(12) UK Patent Application (19) GB (11) 2 226 466 (13) A

(43) Date of A publication 27.06.1990

(21) Application No 8926499.8

(22) Date of filing 23.11.1989

(30) Priority data
(31) 3843006 (32) 21.12.1988 (33) DE

(71) Applicant
Messerschmitt Bölkow-Blohm GmbH

(Incorporated in the Federal Republic of Germany)

Postfach 80 11 09, 8000 Munich 80,
Federal Republic of Germany

(72) Inventors
Gunther Sepp
Richard Benedikter

(74) Agent and/or Address for Service
Barlow Gillett & Percival
Hollins Chambers, 64A Bridge Street, Manchester,
M3 3BA, United Kingdom

(51) INT CL⁵
G01S 17/87

(52) UK CL (Edition K)
H4D DLAA D264 D716 D74X D747 D749 D773
D774 D775 D777 D781 D782 D783

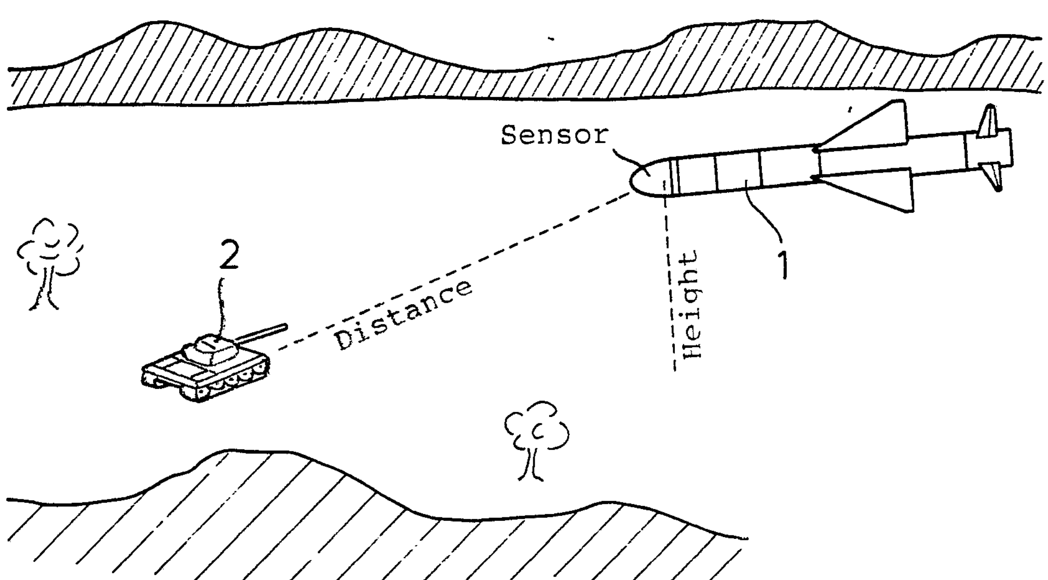
(56) Documents cited
GB 2190177 A **GB 1476504 A** **EP 0201003 A2**
EP 0035101 A1

(58) Field of search
UK CL (Edition J) **H4D**
INT CL⁴ **G01S 17/87**
On-line databases: -WPI

(54) **Means for the detection and identification of individual targets**

(57) To detect and identify individual targets, a low-flying missile has, in its ahead downwards direction seeker head, a laser rangefinder as well as an infrared sensor. After pre-adjustment the infrared sensor sweeps the area ahead and underneath, in the instructed direction, line by line in search of target-characteristic infrared radiation. On acquisition of a likely target due to one or several of the known target characteristics, the target location is determined in elevation and azimuth and held in an intermediate memory with the target coordinates. Then the likely target is automatically locked onto by the laser rangefinder whereby range shift (altitude shifts) are registered as further target characteristics. Final target recognition is then executed in a computing device according to the pre-set pattern.

