(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 953 952 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.11.1999 Bulletin 1999/44

(51) Int Cl.6: G08B 13/19

(21) Application number: 99303364.6

(22) Date of filing: 29.04.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 30.04.1998 GB 9809152

(71) Applicant: Guardall Limited
Newbridge, Edinburgh EH28 8LP, Scotland (GB)

(72) Inventors:
- Willink, Edward Daniel
Reading, RG1 3PP (GB)
- Henness, Alan
Grangemouth FK3 8BL (GB)
- Owers, Ian Alexander
Aberdour, Fife KY3 0TY (GB)
- McKelvie, Martin James Lister
Ladywell West, Livingston EH54 6UT (GB)
- Holme, Roger
Kirkliston, West Lothian EH29 9LBJ (GB)

(74) Representative: Mosey, Stephen George
MARKS & CLERK
Alpha Tower
Suffolk Street Queensway
Birmingham B1 1TT (GB)

(54) Electromagnetic radiation sensing device

(57) An electromagnetic radiation sensing device (20) has an n x m array (22) of detecting elements (24) (where n and m are integers greater than unity). These elements (24) are symmetrically arranged about at least one axis, so as to form at least two sub-arrays (26,28). In response to illumination by electromagnetic radiation the sub-arrays (26,28) produce output signals which are substantially equivalent in magnitude and phase.

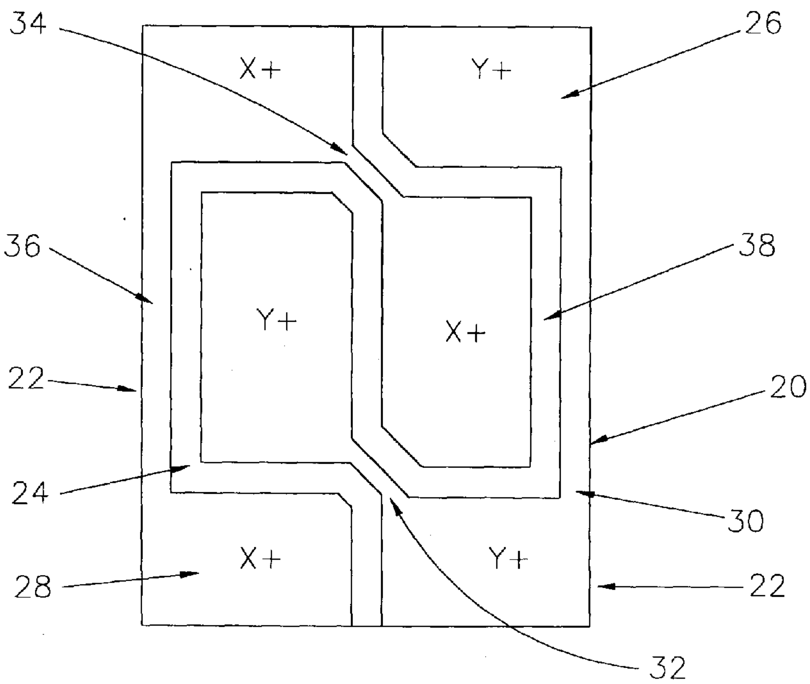

FIG 2

EP 0 953 952 A2

Description

[0001] The invention relates to an electromagnetic radiation sensing device and signal processing methods, this device having particular relevance in the field of pyroelectric passive infra-red detector devices as used in intruder alarm systems.

[0002] Pyroelectric passive infra-red (PIR) detectors have long been established as the preferred actuating sensors for use in intruder detection systems. The generation of a charge within the pyroelectric material by incident electromagnetic radiation is used as the trigger for alarm actuation.

[0003] The majority of current PIR detectors employ a balanced 'dual' element sensor, which utilise only a single amplification channel. Noise, either present in the sensor or the amplification pathway, can result in undesired actuation of the alarm. A solution to this problem is the use of a 'quad' sensor having two output channels each with independent amplification channels, the alarm being actuated only when similar signals are present on both channels, thus reducing the frequency of false alarms. However, current 'quad' sensor based PIR detectors suffer from a pronounced asymmetry in output signals between the two output channels. This is due to asymmetries present in the detector elements themselves. These asymmetries in output signal manifest themselves in both phase and amplitude differences and present severe problems when attempts are made to perform correlation or difference signal processing upon the outputs in order further to reduce the frequency of false alarms.

