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(54) An infra-red detector system.

(57) An infra-red intruder detection apparatus has an optical system comprising a Fresnel plate (7) and an infra-red sensor (5) positioned at the focus of the Fresnel plate. An optical path extending from the Fresnel plate to the infra-red sensor is bounded on either side by first and second mirrors (2, 3) diverging from the sensor towards the Fresnel plate to thereby provide a first fan of field of view for the sensor. A third mirror (4) is preferably disposed above the optical path to thereby provide a second fan of field of view for the sensor below the first said fan.

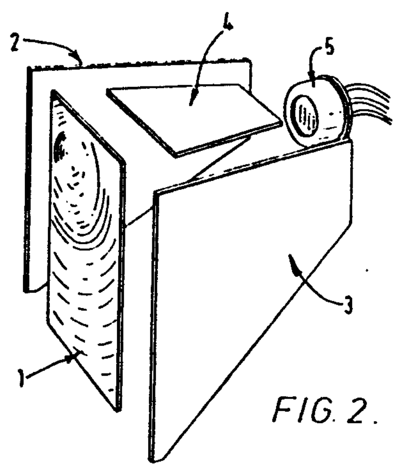

FIG. 2.

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AN INFRA-RED DETECTOR SYSTEM

The invention relates to a motion detection system mainly used as an intruder sensor in burglar alarm systems.

The invention herein described detects changes in infra-red (7-12 micron wavelength) energy collected by a plurality of optical fields-of-view, each focussing on a common infra-red sensing device such that when an intruder moves across the field-of-view the instantaneous infra-red energy level falling on the detector will fluctuate and thus provide a fluctuating electrical signal.

The use of multiple fields-of-view, infra-red intruder sensors and associated signal processing circuits is not new, and intruder detectors using these techniques have been in use in the security industry for many years. The means of achieving a plurality of fields-of-view in currently available intruder sensors fall broadly into two types. One type uses a number of reflective elements such as spherical, parabolic or other conic-section mirrors or mirror segments, located radially around a common infra-red detector such that the detector is at the focus of each mirror. The axis of each mirror is arranged to radiate from the unit radially so that the room or area to be protected is covered by a fan shaped series of fields-of-view. It is common practice to have a further series of mirror segments similarly sharing the common detector, but arranged to provide a further fan-shaped array of fields of view angled below the first set to prevent an intruder moving below them and thus avoiding detection.

The other common type of intruder sensor uses a plurality of refractive elements, typically an array of Fresnel lenses, sharing an infra-red detector located at the common focus of the lenses, which are radially disposed to provide a fan-shaped series of fields of view. Again, further ranks of lenses may be used to provide additional downward-pointing fields of view to prevent an intruder avoiding detection.

In both these techniques, which form the majority of intruder sensors currently available, the infra-red detecting device is typically a commercially available pyro-electric device having two sensing elements electrically connected in opposition, such that changes in infra-red energy falling upon both detectors simultaneously will cause cancellation of signals, whereas energy falling on one or other element will cause an electrical output. Thus, sudden temperature fluctuations of the environment or of the detector housing will not normally causes false alarms. Since both detector elements are located on the focal plane of the focussing mirrors or lenses, each mirror or lens axis provides in effect two fields of view, one for each element. Thus when an intruder moves across the fields of view his infra-red energy will fall upon first one, and then the other, element, to produce, say, a positive-going followed by a negative-going signal. This signal will repeat for each axis traversed, and is used to signal an alarm.

One further system available uses a single focussing element and a plurality of detecting elements which provide a plurality of fields of view.

All of the above systems have some major disadvantages which the invention seeks to overcome. These disadvantages are generally as follows:

Currently available detectors typically use two sensing elements of approximately 1 mm. width spaced apart by 1 mm. In an intruder sensor having a 50 ft. range, any single field of view should be approximately 1 ft. wide at 50 ft. range. Thus a focal length of 50 mm. would be appropriate. In order to keep the electronic amplification required to a minimum in order to avoid a poor signal-to-noise ratio, as much optical gain as possible is required, and f numbers higher then f 3 are desirable. Therefore, in a practical intruder sensor having a 50 ft. range, a single mirror or lens segment will require an area of at least 200 sq. mm. Thus a typical detector having an array of say 10 segments will require a mirror or lens array of at least 2,000 sq. mm. This size of array places a limit on the minimum size of a complete intruder detector and seriously limits natural technical progression towards small and less obtrusive units. In the case of refractive systems, the lens array is commonly made from a polyethylene material, since this is one of the few economically available materials which will allow low-loss transmission of far infra-red energy. Polyethylene is not a rigid plastic, and since the lens array typically forms the front "window" of the intruder sensor, the vulnerability of the unit to accidental or deliberate damage increases with the number of fields of view required. A further practical disadvantage is that the lens array is normally produced as a flat hot-pressed plastic sheet, and is usually curved around a rigid supporting frame to provide the desired fan-shaped arrangement of fields of view.