FIG. 1



GB 2 226 466 A

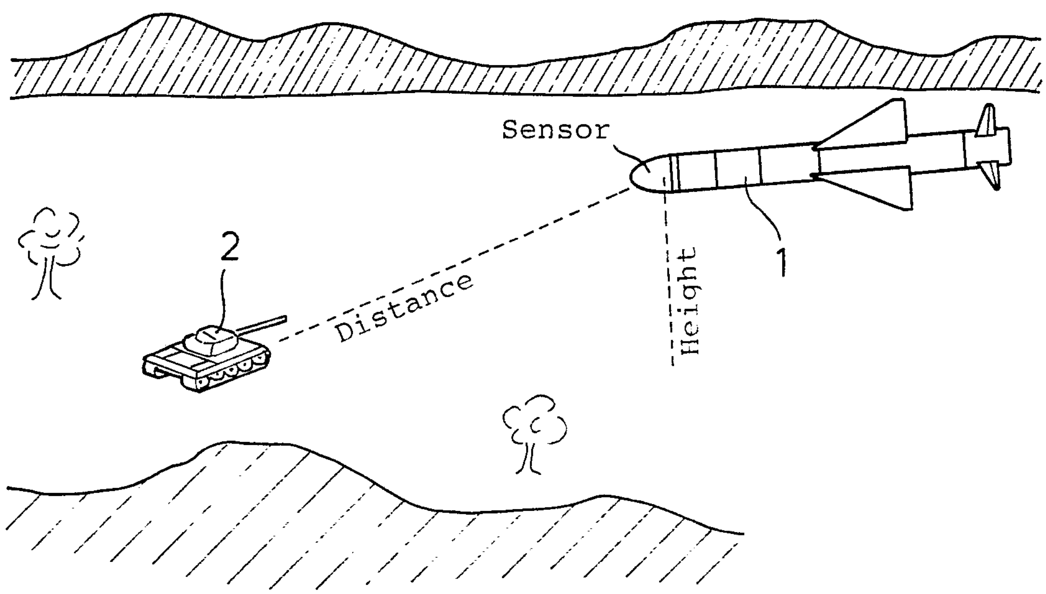


FIG. 1

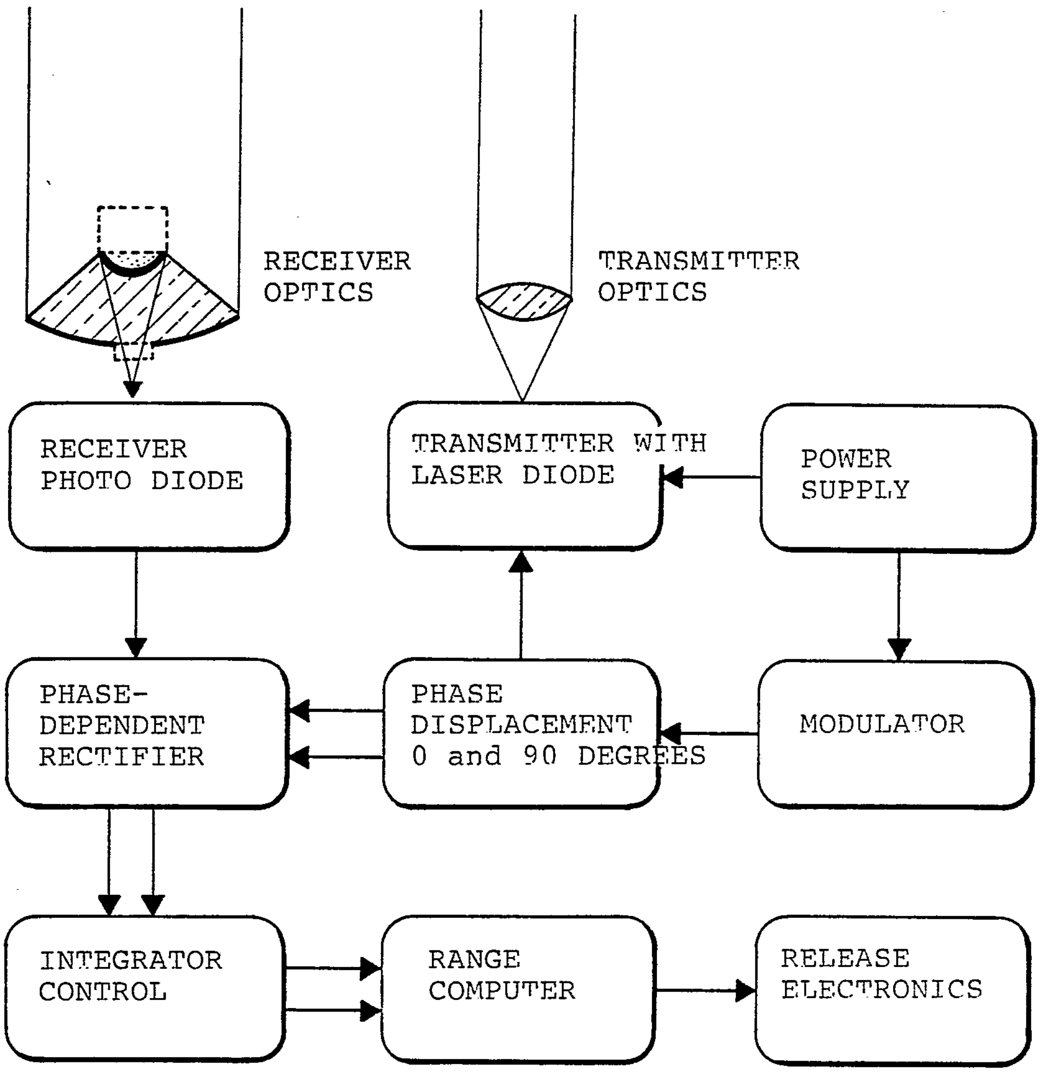

RECEIVER
OPTICS
TRANSMITTER
OPTICS
RECEIVER
PHOTO DIODE
TRANSMITTER WITH
LASER DIODE
POWER
SUPPLY
PHASE-
DEPENDENT
RECTIFIER
PHASE
DISPLACEMENT
0 and 90 DEGREES
MODULATOR
INTEGRATOR
CONTROL
RANGE
COMPUTER
RELEASE
ELECTRONICS

