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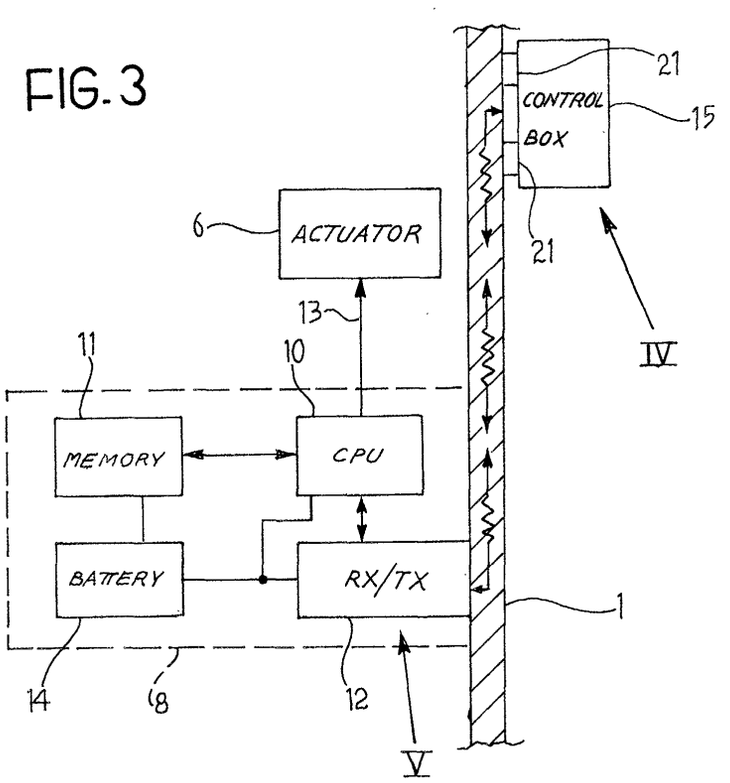
(54) An acoustic-wave control device for a combination lock

(57) A control device for operating a combination lock (2) associated with a body (1) of a door, which includes means (16, 17, 18) for generating a control code for operating the lock (2) and a control unit (10) operable to receive an input control code and to compare it with a predetermined comparison code and, in the event of there being a predetermined relation between the control code and the comparison code, to control the operation of the lock (2).

The means (16, 17, 18) for generating the control code are arranged to generate an acoustic signal for transmitting the code to the control unit (10), by causing a controlled vibration in the body (1) of the door, the control unit (10) also including sensor means (23) for detecting the acoustic signal and determining the corresponding control code.

FIG. 3



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Description

[0001] The present invention relates to a control device for a combination lock, in particular to an electronically operable lock, of a type described in the preamble to Claim 1.

[0002] Electronic locks are known in which an identification code (usually for unlocking the lock) is entered by means of a keypad arranged on the door. A control unit receives this code, accesses a memory and compares it with a list stored therein and, if the code corresponds to one in the memory, interprets this as permitted access and releases the locking device so that the door can be opened. However, the presence of this keypad constitutes a weak point in the door since it is possible to attempt to force the lock by means of the cable connecting it to the keypad.

[0003] Other locks use aerials to transmit the code from a transmitter to a receiver by means of radio signals.

[0004] Japanese Patent Application JP 11-210288 describes an electronic system for controlling a lock associated with a door, which includes means for detecting a knock thereon. When these means recognize that someone has knocked on the door, they alert the control unit which uses a two-way radio to send a signal checking an identification code.

[0005] However, the aerial is also visible and could invite attempts at forcing the lock. On the other hand, if the electronic lock is associated with an armoured door, it is not possible to arrange the aerial inside the door since it would be very difficult for it to receive signals correctly from outside.

[0006] The object of the present invention is to provide a control device for a combination lock of the type mentioned, whereby it is possible to transmit a code for releasing the lock which has no visible elements on the outside of the door which would enable the position of the lock to be recognised, and no weak points enabling it to be forced or broken.

[0007] This object is achieved, according to the present invention, by providing a control device for a combination lock having the characteristics claimed in Claim 1.

[0008] Particular embodiments of the invention are described in the dependent Claims.

[0009] One advantage is that it is possible to fit such a control device to existing locks without having to drill holes or perform other operations in order to run wires between the inside and the outside of the door, operations which would prove somewhat complicated in the case of very thick or heavily armoured doors.