[0004] It is an object of the present invention to provide an improved electromagnetic radiation sensing device which obviates or mitigates these problems.

[0005] It is a further object of the present invention to provide signal processing methods which obviate or mitigate these problems.

[0006] According to the present invention an electromagnetic radiation sensing device comprises an n x m array of detecting elements (where n and m are integers greater than unity), the elements being symmetrically arranged about at least one axis so as to form at least two sub-arrays such that, in use, in response to illumination by electromagnetic radiation the sub-arrays produce output signals which are substantially equivalent in magnitude and phase.

[0007] The axes of symmetry may be two orthogonal axes.

[0008] Preferably the sub-array output signals are substantially equivalent in magnitude and phase when progressively illuminated from an edge of the sub-arrays in either the horizontal or vertical directions by the source of illumination.

[0009] More preferably the horizontal and vertical directions define the two orthogonal axes of symmetry.

[0010] Even more preferably the output response of the sub-arrays to motion of the source of illumination is invariant between any two sub-arrays.

[0011] Desirably the detecting elements are of pyroelectric material.

[0012] The electromagnetic radiation sensing device may be for use in the infra-red region.

[0013] Beneficially at least two electromagnetic radiation sensing devices, as characterised above, are coupled so as to form a multi-channel detector, in which each channel is connected to one sub-array on each of the devices.

[0014] The electromagnetic radiation sensing device may be used to trigger an alarm.

[0015] According to another aspect of the invention, there is provided a method of analogue comparison of input signals, substantially similar in magnitude and phase, in order to produce an output signal, which is utilised as an actuation signal.

[0016] Advantageously an output from an analogue difference comparison of the multi-channel detector outputs is used to trigger an alarm.

[0017] Alternatively an output from a digital correlator, following A/D conversion of the multi-channel detector outputs, acting upon said converted outputs is used to actuate an alarm.

[0018] The invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a view of an example of a pair of electromagnetic radiation sensing devices which embody the present invention;

Figure 2 shows an alternative embodiment of the electromagnetic radiation sensing device of Figure 1;

Figure 3 is a schematic block diagram of the correlation signal processing circuitry.

Figure 4 is a schematic block diagram of the differential signal processing circuitry.

[0019] Two rectangular idealised 'six pad' sensors 10, 11 shown in Figure 1 each comprise a 3 x 2 array 12 of rectangular pyroelectric elements 14, the array being divided into two sub-arrays 16, 18. Figure 1 shows the two 'six pad' sensors 10,11 with the sub-arrays 16, 18 labelled Y and X respectively. This naming convention will be held in respect of detailing sub-array and sensor outputs hereinafter.

[0020] The sub-arrays 16, 18 are symmetrically arranged relative to both horizontal and vertical axes, such that, in use, a large intruder, a large intruder being defined as an intruder substantially filling the field of view of focusing optics, in this case a Fresnel lens 40, Figures 3 and 4, illuminates both sub-arrays 16, 18 equally. This equal illumination results in output signals from both sub-arrays 16, 18 being substantially equivalent.

[0021] In an alternative, more practicable, embodiment shown in Figure 2 a rectangular 'six pad' sensor 20 comprises a 3 x 2 array 22 of detector elements 24, the array 22 being divided into two sub-arrays 26, 28. Adjacent detector elements 24 within each of the sub-arrays 26, 28 are selectively interconnected by narrow active strips 30, 32, 34, 36. In use, the narrow active strips 30, 32, 34, 36, are of a width such that thermal leakage edge effects will reduce pyroelectric efficiency to such an extent that there will be no significant contribution to the output signal from these strips 30, 32, 34, 36 and they are therefore not regarded as detecting elements 24.