FIG. 2

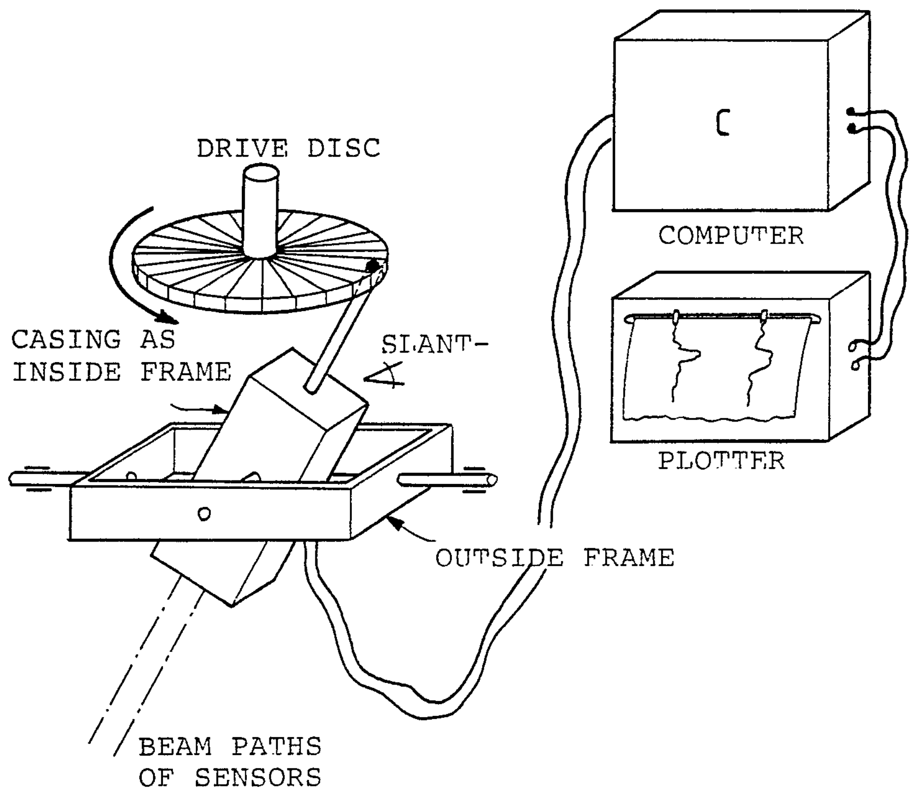

DRIVE DISC
COMPUTER
C
CASING AS
INSIDE FRAME
SLANT-
PLOTTER
OUTSIDE FRAME
BEAM PATHS
OF SENSORS

FIG. 3

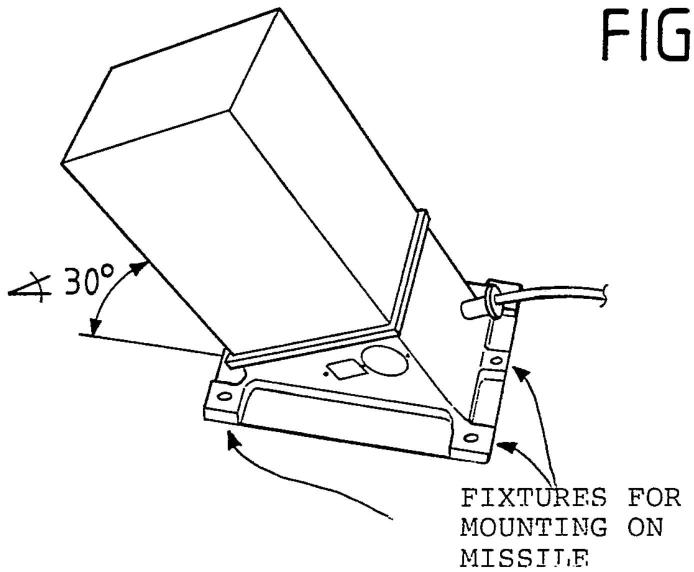


FIG. 4

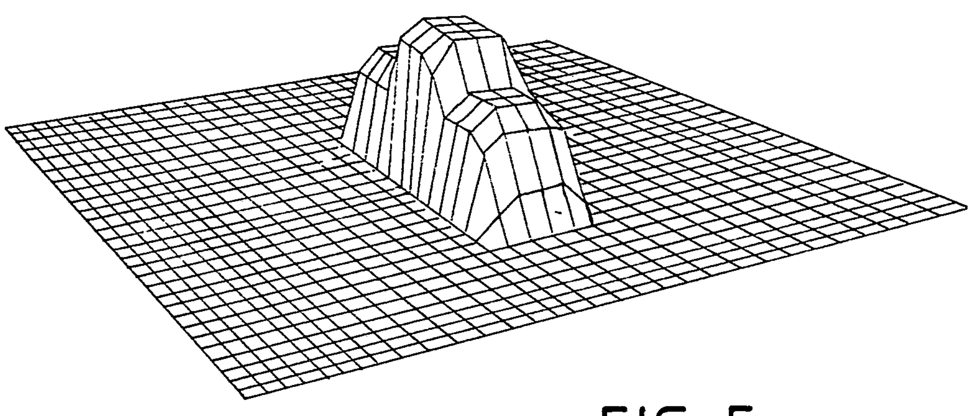


FIG. 5

MEANS FOR THE DETECTION AND IDENTIFICATION OF INDIVIDUAL TARGETS

This invention relates to a method of detection and identification of individual targets.

Such means as used in fast-flying combat aircraft is know from German Patent specification DE 30 48 574 C2 of the applicant.

Therein, radar equipment is used alongside an infrared sensor so as to register a further target characteristic, for example that a motor vehicle is made of metal.

As the target characteristics, such as intensity of infrared radiation, are dependent on environmental conditions such as temperature, time of day, annual season, range of visibility and likely tactical feature (stationary or mobile), it is suggested in the aforementioned patent specification that the pilot/combat observer is given the possibility of actually feeding such fringe conditions of the target characteristics into the sensor-computing electronics.

However, detection by radar is also liable to interference.

An objection of the invention is to improve the aforesaid method in respect of target recognition and to make it suitable for missiles, which represent an autonomous system at least after their separation from the carrier aircraft.

According to the invention a method of detection and identification of individual targets from a low-flying missile, which has an ahead downwards directed seeker head including an infrared sensor and a laser rangefinder, as well as a guidance system, is characterised in that

- the infrared sensor after pre-adjustment (approximate directional advance) sweeps the area ahead and underneath (in the instructed direction) line by line in search of target-characteristic infrared radiation,
- on acquisition of a likely target due to one or several of the known target characteristics after sweeping by the infrared sensor the target location is determined in elevation and azimuth and held in an intermediate memory with the target coordinates, and subsequently
- the likely target is automatically locked onto the laser rangefinder by way of a special device, which registers range shifts (altitude shifts) as further target characteristics, and
- thus the final target recognition is executed in a computer device according to a pre-set pattern.

