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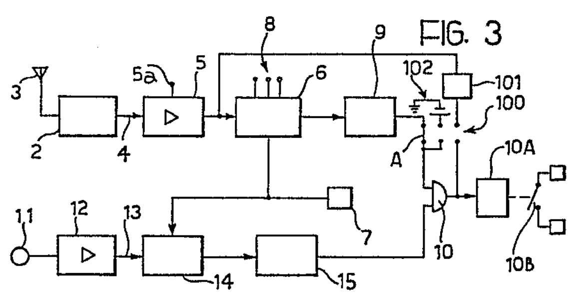
(54) **Monitoring device with infrared and radio-frequency sensor components.**

(57) The device, designed for use in intruder alarm systems, uses a combination of an infrared sensor (11) and a radio-frequency sensor (2, 3) whose operating frequency is substantially in the UHF band.

FIG. 3

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## Description

### Monitoring device with infrared and radio-frequence sensor components

The present invention relates to monitoring devices of the type designed for use in intruder alarm systems (anti-theft systems).

The invention relates more particularly to a monitoring device using a combination of an infrared sensor and a radio-frequency sensor.

Monitoring devices of this type are already known in which a passive infrared sensor (PIR) is coupled to a radio-frequency sensor operating in the X band (5.2-10.9 GHz) in association with a Gunn diode generator acting as the generator of the wavefront for the illumination of the location to be monitored.

A solution of this type provides goods operating results, particularly as regards the possibility of providing effective cover for the monitored location and the possibility of minimizing false alarms resulting from phenomena (rising air currents, etc.) which do not correspond to actual or attempted intrusions into the location being monitored. The intrusion alarm signal is generated only in the event of actual detection of the intrusion by both the sensors.

This prior solution does not, however, solve certain, relatively important, technical problems.

These include, for example, the fact that the stabilization against frequency drifts of the Gunn diode and the mixer of the microwave sensor may be extremely critical and the high energy consumption of the latter.

In addition to creating problems as regards operating simplicity, the retrivability of the components and reliability (MTBF), operation in such a high frequency range requires, for the radio-frequency sensor, the provision of a fairly large transmitting-receiving unit (cavity) which makes it necessary to use a container housing of a larger size which is consequently harder to conceal to avoid its immediate location and identification.

This latter aspect (i.e. the identification of the combined infrared and radio-frequency operation of the device) is of particular importance, since accurate identification of the type of device may enable, or at least facilitate, the use of countermeasures by the person attempting to intrude into the location being monitored.

The object of the present invention is to provide a monitoring device of the above type which, while retaining unchanged the advantages of the known solutions, does not have the above-mentioned drawbacks.

This object is achieved in accordance with the invention by a monitoring device which uses a combination of an infrared sensor and a radio-frequency sensor, characterized in that this radio-frequency sensor is selected with an operating frequency substantially in the UHF band, preferably a frequency of approximately 2.45 GHz.

In accordance with the solution currently preferred, this radio-frequency sensor is integrated in a UHF oscillator of the self-detect type and is provided with a strip aerial substantially coextensive with a support structure (printed circuit board) on which there are mounted both the infrared sensor and the radio-frequency sensor and/or a board including the infrared sensor and its associated electronics, with the electronics relating to the UHF sensor and the UHF oscillator section in a modular version with a connection to the main portion.

The invention will be described below, purely by way of non-limiting example, with reference to the attached drawings, in which:

Fig. 1 is a perspective view, partly in section, of a monitoring device on the invention,

Fig. 2 shows - on a actual scale - a possible embodiment of one of the components forming the device shown in Fig. 1,

Fig. 3 is a block diagram showing the circuit structure of the device of the invention,

Fig. 4 is a further diagram showing a possible embodiment of one of the circuit components shown in Fig. 3, and

Fig. 5 shows a variant for the connection of the circuit diagram of Fig. 3.

In the drawings, and in particular in Fig. 1, a monitoring device designed, for example, for use in an intruder alarm installation, is designated overall by 1.