[0022] Non-conducting guard bands 38 separate the sub-arrays 26, 28 such that, in use, there is no cross talk between said sub-arrays 26, 28.

[0023] The detector outputs can be processed using either correlation signal processing, Figure 3, or difference signal processing, Figure 4.

[0024] As shown in Figure 3, a Fresnel lens 40 focuses radiation from an intruder on to a multi-channel detector 42. The outputs from said detector 42 are passed to independent pre-amplifiers 44, 46. The amplified signals are output to an ASIC 48, wherein band pass filtering occurs, and subsequently to a microcontroller 50.

[0025] The microcontroller 50 includes a eight bit analogue to digital (A/D) converter 52 wherein a population of forty two samples is formed, at a sampling rate of twenty milliseconds, for each of the outputs. These populations of channels X and Y being hereinafter referred to as x and y respectively.

[0026] These populations are compared using a correlation function represented by the following algorithms:

$$Cx,y = \frac{Cov(x,y)}{\sigma_x \sigma_y}$$

(Cx,y = 1 for identical signals) σx and σy are standard deviations of the populations x and y.

$$Cov(x,y) = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x}_n)(y_i - \bar{y}_n)$$

$\bar{x}$ and $\bar{y}$ are the mean of the populations x and y.

[0027] When Cx,y exceeds a pre-determined threshold value, e.g. 0.9, the signals are considered similar enough to produce an alarm and an actuation signal is produced. The case of perfect correlation, Cx,y = 1, is not used to produce an actuation signal as perfect correlation occurs when there is no signal output from the sensors 10, 11.

[0028] To reduce the frequency of false alarms due to static thermal background radiation a consideration of the standard deviation of the populations is calculated. When the standard deviation exceeds a threshold value an actuating signal is produced. A processor 54 of the microcontroller 50 includes a routine which creates an activity signal if, within a predetermined duration time window started when either one of the correlation function process or the standard deviation calculation process produces an actuation signal, the other process produces an actuation signal, i.e. if the standard deviation exceeds its threshold and the correlation function exceeds its threshold within the predetermined duration. The processor also includes a soft counter which acts as an integrator. The count is incremented by each activity signal and decremented every 0.5 seconds. If the count reaches 5 an alarm signal is generated.

[0029] In the case of differential signal processing circuitry shown in Figure 4, output signals from a detector 42 are passed to independent amplifiers 58, 60 the outputs of which are passed to both an amplifier 62 and a differential signal processing unit 64 and compared at the amplifier 62 so as to provide an output signal therefrom which is the difference between the two channels.

[0030] The three signals are processed in the differential signal processing unit 64, wherein comparator thresholds are set which if exceeded in conjunction with substantially the same output from both detector arrays, i.e. there is a small difference signal, an actuation signal is sent to the alarm processing unit 66.

Claims

1. An electromagnetic radiation sensing device characterised in that, an n x m array (22) of detecting elements (24) (where n and m are integers greater than unity), the elements (24) being symmetrically arranged about at least one axis, so as to form at least two sub-arrays (26,28) such that, in use, in response to illumination by electromagnetic radiation the sub-arrays (26,28) produce output signals which are substantially equivalent in magnitude and phase.

2. An electromagnetic radiation sensing device as claimed in Claim 1 wherein, the output signals of any two sub-arrays (26,28) remain substantially equivalent when illuminated by a moving source of illumination.

3. An electromagnetic radiation sensing device as claimed in Claim 2 wherein, the sub-array (26,28) output signals are substantially equivalent in magnitude and phase when progressively illuminated from an edge of the sub-arrays (26,28) in either the horizontal or vertical directions by the source of illumination.

4. An electromagnetic radiation sensing device as

claimed in any of Claims 1 to 3 wherein, the detecting elements (24) are of pyroelectric material.

5. An electromagnetic radiation sensing device as claimed in any preceding Claim which, in use, senses in the infrared region.

6. An electromagnetic radiation sensing device as claimed in any preceding Claim wherein, the axes of symmetry are two orthogonal axes.