[0010] A preferred, but not limitative, embodiment will now be described with reference to the appended drawings, in which:

Figure 1 is a perspective view of the external surface of a door with a lock operated by a control device according to the present invention;

Figure 2 is a perspective view of the inside surface of the door of Figure 1;

Figure 3 is a block diagram illustrating the operation of a control device according to the present invention;

Figure 4 is a block diagram illustrating a detail of Figure 3 indicated by an arrow IV;

Figure 5 is a block diagram illustrating a detail of Figure 3 indicated by an arrow V; and

Figure 6 represents the pattern of a signal generated by a control device according to the present invention.

[0011] Figures 1 and 2 show an armoured door, that of a safe for example, with a body 1 having a lock 2 of a known type. This lock includes a casing 3 containing a mechanism (not shown) able to move bolts 5 so that they enter corresponding cavities in a fixed part of an opening (not shown). This mechanism is controlled electronically by means of an actuator 6, also of a known type. As can be seen from Figure 2, the lock 2 and the actuator 6 are fixed to the inside surface of the body 1 of the door, but they could also be incorporated into the body 1 itself. A handle 7 is present on the outside surface of the door.

[0012] A housing 8 is also secured to the inside surface of the door and contains, as shown in Figure 3, a first portion of the control device of the invention, including an electronic control unit 10, a memory device 11 and a transmitting-receiving unit 12.

[0013] The control unit 10 is connected electrically to the actuator 6 by means of a cable 13 so that it can control the release of the lock 2. This control unit is also connected electrically both to the memory 11 and to the transmitter-receiver 12. A battery 14 supplies power to the electronic components arranged on the body 1 of the door.

[0014] The control unit 10 and the memory 11 are arranged in a known manner, whereby the memory 11 is able to store a comparison code or combination, and the control unit 10 is able to receive an input control code (as will be explained in greater detail later), to compare this received code with the comparison code retrieved from the memory 11 and, should the input code have a predetermined relation with the comparison code, to control the release of the lock 2.

[0015] With reference to Figure 4, a second portion of the control device comprises a control box 15, which is preferably removable and portable, adapted to generate a code controlling the release of the lock. This control box 15 includes a box-like casing 15a containing a control circuit 16 which connects a battery 16a supplying power to the components of the control box 15, a memory 16b, a keypad 17 for entering an identity code, a percussion member 18 able to produce a controlled vibration or acoustic signal in the body 1 of the door, thereby transmitting a control code generated by the control

circuit on the entering of a correct identification code, a microphone 19 able to detect a vibration through the body 1 of the door and a screen 20 for visually displaying data such as, for example, the arrival of a reply signal via the microphone 19, or the power charge of the battery 16a.

[0016] In the present embodiment, the percussion member 18 is constituted by a movable element operated by a solenoid (not shown). When the solenoid is activated by a power impulse, it urges the movable element against the door, causing a knock. It is clear that the percussion member 18 could be constructed in any other way, provided that it is able to cause a vibration in the body 1 in response to an electrical signal from the control circuit.

[0017] Finally, the casing 15a includes fixing means 21 on its contact face, enabling the control box 15 to be secured to the body 1 of the door, in the direction shown by the arrow in Figure 1, so that the identification code can be transmitted. The fixing means are preferably magnetic, if the body 1 of the door is of a metal material, or of any other type, such as suction or form locking means. These means are formed in such a way that the percussion member 18 is able to strike the body 1 of the door. They can have through holes, for example, through which the movable element can run during its strike against the door.

[0018] With reference to Figure 5, the receiving-transmitting unit 12 includes a percussion member 22 able to produce a vibration in the body 1 of the door corresponding to the reply signal described above, and a microphone 23, able to pick up the vibration corresponding to the control code travelling through the body 1 of the door and to convert it into an electrical signal.

[0019] According to a preferred embodiment, there is an additional battery (not shown) inside the housing 8 which is rechargeable by piezoelectric recharging means, able to convert the vibrations into electrical impulses used to recharge the battery.

[0020] An example of the operation of the control device of the invention will now be described, with particular reference to the use of a dynamic combination control code.