This is more particularly a monitoring device using a combination of a passive infrared sensor (PIR) and a radio-frequency oscillator of the self- detect type whose function is to detect the disturbances caused in the respective parts of the electro-magnetic wave spectrum by the presence and movement of an intruder in a monitored location in which the device 1 is installed.

The circuit structure used for the device 1 is shown in Fig. 3.

In Fig. 3, reference numeral 2 indicates a UHF oscillator of the self-detect type connected to a transmitting and receiving aerial 3 in a manner which will be explained in more detail below.

The oscillator 2 has an output line 4 connected to an amplifier 5 able to amplify the signal present on the line 4. In accordance with widely known principles, this signal corresponds to the disturbance of the field of radio-frequency waves present in the location being monitored as a result of the Doppler effect produced by the movement of an intruder in this location.

The signal at the output of the amplifier 5, whose gain is variable and may be selected by acting on a control 5a, so as to vary the sensivity of cover (distance range) of the UHF sensor, is caused to pass through an integrator circuit 6. This is more precisely a so-called delay circuit, controlled by a control circuit whose time constant may be controlled in a selective manner by acting on one or more control terminals 8 so as to regulate the sensivity of detection (minimum extent and duration of the event considered to be detectable) of the UHF sensor. The detection signal emitted at the output of the delay circuit 6 is supplied to a circuit 9 whose function is to generate, from the detection pulse emitted by the circuit 6, a rectangular pulse whose duration may be selected in advance, for example 3-4 seconds. This latter signal is supplied to a logic gate of AND type 10 with two inputs. The connection of the circuit 9 to the gate 10 is formed by a jumper A inserted in a terminal board 100.

The other input of the AND-gate 10 is connected to a further detection branch whose input component is formed by a passive type infrared sensor 11 whose function is to detect, in a known manner, the presence in the monitored location of infrared wavefronts generated by the presence of an intruder in this location.

The signal generated by the infrared sensor 11 is transmitted to a corresponding amplifier 12 which is connected in cascade with two circuits 14 and 15 similar in structure to the above-described circuits 6 and 9 respectively.

The output of the circuit 15 is connected to the logic gate 10 whose output is in turn connected to a relay control circuit 10A which is able to cause, via the closing of a contact 10B, the transmission of an alarm signal from the intruder signalling system (not shown overall) of which the device 1 is part.

The AND mode logic configuration - of the two detection sections (UHF and infrared) provided by the gate 10 in the diagram of Fig. 3 is designed to minimize the probability of false alarms, i.e. the probability that the relay 10A is activated causing the transmission of the alarm signal, as a result of accidental phenomena (for example air current, penetration into the monitored location of light beams from vehicle headlights or from the torches of watchman, starting up of automatic components of domestic electrical products, etc.) not caused by the presence and movement of an intruder in the monitored location. In particular, in the connection arrangement of the terminal board 100 shown in Fig. 3 the relay 10A is activated only when there is at least a partial temporal superimposition of the rectangular pulse signals generated by the circuits 9 and 15. This eliminates the risk of transmission of a false alarm when there is an isolated phenomenon likely to disturb the operation of one of the sensors alone. This is the case, for example, with currents of air moving by convection which are likely to disturb the operation of the infrared sensor 11 but not the operation of the radio-frequency sensor 2.

A further generator circuit, similar in structure to the circuit 9, connected to the output of the amplifier 5 and terminating at the terminal block 100 is designated by 101. As shown in more detail in Fig. 5, the latter is arranged so that it enables, in an alternative manner:

- the connection, via the jumper A, of the output of the circuit 9 to the respective input of the AND-gate 10 (Fig.3), or
- the connection of this input to a voltage source 102 corresponding to a logic level "1" via a jumper B and the connection of the output of the circuit 101 to the output of the gate 10 via a jumper C (Fig. 5).

This latter connection arrangement (which corresponds in practice to the logic sum (OR) of the outputs of the circuits 101 and 15) may be advantageously used in cases in which it is feared that there may be attempts to cover the infrared sensor 11. These attempts are usually carried out by slowly sliding a screen such as a sheet of paper or even a hand in front of the sensor.