Advantageously the missile is a distance missile which does not require initial line-of-sight contact with the target, and can be pre-directed towards a distant coordinate of a suspected target by an aircraft serving as a weapons carrier or a carrier of a weapons-supply system, the homing in and the recognition of the target by the missile then being autonomously achieved by way of the ahead and downwards looking seeking head of the missile, at least during operation against fixed targets, effective operation against mobile targets additionally requiring the computer device to include a time basis so that the relative movement of target and missile is recorded or followed up.

Advantageously the infrared sensor may form part of an overflight sensor in an assembly unit of an aircraft, which overflight sensor is mounted to look ahead downwards in the direction of its vertical axis and includes a laser transmitter with transmitting optics, a laser receiver with receiving optics, an interference filter, lens-coverage apertures, as well as transmitting and receiving electronics with matching elements, and a computing unit whereby the release and tracking of the missile from the aircraft activates the autonomous control or guidance means, of the distance missile including its seeker head, which is activated by way of the release signal.

The laser transmitter is preferably a semi-conductor laser, in particular a hydrocarbon-semiconductor laser, which is operated with amplitude mudulation at a ratio of approximately 1:1 (pulse/pause duration) and whose radiation is collimated by a lens.

The laser receiver is advantageously provided with a catadioptric photo lens which focusses the received beam through lens-coverage apertures and a narrow-band interference filter onto an avalanche-photo diode.

The laser transmitter and the laser receiver preferably both have an associated range-finding device of the phase-measuring type i.e. it measures the phase difference between the transmitted and received signal which is proportional to the travelled path of light.

Preferably the CW-semiconductor laser used has a gallium-arsenide-hetero-structure.

Advantageously, the sensor in the seeker head is cardan mounted in an exterior frame in the vertical axis and therein is displaceable in elevation and azimuth as against a determined null point (time, altitude, speed, lateral deviation) and linked to a computer.

Overall, instead of surface sweeping, line-by-line sweeping in the flight direction (target in line-of-sight) with high resolution has been chosen as being most favourable.

It is possible by virtue of the invention to meet the high demands of measuring-data collection, signal processing and evaluation both in time and space with stationary and mobile targets. Through intelligent sensor composites and the way obtained signals are evaluated, targets are automatically picked up, identified and classified. A possible application of the invention lies in combating targets automatically by firing from above, whereby several targets can be picked up in most rapid succession. This type of combat from above is also effective against camouflaged targets. As an autonomously propelled and guided missile, it can be mounted on different aircraft, and can be reloaded with ammunition. Such an autonomous missile follows the principle of "fire and forget".

In the drawings:

Fig. 1 shows the viewing direction of a laser rangefinder on a missile, with built-in seeker head for target recognition, on approach of a possible target;

Fig. 2 is a block-circuit diagram of the laser rangefinder with continuous wave amplitude modulation;

Fig. 3 is a perspective view of a sensor mounting, connection on the one side to a drive disc, and electrically to a computer and, if required, to a plotter;

Fig. 4 is an enlarged perspective view of a sensor unit built into a casing prior to mounting; and

Fig. 5 is a representation of a detected object in a compilation elevation net, swept by the height-shift sensor or the laser rangefinder.

Fig. 1 illustrates a missile 1 approaching a target 2 at a distance ahead and below. The approach takes place autonomously after separation from the carrier aircraft, and a flight guidance or control unit is built into the missile 1. At the tip of the missile there is a seeker head including various sensors, amongst others for maintaining the flight altitude of the missile whilst approaching the target or suspected target.

The seeker head or the seeker sensor respectively is pivotably mounted, in particular cardan mounted, as will be explained below with reference to Fig. 3. It sweeps the ground in order to detect and identify the target.

identify the target. In this respect, fast sweeping of the slant distance range (line-of-vision to target) with high resolution is particularly important. For this reason it is preferable to provide, in addition to an infrared sensor, a continous wave laser rangefinder which, as a further characteristic of the target recognition, evaluates the distance shifts occurring during the sweep. The ground sweep is line-by-line (no surface sweep is required). Line sweeps in the flight direction are sufficient.

During cruising flight of the missile, the laser sensor can serve as altimeter for controlling the flight altitude which is instructed by the infrared sensor only after detection of a possible target signature. It will then deliver a geometrically tabulated altitude profile of the landscape, the shape of which is characteristically influenced by a target.