[0021] An operator keys into the pad 17 an identification code, constituted for example by decimal numbers. The control circuit 16 converts the entered code into a control code which can be constituted, for example, by a group of three hexadecimal numbers, for each of which an exclusive OR operation is executed using three numbers chosen at random from a series of 250, stored earlier both in the memory 16b of the control box 15 and in the memory 11 of the lock.

[0022] At this point, the control code is converted by the percussion member 18 into an acoustic signal which includes a series of impulses, represented in Figures 3 to 5 by broken arrows across the body 1 of the door. A preferred sequence of these impulses through the signal is shown in Figure 6. This includes a sequence of regularly spaced synchronisation pulses BS, spaced by 40 ms for example, and produced by repeated taps of the percussion member 18 against the body 1 of the door. Between one synchronisation pulse and another, the control circuit 16 reads one bit BC of the generated control code and, should this bit BC be equal to 1, controls the percussion member 18 to impart one tap on the body 1 of the door. Should the bit BC be 0, the percussion member 18 remains still. In the subsequent interval between two synchronisation pulses BS, the control circuit reads the next bit BC and so on until the code is completed.

[0023] The first synchronisation pulse transmitted by the control box 15 travels through the body 1 of the door until it reaches the transmitter-receiver radio 12 through the microphone 23, thereby activating the control unit 10 which starts to read the incoming pulses. At the same time as the code, the control circuit 16 transmits an index in the same way, the function of which will be explained later, and a check sum, in a predetermined order. The control unit 10 analyzes the incoming data: if it recognizes that the transmission is correct (exact number of bits and valid check number) it decodes the sent number using the index as a pointer to find the series of numbers in the memory 11 to use as decrypting key. If the control code is identical to the comparison code stored in the memory 11, the control unit 10 deactivates the lock, memorizes the opening number and transmits data on the state of the battery, using the percussion member 22 of the transmitter-receiver 12 which transmits a reply signal by means of a sequence of pulses similar to that previously described. The control circuit 16 receives the reply signal through the microphone 19, displays the message "DOOR OPEN" or "BATTERY LOW" on the screen 20 and updates the index.

[0024] This index will be used to seek the key and codify the code the next time the door is opened.

[0025] In this way, the code entered by the user is modified by the numerical algorithm according to a key which changes each time the door is opened, thus preventing any misuse of a code which has been recorded by means of a microphone. Retransmission of the same sequence of pulses would not be recognized by the control unit 10, which is expecting a code encrypted by the next group of three numbers.

[0026] Should the sequence of pulses be correct but the code not, attempts at entering the code are counted. If a correct sequence of pulses with an incorrect code is entered three consecutive times, a protection system is activated whereby all activity is blocked for a set period of time (a few minutes, for example).

[0027] On the other hand, should the problem be caused by ambient noise, unexpected knocks on the door, for example, the sequence of pulses will never be recognized as a code and therefore ignored. In such an event, the circuit returns to its normal waiting state.

[0028] It is clear that the invention is not limited to the embodiment described and illustrated here, but that

such modifications may be made to the shape and arrangement of parts as well as to manufacturing and operating details, as are deemed necessary by those skilled in the art, without departing thereby from the scope of the invention, as claimed in the appended Claims.

Claims

1. A control device for operating a combination lock (2) associated with the body (1) of a door, which includes:

   - means (16, 17, 18) for generating a control code for operating the said lock (2), and
   - a control unit (10) for receiving the said control code and comparing it with a predetermined comparison code and provided, should the said control code have a predetermined relation with the said comparison code, to control the action of the said lock (2),

   characterized in that the means (16, 17, 18) for generating the control code are provided to generate an acoustic signal for transmitting the said code to the control unit (10) by causing a controlled vibration in the body (1) of the door, the said control unit (10) including sensor means (23) for detecting the said acoustic signal and determining the corresponding control code.

2. A device according to Claim 1, in which the said means for generating a control code include a percussion member (18) for tapping on the said body (1) of the door so as to generate the said acoustic signal.

3. A device according to Claim 2, in which the said means (16, 17, 18) for generating the control code are contained in a removable and portable box-like casing (15a) which can be placed in contact with the said body (1) of the door so that the signal can be transmitted.

4. A device according to Claim 3, in which the said casing (15a) includes magnetic fixing means (21) for securing it to the door.

5. A device according to Claim 3, in which the said casing (15a) has suction fixing means (21) for securing it to the door.