These attempts are, however, detected by the UHF sensor, whose output signal, amplified at 5, is transmitted directly, via the circuit 101, to the output of the gate 10 so that the alarm relay 10A can be activated in a completely independent manner, from the sensor 11 which may be masked.

In the meantime, the connection of the first input of this gate to the logic level "1" formed by the source 102 in any case makes it possible to take account of an alarm signal generated by the sensor 11 if the latter is not completely masked.

The fact that in the diagram of Fig. 5, the alarm signal from the UHF sensor is sampled upstream of the delay circuit 6 is due to the fact that, in the case of an attempt to obstruct the sensor 11, the phenomena to be detected generally evolve slowly, but produce comparatively intense blips. In other words, the UHF sensor has two outputs with different level of sensitivity. The first of these, which is used when ascertaining the logic product of the signals transmitted by the two sensors (gate 10) corresponds to the output of the circuit 9, connected to the delay 6. The second output, used when ascertaining - at the output of the gate 10 - the logic sum of the signals from both sensors, is that corresponding to the output of the circuit 101, connected to the amplifier 5 upstream of the delay 6.

The salient feature of the invention lies in the fact that the self-detect oscillator 2 operates in a particular frequency range, i.e. in the UHF band (300-3000 MHz) and preferably at a frequency of approximately 2.45 GHz.

A possible embodiment of the oscillator 2 is shown by way of example in Fig. 4.

In Fig. 4, reference numeral 16 designates a transistor forming the core of the oscillator whose operating frequency may be tuned by acting on a capacitor 17 whose capacitance may be varied in a selective manner around 2-5 pF.

The collector of the transistor 16 is connected to the supply voltage 18 of the device 1 which may be supplied from a supply device (not shown) either from the normal electrical mains or from a floating battery to which two resistors 19 and 20 (with resistance values of 2.7 KOhm and 470 Ohm respectively) are also connected in series to the ground/terminal 21 of the oscillator.

The resistor 19 is connected in parallel with a capacitor 22 having a capacitance value of approximately 4-7 pF, while the intermediate connection point of the resistors 19 and 20 is connected to a coil 23 having an impedance value of approximately 100 Ohm whose opposite terminal is connected to the base of the transistor 16. The base of the transistor 16 is then connected to the aerial 3 via a connection line in which there is interposed, in addition to the tuning capacitor 17, a further coil 24 having an impedance value of approximately 50 Ohm. The series of a coil 25 having an impedance value of 80 Ohm and a resistor 26 having a resistance value of 22 Ohm are connected to the emitter of the transistor 16.

A capacitor 27 with a capacitance of approximately 4-7 pF, is connected with one terminal wire to the intermediate point of connection of the two components 25 and 26 whereas the opposite terminal wire leads to the supply line 18.

The terminal of the resistor 26 opposite to the terminal to which the capacitor 27 is connected acts as an output terminal of the oscillator 2 and is therefore connected to the line 4. A further capacitor 28 with capacitance value of approximately 1000 pF and a further resistor 29 with a resistance value of approximately 100 Ohm, connected in parallel, are finally connected between this latter terminal, i.e. the line 4, and the earth point 21.

A further capacitor is finally designated by 30 and acts as a bypass capacitance for the radio-frequency between the supply line 18 and the ground point 21. This latter capacitor has a capacitance value of approximately 2200 pF.

The above resistance, capacitance and impedance values, in the same way as the diagram shown in Fig. 4, are obviously given solely by way of example, since functionally equivalent circuit solutions for UHF oscillators of the self-detect type may be constructed by persons skilled in the art as part of their normal design expertise.

A printed circuit board is designated by 31, in which practically all the circuit components of Fig. 3 are mounted. Alternatively, the whole of the oscillator may be constructed as a module interconnected to the main board 31.

The board 31, shown on an actual scale in Fig. 2, is mounted within a housing 32 acting as a container for the device 1.

In a particularly advantageous embodiment this involve the same type of container used for the infrared radiation detection device disclosed in a prior Italian Patent Application No. 68009-A/85 in the name of applicants.