7. An electromagnetic radiation sensing device as claimed in Claim 6 wherein, the horizontal and vertical directions define the two orthogonal axes of symmetry.

8. Two electromagnetic radiation sensing devices, as characterised in any of the preceding Claims, coupled so as to form a multi-channel detector (42), in which, in use, each channel is connected to one sub-array (26,28) on each of the sensing devices (20).

9. An electromagnetic radiation sensing device as claimed in any preceding Claim wherein, the sensing device is used in the actuation of an alarm.

10. An electromagnetic radiation sensing device as claimed in any of Claims 1 to 8 wherein, the output signal from the sensing device is used in the actuation of an alarm.

11. A method of analogue comparison of input signals, substantially similar in magnitude and phase, in order to produce an output signal, which is utilised as an actuation signal.

12. A method of analogue comparison of input signals as claimed in Claim 11 wherein, an analogue difference comparison of the multi-channel detector (42) outputs is used in the actuation of an alarm.

13. A method of analogue comparison of input signals as claimed in Claim 12 wherein, the alarm is actuated when the output of an analogue difference comparison of the outputs of the two multi-channel detector (42) outputs is less than a threshold value and the multi-channel detector (42) outputs cross respective thresholds.

14. A method of comparison of input signals, substantially similar in magnitude and phase wherein, an output from an analogue to digital (A/D) converter/correlator (52), following A/D conversion of the multi-channel detector (42) analogue outputs, acting upon said converted outputs is used to actuate an alarm.

15. A method of comparison of input signals, substantially similar in magnitude and phase as claimed in Claim 14 wherein, said digital correlator (52) generates an activity signal when the correlation between samples of the each of the multi-channel detector (42) outputs exceeds a threshold value.

16. A method of comparison of input signals, substantially similar in magnitude and phase as claimed in Claim 15 wherein, said digital correlator (52) generates a further activity signal when the standard deviation of a sample of one of the multi-channel detector (42) outputs exceeds a threshold value.

17. A method of comparison of input signals, substantially similar in magnitude and phase as claimed in either of Claims 15 or 16 wherein, a counter is incremented by said activity signal.

18. A method of comparison of input signals, substantially similar in magnitude and phase as claimed in Claim17 wherein, an alarm is actuated if said counter exceeds a threshold value within a specified time period.

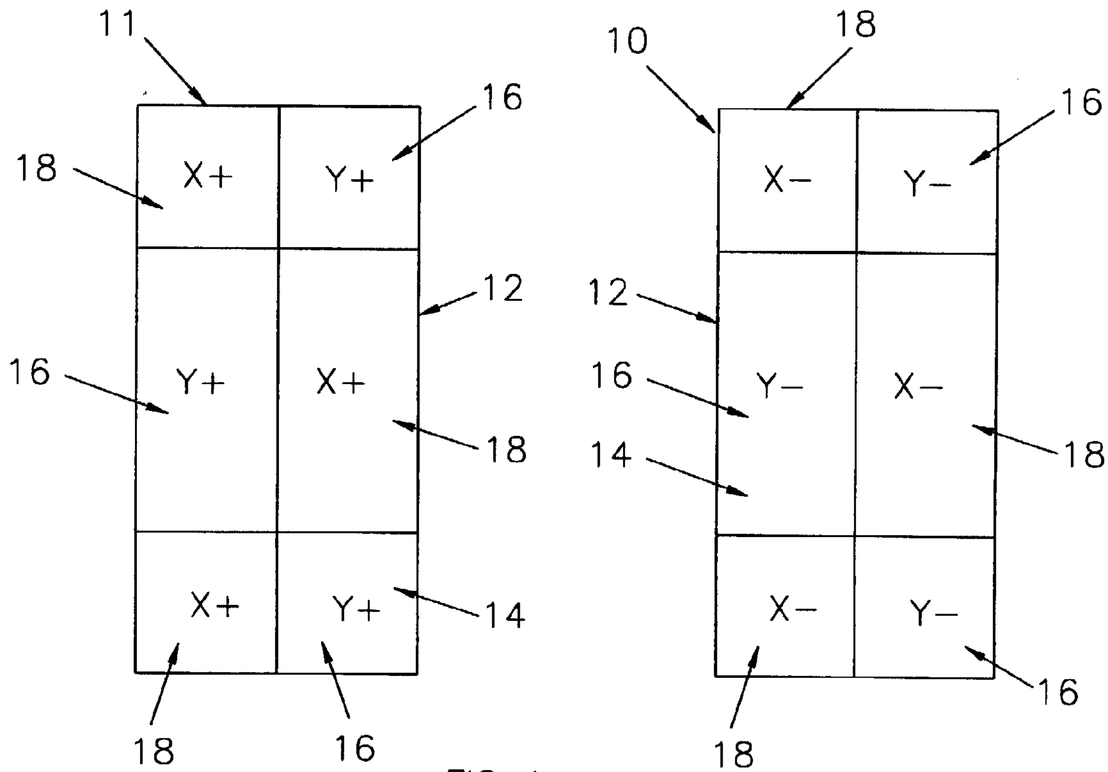
11
16
18
X+
Y+
12
16
Y+
X+
18
X+
Y+
14
18
16
10
18
16
X−
Y−
12
16
Y−
X−
14
18
X−
Y−
16
18