Although ideally each lens segment should be flat, with the bending only occurring at the gaps between the segments, in practice the lens segments take on the general curvature of the array, and thus cause considerable abberation and loss of focus of the intruder's infra-red energy falling upon the detector. The present invention seeks to overcome the disadvantages shown above by providing a means wherein a plurality of fields of view are obtained without the need for a plurality of mirror or lens segments thus giving a considerable space saving in the vulnerable frontal area of a complete intruder sensor.

United Kingdom Patent No. 1 385 410 describes an intruder alarm using a concave mirror divided into separate segments. Such an arrangement can only achieve a good resolving power if the mirror segments have a long focal length and large individual dimensions, for the reasons described above. Furthermore, such an arrangement has a large number of components which require to be accurately positioned, and leads to a complicated and expensive construction. The arrangement of the present invention, in contrast, is simpler, cheaper and easier to construct and adjust.

The present invention which is defined in the claims appended hereto, makes use of plane mirrors and a focussing lens.

The invention will be further described with reference to the accompanying drawings, in which:

Figure 1 is a circuit diagram of a detector circuit suitable for use with the present invention;

Figure 2 is an exploded view of the optical components of the invention;

Figures 3, 4, 5, 7 and 9 are diagrammatic plan views of a system according to the invention showing the optical paths involved; and

Figures 6 and 8 represent electrical waveforms generated by the apparatus according to the invention on the passage of an intruder.

The circuit of Figure 1 shows an infra-red sensor comprising two detectors connected back to back in the input circuit of a band pass amplifier. The output of this amplifier is applied to a threshhold device and when the signal level exceeds the threshhold, an alarm relay is activated.

Figure 2 is an exploded view of the optical components of the invention. A Fresnel lens plate 1 is focussed on the surface of an infra-red sensor 5, the sensor 5 has two detecting elements connected in opposition behind a filter window which allows transmission of infra-red energy of more than 6 microns wavelength.

At either side are positioned a pair of vertical mirrors 2 and 3 inclined at a small angle preferably about 6 degrees, to the optic axis of the Fresnel lens plate 1. Above and in front of the sensor is a further reflector 4 inclined to the horizontal similarly at a small angle.

Figure 3 shows diagrammatically in plan view some of the fields of view generated by this arrangement. As shown in Figure 3, five diverging fields of view are generated, only three of which are shown in the diagram for clarity. A first field of view indicated by dashed lines with single arrows corresponds to an infra-red beam falling normally onto the surface of the lens plate 1 and focussed by it onto the detector 5. A second field of view indicated by the dashed lines with double arrows corresponds to a beam focussed by the lens 1 and reflected by the mirror surface 2 onto the detector 5. A similar field of view not shown in the diagram correspond to a beam symmetrically disposed on the other side of the axis and reflected by the mirror 3.

A further field corresponds to a beam indicated by the triple headed arrows which after refraction by the lens 1 is reflected twice, once at the mirror 3 and a second time at the mirror 2 before reaching the detector 5. A similar field not shown in the diagram exists on the other side of the axis corresponding to reflection first at the mirror 2 and then at the mirror 3.

Figure 4 is a diagrammatic sectional elevation showing how the top mirror 4 provides a lower set of fields of view corresponding to those in Figure 3. The dashed lines with single arrow heads correspond to the upper fields while those with double arrow heads show fields corresponding to reflection by the mirror 4 and inclined downwards in order to detect an intruder below the main fields.

Figure 5 shows how the apparent images of the detector caused by reflectors 2 and 3 determine the positions of the fields of view.

Figure 6 shows a typical electrical signal resulting from an intruder crossing through all fields of view. The positive-going signals result from detector element A receiving energy, and the negative-going signal results from detector element B receiving energy.

Referring to Figure 5, energy collected within field of view A1 will be focussed to fall on to detector element A. Similarly, energy collected within field of view B1 will be focussed to fall on to detector element B. Energy collected within field of view A2 will reach detector element A via plane reflector 2.

Energy collected within field of view B2 will reach detector element B via plate reflector 2.

Energy collected within field of view B3 will reach detector element B via plane reflector 3.

Energy collected from field of view B4 will reach detector element B via plane reflectors 2 and 3.

Energy collected from field of view A4 will reach detector element A via plane reflectors 2 and 3.

Energy collected from field of view A5 will reach detector element A view plane reflectors 3 and 2.

Energy collected via field of view B5 will reach detector element B via plane reflectors 3 and 2.

The relative spacing and angles of the plane reflectors may be changed to give different positions of the fields of view.

Infra-red energy may enter the system from angles wider than those shown by means of further internal reflections between reflectors 2 and 3 before finally reaching the detecting elements. However, in practice this energy will be unfocussed, due to the excessive path length, and also may arrive at the detector front filter window at or above the angle of incidence or cone of acceptance.