The procedure is as follows:

-basic image processing evaluates the size of "hot spots" from picture information and from the laser rangefinder (missile altimeter and picture angle) and selects the "best", i.e. the hot spots matching the target vehicles;

- the altitude maintaining laser rangefinder is swivelled sideways, for example by swivelling mirrors, so that it looks ahead slantingly sideways in flight direction and hits the ground just before the "realistic" hot spot, i.e. a possible target. The altitude is now controlled by extrapolation of the supported missile inertial system, which has up until then been by the laser-rangefinder.

- by means of the rigidly deflected laser beam, the target/possible target as suspected by the hot spot (longitudinal section - line of height) is scanned by the virtue of continued missile movement. If the height shift is compatible with a genuine target, then the target search is terminated and the target which has been located is attacked. If not, a scan to the next "good" hot spot takes place or, if same has already been passed, the rangefinder is swivelled back for maintaining of altitude.

Compared to an IR- picture sensor on its own (array detector, line scanner, etc.) the arrangement of the invention delivers a higher pixel rate, but along with only poorly discriminating (clearly evaluative) picture information.

With a laser rangefinder on its own, particularly one which must look ahead slantingly sideways, i.e. with a great range, and with present laser output, optics, distance resolution etc., only a limited pixel rate would be possible.

In contrast thereto, with the invention, due to pre-selection of the pixels to be scanned by the IR sensor, the pixel rate which is thereby obtained is sufficient for target recognition. Of N^2/s IR pixels only N/s pixels are scanned by the laser rangefinder.

Measuring principle of the laser- rangefinder sensor

As a scanning distance-shift sensor, a continous or quasi-continuous action laser rangefinder is suitable. In the two most frequently used operating methods, the pulse-delay method and the continuous-wave method with amplitude modulation, it is the continuous-wave method that offers specific advantages which is why it is preferred for laser rangefinders for continuous scanning. The principle is briefly described below.

An amplitude-modulated continuous-wave signal is transmitted by a transmitter and, after diffused reflection from a target surface, is received by a receiver. The time of travel of the signal from the transmitter to the reflecting surface and back to the receiver introduces phase difference modulation between the transmitted and the received signal. In other words, this phase difference is a direct measure of the distance to be verified.

The block-circuit diagram in Fig. 2 shows the structure of the amplitude-modulated continuous-wave laser rangefinder.

The laser diode which is used as transmitter and includes collimatoroptics convex/concave (Fig. 2 top right) is driven by a modulator through a driver stage and transmits a modulated light beam (modulation frequency here is a few MHz) which is collimated by series-connected optics. Part of the beam diffusedly reflected from the ground is directed by the receiver optics including two reflectors concave/convex (Fig. 2 top left) onto a photo diode whose output current is rectified after amplification in a double phase-dependent rectifier. The control phases of the phase-sensitive rectifier are drawn from the modulation current by a phase displacement of 0 to 90 degrees. The two outputs of the phase-dependent rectifier are proportional to the sine or the cosine respectively of the phase angle of the receiver signal. As the phase displacement of the receiver signal is proportional in distance to the transmitter signal, the distance can be calculated from the output volumes of the phase-dependent rectifier. The distance can be shown by the computer-plotter as analogue current, or also as a digital value.

Measuring sequence

To illustrate the output and technical possibilities of the laser rangefinder in practical use as a sensor for target recognition, the following procedure is adopted:

First, the sensor is mounted with its cardan-mount such that the swept circular art covers at least 0.25*pi (45 degree angle) over a clear area. The remainder of the circular arc is faded out, in which respect the entry of the measuring-beam paths are marked on the drive disc by a marker and a photo diode. The sensor is switched on and the entire assembly is swivelled around in a diametrical direction over the target vehicle placed in the swept area. The output signal of the measuring sensor is digitalised and fed onto a RAM disc in the computer as sequential data. The data sequence from the stored data is shown in the form of a height-profile sequence. The illustration can be in an area with a surface of 128 times 128 increments. However, this requires a relatively large memory availability in the demonstration computer, thus a reduced density may be desirable. Subsequently, the display program in the computer is initiated, and the values are given as a result of height lines or as a three-dimensional net, respectively, on the display screen and are printed out by the printer. For documentation, the contents of the RAM disc can be transferred to another data carrier (diskette). This illustrates the output of the sensor, in particular regarding the achieved sweep speed.