The housing 32 is substantially formed by a tray-shaped quadrangular body 33 to which there is applied a cover 34 shaped generally as a dome in which there is mounted a Fresnel lens 35. The lens 35 acts as a collection element for the infrared radiation present in the monitored location and can focus this radiation on the infrared sensor 11.

The board 31 is mounted within the tray-shaped body 33 so that it is facing the lens with the sensor 11 mounted in a central position with respect to the board 31.

The reference numerals shown in Fig. 2 designate the corresponding circuit components shown in Figs. 3 and 4, i.e., in addition to the infrared sensor 11, the aerial 3 of the oscillator 2, the transistor 16 and the tuning capacitor 17 of the oscillator 2, the relay 10A and the respective contacts 10B.

It should in particular be noted that the aerial 3, whose overall length is approximately 4 cm, is formed simply by a strip line applied (using known techniques) to the board 31 and therefore substantially coextensive with the latter or, alternatively, on the board on which the module of the UHF oscillator is mounted.

As mentioned above, the possibility of using, for a monitoring device using an infrared sensor in combination with a radio-frequency sensor, a smaller housing, and in particular a housing in practice identical to those used for devices which make use of an infrared sensor alone, is of considerable importance, both as regards the possibility of masking or obstructing the device in the monitored location, and as regards the possibility of making it harder to identify the combined device as such and, consequently, to implement counter-measures.

As regards power consumption, it needs simply to be noted that a monitoring device of the type described has an electrical current consumption of approximately 25-30 mA.

Naturally, without departing from the principle of the invention, the constructional details and embodiments may be substantially modified with respect to those described and illustrated, without thereby departing from the scope of the invention.

In particular, whereas the above description relates to a combined monitoring device with radio-frequency and infrared sensors in which - by means of a different connection of the terminal block 100 - it is possible to provide both the logic product and the logic sum (anti-obstruction function) of the sensor outputs, it could also be envisaged to construct simplified devices in which one or other of the above-mentioned possible connection configuration is used in a fixed manner.

## Claims

1. A monitoring device using a combination of an infrared sensor (11) and a radio-frequency sensor (2, 3), characterized in that the radio-frequency sensor (2, 3) is selected with an operating frequency substantially in the UHF band.

2. A monitoring device as claimed in claim 1, characterised in that this operating frequency is approximately 2.45 GHz.

3. A monitoring device as claimed in claim 1 or 2, characterised in that the radio-frequency sensor is formed by a UHF oscillator (2) of the self-detect type.

4. A device as claimed in any one of claims 1 to 3, characterised in that the radio-frequency sensor (2,3) is provided with a strip aerial (3).

5. A device as claimed in any one of claims 1 to 4, characterised in that the infrared sensor (11) and the radio-frequency sensor (2, 3) have outputs (9, 15) for the generation of respective warning signals and in that alarm signal generator means (10, 10A, 10B) are provided and may be activated only in the presence of both the said warning signals (9, 15).

6. A monitoring device using a combination of an infrared sensor (11) and a radio-frequency sensor (2, 3), particularly as claimed in any one of claims 1 to 4, characterised in that the infrared sensor (11) and the radio-frequency sensor (2, 3) have outputs (101, 15), for the

generation of respective warning signals and in that alarm signal generator means (1O, 1OA, 1OB) are provided and may be activated even in the presence of only one of these warning signals (1O1, 15).

7. A device as claimed in claims 5 and 6, characterised in that it comprises a connection circuit (1OO) interposed between these outputs (9, 1O1, 15) and the alarm signal generator means (1O, 1OA, 1OB) and may be formed so as to provide the logic product (1O, Fig. 3) or as an alternative the logic sum (1O, Fig. 5) of these warning signals.

8. A device as claimed in claim 7, characterised in that the radio-frequency sensor (2, 3) has a first (9) and a second (1O1) output with different levels of sensitivity, and in that the said connection circuit (1OO) forms the logic product (1OO, Fig. 3) and the logic sum (1OO, Fig. 5), from the first (9) and the second (1O1) outputs respectively.