FIG 1

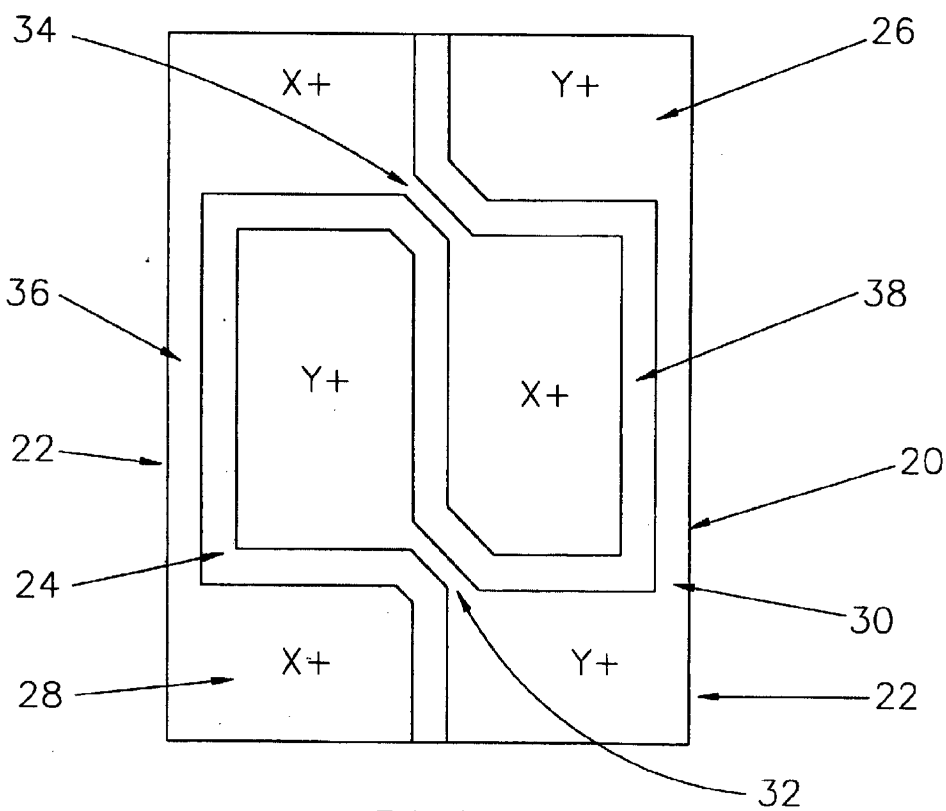
34
26
X+
Y+
36
38
Y+
X+
22
20
24
30
X+
Y+
28
22
32