6. A device according to Claim 3, in which the said casing (15a) has form-locking fixing means (21) for securing it to the door.

7. A device according to any Claim from 4 to 6, in which the said fixing means (21) have a passage allowing the percussion member to tap on the said body of the door.

8. A device according to any preceding Claim, **characterized in that** the said control unit (10) also includes means (22) for generating a reply acoustic signal indicating the operating condition of the lock (2).

9. A device according to Claim 8, in which the said means (22) for generating the reply signal include a respective percussion member (22) able to tap on the said body (1) of the door so as to generate a reply acoustic signal.

10. A device according to any of the preceding Claims, which also includes an additional battery, rechargeable by piezoelectric means, which are able to convert the said acoustic signal into electrical impulses which can be used to recharge the battery.

11. A device according to any preceding Claim, in which the said acoustic signal comprises a sequence of regularly spaced pulses.

12. A device according to Claim 11, in which the said sequence of pulses includes a sequence of synchronisation pulses adapted to synchronise the said sensor means (23) with the generator means (16, 17, 18), with an information pulse being interposed between one synchronisation pulse and the next which indicates the binary value of a corresponding bit of the said control code.

FIG. 1

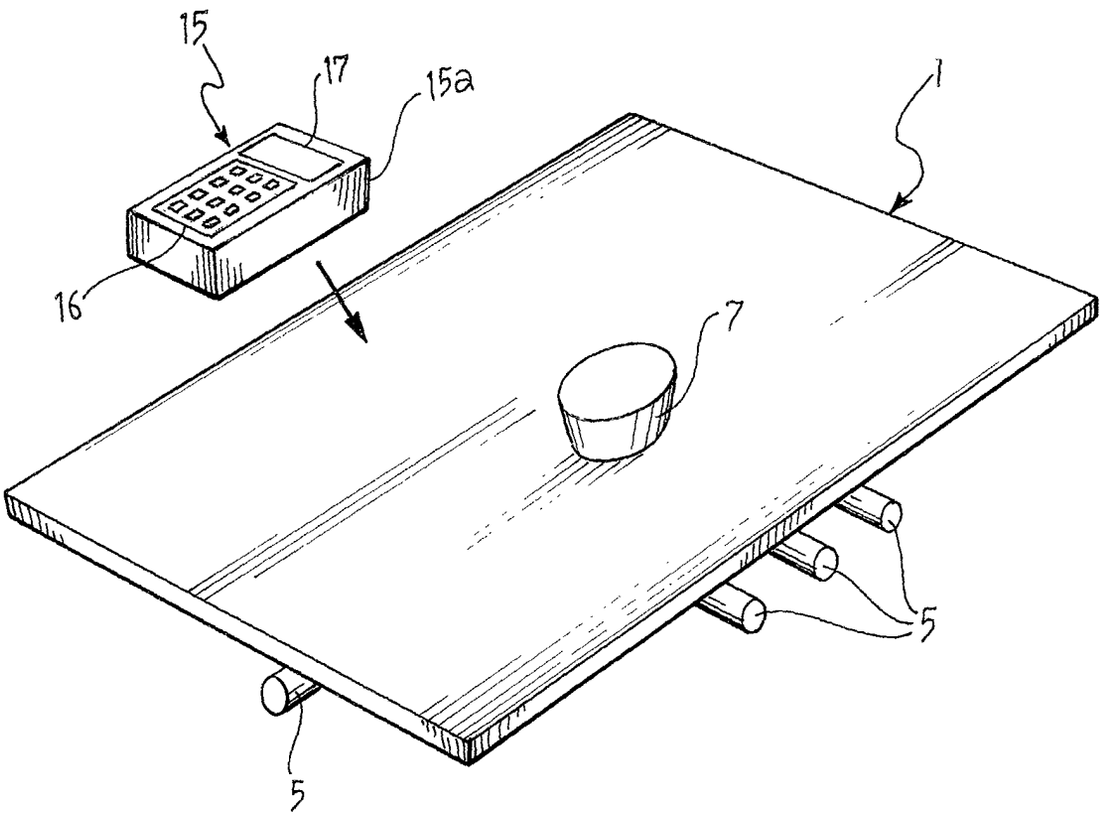


FIG. 2

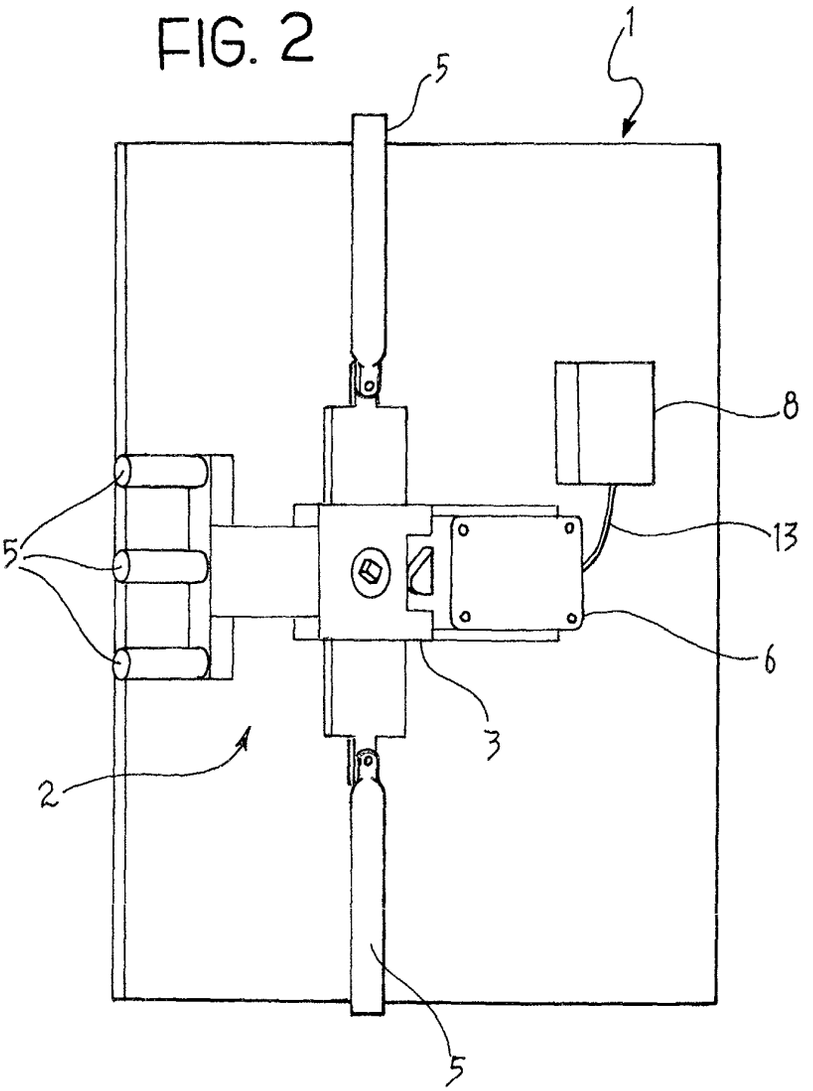


FIG. 6

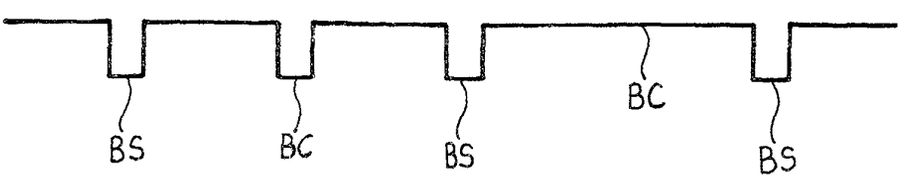


FIG. 3

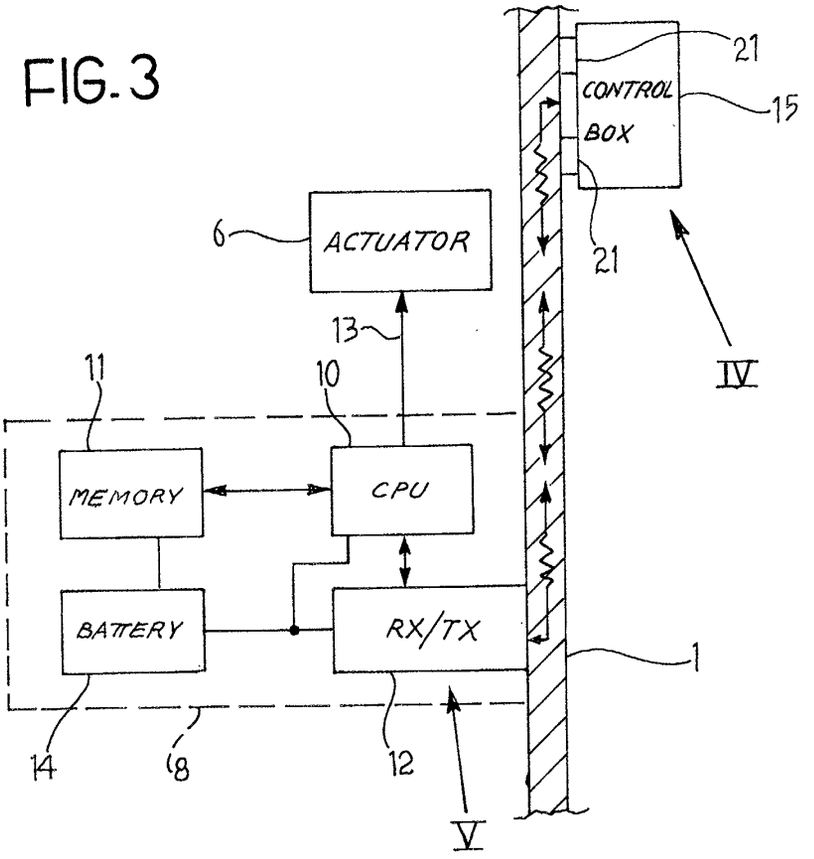


FIG. 4

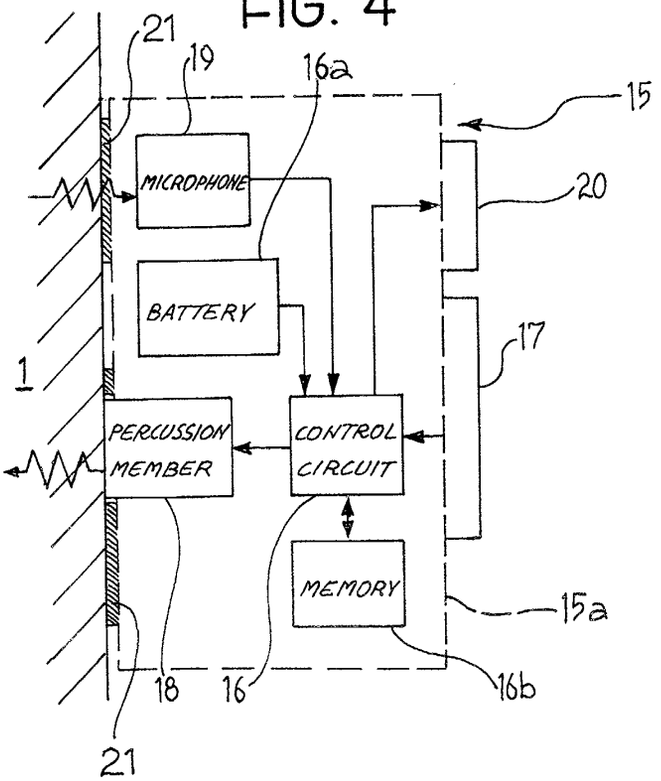
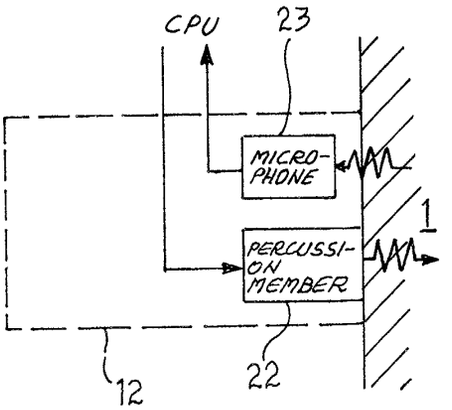


FIG. 5



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EUROPEAN SEARCH REPORT

Application Number
EP 02 42 5010

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X	WO 01 59238 A (GOLDMAN ILAN) 16 August 2001 (2001-08-16) * abstract; claims; figures * * page 1, line 19 - page 3, line 22 *	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 June 2002	Meyl, D

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