Because of the relative angles of plane reflectors 2 and 3, the apparent detector positions do not lie in a plane and some de-focussing occurs. In the practical embodiment, the detector 5 is located closer to the lens than the ideal focal length, and the resulting loss of focus compensated for by a lower f number than would be required for an ideally placed detector. Thus energy arriving at the detector via one or both plane reflectors 2 and 3 will be in focus and all arrive at the detecting element, thereby compensating for reflective losses.

Referring to Figure 4, the addition of plane reflector 4 ensures that energy arriving from locations vertically below fields of view, A1, B1 to A5, B5, and within the lower angled fields of view, will arrive at the detector elements A or B. For example Figure 4 shows the path by which energy from an intruder entering angled fields of view A6 would reach detector element A via plane reflector 4. Clearly, energy entering the other angled fields of view would arrive via reflectors 2 or 3 and 4.

Energy arriving via the reflectors 2, 3 and 4 will be largely de-focussed due to the extra path length. However, in a practical embodiment an intruder sensor would preferably be located about 7ft. (2.1 metres) above the floor and angled such that the main rank of fields of view would be angled at about 10° downwards. The lower angled fields of view angled at about 40° downwards would therefore reach the floor at a distance of some 12 feet (3.6 metres). Thus the de-focussed and therefore wider field of view would still gather sufficient energy from the relatively close intruder. Note: (provided the intruder full fills the field of view, the energy collected will remain constant with his distance from the sensor).

In an alternative arrangement, shown in Figure 7, two positive focus lenses A and B are located in relation to two plane reflectors. The lenses are off-axis segments. The advantage of this embodiment is interleaving of the fields of view to give a higher number of fields of view for a given area of protection. Thus for a given intruder movement, a higher number of electrical fluctuations will occur, allowing pulse counting and storage techniques to improve false alarm rejection.

Figure 8 shows the electrical signal from detector 5 for movement of an intruder across the fields of view.

A further embodiment, shown in Figure 9, shows the axis for lens A going through the lens segment, whereas the axis for lens B is outside the lens segment. This arrangement may also provide means whereby the fields of view may be interleaved or interspaced.

The preferred embodiments herein described use Fresnel type lenses, but normal refractive lenses made from germanium, or other material offering a low loss to 7 - 12 micron infra-red energy, may also be used.

CLAIMS:

1. An infra-red detector system comprising an infra-red sensor connected in a detector circuit and an optical system including reflectors arranged to provide fields of view for the sensor diverging in a fan-like manner, characterised in that the optical system includes a pair of upright plane mirrors (2,3) positioned in front of the sensor (5) and diverging at a small angle so as to produce a plurality of virtual images of the sensor (5), and a focussing lens (1) in front of the mirrors.

2. An infra-red detector system according to claim 1 including a further plane mirror (4) positioned in front of an above the sensor (5) and inclined at an angle to the horizontal so as to produce a lower fan of fields of view.

3. An infra-red detector system according to claim 1 or claim 2 in which the lens is a Fresnel plate bearing a plurality of lens segments.

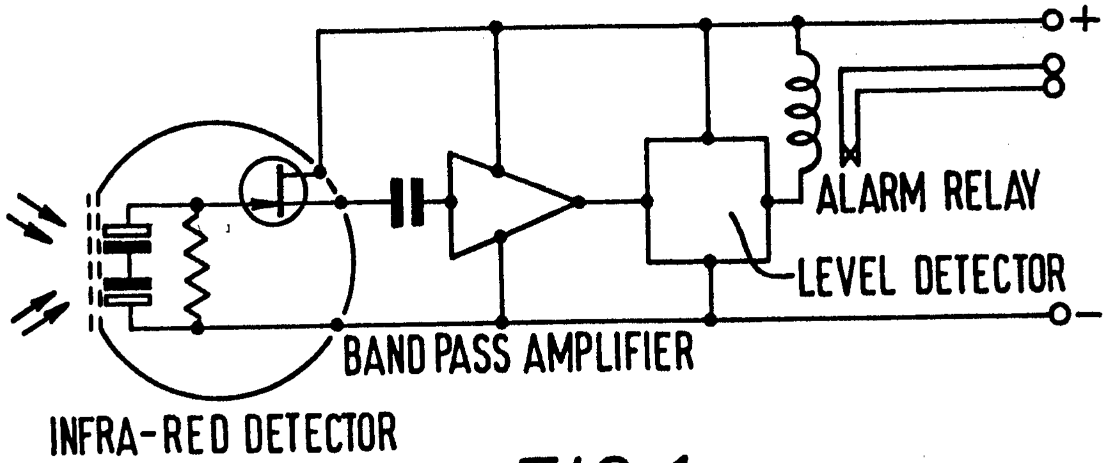
4. An infra-red detector system according to claim 3 in which the optic axis of at least one lens segment lies outside the segment.

