter into the above-mentioned decision criteria. For this purpose, the apparatus is provided with a laser range-finder which comprises a laser 20 as well as a detector 21 which is sensitive in the appropriate spectral region. By means of a drive 18 a quality switch 20.1 of the laser 20 is selected by a logic system 16 as soon as a difference signal has been obtained. At the same time by means of a drive 19 a beam deflector 26 is so selected by the logic system 16 that an irradiated laser impulse arrives at that point in space which corresponds to the picture point, thereby indicating movement. For this purpose, the laser beam deflected by the beam deflector 26 in the elevation direction is directed along the beam path of the locating apparatus by way of an inverting prism 23 rotating at half the azimuthal angular velocity and an inverting prism 24, and irradiated by way of the pivoting mirror 1. The relatively closely-bunched laser beam arrives, inside the field of view covered momentarily by the mirror 1, merely at the picture detail which is detected by the detector element indicating the movement. The laser radiation reflected by the detected object then passes again by way of the mirror 1, the optical receiving system 8 and the inverting prism 9 into the beam divider 10. Here the laser radiation is filtered out of the remaining spectrum by means of a reflection filter 10.1 and is deflected. The laser radiation selected in this way then arrives at the detector 21, which also has a detector row 22 with an identical number N of detector elements as a detector row of the detector 11. The detector row 22 covers the same pictures areas as one of the detector rows 12 and 13 of the detector 11. Thus, there exists for each detector element pair 12.1 13.1 or 12.2, 13.2..... etc a corresponding detector element in the laser range-finder.

The operation of laser range-finders, more especially those having a piezoelectrical beam deflection, is known 'per se' (see German Auslegeschrift No. 22 29 887) and will not be explained further here. The difference of the laser range-finder being used in the present invention consists, however, in that the deflection of the laser beam by the beam deflector 26 is effected at discrete angular spacings which correspond to the quotient from the vertical angle of view of the optical receiving system 8 and the number of detector elements 22.1 ... 22.N, in which respect each detector element is associated with a deflection angle of the beam deflector. Provided between the beam deflector 26 and the swivelling mirror 1 is a lense for extending the angular region since the maximum angular range of the beam deflector generlly does not correspond to the picture angle covered by the detector row. The panoramic locating apparatus of the invention pre-supposes a constant rotary motion of the optical axis in the azimuthal direction, but at least with the knowledge of the exact angular velocity. For this purpose the drive 3, which is an azimuth adjusting motor, is connected electrically by way of a speed regulation 25 to the logical system 16. The rotary motion of the inverting prisms 9 and 23 at half the azimuth angular velocity $\omega/_2$ can be effected by appropriate mechanical coupling with the aid of the azimuth motor 3.

CLAIMS

1. Panoramic locating apparatus for locating moving objects, comprising a mechanism for varying the apparatus's object side optical axis in elevation and with constant angular velocity in azimuth arrangements for determining the angle of elevation and azimuth of the optical axis, a receiving optical system and a radiation-sensitive detector which is arranged in the optical receiving system's focal plane, characterised in that the detector consists of two rows of detectors arranged staggered with regard to one another in the azimuthal direction, each with the same number of detector elements a first of the detector rows engaged firstly by a specific momentaneously-represented image area has a signal delaying mechanism 14, and that the detector elements are connected to a mechanism for forming difference signals from the delayed signals of the first detector row and the signals of a second of the detector rows.

2. Apparatus as claimed in claim 1, characterised by the provision of a laser range-finder comprising a transmitting and receiving arrangement which is coaxial to the object-side optical axis of the apparatus, in which respect arranged in the path of an

emitted laser radiation beam is a beam deflector arrangement for deflecting the laser beam in the elevation direction, which beam deflector arrangement is controllable with the aid of the difference signal obtained.

3. Apparatus as claimed in claim 2, characterised in that the deflection of the laser beam is effected in discrete angular distances which correspond to the quotient from the vertical angle of view of the receiving optical system and the number of detector elements of a detector row.

4. Apparatus as claimed in claim 2 or 3, characterised in that the laser range-finder itself has a detector row which comprises an identical number of detector elements as one of the detector rows of the detector.

5. Apparatus as claimed in claim 4, characterised in that a respective detector element of the laser range-finder is associated with a deflection angle of the beam deflector arrangement.

6. Apparatus as claimed in any one of claims 2 to 5, characterised in that the laser range-finder has an acousto-optical beam deflector.

7. Apparatus as claimed in any preceding claim characterised in that the detectors are infra-red-sensitive detectors and in that the laser range finding is a CO_2-laser.

8. As claimed in claim 7, characterised in that arranged in front of the detectors and of the laser range-finder is an arrangement for wave length-selective beam division.

9. Panoramic locating apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.

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