FIG 2

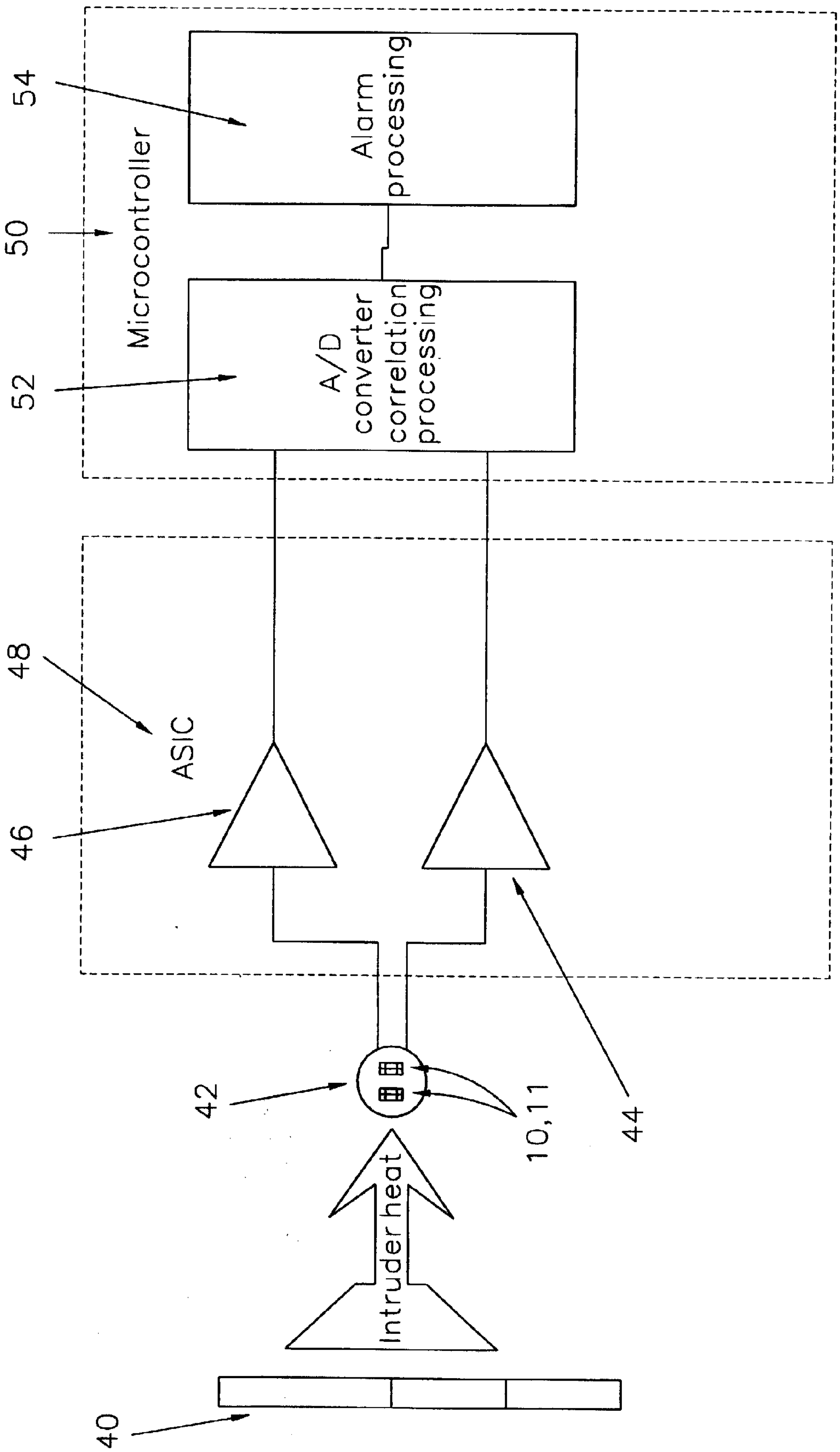
54
50
52
Microcontroller
Alarm processing
A/D converter correlation processing
48
46
ASIC
42
10,11
44
Intruder heat
40