5. An infra-red intruder detection apparatus comprising an infrared sensor for connection in a detector circuit characterised by a lens and first and second plane reflectors arranged so as to provide the sensor with a plurality of fields of view focussed by said lens.

6. An infra-red intruder detection apparatus according to claim 5 characterised in that the lens is a Fresnel

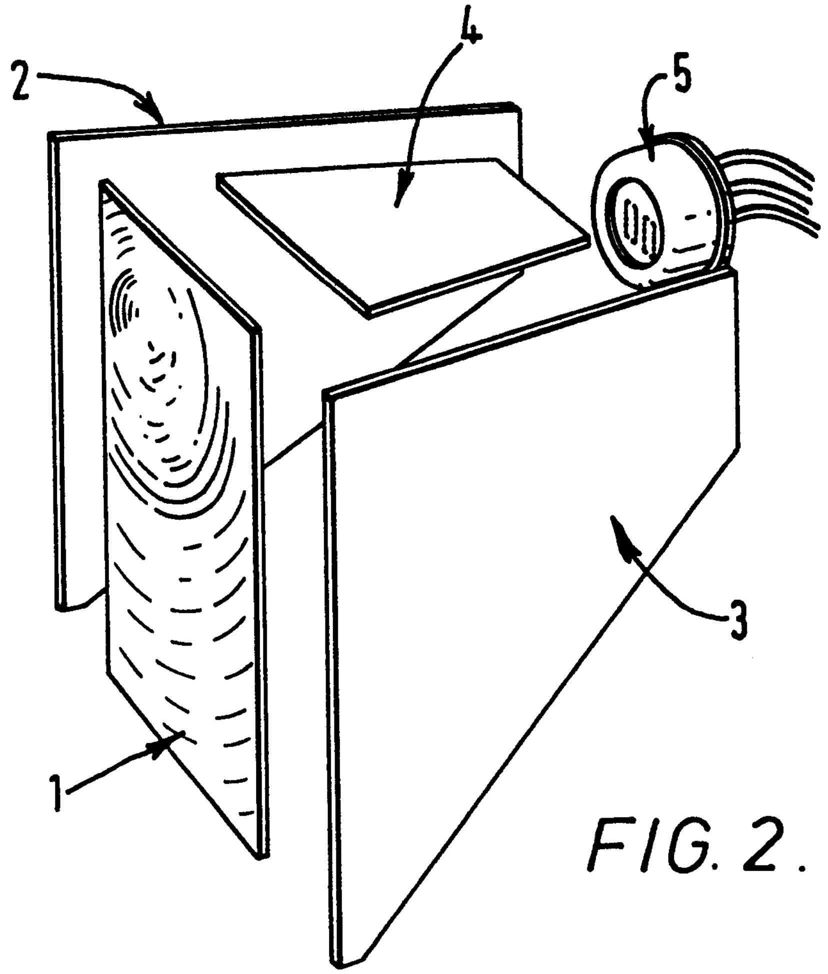
lens defining an optical path extending from the Fresnel lens to the sensor, and said first and second reflectors are disposed on either side of the optical path diverging from the sensor towards the Fresnel lens so as to provide fields of view focussed direct from the lens and via the first and second reflectors.

7. An infra-red intruder detection apparatus according to claim 6 characterised by a third plane reflector discposed above the optical path to provide further fields of view via the third reflector.