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FIG. 1

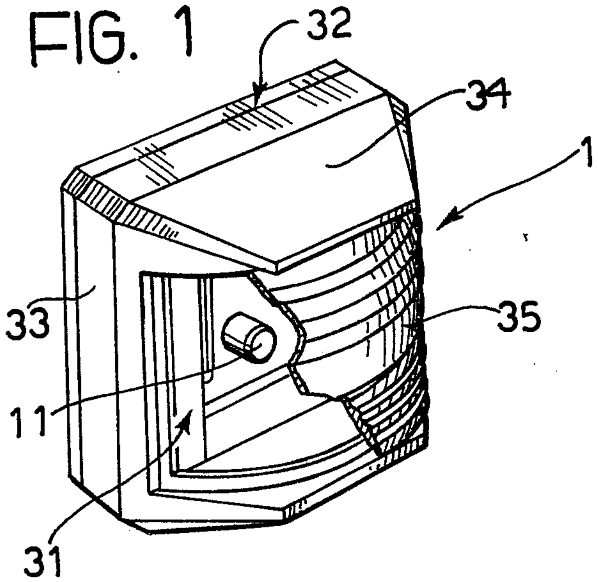


FIG. 5

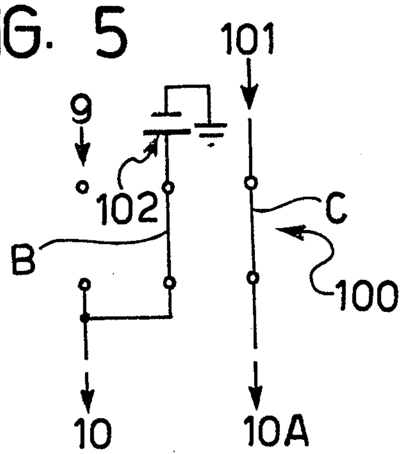


FIG. 4

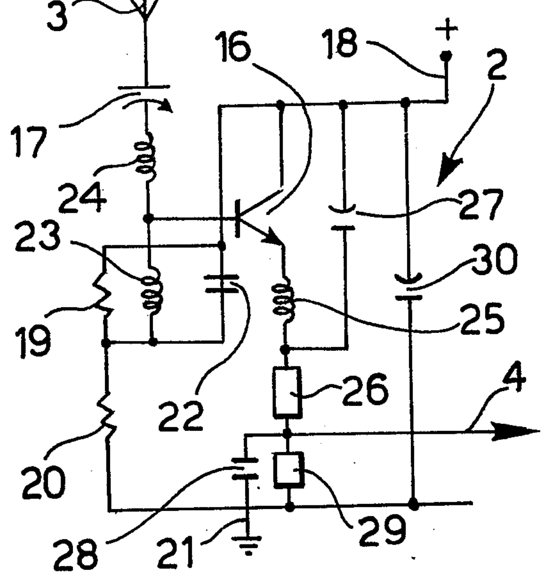


FIG. 2

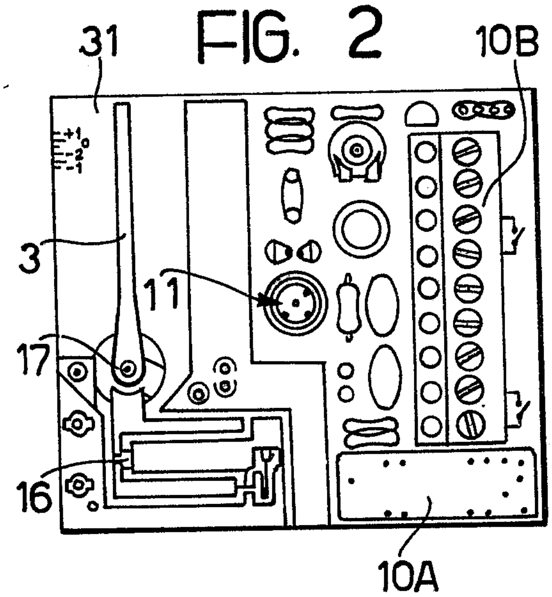


FIG. 3