FIG 3

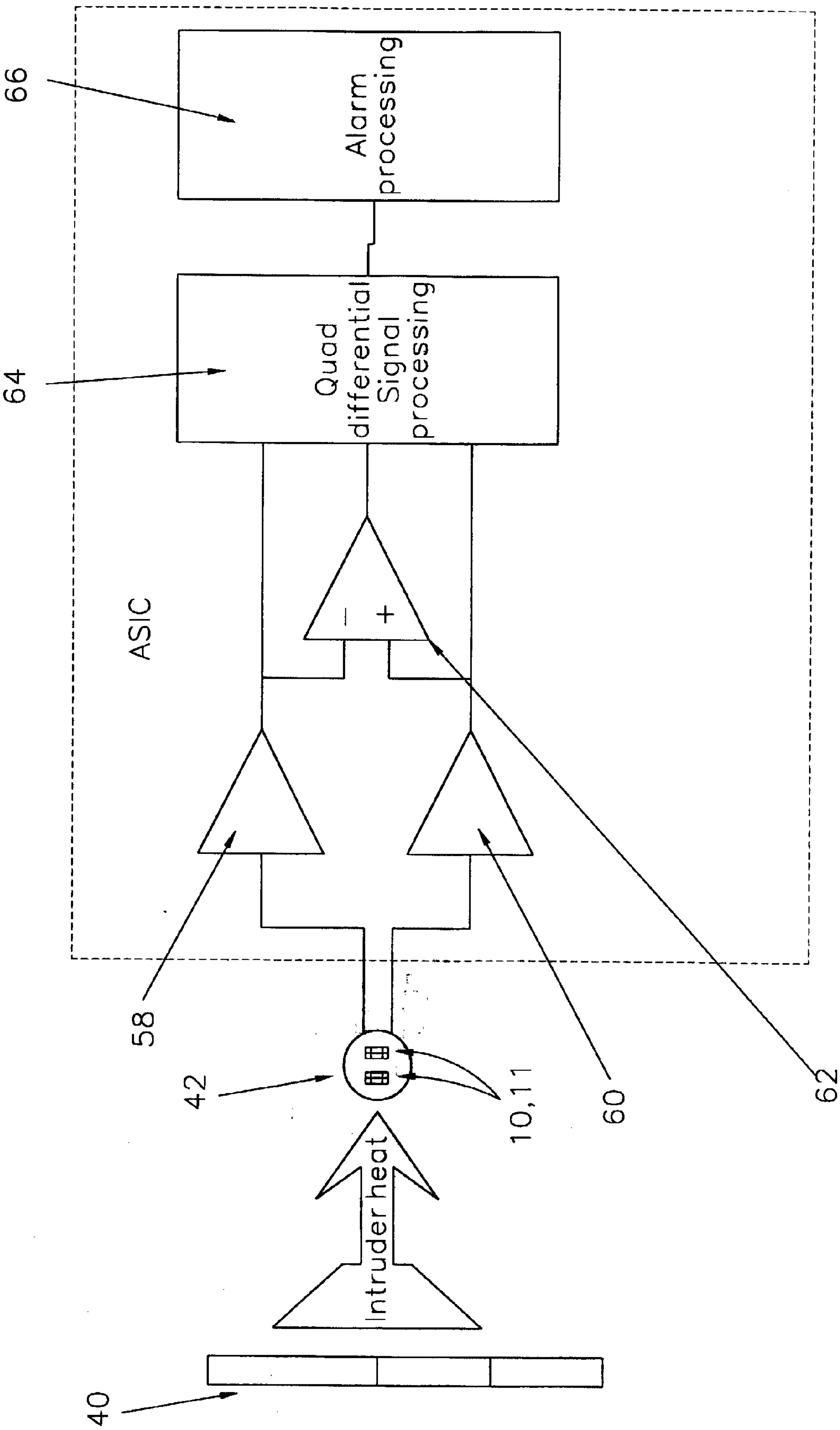
66
Alarm processing
64
Quad differential Signal processing
ASIC
−
+
58
42
10,11
60
62
Intruder heat
40

FIG 4