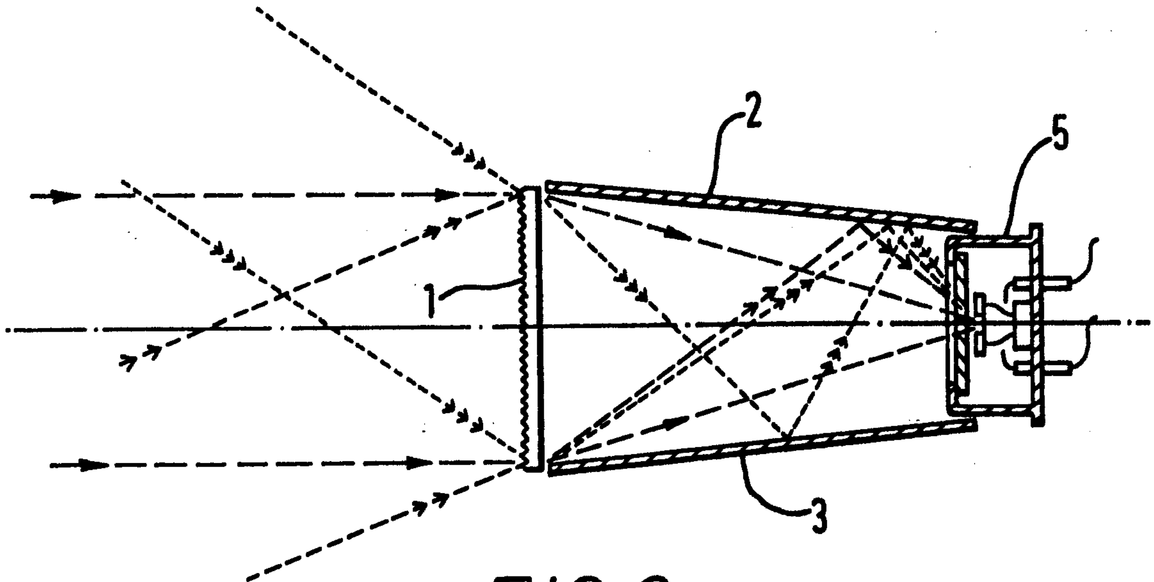
ALARM RELAY
LEVEL DETECTOR
BAND PASS AMPLIFIER
INFRA-RED DETECTOR

FIG. 1.

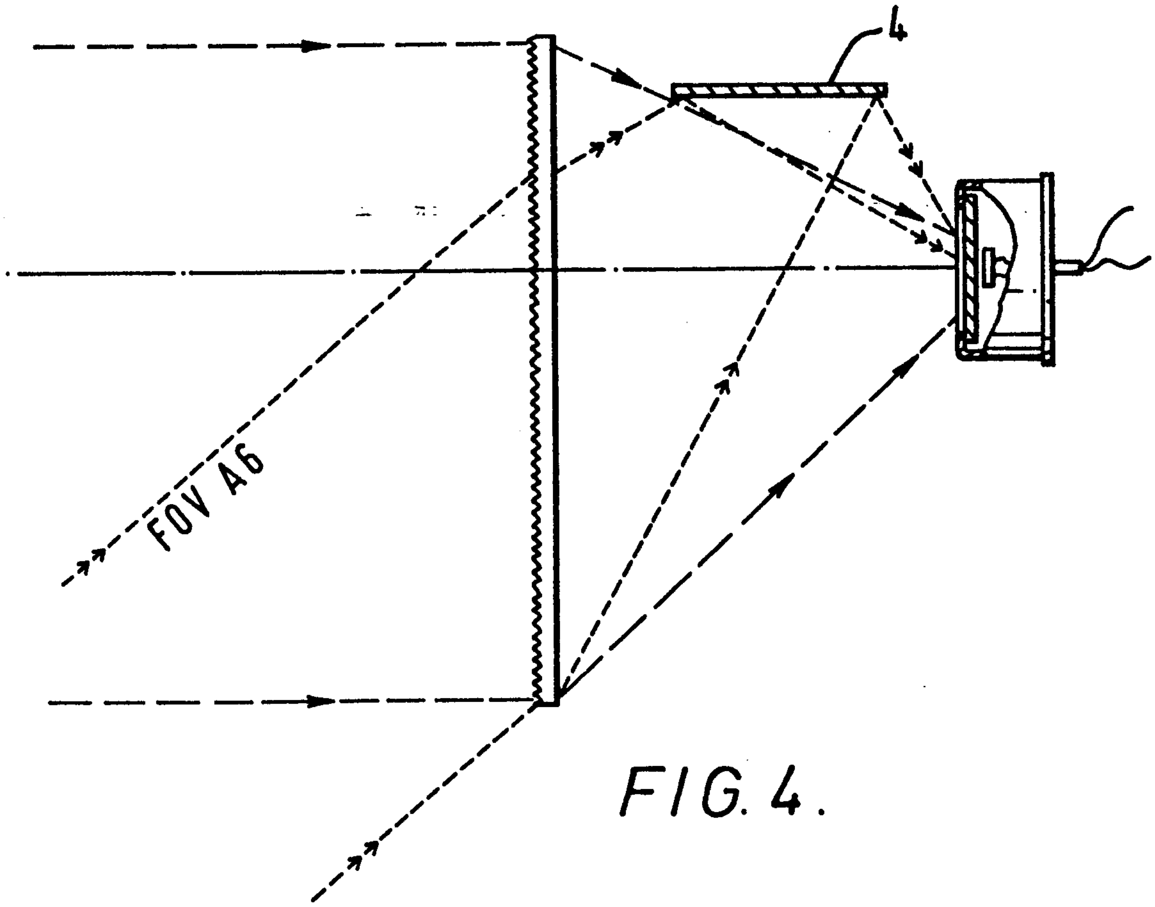


4
2
5
3
1

FIG. 2.



F/G. 3.



F/G. 4.