The real application of the laser rangefinder is shown in the second stage wherein the sensor is rigidly disposed downwards ahead at an angle of 30 degrees to the horizontal. The target vehicle then moves under the sensor through the slanted measuring beam. This results in a height profile of the target vehicle from an elevated viewing position with relatively flat incline and an abrupt drop which can best be shown by shadows thrown from a sideways elevated light source.

The sensor-signal sequence is also recorded and reproduced on the computer display (plotter).

The representation of the height net in Fig. 5 serves to illustrate the method of presentation. This can be drawn much finer, with double density of pixels, but only with increased memory-capacity in the computer. It should be noted that this surface-type illustration was chosen only to demonstrate the principle. In practice, a single sweep along a line in the flight direction may be sufficient as long as there is high resolution. The illustration in connection with the invention thus corresponds to a line-height profile from a slanting bird's eye view.

CLAIMS

1. A method of detection and identification of individual targets from a low-flying missile, which has an ahead downwards directed seeker head including an infrared sensor and a laser rangefinder, as well as a guidance system, is characterised in that

- the infrared sensor after pre-adjustment (approximate directional advance) sweeps the area ahead and underneath (in the instructed direction) line by line in search of target-characteristic infrared radiation,
- on acquisition of a likely target due to one or several of the known target characteristics after sweeping by the infrared sensor the target location is determined in elevation and azimuth and held in an intermediate memory with the target coordinates, and subsequently
- the likely target is automatically locked onto the laser rangefinder by way of a special device, which registers range shifts (altitude shifts) as further target characteristics, and
- thus the final target recognition is executed in a computer device according to a pre-set pattern.

2. A method of target detection and identification as claimed in claim 1, wherein the missile is a distance missile which does not required initial line-of-sight contact with the target, and can be pre-directed towards

a distant coordinate of a suspected target by an aircraft serving as a weapons carrier on a carrier of a weapons-supply system, the homing in and the recognition of the target by the missile then being autonomously achieved by way of the ahead and downwards looking seeker head of the missile, at least during operation against fixed targets, effective operation against mobile targets additionally requiring the computing device to include a time basis so that the relative movement of target and missile is recorded or followed up.

3. A method of target detection and identification as claimed in claim 1 or 2, wherein the infrared sensor forms part of an overflight sensor in an assembly unit of an aircraft, which overflight sensor is mounted to look ahead downwards in the direction of its vertical axis and includes a laser transmitter with transmitting optics, a laser receiver with receiving optics, an interference filter, lens-coverage apertures, as well as transmitting and receiving electronics with matching elements, and a computing unit whereby the release and tracking of the missile from the aircraft activates the autonomous control or guidance means of the distance missile including its seeker head, which is activated by way of the release signal.

4. A method of target and identification as claimed in claim 1, 2 or 3, wherein the laser transmitter is a semi-conductor laser, in particular a hydrocarbon-semiconductor laser, which is operated with amplitude modulation at a ratio of approximately 1 : 1 (pulse-pause duration) and whose radiation is collimated by a lens.

5. A method of target detection and identification as claimed in any preceding claim, wherein the laser receiver is provided with a catadioptric photo lens which focusses the received beam through lens-coverage apertures and a narrow-band interference filter onto an avalanche-photo diode.

6. A method of target detection and identification as claimed in any preceding claim, wherein the laser transmitter and the laser receiver have an associated range-finding device of the phase-measuring type i.e. it measures the phase difference between the transmitted and received signal which is proportional to the travelled path of light.

7. A method of target detection and identification as claimed in claim 5, wherein the semiconductor laser has a gallium-aluminium-arsenide-hetero-structure.

8. A method of target detection and identification as claimed in any preceding claim, wherein the sensor in the seeker head is cardan mounted in an exterior frame in the vertical axis and therein is displaceable in elevation and azimuth as against a determined null point (time, altitude, speed, lateral deviation) and linked to a computer.

9. A method of target detection and identification as claimed in any preceding claim, wherein instead of surface sweeping line-by-line sweeping in the flight direction (target in line-of-sight) with high resolution has been chosen.

10. A method of target detection and identification substantially as hereinbefore described with reference to the accompanying drawings.

Published 1990 at The Patent Office, State House, 66 71 High Holborn, London WC1R 4TP Further copies may be obtained from The Patent Office. Sales Branch, St Mary Cray, Orpington, Kent BR5 3RD. Printed by Multiplex techniques ltd, St Mary Cray, Kent. Con. 1 87