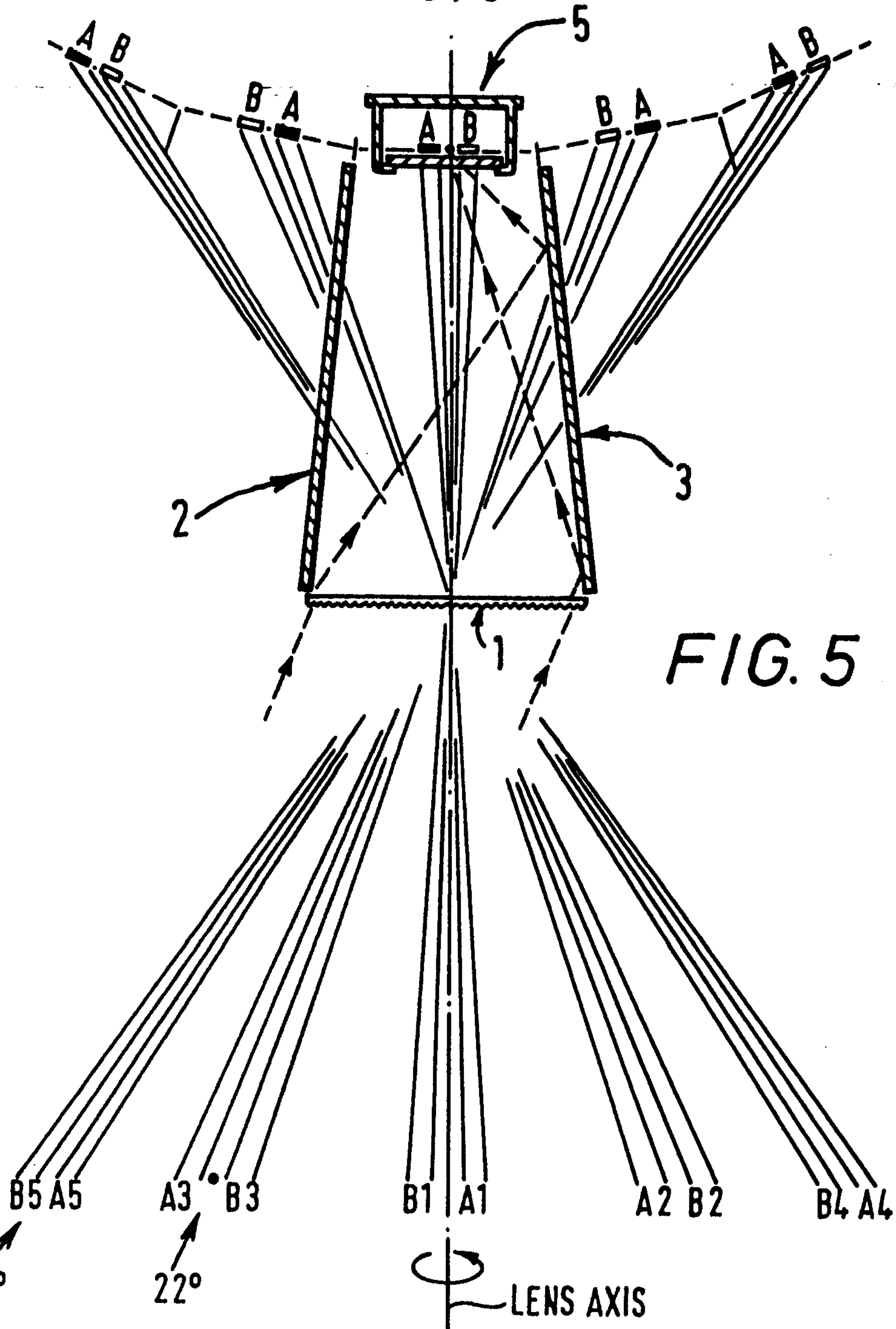
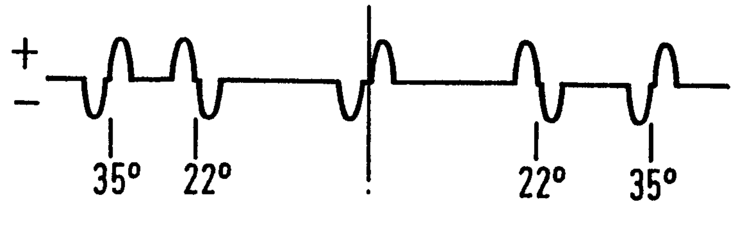


FIG. 5

FIG. 6.



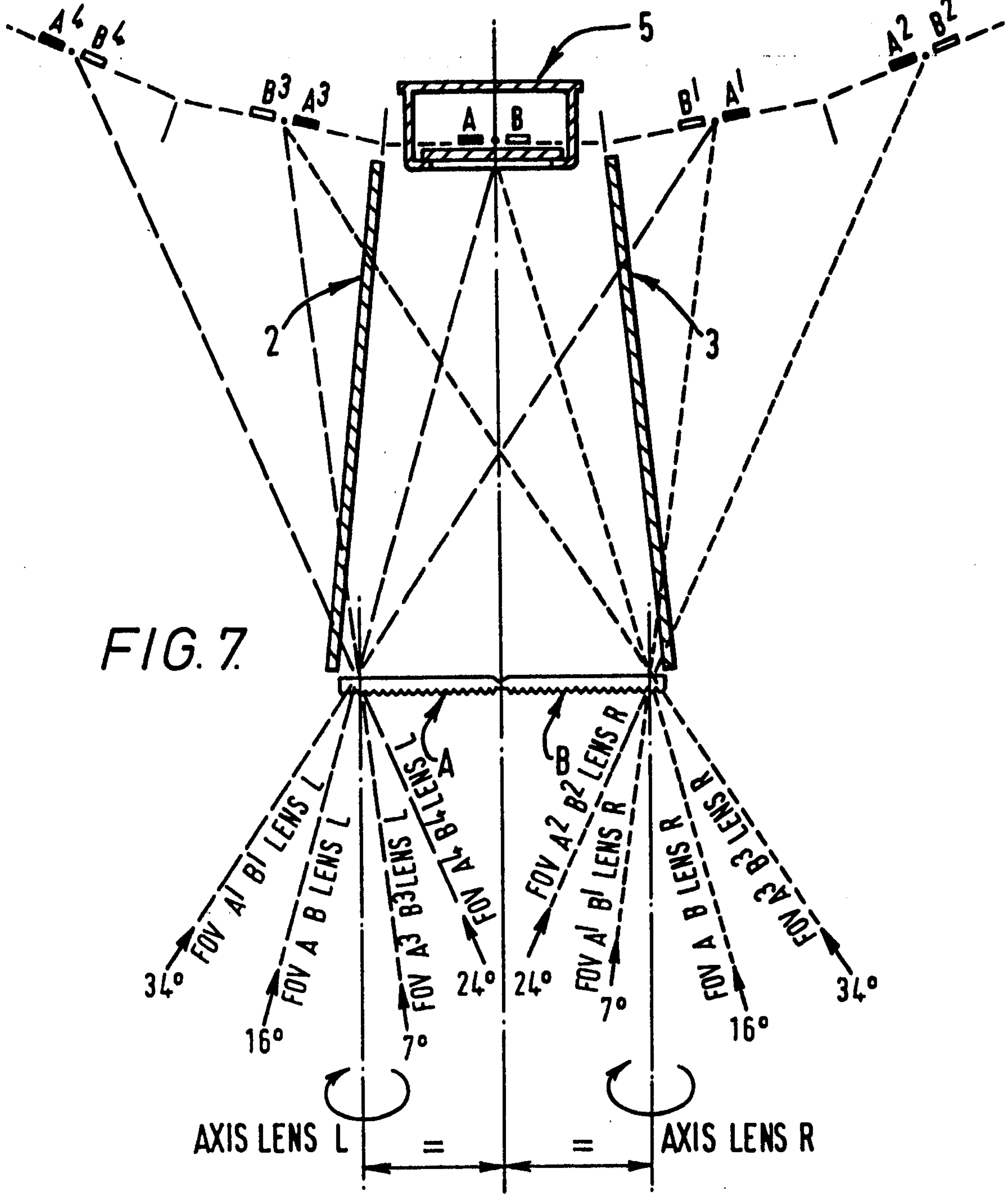
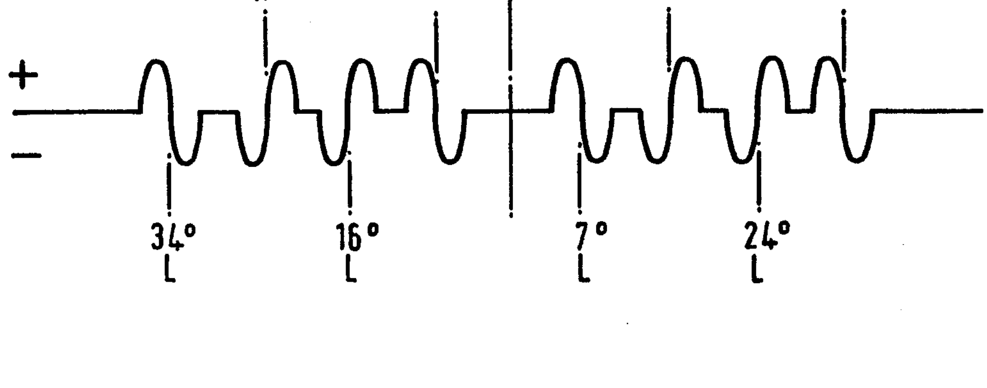

A4
B4
B3
A3
5
A
B
B1
A1
A2
B2
2
3
A
B
FOV A1 B1 LENS L
FOV A B LENS L
FOV A3 B3 LENS L
FOV A4 B4 LENS L
FOV A2 B2 LENS R
FOV A1 B1 LENS R
FOV A B LENS R
FOV A3 B3 LENS R
34°
16°
7°
24°
24°
7°
16°
34°
AXIS LENS L
=
=
AXIS LENS R

FIG. 7.

FIG. 8.


24° R
7° R
16° R
34° R
+
–
34° L
16° L
7° L
24° L

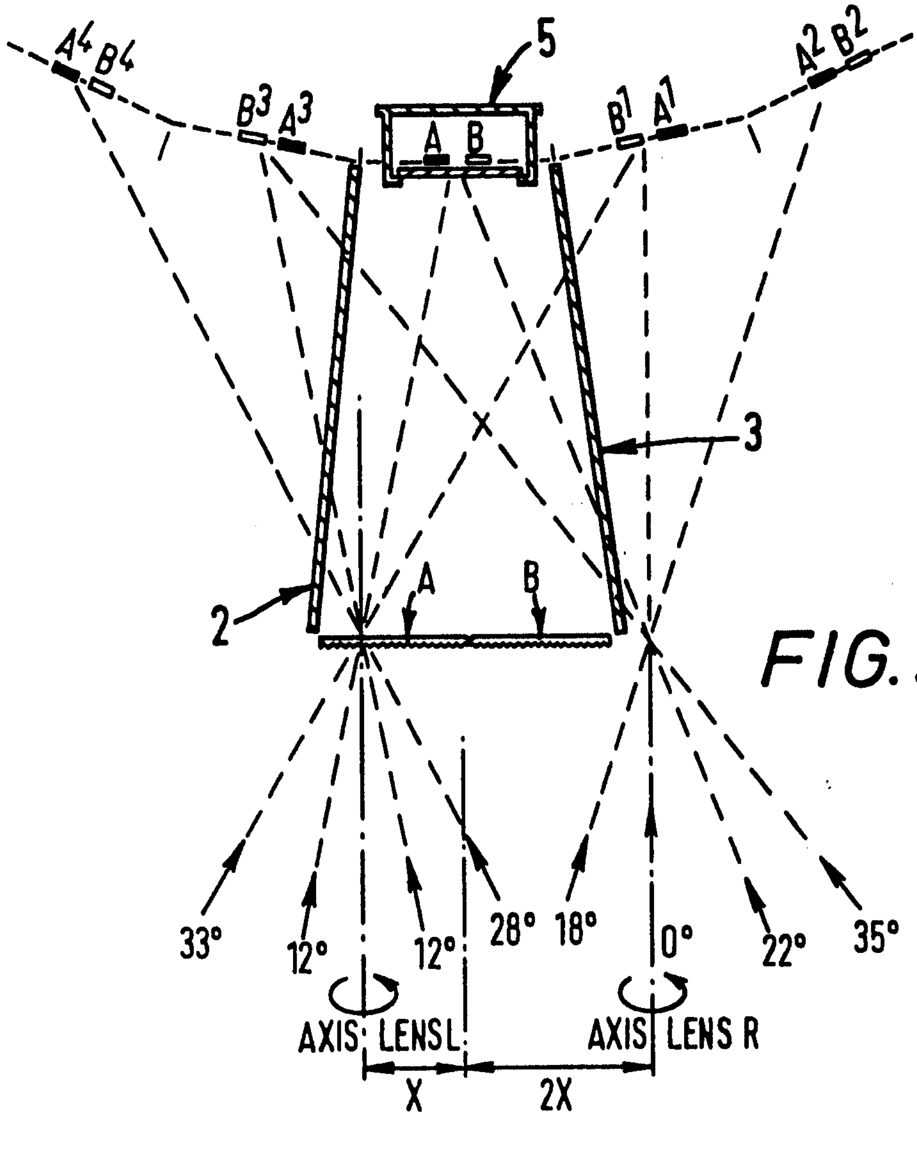

A4 B4
B3 A3
5
A B
B1 A1
A2 B2
3
2
A
B
33°
12°
12°
28°
18°
0°
22°
35°
AXIS LENS L
AXIS LENS R
X
2X

FIG. 9.

European Patent Office

EUROPEAN SEARCH REPORT

0219954

Application number

EP 86 30 6815

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	US-A-4 442 359 (D.B. LEDERER) * figure 2; column 3, lines 30-46 * ---	1,5	G 08 B 13/18
Y	US-A-4 087 688 (H. KELLER) * figure 1; column 3, lines 34-37, claim 6 * ---	1,5	
P,A	DE-A-3 424 135 (R. HIRSCMANN) * figures 1, 2; claim 5 * ---	1,2	
A	DE-A-2 836 462 (WÖRL-ALARM) * figure 3, claim 5 * ---	1	
P,A	EP-A-0 177 130 (MATSUSHITA ELECTRIC WORKS) * figure 23; page 17, lines 13-18 * ---	3,4	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	EP-A-0 065 159 (R. HIRSCHMANN) * figures 1, 2, abstract * ---		G 08 B 13/18
A	US-A-3 703 718 (H.L. BERMAN) * figure 6, abstract;- & GB - A - 1 335 410 (Cat. D) * -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	28-11-1986	BREUSING J

CATEGORY OF CITED DOCUMENTS

- X : particularly relevant if taken alone
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